STUDYING THE TAILGATING ISSUE IN RHODE ISLAND AND ITS TREATMENT

by

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**ABSTRACT**

A human factors study was conducted to investigate the tailgating issue in Rhode Island and possible means for tailgating treatment. Tailgating is an aggressive driving behavior with a deadly consequence. Following a vehicle too close, i.e., with less than two seconds of following distance, is considered tailgating on Rhode Island highways. To mitigate rear-end collisions caused by tailgating, this study aimed to find out causes of tailgating and public's opinions on tailgating issue as well as to identify possible tailgating treatments. Consisting of a vehicle headway analysis and a questionnaire survey, this study first assessed the tailgating situation on major Rhode Island highways. Surveillance videos capturing 8-lane traffic on three test sites of I-95, I-195, and I-295 in Rhode Island were taken during both rush hours and non-rush hours each day in a two-week period during December 2008. Based on the time stamp embedded in videos, vehicle headways were collected by calculating the intervals between two consecutive vehicles on the same lane passing a fixed reference point. Vehicle headways were tabulated in increments of seconds by day of the week, time of the day, and test site. The results identified serious tailgating situation on Rhode Island highways. More than 60% of vehicles were following with less than 2 seconds of headways during rush hours while 38% were tailgating during non-rush hours. It further found that vehicles on the high speed (innermost) lane exhibited the worst tailgating behavior, especially during rush hours. With serious tailgating issue confirmed, a two-phase questionnaire survey was developed to help find the causes of tailgating and to identify drivers' responses to proposed tailgating treatments. The first phase was designed to identify the causes and effects of tailgating, and to gain insights about drivers' understanding and interpretation of tailgating behavior. Nineteen questions presented in PowerPoint slides were shown to 210 subjects participated in this phase to capture their perceptions on various tailgating issues. The second phase was developed to gather drivers' preferences regarding several proposed tailgating treatment systems. These systems, consisting of pavement marking, roadside marking, dynamic message sign, and fixed road sign were presented to 142

subjects in simulated driving videos in six questions. The questions were presented in a sequential manner and the choices shown in a question would depend on the answer chosen in the previous question. Survey results obtained from the first phase found that the majority of drivers did not know what the proper vehicle headway was to keep while following other vehicles on highways. Most of them considered tailgating a serious offense and one of the top three major causes of highway crashes, however, most of them still maintained insufficient vehicle headways while driving on highways. This finding further confirmed the observations made in the vehicle headway analysis, that is, most drivers on Rhode Island highways maintained insufficient vehicle headways. From the second phase of the survey, it found that the majority preferred horizontal bars painted on pavement as a means to help maintain safe following distance. Drivers would be advised to keep two bars visible from the vehicle ahead. Coupled with the pavement marking, most of them preferred to have the overhead graphic-aided dynamic message signs as a way to communicate to drivers about safe following distance. Based on the results of this study, recommendations to Rhode Island traffic management authorities were made. The findings of this study could contribute to the development of a standard tailgating treatment system to be included in MUTCD and help facilitate a more efficient and safer driving on US highway.

Keywords: Tailgating, Vehicle headway, Human factors

## INTRODUCTION

This paper presents a human factors study that investigated tailgating issue in Rhode Island and possible means for tailgating treatments. "Tailgating" is defined as following a vehicle with insufficient vehicle headway. When following a vehicle on highway, vehicle headway is the time interval between the time points that the two vehicles passed the same reference point. Following with a vehicle headway less than 2 seconds is considered insufficient and unsafe. Tailgating is one of the most dangerous and aggressive driving behaviors, and is a major cause of rear-end crash which has resulted in an annual average of 2.5 million incidents in the United States (Lee et al. 2002). Since tailgating is commonly seen on Rhode Island highways, it is important to find effective tailgating treatments to warn tailgating behaviors and to educate drivers maintaining proper *v*ehicle headways. Helping drivers maintain safe following distance could lessen tailgating and mitigate rear-end collisions caused by tailgating.

In this study, a vehicle headway analysis was conducted to assess the tailgating situation on Rhode Island highways. The study next examined drivers' opinions on tailgating behavior and possible tailgating treatments. Various tailgating treatment systems consisting of advisory signs and road markings were developed to assist drivers gauging their following distances. A two-phase questionnaire survey was developed and conducted to assess drivers' understandings and preferences on these systems. The objectives of this study are to assess tailgating behavior on Rhode Island highways, to identify the causes and effects of tailgating, and to capture drivers' preferences regarding tailgating treatments. The study was aimed to find an effective tailgating treatment for the state of Rhode Island. The findings of this study could also contribute to the development of a standard tailgating treatment system to be included in MUTCD and help facilitate a more efficient and safer driving on US highway.

## BACKGROUND

Reviews of literature and past studies involving tailgating issues and tailgating treatments are provided below.

### Tailgating Issues

The National Highway Traffic Safety Administration (NHTSA) defines "Aggressive driving" as "an individual committing a combination of moving traffic offenses so as to endanger other persons or property." More specifically, speeding, tailgating, weaving in and out of traffic, running red lights, or any combination of these activities are generally considered aggressive driving (Teigen, 2007). While many driving patterns are considered aggressive, tailgating is among the most dangerous ones and is a major cause of rear-end crashes.

