ATINER CONFERENCE PAPER SERIES No: CIV2013-0489

Athens Institute for Education and Research
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ATINER's Conference Paper Series
CIV2013-0489

Digital Roadside Advertising and Traffic Safety

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URL Conference Papers Series: www.atiner.gr/papers.htm

ISSN **2241-2891**
2/08/2013

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Dr. Gregory T. Papanikos
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This paper should be cited as follows:

Sisiopiku, V.P., Hester, D., Gan, A., Stavrinos, D. and Sullivan, A. (2013) "**Digital Roadside Advertising and Traffic Safety**" Athens: ATINER'S Conference Paper Series, No: CIV2013-0489.

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Abstract

There is concern that roadside advertising presents a significant risk to driving safety, with conservative estimates putting external distractions responsible for up to 10% of all traffic incidents (Young and Mahfoud, 2007). Studies indicate that any interference that distracts the driver from looking forward from the roadway for more than two seconds significantly increases the chances of crashes and near crashes (Klauer et al., 2006).

The focus of this paper is on digital advertising billboards and their potential link to traffic crashes due to driver distraction. Due to the growing debate on this issue, a need exists to document the state of practice with respect to digital advertising billboards and driver distraction in a clear, systematic, and concise manner.

The paper provides a comprehensive synthesis of findings from an extensive review of national and international literature on the topic of digital billboards and traffic safety. First, it discusses digital advertising billboard technology and industry regulation practices. Emphasis is then placed on studies that investigate links between driver distraction associated with roadside

advertising and traffic safety. Crash studies focusing on statistical analysis of historical data as well as behavioral studies (both naturalistic and driving simulator based) are discussed and contrasted. The paper concludes with a summary of findings and recommendations for future research.

Overall, this paper provides a thorough examination of safety issues associated with the use of digital advertising billboards, which can guide transportation agencies and policy makers on the regulation of digital advertising billboards in the future.

Keywords: Outdoors advertising, digital billboards, driver distraction, traffic safety.

Acknowledgment: Funding for this study is provided by US DOT/RITA through the National Center for Transportation Systems Productivity and Management. The support of the study sponsors is greatly appreciated.

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INTRODUCTION

Since the passing of the Highway Beautification Act (HBA) in 1965, federal, regional, and local authorities in the US have attempted to control outdoor advertising through the introduction of standards and restrictions on size, placement, content, and durability. Naturally, as new technologies emerge in the outdoor advertising industry, authorities must develop new restraints to maintain safe and sustainable industry practice. The digital billboard (DBB) is one such new technology that has appeared in the late twentieth century and flourished in recent years. According to the Outdoor Advertising Association of America (OAAA), the number of digital billboards will grow tenfold in the next decade due to their lucrative potential in the out-of-home advertising market (Dobranski, 2007).

In response to the increase in DBB signs, safety concerns have risen over potential contribution of DBBs to driver distraction. Various studies, including crash analysis studies, behavioral studies, and reviews have resulted in somewhat contradictory conclusions, indicating a need for further research. This synthesis summarizes existing literature on the subject to develop an objective and comprehensive understanding of the current knowledge base.

ROADSIDE ADVERTISING OPTIONS

Conventional (static) billboards first appeared during the 19th century and are considered the oldest form of mass media. Today, there are an estimated 400,000 billboards in the United States (OAAA, 2012). In terms of industry growth rates, outdoor advertising is second only to internet advertising (Marketing Week, 2007). Advantages of outdoor advertising include relatively low entry and operating costs, the ability to appeal to the local market, and the capability to display to a high frequency of viewers.

While static billboards are still dominant, digital billboards are a fast growing sector of the outdoor advertising market. DBBs utilize light-emitting diode (LED) technology to provide vivid displays that can be updated every few seconds using computer input. Because they flash images every four to ten seconds (Copeland, 2010), a single board can advertise to far more clients than a traditional board. Although DBBs are initially more expensive to build compared to their static counterparts, over time they prove to be cost-effective. Contrary to static advertising signs that require a production cycle of one to two weeks for updating, new designs can be updated and posted on a DBB in a matter of hours, making it easier for clients to update their advertisements on a frequent basis (Birdsall, 2008).

