# Observed Driver Glance Behaviour at Roadside Advertising Signs

Daan Beijer, MASc, Alison Smiley, PhD, CCPE, Moshe Eizenman, PhD

## ABSTRACT

Express routes in North America are becoming more crowded, both in traffic density and in visual clutter, resulting in a higher demand for driver attention, a possible concern for regulators. Advertising signs add to this demand on visual attention. This study focused on glance behaviour of 25 drivers at various advertising signs along a Toronto expressway. Subjects averaged glances of 0.57 seconds in duration (sd = 0.41), and 35.6 glances per subject in total (sd = 26.4). Active signs, containing moveable displays or components, comprised 51% of signs, and received significantly more glances (69% of all glances and 78% of long glances). Number of glances was significantly lower for passive signs (0.64 glances per subject per sign) when compared to active signs (greater than 1.31 glances per subject per sign). Number of long glances was also greater for active signs compared to the passive signs. Sign placement in the visual field may be critical. This study provides empirical information to assist regulatory agencies in setting policy on commercial signing.

## INTRODUCTION

The purpose of this study was to determine the possible distracting effect on driver scanning behaviour of roadside advertisements next to a major expressway. This was accomplished using an infrared (IR) eye-tracking device to monitor driver-scanning behaviour in an area with a high number of advertisements, the Gardiner Expressway in Toronto, Ontario, Canada. Advertisements along this route were evaluated for features that might contribute to greater distraction, such as sign type and side of the road.

## BACKGROUND AND RATIONALE

Demand for driver attention is increasing; in-car displays are more compelling and visual clutter and advertisements along roads are increasing. Advertisements along expressways such as the Gardiner Expressway in Toronto have proliferated and become more technically sophisticated. Consequently, regulators may need to know the answers to certain questions to make informed decisions about advertising sign policies. Such questions include:

- To what extent do these advertisements distract driver attention from the road ahead?
- Are some sign types more likely to distract the driver than others?
- Are some drivers more susceptible to distraction than others?

Several studies ((1), (2), and (3)) have indicated that scanning behaviour is dependent on the scene as well as on driver familiarity with the route. These studies demonstrated that subject scanning behaviour is dependent on the visual scene, and that the scanning behaviour of the driver is biased towards certain portions of the visual field. Bhise and Rockwell (4) discovered that familiarity with traffic signs was associated with less scanning time. Accordingly, familiarity with the route and the advertising signs along the Gardiner Expressway may result in fewer and shorter glances being given to the advertising signs. Conversely, familiarity with the route may result in less attention to actual driving, freeing visual capacity for the non-critical road scene (i.e. advertising signs).

Curves in the road are more visually demanding since drivers must look in two different areas: both ahead to check direction and closer to the car to check lane placement. This is likely to result in reduced fixation times, but an increase in the number of glances (5). Therefore, shorter glance durations and a higher frequency of glances are expected for signs that are visible only within curves. Curves may also present opportunities to position signs in the more central field of vision. The Gardiner Expressway has several curves with advertisements placed in such a way that they are in the centre of the driver's line of sight on the straight portion of road approaching the curve. It is possible that advertisements placed in such locations cause greater distraction than similar advertisements in straight portions of the route off the line of sight.

Rockwell (2) and Wikman et al. (6) indicated that spare visual capacity during the driving task allows for safe non-driving related glances of greater than one second. Zwahlen (7) and Rockwell (2) suggest that two seconds is a maximum, as drivers themselves are usually reluctant to look away from the road for longer periods of time. One of the aims of this study is to determine if complex, visually captivating advertising signs will lead to inappropriately long glances off the road.

Driver attention is of interest to regulators and industry alike, since driver safety is often dependant on adequate attention being paid to the driving task. However, attention is difficult to measure directly. Eye movement is a strong indicator of where attention is being directed (8) and is much easier to measure.

Similar to the present study, Mourant and Rockwell (9) used corneal reflection eye tracking to monitor the eye movements of eight subjects to determine the effect of driver route familiarity, to identify visual cues used by drivers, and to study the effect of traffic on eye scanning patterns.

Although Mourant and Rockwell (9) found significant differences in glance behaviour between artificially induced familiar and unfamiliar drivers, this finding was not supported by Beijer (10) when applied to advertising signs. In the latter study, no significant differences were found between drivers familiar with the route and those unfamiliar, when determining glances at roadside advertising. Even so, an unfamiliar driver may be caught unaware, or may miss an important traffic sign, if it is improperly placed or placed in a location with other distracting roadside objects such as advertising signs.

Although there have been several studies that researched driver glance and task sharing behaviour ((2), (7), (9), and (11)), few have looked specifically at glances at roadside advertising. Those that have included driver glances at advertising signs have usually included the advertising signs as a sub-category (12). Hughes and Cole (12) did establish, through verbal reporting, that subjects both looked at and processed advertising signs.

However, Andreassen (13) in a review of five studies on roadside advertising concluded that they did not contribute to accidents. These cited studies were all written in 1970 and earlier. Advertising technology, and road safety engineering have improved significantly since then, therefore, results from the present study and more recent reviews of accident data may be pertinent.

