Traffic Safety Evaluation of Video Advertising Signs

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Road authorities are under increasing pressure from advertisers to allow video advertising in the right-of-way but are understandably concerned about whether video signs constitute a driving hazard. At the City of Toronto's request, a comprehensive assessment of traffic safety impacts related to such signs was carried out in a series of studies involving three downtown intersections and an urban expressway site. An on-road eye fixation study was carried out to determine if drivers look at video advertising signs. Conflict studies were conducted to determine if there were more conflicts on intersection approaches with visible video signs than on those without such signs. A before-and-after sign installation study of headways and speeds on the urban expressway was carried out. Crashes were compared before and after sign installation at the expressway and three intersection sites. Finally, a public survey was conducted to determine if video advertising was perceived to affect traffic safety. On the basis of the eye fixation study and the public survey data, it is apparent that video advertising can distract drivers inappropriately and lead to individual crashes. However, the evidence from other studies was not consistent and suggests that for the particular signs studied, overall impacts on traffic safety are likely to be small. Further studies, especially prospective ones with larger crash data sets, are required to be certain about the findings. A comparison between this study and an earlier one suggests that there are large differences in driver distraction depending on the placement and the environment in which the sign is seen. Further studies are required to determine factors that minimize driver distraction.

Road authorities are under increasing pressure from advertisers to allow commercialization of the right-of-way as one method of developing revenue streams to offset budget constraints. In Toronto, Canada, numerous applications have been made for the right to erect video advertising signs at downtown intersections and along urban expressways. An on-road eye movement study of 61 commercial signs along the downtown portion of the Gardiner Expressway had raised concerns about distraction due to video advertising (*1*). Significantly more glances and, even more important, significantly more glances that lasted ¾ s or longer were made to video signs than to scrolling text, roller bar, or static billboard signs. The effectiveness of video advertising in attracting drivers' attention is no doubt linked to its attributes of movement and brightness, which make it more likely to be noticed by drivers. In addition, video advertising may retain driver attention longer because of the continuous stream of changing images, which are potentially more interesting to look at than static images. Given the greater attention-attracting qualities of video advertising signs, road authorities are understandably concerned about whether these signs constitute a driving hazard.

Although there is much concern about the impact of roadside advertising, there have been few studies in this area, and most of them are dated and deal with static billboards rather than video advertising, which could be expected to be much more distracting (*2*). A review of five such studies, all carried out between 1961 and 1965, concluded that the signs did not contribute to accidents (*3*): two studies showed no effect, two studies that did find an effect were subsequently discredited, and one found an effect but did not separate the conflicts arising from entering and exiting commercial premises from the distracting effect of the signs themselves.

At the request of the city of Toronto, a comprehensive assessment of traffic safety impacts related to video advertising signs was carried out in a series of five studies, each intended to answer specific questions, as follows:

- Study 1, eye fixation. Driver's eye movements were recorded as they drove past video signs located at three downtown intersections and along an urban expressway. This study addressed two questions: Do drivers look at video advertising signs and if so, how frequently and for how long? Do these glances occur at the expense of glances at traffic-related signs and signals, the speedometer, or rearview mirrors?
- Study 2, conflicts. A conflict analysis was undertaken at two of the downtown intersections, comparing conflicts on approaches where the video sign was visible (hereafter referred to as the video approach) with those on approaches where it was not (hereafter referred to as a nonvideo approach). The question addressed was, Does the distraction from video signs lead to an increase in conflicts that might indicate a deterioration in safety?
- Study 3, headways and speeds. Measures of headway and speed were obtained from loop detectors on an affected section of an urban expressway before and after the installation of a video sign. A control section was used for comparison purposes. The question addressed was, Does this distraction increase the frequency of short time headways or increase speed variance?
- Study 4, crashes. Collision frequencies and patterns on the video approach were compared with those on the nonvideo approach before and after the installation of video signs for the three downtown intersections. In addition, collision frequencies and patterns were analyzed

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before and after sign installation for the video sign visible from the Don Valley Parkway (DVP). This study addressed the question, Are there indications of changes in collision patterns or frequency?

