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ROUTIERE AU QUEBEC

S'IMPLIQUER ACTIVEMENT POUR AMÉLIORER LA SÉCURITÉ ROUTIÈRE

Résumé

L'industrie de l'affichage au Québec croit que l'utilisation judicieuse de l'affichage extérieur peut soutenir divers objectifs de sécurité routière, et se déclare prête à appuyer les efforts des différents partenaires publics et sociaux qui partagent une préoccupation à l'égard de cette problématique.

Regroupement de l'industrie de l'affichage au Québec

Février 2006

TABLE DES MATIÈRES

Qui sommes-nous?

Le Regroupement de l'industrie de l'affichage au Québec est formé des quatre entreprises représentant plus de 95 % de l'ensemble de l'activité d'affichage publicitaire au Québec.

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Nos entreprises sont des chefs de file de l'industrie de l'affichage et contribuent activement à la vie des collectivités où elles sont implantées, notamment par le biais d'ententes de diffusion de messages à portée sociale et communautaire.

Ensemble, nos entreprises emploient plus de 500 personnes, directement ou au sein des nombreuses entreprises sous-traitantes, et les retombées de notre activité se chiffrent à environ 75 M $ annuellement.

Les impôts directement versés au trésor québécois représentent plus de 10 M $ par année, sans compter les différentes taxes versées aux municipalités.

Où exerçons-nous nos activités?

Nos activités d'affichage publicitaire doivent d'abord être distinguées des activités d'affichage d'une entreprise (ex. : enseigne pour la raison sociale d'une industrie ou d'un commerce), de même que des affiches dans les vitrines d'un magasin annonçant des produits ou services disponibles sur place. Notre industrie vise spécifiquement l'affichage publicitaire hors-site de nature commerciale, sociale ou caritative.

Nos installations publicitaires sont disséminées le long des principales voies routières, à des endroits stratégiques au plan de la fréquentation.

Les structures érigées par nos entreprises ont beaucoup évolué au fil des ans. Aujourd'hui, ces structures ont un indéniable aspect esthétique, s'adaptent à leur environnement (ex. : limitation des points d'ancrage au sol) et constituent souvent un élément intéressant du paysage urbain.

De plus, des efforts de diversification et d'adaptation aux nombreuses contraintes urbaines ont amené le développement de supports variés : abribus, supports à vélos, affichage vertical, etc.

Quel impact ont nos activités d'affichage sur la sécurité routière?

Les activités d'affichage le long des routes et voies routières sont encadrées par diverses dispositions législatives (deux lois sur l'affichage, respectivement en milieu rural et en milieu urbain, Code de la sécurité routière, Loi sur l'aménagement et l'urbanisme). Ces dispositions président à un partage entre certaines responsabilités qui incombent à l'État québécois et certaines autres qui incombent aux municipalités et MRC.

L'effet de ces diverses dispositions législatives est d'encadrer l'implantation d'affiches à des endroits où elles pourraient constituer un désagrément visuel.

Il est souvent nécessaire de rappeler que, contrairement à certaines idées reçues, l'activité d'affichage publicitaire ne fait pas partie des principaux « irritants » à la sécurité des usagers de la route.

En effet, dans un premier temps, le récent document de consultation produit par la Commission des transports et de l'environnement de l'Assemblée nationale, dans le cadre de sa consultation sur la sécurité routière, de même que la « politique de sécurité routière dans les transports 2001-2005 » du Ministère des transports du Québec, ne relèvent pas cet élément parmi les problèmes de sécurité routière.

Bien plus, les principales lois encadrant l'affichage publicitaire ne sont pas répertoriées parmi l'ensemble des instruments législatifs présidant au partage des responsabilités en la matière (tableau 1, document de consultation de la Commission des transports et de l'environnement, p.5).

Dans un second temps, diverses études sont venues soutenir cette réalité au cours des dernières années (voir annexe 1 pour plus de détails sur ces études).

Brièvement rappelées, ces études confirment l'absence totale de lien causal entre la présence de publicités le long des voies publiques et le taux d'accidents (Bellavance, 2003; Tantala & Tantala, 2004), la capacité des conducteurs à discerner entre les informations qui leur sont suggérées par l'ensemble des stimuli externes à la route elle-même (paysage, affiches, personnes, maisons, etc.) (Virginia Tech Transport Institute, 2004), sans compter le rappel fréquemment démontré, par diverses méthodes d'analyse, de l'absence de lien statistique enregistré aux États-Unis entre la présence de publicités le long des routes et le taux d'accidents.

Une contribution plus active à la sécurité routière

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Les entreprises membres du Regroupement bénéficient de plusieurs centaines de sites très bien localisés, situés à des endroits passants, et peuvent compter sur des structures bien conçues et bien éclairées. De plus, elles jouissent d'une expertise éprouvée en matière de concept publicitaire.

Nos entreprises pourraient, si elles étaient appelées à le faire, contribuer activement à des campagnes ciblées auprès des usagers de la route, de façon sécuritaire (par exemple, sans ajout de panneaux temporaires plus ou moins visibles). Par exemple, en complément au volet « affichage » des campagnes existantes du Ministère des transports, de la Société d'assurance-automobile du Québec ou de l'organisme Éduc'Alcool, on pourrait penser à exercer un rappel visuel constant de l'objectif d'amélioration de la sécurité routière.

Cette contribution pourrait, par exemple, prendre la forme de bandeaux publicitaires ou du recours à une signature particulière, à l'instar de certaines des meilleures campagnes de sensibilisation des dernières années dans le secteur de la santé publique (pour la prévention du sida ou du cancer, contre l'alcool au volant ou la cigarette, etc.).

Conclusion

Comme il est facile de le constater à la lecture des informations résumées ci-haut, les récents développements scientifiques sont venus confirmer l'absence d'impact sur la sécurité routière de l'affichage publicitaire le long des routes.

Les entreprises membres du Regroupement souhaitent cependant aller plus loin et contribuer activement, en partenariat avec les principaux intervenants impliqués dans ce domaine, à des campagnes ciblées de sécurité routière. Leurs installations, bien situées et bénéficiant d'une excellente visibilité, pourraient être mises à profit pour inciter les usagers de la route à adopter un comportement prudent, à divers moments jugés propices pour tenir de telles campagnes de sensibilisation.

Le Regroupement a souhaité tirer parti de la présente consultation pour offrir aux intervenants en sécurité routière la collaboration de ses membres afin d'assurer une meilleure sécurité aux usagers de nos routes.

ANNEXE 1

RÉSUMÉS DES ÉTUDES DE L'INDUSTRIE QUÉBÉCOISE DE L'AFFICHAGE

Note : les trois études les plus récentes et les plus pertinentes sont détaillées sur chacune des trois premières pages de cette annexe, alors que d'autres références, moins récentes mais toujours valides, figurent à titre de rappel sur la quatrième page de l'annexe.

AN EXAMINATION OF THE RELATIONSHIP BETWEEN ADVERTISING SIGNS AND TRAFFIC SAFETY (AUGUST 2004)

Auteurs: M. Tantala & P. Tantala (consulting engineers)

Institution: Transportation Research Board (TRB)

Résumé: L'objet de cette étude est d'examiner la relation entre la présence de panneaux-réclame et la sécurité routière. La première partie de l'étude établit les coefficients de corrélation statistique entre la présence de panneaux-réclame et le taux d'accidents, le long du New Jersey Turnpike, pour quatre années (23,000 accidents). Les scénarios envisagés comprennent des variantes pour tenir compte de la présence des échangeurs. Les résultats établissent la relation entre la densité relative d'accidents et de panneaux-réclame, la « distance de réaction » de l'usager de la route et la distance des panneaux-réclame.

La seconde partie de l'étude se concentre sur l'analyse du taux d'accidents à un lieu spécifique, tant avant qu'après l'installation d'un panneau-réclame. Les résultats font état d'une baisse du taux d'accidents malgré une hausse du volume de trafic enregistré.

Les résultats de cette étude basée sur des méthodes géo-spatiales et géo-statistiques, permettent de conclure que les panneaux-réclame n'ont aucune influence de nature statistique sur les accidents routiers, de même qu'il n'existe pas de relation causale entre la présence de panneaux-réclame et les accidents.

DRIVING PERFORMANCE IN THE PRESENCE AND ABSENCE OF BILLBOARDS (DECEMBER 2003)

Auteurs: S. Lee, E. Olsen & M. DeHart

Institution: Center for Crash Causations and Human Factors, Virginia Tech Transportation Institute

Résumé: L'étude avait pour but de déterminer si le comportement d'un usager de la route était modifié par la présence de panneaux-réclame. Pour ce faire, les participants (représentatifs de la population en général) devaient ignorer le but de l'étude. Ces derniers étaient filmés de façon continue de différents angles, et diverses données recueillies à chaque dixième de seconde permettaient de mesurer l'impact de la présence de panneaux-réclame sur divers paramètres de conduite (changements de voie, vitesse, etc.). Au total, près de 11 000 déplacements d'yeux et 100 000 éléments de données ont été analysés.

Les résultats obtenus indiquent sans conteste que la présence de panneaux-réclame ne cause aucun changement dans le comportement des conducteurs, que ce soit au niveau du comportement visuel, du maintien de la vitesse ou encore du comportement en corridor (voie de circulation).

Par le choix d'un centre urbain de taille moyenne aux États-Unis (Charlotte, Caroline du Nord), de même que par le choix du trajet routier (portions urbaines, semi-urbaines et quasi-rurales) et par la localisation des panneaux-réclame relativement proches de la route, les résultats de cette étude peuvent être généralisés à l'ensemble des milieux urbains.

ÉTUDE SUR LES PANNEAUX-RÉCLAME LE LONG DES ROUTES ET L'INCIDENCE DES ACCIDENTS DANS LE VOISINAGE IMMÉDIAT DE CES PANNEAUX (JUIN 2003)

Auteur: Dr. François Bellavance, PhD Statistiques

Institution: Laboratoire sur la sécurité des transports, Centre de recherche sur les transports, Université de Montréal

Résumé: Cette étude, réalisée sur la base des données d'accidents de la Société d'assurance automobile du Québec (SAAQ) pour l'île de Montréal de 1992 à 1998, démontre l'absence totale de lien causal entre la présence de publicités le long des voies publiques et le taux d'accidents.

L'étude démontre, en utilisant trois méthodes statistiques différentes[1], qu'il n'y a aucune différence dans l'évolution du nombre d'accidents pour une même période entre des sites où il n'y a jamais eu de panneaux prohibés et d'autres sites de configuration similaire où ont été installés plusieurs panneaux qui auraient été prohibés si la Loi 129 avait été en vigueur à cette époque.

[1] Analyses descriptives et cartes de contrôle; évolution du nombre d'accidents dans des zones choisies (par rapport à des zones témoins); séries chronologiques des nombres mensuels d'accidents.

AUTRES RÉFÉRENCES UTILES EN MATIÈRE D'IMPACT DE L'AFFICHAGE SUR LA SÉCURITÉ ROUTIÈRE...

Diverses autres études méritent d'être rappelées malgré le fait qu'elles datent de plus longtemps. Ces études sont disponibles dans la majorité des bibliothèques spécialisées en transport.

- Schwab, Richard N. *Safety and Human Factors Design Considerations for On-Premise Commercial Signs*, 1997, ISA, Alexandria, Virginia.

- Andreassen, David, Technical Report (AIR 000-213), 1984, Australian Road Research Board (voir également le résumé dans *Australian Road Research*, 1985, volume 15, pp. 103-105).

- "*Do Billboards cause Highway Accidents*?" in The Accident Reporter, février 1974.

- Les études réalisées par le Dr. Ernest E. Blanche entre 1961 et 1974 sur différentes artères routières des Etats-Unis, dont « *The Roadside distraction : how big a role does it play in accidents ?* » in Traffic Safety, Nov. 1965, pp. 24-25, 36-37.

- Lauer, A.R. et McMonagle, J. Carl « *Do Road Signs Affect Accidents ?* », 1955, Traffic Quarterly 9 (3), p. 322.

- McMonagle, J. C. « Traffic Accidents and Roadside Features » Highway Research Board, no. 55, 1952, p. 38.

- McMonagle, J. C. « Accident Analysis: Telegraph Road 1947-1948 », Highway Research Board, no. 30, 1951, p. 29.

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REGROUPEMENT DE L'INDUSTRIE DE L'AFFICHAGE AU QUÉBEC

ÉTUDES RÉCENTES SUR L'IMPACT DE L'AFFICHAGE SUR LA SÉCURITÉ ROUTIÈRE

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TABLE DES MATIÈRES

Tantala - 2004

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An Examination of the Relationship between Advertising Signs and Traffic Safety

by

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ABSTRACT

The purpose of this study is to examine the relationship between advertising signs and traffic safety. The first part of this study establishes statistical correlation coefficients between advertising signs and accidents along the New Jersey Turnpike (for more than four years of data and about 23,000 accidents). This study considers various situations, with and without bias from turnpike interchanges. The results are analyzed for a variety of commonly accepted scenarios relating accident density to sign-density (the number of signs), to Viewer Reaction Distance (how far from a sign the driver is potentially within the "influence" of a sign), and to sign proximity (how far the accident is from the nearest sign). The second part of this study examines the incidence of traffic accidents at a specific, recently installed sign and for a period of time both before and after the installation of the sign. After the installation of a specific, advertising sign at a Pennsylvania intersection, the traffic volume increased, the APV (accident rate) decreased, the maximum number of accidents in any given day or week decreased. The results of this study conclude that advertising signs have no significant statistical influence on the occurrence of accidents. These analyses also suggest that no causal relationship between advertising signs and accidents exists. Geospatial and geostatistical methods are used rigorously.

Key Words: Advertising Signs, Traffic Safety, Accidents, Correlation, GIS

INTRODUCTION

The United States has approximately four million of miles of roads, highways, streets, and other traveled ways used for the navigation of motor vehicles. Virtually all of these roads have some type of signage associated with them, whether the signs are directional, informational, regulatory, identifying, advertising, or other types. Signs are necessary in order to promote efficient navigation, to disseminate vital wayfinding or safety information, to identify locations or destinations, to regulate traffic, to advertise, etc. For these functions, signs and roads are inseparable. Unfortunately, traffic accidents on roads also occur in the millions annually. Accidents may be attributable to many factors, including poor road conditions, driver ability, traffic volume, distractions, *etc.* Although advertising signs account for only a small percentage of all signs along roads, advertising signs have been viewed as a cause of distraction-related accidents (*1,2,3*). For this reason, advertising signs are heavily regulated, even though the relationship between signs and traffic safety has not been comprehensively established.

There have been several papers that have reviewed research on the relationship between signs and traffic safety: Andreassen (*4*), Farbry et al (*5*) and Wallace (*3*). The first serious research studying the relationship between accidents and roadside features was the Michigan Study carried out in the early 1950s by McMonagle (*1*), which concluded that accidents are correlated with road complexity (intersections, etc). Similar studies of accidents in different geographic areas followed in Minnesota by Staffeld (*6*), in Iowa by Rusch (*2*), in New Jersey by Blanche (*7*). Ady (*8*) performed a before and after study of accidents near nine specific advertising signs over several years. Holohan (*9*) conducted a series of studies in the mid-1970s at over sixty intersections in Austin, Texas. More recently, the Wisconsin DOT examined the crash rates on Interstate 94 eastbound and westbound adjacent to the Milwaukee County Stadium, for three years before and three years after the installation of a variable message advertising sign (*10*).

This study examines the relationship between signs and traffic safety, and evaluates the correlation between signs and accidents for particular roads and conditions. The study examines two situations which involve signs and traffic. In the first situation, a highway with advertising signs is selected and studied, including analysis of sign location, road conditions, traffic-accident locations, *etc*, for the purpose of determining if traffic accidents are more prevalent at or near existing signs. Statistical correlation coefficients are used as the basis for comparison of the results. In the second situation, the location of a recently installed sign is identified, and the incidence of traffic accidents near the sign is examined, for a time period both before and after the installation of the sign, for the purpose of establishing whether traffic accidents occurred more frequently in the presence of the sign.

SIGN-ACCIDENT CORRELATION

The purpose of the Sign-Accident Correlation part of the study is to examine whether traffic accidents occur more frequently at or near signs on a specific roadway. Essentially, the Sign-Accident Correlation is a comparison of the location of signs and the location of accidents. These two sets of data are quantitatively compared using correlation coefficients.

Methodology

The procedure employed in this study involves collecting accident information for a given road, analyzing and assembling the information into useful data, identifying where advertising signs are located along the road, statistically analyzing the data by comparing the sign locations and the accident locations, and calculating correlation coefficients for these sets of data.

Road

The roadway examined in this part of the study is the New Jersey Turnpike. The New Jersey Turnpike (Turnpike) was selected over other thoroughfares, for many reasons conducive to the study. The Turnpike, shown in Figure 1, is generally oriented northbound-southbound, is a limited-access highway servicing the entire state of New Jersey and through traffic, is operated by the New Jersey Turnpike Authority, and is proximate to several metropolitan areas, including New York City and Newark at its northern end, the state capital of Trenton near its central portion, and Philadelphia near its southern portion. The Turnpike is 113.8 miles long, and extends from the George Washington Bridge (New York State) at its north terminus, to State Route 130 near the Delaware Memorial Bridge (State of Delaware) at its south terminus (mile marker 0). The Turnpike also includes a 6.55-mile spur to its west which allows traffic to and from the Pennsylvania Turnpike. This study does not include the spur portion of the Turnpike.

The Turnpike is a limited-access, toll highway, with 18 entrances/exits (interchanges) along its length; the average distance between interchanges is approximately five miles. Most of the road is divided, with five lanes of traffic in each direction; the northern portion of the highway is further divided, with traffic in each direction segregated into "cars only" and "car and truck" traffic lanes. The posted speed limit along the entire Turnpike is 65 miles per hour. Signage along the Turnpike is strictly regulated, and is subject to local permitting procedures, in addition to state and Turnpike Authority approval.

Signs

Several types of signs exist along the Turnpike, including advertising signs, directional signs, informational signs, emergency signs, markers, *etc*. Figure 1 shows typical signs along the Turnpike. This study examines only large, advertising signs, and only those signs which are intended to principally advertise to traffic on the Turnpike.

The studied signs are graphically located in Figure 1 (each solid dot represents a sign); the signs include both accessory (on-premise) and non-accessory (off-premise) signs. All the signs are freestanding structures, and almost all are large, static, double-faced, advertising to northbound and southbound traffic. Almost all the signs are either internally or externally illuminated; only a few are not illuminated. The number of studied signs is 123: 72 located to the east side of the Turnpike and 51 to the west side of the Turnpike. Twenty-one signs are accessory, 102 are non-accessory, and one sign had its head removed and was temporarily only a sign upright.

The following assumptions are made concerning the signs.

- Because approximately 94% of the signs (116 of the 123) advertise to both northbound and southbound traffic, or have faces generally perpendicular to the traffic lanes, this study assumes that each of the studied signs has the potential to impact traffic safety on both northbound and southbound traffic within the view (or viewer-reaction) distance of the signs.

- Because approximately 92% of the signs (113 of the 123) are illuminated, this study assumes that all signs are illuminated and visible at all times. This study also assumes that each of the studied signs existed during the years for which traffic accidents were examined.

The location of the signs was determined from field-investigation, by identifying the mile marker location (one tenth mile) of each sign; these locations are graphically located in Figure 1, the Sign-Location Plan. The Sign-Location Plan shows that the northern portion of the Turnpike has the highest density of signs, that the central portion has a low to moderate sign density, and that the extreme southern portion has very few signs. Straight-line diagrams, aerial photographs, GIS information, and field-data are used to analyze the location and characteristics of each sign.

Traffic Accidents

Currently, more than 650,000 vehicles travel the New Jersey Turnpike each day. Traffic accident records for the Turnpike are available for certain time periods (*20*). Accidents have been recorded since the Turnpike's completion in 1951 by either the New Jersey Turnpike Authority or the New Jersey State Police. However, only accident data for the past ten years is readily obtainable or computerized. Detailed analysis and assembly of the data indicates that the only years for which reliable accident data is available, are 1998, 1999, 2000, and 2001. Data for 2002 are not available because of recording and storage errors. The total number of accidents for each of these years is listed in Table 1. In all, 22,971 accidents were included in this study. Only reported accidents are part of the study, and all data was obtained from either the New Jersey Turnpike Authority, the New Jersey State Police, and the New Jersey Department of Transportation. For each year, the accident data is segregated and geocoded by mile marker (accurate to one tenth mile), and listed by the number of accidents which occurred at or near each mile marker. Listing the data in this fashion allows a parallel tabulation of sign-location by mile marker, and the subsequent comparison of these parallel sets of data.

Analysis

As stated, both the accident data and the sign locations are assembled, or listed, by mile marker, in order to form a basis for their comparison. Three comparisons of these variables are completed, including a comparison of

- Accident-Density and Sign-Density,
- Accident-Density and Viewer Reaction Distance, and
- Accident-Density and Proximity to Signs.

The above three comparisons are made for each of the four, examined years, and for the aggregate of the four years. A quantitative measure of how well the data compared is obtained by using a statistical correlation coefficient. The results of the correlation coefficient analysis and a discussion of correlation coefficients are in the Results section of this study.

This study also examines a subset of traffic-accident data to assess its relationship to advertising signs. Correlation coefficients are calculated with the same accident data, however excluding those accidents and signs near Turnpike interchanges (entrances/exits) within one mile (½ mile on each side of an interchange). Accident data near Turnpike interchanges have the potential to bias the results, because drivers undertake additional tasks such as lane changes, accelerating/decelerating, negotiating directions, attention to others undertaking additional tasks, *etc* (*13*). These added factors could bias and dilute a study of accident data when compared to typical conditions of straight driving without sources of potential distraction.

Accident Density and Sign Density

This study defines accident density as the number of accidents per mile marker (every tenth of a mile). The sign density, S_m^D, is defined as the number of signs per mile, and is determined using a moving average of the number of signs at each mile marker with a "window" size of one mile, and may be expressed by:

$$\left\{ S_m^D = \sum_{i=1}^{Q} \left[s_i \middle| m - 0.5 \le s_i \le m + 0.5 \right],\ m = 0,\ 0.1, \cdots,\ M \right\} \tag{1}$$

where s_i is the *ith* sign's mile marker location, and Q is the number of signs observed along M, which is the total length of the Turnpike in miles. [The vertical line after s_i in the above equation means "given that", and is not an absolute value symbol.]

The sign density, that is, the average number of signs per mile, varies along the length of the Turnpike, and is shown graphically in Figure 1. The sign density varies from 0 to 9 signs per mile. If a noticeable correlation between signage and accidents exists, then we would expect a significantly larger number of accidents in areas with relatively high sign densities. Histograms illustrating the differences in sign densities and accidents along the Turnpike for data from 1998 to 2001 are shown in Figure 2. Figures 1 and 3 show similar data in the form of a mapped, density plot for sign and accident data along the Turnpike between 1998 and 2001. Our basis for evaluating the relationship between sign locations and accident locations is the correlation coefficient (*21*). The correlation coefficient (ρ) between sign density, S^D, and accident density, A^D, may be calculated using:

$$\rho = \frac{\sum_m (A_m^D - \bar{A}^D)(S_m^D - \bar{S}^D)}{\sqrt{\sum_m (A_m^D - \bar{A}^D)^2 \sum_m (S_m^D - \bar{S}^D)^2}},\ m = 0,\ 0.1, \cdots,\ M \tag{2}$$

The correlation coefficients with their corresponding data are shown in Table 2 for the individual and aggregate years between 1998 and 2001. These coefficients range from -0.098 to +0.219. Figure 4 shows commonly accepted interpretations of correlation coefficients and visual scatter plots to emphasis what various correlation coefficients might represent (*18*). The Correlation coefficients excluding interchange bias are shown with their corresponding data in Table 2 for the individual and aggregate years between 1998 and 2001. While correlation coefficients are a measure of the "strength" of a relationship between two variables, the "significance" of the relationship was also evaluated (i.e., how unlikely a given correlation coefficient will occur given no relations).

Accident Density and Viewer Reaction Distance (VRD)

Accident density, A_m^D, was previously defined as the number of accidents per mile marker (every tenth of a mile). Viewer Reaction Distance (VRD) is a measure of the distance in which a driver has time to "notice" or react to a sign which is in the driver's field of vision. The VRD is the distance to a sign in which the driver is potentially within the "influence" of a sign. Analogously, Viewer Reaction Time (VRT) is the time a driver is within the "influence" of a sign. Reasonable values for VRD were previously determined in previous studies (*15*), and are a function of the driver's speed. The posted speed limit on the Turnpike is 65 mph; this approximately corresponds with a VRD of approximately 0.2 miles and a VRT of 10 seconds. This study uses a binary index, V_m^{VRD}, to represent if a given mile marker is within the VRD, and is represented as

$$\left\{V_m^{VRD} = \begin{cases} 1, & d_m \leq VRD \\ 0 & \text{otherwise} \end{cases}, m = 0, 0.1, \cdots, M\right\} \tag{3}$$

where d_m is the distance to the nearest sign location for m*th* mile marker, VRD is 0.2 (the viewer reaction distance corresponding to a 10 second VRT at the 65 mph on the Turnpike), and M is the total length of the Turnpike in miles. The index d_m is defined as

$$\left\{d_m = \min\left(\left\{|s_i - m|, i = 0,1,\cdots,Q\right\}\right), m = 0, 0.1, \cdots, M\right\} \tag{4}$$

where s_i is the ith sign's mile marker location and Q is the number of signs observed.

The correlation coefficient between accident density, A^D, and viewer reaction distance, V^{VRD}, is calculated similar to that which was previously defined. These correlation coefficients are shown with their corresponding data in Table 2, for the individual and aggregate years between 1998 and 2001. Correlation coefficients excluding interchange bias are also shown with their corresponding data in Table 2 for the individual and aggregate years between 1998 and 2001. Correlation coefficients are determined for data that are within 0.2 miles of the nearest sign, based on the previous discussion of Viewer Reaction Distance. If a noticeable correlation exists between signage and accidents, then we would expect significant changes in the number of accidents occurring 0 to 0.2 miles from any sign.

Number of Accidents and Proximity to Signs

Accident density, A_m^D, was previously defined as the number of accidents per mile marker (every tenth of a mile). An index, P_m, is used to represent proximity to signage, and is simply the distance from a individual mile marker to the nearest sign. P_m may be expressed by:

$$\left\{P_m = |d_m - m|, m = 0, 0.1, \cdots, M\right\} \tag{5}$$

where d_m is the distance to the nearest sign location for mth mile marker and M is the total length of the Turnpike in miles. The correlation coefficients between sign proximity indices, A^D, and accident density, V^{VRD}, are similar to that previously defined. Table 2 shows these correlation coefficients with their corresponding data for the individual and aggregate years between 1998 and 2001. If a noticeable correlation exists between signs and accidents, then we would expect more accidents at locations which are closer to signs.

Correlation coefficients are determined for data that are within 0.4 miles of the nearest sign. Based on previous discussion of Viewer Reaction Distance (VRD), 0.4 miles is twice the 0.2 mile VRD value. If a noticeable correlation exists between signs and accidents, then we would expect significant changes in the number of accidents between the 0 and 0.2 mile range and the 0.2 and 0.4 mile range, and the correlation coefficient would be large (close to ±1.00). However, these correlation coefficients are actually close to zero, indicating almost statistical independence, or no relationship or tendency for signs to influence traffic accidents. Further, when interchange bias is excluded, these correlation coefficients move closer to zero, again suggesting no causal relationship.

Results

This study seeks to evaluate if road signs have an influence on the occurrence of traffic accidents. As discussed, a useful measure of compliance ("association") between two sets of data (signs and traffic accidents) is the correlation coefficient (*16*). If the variables "tend" to go up and down together, then the correlation coefficient will be positive. If the variables "tend" to go up and down in opposition with each other, the correlation coefficient will be negative. By definition, a correlation coefficient can be no larger than +1, and can be no smaller than -1. Values at or near +1 indicate a perfect one-to-one correlation, and values at or near -1 indicating perfect inverse correlation. Values at or near zero indicate statistical independence of one set of data with respect to the other. Statistically, a correlation coefficient of 0.7 or smaller is considered to indicate "weak" correlations, at best, and does not indicate much difference from correlation coefficients of zero (*12*). It is important to note that correlation is not necessarily causation, even though it may be an indicator. Table 2 lists the correlation coefficients obtained for the relationships examined in this study, namely:

- Accident Density and Sign Density,
- Accident Density and Viewer Reaction Distance, and
- Accident Density and Proximity to Sign.

As seen in Table 2 and Figure 5, the correlation coefficients for accident density and sign density are all statistically low, with coefficients ranging from +0.140 to +0.209. When signs and accidents within one-half mile of interchanges are excluded, almost all of the coefficients are lower, and range from +0.077 to +0.199. Each of these coefficients indicates zero to extremely weak correlation between the locations of signs and the locations of accidents. As shown in Figure 6 when interchange bias is excluded, the coefficients are generally closer to zero, further suggesting that no statistical or causal relationship between sign density and accident density exists.

The correlation coefficients results for accident density and Viewer Reaction Distance (VRD) vary between +0.129 and +0.220. These coefficients are low, are close to zero, and correspondingly indicate less than marginal or no correlation between signs and accidents. Again, the coefficients are lower with the exclusion of interchange bias, further suggesting a lack of relationship or dependence between signs and accidents.

Each of the correlation coefficients for accident density and proximity to the sign is negative, indicating that a slight inverse correlation exists regarding sign locations relative to the location of accidents. In other words, the accident rate was higher at locations farther from the nearest sign, but only slightly. These negative coefficients are also close to zero, and we must, therefore, conclude statistical independence. Also of note is the fact that the correlation coefficients are relatively consistent from year to year within each category. No large increases or decreases in the coefficients exist from year to year. This consistency positively influences the confidence in the study results. Additional, preliminary calculations were performed to account for variations in traffic volume along the New Jersey Turnpike. When the discrete values for accident density are weighted by average yearly Turnpike volume rates, the resultant correlation coefficients decrease in all cases compared by an average of 12% (*11*).