## EXPERIMENTAL DESIGN AND PROCEDURE

An on-road study involving 25 drivers was carried out on a 6 km stretch of the Gardiner Expressway – a six lane raised expressway running east-west along the southern edge of downtown Toronto. Onramps and off ramps connect the expressway to Lakeshore Boulevard below. The speed limit on the expressway is 80 km/hr, although the normal speed of traffic is usually 10 – 15 km/hr greater. Traffic along this highway is extremely heavy during the rush hours; however, this study was run between the hours of 10:00 AM and 2:00 PM, when the average traffic was medium to light. The drivers were exposed to a total of 37 commercial advertising signs. The independent sign variables were sign type and side of road. Participant independent variables were gender and familiarity with the Gardiner Expressway. Road independent variables were start direction and start time. The effects of the independent variables were measured using average glance duration, maximum glance duration, and average number of glances per subject per sign.

Due to time, weather, and resource constraints, only 25 subjects were recruited through posters and word of mouth. However, a sample of 25 participants appears to be satisfactory in terms of statistical characteristics and is more than number of subjects used in similar experiments on visual search ((3),(8), and (14)). The participants had a minimum driving experience of 5 years, were 25 to 50 years of age and held a valid driver's licence. The maximum age was set at 50 years so that differences in scanning patterns in older drivers would not be a factor ((15) and (16)). Subject could wear contact lenses, but not eyeglasses, since the latter interfere with the infrared (IR) beams used by the eye tracking equipment, and were therefore a disqualifying factor.

The study took place on an expressway, which would allow for the greatest horizontal and vertical scanning variances (5), presenting an opportunity for the subjects to sample the greatest portion of the visual scene. Subjects were asked to drive as they would normally, and, to avoid frequent in-car glances at the speedometer, subjects were asked to drive the speed of traffic (approximately 90-100 km/hr). Participants were not told of the true nature of the experiment, so as not to influence their visual search patterns. No debriefing was given since many subsequent participants (especially female subjects) were recruited through word of mouth.

This study used the EL-MAR Vision 2000 infrared eye-tracking system, a non-intrusive and safe device. . The EL-MAR system consists of a head mounted infrared tracking system and scene video camera, a power supply, and a VCR. An infrared-blocking visor is attached to the head mounted system to eliminate outside sources of infrared glare, such as the sun, that may wash out the IR eye-tracking system. The system superimposes eye movement data as a crosshair onto a videotape recording of the visual scene. In the experiment, eye position was determined when compared to the eye position measured during calibration performed at the start of the session.

## ANALYSIS OF THE DATA

The data was retrieved from the videotapes manually, requiring frame-by-frame analysis of the participant videos to detect all the glances at commercial signs and measuring their duration. The experimenter recorded the glance duration, the sign that was glanced at, and angle of the glance from the centre of the field of view. Although time and labour intensive, this method ensured that all glances at advertising signs were captured.

### Statistical Analysis

The data were categorized according to the following variables:

- Features of the roadside advertising signs. Each of the signs along the test route was photographed and categorized according to: the type of sign (Billboard, Scrolling Text, Video Image, or Roller Bar), the side of the road and the direction of the test route on which the sign is located. Billboard signs were static advertisements. Roller Bar signs were billboard advertisements placed on vertical rollers that could rotate to show one of three advertisements in succession (note: these signs are also called tri-variate). Scrolling Text signs had a minor active component, which usually consisted of a small strip of lights that formed words scrolling across the screen or in some cases, a larger area capable of displaying text, but not video. Signs with Video Images had a much larger, colour screen, capable of displaying both moving text, and more importantly, moving images.

- Characteristics of the participants and the route. Two characteristics each were recorded for the participants and the route: gender and familiarity with the test route, test start time (10:00 AM or 12:00 PM) and test route start direction (east or west). Familiarity was based on the usage of the Gardiner Expressway. A subject who used this route less than once a week in the last six months was considered unfamiliar. Participants who drove the Gardiner Expressway an average of once or more per week in the six months preceding the experiment were considered familiar.

For each subject, and for each sign looked at, the following measures were recorded:

- Dependent variables. Glance duration was measured from the time a subject began eye movement to a sign to the time he or she began a movement away from the sign (according to the SAE J-2396 standard). The glance duration was based on the number of video frames for each glance at an advertising sign. This value was later converted to seconds (30 frames per second), and the average taken for each subject for each sign feature (AGD). The maximum of these values for each subject was recorded as the maximum glance duration. The number of glances per subject per sign (or sign feature) was also retrieved from the database (recorded as No. glances per sign in Figure 2 and Figure 3). It is important to note that the statistical analysis reported and discussed in the sections to follow was performed only on the subjects who glanced at the signs. The Angle of Glance (viewing angle from the centre of the lane immediately in front of the car to the sign position at the start of the fixation) was also measured in increments of five degrees (Figure 1).