Out of an annual average of 6.3 million police-reported automobile accidents in the US in the past few years, rear-end collisions ranked the highest, with about 2.5 million cases per year, and resulted in more than 2,000 fatalities and approximately 1 million injuries (Lee et al., 2002; National Center for Statistics and Analysis, 2003). Data from Federal Highway Administration (FHWA) indicates that each year, approximately 2.2% of total licensed drivers in the US involve in rear-end crashes (Singh, 2003). Two factors are primarily responsible for rear-end crashes: inattention and tailgating (Dingus et al.,

1997), while the latter is the major contributing cause with a deadly consequence (Carter et al., 1995).

Some past researches showed that a wide range of factors such as driver behavior, traffic condition, road condition, roadway design, state law and regulation, and even personality had effects on vehicle headway (Aycin & Benekohal, 1998; Brackstone & McDonald, 1999; Hogema, 1999; Brackstone, 2003; Rajalin, Hassel, & Summala, 1997). Based on these factors, various car following models were developed to describe the interaction between individual vehicles, or the whole traffic dynamics. However, none of them compared these factors and identified factors that have major effects on following distance.

While driving on highways, driver's reaction time varies from 0.5 second for simple situations to 4 seconds for complex situations and the reaction time in braking is about 2.5 seconds (American Association of State Highway Officials AASHO, 1973). Green (2000) and Summala (2000) reported that simple reaction time is often less than 1 second while decision reaction time could take much longer. According to this, quantified safe following distance has been written into rules of the road. It varies from states to states, but mostly in the forms of "2-second rule". Drivers are advised to keep at least 2 seconds vehicle headway from the vehicle ahead driving in the same direction. Rear-end crash risk increases as vehicle headway decreases. When vehicle headway reduces to zero, a rear-end crash occurs.

**Tailgating Treatments**

Hutchinson (2008) conducted an in-depth investigation in Australia on rear-end crash, tailgating, and the correlation between them. Calculations about how tailgating could lead to rear-end crashes were presented in his study. Although it was shown from some rear end crash investigations that inattention in various forms is a more frequent cause than tailgating, there is no doubt that measures to counter tailgating such as advisory signs, markings on the road surface, and enforcement by the police could be promising in mitigating rear-end crashes.

Rama & Kulmala (2000) conducted a field study in Finland and investigated the effects of 2 variable message signs (VMS) on driver's car-following behavior. The signs warned of slippery road conditions and to keep a minimum following distance. It was performed as a before-and-after experiment at 3 test sites. Results showed that the slippery road conditions sign reduced the mean speed by 1-2 km/hour in addition to the decrease caused by the adverse road conditions. The minimum following distance sign reduced the proportion of cars with following distance less than 1.5 seconds, in addition to a speed reduction of 1 km/hour.

To help drivers gauge their following distances, researches were conducted to assess the effects of regularly-spaced markings on highway pavement. Lertworawanich (2006, 2009) conducted a study to estimate safe car-following distance according to speed limit, and developed the "dot" treatment pavement markings. Headways in term of distance were examined before and after the "dot" marking implementation. It found that headways increased after the marking implementation at a given flow rate and the likelihood of rear-end collisions reduced at the study site. Arrows spaced 40 meters apart implying a gap of about 3 seconds at 60 miles per hour were painted on a U.K. motorway

in a study by Helliar-Symons, Webster & Skinner (1995). They found that, because of the markings, crashes were reduced by 56% at the study site.

A few tailgating treatment programs were pilot-tested in several states such as Pennsylvania, Minnesota, and Maryland. PENNDOT's Tailgating Treatment Program (Safety Improvements) was considered the most successful and was honored a 2001 National Highway Safety Award. On a portion of US route 11 that previously experienced high rates of tailgating, aggressive driving and tailgating has dropped a significant 60% after equipping with reflective dots on the roadway and pavement markings and signs that help motorists gauge their distance behind moving vehicles (Roadway Safety Foundation, 2001). Before the implementation, there were 135 crashes a year costing approximately $1.9 million. After the implementation, yearly crashes decreased to 60 at a reduced cost of $1.3 million. The cost of implementation in the first year is estimated at just over $11,000, including enforcement. After eight to nine months, statistics indicated that crash reductions remained fairly constant, pointing to the success of the program.

Given the successes, relatively low implementation cost and the measurable benefits of PENNDOT program, Minnesota DOT and Public Safety piloted a similar project in 2006. The project was viewed as a tool to educate motorists on how to identify and maintain a minimum safe following distance, and ultimately reduce rear end crashes. Minnesota used similar engineering elements from the Pennsylvania program: elliptical pavement dots, informational signs, and a strong public information campaign. A section of State Highway 55 in Wright County was used to paint 94 elliptical dots, spaced 68 meters apart, along a two-mile segment of the rural, single-lane, 55 mile-per-hour roadway. Vehicle headway data collected prior to and after installation of the pavement marking dots and signs showed that at the mid-point of the marking location, the average gap increased from 2.36 to 2.62 seconds, or 6.98 meters (Minnesota Department of Public Safety, 2006).

