

TEMPORARY BARRIERS REDUCE RUBBERNECKING AND EXTERNAL
DISTRACTION ON ROADWAYS

by

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Abstract

The purpose of the current study was to empirically examine the effects of accident scenes on eye movement as well as driving behavior. Fifty-four participants drove in a driving simulator wearing a head-mounted eye-tracker in three experimental drives, one of which had an accident scene. The participants were put into one of three different conditions (no barrier, partial barrier, or full barrier). The results showed significant main effects of distraction (accident vs. no accident) on dwell frequency and duration, average speed, and root mean square error of the steering wheel angle during the drive with the accident scenes. In addition, the results also showed significant interaction effects between distraction and type of barrier (no, partial, or full) on dwell frequency and duration. The full barrier condition had the biggest effect on decreasing dwell duration and frequency. The findings support the Saliency Effort Expectancy Value (SEEV) model of attention and previous research stating objects high in salience attract attention (Wickens & Horrey, 2008; Itti & Koch, 2000). These findings also support previous research by Mayer, Caird, Milloy, Percival, & Ohlhauser (2010) stating that drivers drive in the safest manner (lowest passing speed) when an emergency vehicles are present with the emergency lights on. Temporary barriers could be used to help decrease the effects of rubbernecking on highways when an accident scene is present (Masinick & Teng, 2004; Potts, Harwood, Hutton, & Kinzel, 2010).

Dedications

To my mother Jill Denicola for always being there to support me in times of need.

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Introduction

Driver distraction is a very problematic safety concern that has captivated many researchers, citizens, and legislators. Consequently, several congressional testimonies and proposed guidelines related to driver distraction have emerged (McCartt, 2009; United States, 2001; National Highway Transportation Safety Administration (NHTSA, 2012). In 2010 the Research and Innovative Technology Administration (RITA) reported that there were 250,272,812 registered vehicles in the United States which demonstrates the need to provide insight into safety concerns for motorists. External distractions cause a significant amount of vehicle crashes; it was the highest single category of distractions (29.4%) as compared to other categories (Stutts, Reinfurt, Staplin, & Rodgman, 2001). Previous research has indicated that barrier could reduce the effects caused by rubbernecking (Masinick & Teng, 2004; Potts et al., 2010) .The purpose of the current study was to empirically examine the effects accident scenes have on driving behavior as well as dwell frequency and duration. It was hypothesized that: the presence of accident scene would cause increased dwell duration and frequency as well as driving decrements, in addition it was also hypothesized that a barrier used to block the driver's view from the accident scene will cause a decrease in the dwell duration and frequency and driving errors when accidents are present. Theoretical implications are support for the SEEV model of attention and evidence to support the study by Mayer et al. 2010 which found that people had the lowest passing speed when emergency vehicles were present with their lights on. Practical implications would be the implementation of barriers to reduce rubbernecking and traffic

analysis to find areas where there are daily accidents and are in need of ways to reduce non-recurrent traffic delays.

Literature Review

Defining and Identifying Driver Distraction

The term driver distraction can be defined several ways, Regan, Hallett, and Gordon (2011) proposed that distraction was a result of the driver diverting attention away from safe driving activities, which reduced the driver's overall capacity of attention. For the sake of clarity the definition proposed by (Regan et al., 2011) is used for the current study. The definition proposed by Regan et al. (2011) restates distraction in terms of driver diverted attention (DDA) - the diversion of attention away from activities critical for safe driving toward a competing activity, which may result in insufficient or no attention to activities critical for safe driving. The paper proposed by Regan et al. (2011) further breaks down the definition of driver diverted attention to include DDA-NDR (non-driving related) and DDA-DR (driving related). DDA-DR is defined as the diversion of attention away from activities critical for safe driving toward a competing driving-related activity. The authors make a further distinction that both non-driving related activities and driving related activities can become a distraction.

Hancock, Mouloua, and Senders (2008) stated that fault for an accident is always attributed after the accident occurs. In American culture our society concentrates on the individual, which causes blame to be displaced onto a singular object or person in many circumstances. Many people could be accused of fault for an accident simply due to the Fundamental Attribution Error. The Fundamental Attribution Error is the tendency to underestimate situational influences and overestimate dispositional influences upon others'

behavior. However, in many cases multiple factors may contribute to the accident (Hancock et al., 2008). Assessing driver distraction on a legal level is often very difficult. There are consequences for admitting being distracted at the time of an accident which leads many people to not report being distracted. This led Hancock et al. (2008) to provide us with a very interesting point in the logic of blame. Blame for an accident that was caused by distraction is always attributed after the incident. The underspecification in our transportation laws and practices leads to circular reasoning with regards to the blame of driver distraction (Hancock et al., 2008). Distraction is attributed in terms of crashes that are presented as being caused by a distraction itself (Hancock et al., 2008). There are possibly many instances where a driver was blamed for an accident but it was actually out of their control and they should not be at fault for the incident. It is still a foreign concept to many people to believe that no one may be at fault and the accident could be due to environmental circumstances.

Regan et al. (2008) stated that many driver distraction laws are “lawgical” but not “logical” (Regan et al., 2008). Many times laws are passed without consulting scientific data that can provide multiple solutions to a problem. In 2001 Robert Shelton, the executive director of NHTSA appeared before congress in a congressional testimony to raise the awareness of driver distraction (United States, 2001). The objective of the testimony was to shed light on distraction research and possibly discuss legislative action to increase road safety (United States, 2001). NHTSA has also proposed guidelines for manufacturers to produce products that are less distracting (NHTSA, 2012).

Wallace (2003) extensively studied driver distraction and estimated that 10% to 30% of all accidents are due to some form of distraction. NHTSA estimated that 25% of police-reported accidents involve some type of driver inattention (Wang, Knippling, & Goodman, 1996). Driving can be a monotonous task and McEvoy, Stevenson, and Woodward (2006) stated that drivers tend to engage in a distracting activity on average once every 6 minutes.

There are two different types of distraction that can occur while a person is driving; internal and external. Internal distraction can be defined as “when a driver is delayed in the recognition of information needed to safely accomplish the driving task, because some event, activity, object, or person within his vehicle, compelled or tended to induce the driver’s shifting of attention away from the driving task” (Treat, 1980). Treat (1980) defined external distraction the same way as internal distraction except that the event, activity, object, or person is outside the vehicle instead of inside. The current study was not concerned with internal distractions and was focused on external events that cause drivers to be distracted. Specifically the external events were accident scenes on the right side of the highway.

External Distractions

Surmountable amounts of in-vehicle distraction research exists in the literature (Mouloua Rinalducci, Hancock, & Abdel-Aty, 2002; Monk, Boehm-Davis, & Traflet, 2004; Strayer, Drews, & Johnston, 2003; Strayer & Johnston, 2001; Stutts, Reinfurt, Staplin, & Rodgman, 2001; Stutts, Feaganes, Rodgman, Hamlett, Meadows, & Reinfurt, 2003). However, external distractions have not been studied as thoroughly (Rupp, 2012). External distractions cause a significant amount of vehicle crashes; it was the highest single category of distractions (29.4%)

as compared to other categories (Stutts, et al., 2001). Therefore, it is important to conduct research to study the decrements caused by external distractions. Despite the obvious relativity, external-to-vehicle distraction has received substantially less attention than internal distraction.

A study was done by Mayer et al. (2010) which looked at speed as a function of emergency lighting, police car orientation, and driver experience. They found that the presence of emergency lights on led to drivers driving in the safest manner, lowest passing speed and overall speed (Mayer et al. 2010). This observation involves not only the individual not wanting to get pulled over or injure emergency personnel, but also serves as a form of rubbernecking. A study done by Regan, Hallett, & Gordon (2011) showed that when a driver voluntarily diverts their attention away from the roadway to a task, event, object, or person that is competing for the same attentional resources, drivers will self-regulate their driving in order to compensate for the distraction they are engaging in. This compensation due to the distraction could be the main reason why we have increased traffic delays even after an accident has been cleared.