Analysis of variance was performed on the glance frequency and duration with respect to characteristics of the participants and the roadside advertising signs.

## RESULTS

Analysis of the results showed no significant differences in any of the route or participant variables. Therefore, the results reported below contain the data points for all subjects. A total of 1091 individual glances at advertising signs were captured during the field experiment. Of these 890 were used for statistical analysis, averaging 35.6 glances per subject, or 1 glance every 12.2 seconds per subject, with a range of 3 glances to 87 glances (note that the subject with 3 glances at signs made many more glances outside the car, just not many at advertisements). In total, 201 outlier glances were removed from the analyzed data. These glances took place during heavier than normal traffic conditions at which time the test vehicle was stopped or nearly stopped in front of a series of signs. When this occurred, the number of glances increased dramatically – to greater than nine glances per subject per sign. .

The lack of any significant interaction at the $p<0.05$ level between participant features (gender and familiarity), route features (start time and start direction) and sign features (type and side of road,), allowed data for all participant and route features to be combined in the statistical analysis, increasing the power of the test.

**Comparison of glances at different sign types**

The signs analyzed were all of a similar size when viewed and measured in a video taken prior to study (Figure 1). Table 1 shows a breakdown of the signs and glances for each sign type. This data is for all signs and subjects and for both directions of the route. As can be seen in Table 1, the active signs captured a greater proportion of the glances, despite being fewer in number than the more passive Billboard signs. Active signs consistently received longer glances in duration and a greater than average percentage of total and long glances while the Billboard signs received less average.

The mean AGD for the study was 0.57 seconds, with a minimum value of 0.13 seconds and a maximum of 2.07 seconds. The standard deviation was 0.41and the variance was 0.16.

Figure 2 shows the effect of sign type on eye glances. There were no significant differences in AGD or max glance duration for the various sign types; however, number of glances was significantly lower ($F(3,91)= 3.27$, $p<0.0024$) for Billboard signs (0.64 glances per subject per sign) when compared to Roller Bar, Scrolling Text, and Video signs (1.32, 1.31, and 1.45 glances per subject per sign, respectively). Almost all of the subjects glanced at each of the four sign types; 96 %, 88 %, 100 %, and 96 % glanced at the large Billboard, Roller Bar, Scrolling Text, and Video signs respectively. Side of road had no significant effect on AGD, maximum glance duration, or number of glances per subject per sign.

**Glances > 0.75 seconds**

An analysis was carried out only on glances longer than 0.75 seconds (194 of 980 glances, or 22.0 %of total glances). In this study, 22 (88 %) of subjects glanced for at least 0.75 seconds at a minimum of one sign, and of these, five (20 %) glanced at signs for longer than two seconds.

Since the glance duration was used as a selection criterion, no analysis was performed on the AGD and Max Glance duration. There was a significant difference ($F(3,50)= 7.42$, $p<0.003$, Figure 3) in the number of long glances for certain sign types. The Roller Bar and Video signs received significantly more long glances per sign (Figure 3) than the Billboard (Roll $p<0.005$, Video $p<0.0001$) and Scrolling Text (Roll $p<0.05$, Video $p<0.002$) signs (Bill = 0.17, Scroll = 0.37, Roll = 0.75 and Video = 0.89).

**Angle of Glance**

Table 2 shows the angle of each glance at an advertising sign. Glances at each sign type tended to stay within a very fine cone (average angle of glance 9.0 degrees from the centre of the field of view). In fact, an average of 79.5 % of glances were within 10 degrees from centre and 97.6 % were within 25 degrees.

**DISCUSSION**

**Overview of Glance Data Results**

AGD is taken as one measure of how willing a subject is to shift attention away from the road scene. A high AGD indicates that the subject is paying less attention to the driving task. The results of the AGD data indicate that on average, subjects were not willing to shift attention away from the road for longer than a set period of time, and this period of time was consistent between subjects, sign features, and traffic conditions. This is consistent with the research of Rockwell (2) and Zwahlen (7). Therefore, sign features or other external variables appeared to have marginal influence on AGD.

The maximum glance duration denotes the longest time a driver is willing to spend on a single sign or class of signs. At least 88% of our subjects glanced for 0.75 seconds or longer at one sign, and 20% glanced for more than 2 seconds at least one sign, however, these long glances only accounted for 22% of the total glances. This indicates that subjects are willing to take longer glances at some signs, however, for the majority of the time, driving conditions do not permit, or the sign itself does not warrant longer glances.

Glances per sign are also an indicator of the attractiveness of a particular sign or a sign type, both in terms of the driver initially fixating on the sign and in returning to the sign for more fixations. The number of glances per subject per sign was the dependent variable that had the greatest sensitivity to sign characteristics. This variable therefore shows the greatest promise for future studies.