Michael, Leeming, & Dwyer (2000) implemented a method to collect tailgating data in an urban setting and assessed the effectiveness of 2 hand-held roadside signs admonishing drivers not to tailgate.Data collected on over 25,000 drivers were studied. They found that one of these signs (with a reference to crashes) had a significantly positive impact on drivers' tailgating behavior comparing to the other one, which expanded the average drivers following headway by 0.18 seconds.

Advisory signs could be part of tailgating treatment to mitigate tailgating behavior. However, improper use of advisory message signs could distract drivers and cause inattention leading to rear-end crashes. To reduce the risk of distracting drivers, the use of graphical images to convey the meaning on roadway signs has been employed in many European countries. It is found in many studies that graphically presented information allowed faster responses than information presented by words (Staplin, Lococo, & Sim, 1990; Hanowski & Kantowitz, 1997; Bruce, Boehm-Davis, & Mahach, 2000). Wang et al. (2007) conducted a pioneer study on the use of graphics on dynamic message signs (DMS) and found that most drivers preferred graphics over text and responded faster to graphic-aided messages than text-only messages. Due to these findings, graphics will be used in some advisory signs in the proposed tailgating treatment systems to help enhance drivers' understanding of and responses to these signs and improve the effectiveness of these systems.

From the above reviews, it shows that these tailgating treatments tested were successful in helping drivers maintain safe following distance, but there is still plenty of room for further improvements. Based on these works, this study seeks to develop an effective tailgating treatment system that is appropriate to the state of Rhode Island.

## DESCRIPTION OF THE STUDY

Two approaches were employed in this study, a vehicle headway analysis to assess the tailgating situation in Rhode Island, and a questionnaire survey to find out the public's perceptions on tailgating and its treatment.

### Vehicle Headway Analysis

In this approach, traffics at three test sites on I-95, I-195, and I-295 in Rhode Island were analyzed. The analysis was made on highway traffic surveillance videos that captured 8-lane traffic taken by three highway surveillance cameras installed on I-95 at Detroit Ave, I-195 at Rte. 114, and I-295 North at Exit 6 (see Figure 1).

Videos taken during both rush hour and non-rush hour each day in a two-week period during December 2008 were provided by Rhode Island Department of Transportation. Rush hour videos were taken between 7:30 and 8:00 am on weekdays (from Monday to Friday) while non-rush hour videos were between 10:00 and 10:30 am. Fifteen one-minute segments were randomly selected from each of the 30-minute video clips for analysis. To determine the vehicle headway for a vehicle in the video clip, a reference line was drawn in the recorded scene, and based on the time stamp (in 1/100 second) embedded in the video, the time when the front bumper of a vehicle reaching the reference line was recorded. By calculating the time difference that two consecutive vehicles crossed the reference line, vehicle headway in hundredths of second was determined for the following vehicle.

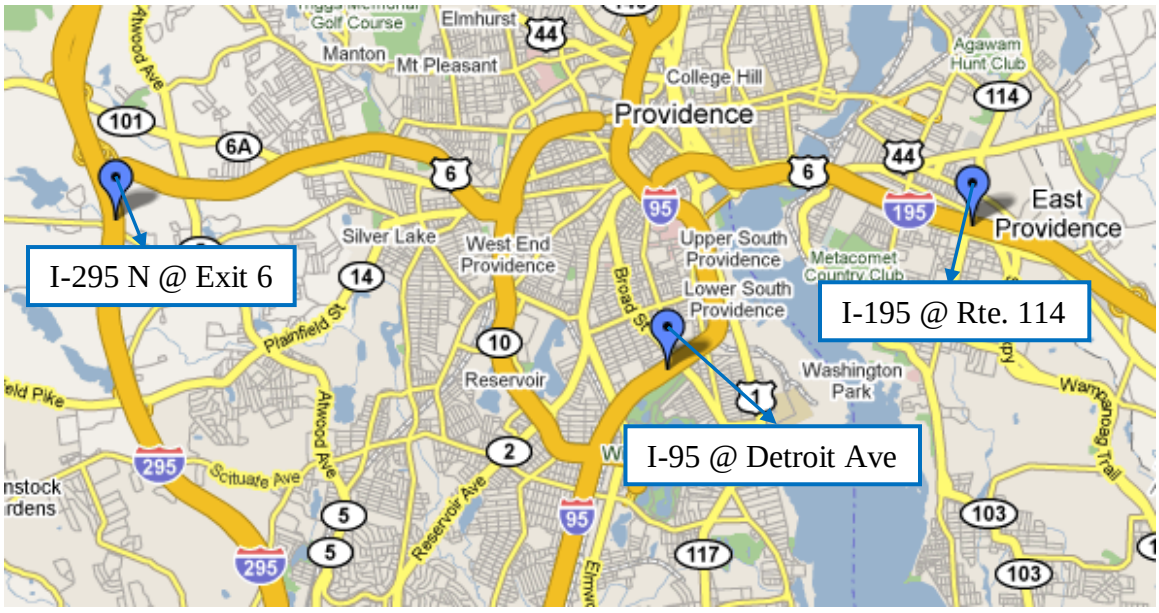



**Figure 1 Locations of highway traffic surveillance cameras**

All vehicles analyzed were classified by their vehicle headways in increments of seconds. Percentages of vehicles that broke the 2-second rule, which means its headway was in between 0 and 2 seconds, were calculated. These vehicles were noted as 2-second rule breakers. To find out if time of the day was a significant factor effecting tailgating, a hypotheses test using paired t-test was employed to compare the tailgating situations (percentage of 2-second rule breakers) between rush hour and non-rush hour on three test sites. The hypotheses are:

$$H_0 : \mu_d = 0$$
$$H_1 : \mu_d > 0$$

where $\mu_d = \mu_{\text{rush hour}} - \mu_{\text{non-rush hour}}$.
These analyses were further broken down by lane and bound since all three highway segments were 8-lane highways with traffics in opposite directions.

**Questionnaire Survey**
Following vehicle headway analysis, a computer based questionnaire survey was designed and deployed in two phases to help find the causes of tailgating and to identify drivers' responses to the proposed tailgating treatments. The first phase was designed to identify the causes and effects of tailgating, and to gain insights about drivers' understandings and perceptions of tailgating behavior. The second phase was developed to obtain drivers' preference regarding proposed tailgating treatment systems.

Some reference markings and advisory message signs of tailgating treatment systems used in the survey were adopted from existing tailgating treatments in the US as well as those currently used in some European countries.

*Design of the Survey* The computer based electronic questionnaire survey was designed using Microsoft PowerPoint® and Visual Basic macros to present the questions and to collect subjects' answers. Questions in the survey might require either a single or multiple answers.

The first phase of the survey contained nineteen questions designed to collect drivers' opinions on tailgating and to find out drivers' perceptions of tailgating and its causes and effects. It also surveyed drivers' behaviors when they were following other vehicles or being followed.

The second phase of survey was designed to identify drivers' preferences on several tailgating treatment systems. A tailgating treatment system might include: reference marking (pavement marking, roadside marking), and advisory message sign (dynamic message sign, variable message sign, or fixed road sign). This phase was presented with both auditory and written instructions starting with information about the proper headway to maintain while driving on RI highways. Four simulated driving videos with different reference markings built in (painted dots, painted arrows, neon/hot-pink roadside panels, and painted bars, see Figure 2) were presented in random sequence to mimic real driving. Six questions were presented in the second phase. The first question surveyed a subject's preference on reference markings. According to the subject's answer, the preferred marking would then be presented in subsequent questions. The second question presented several text messages on fixed signs that could be used in conjunction with the treatment

(see Figure 3). The third question inquired a driver's preference regarding graphic-aided message. The preferred message chosen in the second question was presented with and without graphic in this question. Question four and five were essentially the same as the second and the third but with overhead dynamic signs. The last question was designed to capture a subject's preference on the type of advisory sign to be used in conjunction with the selected reference marking. By completing the second phase of the survey, a preferred tailgating treatment system would be pieced together.