Driving and Attention

It can be reasonably considered that driving requires multiple modes of attention. Drivers have to visually attend to the road, have to be ready to accept and analyze auditory information, and drivers also have to attend to the spatial relationship their car has with other users of the road. Drivers are often also listening to the radio, eating, or doing other activities that are not typically driving related (McEvoy, Stevenson, & Woodward, 2006). Driving is a task that requires visual and motor processing and it has been shown that attentive drivers look at the road 80%-90% of the time (Carter and Laya, 1998; Hughes and Cole, 1988). When drivers have not

been attending to the forward road scene for the appropriate amount of time, it can be inferred that they were distracted by some event. The event caused them to look away from the road ahead of them, therefore distracting them. In chapter 15 written by Regan et al. (2008) in the book *Driver Distraction: Theory, Effects, and Mitigation*; the authors state that “events” like crash scenes, objects moving within the car, mechanical problems, spills, and some other attentionally compelling objects will be of a particularly high level of distraction. The authors concluded that these objects are high in salience in relation to visual attention, making them considerably unavoidable sources of distraction (Regan et al., 2008).

According to the SEEV model of visual attention; the purpose of visual scanning is to make task-important information into the center of the visual field instead of the periphery (Wickens & Horrey, 2008). The SEEV model consists of four factors: Salience and Effort as well as Expectancy and Value. Salience and Effort are considered bottom-up processes while Expectancy and Value are both top-down processes (Wickens & Horrey, 2008). Flashing lights and objects that stand out against their background are considered salient. Effort is a factor that discourages observers from scanning between two locations that have a large distance (Wickens & Horrey, 2008). Salience is the most intuitive attribute and reflects how objects high in this category capture attention easier than other objects that are low in salience (Itti & Koch, 2000). Expectancy is the tendency for people to look at sources with higher information bandwidth more often (Wickens & Horrey, 2008). Value is the notion that observers tend to look at information that is most important to a task (Wickens & Morrey, 2008) Crash scenes are highly salient objects that capture our attention involuntarily (Regan et al., 2008) which causes drivers to compensate for this distraction (Mayer et al., 2010); in the situation of rubbernecking this

consists of slowing down when they are looking upon the accident. It is this deviation of attention away from the roadway that may cause the traffic to persist even after an accident has been cleared from the road. Previous research has shown that visual scanning tends to decrease under heavier mental workload (Recarte & Nunes, 2000) suggesting a limited amount of resources available for attention (Liu & Wickens, 1992).

In a study performed by Strayer, Drews, and Johnston (2003), the authors found that conversing on a cell phone reduced the person's ability to remember billboards while conversing on a hands-free cell phone. The authors suggested that this was due to a form of inattention-blindness which was caused by the attentional resources being directed toward the cell phone conversation, and in insufficient amount directed towards the visual field (Strayer et al., 2003). The evidence in the study by Strayer et al. (2003) supported previous literature (Strayer & Johnston, 2001) in that the interference from the cell phone was observed even though there was no manual manipulation of the phone and the person was fixated on the billboard. While rubbernecking, individuals have to physically look at the accident scene which makes generalization of inattentional blindness to rubbernecking tough. A study examining the effect of external distractors on inattentional blindness would be interesting.

Accident Scenes and “Rubbernecking”

Webster dictionary defines rubbernecking as to look about, stare, or listen, with exaggerated curiosity (Webster, 2012). The general term rubbernecking has been around since 1895 and has been recently been used as “rubbernecker”, a slang term for tourists (Webster, 2012).

One type of external distraction is the presence of an accident scene on the highway. Glaze and Ellis (2003) stated, in a survey of police officers, that looking at accidents and roadway events was the highest single category of external distraction in their study. Another study done by Mayer et al. (2010) which evaluated speed as a function of emergency lighting, police car orientation, and driver experience, the authors found that the presence of emergency lights led to drivers driving in the safest manner. This means that they had the lowest passing speed and overall speed among groups (Mayer et al., 2010). In an attempt to battle the congestion caused by roadside accidents objects like portable incident screens have been developed (British Broadcasting Corporation, 2012). A portable incident screen is a portable screening device that is used to block a motorists' view of an incident (Potts, Harwood, Hutton, & Kinzel, 2010). With the rising curiosity of external-to-vehicle distraction, specifically when there an accident scene on the side of the road, some researchers are starting to look into temporary barriers/screens in order to occlude the driver from being able to see the incident (Masinick & Teng, 2004; Potts et al., 2010). In the current study an external distraction (accident scene) was implemented and examined between groups (no, full, or partial barrier) to observe rubbernecking and to examine eye tracking as well as driving behavioral effects that may occur.

Current Study

This study aims to examine the effects of rubbernecking with an accident scene on the side of the road. Another objective is to examine the impact of a temporary barrier on driving and eye movement behavior while an accident scene is present. The dependent variables assessed were dwell duration and frequency, average speed, and the root mean square error of the steering

wheel angle. The independent variables evaluated were the type of barrier (no, partial, or full) as well as implementation of accident scenes (drives with accident scenes vs. drives without accident scenes).

Hypotheses

1. The presence of the accident scene will cause increased dwell duration and frequency as well as driving decrements compared to the non-distraction drives.
2. A barrier used to block the driver's view from the accident scene will cause a decrease the dwell duration and frequency and driving errors when accidents are present.
3. When no barrier is present while there is an accident scene there will be more driving decrements than if there was a barrier occluding the accident.

Method

Participants

Fifty-four college students were randomly selected from a Southeastern University and assigned to the different experimental conditions. The participants ranged from 18-25 years ($M = 19.37$, $SD = 1.56$) and included 32 females and 22 males. They received extra credits for their participation and were all treated in accordance with the American Psychological Association (APA) guidelines.

Materials

A visual acuity test and several questionnaires were given to the participants to complete. Basic demographic and driving experience questionnaires, as well as a simulator sickness questionnaire (SSQ) were completed before the participants were exposed to the driving simulator (Kennedy, Lane, Berbaum, & Lilienthal, 1993). The participants drove in a GE Patrol SIM mark II medium to high fidelity driving simulator. The simulator had the dashboard, gauges, wheels, and seat from a 1990 Crown Victoria. This simulator consisted of three screens (150-degree view of the virtual roadway ahead) displaying the various driving scenarios. The participants drove in the simulator with an ISCAN ETL-500 head mounted eye tracker. The eye tracker was mounted on top of a baseball cap and was worn by all participants during the drives.

Design and Procedure

Participants were divided into three groups consisting of no barrier, partial barrier, or full barrier condition. Participants were given an informed consent and were able to ask questions or opt-out of the study before participating. After consent was obtained from the participants, they were tested for their vision and were required to have a normal or corrected-to-normal vision of 20/40 or better, following Florida DMV guidelines (Department of Highway Safety and Motor Vehicles, 2011). Then, all participants drove three experimental drive scenarios. The first drive did not have accident scenes; the second drive did involve accident scenes; and the third drive was the same as the first, not involving accident scenes. Before they drove in the experimental conditions, they all engaged in a five-minute practice drive to become familiar with the simulator. After the practice drive ended, they then began their first experimental condition. The first drive with no accident was used as a control drive condition. The temporary barrier used to block the accident from view was a brown fence that extended the length of the drive. The accident scene was comprised of emergency vehicles (police cars and SUVs, as well as fire trucks), and also smokes plumes and fire were simulated. In the partial barrier condition, only the top of the fire truck and Police SUV were visible, the smoke and fire were of relatively large height and were about half visible. In the full barrier condition, the smoke plumes and fire were removed from the scenario in order to keep them out of the driver's view which is similar to being behind a full barrier. The simulated drive consisted of a mile long straight stretch of highway with small gaps in between the different accident scenes. After the participant completed their third experimental drive, which did not have accident scene, they were required

to complete one more SSQ to compare their simulation sickness symptoms before and after the simulated drives. Finally, they were all debriefed and allowed to safely leave the driving laboratory when no simulation symptoms were present.

