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Visual Behavior Differences in Drivers Across the Lifespan: A Digital Billboard Simulator Study

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Abstract

Driver distraction is implicated in a significant portion of motor vehicle collisions; evidence has suggested that billboards can contribute to such distraction, but many knowledge gaps remain. The purpose of this study was to evaluate the effects of various types of billboards (static, 250-foot digital transition, 500-foot digital transition, and a control [no billboard] condition) and age group (teen, middle, and older) on visual behavior through the use of a driving simulator. To address gaps in the existing literature, the effects of age group and billboard type on the following visual attention variables were considered: percent of time participants looked at billboards, average glance length, number of glances, and glance pattern activity. Significant main effects of age group were found, suggesting that teen drivers exhibited significantly different visual behavior as compared to drivers in the other age groups. An Age Group x Billboard Type interaction for one outcome provided some evidence that percent of time spent looking at billboards significantly increased as billboard transition time increased for drivers, except for older adults, who spent more time looking at static billboards. This study helps lay the groundwork for future studies that may consider how young drivers' differential scanning patterns impact driving safety.

Introduction

1.0 Distracted Driving

Driver distraction and the role that it plays in motor vehicle collisions (MVCs) has been the subject of a great deal of research in recent years. In the United States in 2011, driver distraction was cited as a factor in 10% of all MVCs, 17% of MVCs causing injury but no fatalities, and 10% of MVCs causing at least one fatality (National Highway Traffic Safety Administration [NHTSA], 2013). Furthermore, visual fixation on objects outside the vehicle plays an important role in traffic safety. Among the 3,085 drivers in 2011 whose involvement in fatal MVCs was deemed to have been at least in part due to distraction,

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objects outside the vehicle were reported as part or all of the cause of the distraction 188 times, or for about 6% of all distracted drivers involved in fatal MVCs that year (NHTSA, 2013). It is important to remember that these figures may underestimate the scope of external distraction, because the determination of causes for fatal crashes relies on witness report and/or an after-the-fact reconstruction of events by police. One example of a potential agent of external distraction is the presence of advertising billboards.

1.1 Billboards as Distractions

According to the Outdoor Advertising Association of America (OAAA), there were approximately 361,810 advertising billboards in the United States (US) in 2013 (Outdoor Advertising Association of America [OAAA], 2013). This figure includes bulletins, posters, junior posters, and digital billboards (DBBs) which are similar in size to bulletins or posters, typically with two display faces, each of which rotates through a selection of unique advertisements by changing displays every six to eight seconds). This figure does not include thousands of additional bus shelter displays, kiosk and commercial stand displays, wall murals, “spectaculars” (made to order displays in larger-than-standard sizes that may employ bright lights, motion, and other special effects), and vehicle-borne displays (OAAA, 2013). With such a high prevalence of billboards along major highways and interstates, it is crucial to understand the impact of these external distractions on traffic safety. Numerous studies have attempted to examine these effects through the presentation of static billboards (those with only one display, which remains constant) as well as digital billboards (those that alternate displays electronically, typically every 6–10 seconds) in a driving simulator (Bendak & Al-Saleh, 2010; Divekar, Pradhan, Pollatsek, & Fisher, 2012; Edquist, Horberry, Hosking, & Johnston, 2011; Marciano & Yeshurun, 2012; Young & Mahfoud, 2007). These studies have bolstered the argument that billboard-related driver distraction can present a considerable risk in some situations, and begun to identify some of the factors that may modulate this risk, e.g., perceptual load on the roadway and roadsides (Marciano & Yeshurun, 2012) and driver age/experience (Divekar et al., 2012; Edquist et al., 2011). Importantly, however, none have utilized as wide an array of visual attention measures as in the present study. Furthermore, despite the individual findings of each of these studies, the indications of the literature as a whole have been unclear on the specific effects of driver age and experience on distraction by billboards (Decker et al., 2015).