**Participant and Route Characteristics**

While familiarity with the route had no statistical impact on frequency or duration of glances in this study, it is interesting to note that other studies reached different conclusions. Mourant and Rockwell (3) conducted a road experiment where route familiarity and driving conditions were the two independent variables, and found that the "degree of drivers' route familiarity plays an important role in determining visual sampling strategies." As alluded to previously, Mourant and Rockwell (3) artificially induced route familiarity, and it is possible that this also artificially influenced the glance distributions. However, "familiarity" in the present study was defined as "having driven on the Gardiner Expressway more than once per week in the past six months." The two definitions are dissimilar, as are the objectives of the studies, and it is therefore not surprising that they would lead to different results.

It is encouraging to note that there were no interactions between start direction and direction of travel. This indicates that the participants felt sufficiently comfortable with the equipment at the start of the experiment that there was no evidence of order effect. This is in line with Mourant et al. (14), who also found that there was no effect on the dependent variables due to order effect, which in our study equates to equipment and start direction.

**Glances at different sign types**

There were no significant differences in AGD or maximum glance durations related to sign type. However, active sign types (Video, Scrolling Text and the partially active Roller Bar signs) received significantly more glances per sign than the Billboard signs (averaging greater than 1.31 glances per subject per sign compared to 0.64 for the latter). Human visual systems have evolved to be sensitive to movement in the periphery. Therefore, signs with moveable parts (active signs such as the Roller Bar, Scrolling Text and Video signs) are more likely to receive a glance than passive signs. The other point to consider is that Billboard signs may be less prominent in sign type and in location than other types of signs. A Billboard sign is relatively cheap to erect and maintain compared to active signs, and therefore may be placed in less prominent locations.

Although technically an active sign, as it does have moveable components, the Roller Bar signs are in a passive mode the majority of time. They are essentially Billboard signs that can change advertisements at a specified time. Therefore, to see the similarity in number of glances per sign between true active signs (Video and Scrolling Text) and Roller Bar signs was initially surprising. Unless a subject actually catches the Roller Bar sign during a change, it could very well be mistaken for a Billboard. It is likely that some other factor must be influencing the popularity of the Roller Bar sign with subjects. Two possibilities are:

- The low number of Roller Bar signs in combination with their prominent location
- Subjects recognize Roller Bar signs and are curious to see the change to the next advertisement

There are only two Roller Bar signs (one located on the eastbound Gardiner Expressway, and the other on the westbound Gardiner Expressway). Both Roller Bar signs are very large, and are located in prominent locations near other signs, but placed so that they are still easily visible (Figure 1). In contrast, not all Billboard signs were so prominently placed, and therefore these received fewer glances, reducing the overall average glances per sign for

Billboards as compared to the Roller Bar signs. As shown in Table 2, the Roller Bar signs had all of their glances within 10 degrees of the centre of the field of view. This is an indication of the central location of these two signs compared to the other sign types. The central location made it easier to look at the Roller Bar signs since the subject did not have to look far off-road to look at the sign.

Drivers are likely able to distinguish Roller Bar signs from Billboard signs, and may be waiting for the sign to change to a new advertisement. Anecdotal evidence points to some people being able to distinguish a Roller Bar from a Billboard, even at a distance. These same people say they anticipate and watch for the change to a new message/advertisement.

One particular Video sign (sign #67, Figure 1) on the westbound Gardiner, was located along a straight section of road and received 106 out of 128 glances when it was positioned within 10 degrees of the central field of view. Active signs on the right side of the road were often not positioned as close to the road as sign #67, and were usually not placed on the outside of curves which would place them in the central vision like the Scrolling Text sign #64 (84 glances, Figure 1). Consequently, the right side active signs were often further from the driver's central field of view than those on the left side of the road. This meant that they often did not receive glances because the subjects would need to look further off-road and across the car in order to see the right signs compared to the left. Thus, they are naturally more distant from the central line of sight than left signs. Further study on sign characteristics could clarify the degree to which sign location with respect to road features (i.e. curves) influences glances, however, the angle of glance data (Table 2), indicates that proximity to the central field of vision, and not necessarily distance from the road are major factors affecting the attention given to advertising signs. There were Billboard signs on the right that appeared in the central field of view, but these did not have the prime positioning (uncluttered location) and inherent attractiveness (moving text or coloured images) of the active signs (Figure 1). The Billboard sign in the top left of Figure 1 is in a more cluttered location than any of the other three more expensive signs.

Guidelines for in-car displays are designed to reduce distraction from the same active features found in advertising signs: "Visual Information not related to driving that is likely to distract the driver significantly (e.g. TV, video and continuously moving images and automatically-scrolling text) should be disabled while the vehicle is in motion or should only be presented in such a way that the driver cannot see it while the vehicle is in motion"(17). Active signs are designed and permitted to attract the driver's attention, rather than limit the distraction.

Past studies (18), (19), and (20)) that found that the distraction from advertising signs was no greater than other roadside distracters studied, did not consider active signs as a separate category. The results of this study suggest that active advertising signs may result in greater distraction than past studies of the effect of commercial signing might indicate.

**Glances > 0.75 seconds**

Long glances are especially critical when there are cars within 36 metres, or 1.5 seconds. This means that glances 0.75 seconds and greater can pose a serious hazard when following cars too closely. Since 22 of the 25 subjects made at least one long glance at an advertising sign, distraction in this study was not just an isolated incidence involving one or two participants.