Data Analysis

The video data collected for eye-tracking analyses was downloaded from a Sony Handycam DCR-SR45 hybrid video camera and run through the video editing software Avidemux 2.6. The video camera filmed the computer monitor where the eye tracker was plugged into and where the participant's eye behavior was monitored. The driving scene that the participant was viewing as well as the participant's eyeball was visible in the video. The video data were then viewed by a researcher frame by frame to assess the frequency and duration of dwells to the right shoulder where the accident scene and/or barrier were present. The amount of frames was counted for the completion of one minute then was divided by sixty, the total number of seconds in a minute. This number ended up being 29.983 which meant that there were 29.983 frames per second when viewing a video on Avidemux 2.6. The collection of data began after the participant had passed the speed limit sign on the highway and it was no longer in view. At this point in the drive they had just finished merging on the highway and the manipulation (barrier and/or accident scenes) was only barely visible. The time stamp was recorded on the frame directly after the speed limit sign was out of forward view, signaling the beginning of eye-tracking data collection. The amount of frames was then counted each time the participant took a dwell either towards: the right shoulder (where the manipulation was present), any portion of the

barrier or accident scene, speedometer or left/right/rearview mirrors, or left shoulder. The dwells toward the right shoulder when accident scene was present or not present were the only dwells considered to be towards the manipulation created by the researchers; all other dwells were counted as towards other objects and were not deemed as being caused by the independent variable.

The eye-tracker used in the experiment provided the researchers with a crosshairs for where the individual was looking. A dwell was considered to begin when the crosshairs became distorted, at the beginning of the eye movement, and the participant's eyeball had begun the movements for a dwell. A dwell was considered completed when the crosshairs had become clear and was no longer distorted. Driving data were collected by the simulator software GIRC and was loaded onto a Microsoft Excel spreadsheet. All behavior driving data were recorded in numerical values.

All statistical analysis was done through SPSS 20 using a mixed factorial repeated measure ANNOVA analysis.

Missing Data

Missing data were confirmed to be random using Little's Missing Completely at Random test and was shown not to be significant, confirming that the data were missing by random chance ($X^2 = 32.474$, $DF = 33$, $p = .493$) (Little, 1988). The missing data were then filled in using expectation maximization (EM) in SPSS 20.

Results

All results are based on significance at the $\alpha = .05$ level

Dwell Frequency

There was a main effect of Distraction (non-accident drive vs. accident drive vs. non-accident drive), $F(2,102) = 98.02$, $p < .001$, partial $\eta^2 = .66$. Tests of within-subjects contrasts indicated that there was a higher number of dwells in the distraction drive ($M = 11.45$, $SD = 7.18$) than in the two non-distraction drives ($M = 2.98$, $SD = 3.03$; $M = 3.40$, $SD = 2.96$), $F(1, 51) = 138.39$, $p < .001$, partial $\eta^2 = .73$. There was no significant difference between the non-accident drives $F(1,51) = .642$, $p = .43$. In addition there was also a main effect for type of Barrier, $F(2, 51) = 6.55$, $p = .003$, partial, $\eta^2 = .20$ as well as an interaction effect of Distraction by Barrier, $F(4,102) = 15.76$, $p < .001$, partial $\eta^2 = .38$. Tests of within-subject contrasts for the interaction showed that there was a significantly less amount of dwell frequencies during the distraction drive in the full barrier group ($M = 4.88$, $SD = 4.09$) compared to the partial barrier ($M = 13.77$, $SD = 5.96$) and no barrier groups ($M = 15.21$, $SD = 6.58$), $F(2,51) = 22.17$, $p < .001$, partial $\eta^2 = .47$. Post hoc comparisons showed that participants had significantly less dwell frequencies in the first no accident drive no barrier condition ($M = 2.28$) compared to the accident scene no barrier condition ($M = 15.21$); significantly less frequency of dwells during the second non-accident drive no barrier condition ($M = 3.23$) than the accident scene no barrier group, in addition the full barrier accident scene group ($M = 4.88$) has less dwell frequencies than the partial barrier accident scene group ($M = 13.77$). Post hoc comparisons also showed that the

first no accident drive partial barrier group ($M = 3.46$) and the second no accident drive ($M = 3.66$) also had less frequency of dwells than the accident scene partial barrier group ($M = 13.77$). In addition post hoc comparisons showed accident scene no barrier group had significantly more dwell frequencies ($M = 15.21$) than the accident scene full barrier group ($M = 4.88$).

Dwell Duration

There was a main effect of Distraction, $F(2,102) = 103.90$, $p < .001$, partial $\eta^2 = .67$. Tests of within-subjects contrasts revealed longer durations of dwells in the distraction drive ($M = 9.24$, $SD = 5.95$) than in the two non-distraction drives ($M = 1.53$, $SD = 2.02$; $M = 1.76$, $SD = 1.81$), $F(1, 51) = 126.16$, $p < .001$, partial $\eta^2 = .71$. The non-distraction drives were not significantly different from each other $F(1,51) = .48$, $p = .49$. There was also a main effect for the type of Barrier, $F(2,51) = 8.63$, $p = .001$ partial, $\eta^2 = .25$. In addition there was also an interaction effect of Distraction by Barrier, $F = (4,102) = 11.9$, $p < .001$, partial $\eta^2 = .32$. Tests of within-subjects contrasts for the interaction revealed that there was significantly less dwell durations during the full barrier distraction drive ($M = 4.19$, $SD = 2.85$) than in the partial barrier and no barrier distraction drives ($M = 10.74$, $SD = 5.14$; $M = 12.42$, $SD = 6.00$), $F(2,51) = 14.28$, $p < .001$, partial $\eta^2 = .36$. Post hoc comparisons revealed that the accident scene full barrier condition had significantly less ($M = 4.19$) dwell durations than the accident scene no barrier group ($M = 12.42$) and the accident scene partial barrier group ($M = 10.74$). Post hoc comparisons also showed that the accident scene no barrier condition ($M = 12.42$) had significantly longer duration of dwells compared to the first drive with no accident scenes no barrier condition ($M = 0.98$) and the second drive with no accident scenes no barrier condition

($M = 1.85$). In addition the post hoc comparisons showed that the accident scene partial barrier group ($M = 10.74$) had significantly longer dwell durations than the first drive with no accident partial barrier condition ($M = 1.79$) and the second drive with no accident scenes partial barrier group ($M = 1.91$).

