

STATE OF THE ART ROADSIDE ADVERTISING DISPLAYS: EFFECTS ON DRIVER DISTRACTION AND IMPLICATIONS FOR POLICY

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ABSTRACT

Outdoor advertising has existed along the roadside since nearly the dawn of the automobile. From painted messages on barns to today's computer-operated, LED displays capable of high definition video, advertisers have long recognized the value of a "captive audience" - the drivers who must pass their signs. 60 years of research into concerns about driver distraction from such signs has yielded conflicting results, although the most recent studies demonstrate unacceptable levels of distraction, including long glances away from the forward roadway. This paper describes the state-of-the-art of this technology, the latest research findings, and raises urgent issues of needed policy and regulation.

BACKGROUND AND BILLBOARD HISTORY

The concern for driver distraction in all modes of surface transportation is growing daily. The principal focus has been on in-vehicle distractions – from sources such as navigation, entertainment, and communication systems. In the U.S., State and local governments have been acting quickly to ban the use of hand-held mobile telephones and text messaging while driving, although restrictions differ from State to State. Earlier this month, the National Transportation Safety Board (NTSB) [1] instituted a policy that none of its employees may use mobile phones of any kind while driving on official business.

With the exception of a small number of research studies over the years, however, the issue of distraction from external-to-the-vehicle sources has received relatively little attention. Similarly, regulations that address the design, placement, or operation of roadside advertising signs are inconsistent, generally ineffective, and often absent. Those regulations that do exist are rarely based on evidence from research. And yet outdoor advertising constitutes a major, and rapidly expanding industry. The newest technologies permit roadside billboards to be large, bright, and close to the road. The latest digital signs can display messages in full motion, high definition video, or static images that change at will. Billboards can now interact with drivers and target personalized messages to them.

Of all of the potential sources of distraction external to the vehicle – scenic vistas, urban landscapes, crash sites, police activity – only one – the billboard – is *intended* to be a distraction. The sole purpose of a billboard is to capture the driver's attention and hold it long enough to communicate a message that, with rare exception, is completely irrelevant to the driving task.

In the U.S, outdoor advertising has been part of the roadside environment for more than 80 years. From advertisements painted on the sides of barns (see Fig 1), to the legendary “Burma Shave” signs in which a company selling men's shaving equipment posted poetic messages for its product using a series of sequential signs along country roads beginning in the 1930s, to today's large, bright digital billboards, (see Figure 2) the presence of advertising signs adjacent to the roadside has been the subject of periodic research since the 1940s.