SPATIAL COMPARISON

Methodology

The purpose of this Spatial Comparison part of this study is to examine the incidence of traffic accidents at an intersection at a specific, recently installed sign and for an equal period of time before and after the installation of the sign, and to determine if traffic accidents occurred more frequently or less frequently with the presence of the sign. Sign data are statistically compared using histograms and average accident-per-volume (APV) ratios for one year before the sign was installed and for one year after the sign was installed. It should be emphasized that there were no other, substantial changes at the intersection where this selected sign is located, other than the installation of the selected sign, a slight increase in traffic volume, and the winter snowfall.

Location

The selected sign is near the Oxford Valley Mall in Middletown Township, Bucks County, Pennsylvania. The sign is at the northeast corner of the Lincoln Highway (U.S. Business Route 1) and Woodbourne Road. The intersection is controlled by a traffic control signal. The sign was installed on or about January 28, 2002 (*23*).

Sign

The selected sign is a free-standing, double-face, accessory (on-premise) structure with two uprights. Each sign face is rectangular, measures 6 feet high by 15 feet wide, and has a sign-face area of 90 square feet. The top of the sign is approximately 25 feet above the grade adjacent to the sign. The sign faces are internally illuminated and include an electronic-message-panel display. The sign faces are oriented approximately perpendicular to the Lincoln Highway, and are intended to principally advertise to traffic on the Lincoln Highway, and secondarily advertise to traffic on Woodbourne Road. The findings at this location are particularly relevant because of the dynamic nature of the sign itself which, as noted, contains a high-contrast electronic-message-panel. Animation of this feature was observed to include varied aspects of simulated movement including scrolling, wipe-on, wipe-off, blending, and rapid copy variations involving different messages in a constantly changing mode of operation (*13*).

Traffic Accidents

At the Lincoln Highway and Woodbourne Road intersection, the Pennsylvania Department of Transportation (PennDOT) recorded an average, daily traffic-count of 18,500 vehicles in 2001 and 20,000 vehicles in 2002. Data were obtained from police accident reports which were provided by PennDOT for a period of one year before, and one year after, the sign installation at this intersection (*22*). At this intersection, 68 accidents occurred in 2001, which is prior to the installation of the sign, and 60 accidents occurred after the sign installation, which approximately represents a one in a hundred thousand chance of an accident at this intersection based on average traffic volumes. The number of accidents for this part of the study is listed in Table 3.

Analysis

The accident data assembled for this part of the study are based on the proximity to the sign and on when the accident occurred. To examine how this one specific intersection is impacted by the introduction of a sign, comparisons were made of

- changes in traffic accidents-per-volume (APV) ratios, and
- histograms of the accident data on a temporal basis.

Accidents-per-Volume (APV) Ratios

A quantitative measure of comparing traffic safety is to use accidents-per-volume (APV) ratios (*14*). The APV ratio is calculated by

$$\text{APV} = \frac{\text{Number of accidents}}{\text{Annual Traffic Volume}} \tag{6}$$

Table 3 summarizes accidents, annual traffic volumes and APV ratios for the sign at the Lincoln Highway and Woodbourne Road intersection for 2001 and 2002. The number of accidents decreased 11.8% from 2001 to 2002; the traffic volume also increased by 5.3%. If we compared the APV ratios, then the accident rate decreased by 16% after the introduction of the sign at this intersection.

Histogram Comparison

Using the summarized, PennDOT, accident-report data (*22*) we show in Figure 7, the composite distribution of accidents before and after the installation of the sign (on or about January 28, 2002) as a weekly histogram for the Lincoln Highway and Woodbourne Road intersection. A comparison of the histograms of accidents (on either a weekly or a daily basis) at the intersection in 2001 (before sign installation) and in 2002 (after sign installation), indicates no substantial change in accident patterns. The peak number of accidents on any given week decreased from 5 to 4, after the introduction of the sign at the intersection; the peak number on any given day decreased from 3 to 2. The number of accident-free days increased from 42 to 43; the number of accident-free weeks remained the same at 15. Based on the data, no significant change in accident occurrences can be attributed to the introduction of this advertising sign. It should also be noted that the later months of 2002, the year after the installation of the sign, had significantly greater snowfall (*19*). This additional snowfall could be an influencing factor of why the accident occurrence rates were not less than they already are (relative to those in 2001). This is evident because there are slightly more accidents in the winter months (generally weeks 40 to 52) of 2002 than in the rest of the year.

Results

For this sign, the results suggest that advertising signs in and of themselves have no influence on the occurrence of traffic accidents. The most useful measures of traffic-accident occurrence at any specific location (APV, peak daily accidents, peak weekly accidents, accident free days and accident free weeks) are evaluated and compiled in Table 4. After the introduction of this advertising sign, traffic volume increased, the APV (accident rate) decreased, the peak number of accidents on any given day or week decreased, the number of accidents-free days increased, and the number of accident-free weeks remained the same. These measures indicate no significant changes in accident occurrences directly after the introduction of the advertising sign at this busy intersection.

The number of accidents was relatively steady from 2001 to 2002. No large increases or decreases occurred in the values from year to year. With the exception of a new sign, there were no other changes at this intersection. No new buildings, changes in lane/intersection topography, zoning or traffic-light signalization/timing were introduced. The analysis reinforces the results of the Sign-Accident Correlation part of this study and further suggests that advertising signs in and of themselves have no influence on the occurrence of traffic accidents. It should be noted that only a small sample of accident data was evaluated for this sign over a two year period. A more robust analysis will require more accident data over time to further verify how accident rates are changed for this particular intersection and to disregard random year-to-year variations. Preliminary research is currently being conducted to study a larger number of signs over larger periods of time before and after their installations (*11*).

CONCLUSIONS

The results of this study conclude that advertising signs have no statistical influence on the occurrence of accidents. The following are the conclusions of this study.

- Correlation coefficients are statistical measures of the "association" between two sets of data, such as signs and traffic accidents. The correlation coefficients developed in this study consistently confirm, for more than four years of data (about 23,000 accidents), that the coefficient values are generally close to zero (between -0.070 and +0.220).
- The correlation coefficients establish that no statistical relationship between signs and accidents exists. These correlation coefficients also suggest that no causal relationship between signs and accidents exists.
- Turnpike interchanges have the potential to unfairly bias the results because drivers undertake additional tasks, such as lane changes, accelerating/decelerating, and negotiating directions. If the data near Turnpike interchanges is excluded, then the correlation coefficients converge even more closely to zero (between -0.030 to +0.194).
- The interchange bias-free correlation coefficients further reinforce the premise that no statistical relationship between signs and accidents exists. These data also suggest that no causal relationship between signs and accidents exists.
- After the installation of the specific, advertising sign at a Pennsylvania intersection, the traffic volume increased, the APV (accident rate) decreased, the maximum number of accidents in any given day or week decreased and the number of days without accidents increased.

- After the installation of the specific, advertising sign at a Pennsylvania intersection, histogram analysis indicates no statistically significant changes in accident occurrences after the installation of the advertising sign at this busy intersection.

The results of this study conclude that advertising signs have no statistical influence on the occurrence of accidents. These analyses also suggest that no causal relationship between signs and accidents exists. Traffic accidents may be much more likely attributable to, and correlated with, other factors, such as driver fatigue, poor road conditions, driver abilities, traffic volume, legitimate distractions, *etc.*

ACKNOWLEDGEMENTS

This study was funded by a grant from the United States Sign Council Foundation (USSCF) as part of the Council's on-going effort to provide a verifiable body of knowledge concerning sign usage within the built environment. Readers are encouraged to visit the USSCF at http://www.usscfoundation.org.

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TABLE 1. Number of Traffic Accidents on the New Jersey Turnpike

Year	Number of Accidents
1998	5,122
1999	5,348
2000	6,204
2001	6,297
Total	22,971

TABLE 2. Correlation Coefficient Results

Comparison	1998	1999	2000	2001	Aggregate 1998-2001
Accident Density and Sign Density **with** interchange bias	+0.188	+0.140	+0.209	+0.119	+0.209
Accident Density and Sign Density **without** interchange bias	+0.199	+0.097	+0.195	+0.077	+0.193
Accident Density and View Reaction Distance **with** interchange bias	+0.180	+0.158	+0.212	+0.129	+0.219
Accident Density and View Reaction Distance **without** interchange bias	+0.175	+0.117	+0.181	+0.090	+0.194
Accident Density and Proximity to Sign **with** interchange bias	-0.076	-0.057	-0.098	-0.013	-0.077
Accident Density and Proximity to Sign **without** interchange bias	-0.022	-0.061	-0.077	-0.050	-0.026

TABLE 3. Accidents, Volume and APV at Woodbourne Road Intersection

Measure	Prior to Sign (before 28Jan02)	After Sign Installation (after 28Jan02)	
Traffice Accidents			**Total**
on the Lincoln Highway	35	33	68
on Woodbourne Road	33	27	60
Totals	68	60	128
At Intersection			**% change**
Total Accidents	68	60	-11.8%
Average Traffic Volume	6,935,000	7,300.000	+5.3%
APV	0.00098%	0.00082%	-16.3%
APV Equivalent	1 in 101,985	1 in 121,666	

TABLE 4. Spatial Comparison Results

Measure	**Prior to Sign** (before 28Jan02)	**Afer Sign Installation** (after 28Jan02)
Accidents	68	60
APV	0.00098%	0.00082%
APV Equivalent	1 in 101,985	1 in 121,666
Peak Daily Accidents	3	2
Peak Weekly Accidents	5	4
Accident Free Days	42	43
Accident Free Weeks	15	15

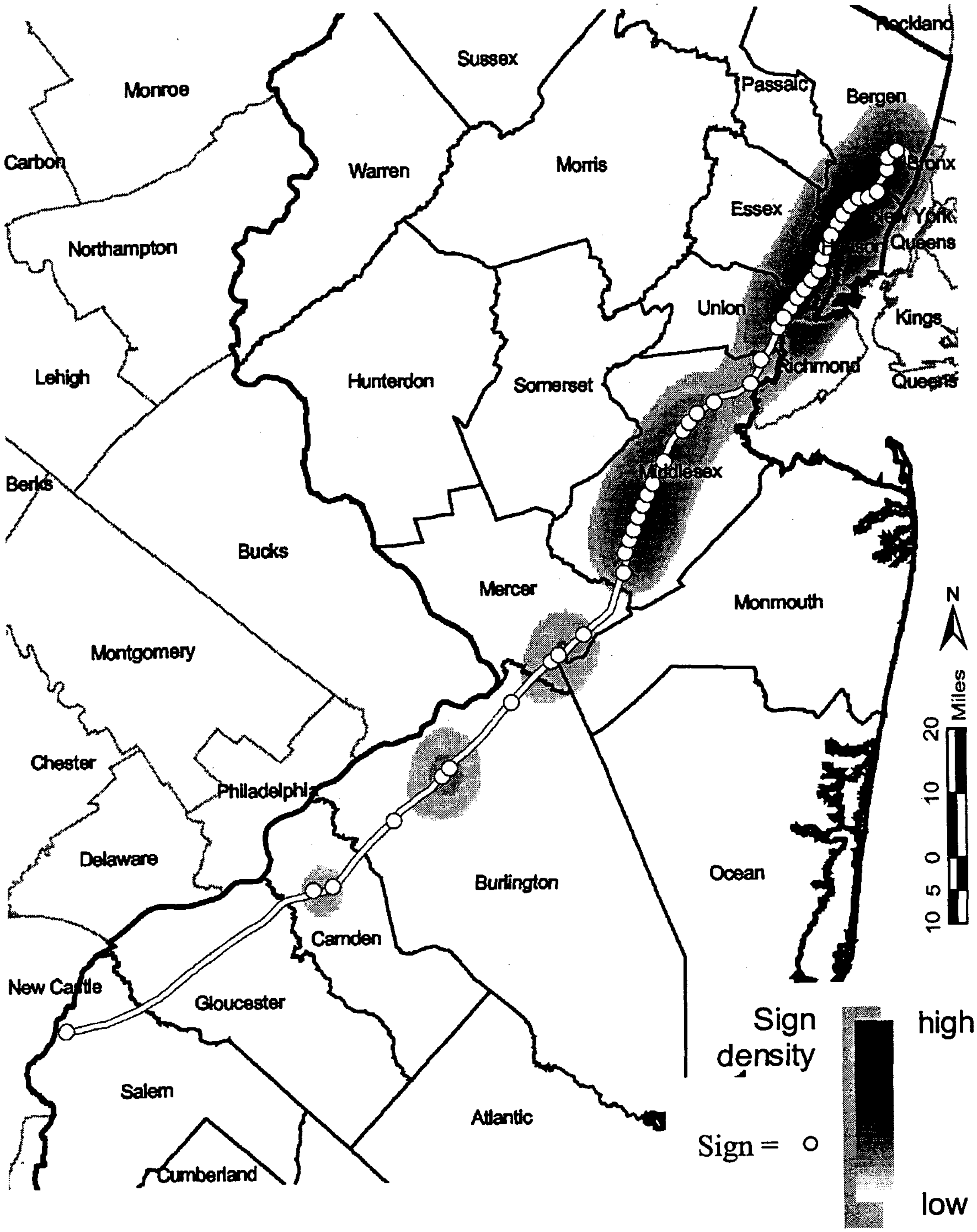
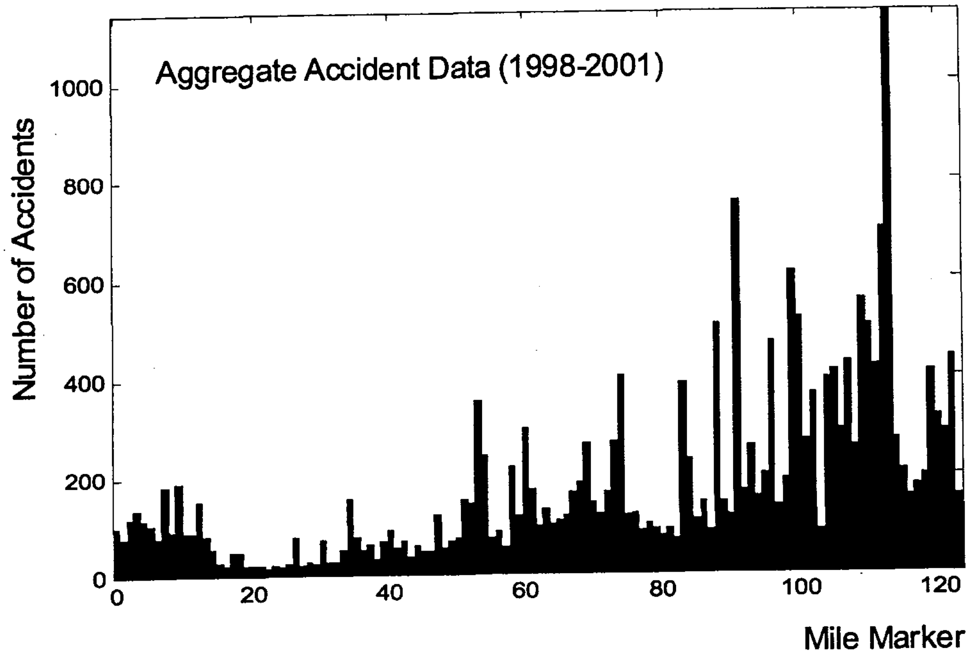