Another difference between static and digital billboards is that DBBs can expand on customer interaction and targeted messaging specific to the demographics of travelers driving past them. Texting, news flashes, countdowns, competitions and real-time snapshots are some of the latest

applications on electronic billboards that are impossible with static billboards (Stilson, 2010).

GUIDELINES AND REGULATIONS

Regulations for control of outdoor advertising exist at the federal and state level. The first mandate was signed in the Federal-Aid Highway Act of 1958, based on which states could voluntarily agree to control outdoor advertising next to interstate highways in accordance with 23 CFR 750, Subpart A in exchange for additional federal aid in highway construction. In 1965, President Lyndon B. Johnston signed the HBA, Public Law 89-285 which mandates that states not only comply with the standards, but remove nonconforming signs. The consequence for noncompliance is a 10% reduction of the state's annual federal aid for highway apportionment. The HBA also controls certain aspects of sign placement, size, and content. Signs must be within 660 feet of the roadway, lighting and spacing must meet Federal/State Agreements (FSAs), and signs have to meet other specified aesthetic standards related to travel centers and landscaping.

The Federal Highway Administration's (FHWA) Outdoor Advertising Control Manual details federal regulations, specifically regarding regulations on commercial electronic variable message signs (CEVMS). Originally, the FHWA considered the prohibition of the signs, and certain states determined that these signs violate the lighting provision in their FSA. In reaction to this, the FHWA issued memorandums during 1996 and 2007 which give states a reference to help determine lighting requirements for signs (FHWA, 2012).The 2007 Memorandum provides guidance on the placement of CEVMS signs in areas subject to control under the HBA of 1965. The HBA requires states to maintain effective control of outdoor advertising next to certain roadways. Signs that meet size, lighting, and spacing standards must be used in agreement with the state and the Secretary. Most of these agreements were signed in the 1960's and 1970's and though CEVMS signs are not prohibited, this guidance allows states to adopt more stringent requirements for changeable message signs. The following standards demonstrate the ranges of acceptability that have been adopted by certain states allowing CEVMS:

- Duration of Message: 4-10 sec; 8 sec recommended
- Transition Time: 1-4 sec; 1-2 sec recommended
- Brightness: Adjust to changes in light levels
- Spacing: Specified in FSAs
- Locations: Specified in FSAs, except where determined unsafe to drivers

Other standards that states use include a default designed to freeze in one display should a malfunction occur, a process for changing displays and lighting levels to ensure safety, and the prohibition of dynamic messages such as animation, flashing, scrolling, and video (Shepard, 2007).

DIGITAL ADVERTISING BILLBOARDS AND TRAFFIC SAFETY

While laws and regulations are vital for ensuring uniformity and protecting the public from unsafe and inappropriate roadside advertising practices, questions still remain about the potential link between roadside advertising and traffic safety. Roadside advertising billboards by nature are intended to draw the driver's attention, thus purposely encouraging drivers to shift their attention away from the driving task. The DBBs brightness may be especially problematic at night and may affect the driver's ability to observe changes in the surrounding environment such as brake lights or signal changes. Moreover, frequently changing images may compel more glances and sequential messages may hold drivers' gazes longer until the entire message is read. Lastly, targeted messages that promote interactivity with the driver are particularly troublesome as they are hypothesized to be distracting to the driver.

Several studies have been performed worldwide to document the relationship between roadside advertising billboards and traffic safety. These include a) crash studies analyzing historical crash records, b) laboratory studies using driving simulators, c) naturalistic studies observing driver behaviors on-road using instrumented vehicles, and d) previous literature reviews. Representative studies and summary findings are presented next. Attention should be paid to the funding source of each study, as not all backing institutions have a neutral interest.