Distracted driving has been formally defined as anytime a driver diverts attention away from the task of driving to an object, person, task, or event not related to driving (Hanowski, 2011; Olsen, Shults, & Eaton, 2013). This definition includes not only visual distraction, but also tasks that are physically and cognitively demanding. Visual distractions encompass distractions that require drivers to take eyes off of the road; physical distractions require one or both of the drivers’ hands to be taken off the wheel; while cognitive distractions comprise distractions that turn the drivers’ mind away from the driving task (Centers for Disease Control and Prevention [CDC], 2014). Distracted driving behaviors become increasingly more dangerous as they grow to include a combination of distraction (visual, physical and cognitive) (Goodwin, Foss, Harrell, & O'Brien, 2012). Because billboards are external distractors (they occur outside of the vehicle), visual and cognitive distractions are the two forms of distraction most relevant in the discussion of billboards. The scope of the current study is limited to driver visual distraction as it relates to advertising billboards.

1.2 Visual Distraction

Visual distraction occurs anytime something causes the driver to take his/her eyes off the road. This type of distraction is especially dangerous because it impairs the detection of unexpected driving-relevant information, including emergent hazards. One simulator study tested these specific effects by measuring the proportion of drivers who fixated on an eminent stimulus in the environment and the latency of the first detection of that stimulus. Visual distraction was shown to significantly delay the detection of emergent stimuli by up to 1 second), which, in real-world situations, translates into a delayed response in avoiding a hazard (Divekar et al., 2012; Smiley, Smahel, & Eizenman, 2004). Several other studies were conducted to analyze the specific visual distraction imposed on drivers fixated on billboards and how long these fixations lasted. Of particular interest were fixations lasting more than 0.75 seconds. After analyzing the mean duration of gaze at billboards and proportion of time spent fixating towards billboards vs. towards the forward roadway, it was discovered that digital billboards attracted more visual attention and longer gazes than conventional static billboards (Edquist, 2008; Lee, McElheny, & Gibbons, 2007). The findings of these research studies indicate that digital billboards produce a great deal of visual distraction, which in turn can significantly impair driving performance.

Although such studies have provided a better understanding of the distracting effects of billboards in the general population, a recent comprehensive review of the literature on visual distraction by billboards concluded that too little research has examined how these distractive effects differ across the lifespan, namely among teens (16–19 years old), middle-aged adults (35–55 years old), and older adults (65 years and older) (Decker et al., 2015). Teenagers (16–19 years of age) and older adults (65+ years of age) are at the highest risk for MVCs due to a variety of factors (Centers for Disease Control and Prevention [CDC], 2011). Teen drivers are one of the most vulnerable driving populations due to their inexperience, poor behavioral control, underdeveloped perception of hazards, and risky behaviors, with MVC’s accounting for 1 in 3 deaths among teens (ages 16–19) (Centers for Disease Control and Prevention [CDC], 2012; Lee et al., 2007; McGwin & Brown, 1999). Older adults are also at an increased driving safety risk for many different reasons, including age-related impairments in vision, loss of hearing, and cognitive declines (AAA Foundation for Traffic Safety, 2013). It stands to reason that external distractions such as billboards would be particularly dangerous for drivers in these age groups and would only exacerbate their already diminished driving capabilities.

1.3 Purpose

The current study aimed to evaluate the distracting effects of advertising billboards through the use of a driving simulator, to provide a safe environment for imposing driver distractions. Participants in three age groups (teen, middle and older) were asked to drive through a simulated scenario embedded with a variety of billboards (static and digital). To address gaps in the existing literature on visual behavior as it relates to digital advertising billboards (Decker et al., 2015), we considered the following visual variables across age groups and billboard types: percent of time participants looked at billboards, average glance length, number of glances, and glance pattern activity.

Method

2.0 Participants

Sixty-six participants were recruited for this study and divided into three groups: 16 – 19 years old for teens (N = 20), 35 – 55 years old for middle adults (N = 21), and 65 and older for older adults (N = 25). Potential participants were recruited using advertisements on social networking websites, flyers, and letters. Advertisements included contact information, information regarding the desired age ranges of the prospective participants and a brief statement explaining that participants would drive a simulator for monetary compensation. To minimize bias, participants were not explicitly informed that this would be a study about digital advertising billboards. Prospective participants called the number listed in the advertisement or letter to receive additional information about the study and were screened for eligibility.