- Study 5, public survey. A survey at three downtown intersections determined whether the public perceived video advertising to have a negative effect on traffic safety.

STUDY SITE DESCRIPTIONS

There were four study sites, including three downtown intersections and one section on an urban expressway, for which video advertising signs were visible.

The three downtown intersection sites were all four-leg signalized intersections with two approach lanes in each direction and a posted speed of 50 km/h. In each case the video sign could be observed on two of the four intersection approaches but not on the other two. Figure 1 illustrates the site at Bay and College Streets.

The DVP site is a divided, controlled-access urban expressway, with three lanes per direction, paved shoulders, and a median barrier. The posted speed limit is 90 km/h. There is a video sign located off the freeway, which is the only commercial sign visible to northbound traffic. The driver's view of this sign is intermittently partially or fully blocked from view by buildings and overpasses. The best sign visibility occurs during a 5- to 7-s period before the driver passes the sign. Figure 2 is a map of the sign location and the affected DVP segment.

Table 1 shows the distance and time over which each video sign was visible as well as the distance and time over which the images on each video sign could be seen clearly enough to identify them; that is, they were legible.

STUDY 1: EYE FIXATION

The aim of the first study was to provide evidence concerning whether drivers looked at video advertising signs and if they did, how that affected their visual search related to other aspects of driving. The reasoning behind the study was that direct evidence of driver distraction would be required to substantiate any claim of changes in headways, speeds, conflicts, and crash frequencies as a result. Smiley et al. provide a full report on this study (*4*). The methodology and results are summarized in the following sections.

FIGURE 1 Video approach on Bay Street northbound toward College Street, Toronto (circle indicates location of video sign).

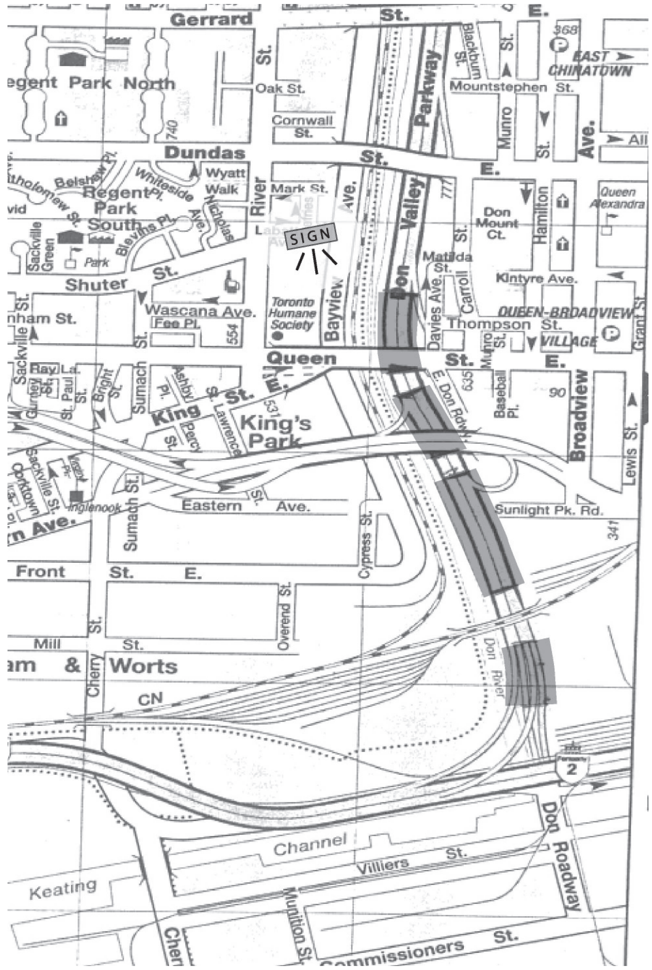

FIGURE 2 Location of DVP sign and affected DVP segment.