Literature Reviews

Several literature reviews and meta-analyses exist on the subject of outdoor advertising and driver distraction. A few of such studies were funded by non-neutral sources, so the results reported should be considered with discernment.

In 2003, Wallace used meta-analysis to investigate whether or not there is a serious safety risk caused by features in the external driving environment. After twelve selected studies were analyzed, Wallace concluded that there seemed to be an association between crash rates and billboards at intersections. The only one of the twelve studies that showed no relationship between crashes and signs was performed on a stretch of road that contained no intersections. Secondly, there was a possible correlation between crash rates, signs, and sharp bends after long stretches of road. Thirdly, concerning the first two conclusions, the evidence was largely situation-specific. Wallace also stated that many studies have shown that billboards had little to no impact on driver safety, but still many indicated outdoor advertising can be a serious threat to road safety. Wallace concluded that the subject is under-researched and recommended that new research is needed to combine past knowledge with current practices paving the way for additional studies in the recent years (Wallace, 2003).

In a parallel effort, Coetzee reviewed and summarized the findings from six previous crash studies. Among the studies considered was a 1951 study done

by the Minnesota Department of Highways that is known as one of the first advertising billboard-driver safety studies. It reported that in a sample of 713 crashes, intersections with 4 or more billboards had a crash rate 3 times higher than at intersections with no billboards. The same year, Iowa State University evaluated crash rates immediately upstream and immediately downstream of billboards and found that crash rates upstream were double the rates downstream. In 1952, the Michigan State Highway Department found that billboards had no effect on crash rates, although it was concluded that illuminated signs exhibited a correlation with crash locations. Crash rates reported in another study found that the addition of one billboard at a given location resulted in a 12.3% increase in crashes, while the addition of 5 billboards resulted in a 61.7% increase in crashes (Coetzee, 2003).

A report facilitated by FHWA reviewed the potential concerns of DBBs on driving safety. Research on driver performance, state regulatory practices, tri-vision signs, literature review, roadway characteristics' relationship to driver distraction, driver characteristics' relationship to driver safety, and the legibility of Changeable Message Signs (CMSs) were included in the report. Also included was a section describing research needs on the subject (Farbry et al., 2001). A similar report released by the FHWA in 2009 described how the recent emergence of DBBs along U.S. roadways has caused a need for a reevaluation of current legislation and regulation for controlling outdoor advertising. Driver distraction is a chief concern. This report consisted of earlier published work, research of applicable research methods and techniques, and recommendations for future research (Molino et al., 2009).

In 2009, Wachtel issued a report under National Cooperative Highway Research Program (NCHRP) Project 20-7 (256) to help state and local governments establish guidelines for outdoor advertising signs. Included in the report is a) an identification of human factors related to digital outdoor advertising, b) an investigation into existing regulations on outdoor advertising in both the U.S and abroad, and c) a review of the current literature on the subject. The studies reviewed in the report were separated into two distinct categories: i.e., neutral research and industry-funded studies. Because the technology of DBBs is relatively novel, more research on the subject has transpired in recent years; out of the 150 studies cited in the report, 20 occurred in the last decade. Wachtel highlighted several successful regulations to serve as models for other entities to consider. He also concluded that the relationship between DBBs and driver distraction is very complex. The dynamic nature of field studies in roadway corridors presents many challenges to achieve objective research, and laboratory studies have a limited relationship with reality. One suggestion to remedy this problem would be to design a study that combines the validity of a field study with the control of a laboratory setting. Moreover, the fact that DBBs are quickly adapting and evolving as technology advances makes offering guidelines on the issue even more challenging. Adding to the complexity is the fact that industry-funded studies may include biased conclusions. However, despite the convolution of the issue, Wachtel concludes that that there is enough of a solid and growing body confirming that

roadside advertising attracts drivers' eyes away from the road for discernibly unsafe periods of time. It remains to be seen whether or not the combination of existing, in progress, and future research is sufficient for the alteration of current industry standards (Wachtel, 2009).