Inclusion criteria included possession of a valid driver's license and being a current driver who had driven at least three of the past seven days from when the telephone interview was conducted. Exclusion criteria for all groups included physical disabilities which would prohibit full participation in the experimental protocol, and the presence of dementia symptoms.

2.1 Procedure

2.1.1 Introduction—Participants meeting criteria for participation were sent a package containing (1) an informed consent document and (2) a map to the location of the experiment either by mail or email depending on the participant's preference. Reminder calls were made to the participant on the day before their appointment to ensure continued interest in participation.

Upon arrival for testing, participants provided staff with the signed IRB consent forms. Tasks were administered by a team of trained research assistants using standardized protocols. One trained assistant led the data collection for each participant. Participants took part in two components during the session: driving in a simulator and completing a series of questionnaires and tasks.

2.1.2 Driving simulator—Participants were familiarized with the simulator during a brief, 2.84 mile, standardized four lane highway calibration scenario to ensure that all participants met a minimum standard proficiency with basic driving tasks (e.g., able to use turn signals, side mirrors, accelerator and brake pedal). Participants then engaged in a task involving driving during day time on a 16-mile simulated four lane bi-directional highway with a median. A variety of billboards were programmed to appear at predetermined distances within the scenario as described in greater detail in the "Measures" section (see Figure 1). Participants were instructed to drive as they normally would on a real interstate and were not explicitly told to attend to billboards while driving.

2.1.3 Questionnaires and Tasks—Participants were escorted into a nearby private room for the completion of several brief questionnaires to obtain demographic information. Research assistants verbally administered the questionnaires and tasks in an interview style. Far visual acuity was also measured.

2.1.4 Debriefing—After completing the driving scenario, questionnaires, and tasks, participants were debriefed. The debriefing included two components: (1) a brief discussion of topics relevant to the present work and (2) the presentation of a take home brochure describing the purpose of the study. Participants received a single monetary payment at the end of the session.

2.2 Measures

2.2.1 STISIM Driving Simulator—Participants drove a total of 16 miles in a computerized driving simulation task to provide a measure of driving performance under specified conditions of interest (STISIM Drive, Systems Technology Inc., Hawthorne, CA). The simulation was displayed on three 20” LCD computer monitors. Participants sat within the simulator’s passenger compartment which provided a view of the roadway and dashboard instruments, including a speedometer. The vehicle was controlled by moving a steering wheel in a typical driving manner and depressing accelerator and brake pedals accordingly (see Figure 2). An on-board stereo sound system provided naturalistic engine sounds, external road noise, and sounds of passing traffic.

The driving scenario featured a four-lane highway with a median, in which traffic flowed in a bi-directional manner and day-time scenery was displayed. Participants were instructed to drive as they normally would. A posted speed limit of 65 mph was displayed periodically throughout the scenario. Visual behavior was coded electronically by supplemental FaceLab eye tracking equipment that was mounted to the simulator dashboard.

2.2.2 Billboards—The driving simulation displayed a mixture of digital and static billboards that were interspersed throughout the drive, always appearing on the right side of the road. Eight billboards were digital (i.e., they transitioned from one advertisement to another at pre-determined points) and four were static (i.e., they did not transition). Transition times for the digital billboards varied to mimic naturalistic digital billboards which transition at different points in time while a driver passes. Two transition time points (i.e., point at which the billboard would transition from one advertisement to another) were established at 250 feet and 500 feet away from the billboard to ensure clear visibility of both the first (initial) and second (changed) advertisements. Therefore, if the billboard was digital, the first advertisement would change to another advertisement once the participant passed the predetermined marker (i.e., 250 or 500 feet from the billboard) while driving.

