

# **Driving Performance and Digital Billboards**

## ***EXECUTIVE SUMMARY OF FINAL REPORT***

**Prepared for:**

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## EXECUTIVE SUMMARY

The most notable findings from this study are as follows:

- Eyeglance results showed that there were no differences in the overall glance patterns between digital billboards, conventional billboards, comparison events, and baseline events during the daytime.
- Drivers did not glance more frequently in the direction of digital billboards than in the direction of other event types during the daytime.
- Drivers took longer glances in the direction of digital billboards and comparison sites than in the direction of conventional billboards and baseline sites during the daytime.
- An analysis of glances lasting longer than 1.6 seconds indicated that these longer glances were distributed evenly across the digital billboards, conventional billboards, comparison events, and baseline events during the daytime.
- The nighttime results indicate that digital billboards and comparison events may be associated with more active glance patterns, as well as with more frequent and longer glances towards the digital billboards and comparison events.
- For the post-drive questionnaire, 42% of drivers mentioned billboards as one of the top five items that caught their attention; note that drivers did not know this was billboard study.
- In an open-ended question, three drivers mentioned billboards as the single most memorable item on the trip, and two referred specifically to the digital billboards as being memorable.

The motivation for the current study was to examine driver performance in the presence of digital billboards, as compared to other driving locations without them. There is a long history of studying billboards in the context of traffic safety but, although the research record covers many years (1951 until the present), it is lacking in volume and is primarily focused on conventional billboards. There were a few epidemiological studies performed in the early 1950's examining traffic accidents in the presence and absence of billboards; however, much of this early work was methodologically flawed. After a long gap in research, there were a few additional studies in the 1960's through the 1980's, none of which demonstrated that billboards are unsafe. More recent studies conducted in Canada have shown that there may be changes in driver behavior associated with video billboards (those with full motion), but those studies do not address the digital billboards of interest in the current study (with a static message that changes instantaneously without special effects).

Traffic accident analysis techniques have improved in recent years with the creation and maintenance of national crash databases. A careful examination of these databases shows that distraction caused by billboards fails to show up in any of the accident databases as an accident cause. Likewise, an examination of numerous driver distraction studies demonstrates that billboards fail to show up as a cause of driver distraction. The overall conclusion from all past research is that conventional billboards in general have not been shown to cause traffic accidents or change driver behavior. However, the question of whether digital billboards change driver behavior in some way cannot be answered by these previous studies; this is the motivation for the current study.

The current study was conducted in Cleveland, OH to assess the effects, if any, of digital billboards on driver behavior and performance. The study was conducted following the model of a previous study conducted in Charlotte, NC that showed no measurable effects of conventional billboards on eyeglance patterns, speed maintenance, or lane keeping. Thirty-six drivers were recruited with males and females equally represented; they were also equally divided by age (older: 50-75, younger: 18-35). Participants drove an instrumented vehicle on their own (without an experimenter in the vehicle) on a 50-mile loop route in the daytime along some of the interstates and surface streets in Cleveland. Participants were not informed about the true purpose of the experiment, and were told that the purpose was to help understand the way people drive in a natural environment. Along the route, participants encountered the following items:

- 5 digital billboards (all that were available on the route). The digital billboards were the standard bulletin size (14 ft x 48 ft) and the copy changed instantaneously every eight seconds (there were no special effects during the transition).
- 15 conventional billboards (similar to those studied in the Charlotte study).
- 12 comparison sites (similar to items you might encounter in everyday driving; comparable to digital billboards in terms of visual activity/attractiveness, including on-premises signs [some with digital elements], logo placards, landmark buildings, and murals).
- 12 baseline sites (sites with no signs).

After the drive, participants completed a questionnaire regarding which types of items and activities they had noticed along the route. Participants were paid a nominal amount for their participation. Twelve participants returned for a nighttime session to explore the potential effects of the digital billboards at night.

The eight seconds leading up to the events of interest were then analyzed in terms of eyeglance patterns, speed maintenance behavior, and lane keeping behavior. With 36 participants and 44 sites, there were 1,584 events available for analysis from approximately 63 hours of data collection. A small amount of data was lost due to cell phone use, sensor outages, sun angle, and vehicle stoppages, leaving 1,540 events for eyeglance analyses. Altogether, 124,740 video frames were analyzed and 10,073 individual glances were identified. The speed data were filtered to remove events as described above, and then further filtered to remove low speed events, leaving 1,494 events in this dataset, with 121,014 data points. The lane position dataset was further filtered to remove events indicating a possible lane change or lane position sensor failure (often due to poor lane markings). After filtering, there were 1,188 events remaining in the lane position dataset, with 96,228 data points.

In terms of demographics, the average age was 28 years for younger drivers and 59 years for older drivers. Most had completed high school, but few had attended college. All participants lived in the Cleveland area, and were familiar with at least some parts of the route. For the post-drive questionnaire, 42% of drivers mentioned billboards as one of the top five items that caught their attention (out of 18 choices). In a later open-ended question, three drivers mentioned billboards as the single most memorable item on the trip, and two referred specifically to the digital billboards as being memorable. By way of contrast, only 25% of drivers in the Charlotte study checked off billboards in their top five list (of 18 choices), and none mentioned billboards as being the most memorable aspect of the trip. Recall that drivers did not know that the purpose

of the study was to examine performance in the presence of billboards; in fact, they did not know that the study had anything to do with billboards.