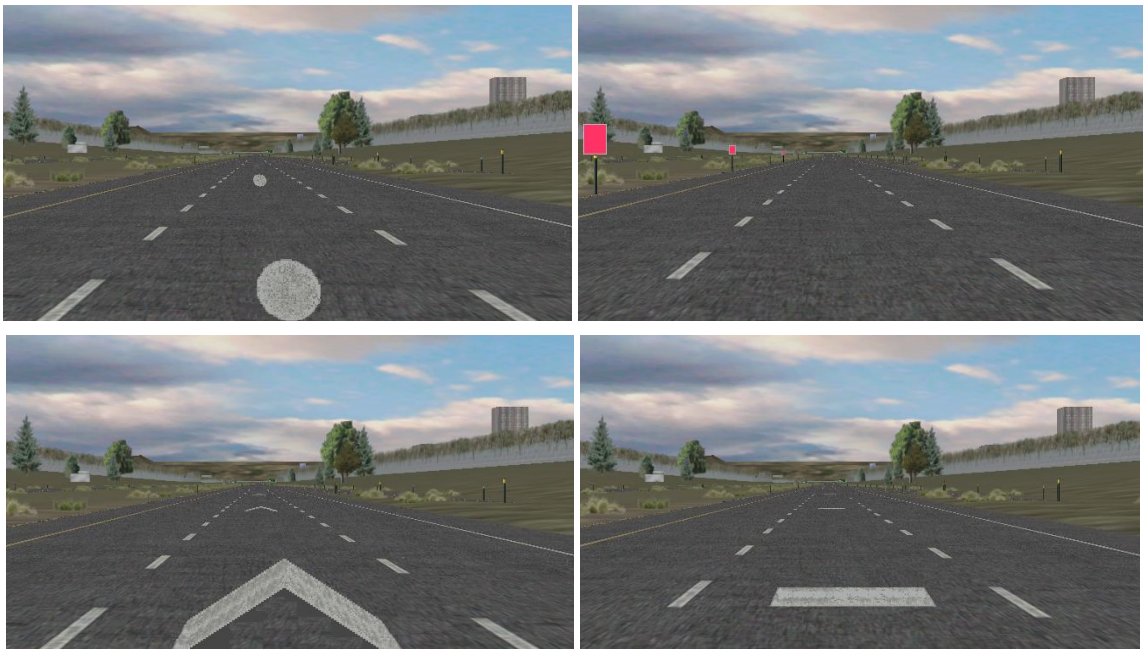


**Figure 2 Screenshots of driving simulation videos in questionnaire**

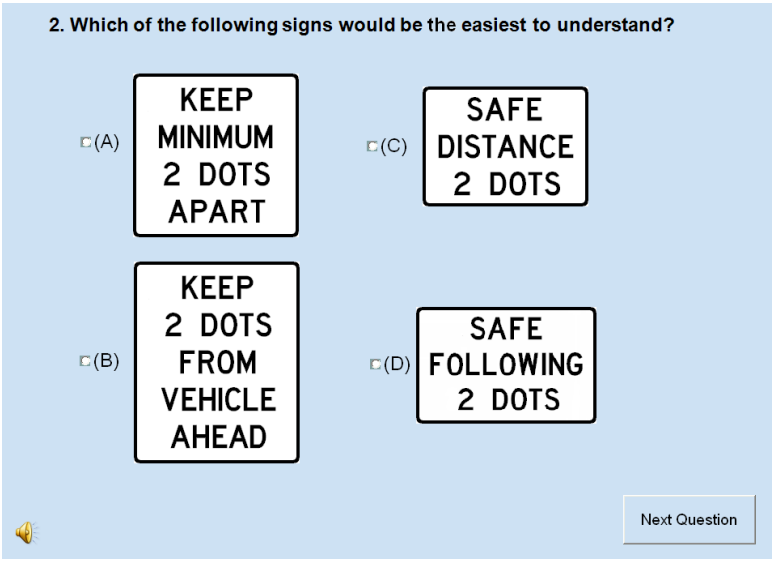



**Figure 3 A sample survey question**

*Survey administration* The two phases of survey were conducted at multiple locations in Rhode Island in order to obtain a representative sample of the Rhode Island driving population. The University of Rhode Island and the Warwick Mall were among several sites where the survey took place. Subjects were randomly recruited at the survey site with voluntary participation. Prior to beginning the survey, each participant read and gave their consents on an electronic consent form, approved by the university's Institutional Review Board. The subject would then start taking the survey presented as PowerPoint slides on a laptop computer. Survey questions were presented one at a time with no time limit. Answers could be made via a computer mouse and keyboard or via verbal communication with the survey assistant.

A total of 210 subjects participated in the first phase. Among them, 91 (43.3%) were between 18 and 40 years old, 72 (34.3%) were between 41 and 60, and 47 (22.4%) were older than 60, and there were 107 females (51.0%) and 103 males (49.0%). There were 142 subjects participated in the second phase. Among them, 76 were females (53.5%) and 66 were males (46.5%); 63 (44.4%) were between 18 and 40 years old, 45 (31.7%) between 41 and 61, and 34 (23.9%) were older than 61. Age and gender percentages of the survey resembled Rhode Island population.

## RESULTS AND DISCUSSION

### Vehicle Headway Analysis

The proportions of vehicles following with less than 2 seconds of vehicle headway, i.e., tailgating, on the three test sites on Rhode Island interstate highways were tabulated in Table 1. The statistics were shown by test sites, by day of the week, and by time of the day.

**Table 1 Percentages of 2-second rule breaker**

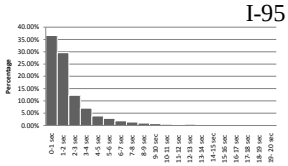
| | Highway sections | | I-95 @ Detroit Ave | I-195 @ Rte. 114 | I-295 N @ Ex. 6 | Total |
|---|---|---|---|---|---|---|
| Day of the week | Monday | RH* | 70.96% | 62.59% | 60.69% | 66.24% |
| | | NRH** | 45.24% | 37.35% | 26.73% | 38.52% |
| | Tuesday | RH | 66.54% | 57.39% | 55.61% | 61.46% |
| | | NRH | 44.62% | 34.46% | 28.10% | 37.85% |
| | Wednesday | RH | 64.22% | 60.92% | 56.48% | 61.41% |
| | | NRH | 41.58% | 38.91% | 29.58% | 37.83% |
| | Thursday | RH | 67.14% | 56.81% | 53.56% | 61.08% |
| | | NRH | 43.71% | 35.64% | 31.61% | 38.59% |
| | Friday | RH | 62.24% | 59.52% | 52.48% | 59.05% |
| | | NRH | 40.62% | 33.04% | 30.04% | 36.02% |
| Total | | RH | 67.01% | 60.95% | 57.01% | 63.76% |
| | | NRH | 43.96% | 37.16% | 29.34% | 37.89% |

*RH: Rush Hour **NRH: Non-rush Hour

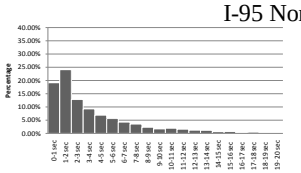
From the analysis, 63.8% vehicles were tailgating during rush hours and 37.9% during non-rush hours. Paired t-tests were conducted at three test sites to compare tailgating during rush hours with non-rush hours. It found that time of the day did affect tailgating behavior significantly (p values = 0 at all three locations). The differences in tailgating percentages were consistent regardless day of the week when comparing rush hours with non-rush hours.