Average Speed

The results showed a significant main effect for Distraction on average speed, $F(2, 102) = 9.31$, $p < .001$, partial $\eta^2 = .15$. Tests of within-subjects contrasts showed that the participants had the lowest average speed during the distraction drive (accident scene present) ($M = 56.20$, $SD = 2.90$) compared to the non-distraction drives ($M = 57.74$, $SD = 3.09$; $M = 57.63$, $SD = 2.01$), $F(1, 51) = 17.26$, $p < .001$, partial $\eta^2 = .25$. The non-distraction drives did not differ significantly from each other $F(1, 51) = .06$, $p = .80$. The results did not show a significant effect for Barrier, $F(2, 51) = 1.25$, $p = .29$. However, there was an interaction effect of Distraction by Barrier, $F(4, 102) = 2.94$, $p = .02$, partial $\eta^2 = .10$. Tests of within-subjects contrasts showed that for the interaction there was a significant difference between the two non-accident drives $F(2, 51) = 3.71$, $p = .03$. There was no significant difference between the accident drive and the two non-accident drives $F(2, 51) = 2.28$, $p = .11$. Post hoc comparisons revealed that accident scene full barrier group ($M = 57.46$) and the second no accident drive no barrier condition ($M = 58.02$) drove significantly faster than accident scene no barrier condition ($M = 55.13$). Post hoc comparisons also revealed that participants drove significantly slower in the accident drive partial barrier condition ($M = 56.09$) compared to the first no accident drive partial barrier group ($M = 58.36$). In addition post hoc comparisons showed that participants

drove significantly slower in the accident scene with no barrier condition ($M = 55.13$) compared to the no accident scene no barrier condition ($M = 56.77$).

Root Mean Square Error of Steering Wheel Angle (RMSE)

There was a significant main effect of Distraction on the root mean square error of the steering wheel angle, $F(2, 102) = 17.807$, $p < .001$, partial $\eta^2 = .26$. Tests of within-subjects contrasts indicated that the participants had a significantly higher amount of steering errors in the distraction drive ($M = .02$, $SD = .11$) compared to the other drives ($M = .02$, $SD = .01$; $M = .02$, $SD = .01$), $F(1,51) = 14.74$, $p < .001$, partial $\eta^2 = .22$. There was also a difference between the two non-distraction drives $F(1, 51) = 27.34$, $p < .001$, partial $\eta^2 = .35$. Pairwise comparisons showed that there were more errors in the accident drive than compared the third drive which did not include accident scenes ($MD = .004$, Std. Error = .001). Pairwise comparisons also revealed a significant difference between the two non-distraction drives ($MD = .006$, Std. Error = .001). The results did not show a significant effect for Barrier, $F(2,51) = 1.66$ or an interaction effect of distraction by barrier $F(4,102) = 1.87$. The no barrier condition had the highest mean ($M = .03$) of the root mean square error of the steering wheel angle during the Distraction drive.

Discussion

The objective of the research was to empirically examine the effects of accident scenes on driving performance and eye movement behavior as well as a temporary barrier's effect on that performance. The research aimed to address the following questions identified in the introduction:

1. The presence of the accident scene will cause increased dwell duration and frequency as well as driving decrements compared to the non-distraction drives.
2. A barrier used to block the driver's view from the accident scene will cause a decrease the dwell duration and frequency and driving errors when accidents are present.
3. When no barrier is present while there is an accident scene there will be more driving decrements than if there was a barrier occluding the accident.

The present findings indicated that people had higher dwell frequencies and longer duration of dwells when an accident scene was present. In addition, the full barrier caused the participants to have fewer dwells and shorter durations of dwells compared to the partial and no barrier groups. Participants also drove slower when an accident scene was present supporting previous research by Mayer et al., (2010). These findings are important because it shows that accident scenes cause a significant amount of dwell frequencies and duration of dwells towards roadside accident scenes. Additionally, participants also had the highest amount of steering wheel errors in the accident condition compared to the non-distraction drives. There was no effect found for the root mean square error of the steering wheel angle for type of barrier or an

interaction effect between Distraction (accident vs. no accident) and Barrier (no, partial, or full). An interesting finding however, is the significant interaction effect of Distraction by Barrier for average speed when there was no significant main effect found for Barrier. Participants drove faster when there was no accident scene regardless of the type of barrier. This finding is interesting as government bodies, as well as highway safety officials, are spending massive amounts of money on roadway barriers in order to prevent distraction and increase traffic flow when roadside accidents are present (British Broadcasting Corporation, 2012).

Dwell Frequency

In the data we found that it supported the first research hypothesis in that the accident scene (distraction) caused the participants to have a higher frequency of dwells toward the right shoulder (where the accident scene and/or barrier were present). The data also supported the second hypothesis by showing that a full barrier had the biggest decrease in dwell frequency. This could be due to the fact that by definition, everything is occluded from view behind a full barrier. Since a brown fence was used to occlude the accident from view, objects had to be removed in order for them to be “covered” by the barrier and out of sight. This included the removal of the smoke plumes and fire as well as the SUV and fire truck. In the partial barrier condition the smoke plumes and fire were very high in salience and were visible for longer than the emergency vehicles. The top portion, including the emergency lights, was visible in the partial barrier condition for all emergency vehicles.

Dwell Duration

The data also supported the first hypothesis that when an accident scene is present there would be longer dwell durations towards the accident than if there was no accident present. The data also supported the second hypothesis which stated that barriers would cause individuals to look at the accident for a smaller amount of time. The accident scene proved to cause the longest dwell durations among groups with a full barrier having the greatest effect to prevent longer durations. This prevention could once again be due to the fact that by definition a full barrier has occluded everything therefore there are not objects high in salience attracting the individual's attention (Regan et al., 2008; Wickens & Horrey, 2008; Itti & Koch, 2000).

Average Speed

The data supported previous research done by Mayer et al. (2010) that reported participants having the lowest passing speed when emergency vehicles were present and the lights were on. In all of the accident scenes, except for the group that had it occluded by the full barrier, emergency vehicles and lights were present and visible. The significant results showed that drivers are either more cautious when emergency personnel are present or that they are compensating for their distraction by slowing down. Since only the average speed was recorded there is not enough evidence to say that the distraction (accident scene) caused them to compensate for their choice to observe the accident. In addition here was no between-subjects effect found for type of barrier. The interaction effect found could possibly be due to error in data analysis or the driver's inability to follow the speed limit assigned by the researcher. It could be possible that, in regards to average speed, a change blindness or car-following paradigm

could be implemented and the individual's variance in speed or headway to the vehicle in front of them could be analyzed.

Root Mean Square Error of Steering Wheel Angle

The results of the study supported previous work that indicated that the presence of an accident scene on a highway causes increased steering wheel angle error (Rupp, Michaelis, & McConnell, 2013). This finding suggests that participants had more variance in lane position due to the accident scene. However, the data indicates that there was not a main effect for Barrier or an interaction between Distraction and Barrier in the objective driving data (average speed and RMSE of steering wheel angle). This finding is interesting as government bodies as well as highway safety officials are spending massive amounts of money on roadway barriers in order to prevent distraction due to roadside events (British Broadcasting Corporation, 2012). The no barrier condition was observed to have the highest mean of RMSE of the steering wheel angle when an accident scene was present however, there was no between subjects effect found in the data so this difference is not significant and does not support the third research hypothesis.

Theoretical and Practical Implications

The data supports the SEEV model of attention in which objects high in salience capture attention (Wickens & Horrey, 2008; Itti & Koch, 2000). Accident scenes are highly salient in nature, with bright lights and colors on the emergency vehicles and in some way are meant to attract our attention. It is when they unintentionally capture attention on the side of the road while driving that it can become a distraction to the driving task. Another theoretical implication

is empirically testing if roadside accidents can cause inattentive blindness. It was shown in previous literature (Strayer, Drews, & Johnston, 2003; Strayer & Johnston, 2001) that hands-free cell phone use can cause people to miss driving information even when they are fixated on it while doing another task (conversing on a cell phone). This could generalize to rubbernecking if the person misses valuable driving information while looking at the accident. Looking at the accident could cause their attentional resources to be concentrated on observing the accident rather than at the driving task at hand. A change detection or car following task should be implemented if inattentive blindness is sought to be evaluated due to the fact that it cannot be observed if there is no secondary task (i.e. change detection, car following, billboard recognition) other than driving involved in the experiment.