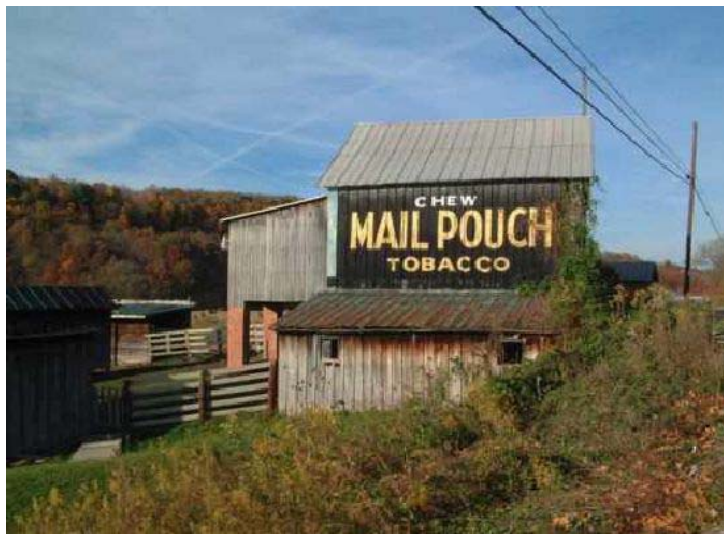


Figure 1 - An early roadside advertisement

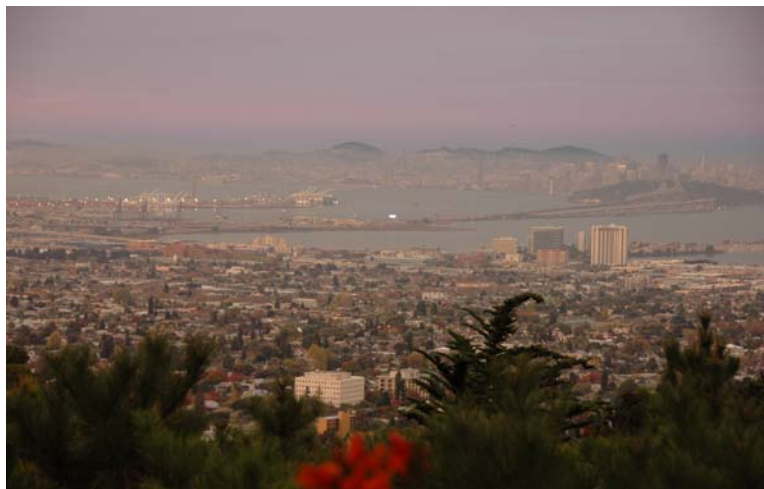


Figure 2 - A Digital Billboard Seen from a Distance of 6 Mi (9.7 Km)

WHAT IS DISTRACTION?

It is important to distinguish inattention from distraction. Inattention may be due to unknown causes or to no cause at all. Operator inattention, for example, may be attributed to fatigue, illness, effects of medication, being “lost in thought” or “day-dreaming.” In contrast, distraction is seen as being due to some causative agent or trigger, although the operator may not know, or may refuse to admit, the specifics of that agent. As reported by Young and Regan [2], it is the presence of this triggering event or activity that distinguishes driver distraction from the broader category of inattention. Distinctions between inattention and distraction are useful both for quantifying the extent of the problem, and for seeking methods to reduce its incidence.

While we might, for example, exhort operators not to drive or to pull off the road and rest when they are fatigued, we cannot identify this as a cause of a crash unless the operator reports it to us, or unless an “intelligent” vehicle has been monitoring the driver’s physiological state. And, at least for operators of personal vehicles, there is little or nothing that authorities can do to minimize the problem of inattention, and certainly cannot eliminate it, beyond providing public service messages or, in the future, implementing a technological solution to warn the driver who presents symptoms of sleepiness. Conversely, when we find, through research or crash records, that the use of mobile telephones, navigation systems, or text messaging while driving is associated with an increased rate of crash or near-crash, authorities may take action (as many have) to prohibit the operator’s use of this technology while the vehicle is in motion. As yet, however, few such restrictions have been developed for distracters outside the vehicle.

BILLBOARD DISTRACTION - 60 YEARS OF RESEARCH

In the U.S. and in several other countries, the question of driver distraction from roadside billboards has been studied for many years. In the early 1950s, the States of Minnesota [3] and Michigan [4] independently found that crash rates increased in the presence of billboards illuminated at night, and at those located close to intersections.

Since these early studies, many more have followed. In some cases, researchers have examined the link between broadly accepted psychological theories of attention, cognition, arousal, and task completion with hypotheses about the causes of distraction from roadside advertising (see, for example, [5], [6], [7]). Others have conducted empirical research in the laboratory (see, for example, [8], [9], [10], [11]) or on the road (see, for example, [12], [13], [14]). With the exception of the early Minnesota and Michigan studies and a handful of others over the years, relatively few epidemiological studies have been undertaken that looked at the relationship between accident locations and billboard placement on a post-hoc basis. This is a result of the known challenges of obtaining sufficient sample sizes, and the enormous difficulties faced in controlling extraneous variables in this real-world setting. Most such studies (see, for example, [15], [16]) have been discredited due to these, and other, foundational weaknesses. Finally, although eye movement studies in instrumented vehicles have been conducted periodically over many years, it is

only in the past few years that these technologies have become sufficiently precise and reliable that they have now begun to shed new light on the issue of driver distraction from roadside billboards [17], [18], [8].

In two recently published reports that review the most recent literature in the field [19], [20], it has become increasingly clear that driver attention is captured by advertising signs along the roadside, potentially to the detriment of safety.

EYES OFF ROAD TIME

Researchers at the Virginia Tech Transportation Institute (VTTI) conducted what has become known as the “100 car naturalistic driving study,” in which 100 participants were given the free and unconstrained use of 100 highly instrumented vehicles to use during the performance of their typical activities of daily living for a period of many months (21). Large volumes of data about vehicle and operator performance, including eye glance data, was captured by unobtrusive on-board equipment, uploaded regularly to the researchers’ central computers, and then analyzed. Of relevance to our question about roadside billboards as a possible source of driver distraction, the 100 car study found that, when drivers looked away from the forward roadway at irrelevant visual stimuli for a period of 2.0 seconds or longer, they were twice as likely to experience a crash near crash. (Previous research by other researchers with in-vehicle distracters [22] identified 1.6 seconds as the threshold for acceptable look-away time).