FIGURE 1. New Jersey Turnpike, Sign-Location Plan, and Sign Density



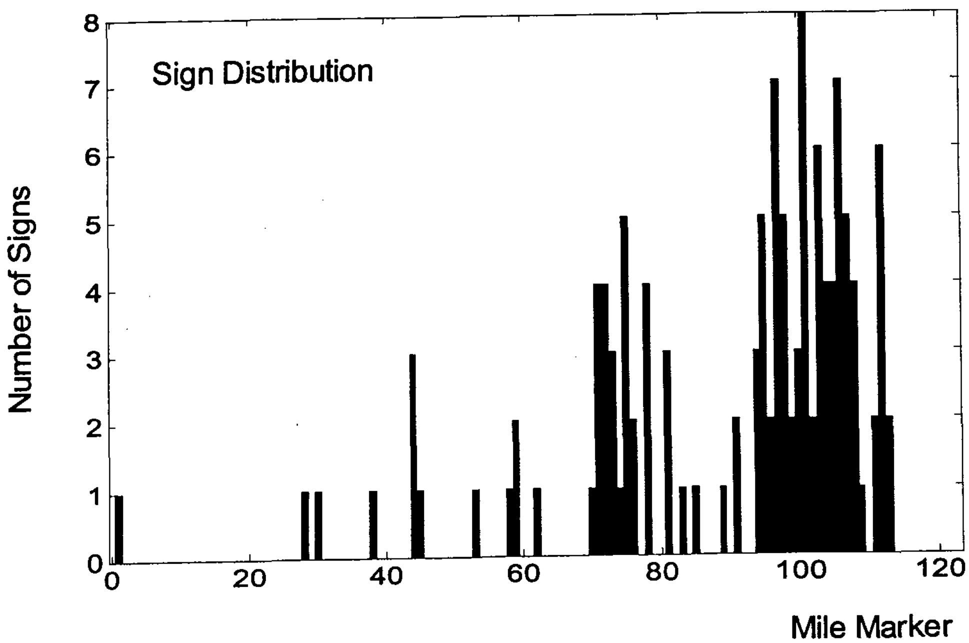


FIGURE 2. Comparison of Accidents with Sign Locations by Mile Marker

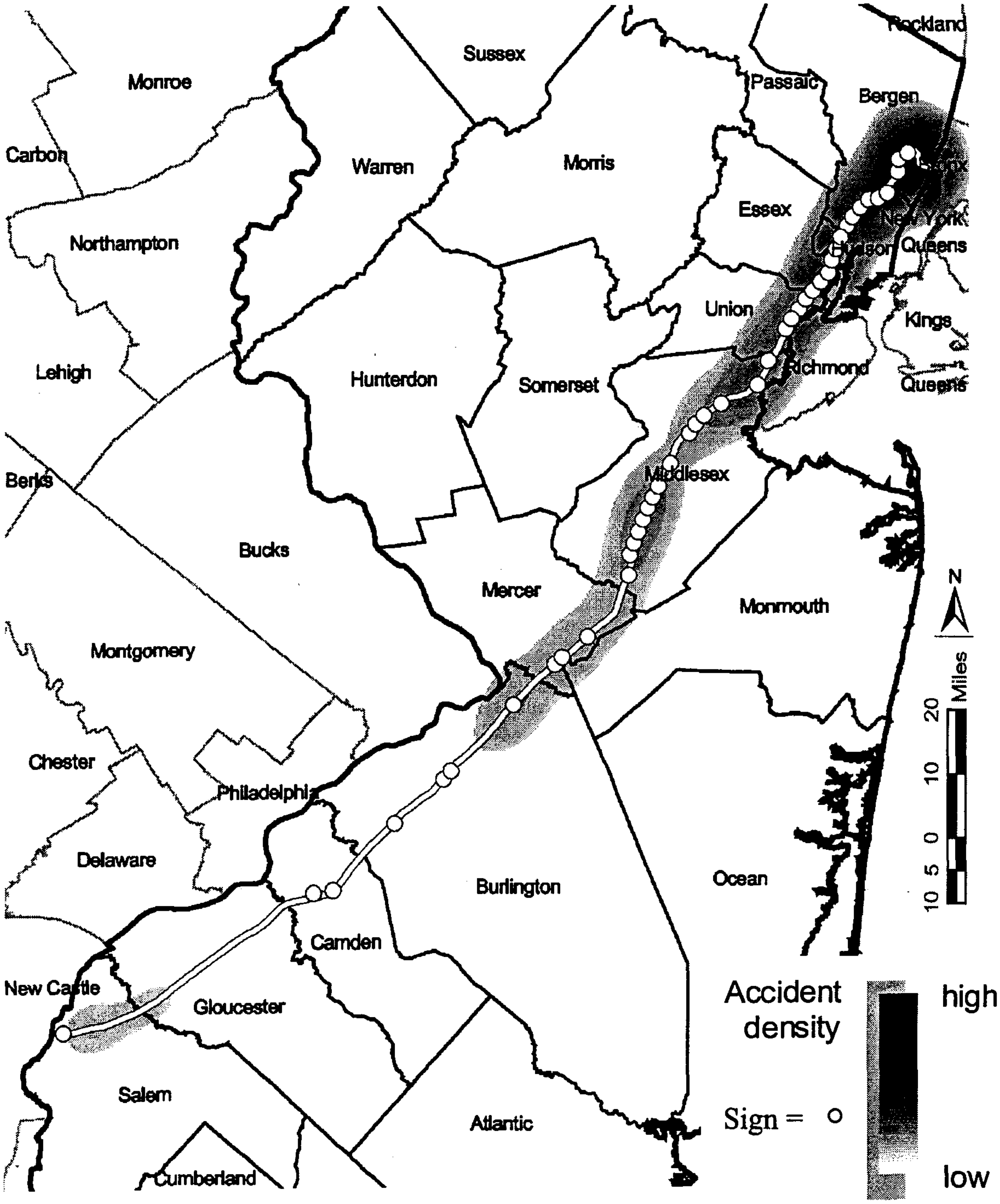


FIGURE 3. Aggregate Accident Density for 1998-2001

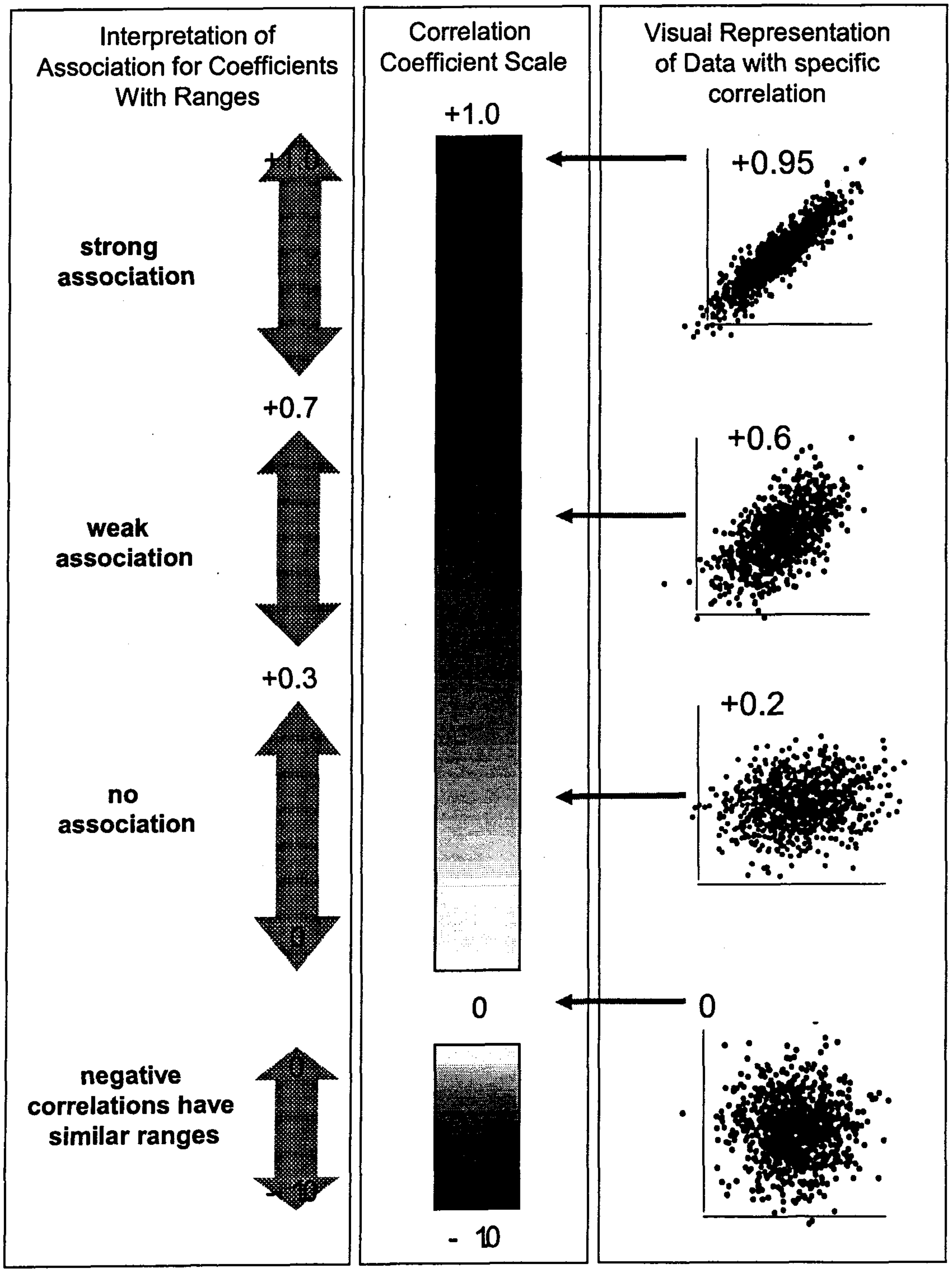


FIGURE 4. Visual Interpretations of Correlation Coefficients

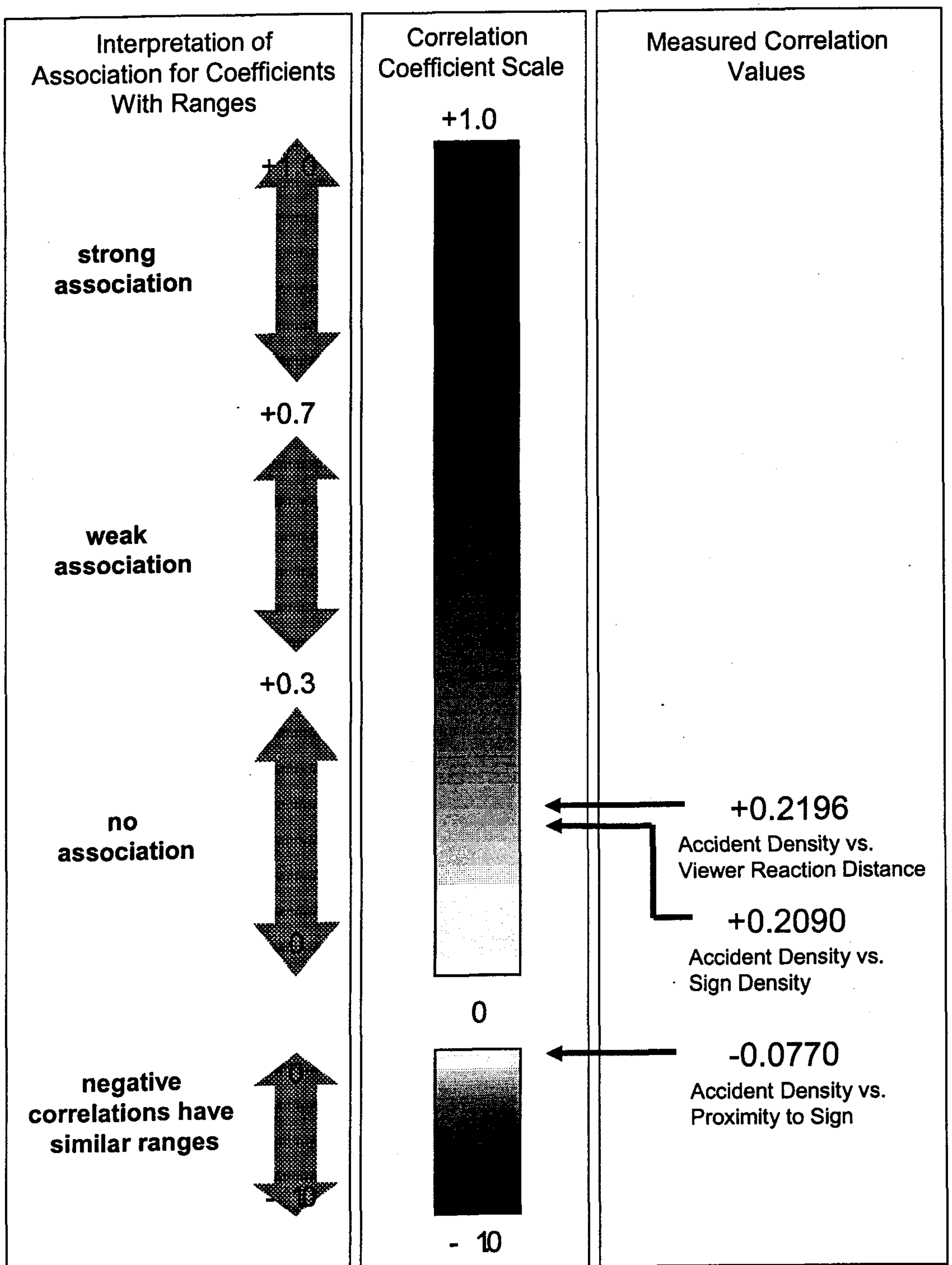


FIGURE 5. Calculated Correlation coefficients with Interchange Bias

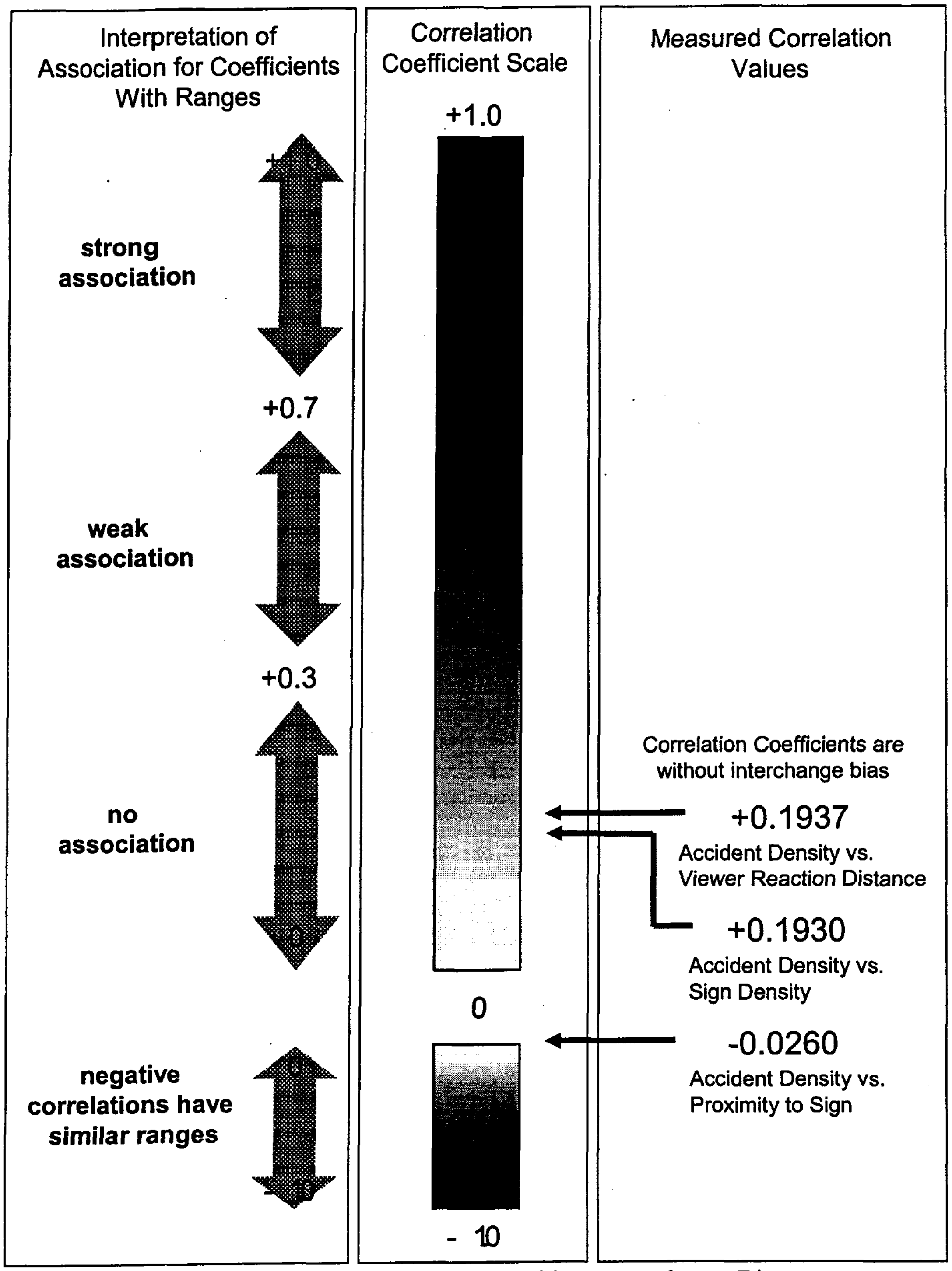


FIGURE 6. Calculated Correlation coefficients without Interchange Bias

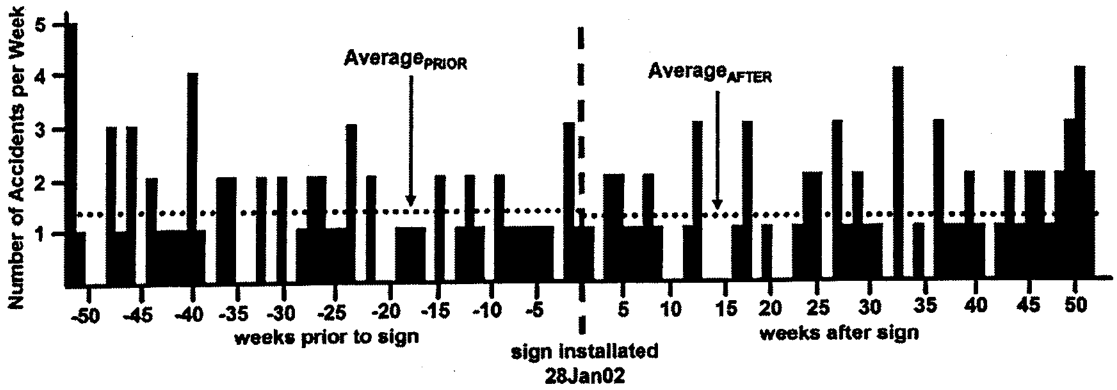


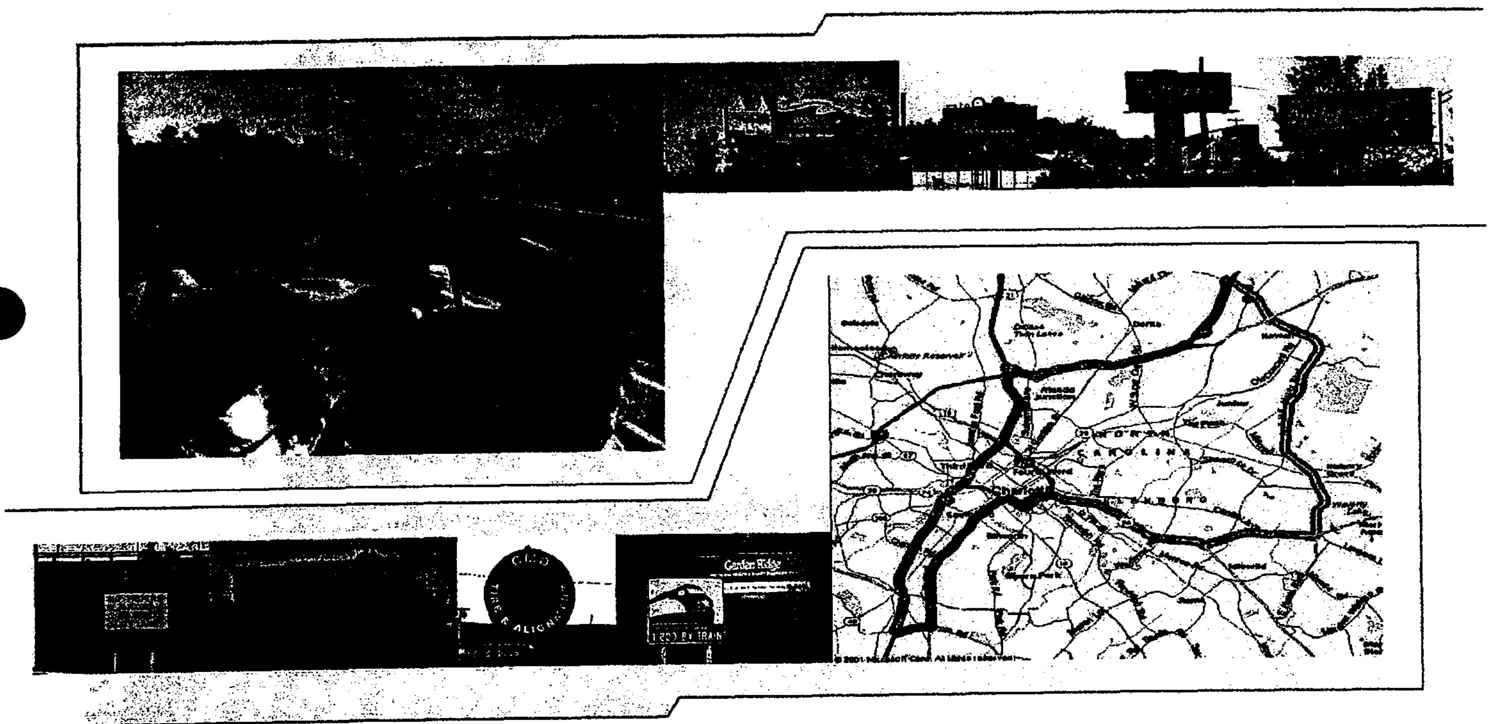
FIGURE 7. Composite Weekly Histogram of Woodbourne Road and the Lincoln Highway Intersection Accidents in 2001-2002

Virginia Tech - 2003

Driving Performance in the Presence and Absence of Billboards

FINAL REPORT

Prepared for
Foundation for Outdoor Advertising Research and Education



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February 29, 2003

ABSTRACT

The current project was undertaken to determine whether there is any change in driving behavior in the presence or absence of billboards. Several measures of eyeglance location were used as primary measures of driver visual performance. Additional measures were included to provide further insight into driving performance--these included speed variation and lane deviation. The overall conclusion from this study is that there is no measurable evidence that billboards cause changes in driver behavior, in terms of visual behavior, speed maintenance, and lane keeping. A rigorous examination of individual billboards that could be considered to be the most visually attention-getting demonstrated no measurable relationship between glance location and billboard location. Driving performance measures in the presence of these specific billboards generally showed less speed variation and lane deviation. Thus, even in the presence of the most visually attention-getting billboards, neither visual performance nor driving performance changes measurably.

In order to capture the forward view and two views of the driver's face and eyes, participants in this study drove a vehicle equipped with cameras. The vehicle was also equipped with a data collection system that would capture vehicle information such as speed, lane deviation, GPS location, and other measures of driving performance. Thirty-six drivers participated in the study, driving a 35-mile loop route in Charlotte, North Carolina. A total of 30 billboard sites along the route were selected, along with six comparison sites and six baseline sites. Several measures were used to examine driving performance during the 7-seconds preceding the billboard or other type of site. These included measures of driver visual performance (forward, left, and right glances) and measures of driving performance (lane deviation and speed variation).

With 36 participants and 42 sites, there were 1,512 events available for analysis. A small amount of data was lost due to sensor outages, sun angle, and lane changes, leaving 1,481 events for eyeglance analysis and 1,394 events for speed and lane position analysis. Altogether, 103,670 video frames were analyzed and 10,895 glances were identified. There were 97,580 data points in the speed and lane position data set.

The visual performance results indicate that billboards do not differ measurably from comparison sites such as logo boards, on-premises advertisements, and other roadside items. No measurable differences were found for visual behavior in terms of side of road, age, or familiarity. However, there was one difference for gender. Not surprisingly, there were significant differences for road type, with surface streets showing a more active glance pattern than interstates. There were also no measurable differences in speed variability or lane deviation in the presence of billboards, as compared to baseline or comparison sites. An analysis of specific, high attention-getting billboards showed that some sites show a more active glance pattern than other sites, but the glance locations did not necessarily correspond to the side of the road where the billboards were situated. The active glance patterns are probably due more to the road type than to the billboard itself. One major finding was that significantly more time was spent with the eyes looking forward (eyes on road) for billboard and comparison sites, as compared to baseline sites, providing a clue that billboards may actually improve driver visual behavior. Taken as a whole, these analyses support the overall conclusion that driving performance does not change measurably in the presence or absence of billboards.

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EXECUTIVE SUMMARY

Introduction

The current project was undertaken to determine whether there is any change in driving behavior in the presence or absence of billboards. Several measures of eyeglance location were used as primary measures of driver visual behavior. Additional measures were included to provide further insight into driving performance--these included speed variation and lane deviation. The overall conclusion from this study is that the presence of billboards does not cause a measurable change in driver behavior in terms of visual behavior, speed maintenance, or lane keeping. A rigorous examination of individual billboards that could be considered to be the most visually attention-getting demonstrated no relationship between glance location and billboard location. Driving performance measures in the presence of these specific billboards generally showed less speed variation and lane deviation. Thus, even in the presence of the most visually attention-getting billboards, neither visual behavior nor driving performance changed measurably.

Methods

Participants in this study drove a vehicle equipped with cameras in order to capture the forward view and two views of the driver's face and eyes. The vehicle was also equipped with a data collection system that would capture vehicle information such as speed, lane deviation, GPS location, and other measures of driving behavior. The video and other data were linked by use of a common time numbering system, and all data were collected at the rate of 10 times per second.

Thirty-six drivers participated in the study. Participants were unaware of the focus of the study on billboards; they were told that the purpose of the study was to examine natural driving behavior, which was also true. The drivers were a diverse group in terms of age, gender, income, education, and ethnicity. They were all familiar with at least some segments of the test route, which was a 35-mile loop route in Charlotte, North Carolina. The route included both interstate and surface streets, and it was mostly urban and suburban in nature. A total of 30 billboard sites from the 80 available along the route were selected with the assistance of an outdoor advertising company in Charlotte, North Carolina and representatives from the Outdoor Advertising Association of America (OAAA). The route included billboards of various sizes on both sides of the road, as well as billboards on both interstates and surface streets. In addition, six comparison sites (e.g., logo signs, on-premises signs, etc.) and six baseline sites (i.e., no visual elements such as buildings or signs present) were included for comparison purposes.

Participants were oriented to the study and the experimental vehicle before they began driving the route. After a short practice route with the experimenter, each participant drove the route unaccompanied and with the assistance of route directions mounted on the dashboard. Data were collected unobtrusively by using hidden sensors. The data were then stored on compact disks for later analysis. After returning to the starting point, drivers completed a demographic and driving questionnaire and were then paid a token amount in appreciation for their time.

The experiment was designed so that the elements of participant age (younger/older), participant gender (male/female), side of road (left/right), and type of site (billboard, comparison, or baseline) were equally represented. Several measures were used to determine whether driver behavior varied during the 7-seconds preceding the billboard site, as compared to other types of sites. These included measures of visual behavior (eyeglance locations of forward, left, and right) and driving performance (lane deviation and speed variation). The measures were statistically analyzed in terms of the controlled elements of site type, age, gender, and route, as well as by road type and familiarity. An additional analysis examined visual and driving performance in the presence of certain high-profile billboards that might be expected to be the most attention-getting along the route.

The eyeglance data were analyzed by four trained data analysts who used a customized software package. The software used GPS location data for site, route, and vehicle identification on an electronic road map. Glances were analyzed down to a tenth of a second, in terms of both length of glance and glance locations. Analysis of vehicle speed and lane position variability was accomplished with a computerized post-processing procedure on the raw data file. Each analyzed event was 7 seconds long.

With 36 participants and 42 sites, there were 1,512 events available for analysis from approximately 54 hours of data collection. A small amount of data was lost due to sensor outages, sun angle, and lane changes, which left 1,481 events for eyeglance analysis and 1,394 events for speed and lane position analysis. Altogether, 103,670 video frames were analyzed and 10,895 glances were identified. There were 97,580 data points in the speed and lane position data set.

Questionnaire Results

The average participant age was 25 years for younger drivers and 56 years for older drivers. On average, drivers had completed 14 years of education (high school plus two years of college). In terms of marital status, 78% of participants were single or married, while 14% were divorced and 8% were widowed. Over 61% of drivers were European (Caucasian), and 39% of drivers were of an African American, Native American, or Multi-racial background. Seventy-two percent of drivers reported an annual income of less than $49K. All drivers were familiar with the roadway system in Charlotte, North Carolina, and most drivers both lived and worked there.

Analysis of the questionnaire results revealed that the most common items that caught drivers' attention during the route were traffic, other drivers, road signs, and highway signs, as well as construction, landmarks, landscaping, and buildings. Only 25% of drivers indicated that billboards caught their attention during the drive. Upon further discreet inquiry, these drivers indicated that they either tended to look at billboards in general or at specific billboards that caught their attention.

Other questions asked drivers to indicate what was memorable about the drive or what they noticed about other drivers. Most comments involved traffic, construction, weather, or aggressive driving by other drivers. Many drivers indicated that they typically also performed other activities while driving, such as listening to music, talking on a cell phone, eating, drinking, smoking cigarettes, or talking to passengers. The last question asked drivers to reiterate the purpose of the study; all of the drivers indicated that the study was designed to examine natural driving behavior, which is what they had been told at the beginning.

Forward Visual Scanning Behavior Results

The visual behavior results indicate that billboards are not measurably different from comparison sites such as logo boards, on-premises advertisements, and other roadside items. The analysis of eyeglance patterns provided insight as to whether drivers displayed more active glance performance when passing billboards. Glances were analyzed in terms of number of glances, average duration of glances, and total duration of glances for each of three site types: billboard, baseline, and comparison sites. Billboard sites did not differ significantly from the comparison sites for left-forward glances, but they did differ from baseline sites. There were also a difference in terms of left-forward total glance duration; billboard and comparison sites had significantly longer left-forward total glance durations than baseline sites, but they did not differ from one another. There were no differences for the average glance durations in any direction between three site types. Out of nine visual performance measures, there were no cases for which the billboard site type differed significantly from the comparison site type, and there were only two cases for which both billboard and comparison sites differed from baseline sites.

In terms of side of road, age, or familiarity, no differences were found for eyeglance behaviors, and there was only one difference for gender. Females displayed longer average and total right-forward glance durations across all site types; this difference, although significant, was relatively small in terms of magnitude and does not appear to have any practical significance.

Not surprisingly, there were significant differences for road type, with surface streets showing a more active glance pattern than interstates. More glances were observed in all directions on surface segments, as compared to interstate segments. The average and total center forward glance durations were longer for the interstate segments; in most cases, the right- and left-forward average and total glance durations were shorter on the interstate than on surface streets. In most cases, surface road sites have more signs, buildings, and other features closer to the side of the road, so it is not surprising that drivers would look at locations other than center forward while driving in these areas.

Speed Variability Behavior Results

Speed maintenance behavior was not measurably different in the presence of billboards, as compared to comparison and baseline sites. Significant differences were found for side of road, familiarity, and road type; however, from a practical perspective, differences were small. Sites on the right were associated with less speed variation than those on the left. Drivers also exhibited less speed variation for sites rated as familiar. The largest difference was in terms of road type--sites on the interstate had less speed variability than did sites on the surface streets.

Lane Deviation Behavior Results

Lane maintenance behavior was not measurably different in the presence of billboards, as compared to comparison and baseline sites. Lane position analysis revealed differences only for side of road. For sites on the left side of the road, lane position varied by 10 inches during the 7-second segment, as compared to 7.5 inches for sites on the right side. These differences, although significant, are within the expected range of deviation.

Specific Board Analysis Results

An analysis of specific boards was performed to determine: 1) how specific billboards compared to other billboards, as well as specific baseline and comparison sites in terms of eyeglance and driving performance measures; and 2) how the eyeglance measures corresponded to the placement of the billboards (left or right) in relation to the road. By choosing the four billboards that might be expected to draw the most glances (as well as two more ordinary boards) and comparing their results to all other sites, it became obvious that the selected billboards did not change visual performance. Some billboard sites seemed to have a more active glance pattern than others, but since the glance directions at these sites did not correspond to the side of the road where the billboards were situated, this was most likely due to road type differences.

Eyes-Off-Road Analysis Results

Eyes-off-road percentage was significantly greater for baseline sites than for billboard and comparison sites, providing some indication of potential improvement in driver visual performance in the presence of billboards. However, there was no measurable difference in the direction of these non-forward glances for baseline, comparison, and billboard sites.

Study Parameters

This study was conducted in a specific city chosen to be representative of mid-sized U.S. cities. The route was chosen to include both urban and suburban sections, and some sections were close to rural in nature. The billboards in Charlotte, North Carolina are generally situated close to the side of the road, therefore placing the boards within the forward-view of the participants for a longer period of time than if they were further offset from the road. Both the setting (urban/suburban/rural) and the billboard offsets were typical of most billboard locations found in the U.S. For each of the above-mentioned parameters, every attempt was made to conduct a balanced, representative study for which the results could be generalized to other cities and routes.

One limitation of this study was that there were few electronic boards along the route, so no conclusions can be drawn regarding driver behavior in the presence of this type of billboard. All three of the electronic billboards available on the route were included, however, for a total of 10% of the sampled billboards. Future research into this topic should focus on routes with a greater number of available electronic billboards so that an electronic/non-electronic analysis can be conducted.

Conclusions

The overall conclusion from this study is that the presence of billboards does not cause a measurable change in driver behavior, in terms of visual behavior, speed maintenance, or lane keeping. A rigorous examination of individual billboards that could be considered to be the most visually attention-getting demonstrated no measurable relationship between glance location and billboard location. Driving performance measures in the presence of these specific billboards generally showed less speed variation and lane deviation. Thus, neither visual behavior nor driving behavior changes measurably, even in the presence of the most visually attention-getting billboards. One major finding was that significantly more time was spent with the eyes looking forward (eyes on road) for billboard and comparison sites, as compared to baseline sites, providing a clue that billboards may actually improve driver visual behavior.

INTRODUCTION

There is a long history of studying billboards in the context of traffic safety, but although the research record covers a many years (1951 until the present), it is lacking in volume. There were a few early epidemiological studies in the early 1950's examining traffic accidents in the presence and absence of billboards. As will be seen, much of this early work was methodologically flawed. After a long gap in research, there were a few other studies in the 1960's through the 1980's, none of which demonstrated that billboards are unsafe. 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 billboard distraction 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 lead author of this report recently participated on an expert panel charged with providing recommendations for a minimal data set to be included on police accident reports; billboards were never raised as a possible distraction or as an item that should be included on these accident reports.

However, the argument continues to be raised that billboards may pose a traffic safety hazard. The safety argument follows this train of logic: billboards are designed to capture attention and are therefore designed to divert the driver's eyes from the forward view. Therefore, if billboards perform the job that they are designed to do, they then affect driver behavior and are thus a safety hazard. A search of the literature revealed that no research has been conducted inside the vehicle in a naturalistic manner to determine if billboards somehow affect driver behavior. The current project was therefore undertaken to fill this research gap and to determine whether billboards do in fact cause a change in driver behavior as he/she passes a billboard location. Several measures of eyeglance location were used as primary measures of driver visual behavior. Additional measures of driver performance were included to provide further insight--these included speed variation and lane deviation. Drivers in this study used an instrumented vehicle and were uninformed as to the underlying purpose of the study itself.

The report is organized as follows: a literature review, covering topics such as early accident analysis studies, sign conspicuity studies, and later safety and driver distraction studies; a methods section; a results section; conclusions; references; and supporting material contained in appendices.

REVIEW OF PREVIOUS RESEARCH

Early Epidemiological Studies

Early studies from the 1950's attempted to correlate the occurrence and frequency of accidents with the location of billboards or other roadway or roadside features. For example, a series of studies by the Minnesota Highway Department (Rykken, 1951) analyzed accident features in order to determine whether there was any direct relationship between accident frequency and type and several elements of roadway and road-side design, including advertising sign type and location. Accident reports from a 500-mile portion of US highway were analyzed from 1947 to 1949 in conjunction with information regarding geometric design, access points, and advertising signs. While a relationship between frequency of access points and accident occurrence was evident, no apparent relationship was found between accident occurrence and advertising sign type or location.

Rykken (1951) added that more accurate accident reports may reveal an unexpected relationship between signs and accidents: the absence of signs when no other roadside objects are present may increase the likelihood of accidents by decreasing the driver's sense of a need for caution. Immediately after 45 miles of highway with no billboards or advertising sings in viewable distance, a roadside interviewing station investigated driver response. Because drivers expressed a feeling of fatigue and unease after having driven the section, the author postulated that the combination of a small number of detracting features and the complete absence of billboards produced a feeling of security, which tends to result in higher average driving speed. Several severe accidents that occurred over that stretch were attributed to excessive speed.

McMonagle, a researcher with the Michigan State Highway Department, analyzed 2,675 accidents on a 70-mile strip of highway from 1947 to 1948 in order to measure the relationship between accidents and highway design and roadside features (McMonagle, 1951). The strip of road included a variety of roadside features and design characteristics, including the number of lanes and traffic volume. Findings showed that the highest incidence of crashes occurred near intersections, particularly when gas stations, restaurants, and other establishments were clustered nearby. Only a slight association (correlation coefficient .11) existed between large advertising signs and accidents. While total advertising signs correlated with accident frequency to a greater degree (correlation coefficient .41), advertising signs still contributed less to accident frequency than did groupings of design features or roadside features such as gas stations.

In an attempt to correlate accident frequency with density of advertising and roadside business, Rusch (1951) analyzed crash reports originating in 1947 and 1948 that examined sections of highway distributed across Iowa. Stretches of road approaching 24 representative cities with a population of 5,000 or more in 1947 were included in the study. The position of an accident was classified by density of advertising and business on the adjacent roadside, and the accident itself was assigned one of three causes: 1) roadside business, 2) inattention or misdirected attention, or 3) an "other causes" category. Roadside business was listed as the cause of an accident only if the business was specifically named in the accident report, as in the case of a vehicle exiting a gas station and being struck by oncoming traffic. Results showed that twice as many collisions occurred on the portions of road in the high-density category than occurred on the other parts of the test stretches put together. More accidents were attributed to inattention than to any other cause in the high-density category. In the low-density category, more accidents were attributable to miscellaneous causes than to business and inattention combined. Sections of highway in the low-density category showed lower accident rates than those in the high-density category, even when traffic volume was held constant. Also, accidents on low-density stretches occurred more sporadically and with less of a tendency to recur in the same locations the following year. In reference to this study, Andreassen (1985) later claimed that the "greatest number of inattention accidents occurred on the sections where business and advertising predominated as the roadside property usage, but this does not prove anything about the effect of advertising signs on accident occurrence."

Overall, these early studies provided some initial insight into accident causation, but did not demonstrate that billboards or other advertising signs were a possible cause of accidents. In fact, intersections and high density roadways combined with inattention were most commonly associated with increased number of accidents. As a matter of fact, later analysts using modern statistical techniques critiqued these early studies as being methodologically flawed (e.g., Wachtel and Netherton, 1980; Andreassen, 1985).

Research Related to Attention and Perception of Signs and Billboards

After these early studies, there was approximately a 15-year gap before researchers once again began to study signs (in some cases including billboards) in a scientific manner. In these next studies, the focus was more on the transmittal of sign information and visual performance in the presence of signs. Johansson and Rumar (1966) conducted a two-part study to investigate the amount of information traffic signs imparted to drivers on a 105-mile stretch of road in Sweden. In the first part of the study, five participants were driven past the 424 road signs on the route and asked to record each one by pressing a button as they passed it. The participants recorded an average of 90% of the signs. In the second part, one of five temporary signs was set up on the road, and about 200 drivers were stopped just after they passed it and asked whether they had noticed its presence or what it said. A total of 47% of drivers noticed having just passed a sign, with significant differences depending on the meaning of the sign. For example, a sign warning a change in speed limit was remembered the most often, followed by a sign for police control. The authors concluded that traffic signs usually fail to catch drivers' attention, and the level of efficacy depends on the amount of personal risk implied by the message.

Tachistoscopy, the study of visual perception via a machine that flashes images on a screen for a set fraction of a second, was used by Gutman (1972) to investigate the efficacy of illustration and copy placement in outdoor advertisements. Ads were manipulated photographically before being shown to 96 different participants. Each participant was asked to identify the advertiser and repeat the words seen in the advertisement, specifically reporting which aspect was seen first. Four layouts, two horizontal and two vertical, were tested. Horizontally, the copy was on one side and the illustration on the other; if the illustration was on the left, the copy was on the right, and vice versa. Vertically, either the illustration was on top with the copy underneath it or the copy was on top with the illustration on bottom. Findings showed that illustrations are usually the first focus of attention, regardless of their placement in the layout. Because the eye tends to scan from left to right, words were most effective when placed to the right of the illustration. Both vertical layouts were ineffective, most likely because the eye's preference for horizontal movement slows perception on a vertical plane.

An article by Johnston and Cole (1976) summarized five experiments that investigated the distracting impact of irrelevant information. Johnston and Cole hypothesized that a multiplicity of contributing factors may be involved in any collision, and establishing their relevance is often complicated by driver motivation when making police and insurance reports. For these same reasons it is difficult to unequivocally claim that outdoor advertising plays no role whatsoever in accident occurrence. However, Johnston and Cole put forward three hypotheses concerning the impact roadside advertising has on drivers, as follows:

1. A driver may visually sample the traffic environment at an appropriate rate, responding to cues by accelerating, steering etc. In the intervals between these samples, the driver may attend to information irrelevant to the driving task in such a way that advertising displays do not interfere with driving performance.
2. *The Distraction Hypothesis.* In part, the driver's visual sampling of the traffic environment while driving may be spent looking at roadside advertising. If the driver's sampling rate is inappropriate for the surrounding events, the driver may be unable to avoid potentially dangerous situations. This is mitigated by the fact that the driver can ignore information judged to be irrelevant to the driving task.
3. *The Confusion Hypothesis.* The background luminance, color, or movement of advertising signs may camouflage critical information in the driving environment.

Laboratory investigation of distraction, as summarized by Johnston and Cole (1976), shows that primary task performance tends to show only a small decrement in the presence of manifold distractions. The distracting stimuli used in these studies were characterized by their irrelevance to the participants' main activity. Human performance on sensory-motor tasks follows a U-shaped curve so that the optimum performance can be found when stimulation is fairly high. If a driver is "under-aroused," listening to a car radio has been shown to improve performance by increasing the level of stimulation. In short, laboratory knowledge concerning distraction shows that the effect of irrelevant stimuli is complex and depends on four things: 1) the nature of the primary task, 2) the level of arousal, 3) the type of distraction, and 4) the psychological "set" of the observer at the time.

Johnston and Cole (1976) performed five experiments, each building upon the previous one, to investigate the potential distraction (rather than the confusion) aspect of advertising displays. All five experiments used a rig similar to a driving simulator, in which the participant sat in the middle of a hemi-cylindrical screen. The primary tracking task required the participant to move a joystick in the direction indicated by a small, changing arrow in the middle of the screen. A small monetary reward for correct responses was used in the first three experiments to ascertain that this task was given priority. For experiments 3, 4, and 5, a second task was added to amplify any distraction effects from the advertisements. The secondary detection task involved pressing a button in response to infrequent spots of light in the periphery of the visual field. Distractor images, selected from advertisements in magazines by virtue of their content and their similarity to typical billboard imagery, were displayed while the participant performed these two tasks. Eight product groups (such as food and baby products) provided 30 to 40 ads each, which were then redistributed randomly into 20 groups of 12. Each group was shown sequentially to each participant so that no distractor slide was presented more than once. In the first experiment, the ads moved from 5° off center to 45° in the left visual field. In the following experiments, the ads remained stationary directly above the arrow in the center of the screen. In later experiments the ads also flashed to increase their distractive qualities.

The findings of the five experiments performed by Johnston and Cole (1976) were as follows:

1. Differences in tracking performance were not the result of distraction stimuli in the first experiment, but they were a function of the frequency of tracking arrow presentation because of the increase in perceptual load.
2. Temporal uncertainty in the presentation of the tracking arrow reduced tracking performance by increasing perceptual load heavily. The presence of distraction was associated with a significant fall in mean tracking score when the participant's perceptual load was this high. The magnitude of the fall, though significant, was very small.
3. When the perceptual load was greatest, an interaction between the secondary task and the distracting images actually caused an increase in performance on the tracking task, possibly due to an arousal effect. Distraction caused a significant, though very small, decrement in performance on the secondary detection task.
4. When distraction advertisements were presented at high visual contrast, tracking task performance increased if the secondary detection task was being performed at the same time. As in experiment 3, an arousal effect was hypothesized to explain the improvement. Performance on the secondary detection task itself was significantly worse when distractions were presented, even though primary task performance increased.
5. The findings of the previous experiments were corroborated. Only at the highest perceptual load did distraction have an effect (a negative one) on tracking performance.