The 16-mile drive was further broken into four equal parts for development purposes. Each part consisted of the following: 1) a digital billboard that transitioned (i.e., changed from one advertisement to another) when the driver was 250 feet away from the digital billboard, 2) a digital billboard that transitioned (i.e., changed from one advertisement to another) when the driver was 500 feet away from the digital billboard, 3) a billboard that was static and therefore did not transition, and 4) a baseline segment that did not include a billboard at all.

Each of these 4 parts spanned one mile each (i.e., yielding one billboard per mile) and was populated in a counterbalanced order according to a Latin square design.

The transition criteria and design of the billboards were based off the Alabama Outdoor Advertising Code outlined in the Alabama Department of Transportation's Procedure and Requirements for Outdoor Advertising (Ala. Code 1975 § 450-10-1). To maintain consistency with Alabama guidelines and to maximize external validity of study results, the billboards embedded in the simulated scenario met the following four criteria: (1) the size dimensions for all billboards were 14 feet by 48 feet, (2) at least 500 feet between billboard structures was maintained, (3) at least 8 seconds elapsed between the transition of one advertisement to another within individual billboards, and (4) digital billboards did not consist of flashing or moving lights. Additionally, real world digital billboards on Alabama roadways were considered in the development of the billboards embedded in the scenario. The following four main components of a typical billboard were defined and appeared in all billboards presented in the scenario: (1) a large visual image or photograph, (2) the title of a business or marketed product, (3) either a slogan or a statement, and (4) an exit number (see Figure 3).

A total of 16 billboards were presented in the simulation drive. The billboard order was fixed across participants, with each billboard only being presented once per simulation. Each billboard was presented at a predetermined distance within the simulation. The billboard spawned, or appeared, once the participant reached the predetermined distance into the simulation. Individual billboards were designed to maintain consistency and balance across particular variables such as complexity, font size, color, word count, billboard components (as indicated in the previous paragraph), and right or left image placement. To vary the types of billboards presented, four categories were established: food (e.g., restaurants), goods (e.g., products), services (e.g., businesses), and destinations (e.g., vacation spots).

2.2.3 Eye tracking—FaceLab software Version 5.0, manufactured by Seeing Machines, was used to track participants' eye movements as they drove through the simulation. Eye gaze coordinates (X, Y, and Z) were recorded by FaceLab and served as the primary source of visual data, providing the exact position of the participant's gaze on the simulator screens. To calibrate the FaceLab software to each individual participant's eye gaze, a research assistant manually set seven annotation points, each on the center screen (corresponding to the upper left corner, middle of left side, lower left corner, center of monitor, upper right corner, middle of right side, and lower right corner). In most cases, however, the system did not calibrate the participant's gaze perfectly (that is, with 100% accuracy). Therefore, raw data were adjusted by calculating the percent error between the recorded and expected (actual) X, Y, and Z gaze coordinates. The correction was then applied to the data set on a per participant basis to ensure the values were an accurate representation of where the participant was looking throughout the simulation.

2.2.4 Participant Demographics—Demographic variables of participants (e.g., gender, age, days driven per week) were collected through a laboratory-developed questionnaire.

2.2.5 Visual Acuity—Far visual acuity was measured with a GoodLite Model 600A light box with the ETDRS chart using standard procedures. Participants were tested at a distance of 10 feet with corrective lenses (when applicable). Scores were assigned using a method which provides credit for each letter correctly identified. Scores can range from 0 to 90, with higher scores indicating better acuity (Ball et al., 2002).

2.2.6 Outcome Variables—All outcome variables were stratified by age group (teen, middle, and older) and billboard type (static billboard, digital 250-foot billboard, digital 500-foot billboard, and control [no billboard]). The following four indicators of visual behavior were recorded by the eye tracking equipment:

a. Percent time for participants' gaze was calculated as the percent of time a participant looked at a billboard when a billboard was present. Coordinates of eye gaze were compared to the known billboard coordinate values as a function of time to calculate the total amount of time a participant looked at a particular billboard, and eventually summed to yield the percent of time participants looked at billboards throughout the simulation.

b. Number of glances was calculated as the number of times participants glanced at a billboard when a billboard was present. Glance types were stratified by length of glance (≥ 0.75 seconds and ≥ 2.0 seconds) to be consistent with previous work (Decker et al., 2015). 0.75 seconds has been suggested as the minimum perception-reaction time (PRT) for a vehicle slowing ahead of the driver (Smiley et al., 2004), and long glances of 2.0 seconds or longer have been shown in naturalistic studies to be especially associated with MVCs and other traffic incidents (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006);

c. Average glance length was calculated as the average length of glances at a billboard when a billboard was present; and

d. Glance pattern activity (GPA), was measured as the number of glances made to any location per unit of time (Lee et al., 2007).