The duration of driver eye glances away from the forward roadway toward irrelevant stimuli is arguably the most relevant measure of driver distraction, and one that is quite amenable to precise measurement (with the proper equipment and techniques). It is important, of course, to distinguish between driving-related visual inattention (e.g. checking mirrors, instruments, traffic in adjacent lanes) that has been shown to have a facilitating effect, from inattention that results from eye-glances toward driving-irrelevant stimuli (including billboards).

In an important article, Horrey and Wickens [23] demonstrate the value of analyzing the tails of the statistical distribution when looking at measures such as glance duration, rather than the traditional approach of studying the means. This is because traffic safety experts must be concerned with the poorer performers, the outliers, rather than the “average” driver.

Ironically, it was in a study conducted on behalf of the outdoor advertising industry [14], that the clearest findings yet have emerged to suggest that roadside digital billboards (whether “on-premise” or “off-premise”) capture the driver’s attention for longer intervals than either traditional, fixed billboards or comparable roadside sections in which no billboards were present. The researchers used a variant of the naturalistic methods in the 100 car study discussed above, and measured four different types of eye movement behaviors. For reasons that remain unexplained, the researchers performed a statistical analysis of all of their measures *except* the one of most relevance – the longest eye glances. Although it is not possible to thoroughly analyze this data after the fact, it appears that there are substantial

differences in glance duration made to digital billboards vs. glances made to traditional billboards or roadside sections without billboards.

Table 1 - Grouped Interpreted Data of Longest Eye Glances to Road Sections with and Without Digital Billboards – (Source, [14], Figure 23

Roadway Section	Glances > 1.6 s	Glances > 2.0 s	Glances > 3.0 s
No Billboard + Traditional Billboard	15%	7%	0
Digital Billboards – On- and Off-Premise	34%	17%	5%

These findings, taken from the tails of the distribution of glance duration, demonstrate obvious differences between those road sections in which digital advertising signs were visible and those in which they were not.

In describing an abbreviated nighttime data collection, the authors reported that all four of their eye glance measures showed that digital advertisements were more distracting than traditional billboards or baseline (no-billboard) locations and, they believed, “would show statistical significance” had their study sample been larger (p. 64).

RECENT TRENDS IN ROADSIDE ADVERTISING

On-premise signs

In the U.S., the traveled lanes, plus medians, shoulders, and whatever additional adjacent land is present on the property owned by the road authority is collectively known as the “right-of-way” (ROW). This is equivalent to what is known as the “road reserve” in some other countries.

Traditionally, commercial advertising is prohibited anywhere within the ROW, with the exception of certain types of generally small, uniform signs that may indicate the name of a business that has agreed to beautify a section of the road, or for signs that advise a motorist that a specific service may be found at the next interchange. However, when a business is located adjacent to (but beyond) the ROW, it may generally erect an advertising sign oriented to road users, provided that the sign advertises products or services that are available on the premises on which the sign is located. In the U.S., this is referred to as an “on-premise” sign. This is distinguished from an “off-premise” sign, generally known as a billboard, in which the product or service being advertised is not conducted on the premises at which the billboard is located. Billboards are regulated more stringently than on-premise signs, under the principle that the latter identify the actual business establishment, and may be the only method by which the particular business can make its presence known to the traveler. In the past, on-premise signs caused little concern from the perspective of driver distraction, because they tended to be small and to present a fixed message. However, with the advent of digital sign technology and the transformation of roadside businesses into large shopping centers or malls in which many

(sometimes hundreds) merchants may be “on premise,” these roadside advertising signs have grown in size, brightness, and flexibility. Because of less stringent regulatory control, on-premise signs can generally be much larger than billboards, closer to the road, and often are permitted to present dramatic visual effects, including full motion video, that are prohibited on billboards. For these, and other, reasons, on-premise signs have recently generated increasing concern to road safety authorities in the U.S.

Advertising within the roadway right-of-way

As in many other countries, road authorities throughout the U.S. are increasingly deploying Changeable Message Signs (CMS) as part of the larger IT infrastructure, to warn drivers of accidents, delays or other incidents; to provide information about travel time to key destinations; and to suggest alternate routes in the event of extreme congestion. These signs have occasionally been used for other purposes, including “public service messages” (e.g. “Blood Drive”), and general road safety campaigns (e.g. “Buckle Up for Safety.”) A recent survey of road authorities (24) found that the public was generally opposed to the use of these signs for non-traffic safety purposes, and traffic safety experts have long been concerned about the adverse effects of change blindness that might result from a driver encountering such a sign displaying an urgent traffic safety message when it more typically presents a message that is unrelated to traffic safety.