To summarize, distracting advertisements had no significant effect on task performance until the perceptual load became high, whether by speed or temporal uncertainty of stimulus presentation. When the secondary detection task was added, distracting advertisements had the opposite effect: they improved performance on the main task, although performance on the secondary task suffered. The arousal effect hypothesized by Johnston and Cole (1976) to explain this improvement asserts that stress on the participants increased to a level nearer their optimum, raising vigilance according to priority. Andreassen (1985) later summarized the Johnston and Cole research by giving the following pointers for billboard design: control glare; make the message simple; allow no signs in places where drivers will be "highly loaded;" and control novel, sensuous, or moving displays.

A study by Boersema and Zwaga (1985) investigated the degree to which the physical environment of a target affects its conspicuity. Visual conspicuity of any object is determined by its physical properties, its relation to what surrounds it (contrast), and the cognitive set of the observer. Participants were asked to locate routing signs in pictures of a train station, and the number of advertising signs competing for attention was varied systematically in the pictures. The results indicated that it took longer to locate the routing signs when there were advertisements in the immediate vicinity.

Luoma (1988) performed a study to investigate the degree to which conscious perception and eye fixation while driving are interdependent. Drivers wore a machine on their heads that calculated the direction and duration of their eye fixations while they drove a 50 km route. Glances toward five types of objects (traffic signs, lane markings, crosswalks, roadside advertisements, and houses) were specifically monitored. Findings showed that fixation did not necessarily indicate perception. Rather, the length of time necessary for a fixation to become a perception depended on the nature of the object being seen. Roadside advertisements required a very long fixation time, about four times as long as any other category tested.

According to Luoma (1986), the roadside advertisement is recessive in the visual field if there are numerous targets relevant to the driving task. This was the finding of a study designed to investigate eye movement, fixation, and perception of billboards and traffic signs, whether billboards disturb perception of signs. The study also examined how well billboards and traffic signs remain in memory. Participants were shown daylight images in succession, some of just a road, some of the same scene with a traffic sign or a billboard, and some with both. Questionnaires were administered at irregular intervals in order to check the participant's memory of recent images. The perception of a billboard was found to be dependent upon the simplicity of its pictures, internal contrast, and easy outlining. The presence of billboards in a picture was found to decrease the perception of traffic signs by an average of 34%. Perception of traffic signs was disturbed most seriously by billboards that were difficult to perceive correctly or that communicated their message poorly. The presence of billboards slightly improved recall of the meaning of perceived traffic signs. Billboards did not significantly affect the perception of oncoming traffic.

A second experiment in the same study by Luoma (1986) used the same protocol with similar images taken at night. Under these conditions, billboards disturbed the perception of traffic signs an average of 39%. They just barely disturbed the perception of oncoming traffic, and even less for billboards that had a traffic sign included with the image.

Across both tests, billboards were found to remain in a person's memory longer than traffic signs. A third study using similar methodology investigated eye movement and fixation with perception. In daylight, the presence of a billboard did not alter eye fixation patterns but did decrease perception. At night, billboards both changed fixation patterns and decreased perception. The authors concluded that billboards are primarily disturbing when the driver feels capable of perceiving everything necessary while spending attention on billboards as well. When there are numerous stimuli in a complex driving environment, drivers can seek out what is important without being negatively affected by billboards.

Donthu, Cherian, and Bhargava (1993) attempted to identify and quantify the factors that influence how well outdoor advertising is recalled in a naturalistic setting. Ten new billboards were erected on a 30-mile stretch between a suburb and a downtown exit, between 45 and 60 days prior to the beginning the study. Telephone interviews were conducted with 142 adults who commuted past these signs every day. The interview regarded their ability to recall ads, what aspects they recalled, and their attitude towards the ads. Factors found to influence recall included the following:

- Location: highway or surface street
  - Highway produced superior recall
- Position: right or left side of the road
  - Right side was superior
- Number of words
  - Seven or less was superior to eight or more
- Color: black and white or color
  - Black and white was superior
- Respondent involvement with the product
  - The more involved the observer was with the product, the better the recall
- Attitude toward outdoor advertisements in general
  - The more positive the respondent's attitude, the better the recall

The authors postulated that black and white advertisements were more effective than color because black and white ads were very rare in the strip of billboards investigated. Based on these findings, Donthu et al. (1993) advised using uncommon execution similar to this coloration example, placing the advertisements on the right hand side of highways, and using few words.

A study by Boersema, Zwaga, and Adams (1989) identified two types of conspicuity that describe the attention-getting properties of an object in the visual field, such as a billboard on the side of the road. The ease with which an object can be seen once the observer is specifically searching for it is called search conspicuity. The ease with which an object is seen when it is not being searched for is called attention conspicuity. Both of these types of conspicuity have traditionally been measured by laboratory search and response tasks in which a participant presses a button or otherwise verifies identification once the object has been located in his or her visual field.

The time it takes a participant to do this task, the reaction time, is composed of two parts: first the participant must correctly identify the object (search time), then the participant must decide what to do about it (processing time). Boersema, Zwaga, and Adams (1989) devised an experiment to eliminate processing time in the measurement of an object's conspicuity characteristics, since processing demands change between participants, making it a source of error variance. Absolute search time was measured by eye fixations alone, erasing the variation in responses. Eye movement data was shown to be a sensitive measure of the conspicuity of visual targets in realistic scenes. The details of this experiment were very similar to a prior study by Boersema and Zwaga (1985) in which 54 participants were asked to identify routing signs in slides of train stations. The slides were photographically manipulated to show exactly the same scene with 0, 1, or 3 advertisements. The number of eye fixations was found to increase significantly with the number of advertisements in the scene. The increase in fixations resulted in increased search time, showing that the presence of advertisements in an environment can decrease the efficiency with which information can be found. Once identified, the time it took to process and react to the information did not change with variation in the number of advertisements in the scene. It should be noted that these types of experiments, which do not involve driving, do not take into account the fact that drivers generally allocate most of their attention to the primary task of driving, and only allocate attention to other tasks as excess attention becomes available.

Distraction is difficult to measure, partially because it is difficult to quantify the distribution of attention. Eye movement recordings and verbal report techniques were used by Hughes and Cole (1986) and Luoma (1988) to determine where the drivers' attention was directed, but the expensive nature of these measures, along with uncertainty regarding the underlying attentional processes, can present problems. Hoger (2001) measured attention through response time to flashes of light located on varying images in a simulated driving scene. This Signal Location Task (SLT) was designed so that the time it took to locate the light signal depended on its proximity to the place the attention had been resting originally. This allowed the researchers to record what objects drivers were directing their attention toward, without the cumbersome problems associated with distraction measurement.

Hoger (2001) used SLT to measure the amount of attention that drivers directed to outdoor advertising compared to other cars on the road (traffic), traffic signs (information), and irrelevant locations in the periphery (e.g., clouds and trees). Reaction times were significantly shorter when the targets were located on task-relevant images (e.g., traffic or traffic signs). Reaction times were also shorter for billboards than for meaningless items in the periphery, which reveals that billboards do attract more attention than entirely task-irrelevant objects do.

Jones (2001) provides engineering guidelines for design and placement of effective information and guide signs along major roads by summarizing current standards. The Manual on Uniform Traffic Control Devices (*MUTCD*), from which current standards are drawn, addresses the use of changeable message signs (CMSs), specifying font size (from 11 to 18 in.) and minimum legibility distance (650 ft. if portable, but 1000 ft if in high-speed locations). The point of *MUTCD* recommendations on CMSs is to maximize the ease with which a driver can understand and process the information.

The initiation of billboard regulation sparked a need for formal signage along freeways to direct motorists to service facilities such as restaurants and gas stations. Specific service signs (logo placards) are also addressed by *MUTCD,* as reported in Jones (2001). These signs advertise services at nearby exits and are used primarily on freeways. GAS, FOOD, and LODGING are examples of headings on the signs; each sign, commonly referred to as a logo placard, has up to six standardized logos that show what facilities can be accessed at the next crossroad. Limitations to this program are that only "qualifying" facilities or attractions can be advertised on these signs, and their use was originally intended to be limited to rural areas. Tourist-oriented directional signs (TODS) on conventional highways are also used to advertise small businesses such as potteries and fruit stands.

Compact urban areas mandate the prioritization of signs to prevent driver overload, while higher speeds dictate placement of signs well in advance to allow the driver time to process and react appropriately. Because guide signing is an integral part of the system, it needs to be incorporated into the early stage of highway planning and design (Jones, 2001). A highway with an optimal physical design will not operate safely if it does not have a good signing system.

The complexity of the visual field has been said to affect a driver's abilities to detect a specific stimulus. Researchers Akagi, Takuya, and Motoda (1996) of the Japanese Ministry of Construction performed an experiment to investigate whether the visual noise ratio (defined as the area of cluttering signs compared to the total field of view) is correlated with eye fixation patterns and sign detection distance. They also examined the effectiveness of the visual noise ratio as an index to express the degree of visual complexity in the driving environment.

Fixation pattern results showed that fixation time decreased as clutter increased, but fixation velocity increased at the same time. This means that drivers look at a greater number of objects more quickly when surrounded by a complex visual field. Akagi et al. (1996) postulated that an increase in the visual noise ratio creates greater stress for drivers and may contribute to an increase in accident frequency.

The detection distance decreased as the visual noise ratio increased, but this effect differed in its intensity according to the age and gender of the subject. The detection distance of males was longer than that of females, but visual noise interfered with male detection distance more than with female detection distance. As the age of participants increased, detection distance decreased. Akagi et al. (1996) considered older drivers more susceptible to visual noise. The visual noise ratio was found to be a very useful index in investigating the effects of visual complexity in Japan, and it revealed that female and younger drivers are comparatively unaffected by visual noise.

Garvey, Thompson-Kuhn, and Pietrucha (1995) performed a synthesis of past and present research knowledge in the field of sign visibility. They found that visibility research tended to fall into one of two categories: sign detection (a function of sign conspicuity) or sign legibility. Sign placement, which is described as the sign's height, offset, and surround (or immediate environment), most strongly affect detectability. Lateral and vertical offset from the side of the roadway can be used to maximize detection distance, especially when far from hills, curves, and intervening visual targets. Much research has shown that conspicuity is greatest when signs are erected as close to the driver's line of sight as possible--the larger the eccentricity (degrees off center), the smaller the chance the sign will be noticed. The visual complexity of the sign's surround also has a high impact on its conspicuity, meaning that the more items there are for the driver to look at, the less likely he or she is to notice the sign in question. Night vision of retroreflective signs is even more strongly influenced by these factors, so the eccentricity needs to be carefully tailored to the manufacturer's specifications and the surround needs to be as simple as possible. A sign's external contrast ratio is the luminance of the sign compared to the area immediately surrounding it. As that ratio increases, whether during the day or night, so does the sign's conspicuity. Size, shape, internal contrast (the colors of letters or illustration compared to the color of the background on the sign), and edge definition (heightened by borders around the outside of the sign) of the sign all play a role in detectability as well.

Legibility can be impacted strongly by many of the same factors, primarily because they lengthen the available time for the driver to notice and read the sign (Garvey et al., 1995). Familiar copy can be recognized and read at much greater distances than novel copy can, so one of the most successful advertising strategies, rather than manipulating font and presentation, is to make the target audience as familiar with the slogan as possible. Symbols create a much longer legibility distance, but they are not comprehensible to as many drivers as alphanumeric messages are. Copy presentation issues that impact legibility include letter case, font, stroke-width, abbreviations, letter height, color, and contrast.

More Recent Epidemiological and Driver Distraction Studies

A critical research review sponsored by the Federal Highway Administration (Wachtel and Netherton, 1980) summarized knowledge concerning commercial electronic variable-message signage (CEVMS) in an effort to recommend national standards for their regulation. The review focused on their potential impact on the three areas of public interest that the Highway Beautification Act was drafted by Congress to protect: promotion of highway safety, preservation and enhancement of natural beauty along highways, and protection of highway investment. Only the portions of their report relating to safety will be addressed here.

Literature regarding safety issues was found to concern two types of studies: accident analyses and human factors studies. Wachtel and Netherton (1980) opined that roadside advertising research based on accident studies has had limited value owing to either insufficient information concerning location and traffic or problems with statistical analysis and sampling error. While some studies have found positive relationships between outdoor advertising and accident frequency, others have arrived at the opposite conclusion.

According to Wachtel and Netherton (1980), human factors laboratory research techniques are capable of gathering much more precise, reliable, and valid data in an attempt to measure and explain the effect of outdoor advertising on driver behavior. Literature from several related fields indicated that outdoor advertising probably does not notably hurt driving performance when driving conditions are favorable (in terms of weather, traffic, road, vehicle, etc.). This is because the driver has sufficient spare processing capacity to pay attention to the signs without compromising the primary task. When stimulation is extremely low, as when there is very little traffic and very little to look at or to decide, unusual environmental features such as road signs may *increase* the driver's arousal and *improve* driving performance. When the driving task becomes highly demanding, the outdoor advertising must compete with more vital information sources such as traffic, weather, and official signage. Because the driver's attentional capacity is finite, CEVMS could pose a threat, particularly due to their technological advantage over conventional billboard advertising. Variable-messages can attract attention at greater distances, hold the attention longer, and portray more images and information, all of which may contribute to an overloading of driver capacity.

Courts have preferred the logic that legislatures should try to minimize the risk of distraction when high driving concentration is needed, assuming that a driver cannot give sufficient attention to vehicle control if he is reading a billboard (Wachtel and Netherton, 1980). Even with expert witnesses to the contrary, this has been the trend; when expert witnesses have disagreed about the impact of outdoor advertising, legislatures have tended to restrict outdoor advertising using the safety argument as a fallback position.

In a review of published literature relating accidents to advertising signs, Andreassen (1985) brought attention to weaknesses in the small amount of research that has been conducted in this area. Almost all studies have relied on correlations and/or subjectively assigned "inattention" factors, which can only produce very tenuous evidence for a causal link between advertising and accident frequency.

Garvey et al. (1995) reviewed the studies that attempted to directly evaluate the relationship between traffic accidents and advertising signs. The common problem with these studies is attributing accident causation; high-advertising and low-advertising sites may have different accident frequencies because of differing traffic densities, pedestrian activity, and roadway geometry. Although most evidence argues against a strong causative link, it is still not possible to ascertain the existence or nature of the relationship between advertising and accidents.

Dynamic and high-resolution imaging, such as that seen on electronic billboards (EBBs) and tri-panel signs, have raised questions about safety implications with regard to driver distraction. A literature review sponsored by the Federal Highway Administration (Farbry, Wochinger, Shafer, Owens, and Nedzesky, 2001) summarized current knowledge in this research field, assessed areas needing exploration, and developed a research plan to address them. While some EBBs display motion and color with fine detail, others just show a short sequence of words in which each letter is composed of a matrix of light emitting diodes (LEDs) (Farbry et al., 2001). This type of display is used by governmental agencies to present information to drivers and is known by several different acronyms: variable message sign (VMS); dynamic message sign (DMS); and changeable message sign (CMS), which will be used in this report. A tri-panel sign, also known as a tri-vision sign, is composed of triangular cylinders that rotate periodically, showing a different composite image in between each rotation. The only movement is that of the images in transition.

Studies attempting to draw causality from correlation between dynamic billboards and accident frequency run into the same difficulties found by studies investigating static billboards and accidents (Farbry et al., 2001). Common obstacles include consistently confounding traffic conditions in areas with heavy advertising, incomplete or inaccurate accident reports, and driver motivation to omit distraction when reporting crash causality. Even given these stumbling blocks, the correlation is still statistically clear: after a dynamic, illuminated billboard is installed, crash rates go up. A common trend was exemplified when a 35% increase in sideswipe and rear-end accidents on an interstate occurred after a variable message advertising sign was put up on the side of a sports stadium. The correlation, while rarely this dramatic, is a consistent one. However, even a correlation this strong is not sufficient evidence to assume causality. Enough other variables were held to be confounding the situation that the sports stadium sign was not deemed a traffic hazard in and of itself, and it remained in place for 16 years.

Correlations alone provide little fodder for the development of countermeasures. Researchers hypothesize that a safety hazard is posed by dynamic advertising because it may cause greater distraction, which can be measured in several formal ways. One common method is to ask the driver to perform another task while driving, then to measure the degree to which the safe operation or control of the vehicle is affected. Lack of control is typically quantified by one of three measures: lateral deviation, maintenance of appropriate speed, and/or braking for emergencies. Lateral deviation is defined either as: 1) the degree to which the vehicle swerves away from the center of the appropriate lane, or 2) a measure of the variability in steering wheel position. Maintenance of appropriate speed refers to the headway between the vehicle and the vehicle ahead; if the lead vehicle slows down, the participant vehicle should also slow down and maintain an appropriate speed to keep the headway constant. Some experiments present an emergency and measure distraction by the amount of time it takes the participant to respond appropriately.

The literature review by Farbry et al. (2001) revealed that the two demographic groups most susceptible to the dangers of distraction while driving are drivers over the age of 65 or under the age of 24. Older drivers' visual processing speed and attention degrade with age, resulting in little to no spare resources with which to encode and process anything but the most important information in the driving environment. Younger drivers usually have faster processing speeds, but they are less experienced and less efficient at resource allocation. Among other weaknesses, younger drivers take more risks, may not recognize hazards, and have poor focus on the driving task itself. Because of this, younger drivers may be more vulnerable to having their attention drawn by irrelevant but attention-getting stimuli.

Other than age, a variable that may influence the degree to which a sign distracts a driver is route familiarity (Farbry et al., 2001). A driver who is new to a road may be looking for navigational or service cues, and this task may take longer in a more complex visual environment containing numerous advertising signs. On the same road, a familiar driver may not look around much since he has all the information he needs already. Familiar signs may be less likely to attract the attention of a driver who knows the roadway well and whose primary navigational interests may be traffic conditions and incidents. According to this theory, a visitor would be more likely to be distracted by an advertising sign than would a commuter.

Research regarding distraction, conspicuity, and legibility revealed that an increase in distraction, a decrease in conspicuity, or a decrease in the legibility of a sign may cause an increase in the crash rate (Farbry et al., 2001). The review shows that, at this point, there is no effective technique for evaluating safety effects of EBBs on driver attention or distraction. Crash studies may show a positive correlation between dynamic signs and crash rates, but driver age and route familiarity are examples of confounding variables whose interference may hide the fact that very little causality can be proven.

Recently, much attention has been focused on the causes and effects of distraction on driving, especially in the area of cellular phones and other in-vehicle technology. A review of the recent driver distraction literature failed to reveal any studies in which outdoor advertising was mentioned as a cause for driver distraction. As further proof of this, the principal investigator for this project recently served on the advisory panel for the revised Model Minimum Uniform Crash Criteria in which transportation safety experts recommended revisions to the minimum set of data to be collected as part of every crash report. There were lengthy discussions about which distraction variables should be recommended, and the words "billboard" or "advertising" were never mentioned.

The national crash databases do not mention billboards in their list of driver distractions. The two most prominent databases are the General Estimates System (GES), which estimates the number of all crashes based on a representative sample, and the Fatal Accident reporting System (FARS), which is a true census of every fatal crash. The only mention of billboards in the 216 page user's manual for the GES database is in the Driver's Vision Obscured By variable, which has a category of Building, Billboard, or Other Design Features (GES, 2002). In other words, if an accident was caused by a driver's vision being obscured, billboards would be lumped together with buildings and other design features, both of which are much more common than billboards. The same holds true for the FARS user's manual of 458 pages -- billboards are only mentioned in the Driver's Vision Obscured By variable, and they are lumped together with buildings (Tessmer, 2002).

One very recent study of driver distraction (Glaze and Ellis, 2003) reported one mention of the word "billboard" in the context of an accident caused by driver distraction. Glaze and Ellis performed a study to determine the nature of distraction/inattention crashes in the state of Virginia. A complex system of accident report sampling was administered via surveys sent to all seven Virginia state police divisions, four selected counties, and fourteen independent cities. Roughly 2,800 crash scenes were reported, involving a total of almost 4,500 drivers. At least one distracted driver was involved in 98% of those crashes. Every accident report had a space to write an open-ended description of the main distracting factor in the accident, and over 1,400 responses were recorded. One response included a billboard being repaired as a causal factor for driver distraction leading to a crash. No mention of outdoor advertising was made in any other place in the study, despite the fact that 35% of distracters were outside of the vehicle in question (62% were in-vehicle and 3% were unknown). The same study reported 25 cases of drivers being distracted by traffic signs or signals.

Conclusions from Literature Review

Historical correlation studies tried to draw relationships between outdoor advertising and accident frequency, but those studies, whose findings were inconclusive at best, have been discredited because of flawed methodology. Data gathering and analysis techniques have greatly improved in recent years, but billboards still fail to show up in any of the accident databases as an accident cause or in any of the driver distraction studies as a distraction cause.

Research Questions

The current project was undertaken to determine whether billboards do in fact change driver behavior when passing a billboard location. Several dependent measures were selected to serve to provide insight into driver behavior and performance. Past research has indicated that eyeglance position, speed variation, and lane deviation provide excellent measures of driver performance. The following six research questions were developed to answer the overall question of whether billboards change driver behavior:

1. Does a driver's forward scanning behavior (glances through the windshield--center forward, left forward, and right forward) change in the presence of billboards, as compared to baseline and comparison sites?
2. Does a driver's speed maintenance behavior (standard deviation of speed) change in the presence of billboards, as compared to baseline and comparison sites?
3. Does a driver's lane keeping behavior (standard deviation of lane position) change in the presence of billboards, as compared to baseline and comparison sites?
4. Does a driver's forward scanning behavior, speed maintenance behavior, or lane keeping behavior change in the presence of certain highly-attention getting billboards, as compared to standard billboards?
5. Does a driver's eyes off road percentage (sum of all glance times except center forward, left forward, and right forward divided by sum of all glance times) change in the presence of billboards, as compared to baseline and comparison sites?
6. If a driver's eyes off road percentage changes in the presence of billboards, as compared to baseline and comparison sites, are there then corresponding differences in off road glance allocations (i.e., other exterior locations, rear view mirror, and other interior locations)?

METHOD

Experimental Design

This study was conducted as a mixed factors research design (a 2 x 2 x 2 x 3 design, with 4 between-subjects cells). There were five independent variables: gender, age, route familiarity, event type, and road type. The between-subjects independent variables were gender (male or female) and age (younger or older). The original within-subject independent variables were route familiarity (unfamiliar or familiar) and event type (billboard, baseline, or comparison). An additional within-subject independent variable of road type was added post-hoc (interstate or surface road). All of the participants drove each of the segments and were exposed to all of the billboards and comparison events.

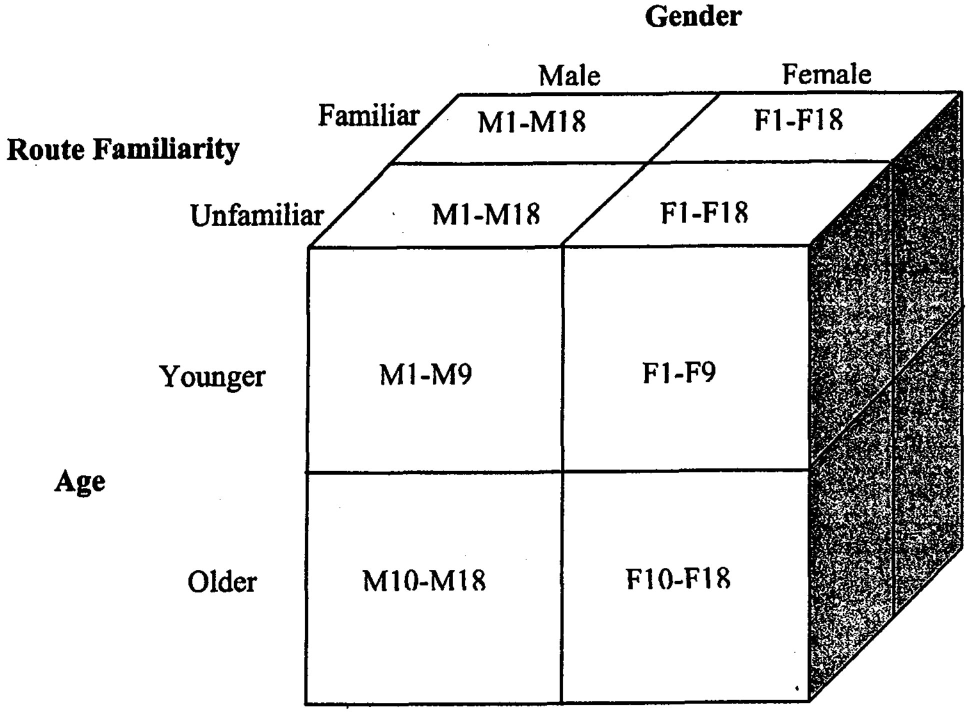

Figure 1. Assignment of Participants to Experimental Conditions.

Independent Variables

The five independent variables are listed in Table 1.

Table 1. Independent Variables

Independent Variable	Levels
Age	Younger (18-35) or Older (50-75)
Gender	Male or Female
Route Familiarity	Unfamiliar or Familiar (familiarity with 4 segments determined for each subject)
Event Type	Billboard, Baseline (no billboards) or Comparison (other distracters)
Road Type	Interstate or Surface Street

Age and Gender. Of the 36 participants, eighteen were younger drivers (18 to 35 years old) and eighteen were older drivers (50 to 75 years old). Eighteen of the participants were male and eighteen were female. Age was equally balanced across gender, as is illustrated by Figure 1 (e.g., of the 18 younger participants, 9 were male and 9 were female).

Route Familiarity. Route familiarity referred to how often a section was normally driven by the participant per week (e.g., unfamiliar = drove section less than once per week; familiar = drove section at least once per week). Route familiarity was ascertained after the drive by asking participants how familiar they were with the various segments they had just driven.

Event Type. The three event types included billboard, comparison, and baseline. All of the participants were exposed to all three event types. Events were 7 seconds long. The end of an event was the point at which the experimental vehicle passed the object, and the start of the event was then defined as 7 seconds before the end point.

Road Type. The two road types were interstates and surface roads. All of the participants were exposed to both road types. Approximately 40% of the route consisted of interstate segments, with the remainder being classified as surface streets.

Billboards. Billboard events were defined as areas in which designated billboards were visible. These were identified by GPS (latitude and longitude) coordinates associated with their exact location near the roadway. There were 5 billboard types, resulting in a total of 84 available billboards (see Table 2).

Table 2. Billboard Type, Description, Number of Available Billboards

Media Type	Description	Number of Boards
14' x 48' Bulletin (14x48)	Large billboard, 14 feet (h) by 48 feet (w)	47
10'6" x 36' Bulletin (10x36)	Large billboard, 10 feet 6 inches (h) by 36 feet (w)	15
Standard Poster (SP)(12'x 25')	Medium billboard, 12 feet (h) by 25 feet (w)	15
Junior Paint (Jr P) (<10'6" x <36')	Various billboard sizes smaller than 10'6" by 36'	5
Permanent Paint (PP) (10'6 x 36' or 14' x 48')	Billboard, 10'6" by 36' or 14' by 48', "permanent" in that only one company's advertisements are displayed on this board	2
Total		**84**

Billboard Selection. Of the total set of billboards available on the route, a sample of 30 billboards was selected for efficiency of data reduction and to ensure a balanced sample. The sample was selected so that it was balanced in terms of side of the road, media type, road type, and where possible, varying degrees of "visual clutter." None of the selected boards were located directly prior to or after a road exit or entry. Preliminary review of the video indicated that drivers were likely to be changing lanes or monitoring items such as road signs during these times, which could confound the results of the analysis. Side of the road was equally represented, and 57% of boards were 14' x 48' bulletins. The remaining 43% were a mixture of smaller boards, including standard poster (20%), junior paint (13%), and 10'6" x 36'bulletins (10%). Table 3 lists the selected billboards, while the locations of the selected billboards are indicated by aqua blue dots (●) in Figure 2.

Comparison sites. Comparison events were areas with other potential roadside distracters. Examples include other forms of outdoor advertising such as "on-premise signs," logo placards, and variable message signs. These are shown as yellow dots (O) in Figure 2.

Baseline events. The baseline event type referred to areas with no billboards or other distracters visible. These areas served as locations with which to compare velocity, lane position, and glance patterns and are indicated by red dots (●) in Figure 2.