The data also supported hypothesis proposed by Masinick and Teng (2004) and Potts et al. (2010) in that a barrier would help negate the effects of rubbernecking. The full barrier group and the lowest amount of dwell frequencies and the shortest duration of those dwells. A practical implication would be the implementation of a full barrier that completely blocks the accident scene to help improve traffic delays once the accident is cleared.

Limitations

During the course of the study there were several confounds that became evident. The first confound was the low workload of the drive. With no additional traffic on the road the participants had a relatively easy one mile straight path of highway to navigate. Increasing the workload by adding traffic to the scenario would cause drivers to have to pay more attention to

the road (Recarte & Nunes, 2000) and could also cause them to have more driving errors caused by distraction of the accident scenes than the current study.

The second confound was the coding of the eye tracking data. The eye tracking data were coded by counting individual frames when participants were looking towards the right shoulder (where the manipulation was) or any other object not counting the road. This is a trivial way to code eye tracking data because it is subjective to whoever is doing the coding. The current study only had one rater for the videos which causes concern for inter-rater reliability. Due to the enormous amount of time needed to code one entire experimental session and the nature of the project, only one person coded the data. This does not pose a concern for the objective driving data which was captured in numerical values by the driving simulator, but poses a threat to the eye-tracking data used in the study. The equipment available does not allow for the two data streams (driving and eye-tracking) to be combined and coded in an objective way. In future studies where counting frames is the only way to code eye-tracking data, a strict coding script must be used so that all raters agree on what is considered a dwell and what is considered “off of the road.” In the current study a dwell was considered to be started when the crosshairs for the eye-tracker became distorted and was considered finished when the crosshairs became solid and was no longer moving. This became difficult because the lag of the video recording and the lag of the eye tracker would cause the crosshairs to remain distorted even if when looking at the person’s eyeball, they were looking straight. In this instance a dwell was counted when they began their look off of the road or toward the speedometer or any mirror and was counted until the crosshairs began another movement toward a different object. An example of this would be if an individual looked at the left-side mirror, then to the road, then up to the rearview; the

movements being so fast that the eye tracker could never catch up and thus would never become completely solid.

Another limitation was the actual scenario itself and issues with saliency. We were able to program accidents into the scenario, but there are some objects that cannot be removed that happened to be high in saliency. Towards the end of the drive there was a grey billboard on the left side of the road that is a contrasting color to the background behind it causing it to be high in saliency (Wickens & Horrey, 2008). Removing this object is impossible since it is programmed into the scenario. In addition to the billboard there are highway markers that have a silver base but a bright white top that seemed to attract the attention of many participants, as described in the SEEV model of attention (Wickens & Horrey, 2008). These highway markers are also programmed into the scenario computers and cannot be removed. In the no barrier condition they are of particularly high saliency because they have a white tip against the dark-brown forest in the background. The brown fence used as a barrier was not as dark as the forest background and somewhat diminished the highway marker's saliency. When there was no barrier present however; participants still had their attention caught by the highway markers.

Items used in the scenario (i.e. fire and smoke plumes) were of particularly high saliency and were also visible for longer than other items in the accident scenes (fire trucks, Police SUV, police cars, and car accidents). The reason these were included in the scenario was to try and avoid a monotonous drive and to avoid repetitiveness of the accident scenes. The smoke plumes and fire were barely occluded in the partial barrier accident scene because of their height. The smoke plumes and fire rose above all of the other objects in the scenario and were very high in

saliency compared to the background of the sky, causing the people to be drawn to it for a longer period of time because of extended exposure to the objects (Wickens & Horrey, 2008; Itti & Koch, 2000; Regan et. al., 2008).

Future Research

A future study is being planned where the participants will engage in a higher workload condition. The higher workload condition will consist of traffic on the highway as well as either a car-following task or a change detection task. This should make the task of driving harder and would allow for the removal of the fire and smoke plumes. In addition to making the driving task harder the traffic and supplemental task will require the drivers to be more engaged; possibly providing evidence supporting the hypothesis that the no barrier no accident condition and full barrier no accident scene would be statistically insignificant from each other. In the future study a strict coding script will be developed to code the eye-tracking data. Multiple people will code the data and will be cross examined to ensure there are no differences in coding practices.

Appendix A: Approval of Exempt Human Research



University of Central Florida Institutional Review Board
 Office of Research & Commercialization
 12201 Research Parkway, Suite 501
 Orlando, Florida 32826-3246
 Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: UCF Institutional Review Board #1
 FWA00000351, IRB00001138
 To: Mustapha Mouloua and Co-PI: Nicholas P. Colon
 Date: January 16, 2013

Dear Researcher:

On 1/16/2013, the IRB approved the following minor modification to human participant research until 11/01/2013 inclusive:

Type of Review: IRB Addendum and Modification Request Form
 Modification Type: The eye-tracking system is changing from a dash-mounted system to a head-mounted tracking system. In addition, the study design has changed from a 2x3 mixed factorial to a 3x3 mixed factorial design. A revised protocol has been uploaded in iRIS and a revised Informed Consent has been approved for use.
 Project Title: Analyzing the effects of rubbernecking on driving performance
 Investigator: Mustapha Mouloua
 IRB Number: SBE-12-08805
 Funding Agency:
 Grant Title:
 Research ID: n/a

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30 days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at <https://iris.research.ucf.edu>.

If continuing review approval is not granted before the expiration date of 11/01/2013, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewska, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 01/16/2013 01:20:29 PM EST


 IRB Coordinator

Appendix B: Tables

Table 1: Descriptive Statistics for Demographics

	Mean, Standard Deviation, and Median of Demographic Information											
	No Barrier				Partial Barrier				Full Barrier			
	<i>M</i>	<i>SD</i>	<i>MDN</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>MDN</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>MDN</i>	<i>n</i>
Sex*	0.28	0.46	0	18	0.53	0.51	1	19	0.41	0.51	0	17
Age	19	1.33	18.5	18	19.16	1.74	19	19	20	1.46	20	17
Miles per Week	102.78	102.03	55	18	110.84	125.81	50	19	120.59	124.59	100	17

*Sex was coded 0= Female 1= Male

Table 2: Descriptive statistics for dwells towards manipulation

Descriptive Statistics For Dwells Towards Manipulation				
Cond		Mean	Std. Deviation	N
DWELLS_TO_BAR_AC	No	15.2103	6.58461	18
	Barrier			
	Partial	13.7689	5.96336	19
	Barrier			
	Full	4.8826	4.08840	17
DWELLStoBAR_NAC	Barrier			
	Total	11.4518	7.18296	54
	No	2.2797	1.89015	18
	Barrier			
	Partial	3.4551	3.91772	19
DWELLS_TO_BAR_NAC2	Barrier			
	Full	3.2027	2.89626	17
	Barrier			
	Total	2.9839	3.02562	54
	No	3.2315	3.83884	18
DWELLS_TO_BAR_NAC2	Barrier			
	Partial	3.6591	2.32093	19
	Barrier			
	Full	3.2783	2.67887	17
	Barrier			
	Total	3.3967	2.95994	54