When only long glances are considered, the differences between sign types reaches significant levels ($p<0.01$) with video signs receiving more than five times as many long glances as large Billboard signs (Figure 3). When the data were examined more closely, it was found that the number of long glances received by Video signs was very unevenly distributed (Table 1). The most looked at sign (#67) received more than three times the number of long glances than the next most looked at sign.

**Angle of Glance**

The angle of glance showed great promise as a tool for further analyzing driver glance behaviour. However, this was not the main purpose of this study, and therefore was not analyzed in depth. Certain facts are immediately obvious from Table 2. First, the Billboard signs had the smallest percentage of glances directed within 10 degrees.

This is due to the general placement of these signs and their legibility. Billboard signs tended to be placed in less desirable areas, which tended to be further away from the central portion of the field of view. In addition, as one approaches a sign, it moves to the periphery. Billboards, being smaller than other signs, may not have captured attention within the 10-degree centre of field of view because they were too far away to read clearly. When they became legible, they were outside the 10-degree central cone.

The second feature of note is that the Roller Bar signs received all of their glances within the central 10 degrees in the field of view. This is because these two signs are positioned in such a way that they are always within the central 10 degrees unless one is very close to the sign. This might explain why these signs displayed a much higher attractiveness than Billboard signs.

Lastly, it is evident that the great majority of glances were within 25 degrees from centre. This indicates that subjects were unwilling or unable to look at signs at greater than that eccentricity.

### General Comments and Observations

Manual analysis of the data allowed for a very detailed understanding of the effects of commercial signs, even though it was very time consuming and manpower intensive. Observations on eye scanning before and after glancing at the signs, traffic data and road conditions were noted, and could be further developed. The manual analysis also ensured that signs outside the range of the camera, but not the driver's eye, were not missed. If a subject made an off-road glance, but did not appear to be looking at a nearby sign, the investigator could fast forward the video to a point where that target was closer and determine whether the object of interest to the subject was actually an advertising sign.

Observations of driver scanning behaviour during this study suggest that several glances at off-road items are initiated by a glance at another item or by a driving related task, such as a mirror or lane check. One would then expect that right side signs would receive more glances, since signs on this side would be more in the central vision when the driver checks the rear view mirror. Although it was the case, in that mirror checks often led to glances at signs, the mirror checks themselves did not occur frequently enough to make an impact on the glance behaviour. In fact, it is possible that passing cars in the left lane, and oncoming traffic proved more of a distraction. Motion of large objects (i.e. cars and trucks) on the left side of the periphery may have contributed to glances to the left, and hence, to glances at the left signs, in addition to these signs being closer to the central field of view. Finally, signs on the left may have had content that is more attractive - this aspect has not yet been fully analyzed and could be the subject of future study.

Subject comments indicated that the equipment, when fitted properly and equipped with the counterweight bags, provided very little interference with normal driving habits, and was not unduly uncomfortable.

## CONCLUSIONS

Analysis of data from this field study has uncovered several points that have practical implications for regulating bodies. The results provide guidance for future policies regarding signage along the Gardiner Expressway and may be applicable to other major Canadian Expressways.

- Participant and Route Characteristics. There were no significant differences in AGD, maximum glance durations, or number of glances per subject per sign for either of the participant (gender and route familiarity) or route characteristics (start time and start direction).

- Sign Type. Signs with active components receive significantly more glances per sign than Billboard signs (greater than 1.31 glances per subject per sign vs. 0.64 for Billboard signs). While recognizing that movement adds to the attractiveness of the sign, and that scrolling text or video is effective in transmitting a message, reasonable usage of such signs should be regulated to minimize inappropriate glances. Greater driver distraction, especially where headways are short and traffic speed varies, can lead to greater risk of accidents.

- Sign placement. Sign placement in the field of view may be a more important determinant for the number of glances than lateral distance from the road. Signs in the centre field of view tend to receive more glances, regardless of distance from the road. Present policies regarding distance of signage do not distinguish between straight sections and curves. Yet, these sections affect where the sign appears in the driver's field of view and how much attention it is likely to receive. A better approach would be to use line of sight or angle from centre of lane as a determinant of placement. Further study in this regard should be considered.

- Long Glance Durations (Glances >0.75 seconds). Active signs, especially Video signs, received significantly more long glances than passive Billboard signs. These glances are especially critical when there is traffic within three stripe-gaps, as this will cut the time available to react by drivers in half (assuming a 1.5 second reaction time).

**FURTHER STUDY**

This field study provided significant insight into driver-advertising sign relationships. It also highlights some areas that merit further work.

- This study does not include data on the total length of time away from the road. For example, it was observed that several subjects glanced at multiple signs during one off road glance. These individual glances may not have taken much time, but the total sequential off-road glance time may have been significant and much closer to the maximum safe period of 2 seconds as suggested by Zwahlen (7).