2.3 Data Analytic Technique

All statistical analyses were conducted using SPSS version 21. First, descriptive statistics of key demographic variables were obtained for participants, stratified by age group. Then, a repeated measures analysis of covariance (RM ANCOVA) was used to determine the effect of age group (teen, middle, older) and billboard type (static, digital 250-foot transition, digital 500-foot transition, control [no billboard]) on all visual behavior outcome variables (percent time, average glance length, number of glances, GPA), as well as to inspect any Age Group x Billboard Type interactions. Far visual acuity served as the covariate in all analyses. *P*-values less than 0.05 were considered significant for all analyses. Post-hoc analyses were used to further inspect significant RM ANCOVA main effects and interactions.

Results

3.0 Participant Characteristics

Of the 66 participants recruited, 12 participants were excluded from the analysis. One of those participants was excluded due to simulator sickness, and eleven were not included in the analysis due to inability to calibrate eye tracking equipment or inaccuracies in eye tracking data that were collected. The resulting sample of 54 participants was used for analyses. The resulting sample had an equal number of participants in each age group (n=18). Table 1 presents descriptive statistics of the sample. There was a significant difference among groups on far visual acuity, $F(2, 51) = 4.64$, $p < .05$. Simple contrasts indicated older drivers had significantly worse far visual acuity as compared to teen drivers ($p = .007$) and middle age drivers ($p = .018$).

3.1 Primary Visual Attention Analyses

All results are summarized in Table 2 and discussed in the sections that follow.

3.1.1 Percent Time—A significant main effect of age, as well as an Age Group x Billboard Type interaction was revealed for percent of time participants looked at billboards when a billboard was present. Post hoc analyses indicated that teens looked at billboards for a significantly greater percentage of time than did middle and older age groups. The 2-way interaction of age group and billboard type shows that, generally, for each age group, the percent of time spent looking at billboards significantly increased as billboard transition time increased, except for older adults, who spent more time looking at static billboards (see Figure 4).

3.1.2 Number of Glances—For the number of glances per billboard that lasted at least 0.75 seconds, there was a main effect of age group. Post-hoc analyses indicated that teens had significantly more glances lasting at least 0.75 seconds than both middle and older age groups. Similarly, for glances lasting at least 2.0 seconds, there was a main effect of age group. Post-hoc analyses showed that teens had significantly more glances lasting at least 2.0 seconds compared to the middle age group, and marginally significantly more glances compared to the older age group ($p = 0.050$). Percent of glances stratified by length of glance appear in Table 3.

3.1.3 Average Glance Length—For the average length of glance per billboard, there was a main effect age group. Post-hoc analyses showed that teens made significantly longer glances compared to those in the middle and older age groups.

3.1.4 Glance Pattern Activity—There were no significant effects for Glance Pattern Activity.

Discussion

4.0 Discussion of Findings

The purpose of this study was to use a driving simulator platform to assess billboard-related distraction's impact on visual behavior in drivers across the lifespan. This study is among the first to look at billboard distraction across different age groups, namely, teens (16–19) and older drivers (aged 65+), both of whom have the highest rates of motor vehicle collisions per mile driven. In general, teen drivers showed a differential visual behavior pattern as compared to middle age and older drivers, regardless of presence of billboards. Exploratory findings considering percent increase from baseline to 500-ft transition billboards in number of glances indicated that even though middle age and older adults showed greater percent increase, teens had higher mean levels of glances (short and long) and spent more percent time looking at all billboard types. Other work has shown the detrimental impact of taking eyes off the road for an extended period of time for novice, teen drivers (Divekar et al., 2012). Teens may also be more willing to engage in other risky driving behaviors such as texting on a phone while driving which may require them to take their eyes off the road, thus impacting driving safety (Klauer et al., 2014).