Table 3: Descriptive statistics for dwell duration on manipulation

Descriptive Statistics For Dwell Duration on Manipulation				
Cond		Mean	Std. Deviation	N
DUR_ON_BAR_SEC_AC	No	12.4199	6.00012	18
	Barrier			
	Partial	10.7376	5.13961	19
	Barrier			
	Full	4.1926	2.85312	17
Dur_on_bar_SEC_NAC	Barrier			
	Total	9.2379	5.94863	54
	No	.9805	1.07168	18
	Barrier			
	Partial	1.7917	2.40735	19
DUR_ON_BAR_SEC_NAC2	Barrier			
	Barrier			
	Full	1.8049	2.29081	17
	Barrier			
	Total	1.5254	2.01797	54
DUR_ON_BAR_SEC_NAC2	No	1.8519	2.56884	18
	Barrier			
	Partial	1.9083	1.46617	19
	Barrier			
	Full	1.5586	1.16448	17
DUR_ON_BAR_SEC_NAC2	Barrier			
	Total	1.7794	1.81093	54

Table 4: Descriptive statistics for steering wheel angle RMSE

Descriptive Statistics for Steering Wheel Angle RMSE				
Cond		Mean	Std. Deviation	N
Accident D2	No Barrier	.02643318	.014570623	18
	Partial Barrier	.02363200	.006055431	19
	Full Barrier	.02060845	.010069860	17
	Total	.02361387	.010805525	54
No accident D1	No Barrier	.02297121	.010986917	18
	Partial Barrier	.01960094	.004816902	19
	Full Barrier	.02134339	.006227072	17
	Total	.02127291	.007764570	54
No accident D3	No Barrier	.02103380	.008156598	18
	Partial Barrier	.01477689	.005636716	19
	Full Barrier	.01721536	.006917721	17
	Total	.01763019	.007313374	54

Table 5: Descriptive statistics for average speed

Descriptive Statistics for Average Speed				
Cond		Mean	Std. Deviation	N
avgspeedAC	No	55.1297	3.32550	18
	Barrier			
	Partial	56.0929	2.94626	19
	Barrier			
	Full	57.4649	1.80903	17
	Barrier			
	Total	56.2037	2.89647	54
avgspeedNAC	No	56.7736	3.79873	18
	Barrier			
	Partial	58.3649	2.52782	19
	Barrier			
	Full	58.0614	2.74676	17
	Barrier			
	Total	57.7389	3.09301	54
avgspeedNAC2	No	58.0171	2.42812	18
	Barrier			
	Partial	57.1609	1.35919	19
	Barrier			
	Full	57.7445	2.15846	17
	Barrier			
	Total	57.6300	2.01469	54

Appendix C: Graphs for Main Effects

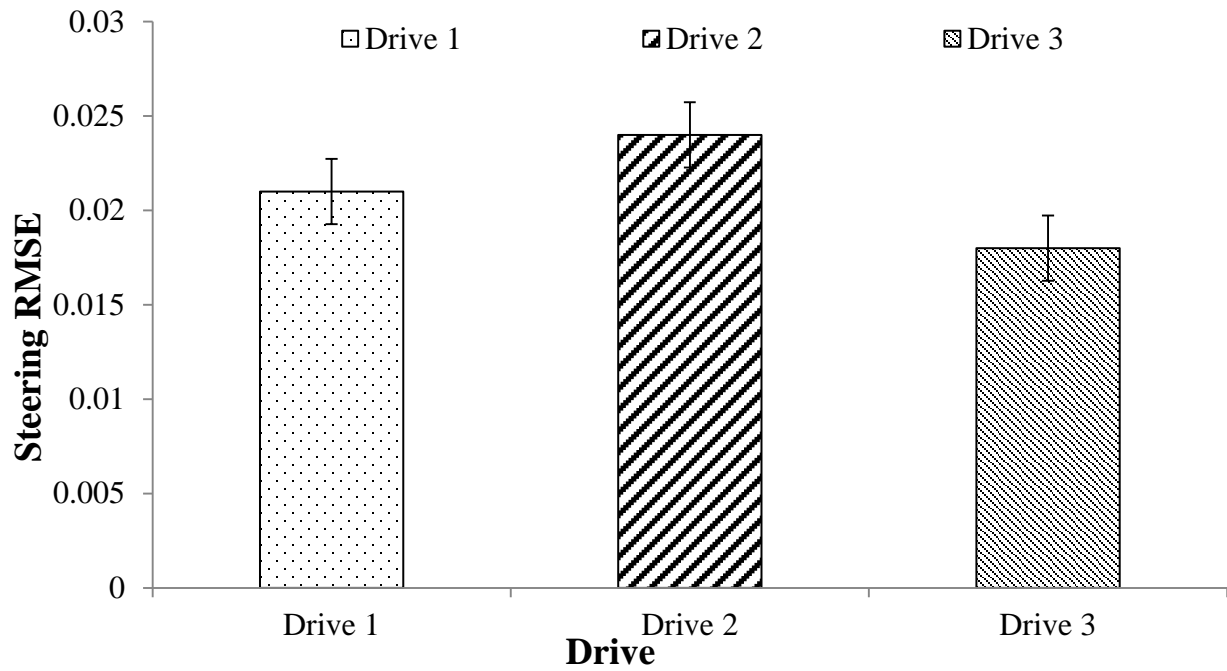


Figure 1: Means for main effect for RMSE of steering wheel angle. Error bars are standard error

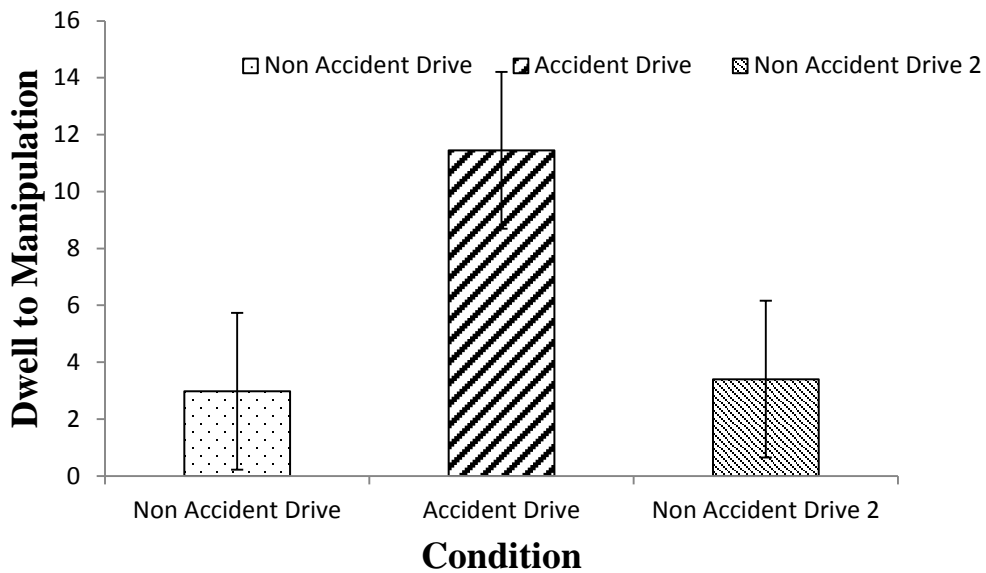


Figure 2: Means for main effect for dwells towards manipulation. Error bars are standard error.