Table 3. Billboard Sample Indicating Name (billboard #), Side of the Road, Media Type, Latitude, Longitude, and Specific Site Location Information

Name	Side	Media type	Latitude	Longitude	Site
8441	R	14X48	35.27865	-80.79637	4827 I-85 NORTH S/O SUGAR CREEK ROAD WS
8489	R	JR. P	35.27728	-80.81391	4031 I-85 NORTH S/O DERITA ROAD WS
12209	L	14X48	35.27642	-80.81382	I-85 0.2 mi S/O GRAHAM STREET ES
13052	L	14X48	35.27513	-80.82055	I-85 0.3 mi S/O GRAHAM ST ES
8537	R	14X48	35.27559	-80.82232	3639 I-85 NORTH WS
8532	L	14X48	35.27421	-80.82535	3340 I-85 NORTH ES
8568	R	14X48	35.27446	-80.82939	3399 I-85 NORTH N/O STATESVILLE AVE/RD WS
8574	L	14X48	35.27273	-80.83054	3210 I-85 NORTH N/O STATESVILLE AVE/RD ES
13346	R	14X48	35.24167	-80.85136	I-77 0.1 mi S/O HWY 16 (BROOKSHIRE) WS
8960	R	14X48	35.23256	-80.86009	I-77 SOUTH @ SECOND STREET WS
8998	L	14X48	35.22705	-80.86136	I-77 SOUTH 0.2 mi N/O INDEPENDENCE BLVD ES
9027	R	JR. P	35.22245	-80.86828	I-77 SOUTH @ W. INDEPENDENCE BLVD WS
9034	L	14X48	35.21395	-80.87255	I-77 SOUTH 0.3 mi N/O REMOUNT RD ES
9071	R	14X48	35.21271	-80.8744	I-77 SOUTH 0.1 mi N/O REMOUNT RD WS
9106	L	JR. P	35.18121	-80.88652	I-77 SOUTH @ WOODLAWN ROAD ES
9128	L	14X48	35.17475	-80.88614	I-77 SOUTH @ SOUTHERN RAILROAD ES
9159	R	14X48	35.17378	-80.88711	I-77 SOUTH S/O SOUTHERN RAILROAD WS
7716	L	14X48	35.16352	-80.88649	511 TYVOLA RD NS
7723	R	10X36	35.16536	-80.88029	900 TYVOLA RD SS
3240	L	SP	35.16852	-80.87622	5100 SOUTH BLVD N/O TYVOLA RD WS
3197	R	SP	35.17213	-80.87553	4837 SOUTH BLVD S/O INWOOD DR ES
3130	L	SP	35.18526	-80.87628	4230 SOUTH BLVD S/O SCALEYBARK RD WS
13351	R	10X36	35.18681	-80.87557	4127 SOUTH BLVD ES
3068	L	SP	35.19762	-80.86968	3040 SOUTH BLVD N/O GREYSTONE RD WS
13353	R	JR. P	35.19774	-80.86876	3033 SOUTH BLVD ES
13200	L	10X36	35.20568	-80.79402	2801 E INDEPENDENCE 0.4 mi W/O EASTWAY NS
7194	R	14X48	35.20232	-80.78991	3200 E INDEPENDENCE BLVD 0.1 mi W/O EASTWAY DRIVE SS
1856	R	SP	35.20015	-80.76359	4932 ALBEMARLE RD @ PUTT PUTT SS
7245	L	14X48	35.20156	-80.7621	5101 ALBEMARLE RD E/O GREENBROOK DR NS
1895	L	SP	35.20336	-80.74105	6115 ALBEMARLE RD W/O FARM POND LN NS

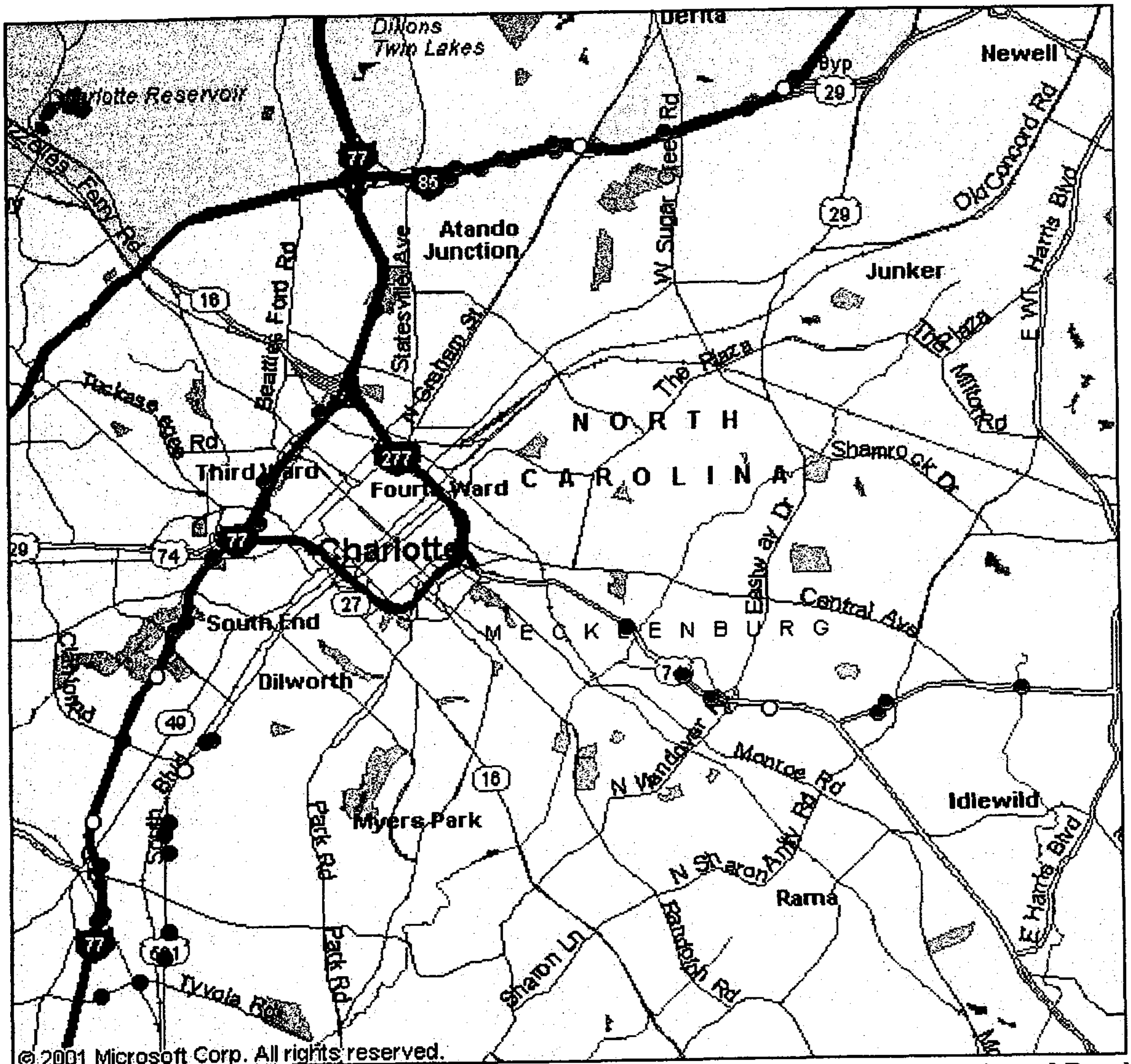

Figure 2. Map Illustrating Billboards (aqua blue), Comparison Sites (yellow), and Baseline Sites (red).

Dependent Variables

The dependent variables are discussed in more detail in the results section, but they are reviewed briefly here. The purpose of the study was to determine if there are changes in driver behavior in the presence of billboards. Eleven dependent measures were used as indicators of driver behavior: nine eyeglance measures and two driving performance measures. The nine eyeglance measures included: total number of glances for center forward, left forward, and right forward; total glance duration for center forward, left forward, and right forward; and average glance duration for center forward, left forward, and right forward. Keep in mind that all glance locations reported here were out of the front windshield, but varied in location within the forward view. The two driving performance measures were speed deviation and lane deviation. Additional analyses examined driver glance behavior to certain other locations, including interior locations and exterior locations other than forward. The next section lays the groundwork for the selection of these dependent variables, which are similar to those typically used in transportation safety research.

Selection of Dependent Variables Based on Previous Driving Studies

Measures of Visual Demand

According to Farber, Blanco, Foley, Curry, Greenburg, and Serafin (2000), typical measures of visual demand include: (1) glance frequency, (2) glance duration, (3) average duration per glance, and (4) total eyes-off-road time; such measures are time-consuming to record and analyze but are typically used as forms of visual distraction measures. For example, driving research has been conducted on the performance of completing in-car tasks such as adjusting the radio, viewing in-car displays (e.g., speedometer) or interacting with a navigation system (Dingus, Antin, Hulse, & Wierwille, 1988; Gellatly & Kleiss, 2000; Kurokawa & Wierwille, 1990; Tijerina, Palmer, & Goodman, 1999). Visual glance duration and the number of glances per task were investigated while performing conventional in-vehicle tasks and navigation tasks (Wierwille, Antin, Dingus, & Hulse, 1988). Findings indicated that glance frequency varied depending upon the task, and that glance duration for a single glance ranged from 0.62 s to 1.63 s. The mean number of glances across all tasks was between 1.26 and 6.52 glances. Zwahlen, Adams, and DeBald (1988) reported that "out of view" glance times (rear view mirror, speedometer, etc.) ranged from 0.5 s to 2.0 s during straight driving. Another example was an experiment by Parkes, Ward, and Vaughan (2001), which measured glance frequency, glance duration, and average duration per glance to evaluate two in-vehicle audio systems, in terms of total "eyes off road" time.

Mirror Glance Duration

Based on available literature discussed in this section, mirror glance times range from 0.8 s to 1.6 s (M = 1.1 s). Searches to the rear (blind spot) appeared to require a minimum value of 0.8 s. Nagata and Kuriyama (1985) investigated the influence of driver glance behavior in obtaining information through door and fender mirror systems. For door mirror systems, they reported that the average glance duration to the near-side (i.e., right side in this case) mirror was 0.69 s. Rockwell (1988) reported that the average glance duration to the left mirror was 1.10 s (SD = 0.33 s). This finding was consistent across different participants in three different experiments over a six-year period using the same data gathering and reduction technique. Taoka (1990) modeled eye glance distributions of Rockwell and found they could be well represented by means of a lognormal distribution. Taoka reported that the average time for viewing the left-side mirror was also 1.10s (SD = 0.3 s). The 5th percentile value was 0.68 s and the 95th percentile was 1.65 s. For right side mirror glances, Nagata and Kuriyama (1985) reported that average glance duration for the far-side mirror was 1.38 s (angle difference from the vertical axis of 70 degrees), while Rockwell reported an average glance duration of 1.21 s (10% larger than left glances), with an approximate standard deviation of 0.36 s. For the rear view mirror, Taoka (1990) reported that the average glance time was 0.75 s (SD = 0.36 s). The 5th percentile value was 0.32 s and the 95th percentile was 1.43 s.

Search and Scan Patterns

Early research included the investigation of visual search and scan patterns while driving (Mourant, Rockwell, & Rackoff, 1969; Mourant & Rockwell, 1970; 1972). It was found that as drivers became familiar with a route, they spent more time looking ahead, they confined their sampling to a smaller area ahead, and they were better able to detect potential traffic threats (e.g., movement in the periphery). Mourant and Rockwell (1970) found that peripheral vision was used to monitor other vehicles and lane line markers, that novice and experienced drivers differed in their visual acquisition process, and that novice drivers may be considered to drive less safely.

A recent field study investigated the influence of fatigue on critical incidents involving local short haul truck drivers (Hanowski et al., 2000). Fatigued drivers involved in critical incidents when making lane changes spent more time looking in irrelevant locations (i.e., locations other than out-the-windshield, out-the-windows, at the mirrors, or at the instrument panel). The mean proportion of time spent looking at irrelevant locations was 0.08. However, during normal lane changes (not a critical event), the mean proportion of time that drivers spent looking at irrelevant locations was 0.03, a significant difference. In terms of eye behavior, it appears that fatigued drivers involved in critical incidents pay less attention to relevant locations such as the road ahead and appropriate mirrors.

Velocity

Velocity (traveling speed) has been used as a measure of driving performance for several decades. For example, Brown, Tickner, and Simmonds (1969) found that driving while telephoning had a 6.6% reduction in speed, as compared to driving alone, in an early closed-circuit driving experiment. They also concluded that telephoning while driving may impair perception and decision-making skills. More recently Alm and Nilsson (1994) concluded that a mobile telephone task while driving led to a reduction in speed level. In another effort, Tijerina, Kiger, Rockwell, and Tornow (1995) assessed driver workload for commercial vehicle operators in conjunction with using an in-vehicle device. Various measures were monitored including speed variance, which was highest for activities involving radio tuning and 10-digit cell-phone dialing tasks. Another study monitored speed for a driving study involving talking on a cell phone or talking to a passenger (Waugh, Glumm, Kilduff, Tauson, Smyth, & Pillalamarri, 2000). Results indicated that driving speeds were lower when talking on the phone, as compared to talking to the passenger.

Lateral Position

Lateral lane position or deviation is one of the most common measures of driver performance and distraction (Salvucci, 2002). Lane position can be measured in terms of lane exceedances (i.e., drift across the line between the current lane and the next lane) or in the absence of actual lane crossings, lateral position in terms of distance from the center of the lane or the side lane line markings. Various researchers have used lateral position. For example, Serafin, Wen, Paelke, and Green (1993) conducted an experiment involving a driving simulator and car phone tasks. Greater lane deviation was observed for dialing while driving as compared to tasks involving listening, talking, or mental processing. In another study, Alm and Nilsson (1994) reported that for difficult driving tasks, a mobile telephone task had an effect on the drivers' lateral position during various 500 meter driving segments. Results indicated that the mobile-telephone task made drivers drive closer to the right lane line, especially for complex tracking tasks. In another study, Tijerina, Kiger, Rockwell, and Tornow (1995) evaluated various measures, including lane position variance and lane exceedances. They concluded that lane keeping was degraded when performing message reading tasks.