The distributions of vehicle headways for both rush hours and non-rush hours at the three test sites are shown in Figure 4. Vehicle headways collected ranged from less than 1 second to more than 30 seconds. It should be noted that large vehicle headways were not generally considered "following" and thus the distributions displayed here included only up to 20 seconds of vehicle headways. It is noticed that the majority of vehicles drove with vehicle headway less than 2 seconds during rush hours where more than half of that were following with less than 1 second of headway. During non-rush hours, less tailgating behaviors were observed and most occurred in the 1-2 seconds interval.

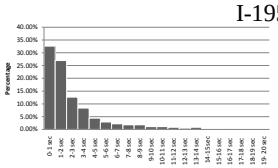
I-95 Rush hour



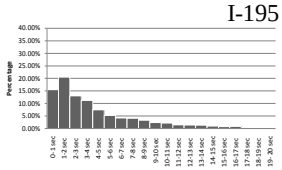
I-95 Non-rush hour



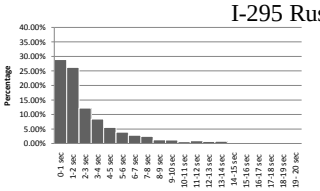
I-195 Rush hour



I-195 Non-rush hour



I-295 Rush hour



I-295 Non-rush hour

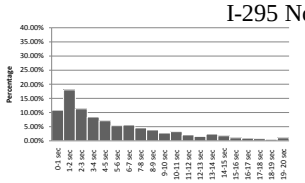


**Figure 4 Distributions of vehicle headways**

To further assess the tailgating situation, the percentages of tailgator, i.e., the 2-second rule breaker, were broken down by lane and bound (see Table 2). It showed that vehicles on the high speed (innermost) lane exhibited the worst tailgating behavior especially during rush hours while the outermost lane had the lowest tailgating

percentage (except I-295). This could be due to the fact that tailgating is correlated with speed, and vehicles travelling in high speed tend to tailgate to follow the leading vehicles. Comparing to their opposite bounds, I-95 north bound and I-195 west bound had worse tailgating situation especially during rush hours. This might be due to the large vehicle volumes entering the Providence metropolitan area during rush hours.

**Table 2 Percentages of tailgators by lane and bound**

| | Lanes (from left) | | Innermost lane | | 2nd lane | | 3rd lane | | Outermost lane | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time of the day | | Rush hour | Non-RH | Rush hour | Non-RH | Rush hour | Non-RH | Rush hour | Non-RH |
| Highway sections | I-95 @ Detroit Ave | North | 79.62% | 47.46% | 72.96% | 46.67% | 68.28% | 54.43% | 62.58% | 41.78% |
| | | South | 70.27% | 46.09% | 63.76% | 47.06% | 53.93% | 45.31% | 41.35% | 33.93% |
| | I-195 @ Rte 114 | East | 67.76% | 36.47% | 59.49% | 36.97% | 55.81% | 36.62% | 36.58% | 17.37% |
| | | West | 72.38% | 43.14% | 65.84% | 43.35% | 55.36% | 33.59% | 52.78% | 26.55% |
| | I-295 N @ Ex. 6 | North | 73.15% | 38.10% | 23.50% | 20.33% | 19.49% | 25.24% | 55.03% | 30.43% |

The vehicle headway analysis provided strong evidence that serious tailgating occurred on major highways in Rhode Island and posed serious traffic safety concerns on highway driving. This finding strongly supported the need to implement a tailgating treatment system on Rhode Island highways. Since tailgating issue was worse on the innermost lane, it might be more effective to place tailgating treatments, including roadside markings and advisory signs, on the left side of the innermost lane to mitigate tailgating behavior.

**Questionnaire Survey**

With serious tailgating confirmed on Rhode Island highways, a two-phase questionnaire survey was developed to help find the causes of tailgating and to identify drivers' responses to proposed tailgating treatments.

To help identify major causes of crashes, the subjects were asked to select and rank the top three causes among thirteen. According to the weighted scores (one got 3 points for being ranked the first, 2 points for second and so forth), the top three leading causes of crashes were: distraction (22.1%), speeding (20.3%), and tailgating (13.0%).

When subjects were asked about the possible reasons of following other cars, the majority (70.0%) indicated that they usually did not follow other cars. Only a few of them did it to maintain speed more easily (13.8%) or to avoid speeding tickets (14.8%). When asked if they intentionally followed other cars closely while driving on highways, 67.6% of subjects indicated that they never did that. When asked about the reasons of not following other cars, 49.5% of subjects indicated that it's safer not following other cars too closely; 30.0% thought following too closely was against the law; 17.1% of subjects considered following too closely could obstruct their views, and the rest did not follow since they considered others were driving too slow.