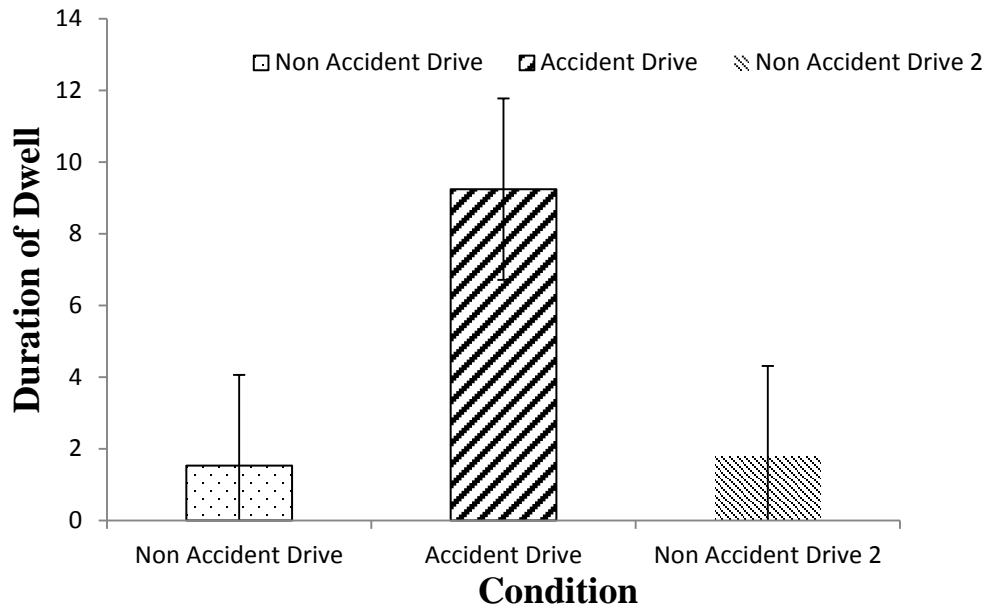


Figure 3: Means for main effect of duration of dwells towards manipulation. Error bars are standard error.

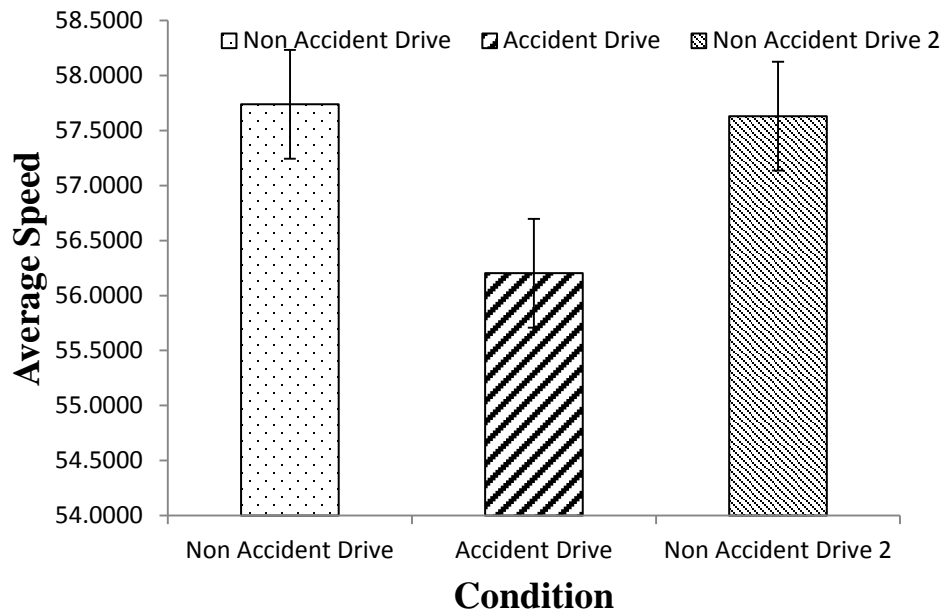


Figure 4: Means for main effect of average speed. Error bars are standard error.

Appendix D: Graphs for Interaction Effects

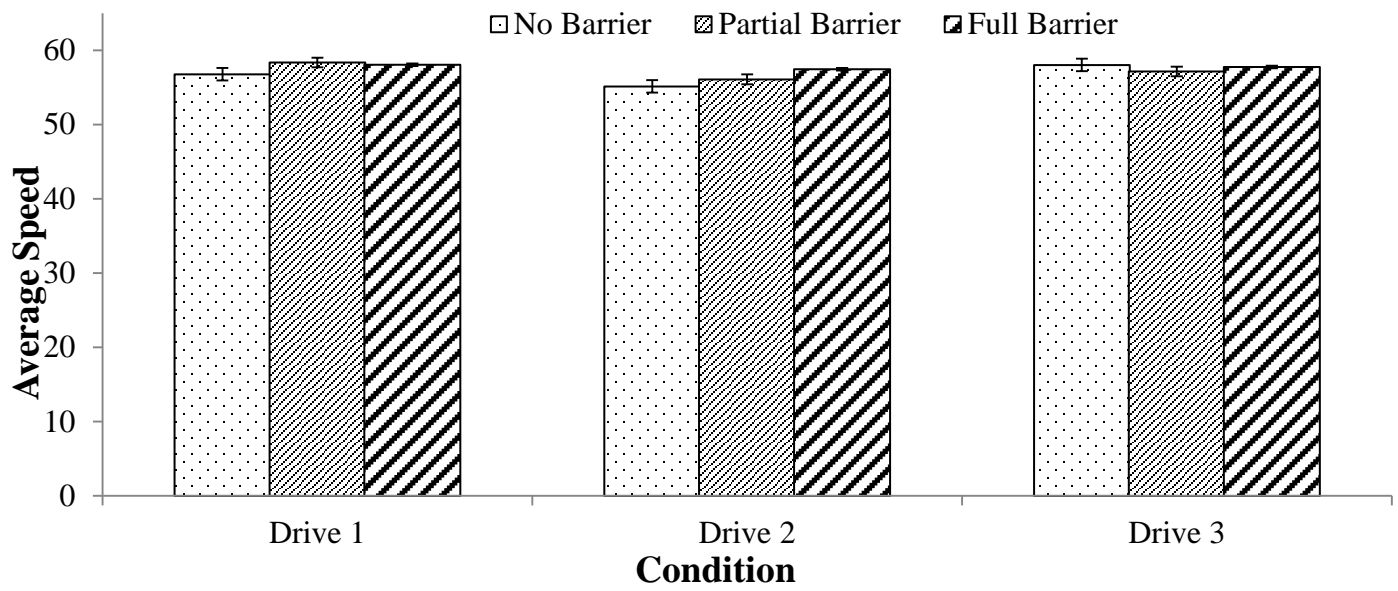


Figure 5: Means for interaction effect of average speed. Error bars are standard error.