Participants

Thirty-six participants who were familiar with the Charlotte, North Carolina freeway system and downtown area were recruited. Participants were recruited via newspaper advertisement (Figure 3) and flyers. Participant selection was determined after a telephone screening and selection process. All participants were between the ages of 18 and 73, with equal gender representation (18 female, 18 male). Figure 4 illustrates an example of a participant (actually an experimenter) seated in the experimental vehicle.

```
Car Drvrs Wanted 4 Study:
18-35 or 50-75 yrs old, 2 hrs
@$20/hr: 800-XXX-XXXX or
firstname.lastname@vt.edu
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Figure 3. Example of 4-line Straight-Text Newspaper Advertisement.

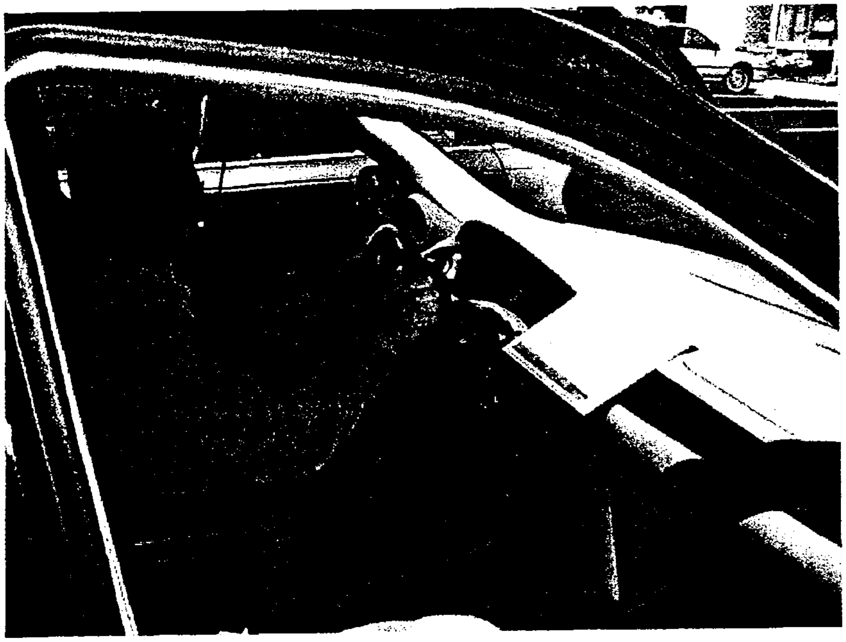

Figure 4. Participant Seated in Experimental Vehicle.

Route and Equipment

Route

The pre-planned loop route was approximately 35 miles long and consisted of sections on Interstates 77 and 85, as well as surface streets through downtown Charlotte, North Carolina and extending into more rural/suburban areas. Prior to collecting any data, experimenters from the Virginia Tech Transportation Institute (VTTI) visited the area several times in order to determine the final route by verifying the presence of suitable billboards. A potential 65-mile route was originally recommended by associates from Adams Outdoor Advertising, a local company located in Charlotte, North Carolina. After personal examination of the suggested route, the final 35-mile route was selected so that it could be completed in a timely manner, while still allowing participants to be exposed to a mixture of interstate, downtown, and residential road segments. This loop contained a variety of billboards and other outdoor advertisements (e.g., on-premise signs, logo placards), as well as standard DOT roadway signs. Adams Outdoor Advertising also provided GPS locations for each billboard of interest. Figure 5 illustrates the final route used for data collection. Table 4 lists the directions used for the experiment. The directions were mounted on the dashboard as illustrated by Figure 6.

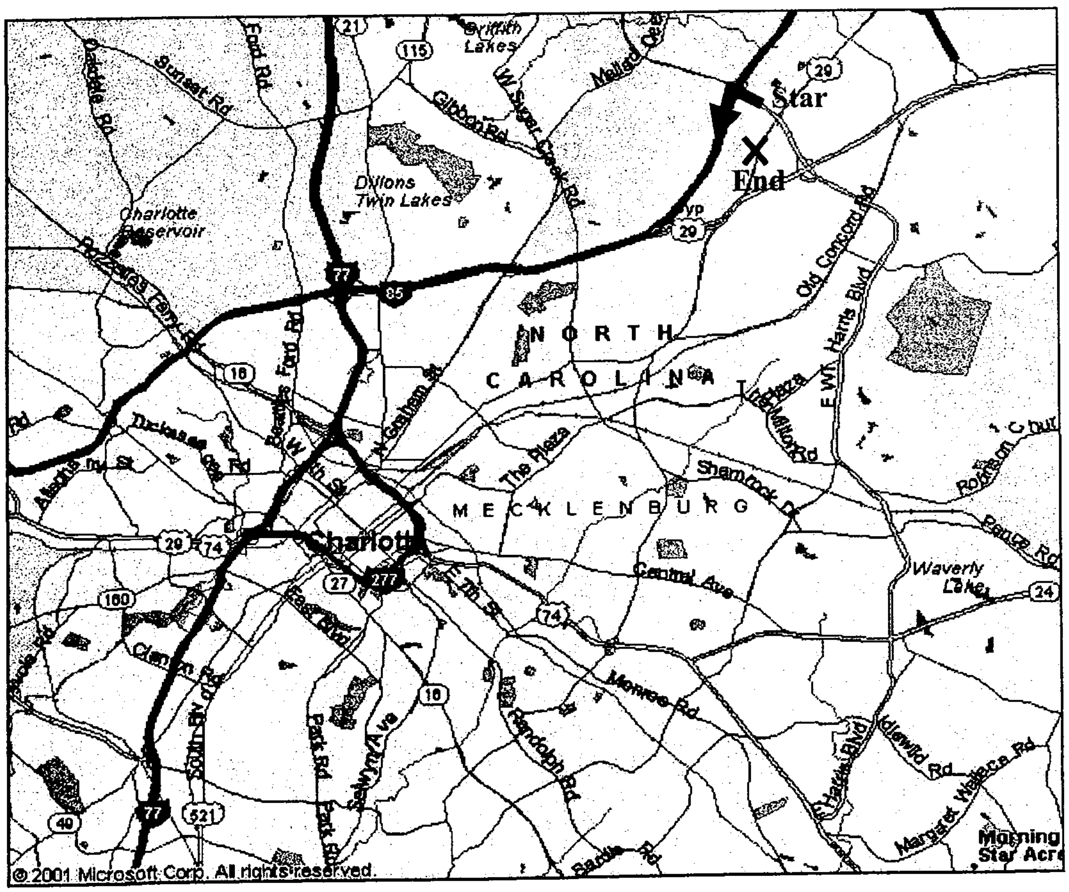

Figure 5. Map of 35-mile Loop Route in Charlotte, North Carolina.

Table 4. Directions for 35-mile Loop Route in Charlotte, North Carolina

Directions	Distance	Notes
Take W.T. Harris Blvd to I-85 SOUTH (LEFT LANE)	0.5 miles	STAY LEFT
Take I-85 to I-77 SOUTH	[illegible] mi.	
Take I-77 to Tyvola Rd. (Exit 5)	8.6 mi.	
Go LEFT onto Tyvola Rd. to South Blvd	0.6 mi.	
Go LEFT onto South Blvd to Stonewall St.	4.5 mi.	Go under 277
Go RIGHT onto Stonewall St. to McDowell St.	0.4 mi.	
Go LEFT onto McDowell St. to 5th St.	0.4 mi.	
Go RIGHT onto 5th St.		Past Trade St
5th St. turns into Independence Blvd (Highway 74/27)	0.3 mi.	
Take Independence Blvd to Albemarle Rd	3.9 mi.	
Go LEFT onto Albemarle Rd/24/27 to W.T. Harris	2.5 mi.	1st light past Varnadore (large white bldg on left)
Go LEFT onto W.T. Harris Blvd to Tryon St.	[illegible] mi.	Past University City Blvd
Go LEFT onto Tryon St. to Residence Inn Hotel	350 yards	On RIGHT side

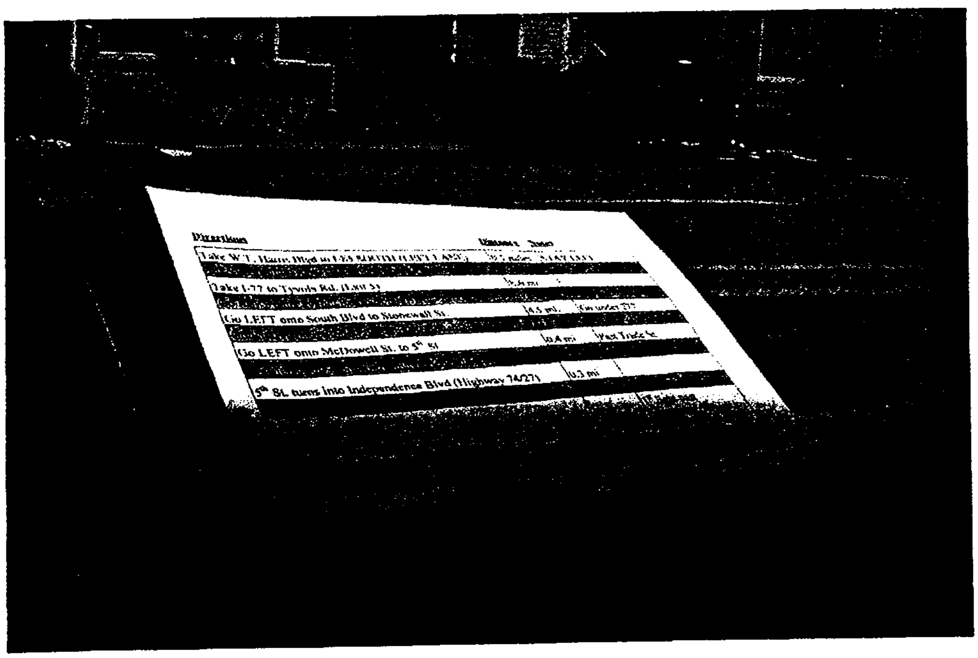

Figure 6. Directions Mounted on Dashboard of Vehicle.

Practice Route. A short, 1-mile practice route was also included. This route was driven prior to data collection on the 35-mile loop route. During the practice route, the experimenter rode as a passenger with the participant to make sure that the participant was familiar with the directions and the vehicle's displays and controls. Figure 7 illustrates the practice route used for data collection and Table 5 lists the directions.

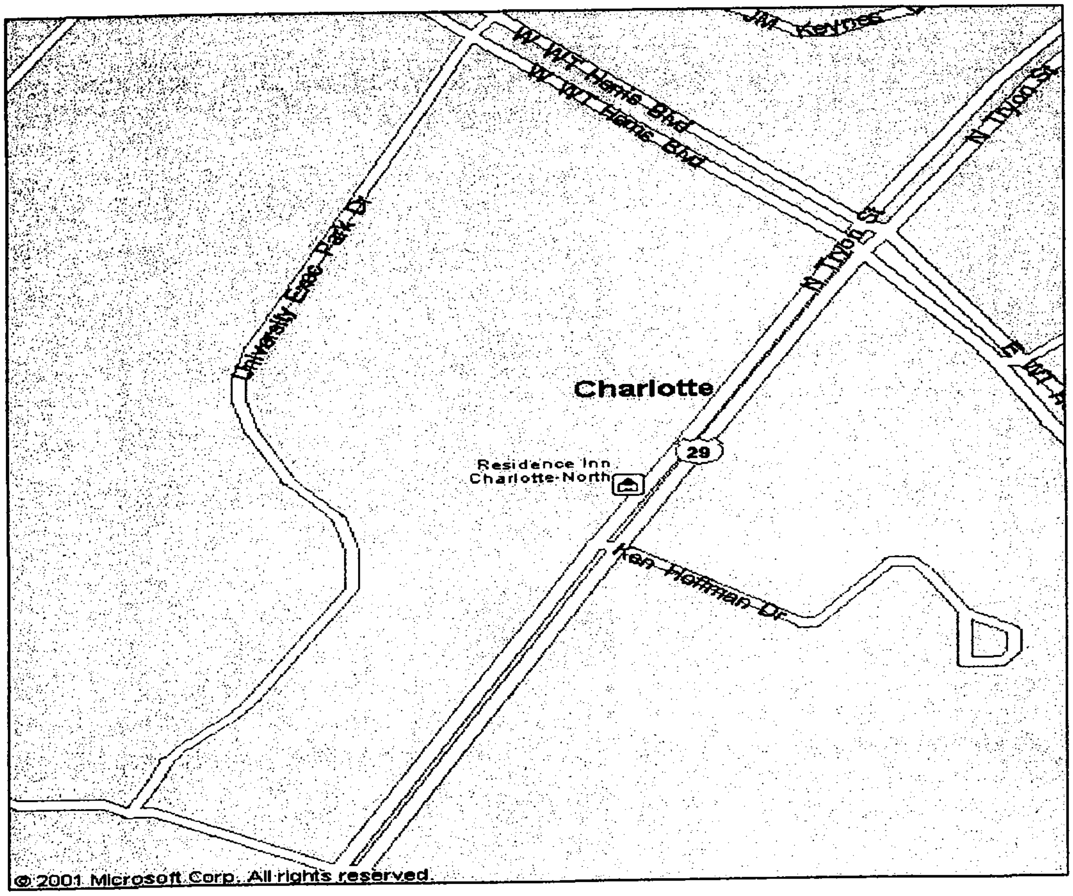

Figure 7. Map of Practice Loop in Charlotte, North Carolina.

Table 5. Directions for 1-mile Practice Route in Charlotte, North Carolina.

Directions	Distance	Notes
Turn right onto the North Tryon Street		
[redacted]		
Go to University Exec Park Dr. and turn RIGHT	125 yards	
[redacted]		

Vehicle

A 2002 Chevrolet Malibu was used in this study and is shown in Figure 8. The vehicle had an automatic transmission, an adjustable steering wheel, and other standard features.

Figure 8. Experimental Vehicle, 2002 Chevrolet Malibu.

Data Collection System

The vehicle was instrumented with a data collection system, including cameras, a computer, and sensors that continuously collected data. The system was activated approximately 2 minutes after the ignition was turned on and was deactivated when the driver turned it off. A video system with four cameras was used. Two cameras were mounted on the back side of the rear-view mirror--one facing forward left and the other facing forward right (Figure 9). This captured the forward views of the roadway, as well as the sides where billboards and other objects were visible. The other two cameras captured the driver's face from two perspectives. One camera was mounted on the top left corner of the windshield near the A-pillar (Figure 10). The other camera was mounted just above rear view mirror (Figure 11). Both faced the driver and captured head and eye movements. Figure 12 depicts these camera views. Since data reductionists needed to review all four video channels simultaneously, a quad-splitter was used to fuse the images. This produced a single, compartmentalized image such that each camera was presented in one of four locations (Figure 13). The quad splitter, computer, monitor, and keyboard were located in the trunk of the vehicle as shown in Figure 12. Finally, Figure 14 illustrates these components and how they interacted with sensors.

Figure 9. Forward Facing Cameras Mounted Behind the Center Rear View Mirror.

Figure 10. Driver Face Camera, Mounted on the Top Left Corner of the Windshield near the A-Pillar.

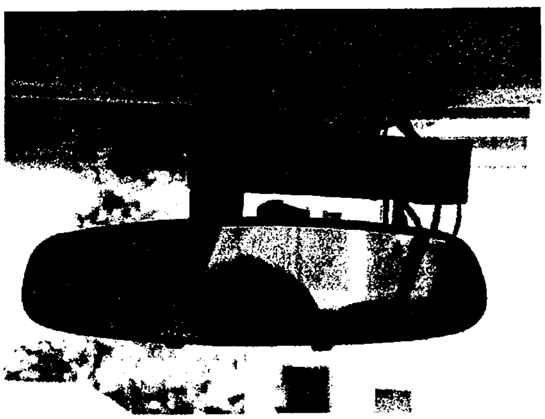

Figure 11. Driver Face Camera Mounted Above Rear View Mirror.

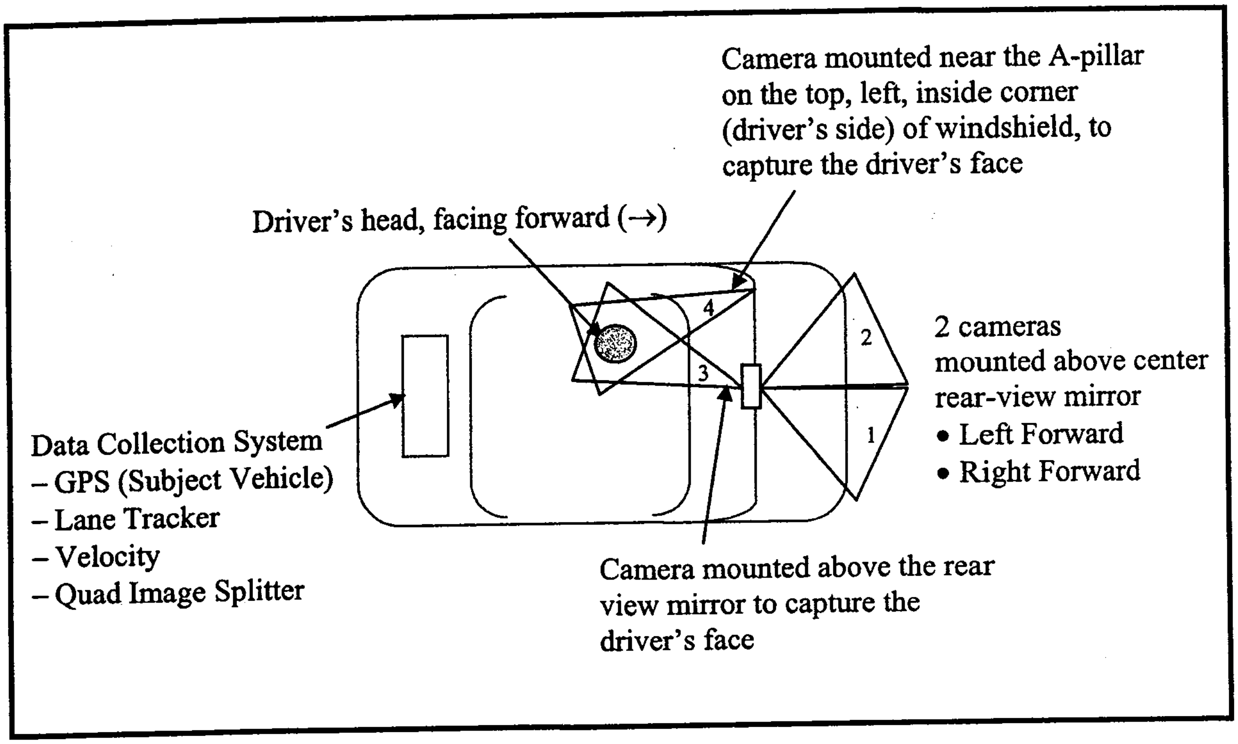

Figure 12. The four camera views recorded in the instrumented vehicle: (1) right forward view, (2) left forward view, (3) right side of driver's face, (4) left side of driver's face, and Data Collection System.

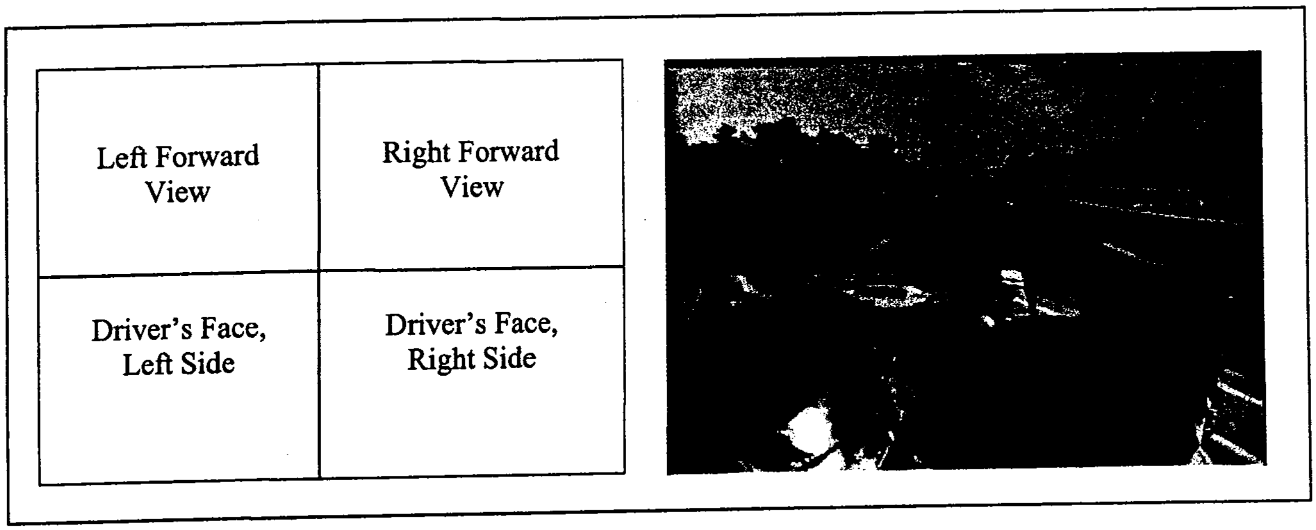

Figure 13. Diagram of Simultaneous Presentation of Four Camera Views.

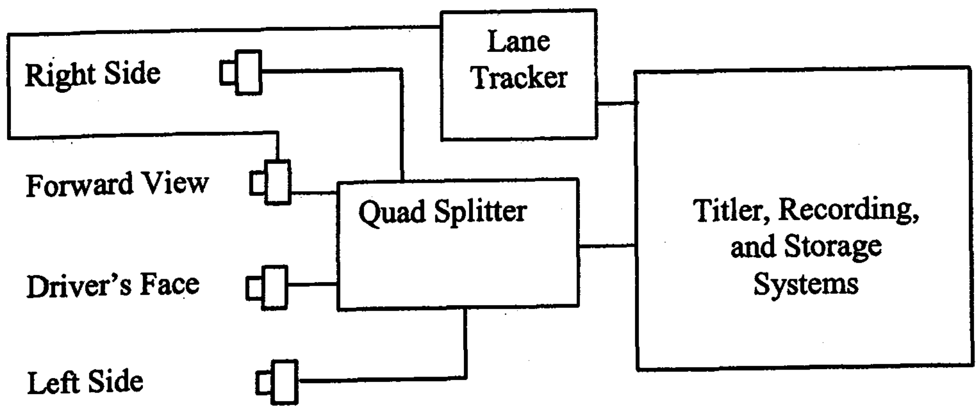

Figure 14. Components of the Data Collection System.

All video data were recorded at 30 Hz (30 frames per second), using MPEG 1 compression algorithms at a rate of 4 MB per minute. Driving performance data, including lane position and velocity, were collected at 10 Hz (10 times per second). The lane tracking system used fuzzy logic and statistical probabilities to detect lane edges in the forward camera view. Lane position was collected with a resolution of ± 2 inches from the center of the lane. Raw performance data, including lane position, velocity, and video data, were saved on the hard drive of a laptop computer and then backed up onto individual CD ROMs for each participant. After each trial, the experimenter reviewed the data to assure that the data collection system performed to specification.

Procedure

Participant Recruitment and Screening

Straight-text newspaper advertisements were placed in the *Charlotte Observer* (Figure 3), and flyers were posted in strategic locations in Charlotte, North Carolina to solicit volunteer participants for the study. Respondents were instructed to contact the experimenter via email or by telephone. A telephone/email screening form (Appendix A) was used to collect general information on age, gender, medical, and driving history, familiarity with the route(s), and use of corrective lenses or sunglasses. A list of potential participants was compiled as screenings were completed, and participants who met all of the required criteria were then contacted to set up an appointment for participation. The participant met the experimenter on the appropriate date and time in the hotel lobby of the Residence Inn on North Tryon Street, in Charlotte, North Carolina.

Experimental Protocol

Upon arrival, each participant presented a valid driver's license for the experimenter's inspection. Each participant then completed a health screening questionnaire, an informed consent form (Appendix B), and payment forms. Participants then received an orientation (including the practice route), drove the 35-mile experimental route, completed a post-drive questionnaire (Appendix C), and received $20/hour for their time. Most participants completed the experiment in 2 hours. All procedures for recruitment and data collection were approved by the Virginia Tech Institutional Review Board, as required by federal and state law.

Before testing began, four pilot participants were recruited to test the route directions and provide additional feedback as a final check of the route and experimental set-up. For the first two pilot participants, the experimenter accompanied the participant by sitting in either the front passenger seat or in the rear seat. The second two pilot drivers completed the entire experiment without an experimenter in the vehicle, in order to simulate actual data-collection conditions.

A total of 38 drivers were recruited for the full experiment. One of the older drivers chose not to participate after completing the orientation because he was uncomfortable with freeway driving. Another participant completed the experiment, but the data were not used because it rained during most of the session. Of the 36 drivers who completed the experiment, three repeated the experiment on a later date due to rain or heat-related equipment problems, which were later resolved. That is, their initial data were not used and were replaced with the second driving session.

The order in which participants took part in the experiment was counterbalanced for age and gender to the degree possible, as illustrated by Table 6. This was done to eliminate any effects of unusual traffic or road construction conditions across participants. For example, if all of the older females had participated at the beginning of the study, and there had been some unusual conditions during that time, the data for these participants might differ from that of other participants.

Table 6. Counterbalancing of the Participants' Order of Participation (Age by Gender).

	Gender	
Age	**Male**	**Female**
Younger	M1	F1
Older	M10	F10
Younger	M2	F2
Older	M11	F11
Younger	M3	F3
Older	M12	F12
Younger	M4	F4
Older	M13	F13
Younger	M5	F5
Older	M14	F14
Younger	M6	F6
Older	M15	F15
Younger	M7	F7
Older	M16	F16
Younger	M8	F8
Older	M17	F17
Younger	M9	F9
Older	M18	F18

The informed consent form explained the general purpose of the experiment to the driver and obtained his/her permission to participate in the study. After the required paperwork was completed, the following script describing the experiment was read aloud to the participant:

> Today we will have you drive a pre-determined loop route along major freeways and highways. The vehicle that you will be operating is specially equipped with instruments that collect information about your driving habits. The purpose of this study is to collect information about the way people drive under normal circumstances, in order to improve driver safety. We want you to drive as you would if you were in your own vehicle and were driving, for example, to visit a friend, do an errand, or go to work. With this in mind, we will also want you to obey all typical traffic regulations as you normally would, including, but not limited to, posted speed limits, lane markings, and traffic control devices (such as stoplights).
>
> I will be riding in the passenger seat during a 5-minute orientation drive. You are welcome to ask questions if necessary, as this orientation will help you become familiar with the vehicle and its controls. As always, our first priority is your safety. If at any time you feel uncomfortable please inform me and we can make any necessary adjustments or end the study early.

After the 5-minute orientation, I will exit the vehicle and have you drive the pre-determined route, which will bring you back to this location. This route will take about 1.5 hours. A map and written instructions will be provided for your reference, and I will also review the route with you before you depart. After the route is completed, I will debrief you and the session will be complete.

Do you have any questions I can answer at this time?

The experimenter then reviewed the map (Figure 5) and directions (Table 4) in detail. A laminated copy of the map was stored in the glove compartment for easy reference. A laminated copy of the directions was prominently displayed on the dashboard (Figure 6). A cellular telephone was also stored in the glove compartment for emergency use only.

The experimenter then oriented the participant to the vehicle, including adjustment of the seat, seat belt, mirrors, and steering wheel. Displays and controls were also reviewed, including a review of the map, directions, and cell phone operation instructions. The participant then drove the 5-minute orientation route, with verbal reminders provided by the experimenter when required. After the orientation route was completed, the experimenter checked the data, reminded the participant to drive as they normally would, and then returned to the hotel. The participant drove the 35-mile loop route, which eventually brought them back to the hotel.

After the experiment, in-vehicle eyeglance calibration was completed in the hotel parking lot. With the vehicle parked, the experimenter sat in the passenger seat and provided verbal instructions. The protocol included having the participant sit as if driving, while alternating 3-second glances to various locations with a default forward glance location. The glances included left blind spot, left window, left mirror, left forward, forward, right forward, right mirror, right window, right blind spot, rear view mirror, instrument panel (speedometer), and climate and radio controls.

After the eyeglance calibration, the participant and the experimenter returned to the hotel lobby, where the post-drive questionnaire was completed (Appendix C). The experimenter then reviewed the questionnaire to make sure that all of the answers were legible. Item #3, "Please check the top five items that most caught your attention during your drive," included a "Billboards" option (among a list of 18 possible items). If the experimenter noticed that "Billboards" had been marked, he asked about every checked item in an attempt to discover the details as to what caught their attention. For the billboard item specifically, the experimenter noted what aspect of the billboard caught the participant's attention, without conveying the importance of that particular topic. Payment was then issued to the driver at a rate of $20 per hour, (2 hours in most cases, for a total of $40) and a payment log was signed to verify that funds were received. At no time was the participant made aware that this experiment was related to driving behavior regarding billboards or other roadside items.

Data for each participant were briefly reviewed to verify that all the cameras were operating correctly and that data had been recorded. Data and video files were then transferred from the data collection system's computer to a portable laptop computer. Each participant's data were copied onto a separate CD ROM as a second back-up measure. The results from the post-drive questionnaire were then entered into an Excel spreadsheet for later processing.

Data Reduction

Analyst Training

Four data analysts worked on this project under the supervision of the principal investigator. All analysts were experienced in video data reduction prior to this project. Training began with a 2-hour session in which the user manual was reviewed and the analysis software was demonstrated by the experimenter. Relevant functions were shown, and the process of how to load the map and associated GPS coordinates was explained. Prior to actual data analysis, each analyst spent an additional eight hours mastering eyeglance direction determination and spreadsheet use. This period included time with an experienced analyst present. A large part of that time was dedicated to establishing inter-analyst reliability by comparing judgments and modifying techniques until all analysts' independent determinations matched. Throughout the entire analysis effort, at least one experienced analyst was available at all times to answer any questions or review particular cases as needed. "Spot checks" were performed throughout the data reduction process, with input provided as needed to maintain a high level of consistency. Robust reliability was further assured by ascertaining that each analyst recorded a portion of the data from each participant (i.e., a portion of the data for each of the 36 participants was analyzed by each analyst). As a rule, no more than 50% of the data for any participant was analyzed by a single analyst. As events were completed, a written record was created with the analyst's initials and date of completion.

Software

This section outlines the data reduction software program developed to analyze billboard, comparison, and baseline events. The software, called the 100-Car Analyzer or HundredCarLite, was originally developed by software engineers at the Virginia Tech Transportation Institute for a large-scale naturalistic driving study known as the 100 Car Study (Neale, Klauer, Dingus, Holbrook, & Petersen, 2001). This program integrates Microsoft MapPoint 2003 using GPS data for billboard, comparison, and baseline site locations with the data obtained from the multiple sensors in the test vehicle via a graphical interface. A total of 36 files (representing the route driven for each participant) were analyzed. After a file was opened, the software presented the analyst with the relevant windows required for data identification and reduction. The MapPoint application allowed the analyst to view a map of the Charlotte, North Carolina area, showing the relationship between the site and the roads so that video could be compared with GPS data during site identification and eyeglance analysis. The map illustrated the route and the location of the vehicle, which was represented by a green vehicle icon that moved as the event was played. This map served solely as a visual display and could not be manipulated. The analyst training manual (Appendix D) provides more detail on the methods used by the data analysts, including screen captures of the software program.

The vehicle video and data files were manipulated with the windows displaying a basic map called MapPlotForm. This represented the GPS data, showing the complete path of the vehicle, and allowed the represented data to be selected by means of GPS coordinates. This window also allowed for the analyst to move the vehicle along the route simply by a drag-and-drop action.

The VideoForm window showed four channels of video (Figure 13). Starting from the upper-left corner of Figure 13, the four channels were: (i) left forward view, (ii) right forward view, (iii) drivers' left face view, and (iv) drivers' right face view. This video was reviewed in conjunction with the GPS data in order to identify and analyze events. In addition, analysts referred to the video while performing the eyeglance analysis. The VideoForm window showed digital video corresponding to the same tenth of a second in time as the other data being examined; in other words, the video and other data were synchronized with a common time stamp. The video and matching data files could be changed one sync number (i.e., one tenth of a second) at a time, at a real-time play speed, in fast forward, or fast reverse via the VideoForm controls.

When the video was changing, HundredCarLite fed the continually updated vehicle GPS coordinates into the MapPoint software. A small moving vehicle icon used the changing coordinates to trace the appropriate path on a map of Charlotte.

Microsoft Excel was used to enter data as the analysts reviewed each event. Each participant had a workbook with 10 worksheets: three for site identification, six for eye glance analysis, and one summary sheet for that participant's complete set of results. The summary data from each participant was amassed via a separate workbook and put into a format compatible with the statistical analysis software.

Procedure

Data reduction was performed by the four analysts for each of the 36 data files. This occurred in three steps: software preparation, event identification, and eyeglance analysis. A detailed procedural instruction manual outlining each step was prepared for analyst training purposes (see Appendix D).

Software Preparation

The analyst used HundredCarLite to open the video and data files for the participant being analyzed. Once the files were completely loaded, the option to open a MapPoint display of Charlotte became available. After opening MapPoint, the analyst imported data so that every site to be identified would appear as a colored dot. Billboards in the same vicinity that were not analyzed were also displayed (as black dots) for reference to facilitate proper board identification. The site colors were labeled by category either as a billboard, comparison, baseline, or other. The appropriate Excel spreadsheet for that participant was also opened.

Event Identification

The analyst used the MapPlot window of HundredCarLite to locate the vehicle icon in the immediate vicinity of the site's dot in MapPoint. The end of an event was defined as the sync number at which the test vehicle passed the site, and the event's beginning was calculated to be at seven seconds before the end point. Identification of the end point combined two methods: the GPS data was used to align the vehicle directly in conjunction with the site, and then the video was used to visually confirm accurate GPS positioning (Figure 15)

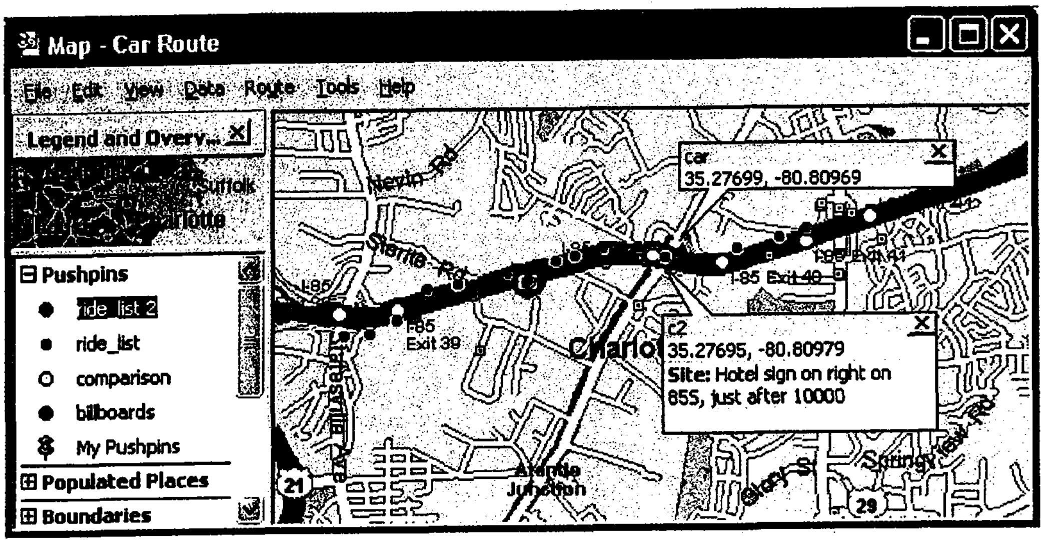

Figure 15. MapPoint Map Showing Vehicle Icon Centered on Comparison Site (#c2) in Preparation for Event Identification.

Eyeglance Analysis

The first step in eyeglance analysis was familiarization with the participant's individual glance patterns by means of a glance location calibration video, during which participants looked at specific places according to a set script. As described in the procedures section, eye calibration was conducted *after* data collection was complete, in order to serve as a record of where drivers typically look. Analysts reviewed these records so that they could become familiar with the participant's particular glance style. The analyst was thus able to conduct the glance analysis according to each participant's particular glance styles. Glances were coded according to the following abbreviations:

F - Forward
RF - Right Forward
LF - Left Forward
RVM - Rear View Mirror
OX - Outer eXterior, including side mirrors, side windows, blind spot etc.
DIR – glances toward the experimental route DIRections
OINT - Other INTerior, including speedometer, sun visor, cell phone etc.

Analysts reviewed events from beginning to end, one tenth of a second at a time, determining the direction of glance for every 10th of a second for the seven-second duration of the event. New glances were recorded as the sync number at which the participant's glance *rested* in a new location. Transition time to the new location was included in the glance location the driver was moving *away* from. Spreadsheets automatically calculated the duration of each glance. Summary information for each event included the number of glances, average glance duration, number of glances in each direction, and the average duration of glances in each direction.

Final Reduced Data Set

With 36 participants and 42 sites, there were 1,512 events available for analysis from approximately 54 hours of data collection. A small amount of data was lost due to sensor outages, sun angle, and lane changes, leaving 1,481 events for eyeglance analysis and 1,394 events for speed and lane position analysis. Altogether, 103,670 video frames were analyzed and 10,895 glances were identified. There were 97,580 data points in the speed and lane position data set.

Statistical Analysis

Descriptive statistics were calculated using an Excel spreadsheet and the Pivot Table tool. All other statistical analyses were conducted using SAS statistical software. The analysis of variance (ANOVA) statistical technique was used; in SAS this was accomplished by means of the general linear model (GLM) procedure. Where significant differences were found, and there were more than two levels of the independent variable, a post-hoc analysis was run using the Least Squares Difference procedure in SAS to determine which levels were significantly different from which other levels. (For independent variables with just two levels that differ significantly, a simple examination of the means will demonstrate which level is significantly greater than the other.)

RESULTS

Post-Drive Questionnaire

The post-drive questionnaire (Appendix C) was completed after the route was driven. It gathered information such as route familiarity and items noticed while driving; it also collected demographic and personal information, including education level, marital status, ethnicity, and income. The questionnaire was designed by VTTI driving researchers, with input from OAAA representatives. It was also reviewed by Dr. Charles R. Taylor, Professor of Marketing at Villanova University in Pennsylvania, who has worked extensively with surveys and is considered an expert in the marketing and data collection field.

Demographics Overview

In terms of demographics, the average age was 25 years for younger drivers and 56 years for older drivers. The sample of drivers was quite diverse in terms of education level, marital status, ethnicity, and income. Most drivers lived or worked in Charlotte, North Carolina and were familiar with most of the route. The following sections provide details for relevant information about the sample of drivers. Table 7 presents these findings as well.

Age

The sample of 36 drivers ranged in age from 18 to 73 years old. The mean age of all participants was 40.5 years ($SD = 17.2$). The younger drivers ranged in age from 18 to 33 years old, with a mean of 24.6 years ($SD = 4.7$). The older drivers ranged in age from 50 to 73 years old, with a mean of 56.3 years ($SD = 7.3$).