The U.S. Sign Council issued a response to the 2009 Wachtel report that is critical of Wachtel's work, claiming that his recommendations were limited in scope, and unnecessarily criticized studies that use scientific methods. The Council, which is funded by the advertising industry, also claimed that only a small percentage of the literature reviewed in the report involved field studies, and that the author invited the reader to "take a circuitous path around existing studies" on digital billboards and driver distraction in order to reach a conclusion that billboards are a distraction (Crawford, 2010).

In a follow-up report, Wachtel focused on how digital billboards distract U.S. drivers. The report suggested that DBBs cause drivers to be less observant of stopping cars ahead of them, and contribute to vehicle drifting into adjacent lanes. The report also offered suggestions on ways to control the effects of digital advertising, which include controlling the lighting of the signs, keeping the signs simple, and prohibiting message sequencing (Wachtel, 2011).

Crash Studies

Most crash studies involve statistical analyses of historical crash databases. Such studies can provide fast and easy-to-obtain results, although often the final conclusions can be limited in scope and analysis due to the highly variable and confined nature of crash data.

In a 2010 report, Tantala and Tantala examined the statistical relationship between digital billboards and traffic safety in Albuquerque, New Mexico. Analysis of traffic and crash data was conducted for a 7-year period on local roads near 17 DBBs. Each billboard contained one digital plane that was converted from traditional signage between 2006 and 2007. First, the researchers reviewed the frequency of crashes near the billboards before and after conversion to digital. Ranges analyzed in the study included 0.2, 0.4, 0.6, 0.8, and 1.0 miles both upstream and downstream of each sign. Also, time of day and age of driver dynamics were factored into the study. Secondly, the researchers performed a spatial analysis to investigate the potential correlation between the locations of billboards and crashes. The results of the study indicated that the 17 digital billboards in Albuquerque have no significant relationship with auto crashes. Specifically, crash rates near the digital boards showed a 0.3% decrease in crash rate within 0.6 miles of the signs over a period of six years. Furthermore, the spatial component of the study found no significant clustering of crashes in the vicinity of billboard sites (Tantala and Tantala, 2010a).

Tantala and Tantala (2010) also examined the statistical correlation between digital billboards and crash data in Henrico County and Richmond, Virginia. The study analyzed crash data in the vicinity of 14 digital billboards along routes near 10 locations. Data sources included municipal police departments,

Henrico County, and the Virginia Department of Transportation (VDOT). The structure of the research was similar to the Albuquerque study; 7 years of accident data of 40,000 crashes were examined at sites near the selected billboards, which were converted from conventional to digital faces during the time period of 2006 to 2009. Once again, temporal and spatial components were investigated within ranges of a half mile upstream and downstream of the billboards. An Empirical Bayes Method (EBM) analysis was utilized to approximate the number of crashes that could be expected without the presence of signs. Results indicated that digital billboards in the Richmond area have no statistically significant relationship with crash occurrence. The evaluation of the EBM analysis indicated that the actual number of accidents in each location was consistent with what would be expected with or without the institution of digital billboards (Tantala and Tantala, 2010b).

In 2012, Yannis and colleagues conducted a statistical analysis applied on road sites in Athens, Greece metropolitan area. The goal of the research was to investigate the relationship between the placement and removal of advertising signs and the related occurrence of road incidents. Crash data from the test sites were obtained from the Hellenic Statistical Authority database and analyzed. The analysis showed no correlation between road crashes and advertising signs in any of the nine sites examined (Yannis et al., 2012).

In another research effort, the city of Toronto requested an investigation of the effects of billboards and safety on three downtown intersections and one expressway. Five distinct studies were carried out: a. an eye movement study; b. a conflict study at intersection approaches; c. a speed study; d. crash analysis, and e. a public questionnaire survey. Results from the first study indicated that drivers glanced at video signs 50% of the time, with 20% of all glances lasting more than 0.75 seconds. The conflict study revealed that significantly more braking occurred near intersections in the presence of video signs. The third study confirmed that driving speed decreased and speed variance increased after the billboard sign was installed. In the fourth study, there was no substantial increase in crashes near signed approaches. Lastly, 65% of those surveyed believed video signs are distracting, around half believed they have a negative impact on traffic safety, and 86% said there should be restrictions on video advertising (Smiley et al., 2005).