When they were asked about the definition which best described tailgating, 76.2% of subjects chose "following too close to the vehicle ahead" and only 11.4% chose "insufficient following distance". This indicated that most drivers had only a qualitative idea of what tailgating means instead of a quantitative one. "Heavy traffic", "slow car

ahead of my vehicle", and "I am in a hurry" were among the top 3 choices selected by subjects when asked to choose all applicable causes of tailgating.

When they were asked about their reactions when being tailgated, most indicated that they were affected by tailgators, and most of drivers affected by tailgators reacted passively. The top choice of reactions was "change lanes to let the tailgator pass" (33.4%). Their possible reactions also included "slow down to force the tailgator to get away", "speed up", "tap the brake", and "ignore the tailgator".

The majority of subjects (77.1%) indicated that they knew what the proper vehicle headway was, 73.8% indicated that keeping a safe vehicle headway was very important, and 90.5% believed that they kept a safe vehicle headway most of the time. Those answers contradicted the findings that serious tailgating existed on Rhode Island highways.

When questioned "how much distance do you maintain when driving at 60 mph on highways", 95% of subjects indicated that they maintained a vehicle headway less than 11 car lengths, and almost half were keeping less than 4 car lengths (see Figure 5). These answers exposed serious tailgating issue by showing that the majority of drivers who took the survey did not know what the proper vehicle headway was, and drove with insufficient following distance. When driving at 60 mph, 2-second vehicle headway requires a following distance of 11 car lengths (assuming a car length of 4.7 meters/15 feet). Although 75.2% of subjects indicated in another question that they maintained a vehicle headway equal to or greater than 3 seconds, it is not likely they kept a 3 seconds of headway which is about 16 car lengths. Subjects' opinions on vehicle headway expressed in car lengths could be more reliable since 78.6% of them preferred using car lengths to measure vehicle headway. This finding from the survey, in fact, did not contradict but confirm the serious tailgating situation identified in the vehicle headway analysis.

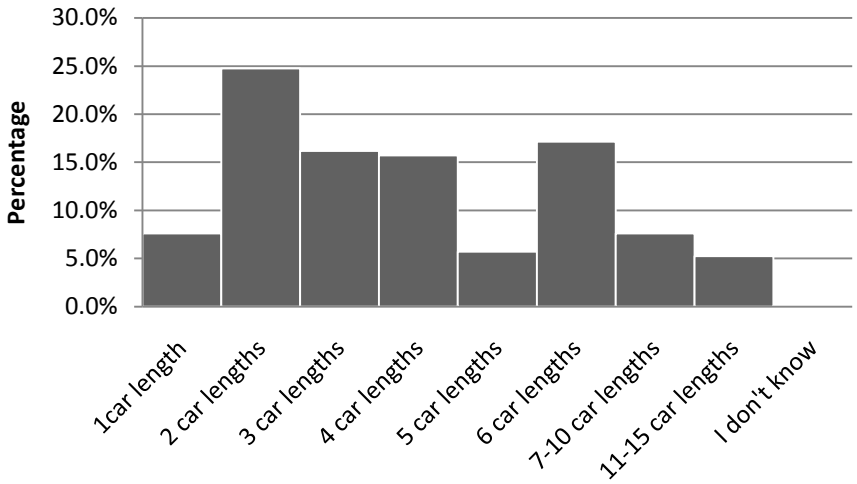



**Figure 5 Vehicle headways maintained by drivers when driving at 60 mph**

When asked about components in an effective tailgating treatment system, 63.8% of subjects preferred a combination of both advisory message signs and reference markings. There were 37.3% of subjects selected the painted horizontal bars as pavement marking,

20.1% chose neon panels, and 33.2% chose painted arrows. Some thought the roadside neon panels distracting while others felt that the arrows might suggest drivers to speed up. Differed from other age groups, drivers over 60 preferred the painted arrows (32.3%) over painted bars (29.4%) thought the difference was not significant. The female and male drivers did not show any difference in their answers.

When asked which sign massage would be the easiest to understand, most subjects (40.1%) chose the lengthiest-worded one (for example, "Keep 2 bars from vehicle ahead") over others. "Safe distance 2 bars" ranked second (33.1%). This might be due to the fact that subjects were in a static environment where they could take as much time as they want to read the messages, and in that case, more information in the message helped their understanding. When graphics were added to text sign message (see Figure 6), graphic-aided message signs were mostly preferred (86.6%) over text-only ones.