A marginally significant main effect of billboard type was found for long glances (over 2.0 seconds), suggesting the digital 500-foot transition billboards seemed to evoke more looks than the other types of billboards. These findings are supported by previous studies examining the impact of billboards on driver distraction, such as that by (Chattington, Reed, Basacik, Flint, and Parkes (2009), who found that full motion video billboards were associated with more glances away from the road than stationary, or static, billboards. The present study is among the first to consider the effects of age and billboard types on driver visual distraction from billboards. The significant Age Group x Billboard Type interaction for percent of time looking at billboards, provided some evidence that teens diverted their gaze towards billboards significantly longer than other age groups, and especially when digital billboards were present. Our findings are supported by previous work that has also found that the visual behavior of teens may be more affected in the presence of billboards as compared to more experienced drivers (Chan, Pradhan, Knodler, Pollatsek, & Fisher, 2008; Edquist et al., 2011), though our work is the first to consider older age groups (aged 65 and up) for comparison.

The literature review conducted by Decker et al. (2015) concluded that the risk associated with billboards in most driving situations is likely minimal, but that this risk can vary widely with billboard characteristics, and possibly with driver, road, and traffic characteristics. Thus, the review suggested that future research in the field focus on identifying the specific qualities of drivers, billboards, and roadway/traffic environments that correspond to the highest risk of billboard-related distraction, and quantifying such distraction in these highest-risk situations and populations (i.e., as opposed to in the average, relatively low-risk case). By collecting data within a varied and thorough set of visual behavior measures, the present study has provided additional support for the idea that drivers who are young and inexperienced are at an elevated risk of visual distraction, not only in the presence of external objects such as billboards, but also when driving in general and thus should be given special attention in further research on the topic.

The present study also addresses several other knowledge gaps and findings identified by Decker et al.'s (2015) review. First, it supplements the relatively small and inconclusive body of evidence on the rates at which static and digital billboards attract glances of ≥ 2.0 seconds in duration, which is important because of the demonstrated safety impact of such long glances (see, e.g., Klauer et al., 2006). Among the middle age group of drivers, the present study revealed rates of glances ≥ 2.0 seconds that were low and were similar to those reported by other studies (see Decker et al., 2015). However, the rates were much higher among young drivers, and were higher than those reported in previous studies. Furthermore, the high standard deviations observed in these rates among young drivers may suggest that further sources of individual variability in susceptibility to distraction remain to be identified, even within age/experience groups; if identified, these differences could perhaps be amenable to educational interventions. Second, the present study supported the conclusion that billboards do not significantly affect glance pattern activity, and thus that this may not be a useful measure of driver visual distraction in future studies.

4.1 Strengths and Limitations

While the present study is among the first to consider the impact of billboards across the lifespan, the teen driver group did not include many "novice" drivers (i.e., newly licensed drivers). Rather, it consisted primarily of 18- and 19-year-olds, making it difficult to generalize our findings to a younger, less experienced group of drivers. While driving simulators provide much needed experimental control to test hypotheses with regard to driving safety, it is difficult to truly ascertain the degree to which simulated driving performance models real world driving behavior or how well simulated billboards model real world billboards. For example, in the real-world, digital billboards feature characteristic brightness and vividness that could capture the attention of drivers; however, this is something that is difficult to emulate in a simulator. Despite this limitation, billboards seemed to evoke the visual attention of participants even though we did not explicitly instruct them to look at them.

Nevertheless, the driving simulator platform enabled us to view how participants might react to the same billboard – something that would have been difficult to examine in a naturalistic driving study. Participants were also not told that the study was examining billboard distraction, so we were able to see participants' natural behavior in passing billboards while driving in an environment similar to that encountered in the local area.