Methodology

Driver eye movements were recorded by using a head-mounted EL-MAR Vision 2000 eye tracking system for 16 subjects, aged 25 to 50 years, as they drove along the DVP past the single video sign and then through the three downtown intersections on both video and nonvideo approaches. Subjects drove a passenger vehicle equipped with a second brake and were accompanied by a driving instructor and researcher. To avoid influence on eye movement behavior, subjects were not told the true purpose of the experiment, only that the study would examine eye movement behavior in a variety of driving environments in Toronto. The study was conducted during the summer in dry conditions in the daytime between the hours of 1000 and 1400. The final data sample included eye movement recordings from 69 intersection approaches and 14 passes of the video sign on the DVP. Only glances that occurred while the vehicle was in motion were measured.

Results

The eye movement study indicated that the four video signs studied attract driver attention in that the probability of a driver's looking at the sign on a given approach was almost 1 in 2. The average glance

TABLE 1 Video Advertising Sign Legibility

Intersection	Direction	Distance Legible	Time Legible at Speed Limit	Distance Visible	Time Visible at Speed Limit
Yonge and Bloor	EB*	190 m	13.4 s	260 m	18.7 s
(50 km/h)	SB	180 m	13.0 s	400 m	28.8 s
Bay and College	NB*	125 m	9.0 s	200 m	14.4 s
(50k m/h)	WB	150 m	10.8 s	210 m	15.1 s
Spadina and Dundas	SB*	190 m	13.4 s	690 m	49.7 s
(50 km/h)	WB	180 m	13.0 s	660 m	47.5 s
DVP (90 km/h)	NB*	450 m**	18 s	820 m **	33 s

EB = eastbound, SB = southbound, NB = northbound, WB = westbound.
*Direction of travel for eye tracking analysis.
**Segments on which sign was obscured by overpasses were excluded.

length was 0.5 s, similar to those found in studies of traffic signs. In some cases glances at video signs were made unsafely, that is, at short headways (1 s or less), for long durations (1.47 s), and at large angles (up to 31 degrees) off the line of sight. Considering all four video signs, about one-fifth of the glances lasted longer than 0.75 s, the time that is considered to be equivalent to minimum perception–reaction time to the slowing of a vehicle ahead. A total of 38% of the headways measured during glances at video signs were less than 1 s. Almost one-fourth of the glances were at 20 degrees or greater off the line of sight. Since perception–reaction time to an unexpected event can take on the order of 0.75 to 1.5 s, glances at video signs at such angles and headways could result in drivers' not detecting the slowing of the vehicle ahead, a frequent event in congested downtown and DVP traffic, and not stopping in time. However, it must be noted that for the particular signs and sign placements in this study, glances at static signs (billboards and bus shelter ads) were made at even larger angles and more frequently at shorter headways than those at video signs. Furthermore, the longest glance recorded was for a static sign.

Although drivers looked at the video signs on almost half the occasions that they were present, the majority of glances were looking ahead at traffic, 76%. The next most prominent category was traffic signals and street name signs (7%) followed by pedestrians on the sidewalks (or distant from the road), who did not present a potential conflict with the driver (6%). Although there was a greater proportion of glances at commercial signs (static billboard plus video signs) on the video approach, this finding appeared to be due mainly to the lack of billboards on the nonvideo approaches at two of the three intersections. At the intersection of Yonge and Bloor Streets, a billboard that was visible on the nonvideo approach had been placed on the reverse side of the video sign and was roughly equivalent in size to the video sign. Although the video sign was on the same side of the road as the driver, the billboard was on the opposite side, and thus drivers had to look further off the line of sight to see the billboard. Despite this larger angle on the nonvideo approach, the billboard received almost twice the number of glances received by the video sign on the video approach.

No evidence was found that glances at video signs reduced the proportion of glances at traffic signs or signals. There was a trend toward a greater proportion of glances at mirrors or speedometers on the video approach. From the few occasions on which there were potential conflicts with pedestrians and cyclists, there is no evidence that drivers on the video approach were less likely to detect them.

Glances at video signs as compared with those at static commercial signs were associated with longer headways and were made closer to the line of sight. Both findings indicate greater safety for video sign glances.

