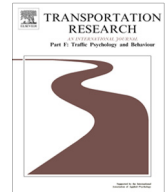




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Visual behavior differences in drivers across the lifespan: A digital billboard simulator study



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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 \times 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.

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1. Introduction

1.1. 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 3085 drivers in 2011 whose involvement in fatal MVCs was deemed to have been at least in part due to distraction, 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

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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.

1.2. 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 s) 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.

1.3. 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 s), 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 s. After analyzing the mean duration of gaze at billboards and proportion of time spent fixating toward billboards vs. toward 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.

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