Future studies may consider whether participants recall certain types of billboards (e.g., food advertisements vs. public health announcements vs. variable message signs) more readily than others or whether billboard placement (i.e., right vs left) and size have a differential impact on driver distraction. Studies could also consider what specific aspects of billboards (e.g. graphics, slogans, exit numbers) are more easily recalled or divert driver's attention from the roadway more readily. Finally, it would be important to link visual behavior to driving performance metrics to further clarify the role that driver inattention by external distractions such as digital billboards has on driving safety.

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Highlights

- This study examined the effects of age and advertising billboard type on drivers' visual behavior via the following performance outcome variables: percent of time participants looked at billboards, average glance length, number of glances, and glance pattern activity.
- Teen drivers diverted their visual attention away from the road more than middle aged and older drivers.
- An Age Group x Billboard Type interaction suggested that percent of time spent looking at billboards significantly increased as billboard transition time increased for drivers, except for older adults, who spent more time looking at static billboards.
- Future studies should consider how differential visual scanning patterns across age groups are related to specific driving behaviors that may increase crash risk.

Figure 1.
Screenshot of driving scenario with billboard embedded.

Figure 2.
Photograph of the STISIM driving simulator.

Figure 3.
Sample embedded billboard with labels.

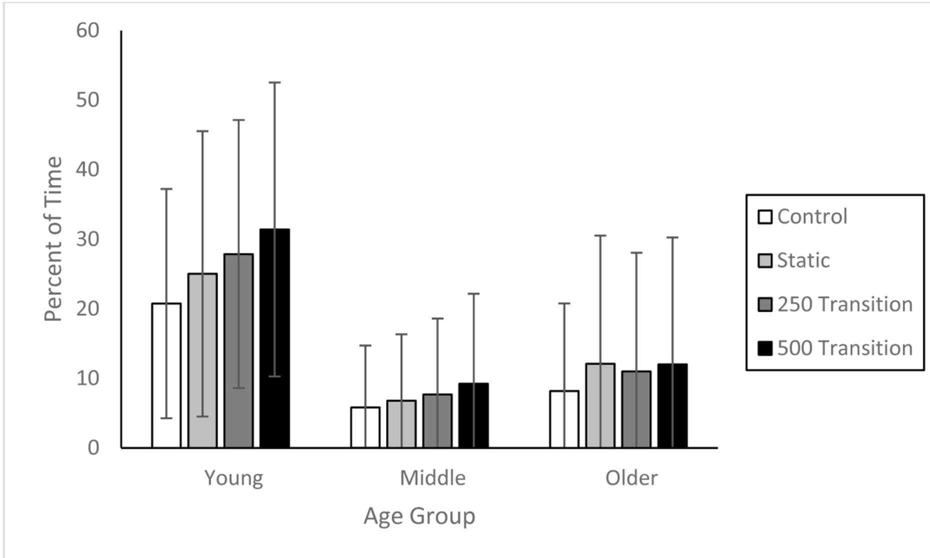

Figure 4.
Percent of time participants looked at billboards, stratified by age group and billboard type.

Table 1

Participant Characteristics.

	Teen Drivers (*n* = 18)	**Middle Age Drivers (*n* = 18)**	**Older Drivers (*n* = 18)**
	Mean ± SD	**Mean ± SD**	**Mean ± SD**
Age (years)	18.98 ± 1.26	44.76 ± 5.78	72.46 ± 7.51
Days Driven During Week	6.44 ± 1.10	6.89 ± 0.47	5.22 ± 1.48
Far Visual Acuity (0–90)	86.43 ± 4.25	85.32 ± 6.27	77.68 ± 14.38
	Frequency (%)	Frequency (%)	Frequency (%)
Gender			
Male	11 (61.1)	7 (38.9)	8 (44.4)
Female	7 (38.9)	11 (61.1)	10 (55.6)
Ethnicity			
Caucasian	12 (66.7)	10 (55.6)	11 (61.1)
Minority	6 (33.3)	8 (44.4)	7 (38.9)