The most distracting sign, as indicated by the proportion of subjects who looked at it and the total number of glances made to it, was the sign at Bay and College Streets (see Figure 1). This finding was despite the fact that this sign was visible for the shortest time—about 70% of the time available at the other two downtown intersections. It was also smaller than the other signs, and subjectively the content was less entertaining. However, it was mounted lower, closer to the driver's line of sight (2 degrees off the line of sight vertically as compared with 5 degrees for the other signs), and was in a relatively less cluttered environment, making it much more conspicuous. However, it was further off the line of sight horizontally than the other two intersection signs (6 degrees versus 3 and 4 degrees), which would have been expected to discourage glances. Nonetheless it attracted the most glances and at the widest angles.

STUDY 2: CONFLICTS

If video signs distract drivers, it may be possible to observe an increase in the number of conflicts recorded on approaches with a video sign compared with those without such signs. Conflict studies were conducted at two of the intersections at which observations were made of driver eye fixations: Bay and College Streets and Yonge and Bloor Streets. Conflicts were examined in relation to three types of behavior as drivers approached the intersection:

- Braking without good cause,
- Unwarranted lateral lane displacements, and
- Delayed start on green.

All of these behaviors potentially lead to sudden decreases in headways, which in turn can lead to rear-end or sideswipe collisions.

Methodology

At each intersection, there were two video and two nonvideo approaches. The basis for selection of two approaches for comparison was that they were as geometrically similar as possible, so that differences in conflict rates could be attributed to the presence of the video sign and would not be influenced by differences in geometry.

Observers were placed on the video and nonvideo approaches at a distance of about 70 to 80 m from the intersection, which provided them with a clear view of vehicles approaching each intersection. These observers counted and recorded the number of brakings (without good cause) and lateral lane displacements in the center lane. (Because of the use of the curb lane for loading and unloading passengers, which could have compromised the reliable detection of conflicts, only vehicles in the center lane were observed.)

As a control for exposure, the total number of vehicles eligible to be counted if braking or unwarranted displacements took place was also counted so that the proportion of vehicles engaged in these behaviors on each approach could be recorded. In order to assess delayed starts on green, the time from the commencement of the green signal until the front wheels of the fifth vehicle in the queue crossed the stop line was measured, both for the video and nonvideo approaches. From initial observations, the sample sizes were large enough to detect a difference larger than 10% had such differences been present. Observations and measurements were conducted on weekdays in off-peak daytime periods during clear and dry weather conditions.

Four observers worked 15-min shifts followed by a 15-min rest break and rotated between the approaches. This schedule ensured that each observer received adequate rest and stayed alert throughout the data collection process. To avoid bias, the observers and their supervisor were blind as to the actual purpose of the study. They were told that the city was interested in gaining a greater understanding of driver behavior at signalized intersections.

Results

At Yonge and Bloor Streets, there was a significantly higher incidence, by 60%, of drivers who applied their brakes without good cause on the video compared with the nonvideo approach (19% versus 12%). In contrast, there was no significant difference at the $p < 0.05$ level in the extent of unwarranted lateral lane displacements or in the time it took for the fifth vehicle in a queue to cross the stop line after the commencement of green. At Bay and College Streets, no significant differences at the $p < 0.05$ level were found for any of the three observed behaviors.

Since the video and nonvideo approaches were geometrically similar and had similar speeds and pedestrian activity, the only reason that could be found for increased braking on the video approach at Yonge and Bloor Streets was the presence of the video sign.

STUDY 3: HEADWAYS AND SPEEDS

If video signs distract drivers, it may be possible to see the results on speeds and headways between vehicles on an affected segment. Some distracted drivers might slow, resulting in greater speed variability, or might allow unsafe headways to develop when they fail to detect the slowing of the vehicle ahead. To test this hypothesis, speed, flow (vehicles per hour passing a point), and occupancy (the percentage of time that the point is occupied by a vehicle) were compared before and after installation of the video sign visible from the DVP.

Methodology

Data were collected from one mainline traffic detector station in the northbound lanes of the DVP, from which the video sign could be seen, and compared with data from a detector station suitable as a control in the southbound lanes, roughly opposite the northbound detector station. The sign was activated in April 2001. The before-and-after months compared were

1. May 2000 compared with May 2001 (immediately after activation) and
2. May 2000 compared with May 2002 (one year after activation).