Laboratory Studies

In addition to crash analysis studies, research on driver behavior in a laboratory experimental setting is another type of study utilized for driver safety research. Advantages of this approach include the ability to control variables, the ease of use of simulators, and the avoidance of costs and complications of road tests. However, laboratory tests have the potential for inaccurate representation of reality during simulations, which in turn can result in skewed conclusions.

Young and Mahfoud designed a study which utilized a simulator to record driver attention, mental workload, and performance in urban, roadway, and

rural environments. Results indicated that roadway advertising decreased driver control, increased mental workload, and can draw attention away from relevant traffic signs. The effects of billboards may be increased when drivers are in a monotonous section of roadway. As such, discretion is advised when placing roadside advertising (Young and Mahfoud, 2007).

In Australia, Edquist and colleagues performed a driving simulator experiment that investigated the effects of billboards on drivers. This study involved 48 participants in three age groups (18-25, 25-55, and 65+). Data were collected from the brake pedal, accelerator, and steering wheel. Head and eye movements were tracked using the FaceLab tracking system. The simulated environment contained three-lane divided arterial roads in commercial and industrial districts. Billboards presented during the tests displayed logos of enterprises with a large Australian advertising presence; both static and dynamic boards were presented. The presence of advertising billboards altered drivers' attention patterns, increased the reaction time to road signs, and increased general driving errors. Responses to road signs were delayed by 0.5-1 seconds in the presence of billboards. The results for dynamic signs did not significantly differ from static signs (Edquist et al., 2011).

In another laboratory study, Divekar and his colleagues investigated distractions external to the vehicle. Because almost one-third of distraction-related crashes are thought to be outside the vehicle, the group posed two questions: a) why do experienced drivers take long glances at external distractions when they are not willing to do such in response to internal distractions?, and b) if experienced drivers are monitoring visible hazards in the road ahead, are they forgoing their ability to anticipate hidden hazards? To answer the questions, a driving simulator was used to measure subjects' eye movements and vehicle position and speed. Both novice and experienced drivers executed an exterior search task to replicate an external distraction such as a digital billboard. The conclusion was that long glances of both novice and experienced drivers inhibited their ability to anticipate unseen roadway hazards (Divekar et al., 2012).

In 2012 Marciano and Yeshurun conducted a study that involved 18 participants in two experiments in a simulator. One simulation contained billboards and the other was a control simulation without billboards. Measurements of median speed, mean number of crashes, and reaction time to events were recorded while road congestion and events were altered. Results revealed that the presence of billboards increased the time required to respond to a potentially dangerous event, and speeds were much higher in the signed simulation experiments (Marciano and Yeshurun, 2012).

Bendak and Al-Saleh used a simulator and a survey to investigate the role that roadside signs have on driver attention. In the simulation, twelve volunteers traveled on two paths, one with signs and one without signs. The results indicated that drifting from the lane and the reckless crossing of dangerous intersections were substantially worse on the billboard signed path. Three other performance indicators (i.e., number of tailgating times, speeding, and changing lanes without signaling) were also worse in the signed path, but

the difference was negligible. In the survey, 160 drivers were questioned about safety of billboard signs. Half of the respondents reported being distracted at least once by roadside advertising signs, and 22% specified that such signs put drivers in dangerous situations (Bendak and Al-Saleh, 2010).

Naturalistic Studies

Naturalistic studies involve supervised road tests using instrumented vehicles that allow observation of driver behaviors while on the road. Advantages of such studies include the ability to test driver behaviors as they utilize the actual road environment. However, naturalistic studies tend to be expensive, difficult to control, and labor- and time-intensive.