Table 2

Repeated Measures ANCOVA Between Age Group, Billboard Type and Visual Attention Outcomes

	Control	**Static**	**250-ft**	**500-ft**			
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**ME Age**	**ME BT**	**Age * BT**
Percent time							
Teen	20.74 (16.48)	25.02 (20.53)	27.85 (19.28)	31.39 (21.14)	$\boldsymbol{F}$ **(2, 51)**	F(3, 153)	$\boldsymbol{F}$ **(6, 153)**
Middle	5.80 (8.91)	6.78 (9.53)	7.68 (10.91)	9.23 (12.94)	**= 8.07**	= 0.92	**= 2.48**
Older	8.17 (12.60)	12.10 (18.43)	10.99 (17.07)	12.00 (18.25)	$\boldsymbol{p}$ **= 0.001**	p = 0.433	$\boldsymbol{p}$ **= 0.026**
Number of Glances							
Glance ≥ 0.75 sec							
Teen	1.89 (1.70)	2.25 (2.19)	2.39 (1.78)	2.79 (2.06)	$\boldsymbol{F}$ **(2, 51)**	F(3, 153)	F(6, 153)
Middle	0.36 (0.67)	0.47 (0.96)	0.60 (1.03)	0.75 (1.20)	**= 7.02**	= .71	= 0.67
Older	0.76 (1.34)	1.00 (1.61)	1.06 (1.88)	1.06 (2.07)	$\boldsymbol{p}$ **= 0.002**	p =.548	p = 0.671
Glance ≥ 2.0 sec							
Teen	0.33 (0.51)	0.49 (0.69)	0.39 (0.58)	0.56 (0.62)	$\boldsymbol{F}$ **(2, 51)**	F(3, 153)	F(6, 153)
Middle	0.04 (0.18)	0.06 (0.14)	0.07 (0.17)	0.07 (0.21)	**= 3.95**	= 2.59	= 0.91
Older	0.13 (0.41)	0.26 (0.55)	0.19 (0.47)	0.15 (0.44)	$\boldsymbol{p}$ **= 0.026**	p = 0.055	p = 0.488
Average Glance Length							
Teen	0.50 (0.33)	0.55 (0.40)	0.67 (0.39)	0.67 (0.32)	$\boldsymbol{F}$ **(2, 51)**	F(3, 153)	F(6, 153)
Middle	0.22 (0.21)	0.28 (0.22)	0.29 (0.21)	0.29 (0.25)	**= 6.30**	= 0.27	= 1.28
Older	0.27 (0.35)	0.35 (0.39)	0.35 (0.40)	0.28 (0.33)	$\boldsymbol{p}$ **= 0.004**	p = 0.844	p = 0.271
Glance Pattern Activity							
Teen	1.69 (0.42)	1.74 (0.40)	1.70 (0.34)	1.75 (0.31)	F(2, 51)	F(3, 153)	F(6, 153)
Middle	1.85 (0.55)	1.90 (0.42)	1.87 (0.42)	1.89 (0.39)	= 0.78	= 0.11	= 1.40
Older	1.88 (0.55)	1.69 (0.52)	1.85 (0.45)	1.81 (0.48)	p = 0.463	p = 0.953	p = 0.218

Note. Bold signifies $p < .05$; BT= Billboard Type; Far Visual Acuity served as covariate.

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Table 3

Percentage of glances stratified by length of glance (≥ 0.75 and ≥ 2.0).

	Control		Billboard					
			Static		250		500	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Percent ≥ 0.75 sec								
Teen	23.90	17.84	22.94	21.57	26.81	21.62	28.06	19.29
Middle	5.34	9.82	6.20	10.34	7.35	10.59	9.45	12.56
Older	12.02	20.34	11.68	16.47	15.95	27.97	8.98	18.47
Percent ≥ 2.0 sec								
Teen	4.04	7.06	4.92	7.19	3.98	7.79	5.31	6.27
Middle	0.54	2.28	0.69	1.76	0.71	1.76	0.75	2.36
Older	1.85	5.94	2.66	5.91	1.89	4.52	1.36	4.02