For each set of data, 20-s averages of speed, flow, occupancy, and average vehicle length in the median lane (Lane 1) were calculated. Observations during congested periods were removed since congested operation would be unlikely to be affected by the sign. Congested periods were identified on the basis of low speed (<60 km/h), high occupancy (>30%), or both. Periods with bad or missing data were also removed.

Results

Before-and-After Speed and Occupancy Comparisons

Before-and-after comparisons of average speed, occupancy, and their standard deviations were made by calculating the ratio of the after-period measure to the before-period measure, adjusted for changes in these measures at the control site (i.e., the southbound detector station). Thus a ratio of more than 1 indicates an increase in a measure after sign installation, and vice versa. The results indicate a minor decrease in mean speed (i.e., ratio <1) for most flows when May 2001 and May 2002 (after installation) are compared with May 2000 (before installation). This finding was accompanied by a corresponding increase in mean occupancy for these same comparisons and an increase in the standard deviation of speed for most flow levels (i.e., ratio >1). A decrease in speed may be anticipated to improve safety; however, the increase in mean occupancy (i.e., decreased headway) and increased speed variance would likely lead to a decrease in safety.

Proportion of High 20-s Flows in Time Period

For the morning and afternoon peak periods and the northbound and southbound directions separately, the average flow and proportion of 20-s flows above a certain level (2,340 vph) were computed. These are indicators of dangerous headways (inverse of flow, i.e., <1.5 s). The results indicate an increase in the proportion of northbound (video approach) high flows when May 2001 and May 2002 are compared with May 2000. However, this increase was matched by an increase in this measure for the southbound (nonvideo) direction unaffected by the sign and so could not be attributed to the sign.

The results of the speed-flow-occupancy analysis are inconsistent and therefore inconclusive. The results of high-flow (short-headway) analysis do not support the indications from the speed and occupancy analysis of a possible deterioration in safety and operations. The negative impacts suggested by the speed and occupancy analysis are also not supported by the results of the collision analysis presented next.

STUDY 4: CRASHES

If drivers are distracted by video signs, they may slow or they may be delayed in responding to the vehicle ahead, resulting in an increase in collisions, particularly rear-end collisions. Collision frequency and pattern data were analyzed for the three downtown intersections with video signs and for the DVP section on which a single video sign is visible.

Downtown Intersection Sites with Video Signs

Methodology

The methodology employed for the three downtown intersection sites was a before-and-after study using the approaches on which the signs are not visible to control for changes in safety that may be unrelated to the video sign. The before and after periods for each location were as follows:

Intersection	*Before Period*	*After Period*
Yonge–Bloor	Jan. 1996 to Nov. 1999	Jan. 2000 to Oct. 2002
Bay–College	Jan. 1996 to Dec. 2000	Feb. 2001 to Oct. 2002
Spadina Ave.–Dundas St.	Jan. 1996 to Nov. 2000	Jan. 2001 to Oct. 2002

Construction records were reviewed, and they indicated no significant activity during the analysis period that may have affected the results.

Collisions were identified as related to the video approaches if at least one vehicle in the collision originated on either of those approaches. All other collisions were assigned to the comparison (nonvideo) approaches.

The empirical Bayes methodology was used to properly account for the effects of traffic volume changes by using safety performance functions that relate crash experience to the average daily traffic (ADT) entering an intersection. These safety performance functions were available from previous studies done by the city. The methodology for combining data to get an average effect over the three intersections was the weighted log odds ratio. Significance tests at the 5% level were performed on the log odds ratios calculated. The average effect cited is the exponent of that ratio and is also stated in terms of a percent increase or decrease. For example, an effect of 1.006 indicates a percent increase of 100 (1.006 − 1), or 0.6%.

Results

Table 2 shows total, injury, and rear-end collisions before and after sign installation on the affected (video) and comparison (nonvideo) approaches, together with the average effect for the three intersections considered together. Overall, there was no effect on total collisions (0.6% increase on video approaches). There was a nonsignificant 43.2% increase in injury collisions. For rear-end collisions there was a nonsignificant 12.9% increase on approaches where the video sign was visible. None of the results is statistically significant ($p > 0.05$) because of the small sample size of collisions.