- Further analysis of sign placement and the dependent variables, may lead to information on the relative importance of lateral distance from the road and viewing angle. The viewing angle from centre of the line of sight appears to be of greater importance than distance from the road.

- There were several signs that received considerably more glances than average. Individual study of these and similarly attractive signs might determine more clearly the specific features that make them so distracting.

- This study was limited in that objects that the subjects were looking at immediately before or after glancing at the sign were not examined in detail. It is suspected that these data will reveal patterns of scanning behaviour that may lead to a greater understanding of the effect of advertising signs on drivers. Drivers may be more prone to looking at a certain sign because of its proximity in the visual field to a pertinent object such as a roadway exit sign, or an onramp, which are critical to safe driving.

- Such predictors could also be used to enhance future studies specifically relating roadside advertising and road safety. This relationship needs further study, especially in light of the new active technologies used in advertising signs.

Further study into these areas will help to determine which type of sign is more likely to attract driver attention. Additional study of the data collected in this experiment, as well as that collected in future studies of driver eye movements, can lead to empirically based guidelines for regulators to ensure safer roadways.

**ACKNOWLEDGEMENTS**

This paper is based on data gathered from a University of Toronto M.A.Sc. thesis titled *Driver Distraction due to Roadside Advertising* (10), sponsored through Human Factors North by the Ministry of Transportation of Ontario.

**TABLES AND FIGURES**

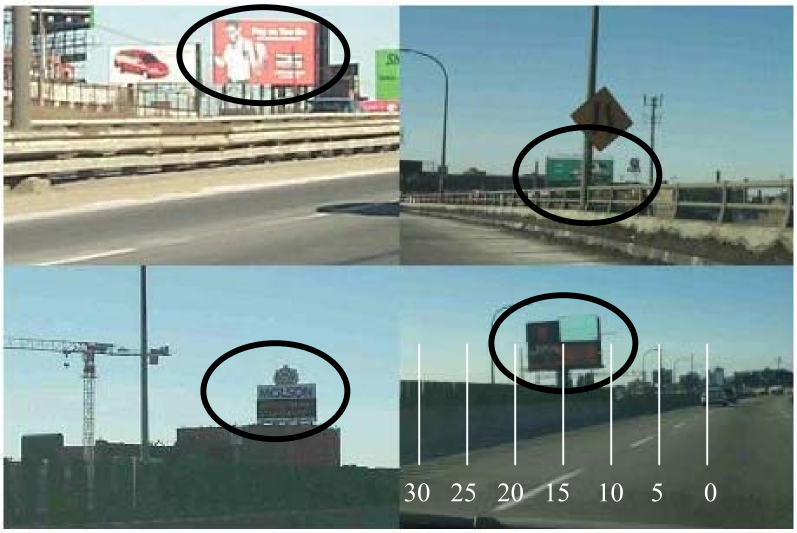


**Figure 1: Photographs showing clockwise from top left: a Billboard sign, a Roller Bar sign, a Video Sign (sign # 67), and a Scrolling Text sign (sign # 64). The bottom right picture shows the 5-degree increments used to measure the glance angle. The sign, as depicted, is at 15 degrees (NB: increments may not be to scale).**

**Table 1: Summary of number of signs by type and distribution of all recorded glances and of long glances (>0.75 seconds).**

| | Signs | | All Glances | | | Long Glances | | |
|---|---|---|---|---|---|---|---|---|
| Sign Type | # | % Total | # | Avg # per sign | % of Glances | # | Avg # per sign | % of Long |
| Bill | 18 | 49% | 280 | 15.56 | 31% | 43 | 2.39 | 22% |
| Roll | 2 | 5% | 58 | 29.00 | 6% | 12 | 6.00 | 6% |
| Scroll | 12 | 32% | 392 | 32.67 | 43% | 79 | 6.58 | 40% |
| Video | 5 | 14% | 174 | 34.8 | 19% | 62 | 12.40 | 32% |
| Totals | 37 | | 890 | 24.05 | | 196 | 5.30 | |