Education Level

Participants were surveyed regarding the highest education level they had completed. The number of responses and equivalent number of years were used to calculate the product. This was used to calculate the mean education level for the sample by dividing the total number of years completed by the number of participants (500/36). The average was 13.9 years of education completed (equivalent to high school plus two years of college).

Marital Status

Most drivers were either single or married, while 14% of participants reported they were divorced and 8% (all older females) reported that they were widowed.

Ethnicity

Participants came from a variety of ethnicities. Over 60% were European (Caucasian). Almost 40% of drivers were of African American, Native American, or Multi-racial background.

Income

Of the 35 participants who reported their annual household incomes on the questionnaire, the largest number (15 participants or 43%) were in the $25,000 to $49,000 range.

Table 7. Summary of Demographic Results.

CATEGORY	LEVELS				
Age (mean)	**Younger Drivers**	**Older Drivers**	**All Drivers**		
	24.6 years	56.3 years	40.5 years		
Education Level	**Jr. High**	**High Sch.**	**2-Yr Deg.**	**B.A./B.S.**	**M.A./M.S.**
	3%	39%	25%	25%	8%
Marital Status	**Single**	**Married**	**Divorced**	**Widowed**	
	39%	39%	14%	8%	
Ethnicity	**European**	**African-American**	**Native American**	**Multi-Racial**	
	61%	17%	14%	8%	
Income Level	**$0-24K**	**$25-49K**	**$50-74K**	**$75-99K**	
	29%	43%	23%	6%	

Route Familiarity

Route familiarity was assessed by three items in the questionnaire. Specific topics addressed were: location of work, location of home, and frequency of driving on roads in the experimental route (defined as familiarity). Table 8 presents the route familiarity findings.

Living and Working Location. All drivers reported that they were familiar with the Charlotte, North Carolina area and had driven on the interstates and surface roads included in the route. Over 70% of drivers reported that they lived and worked in Charlotte, North Carolina. Two drivers (6%) reported that, although they were familiar with Charlotte, they no longer lived or worked in the area.

Familiarity. Route familiarity was also evaluated in terms of six route segments that represented various types of driving (i.e., interstate vs. downtown Charlotte). Drivers were asked to indicate if they were either "familiar" (driven at least once a week) or "not familiar" (driven less than one time a week) with each segment. In some cases, participants inquired about this question item, indicating (verbally) that, although they were quite familiar with certain areas, they may not drive on them every week. Nonetheless, the results indicated that overall, drivers were familiar with the route, particularly Independence Boulevard which was a major roadway segment (81% were familiar with this segment).

Table 8. Route Familiarity Data – Percentage Reported.

Route Familiarity	72% work & live in Charlotte	11% work in Charlotte, live elsewhere	11% live in Charlotte, work elsewhere	6% work & live elsewhere		
Route Segment	69% familiar with I-85 section	64% familiar with I-77 section	61% familiar with Tyvola Rd, South Blvd., and downtown	81% familiar with Independence Blvd. (74/27) section	44% familiar with Albemarle Road (24/27) section	69% familiar with Harris Blvd. section

Overview of What Drivers Noticed

Drivers primarily noticed items such as traffic and other drivers, road or highway signs, and construction taking place along the road. Nine of 36 drivers (25%) marked "billboards" as one of the top five items (out of 18 items) that caught their attention during the drive. Two drivers mentioned specific billboards that they remembered. Aggressive driving seemed to be the most prevalent comment regarding other drivers. Participants engaged in a variety of activities while driving--listening to the radio or CD player and using the cell phone were the most prevalent. At no point was it apparent that any participant knew the specific purpose of the study; all responses indicated that drivers believed the study was related to observing drivers in a natural driving situation, which was also true. The following sub-sections describe findings in more detail, with tables illustrating drivers' responses.

<u>Attention Getters.</u> Participants were asked to indicate "the top five items that most caught your attention during your drive." Over 50% of drivers indicated that they paid attention to traffic, other drivers, road signs, and highway signs. For those drivers that indicated "billboard" as one of the items that caught their attention, the experimenter asked them to verbally expand upon all items. For billboards in particular, five drivers made noteworthy comments. A female driver indicated that she "just notices them in general." One male driver indicated that he worked in marketing and had a habit of viewing all billboards. Comments were made by two female drivers in reference to "gentlemen's club" billboards. One of these same participants said that they noticed "the woman in a suit getting out of a swimming pool." Another female driver indicated that she paid particular attention to billboards that were for gas stations or restaurants. Table 9 lists the number of responses and the percentage of drivers marking each item for this item on the questionnaire.

Table 9. Items That Caught Attention during Route: Number of Responses and Percent of Drivers Marking Item.

Questionnaire Item	Number of Responses	Percent of Drivers
Traffic	31	86.1%
Other Drivers	24	66.7%
Road Signs	21	58.3%
Highway Signs	18	50.0%
Construction	16	44.4%
Landmarks	15	41.7%
Landscaping	12	33.3%
Buildings	10	27.8%
Billboards	9	25.0%
Emergency Vehicles	8	22.2%
Gas Stations	7	19.4%
Restaurants	6	16.7%
Apartments/housing	5	13.9%
Motels/Hotels	3	8.3%
Pedestrians	1	2.8%
Walls	1	2.8%
Total	**187**	

Most Memorable. Participants were asked "What was most memorable about the drive?" This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. A total of 35 comments were made. Over 68% of the comments were related to construction, weather/view, the experimental vehicle, or traffic, as presented in Table 10. Note that no one mentioned billboards as being most memorable.

Table 10. Most Memorable Items: Number and Percent of Comments.

Comment Category	Number of Comments	Percent of Comments
Construction	7	20.0%
Weather/view	7	20.0%
Vehicle	6	17.1%
Traffic	4	11.4%
New route	3	8.6%
Cut off/near accident	2	5.7%
Emergency vehicle(s)	2	5.7%
Aware of being monitored	1	2.9%
Bumper sticker	1	2.9%
Convertible with kids	1	2.9%
Speed limit changes	1	2.9%

What Bothers You?

Participants were asked, "What bothers you about other drivers?" This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. A total of 30 comments were made. The large majority of the comments were related to aggressive maneuvers or questionable driving behavior such as tailgating, being cut off, not using turn signals, or driving slowly in the fast lane (Table 11).

Table 11. "What Bothers You?" : Number and Percent of Comments.

Comment Category	Number of Comments	Percent of Comments
Tailgating	7	23.3%
Cut off	6	20.0%
No signal	5	16.7%
Speeding	3	10.0%
Aggressive	3	10.0%
Slow in fast lane	3	10.0%
Cell phone talking	1	3.3%
Drivers who don't pay attention	1	3.3%
Inability to adjust to conditions	1	3.3%

<u>*Other Activities.*</u> Participants were asked, "What other activities do you engage in while driving?" This was an open-ended question, so the comments varied. For ease of categorization, similar comments were grouped where possible. A total of 72 comments were made. Listening to the radio or CDs was the largest single activity, making up over 26% of the comments. Using the cell phone was also common (15%). Other activities included singing or talking, drinking, smoking cigarettes, and eating, as presented in Table 12.

Table 12. Other Activities Engaged in While Driving: Number of Responses, Percentage of Responses, and Cumulative Percentage.

Comment Category	Number of Comments	Percent of Comments
Listen to radio/CDs	19	26.4%
Cell phone	11	15.3%
Sing/talk w/self	7	9.7%
Drinking	6	8.3%
Smoking	5	6.9%
Eating	4	5.6%
Adjust radio/CDs	4	5.6%
Driving/steering	3	4.2%
Talk w/others	3	4.2%
Adjust AC/windows	2	2.8%
Watching	2	2.8%
Fix hair/lipstick	2	2.8%
Reading billboards	1	1.4%
Reach into purse	1	1.4%
Chewing gum	1	1.4%
Flash cards at stop lights	1	1.4%

Other questions asked participants for additional input about the written directions and the purpose of the study. Substantively relevant participant responses included three separate suggestions relating to conducting a driving study with passengers or children, the effect of video cameras on driving behavior, and the statement that "driving in my own car would be more 'normal.' " While no one reported problems with the directions, three drivers did get off-route at one point during their trip; however, very few data points were missed. Drivers were also queried as to their recollection of the purpose of the study; all responses were within the scope of what they had been told verbally and in the informed consent form.

Forward Scanning Behavior: Site Type

This set of analyses was undertaken to answer the following research question:

1. Does a driver's forward scanning behavior (glances through the windshield--center forward, left forward, and right forward) change in the presence of billboards as compared to baseline and comparison sites?

There were three site types studied in this experiment: baseline sites, comparison sites, and billboard sites. Baseline sites were areas with no billboards, on-premises signs, or buildings close to the road, while comparison sites were selected sites including logo signs, on-premises signs, and unique architecture. For site type, two of the nine eyeglance dependent variables showed significant differences. These were observed for only left-forward glances for both the number of glances and total glance duration, as illustrated by Table 13. For the number of left-forward glances, billboard sites had significantly more glances than baseline sites, but comparison sites did not differ significantly from either billboard or comparison sites. For total glance duration, participants looked left forward for exactly the same amount of time for both billboard and comparison sites (no significant difference). However, a significantly shorter time was noted when passing baseline sites. Figures 16-17 illustrate the significant differences graphically. Appendix E contains descriptive statistics for all eyeglance measures by individual site type (i.e., individual baseline, comparison, and billboard sites).

Table 13. Average Glance Statistics and Probabilities for Site Type.

	Site Type			
	Baseline	**Billboard**	**Comparison**	**Probability**
Number of Glances				
Center Forward	3.46	3.58	3.32	n.s.
Left Forward	[redacted]	[redacted]	[redacted]	[redacted]
Right Forward	1.32	1.44	1.31	n.s.
Average Glance Duration (seconds)				
Center Forward	1.88	1.87	2.07	n.s.
Left Forward	0.23	0.32	0.37	n.s.
Right Forward	0.38	0.45	0.42	n.s.
Total Glance Duration (seconds)				
Center Forward	4.62	4.50	4.64	n.s.
Left Forward	[redacted]	[redacted]	[redacted]	[redacted]
Right Forward	0.74	0.91	0.86	n.s.

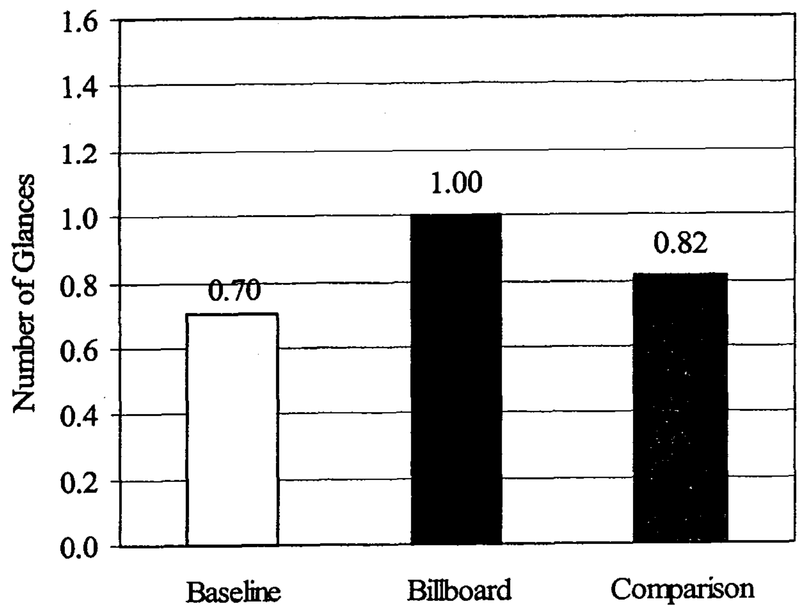

Figure 16. Number of Left Forward Glances by Site Type (significant at $p = 0.0021$). Billboard sites differ significantly from baseline sites, but comparison sites do not differ significantly from either billboard sites or baselines sites.

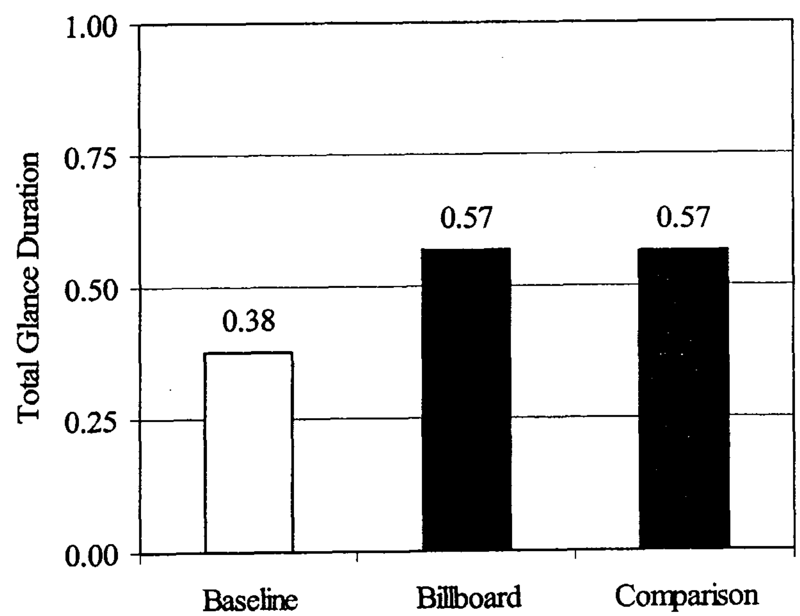

Figure 17. Total Left Forward Glance Duration in Seconds by Site Type (significant at $p = 0.0245$). Billboard sites did not differ significantly from comparison sites, but both billboard and comparison sites differed significantly from baselines sites.

Forward Scanning Behavior: Side of Road, Age, Familiarity, Gender, and Road Type

This set of analyses was undertaken to answer auxiliary research questions about other factors that may influence forward scanning behavior. For side of road (right, left), age (younger, older), and familiarity (familiar, not familiar), there were no significant differences revealed in terms of any of the eyeglance dependent measures. However, in terms of both average glance duration and total glance duration, differences were observed for gender in right-forward glances, as illustrated by Table 14 and Figures 18-19. While there was no significant difference in the number of glances to the right-forward, females had significantly longer total and average glance durations to the right-forward than did males.

Table 14. Average Glance Statistics and Probabilities for Gender

	Gender		
	Female	**Male**	**Probability**
Average Glance Duration (seconds)			
Right Forward	[redacted]		
Total Glance Duration			
Right Forward	[redacted]		

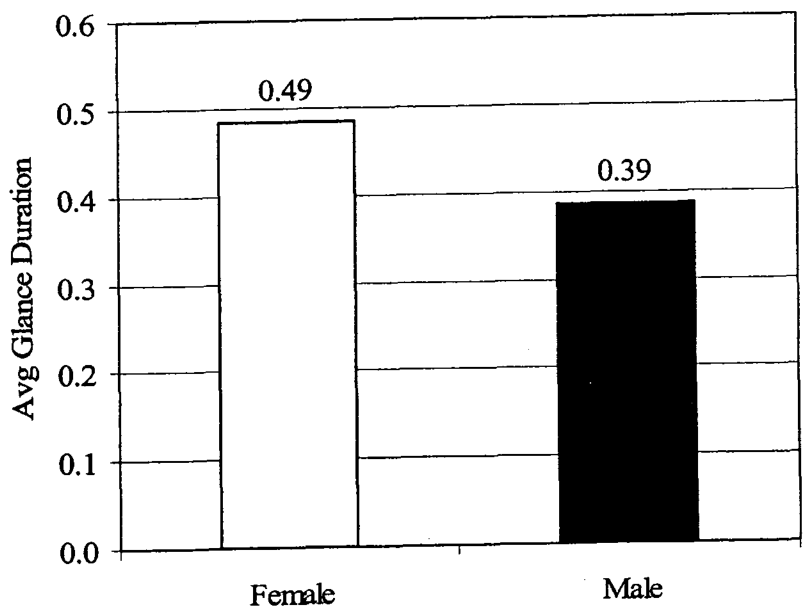

Figure 18. Average Right Forward Glance Duration in Seconds for Gender (significant at $p = 0.0383$).

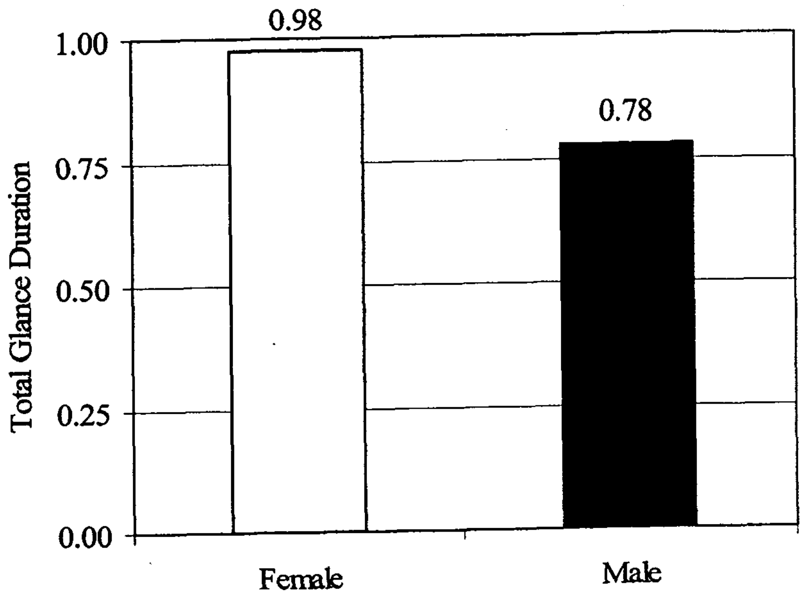

Figure 19. Total Right Forward Glance Duration in Seconds for Gender (significant at $p = 0.0451$).

Road type yielded the largest number of significant findings--far more than the site type analysis. Analysis of interstate versus surface roads found differences for almost all glance measures, in terms of number of glances, average glance duration, and total glance duration, as illustrated by Table 15. Figures 20-27 illustrate these differences graphically. As a reminder, interstate refers to Interstate 85 and Interstate 77, while surface refers to roads such as Tyvola Road, South Boulevard, Independence Boulevard, and Albemarle Road. Observed differences were systematic, almost without exception--surface roads scored significantly higher on nearly all counts, whether it referred to higher numbers of glances or longer durations (averages or totals). Forward-glance durations, average and total, were significantly longer for interstate than for surface roads.

Table 15. Average Glance Statistics and Probabilities for Road Type.

	Road Type		
	Surface	Interstate	Probability
Number of Glances			
Center Forward	[redacted]	[redacted]	[redacted]
Left Forward	[redacted]	[redacted]	[redacted]
Right Forward	[redacted]	[redacted]	[redacted]
Average Glance Duration			
Center Forward	[redacted]	[redacted]	[redacted]
Left Forward	0.33	0.30	n.s.
Right Forward	[redacted]	[redacted]	[redacted]
Total Glance Duration			
Center Forward	[redacted]	[redacted]	[redacted]
Left Forward	[redacted]	[redacted]	[redacted]
Right Forward	[redacted]	[redacted]	[redacted]

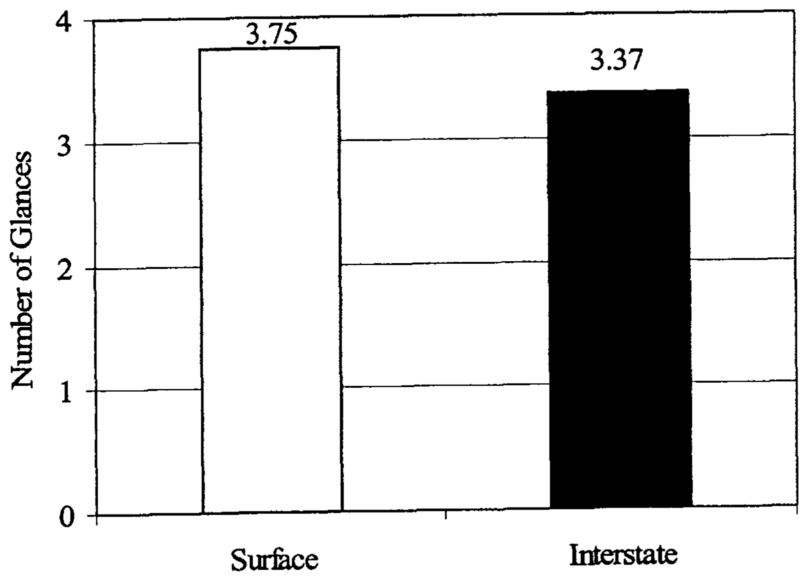

Figure 20. Number of Center Forward Glances by Road Type (significant at $p = 0.0003$).

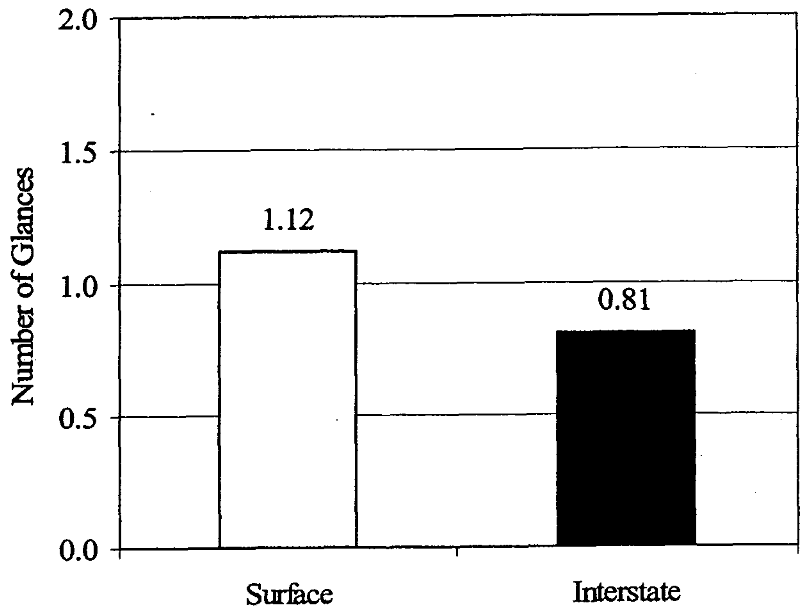

Figure 21. Number of Left Forward Glances by Road Type (significant at $p < 0.0001$).

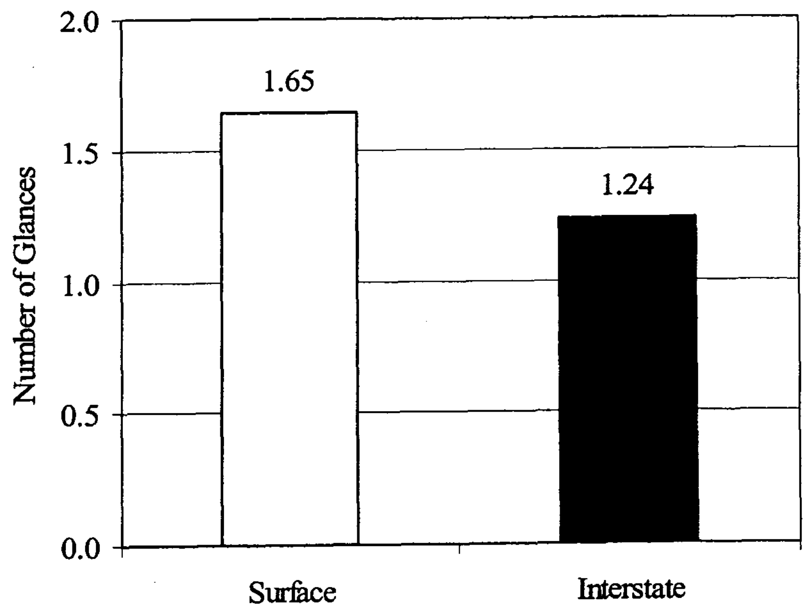

Figure 22. Number of Right Forward Glances by Road Type (significant at $p < 0.0001$).

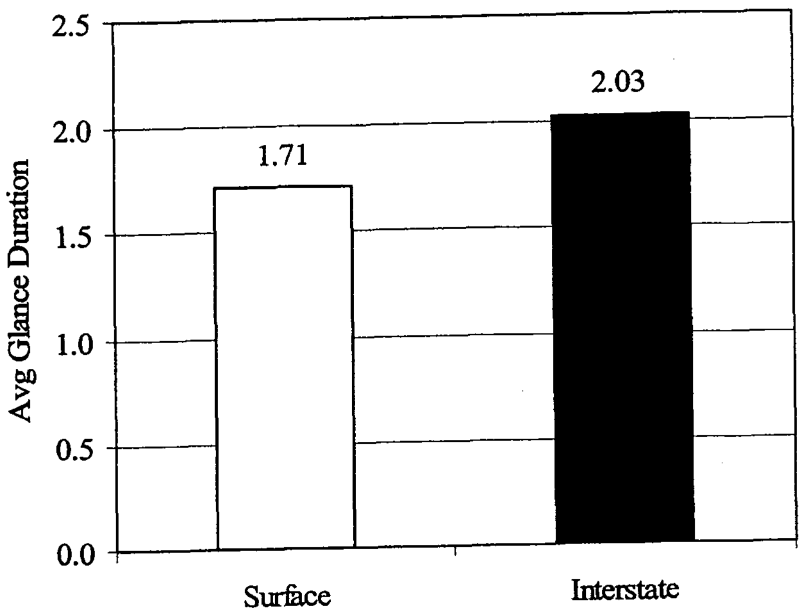

Figure 23. Average Forward Glance Duration in Seconds by Road Type (significant at $p = 0.0012$).

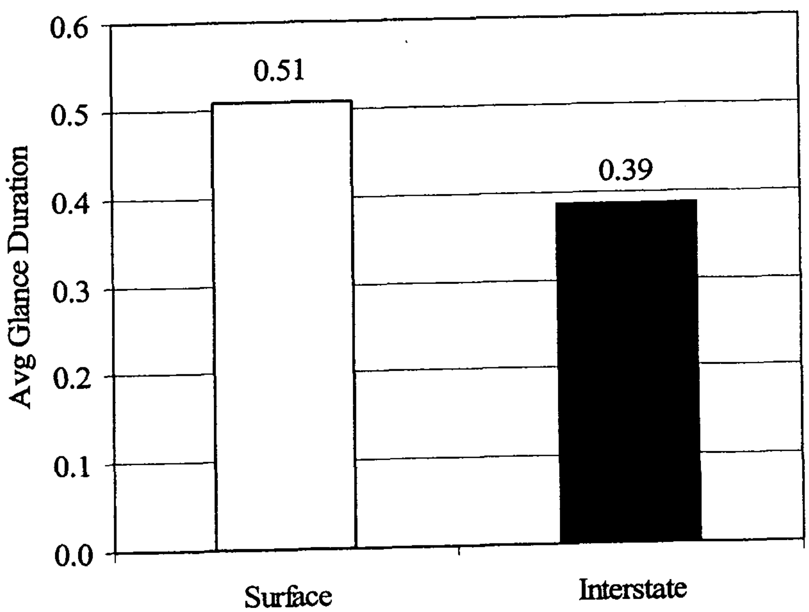

Figure 24. Average Right Forward Glance Duration in Seconds by Road Type (significant at $p < 0.0001$).

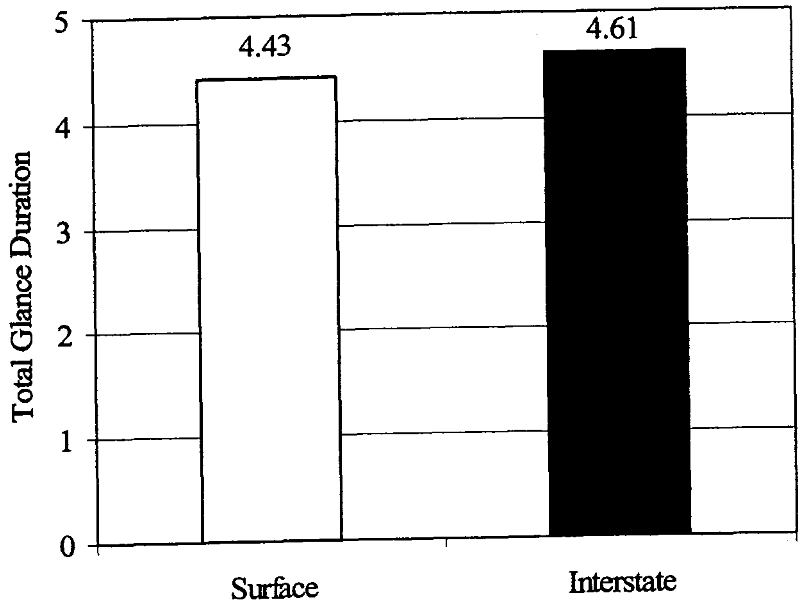

Figure 25. Total Forward Glance Duration in Seconds by Road Type (significant at $p = 0.0160$).

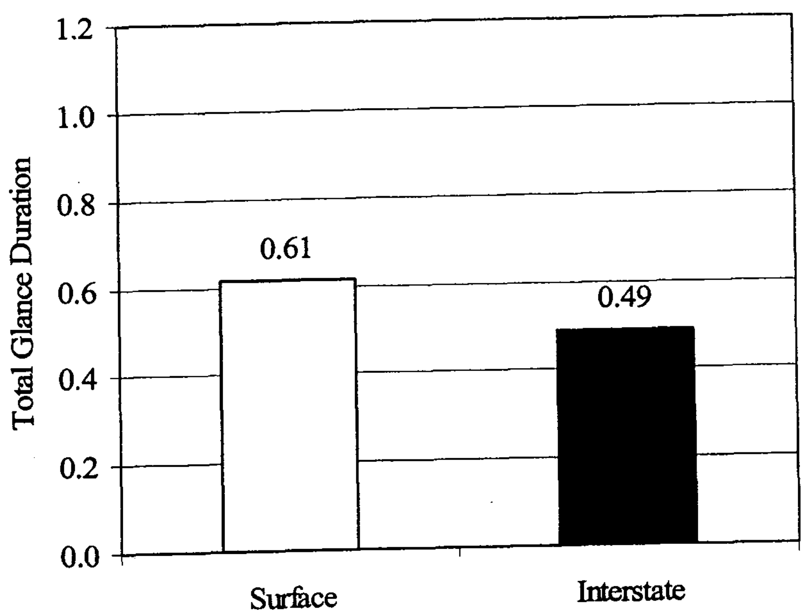

Figure 26. Total Left Forward Glance Duration in Seconds by Road Type (significant at $p = 0.0027$).

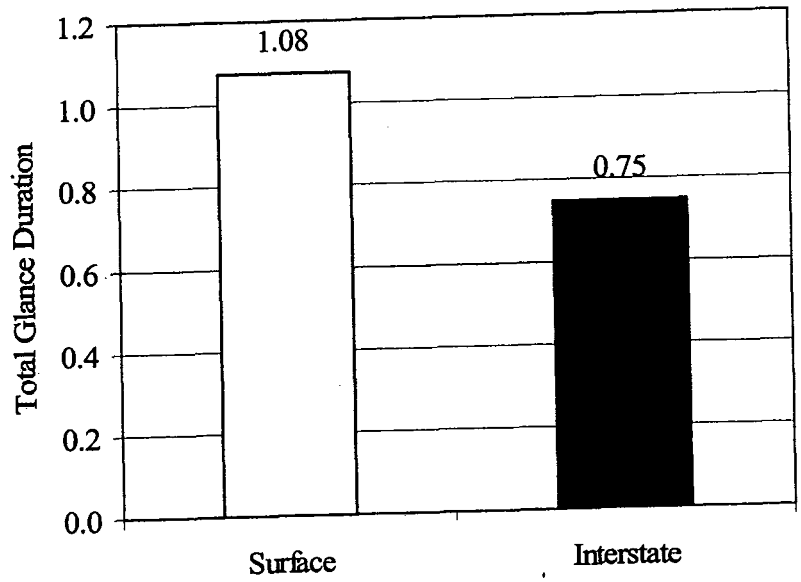

Figure 27. Total Right Forward Glance Duration in Seconds by Road Type (significant at $p < 0.0001$).

Speed Maintenance Behavior

This set of analyses was designed to answer the following research question:

1. Does a driver's speed maintenance behavior (standard deviation of speed) change in the presence of billboards, as compared to baseline and comparison sites?

In terms of speed variation, as measured by the standard deviation of speed over the 7 seconds of interest for each event, there was no significant difference between billboard, comparison, and baseline sites. Sites of all types on the left were associated with significantly greater speed variation, as compared to sites on the right ($p = 0.0005$). In terms of route familiarity, segments that were rated as familiar had significantly less speed variation, as compared to route segments that were not familiar ($p = 0.0343$). Speed variation was greatest for road type--sites on the interstate had less speed variation, as compared to surface roads ($p < 0.0001$). Table 16 presents the descriptive statistics for speed and Figures 28-30 illustrate the significant differences graphically.

Table 16. Standard Deviation Statistics for Speed.

Mean Standard Deviation of Speed (mph)				
Site Type	Baseline	Billboard	Comparison	Probability
	0.61	0.99	0.82	n.s.
Side	Left	Right		Probability
	[redacted]			
Age	Older	Younger		Probability
	0.87	0.95		n.s.
Gender	Female	Male		Probability
	0.96	0.86		n.s.
Familiarity	Familiar	Not-Familiar		Probability
	[redacted]			
Road Type	Surface	Interstate		Probability
	[redacted]			

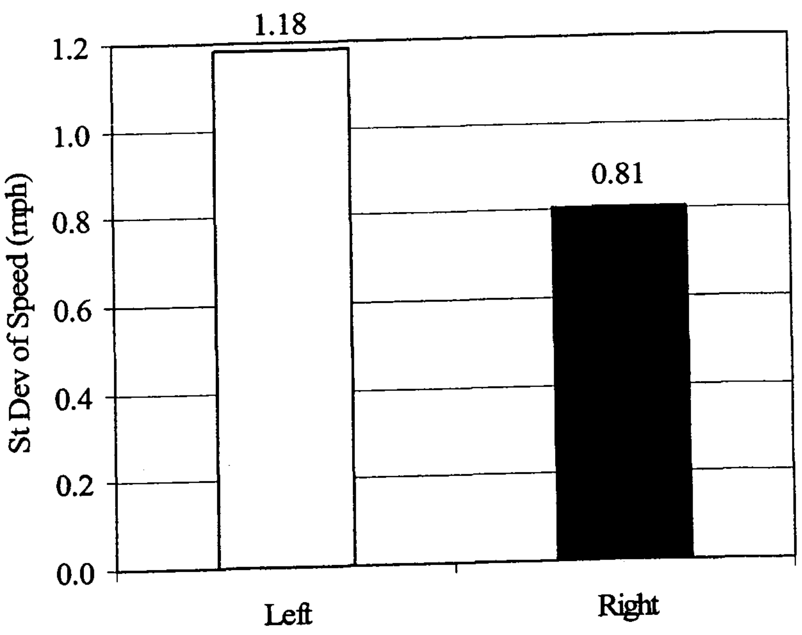

Figure 28. Speed Variation by Side of Road (significant at $p = 0.0005$).

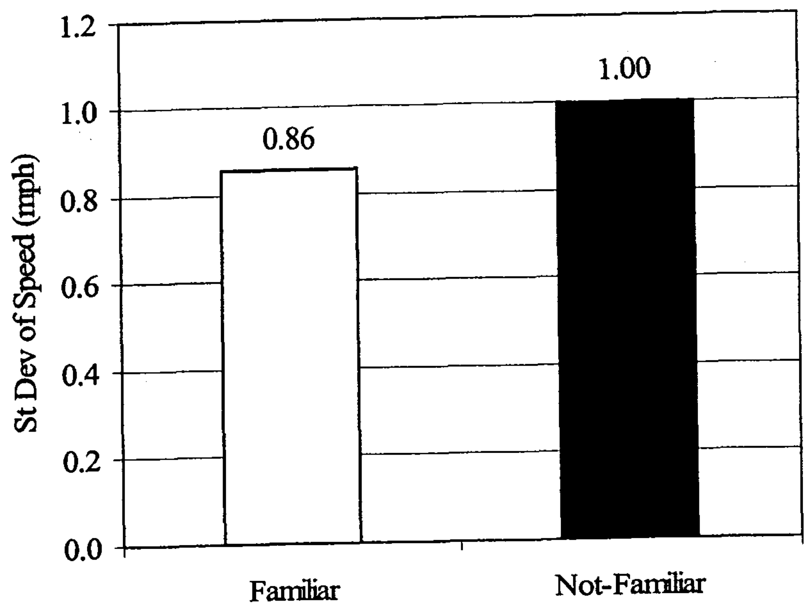

Figure 29. Speed Variation by Familiarity (significant at $p = 0.0343$).

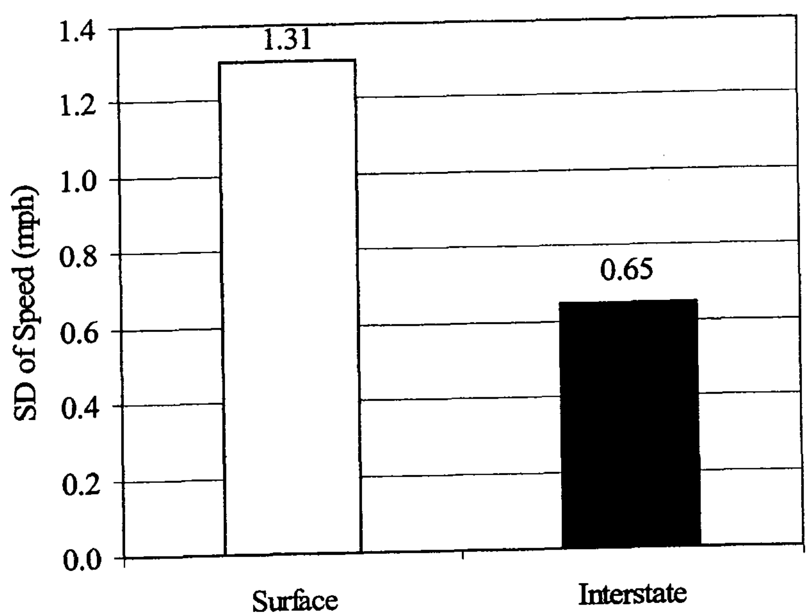

Figure 30. Speed Variation by Road type (significant at $p < 0.0001$).

Lane Keeping Behavior

This set of analyses was designed to answer the following research question:

1. Does a driver's lane keeping behavior (standard deviation of lane position) change in the presence of billboards, as compared to baseline and comparison sites?

In terms of lane position (standard deviation of lane position in inches), significant differences were only found for side of road. Locations associated with the right side of the road had significantly less lane position standard deviation as compared to sites on the left side ($p = 0.0106$). Table 17 presents the descriptive statistics for lane position and Figure 31 illustrates the single significant difference graphically.

Table 17. Standard Deviation Statistics for Lane Position.

Mean Standard Deviation of Lane Position (inches)				
Site Type	**Baseline**	**Billboard**	**Comparison**	**Probability**
	6.40	8.97	7.04	n.s.
Side	**Left**		**Right**	**Probability**
	[redacted]		[redacted]	[redacted]
Age	**Older**		**Younger**	**Probability**
	8.61		8.04	n.s.
Gender	**Female**		**Male**	**Probability**
	8.18		8.47	n.s.
Familiarity	**Familiar**		**Not-Familiar**	**Probability**
	8.12		8.69	n.s.
Road Type	**Surface**		**Interstate**	**Probability**
	9.25		7.71	n.s.

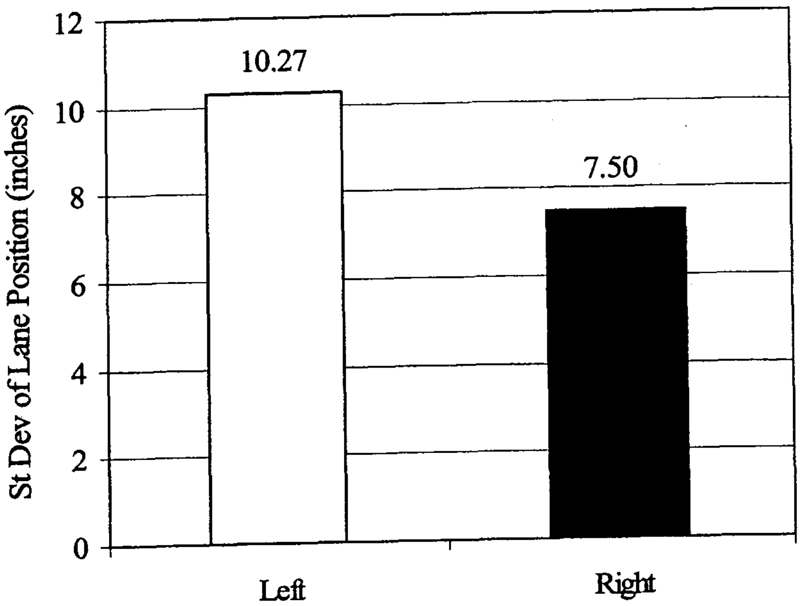

Figure 31. Lane Position Variation by Side of Road (significant at $p = 0.0106$).

Analysis of Selected Highly Attention-Getting Boards

This set of analyses was designed to answer the following research question:

1. Does a driver's forward scanning behavior, speed maintenance behavior, or lane keeping behavior change in the presence of certain highly-attention getting billboards, as compared to standard billboards?

An additional analysis was conducted to first determine whether there were significant differences between individual billboards (only billboards were included in this analysis; comparison and baseline sites were excluded). This initial analysis showed significant differences for 9 of the 11 dependent variables analyzed to this point--all except left-forward and right forward average glance duration. Six specific boards were then chosen out of the set of 30 boards for in-depth analysis, emphasizing the expected worse-case scenarios. Four out of the six boards were chosen because they were considered to be more attention-getting than the average billboard. Two changeable message boards, two high attention-getting boards (as judged by the researchers and mentioned by two participants), and two fairly standard comparison boards were chosen. One of each pair was on the left side of the road, and one of each pair was on the right side of the road.

The Least Squares Difference statistical procedure was used to determine how each of these boards differed from every other board in the set of 30 billboards. The results are shown in Table 18 for those dependent variables for which initial significant differences were found (thus this table has nine rows instead of 11). If a significant difference is indicated in a cell in this table, it means that that board was significantly different from at least two other boards out of the entire set of 30 billboards for this variable. Following the table, findings for each of the specific billboards are discussed in more detail.

Table 18. Results for Selected Highly Attention-Getting Billboards.

Boards: Dependent Variables	#8998: Electronic (Left side)	#8537: Electronic (Right side)	#9159: Attention-getting (Right)	#7716: Attention-getting (Left)	#9128 Standard copy (Left)	#13351 Standard copy (Right)
Number of Center Forward Glances	Sig. more CF glances (board on left)	No sig. diff. (board on right)	Sig. fewer CF glances (board on right)	Sig. more CF glances (board on left)	Sig. fewer CF glances (board on left)	Sig. more CF glances (board on right)
Number of Left Forward Glances	Sig. more LF glances	Sig. fewer LF glances	No sig. diff.	Sig. more LF glances	Sig. fewer LF glances	Sig. more LF glances
Number of Right Forward Glances	Sig. more RF glances	No sig. diff.	Sig. fewer RF glances	Sig. more RF glances	Sig. more RF glances	No sig. diff.
Average Glance Duration – Center Forward	Sig. lower avg. glance duration	No sig. diff.	Sig. higher avg. glance duration	No sig. diff.	Sig. higher avg. glance duration	Sig. lower avg. glance duration
Total Glance Duration - Center Forward	No sig. diff.	Sig. higher total glance duration	Sig. higher total glance duration	Sig. higher total glance duration	Sig. higher total glance duration	No sig. diff.
Total Glance Duration - Left Forward	Sig. higher total glance duration	Sig. lower total glance duration	Sig. lower total glance duration	No sig. diff.	Sig. lower total glance duration	No sig. diff.
Total Glance Duration - Right Forward	Sig. higher total glance duration	Sig. lower total glance duration	No sig. diff.	No sig. diff.	Sig. lower total glance duration	No sig. diff.
Standard Deviation of Speed	Sig. less speed variation	Sig. less speed variation	Sig. less speed variation	Sig. more speed variation	Sig. lower than some, higher than some	Sig. lower than some, higher than some
Standard Deviation of Lane Position	Sig. less lane position variation	Sig. less lane position variation	Sig. less lane position variation	Sig. more lane position variation	Sig. less lane position variation	Sig. less lane position variation

An examination of Table 18 reveals several interesting patterns. Electronic billboard #8998 on the left side showed a very active eyeglance pattern that did not necessarily correspond to the location of the sign on the left side of the road (e.g., total glance duration to the right was significantly greater for this board than for some other boards, even though the sign was on the left). Speed variation and lane deviation were significantly lower for this board. The other electronic billboard (on the right) showed a pattern of greater glance duration to the center forward location with significantly less speed variation and lane deviation than for other boards. Taken together, these results show no evidence of greater visual distraction in the direction of a changeable message billboard.

For attention-getting billboard #9159 on the right side of the road, there was no evidence of a greater number of glances to the right (significantly fewer right forward glances than for other boards) or for longer glance durations to the right (no significant difference) during the seven seconds preceding the subject vehicle passing the billboard. Speed variation and lane deviation were significantly lower for this board than for many of the other boards. The other attention-getting billboard (on the left side of road) showed an active eyeglance pattern, which had significantly more glances in all directions, not just to the left. Lane deviation and speed variation were both significantly higher for this board, as compared to others. This could mean that the traffic in this area was usually heavy or that this was a visually cluttered area, causing an active glance pattern and greater driving performance variations.

The first standard (not electronic, not especially attention-getting) board was #9128 on the left side. There were significantly more glances to the right side for this board, with few other differences noted. None of the differences were in the direction of more glance activity to the left. Speed variation had mixed results (i.e., lower than some boards, higher than others), while lane deviation was lower for this board. The other standard billboard (#13351on the right side) showed very few significant differences, and none of the differences were to the right. As for the first standard board, speed variation had mixed results (i.e., lower than some boards, higher than others), while lane deviation was lower for this board than for others.

This analysis provides insight into the overall results. In the two cases where significant site type differences were found (number of left forward glances and left forward total glance duration), the question arises as to whether these left forward glances correspond to glances to specific billboards. It becomes apparent that this was not the case when the four billboards that might be expected to draw the most glances were compared to two standard boards. Some billboard sites seemed to have a more active glance pattern than others, but the glance directions did not correspond to the side of the road where the billboards were situated.

Eyes-Off-Road Percentage

This set of analyses was designed to answer the following research question:

1. Does a driver's eyes off road percentage (the sum of all glance times except center forward, left forward, and right forward divided by the sum of all glance times) change in the presence of billboards, as compared to baseline and comparison sites?