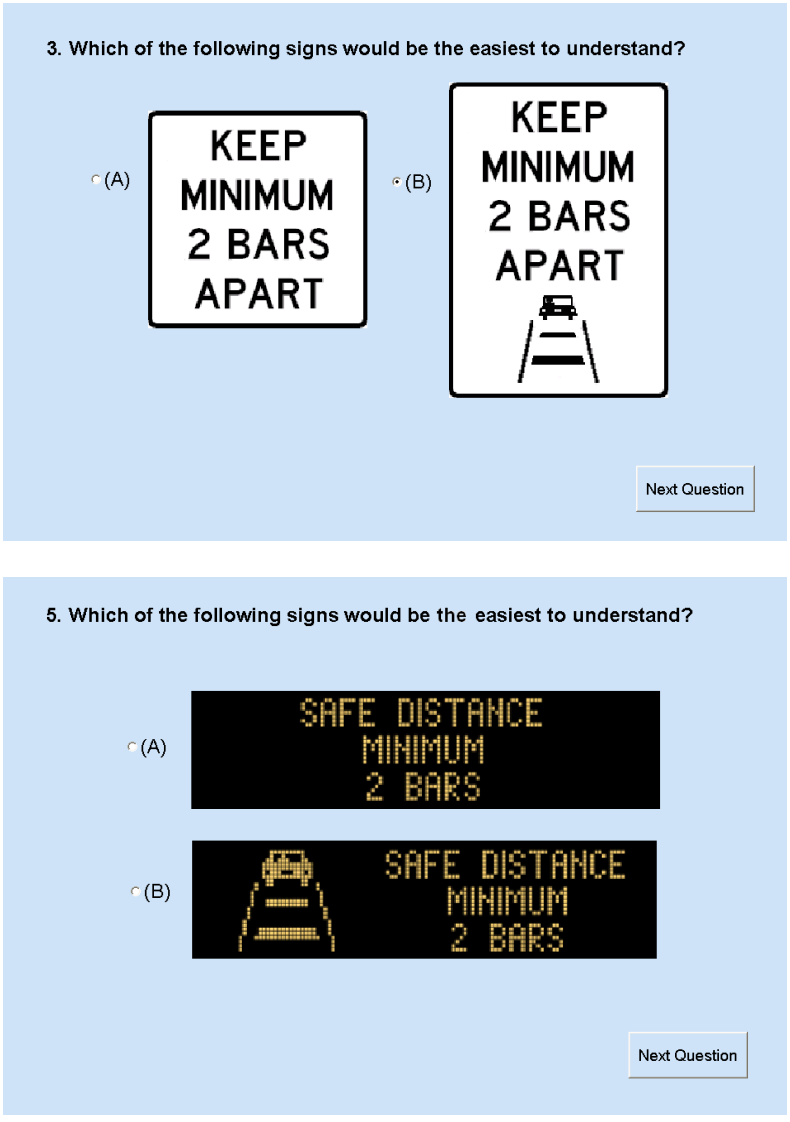



**Figure 6 Text signs and graphic-aided message signs**

When similar questions were asked with regard to overhead dynamic message signs, similar responses were obtained. 45.1% preferred the sign with the lengthiest wording and 81.7% preferred it with graphics. When asked about which traffic sign drivers most likely would pay attention to while driving, subjects preferred the overhead dynamic message signs (46.7%) over the fixed road signs (29.6%) and the roadside variable message signs (23.9%).

The findings of the first phase survey showed that the majority of drivers considered tailgating a serious offense and one of the top three major causes of highway crashes. Most of them, however, had only a qualitative sense of what tailgating was about and did not know what the proper vehicle headway was to keep while following other vehicles on highways. As most indicated in the survey, they did not maintain sufficient vehicle headways. This finding confirmed the observations made in the vehicle headway analysis. From the second phase of the survey, it found that the majority preferred regularly-spaced horizontal bars painted on pavement as reference marking to help drivers gauge safe following distance. Coupled with the pavement marking, most of them preferred employing overhead graphic-aided dynamic message signs as advisory message signs to communicate to drivers about safe following distance.

## CONCLUSION AND FUTURE WORK

This study employed a vehicle headway analysis and a questionnaire survey to examine the tailgating issue in Rhode Island and to find possible means for tailgating treatments.

In the vehicle headway analysis, serious tailgating behaviors were identified during rush hours. Compared to rush hours, less tailgating was observed during non-rush hours but there were still about 37.89% vehicles following with insufficient headways.

Tailgating percentages by lane and bound break-downs showed that tailgating issue was worse on the innermost lanes and in areas with high traffic volume. The results of vehicle headway analysis suggested an urgent need of an effective tailgating treatment system in Rhode Island.

The findings of the survey indicated that the majority did not know what the proper vehicle headway was to keep and maintained insufficient vehicle headways while following other vehicles on highways. This confirmed the observations made in the vehicle headway analysis. Among proposed tailgating treatments, the majority preferred horizontal bars painted on pavement as a means to help maintain safe following distance, and overhead graphic-aided dynamic message signs as a way to communicate to drivers about safe following distance. Based on this study, it is recommended to Rhode Island traffic management authorities that a proper tailgating treatment system should be implemented. The system could include horizontal bar pavement markings and overhead dynamic message signs displaying graphic-aided advisory messages. Roadside fixed signs displaying similar messages could also be included.

After the implementation of recommended tailgating treatment system, before and after statistics would be collected and analyzed to assess the effectiveness of the system in treating tailgating and reducing rear-end crashes. The findings of this study could contribute to the development of a standard tailgating treatment system to be included in MUTCD and help facilitate a more efficient and safer driving on US highway.

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