Considering collisions at individual intersections, results at two of the three intersections (Spadina–Dundas and Bay–College) are indicative of an increase in rear-end as well as total collisions on the video compared with the nonvideo approach. The former is statistically significant ($p < 0.02$, effect not shown). However, the results at the third intersection, Yonge and Bloor, show an nonsignificant decrease in total and rear-end collisions.

Further analysis of the Yonge and Bloor Streets sign was carried out with an expanded database that added the intersection collisions to those classified as midblock for which at least one vehicle was heading toward the intersection. The motivation for this analysis was that the sign at the Yonge and Bloor Streets intersection, because of its height, may encourage looks from a greater distance back from the intersection than the sign at Bay and College Streets. (Indeed, a subsequent analysis of the angle and distance at which the glances were made confirmed this supposition.) The further analysis did not materially alter the conclusions in that the effects were in the same direction (increase or decrease) when the within-block effects were compared

TABLE 2 Total, Injury, and Rear-End Collisions Before and After Sign Installation

			Affected Approaches			Comparison Approaches		
				Collisions			Collisions	
Intersection	Months Before	Months After	Direction	Before	After	Direction	Before	After
Total collisions								
Bloor and Yonge	47	34	SB;EB	32	24	NB;WB	26	29
Bay and College	60	21	NB;WB	28	11	SB;EB	13	4
Spadina and Dundas	59	22	SB;WB	43	23	NB;EB	38	14
Average effect* = 1.006 (0.6% increase – *p*-value = 0.9681 – statistically insignificant)								
Injury collisions								
Bloor and Yonge	47	34	SB;EB	9	10	NB;WB	6	6
Bay and College	60	21	NB;WB	13	7	SB;EB	5	3
Spadina and Dundas	59	22	SB;WB	9	8	NB;EB	10	3
Average effect* = 1.432 (43.2% increase – *p*-value = 0.1806 – statistically insignificant)								
Rear-end collisions								
Bloor and Yonge	47	34	SB;EB	11	6	NB;WB	12	15
Bay and College	60	21	NB;WB	2	6	SB;EB	3	3
Spadina and Dundas	59	22	SB;WB	12	9	NB;EB	12	3
Average effect* = 1.129 (12.9% increase – *p*-value = 0.6527 – statistically insignificant)								

*The average effect is for all three intersections combined. It is the exponent of the weighted log odds ratio.

with those effects based on the city-classified intersection-related collisions.

DVP Before-and-After Crash Analysis

Methodology

The methodology employed to analyze before-and-after collision data was a before-and-after study using a comparison group to control for changes in safety that may be unrelated to the video sign. Safety performance functions were not available to do a formal empirical Bayes analysis as was done for the downtown intersections. The before period was January 1996 to March 2001. The after period was May 2001 to October 2002.

The video segment is northbound on the DVP from Eastern Avenue to 160 m north of Queen Street with the sign located as shown (see Figure 2). Three different potential nonvideo, southbound DVP comparison segments were used: Queen to Dundas, Eastern to Queen, and Eastern to Dundas. The most appropriate is Eastern to Queen since the other two include the Eastern-Richmond exit diverge, which is likely to increase collision frequency.

Collisions identified by the city as interchange-related and those that did not occur on the DVP but were not identified as interchange (i.e., those that occurred on ramps or on overpasses) were excluded from the analysis. Because of the short after period and the small number of collisions, the analysis only considered changes in collisions overall and did not separate out individual collision types, as was done in the analysis of the downtown intersections.

Results

As can be seen from Table 3, total collision frequency remained unchanged and there was a negligible increase in injury collision frequencies on the video approach based on the most comparable section, that is, the comparison between Eastern and Queen.

There were large decreases in collisions on the video approach based on the two other comparison groups, but the effects have large standard errors and are insignificant at the 5% level except for those for total collisions using the southbound Queen to Dundas segment as the comparison group. As mentioned earlier, this is not the most appropriate comparison group in that it includes a ramp diverge, a feature not present on the video segment.