These official CMS are expensive to erect, operate, and maintain. Many such signs are old and obsolete. They need to be replaced – but in many cases the highway agencies cannot afford to do so. In a number of recent instances the outdoor advertising industry has proposed to replace these signs with state-of-the-art displays at no cost to the road authorities, provided that they may use the signs for advertising purposes when they are not in use for displaying a traffic safety message. Although several agencies are considering this possibility, the concept has raised a furor within the traffic safety community. Indeed, the U.S. Government's Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) (25) explicitly forbids the use of advertising on any official traffic signs or their supports. Figure 3 displays a conceptual sign that might be used for traffic control and advertising.



Figure 3 - Artist's Rendering of Proposed Official CMS Within the Roadway Right-of-Way that Would Also Display Advertising

THE NEWEST TECHNOLOGIES; THE NEWEST THREATS

Personalized billboards

Some "smart" billboards monitor the passive local oscillator signals emitted by the radios of passing vehicles. These signals reflect the radio frequency to which the radio is tuned. By combining this data with other database information about consumer demographics, the billboard can present messages that are "personalized" to the drivers passing the sign at any given time [26]. Other billboards can read the code on the Radio Frequency Identification (RFID) keys that are increasingly used in newer vehicles. In a recent experiment, owners of Mini automobiles were given a personal greeting as they passed one of the company's billboards. (See Figure 4).



Figure 4 - A billboard for the Mini automobile. A sensor on the sign reads information from the vehicle RFID key and displays a greeting to the owner.

Billboards that require a response from the driver

In Belgium, one billboard offers a prize of an automobile to the winner of a lottery. The lottery is entered by a driver texting a code to the sign as he or she passes it, and then answering a question (also via text message) generated by, and displayed on, the sign.

Billboards that record personal information from drivers

Many digital billboards are equipped with video cameras that can record approaching traffic. One manufacturer has supplemented the camera with an infrared light source, and claims to be able to record the eye movements of drivers approaching the billboards [27]. While this service is suggested as a means to demonstrate to sign owners the attention being paid to their sign, it is but a small technological step to combine such eye movement recordings with other available demographic information to target highly personalized messages or other “services.”

Billboards on moving vehicles

A new trend in the U.S. is the installation of large digital billboards using LED technology on the sides of tractor-trailers (see Figure 5). In some cases, these signs are as large as 9 x 16 feet (2.7 x 4.9 meters). These signs can display their messages, including full motion video, while the truck is driving within the traffic stream. To date, very few government agencies have addressed this new potential source of distraction.



Figure 5. An Example of a Tractor-Trailer Equipped with an LED Screen to Display Digital and Video Advertising in Traffic or While Stopped

SUMMARY AND CONCLUSIONS

Those researchers who have reviewed the primary research over the years, as well as those who have conducted their own research and those who have sought to apply human factors principles and practices to the control of roadside billboards are in broad agreement that outdoor advertising signs in general, and digital signs in particular, if permitted adjacent to roads, should be design, placed, and operated within certain constraints so as to minimize the adverse effects of driver distraction at road locations and traffic situations in which there may be little margin for error:

- a. Controls, based on empirical research, should be placed on the two most attention-getting characteristics of such signs – the message change interval and nighttime luminance levels
- b. Such signs should not be permitted near intersections or interchanges, route diversions and lane drops, near important official traffic control devices, or at the apex of horizontal curves
- c. Such signs should be limited in the amount of information that they display, and should be designed in accordance with good human factors principles for maximum legibility and readability.

Many countries have already enacted some or all of the controls listed above. Many of these are based on sound research and good human factors practice. What remains before us is to harmonize such controls and regulations, and to take a proactive position in advance of the widespread application of the newest technologies.

There is no disagreement that outdoor advertising adjacent to the roadside is an irrelevant stimulus and a distracter that is unlikely to enhance road safety except in the most unusual of circumstances. However, because of issues of land use, zoning, free enterprise, and free speech, such displays may be permitted in certain locations where they are visible to road users. It is up to the cognizant roadway authorities to

develop principles and regulations that balance the rights of the billboard owners/operators with their obligation to protect the safety of the traveling public. While uncertainties remain about the many specific characteristics of billboard design, placement and operation that have the greatest impact on driver distraction, enough is known from decades of research to develop meaningful and appropriate regulations, while permitting the continued operation of such signs under appropriate conditions.

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