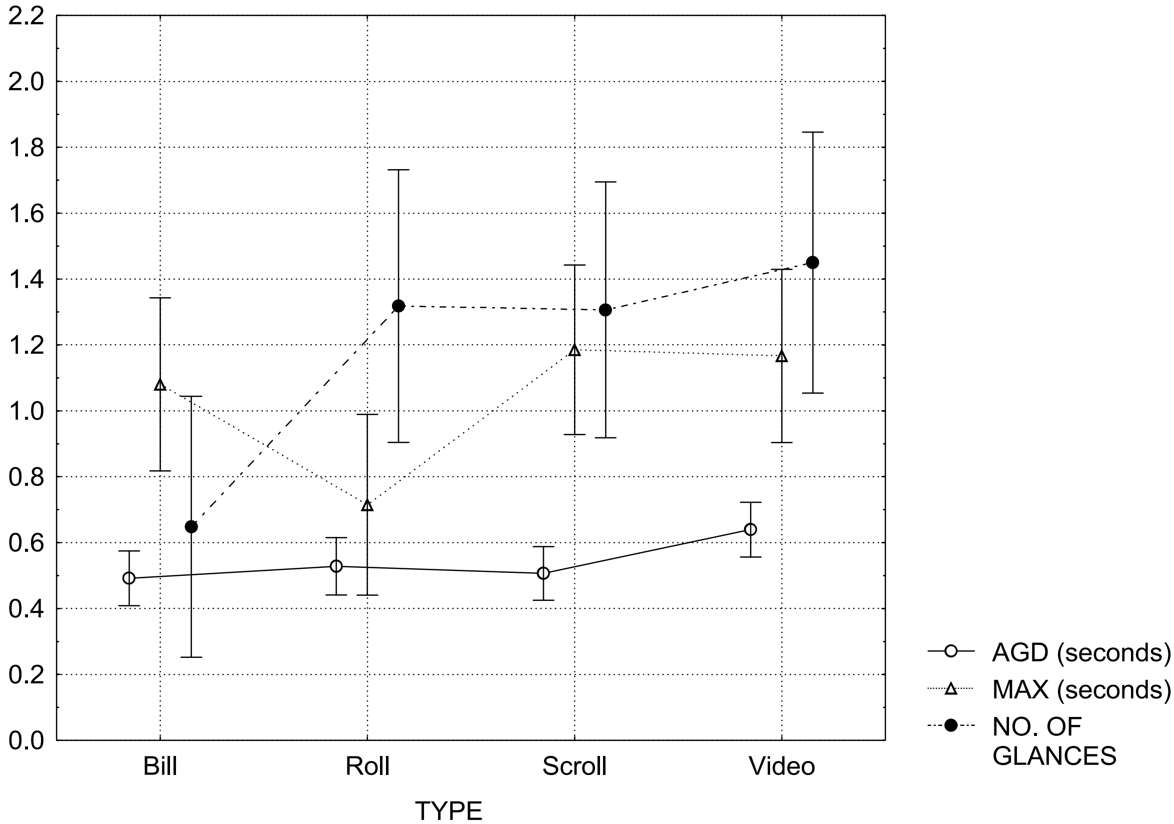


**Figure 2: Effect of sign type on eye glance behaviour with standard error bars**

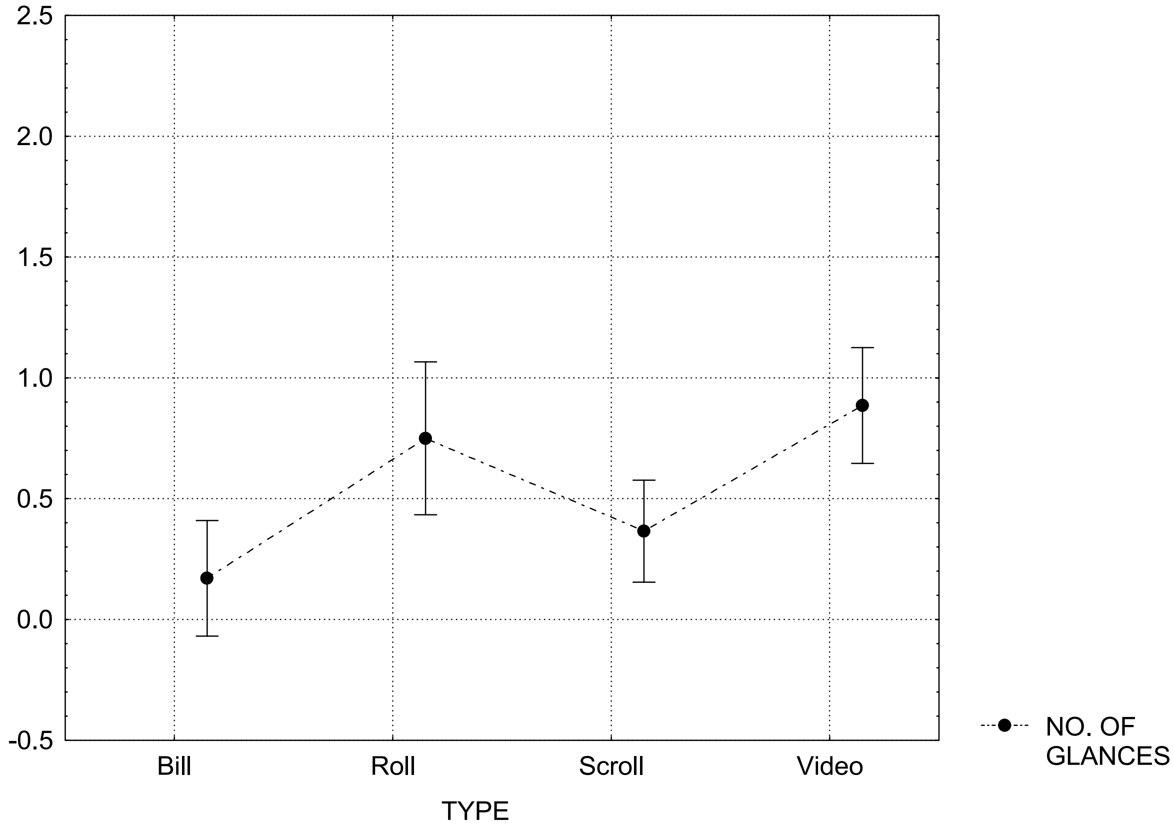


**Figure 3: Effect of sign type on eye glance behaviour for glances 0.75 seconds or greater with standard error bars**

**Table 2: Sign type and Angle of glance from the centre of the lane at the time of**

| Sign Type | Average Angle of Glance | Maximum Angle of Glance | Glances within 10° of centre of FOV | Glances within 25° of centre of FOV |
|---|---|---|---|---|
| Billboard | **9.6 °** | **75 °** | **73.9 %** | **96.1 %** |
| Roller Bar | **5.3 °** | **10 °** | **100 %** | **100 %** |
| Scrolling Text | **8.6 °** | **45 °** | **76.5 %** | **97.6%** |
| Video | **10.1 °** | **35 °** | **67.8 %** | **96.6 %** |
| All | **9.0** | **41.3** | **79.5 %** | **97.6 %** |

**REFERENCES**


(1) Theeuwes, J., and Hagenzieker, P. (1993). Visual Search Of Traffic Scenes: On The Effect Of Location Expectations. Vision in Vehicles – IV, A.G. Gale et al. editors, Elsevier Science Publishers BV, 1993.

(2) Rockwell, T.H. (1988). Spare Visual Capacity In Driving-Revisited: New Empirical Results For An Old Idea. *Vision in Vehicles II*, A.G. Gale et al. editors, Elsevier Science Publishers BV, 1988.

(3) Mourant, R.R. and Rockwell, T.H. (1970). Mapping eye movement patterns to the visual scene in driving: An exploratory study. *Human Factors* 12(1) pp81-87.

(4) Bhise, V.D., and Rockwell, T.H. (1972). *Development Of A Driver-Information-Acquisition Based Operational Tool For The Evaluation Of Highway Signs*. Presented to the 1973 Annual Meeting of the Highway Research Board, Washington DC.

(5) Crundall, D.E. and Underwood, G. (1998). Effects Of Experience And Processing Demands On Visual Information Acquisition In Drivers. *Ergonomics* 1998 41(4), pp448-458.

(6) Wikman, A., Nieminen, T., and Summala, H. (1998). Driving Experience and time-sharing during in-car tasks on roads of different width. *Ergonomics*, 1998, 4242(3), pp358 – 372.