Eyeglance results showed that there were no differences in the overall glance patterns (percent eyes-on-road and overall number of glances) between event types (digital billboard, conventional billboard, comparison events, and baseline events). Drivers also did not glance more frequently in the direction of digital billboards than in the direction of other event types. However, drivers did take longer glances in the direction of digital billboards and comparison sites than in the direction of conventional billboards and baseline sites. Given that three of the comparison sites had digital components, the similar eyeglance findings for these two event types are not surprising. An analysis of glances lasting longer than 1.6 seconds showed no obvious differences in the distribution of these longer glances across event types.

There were differences in speed maintenance, with conventional billboards showing greater variation in speed than digital billboards. However, this was thought to be the result of a road type interaction, given that all of the digital billboards were on interstates. When only interstate events were considered in the analysis, there were no significant differences in speed maintenance across event types. There was a trend towards poorer lane keeping performance for digital billboards and conventional billboards; however, this trend failed to reach significance.

A smaller exploratory study was also conducted at nighttime using a slightly shortened route. Given that the digital signs being studied were intrinsically illuminated, this was felt to be an important first step in determining whether there are driver performance differences in the presence of these signs under different levels of ambient illumination. Twelve drivers were used, again divided equally by age and gender. All of the nighttime drivers had previously driven the route during the daytime and were thus somewhat familiar with the route (so were unlikely to get lost or go off route). The nighttime study was exploratory in nature with fewer data points, so these data were examined descriptively rather than analyzed statistically (due to lack of statistical power).

Four eyeglance measures were examined for the nighttime data: eyes-on-road percent, overall glance frequency, mean glance duration in the direction of an event, and mean number of glances in the direction of an event. The eyes-on-road measure showed that digital billboards and comparison events tended to have less eyes-on-road time at nighttime than either baseline events or conventional billboards. The overall glance frequency was also higher in the presence of digital billboards and comparison events than in the presence of baseline events and conventional billboards. These two findings taken together show a more active glance pattern at nighttime in the presence of these two event types. The mean glance duration for glances in the direction of an event also showed higher values for digital billboards and comparison events. Finally, the mean number of glances in the direction of an event also showed digital billboards and comparison events as having higher values than either baseline events or conventional billboards. Taken together, these four findings indicate that digital billboards and comparison events *may* result in more active glance patterns overall, as well as more frequent and longer glances towards the digital billboards and comparison events at nighttime.

Two driving performance measures were examined for the nighttime data: standard deviation of speed and standard deviation of lane position. The standard deviation of speed appeared to be higher in the presence of both conventional and digital billboards than for baseline and comparison events. Lane keeping also showed a trend towards greater lane deviations in the presence of both digital billboards and conventional billboards.

The luminance values of many of the billboards, comparison events, and baseline events were also measured at nighttime. The digital billboards had noticeably higher luminance values than any of the other event types, even though their luminance was automatically reduced at night. This probably explains some of the driver performance findings in the presence of the digital billboards. The overall ranking of luminance by event (digital billboards were the highest, followed in order by comparison events, conventional billboards, and baseline events) closely mirrors the rankings of many of the performance measures for both daytime and nighttime, including eyeglance, speed maintenance, and lane keeping.

The overall conclusion, supported by both the eyeglance results and the questionnaire results, is that the digital billboards seem to attract more attention than the conventional billboards and baseline sites (as shown by a greater number of spontaneous comments regarding the digital billboards and by longer glances in the direction of the billboards). The comparison events, 25% of which included signs with digital components, showed very similar results to the digital billboards. Thus, there appears to be some aspect of the digital billboards and comparison events that holds the driver's attention, once the driver has glanced that way. This is most likely the result of the intrinsic lighting of these signs, which is noticeable even during the daytime. Drivers may also have maintained longer glances towards the digital billboards in the hopes of catching the next message (knowing that the message changes periodically). Although exploratory in nature, the nighttime results were very similar to the daytime results, with indications of degraded driving performance for digital billboards and comparison events.

These particular LED billboards were considered safety-neutral in their design and operation from a human factors perspective: they changed only once every eight seconds, they changed instantaneously with no special effects or video, they looked very much like conventional billboards, and their luminance was attenuated at night. It is thus quite likely that digital signs with video, movement, higher luminance, shorter on-message duration, longer transition times, and special effects would also be related to differences in driver behavior and performance. Because of the lack of crash causation data, no conclusions can be drawn regarding the ultimate safety of digital billboards. Although there are measurable changes in driver performance in the presence of digital billboards, in many cases these differences are on a par with those associated with everyday driving, such as the on-premises signs located at businesses. Conventional billboards were shown both in the current study and in the Charlotte study to be very similar to baseline and comparison events in terms of driver behavior and performance; thus, the design of digital billboards should be kept as similar as possible to conventional billboards.