Akagi and colleagues employed naturalistic studies to measure the amount of information from billboards and the visibility of road signs in Japan, where, due to lack of regulations, roadside advertising billboards are abundant, often creating roadside clutter. The study confirmed that the more visual noise from billboards, the more difficulty a driver had recognizing a highway number sign. There was also a gender study undertaken which found that female drivers were less affected by visual noise than male drivers, even though their absolute visible distances were shorter than those of male drivers (Akagi et al., 1996).

A German study highlighted various roadside advertisements that might cause driver distractions. Using 16 drivers, Kettwich and colleagues performed several naturalistic driving experiments in an urban setting. Eye movement was measured with an eye tracking system that involved three cameras focused on the eyes of the driver and one camera recording the road. The number of glances and the duration of glances were recorded in different driving environments, which included pillar advertisements, video billboards, event posters, and company logo signs. Results indicated that there was no substantial distraction caused by the signs, and that gaze duration towards signs decreased as driving complexity increased (Kettwich et al., 2004).

Another study used road tests in Toronto to analyze glance behaviors of 25 drivers in the presence of advertising signs. The average duration of glances recorded was 0.57s, with a standard deviation of 0.41. There was an average of 35.6 glances per subject (standard deviation = 26.4). Active signs (i.e., signs that contained movable displays) accounted for 69% of glances and 78% of long glances. Moreover, active signs were associated with 1.31 glances per subject per sign, more than double the 0.64 glances per subject per sign associated with passive signs (Beijer et al., 2004).

In 2007, the Virginia Tech Transportation Institute, sponsored by the advertising industry, published a document detailing a study on DBBs and driver distraction. In the study, eye glance tests revealed that there were no differences in glance patterns between digital billboards, conventional billboards, comparison events, and baseline events during the day. Drivers took longer glances at digital billboards and comparison events than the other types. During night, drivers took longer and more frequent glances at digital billboards and comparison events (Lee et al., 2007).

CONCLUSIONS/RECOMMENDATIONS

As expressed by Wachtel, there exists no single study approach that can answer all of the many questions associated with the issue of roadside advertising and traffic safety. A number of studies were examined as part of this literature review and synthesis effort and, while the list is not all exhaustive, it provides a good mix of representative studies reporting on digital outdoor advertising and traffic safety.

Studies in general agreed that the relationship between digital billboards and driver distraction is very complex. Many research studies provided evidence that roadside advertising attracts drivers' eyes away from the road but often disagreed about whether or not the distraction increases traffic safety risk.

Meta-analysis studies confirmed an association between crash rates and billboards at intersections, and intersections with 4 or more billboards had significantly higher crash risk than those without billboards. However, no relationship between crashes and signs was observed on stretches of road that contained no intersections.

Several crash studies involving statistical analyses of historical data near digital billboard locations reported no statistically significant relationship with crash occurrence arguing that billboards have little to no impact on driver safety. However, laboratory studies confirmed that the presence of advertising billboards decreased driver control, increased mental workload, increased the time required to respond to a potentially dangerous event and increased driver errors. Specifically, DBBs caused drivers to be less observant of stopping cars ahead of them, and also contributed to vehicle drifting into adjacent lanes.

Naturalistic studies reported mixed findings. Some studies concluded that there was no substantial distraction caused by the advertising signs, and that gaze duration towards signs decreases as driving complexity increased. Others provided evidence of increased number of glances per sign and longer glazes in the presence of digital advertising billboards compared to static counterparts.

Overall, the crash analyses, laboratory experiments, naturalistic studies, and literature reviews suggest that there is evidence for a correlation between advertising billboards and increased driver distraction. However, local conditions, experimental settings, and other factors may play a role in the impact that driver distraction due to advertising billboards has on traffic safety.

It should be also noted that existing research on the subject is limited due to a lack of standardized methods and practices, data reliability, appropriate assumptions, relevant hypotheses, and objective intentions. Consequently, new research on outdoor advertising options and driver safety will prove paramount in the near future, especially because of the dynamic state of the industry and the fact that many related studies are currently outdated.

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