STUDY 5: PUBLIC SURVEY

Methodology

A questionnaire was designed to survey the public with respect to their opinions on the safety of video advertising signs. A total of 152 persons were surveyed: 94 men and 58 women. Of the total, 37 were 18 to 29 years old, 90 were 30 to 55 years old, and 23 were over 55. (Ages for two subjects were not recorded.) Participants were approached at the three downtown intersection sites where video signs were installed.

Results

With respect to the impact of video signs on driver attention to pedestrians or cyclists, 65% of those surveyed said that these signs have a negative effect. With respect to video advertising signs in the downtown area, 59% said that as a driver, their attention is drawn to such signs and 49% of those indicated a negative effect on driving safety. With respect to these signs on the Gardiner Expressway, 59% said that as a driver, their attention is drawn to these signs and 44% of those indicated a negative effect on driving safety.

With respect to restrictions on video advertising in the interest of traffic safety, 86% of subjects said there should be such restrictions. Participants were offered sample restrictions, including "not on highways," "not at intersections," "light level at night," and "other." Of the total, 73% said that video signs should not be placed at intersections; 62% said the signs should not be on highways.

Given the small sample, a surprising number of drivers had experienced near-collisions—nine out of 152—and two had experienced rear-end collisions that they associated with video advertising signs.

TABLE 3 Before-and-After Collision Analysis of DVP Segment Possibly Affected by Video Sign for Total Collisions and Injury Collisions

	Before Period Collisions (Jan. 1996 to March 2001)		After Period Collisions (May 2001 to Oct. 2002)		Ratio of After to Before, Normalizing for Differences in Before and After Period Length		"Effect" for Affected Segment Using Specific Comparison Group (standard error) (*p*-value)	
Section	Total	Injury	Total	Injury	Total	Injury	Total	Injury
NB affected segment	50	16	10	4	0.700	0.875	n/a	n/a
SB comparison (Eastern to Dundas)	140	41	39	10	0.975	0.854	0.682 (0.253) [0.2088]	0.864 (0.481) [0.7772]
*SB comparison (Eastern to Queen)	62	19	11	3	0.621	0.922	1.000 (0.423) [1.000]	1.093 (0.631) [0.8831]
SB comparison (Queen to Dundas)	78	22	28	7	1.241	1.114	0.521 (0.200) [0.0166]	0.628 (0.355) [0.2946]

Shaded results are statistically significant ($P < 0.05$).
*Most appropriate collision comparison.

Participants were asked to rate various driver distractions on a scale of 1 to 7 (1 = not at all distracting, 7 = very distracting to drivers). Video advertising signs were rated at 3.7, higher than billboards (2.1) but close to the same as road construction (4.0) and lower than in-car cell phone use (5.6) in terms of distraction.

DISCUSSION OF RESULTS

A wide range of methods was used to address the question of whether drivers are distracted from the driving task by video advertising signs and whether that distraction has subsequent impacts on headways, speeds, conflicts with other vehicles, and crashes.

With respect to whether drivers were distracted while their vehicles were in motion, eye movement results suggest that a substantial proportion of drivers will look once or more at a given video advertising sign, on average half at the downtown-intersection signs and a third at the sign on the DVP. Clearly, some video signs are more distracting than others. An earlier study of commercial signs on the Gardiner Expressway (*1*) in Toronto (see Figure 3) found that one of the video signs attracted on average 5.1 glances per exposed subject, considerably more that the 0.9 glance per exposed subject for the DVP video sign. The longest glance at the Gardiner Expressway video sign lasted 3.2 s compared with 1.1 s for the DVP sign. Compared with the DVP sign, the Gardiner Expressway video sign was visible and legible for considerably longer (84 s versus 38 s visibility and 24 s versus 18 s legibility at the speed limit of 90 km/h), had an uninterrupted view, and, most important, was on a curve so that it appeared close to the center of the driver's line of sight for about 24 s during the approach.