(7) Zwahlen, H.T. (1988). *Safety aspects of cellular telephones in automobiles. (Paper No. 88058).* Paper presented at the International Symposium on Automotive Technology and Automation (ISATA), Florence, Italy. May, 1988).

(8) Hoffman, J.E., and Subramaniam, B. (1995). The role of visual attention in saccadic eye movements. *Perception and Psychophysics* 57(6) pp787-795.

(9) Mourant, R.R. and Rockwell, T.H. (1972). Strategies of visual search by novice and experienced drivers *Human Factors* 14 pp325-335.

(10) Beijer, D.D. (2002). *Driver distraction Due to Roadside Advertising*. University of Toronto Press, Toronto, Ontario, Canada.

(11) Rumar, K. (1990). The basic driver error: Late decision. *Ergonomics* 33 (10/11) pp1281 – 1290.

(12) Hughes, P.K., and Cole, B.L. (1986). What attracts attention while driving? *Ergonomics* vol 29 (3) pp 377-391.

(13) Andreassen, D.C. (1985). *Traffic accidents and advertising signs.* Australian Road Research Board. Internal Report AIR-000-213.

(14) Mourant, R.R., Rockwell, T.H., and Rackoff, N.J. (1969). *Drivers' Eye Movements And Visual Workload.* Highway Research Record, No. 292, 1-10.

(15) Babbitt Kline, T.J., Ghali, L.M., and Kline, D.W. (1990). Visibility distance of highway signs among young, middle-aged and older observers: Icons are better than text. *Human Factors* 32(5) pp609-619.

(16) Brouwer, W.H., Waterink, W., van Wolffelaar, P.C., and Rothengatter, T: (1991). Divided attention in experienced young and old drivers: lane tracking and visual analysis in a dynamic driving simulator. *Human Factors* 1991, 33(5), pp573-582.

(17) Association of Automobile Manufacturers (2000 (Draft)), *Statement of Principles on Human Machine Interface (HMI) for In-Vehicle Information and Communication Systems*

(18) Lauer, A., and McMonagle, J.C. (1955). *Do roadside signs affect accidents?* Traffic Q 9(3) pp322-29.

(19) Johnston, A. and Cole, B. (1976). *Investigation of distraction by relevant information*. Australian Road Research 6(3) pp32-33.

(20) Hughes, P.K., and Cole, B.L. (1984). *Search and attention conspicuity of road traffic control devices*. Australian Road Research 14(1) pp1-9.