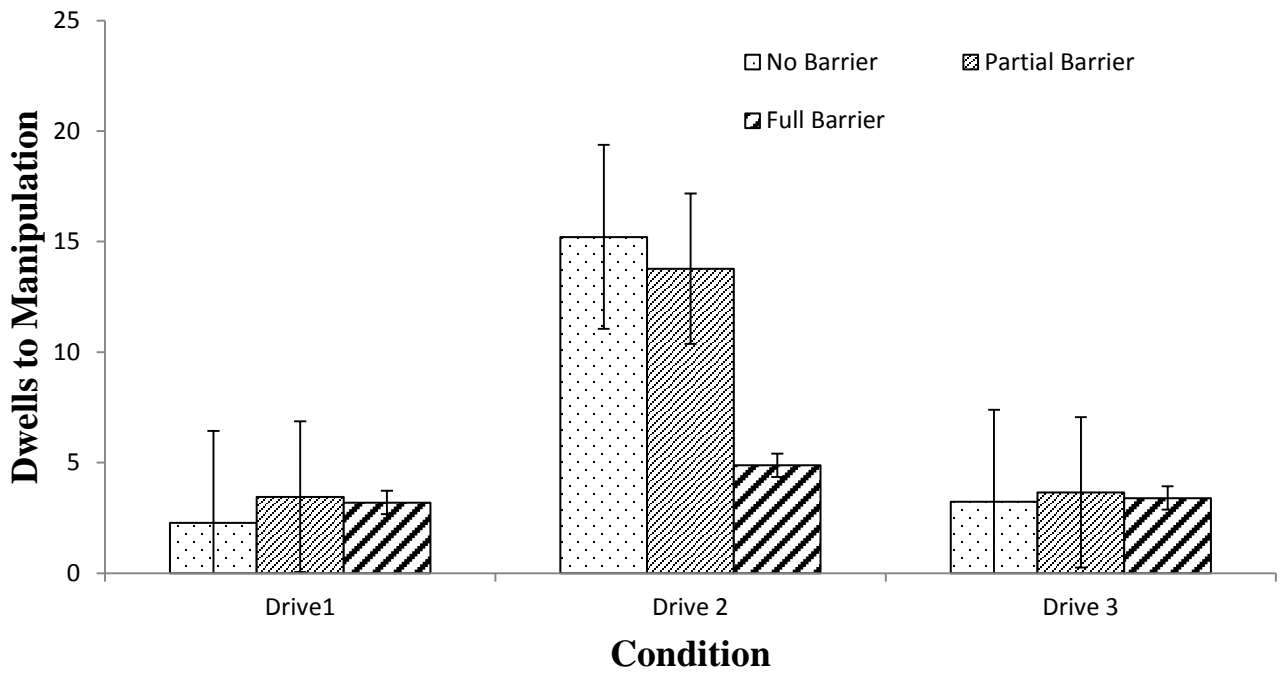


Figure 6: Mean for interaction effect of dwells towards manipulation. Error bars are standard error.

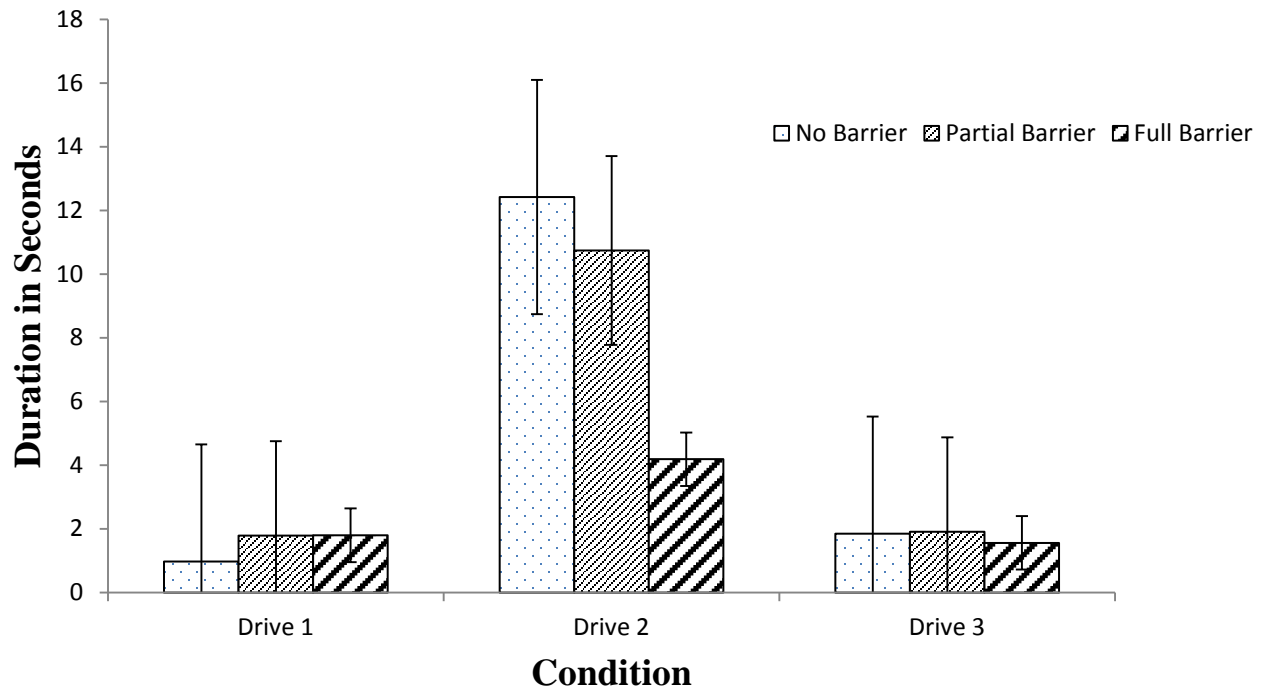


Figure 7: Means for interaction effect of dwell duration at manipulation. Error bars are standard error.

Appendix E: Demographic Questionnaire

Please provide the following information:

1. Please indicate your sex? **Female** **Male**
2. What is your chronological age? _____
3. Are you? **Right handed,** **Left handed,** or **Ambidextrous**
4. Approximate number of hours you spend driving in typical week: _____
5. Approximate number of miles you drive in typical week: _____
6. How many of the hours you drive each week are on major highways? _____, stop and go city roads? _____
7. Please rate your expertise while driving: **Poor** **Fair** **Average** **Good** **Excellent**
8. Do you have a valid Driver's License? **Yes** **No**
9. Do you wear the following when you drive? **Glasses** **Contacts**
10. Number of points currently on driver's license: _____
11. Do you have any condition that might impair your driving? **Yes** **No**
12. Please specify how were these points obtained (e.g., if 5 points: 3 for an accident and 2 for speeding): _____
13. How many accidents have you been involved in where you were the driver? _____
14. For how many of those accidents were you deemed at fault? _____
15. Were you under the influence of a substance when any of these accidents occurred?
 Yes **No**
16. What type of vehicle do you normally drive? _____

Appendix F: Pictures from Driving Scenarios



Figure 8: View of billboard that cannot be removed



Figure 9: White highway marker than cannot be removed.

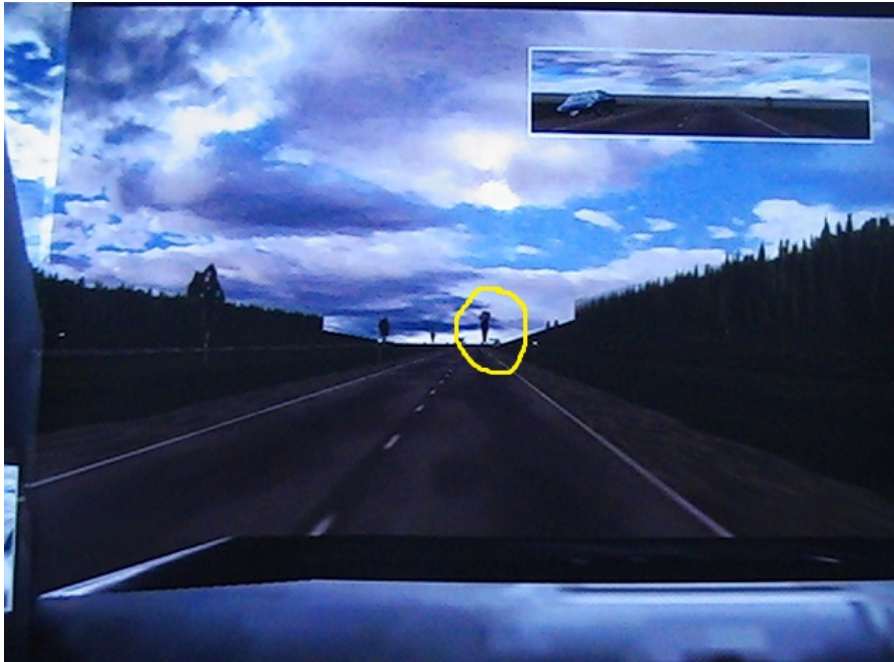


Figure 10: View of police car and smoke plumes from afar. Notice the difference in size between the two



Figure 11: Partial barrier accident scene condition with fire truck and simulated fire visible

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