The number of glances per individual video sign was small, and so statistically significant differences in looking behavior were not found. The most distracting sign as indicated by the proportion of subjects who looked at it, the total number of glances made to it, and the fact that it attracted glances farthest off the driver's line of sight was the sign at Bay and College Streets. This finding was despite the fact that this sign was smaller than the other two signs, had subjectively less interesting content, was farther off the line of sight horizontally than the other two intersection signs (6 degrees versus 3 and 4 degrees), and was visible for the shortest time (9 s at the speed limit or about two-thirds of the time available at the other two downtown intersections). In terms of attention-attracting advantages, this sign was mounted lower, was closer to the driver's line of sight (2 degrees off the line of sight vertically as compared with 5 degrees for the other signs), and was in a relatively less cluttered environment, making it much more conspicuous.

While glancing at the Bay and College Streets sign, one subject looked at an angle of 31 degrees while traversing the intersection. It would be difficult to detect the slowing of a vehicle ahead while looking at such an angle.

Conflict studies were made at two downtown intersections. Only one conflict measure showed a significant difference between the video and nonvideo approaches; however, the effect was sizeable. At Yonge and Bloor Streets, the incidence of drivers applying their brakes without good cause was significantly higher (by about 60%) on the video approach. There were no statistically significant increases in conflicts at the Bay and College Streets intersection, despite the fact that this sign appeared to attract a higher proportion of glances, longer glances, and glances at wider angles than the sign at Yonge and Bloor Streets.

The results of the collision analysis for the downtown intersections were insignificant and inconsistent. Also, the direction of effect did not support the conflict study analysis in that collisions decreased on the video approaches after sign installation at the Yonge and Bloor Streets intersection.

For the DVP segment affected by the video sign there was no consistency between the results for the two sets of analyses conducted (headway-speed-occupancy and collision).

The results of the public survey showed that 65% of those surveyed perceived a negative impact of video signs on safety due to driver distraction. Given the small sample, a surprising number of drivers had experienced near-collisions (nine out of 152) and two had experienced rear-end collisions that they associated with video advertising signs. Video advertising signs were rated close to the same as road construction in terms of distraction. This finding is a concern given that road construction is associated in many studies with an increase in crashes (*5*).

CONCLUSIONS

On the basis of the five studies reported here and the amalgamation with the results of an earlier study of eye movements for a video sign on the Gardiner Expressway, it cannot be concluded at this time that video advertising signs are either safe or unsafe. The eye fixation study, which was carried out with a relatively safe group of drivers in the daytime, showed that on average, with respect to number and duration of glances, advertising signs were responded to in a similar manner to traffic signs. Nonetheless, there were individual examples of unsafe behavior associated with glances at signs.

The conflict study showed evidence of unsafe behavior at one of the two intersections studied. Although the collision study also found evidence of unsafe behavior, the negative impacts were not found at the same intersection where conflicts were significantly higher for the video approach.

The headway-speed-occupancy and collision analyses for the DVP segment that was affected by the video sign show nonsignificant and inconsistent impacts on safety. Longer after periods would be desirable for a more reliable examination of changes in collision frequency.

The public survey indicated that a majority of drivers believed that video signs negatively affect driving safety, a surprising number given the size of the sample that had experienced near-collisions or collisions that they attributed to distraction by video signs.

Although the evidence is by no means clear cut in one direction or the other, it is intuitively obvious that any distraction during the

FIGURE 3 Distracting video sign (5.1 glances per exposed subject) westbound on Gardiner Expressway, Toronto (*1*).

driving task within a busy environment increases the level of risk. On the basis of the eye fixation study and the public survey data, it is apparent that video advertising can distract drivers inappropriately, leading to individual crashes. However, the evidence from the headway and speed, conflict, and crash studies was not consistent as to the traffic safety impact, suggesting that for the particular signs studied, overall impacts on traffic safety are likely to be small. Further study with larger crash data sets are required to be certain. In addition, a prospective before-and-after safety study may be more definitive in that it would be possible to compare before- and after-installation conflict rates and to try to better control for the effects of changes in safety due to other factors.

A comparison between this study and an earlier one suggests that there may be large differences in driver distraction dependent on the placement and environment in which the sign is seen. Therefore, it was recommended that the city adopt a cautious approach to allowing additional video signs at this time. Further eye fixation studies are required to determine design and placement factors that keep driver distraction to a minimum.

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