Glances to all locations, not just center forward, left forward, and right forward, were captured during the video analysis; this analysis made use of the full set of eyeglance data. The eyes-off-road (EOR) percentage is often used by transportation safety researchers as a measure of driver attention to the driving task. For this analysis, the total time of eye glances to off road locations (any positions other than center forward, left forward, and right forward) was divided by 7 seconds (total event duration) to produce a measure of EOR percentage.

Results showed a significant difference in EOR percentage ($p = 0.0226$) for the site type independent variable. The Least Squares Difference statistical procedure was used to determine which site types differed from one another. Results showed that billboard and comparison sites exhibited significantly less EOR time than baseline sites. Conversely, this means that drivers exhibited significantly more *eyes-on-road* time in the presence of billboards and comparison sites than for baseline sites. Table 19 provides the descriptive statistics for this analysis and Figure 32 illustrates the magnitude of this effect.

Table 19. Eyes-off-Road Percentages for Site Type.

	Mean Eyes-off-Road Percentage			
Site Type	**Baseline**	**Billboard**	**Comparison**	**Probability**
	18.1%	13.4%	14.6%	0.0226

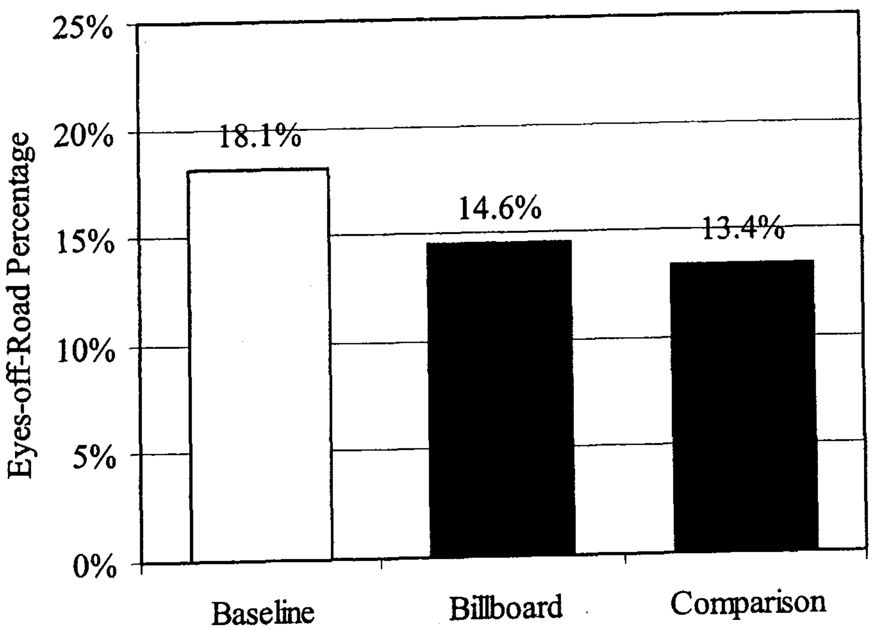

Figure 32. Eyes-off-Road Percentage by Site Type (significant at $p = 0.0245$). Billboard sites did not differ significantly from comparison sites, but both billboard and comparison sites differed significantly from baselines sites.

Non-Forward Glance Location Percentages

This set of analyses was designed to answer the following research question:

1. If a driver's eyes off road percentage changes in the presence of billboards, as compared to baseline and comparison sites, are there then corresponding differences in off road glance allocations (i.e., other exterior locations, rear view mirror, and other interior locations)?

Given that significant differences were noted in the EOR percentage for baseline vs. billboard sites, were there also difference in the percentage of time that drivers spent looking at certain off-road locations such as other exterior locations, the rear view mirror, and other interior locations? Glances to exterior locations other than through the front windshield (e.g., to the left and right mirrors, left and right blind spots, etc.) may be an indicator that a driver has extra visual capacity available to monitor surrounding traffic more closely. Glances to the rear view mirror are considered part of the driving task, so finding differences in the percentage of time spent glancing at this location could indicate differences in the other visual demands of the driving task. Finally, more time spent glancing at interior locations would indicate a compelling secondary task taking the driver's visual attention away from the primary task of driving. For these analyses, the total time of any eye glances to exterior locations other than forward locations, to the rear view mirror, and to interior locations other than rear view mirror was divided by 7 seconds (total event duration) to produce three measures of non-forward glance location percentage. The results showed no significant differences in non-forward glance locations percentages for any of these three measures for the site type independent variable.

DISCUSSION AND CONCLUSIONS

Method

As discussed in the literature review section of this report, past research efforts have attempted to determine the safety impact of billboards, although the impetus behind these research efforts has often been grounded in aesthetic or even moral concerns. To date, billboards have neither been proved to be a quantifiable cause of accidents nor proved to result in driver distraction. The purpose of this project was to further investigate the driver distraction aspect; specifically, whether billboards cause eyeglance diversions away from the forward view, an increase in speed variation, or an increase in lane deviation, all of which are commonly used by transportation researchers as indicators of driver distraction. An instrumented vehicle (with no experimenter present) was driven by 36 participants who were unaware of the underlying purpose of the study. Participants represented a range of age, gender, ethnicity, income, and education levels. The route was a 35 mile loop-route in Charlotte, North Carolina, consisting of both interstate and surface streets. A total of 30 billboards, 6 comparison sites, and 6 baseline sites were analyzed in terms of nine eyeglance measures and two driving performance measures.

Post-Drive Questionnaire

The average participant age was 25 years for younger drivers and 56 years for older drivers. On average, drivers had completed 14 years of education (high school plus two years of college). For marital status, 78% of participants were single or married, while 14% were divorced and 8% widowed. Over 61% of drivers were European (Caucasian) and 39% of drivers had an African American, Native American, or Multi-racial background. Seventy-two percent of drivers reported an annual income of less than $49K. All drivers were familiar with the roadway system in Charlotte and most drivers both lived and worked there.

Analysis of the questionnaire results revealed that the most common item that caught drivers' attention during the route included traffic, other drivers, road signs, and highway signs, as well as construction, landmarks, landscaping, and buildings. Only 25% of drivers indicated that billboards caught their attention during the drive. Upon further inquiry, these drivers indicated that they either tended to look at billboards in general or at specific billboards that caught their attention. None of these nine drivers indicated that they found billboards to be distracting. Other questions asked drivers to indicate what was memorable about the drive or what they noticed about other drivers. Most comments involved traffic, construction, the weather, or aggressive driving by other drivers. Many drivers indicated that they also typically performed other activities while driving (e.g., listening to music, talking on a cell phone, eating, drinking, smoking cigarettes, or talking to passengers).

Overall Results for Eyeglance and Driving Performance Measures

Table 20 presents the results for each dependent and independent variable. This table is presented here as a reference tool for the discussions of the results which follow. It is worth noting that road type had by far the greatest number of significant findings across all dependent variables, indicating that surface roads exhibit greater degradations in driver visual behavior and driving performance than do interstates. This finding is much more pronounced, usually by an order of magnitude, than for the same dependent variable in regard to site type (billboards versus comparison sites versus baseline sites).

Table 20. Summary of All Results (NS = not significant).

Independent variables / Dependent variables	Site Type	Side of Road	Age	Gender	Familiar	Road Type	Specific Board
Number of Center Forward Glances	NS	NS	NS	NS	NS	*0.0003*	*<0.0001*
Number of Left Forward Glances	*0.0021*	NS	NS	NS	NS	*<0.0001*	*0.0002*
Number of Right Forward Glances	NS	NS	NS	NS	NS	*<0.0001*	*0.0025*
Average Glance Duration – Center Forward	NS	NS	NS	NS	NS	*0.0012*	*0.0010*
Average Glance Duration – Left Forward	NS	NS	NS	NS	NS	NS	NS
Average Glance Duration – Right Forward	NS	NS	NS	*0.0383*	NS	*<0.0001*	NS
Total Glance Duration - Center Forward	NS	NS	NS	NS	NS	*0.0160*	*<0.0001*
Total Glance Duration - Left Forward	*0.0245*	NS	NS	NS	NS	*0.0027*	*0.0049*
Total Glance Duration - Right Forward	NS	NS	NS	*0.0451*	NS	*<0.0001*	*0.0056*
Standard Deviation of Speed	NS	*0.0005*	NS	NS	*0.0343*	*<0.0001*	*<0.0001*
Eyes-Off-Road Percentage	*0.0226*	NS	NS	*0.0494*	NS	*0.0016*	NA
Exterior Locations Percentage	NS	NS	NS	NS	NS	NS	NA
Rear View Mirror Percentage	NS	*0.0012*	NS	NS	NS	*0.0112*	NA
Interior Locations Percentage	NS	NS	NS	NS	NS	*0.0370*	NA

Forward Scanning Behavior

1. Does a driver's forward scanning behavior (glances through the windshield—center forward, left forward, and right forward) change in the presence of billboards, as compared to baseline and comparison sites?

This analysis of forward scanning behavior provided insight as to whether drivers changed their forward scan patterns when passing billboards. Glances were analyzed in terms of number of glances, average duration of glances, and total duration of glances for each of three site types: billboard, baseline, and comparison sites. Billboard sites had significantly more left forward glances, as compared to the baseline sites, but did not differ from the comparison sites. There was also a difference in terms of total glance duration; billboard and comparison sites had significantly longer left forward total glance durations than baseline sites, but they did not differ from one another. This was not a surprising finding, since baseline sites were chosen to have fewer buildings, signs, and other items thought to catch the attention of the driver. There were no differences for the average glance durations in any direction between three site types.

As indicated in the literature review, some researchers have suggested that driving performance may improve in the presence of billboards (Rykken, 1951; Wachtel and Netherton, 1980). If this were the case, one might expect to find a more active forward scanning pattern in the presence of billboards, since the forward view is the primary visual channel for driving. The only measures with significant differences between billboard and baseline driving were left forward--there were more glances and greater total glance duration for the billboards sites. This more active left forward scan pattern *may* indicate improved driving performance in the presence of billboards; however, no definite conclusions can be reached from the available data. It should be noted that left forward is the direction of oncoming traffic, so it can be stated that *drivers took more glances and spent more total time looking in the direction of oncoming traffic when billboards were present as compared to baseline sites.*

No differences were found for eyeglance behaviors in terms of side of road, age, or familiarity, and only one finding was revealed for gender. Females displayed longer average and total right forward glance durations across all site types; this difference, although significant, was relatively small in terms of magnitude and does not seem to have any practical significance.

Not surprisingly, there were significant differences for road type, with surface streets showing a more active glance pattern than interstates. More glances were observed in all directions on surface segments as compared to interstate segments. The average and total center forward glance durations were longer for the interstate segments; in most cases, the right and left forward average and total glance durations were shorter on the interstate than on surface streets. It is not surprising that more glances were made to the sides for surface road sites, where speeds are lower and more side items are available to view. In most cases, surface road sites have more signs, buildings, etc. to look at, and it is not surprising that drivers would look at locations other than center forward while driving in these areas. Also, some differences may be attributed to drivers looking left to monitor traffic in the adjacent or oncoming lanes, or looking to the right to monitor vehicles merging onto the roadway or exiting from the roadway.

Speed Variability

1. Does a driver's speed maintenance behavior (standard deviation of speed) change in the presence of billboards, as compared to baseline and comparison sites?

There was no indication of speed variability in the presence of billboards (the site type main effect was not significant for this dependent variable). In terms of speed variability, statistically significant differences were revealed for side of road, familiarity, and road type; however, from a practical perspective, differences varied by no more than 0.7 miles per hour (or 1 foot/second). For side of road, sites on the right were associated with lower deviations in speed (difference of 0.4 mph). For sites rated as familiar, drivers had lower speed variations (0.1 mph difference). The largest difference was in terms of road type: sites on the interstate had lower speed variability than did sites on the surface streets (0.7 mph difference).

Lane Deviation

1. Does a driver's lane keeping behavior (standard deviation of lane position) change in the presence of billboards, as compared to baseline and comparison sites?

Lane deviation did not differ in the presence of billboards. Lane position analysis revealed differences only for side of road. For sites on the left side of the road, lane position varied by 10 inches during the 7-second segment as compared to 7.5 inches for sites on the right side. These differences, although significantly different from one another, are within the expected range of deviation of 5 to 62 inches (reported by Alm & Nilsson, 1994; Serafin et al. 1993, for simulated driving).

Specific Board Analysis

1. Does a driver's forward scanning behavior, speed maintenance behavior, or lane keeping behavior change in the presence of certain highly-attention getting billboards, as compared to standard billboards?

A rigorous analysis of specific boards was performed to determine: 1) how specific billboards compared to other billboards in terms of eyeglance and driving performance measures, and 2) how the eyeglance measures corresponded to the placement of the billboards (left or right) in relation to the road. By choosing the four billboards that might be expected to draw the most glances, as well as two more ordinary boards and comparing their results to all other billboards, it became obvious that this was not the case. *Some billboard sites seemed to have a more active glance pattern than others, but the glance directions did not correspond to the side of the road where the billboards were situated.*

Eyes-Off-Road Percentage

1. Does a driver's eyes off road percentage (sum of all glance times except center forward, left forward, and right forward divided by sum of all glance times) change in the presence of billboards, as compared to baseline and comparison sites?

Drivers had a greater percentage of eyes-off-road (EOR) time for baseline sites than for billboard and comparison sites. Likewise, drivers spent a greater proportion of time looking forward for billboard and comparison sites than for baseline sites. In combination with the more active left forward scan pattern discussed previously, this is another indication that driving performance may actually improve in the presence of billboards, as compared to baseline areas, an idea originally proposed by Rykken (1951) and Wachtel and Netherton (1980).

Non-Forward Glance Location Percentages

1. If a driver's eyes off road percentage changes in the presence of billboards, as compared to baseline and comparison sites, are there then corresponding differences in off road glance allocations (i.e., other exterior locations, rear view mirror, and other interior locations)?

There were no significant differences in the non-forward glance allocations among the three site types. The allocation of the additional off-road glances for baseline driving were distributed in approximately the same proportions among other exterior locations, rear view mirror, and other interior locations as was true for billboard and comparison sites.

Limitations of the Research Method

This study was conducted in a specific city chosen to be representative of mid-sized U.S. cities. The route was chosen to include both urban and suburban sections (and some sections were close to rural in nature). The billboards in Charlotte, North Carolina are generally situated close to the side of the road, therefore placing the boards within the forward-view of the participants for a longer period of time than if they were further offset from the road. Both the setting (urban/suburban/rural) and the billboard offsets were typical of most billboard locations found in the U.S. For each of the above-mentioned parameters, every attempt was made to conduct a balanced, representative study for which the results could be generalized to other cities and routes.

One limitation of this study was that there were few electronic boards along the route, so no conclusions can be drawn regarding driver behavior in the presence of this type of billboard. All three of the electronic billboards available on the route were included, however, for a total of 10% of the sampled billboards. Future research into this topic should focus on routes with a greater number of available electronic billboards so that an electronic/non-electronic analysis can be conducted.

Conclusions

Based on over 1,500 events in which a driver passed a billboard, comparison site, or baseline site, the overall conclusion from this study is that the presence of billboards does not cause a measurable change in driver behavior, in terms of visual behavior, speed maintenance, or lane keeping. A rigorous examination of individual billboards that could be considered to be the most visually attention-getting demonstrated no measurable relationship between glance location and billboard location. Driving performance measures in the presence of these specific billboards generally showed less speed variation and lane deviation. Thus, neither visual behavior nor driving behavior changes measurably, even in the presence of the most visually attention-getting billboards. One major finding was that significantly more time was spent with the eyes looking forward (eyes on road) for billboard and comparison sites, as compared to baseline sites, providing a clue that billboards may actually improve driver visual behavior.

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APPENDICES

Appendix A. Initial Contact Participant Screening Questionnaire

My name is Erik Olsen and I'm a researcher with the Virginia Tech Transportation Institute in Blacksburg, VA. Thank you for your time – We are collecting names of potential participants now. The project involves participation in a driving study to help researchers understand how people drive.

This study involves meeting me at the University Residence Inn Hotel in Charlotte, NC on N. Tryon St. one time for approximately 2 hours. During this session you would help us by completing some questionnaires, having a short eye exam, driving one of our vehicles along a pre-selected route for about 35 miles, and filling out a questionnaire after the drive. The vehicle will be equipped with data collection equipment to allow observation of recordings of the drive.

Name:________________________ Male/Female

I would like to write down your phone number or phone numbers, and/or email where you can be reached and hours/days when it's best to reach you.

Phone Numbers ______________________________ Age: _____

Best Time to Call ____

Email ___________________________

Next, I would like to ask you several questions to see if you are eligible to participate.

Questions

1. Do you have a valid driver's license?
   Yes _____ No _____
2. How often do you drive each week?
   Every day ____ At least 2 times a week___ Less than 2 times a week_____
3. How old are you? ______ (stop if not 18-35 years old or 50-75 years old.)
4. What type of vehicle do you usually drive?________________________
5. Have you previously participated in any experiments at the Virginia Tech Transportation Institute? If so, can you briefly describe the study?
   Yes _____ ____
   No _____
6. How long have you held your drivers' license? ______________________________

7. Are you able to drive an automatic transmission without assistive devices or special equipment?
Yes _____ No _____

8. Do you have a history of any of the following? If yes, please explain.

Stroke	No____	Yes___
Brain tumor	No____	Yes___
Head injury	No____	Yes___
Epileptic seizures	No____	Yes___
Respiratory disorders	No____	Yes___
Motion sickness	No____	Yes___
Inner ear problems	No____	Yes___
Dizziness, vertigo, or other balance problems	No____	Yes___
Diabetes	No____	Yes___
Migraine, tension headaches	No____	Yes___

9. (Females only, of course) Are you currently pregnant?
Yes _____ No _____ (If "yes" then read the following statement to the participant: "*It is not recommended that pregnant women participate in this study. However, female participants who are pregnant and wish to participate must first consult with their personal physician for advice and guidance regarding participation in a study where risks, although minimal, include the possibility of collision and airbag deployment.*")

10. Are you currently taking any medications on a regular basis? If yes, please list them.
Yes _____ ______________________________
No _____

11. Do you have normal or corrected to normal hearing and vision? If no, please explain.
Yes _____
No _____ ______________________________

12. Would you be willing to drive without wearing sunglasses?

13. Have you ever had radial keratotomy, LASIK, or other eye surgeries? If yes, please specify.
Yes _____ ______________________________
No _____

A total of 2 hours of time will be needed. What days and times would you be able to participate?

Saturday:	9:30	11:30	1:30	3:30
Sunday:	9:30	11:30	1:30	3:30
Monday:	9:30	11:30	1:30	
Tuesday:	9:30	11:30	1:30	

Thank you for your time. I will contact you to schedule a session if you are selected as a participant.

Appendix B. Informed Consent Form

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

Informed Consent for Participants of Investigative Projects

Title of Project: Influence of driver characteristics on driving performance

Investigators: Dr. Suzanne E. Lee, Research Scientist, Virginia Tech Transportation Institute.

Mr. Erik C. B. Olsen, Graduate Research Assistant, Virginia Tech Transportation Institute.

I. The Purpose of this Research Project
This study will collect driver performance data to help understand the way people drive in a natural environment (with no experimenter present). The goal of this study is improve the understanding of how people drive.

II. Procedures
For this study you will be asked to drive on a loop-route on freeways and highways in Charlotte, North Carolina. We want you to drive as you normally would on any roadway, following the typical laws and regulations of the road. The session is expected to last about two hours, including this orientation. You will then be paid for your participation.

This vehicle contains sensors and data processing equipment that will capture aspects of your driving behavior. Small video cameras are also mounted in the vehicle. One of these cameras will be directed toward your face while you are driving. The equipment has been installed in such a way that you will hardly be able to notice its presence. It will not interfere with your driving, and there is nothing special that you will need to do in regard to the equipment.

This experiment will consist of five experimental stages:

1. Introductory stage
This stage consists of preliminaries. You will be asked to read the informed consent form. Once you have signed this form, we will also ask to see your driver's license, and an eye exam will be administered. Finally, we will have you complete a medical questionnaire. Once you have completed this stage we will go on to stage 2.

2. Familiarization with the test vehicle
While the instrumented vehicle is parked you will be shown how to operate the vehicle (for example, lights, mirror adjustments, windshield wipers, etc.) as this may be different from your personal vehicle. You will then be asked to set each control to the best level for your comfort and driving performance. You will then take a short drive with the experimenter riding along in the passenger's seat to become familiar with the vehicle. This stage should take approximately 15 minutes.

3. Preparation for loop route
The experimenter will then review the loop-route with you. You will be given a map and written directions that the experimenter will review with you

4. Driving the loop route
You will then drive the instrumented vehicle for approximately 1.5 hours over the pre-planned loop route of approximately 63 miles. You are expected to follow the posted speed limit and to wear your seatbelt. Also, please stay in the right-hand lane to the extent possible during the drive. The loop route is to be completed in one session if possible.

5. Debriefing and Payment
After completing the experiment, you will return here for a short debriefing session. You will then be paid for your participation. It is expected that the complete session will last approximately 2 hours, including orientation, loop-route, and debriefing.

III. Risks
Anytime you operate a motor vehicle there are certain risks involved, and this study is no different. Although minimal, risks include the possibility of collision and airbag deployment. However, every effort has been made to ensure your safety such that any risk toward you and others is minimized.

IV. Benefits of this Research Project
The information collected from this project will provide new information on how people tend to drive in a natural setting. This information will be used to improve roadway and vehicle design, so that roadside and in-vehicle devices can be better designed to fit in with what people expect. While there are no direct benefits of participating in this study (apart from payment), you may find the experiment interesting. No guarantee of benefits has been made to encourage you to participate. However, to avoid biasing other potential participants, you are requested not to discuss this study with anyone for at least 8 months after participation.

V. Extent of Anonymity and Confidentiality
The results obtained from this study will be kept completely anonymous. Your name will not appear on data derived from your session. Only a number will differentiate your data from others who take part in the study. This number, and not your name, will also be used in subsequent data analyses and reports.

As indicated, video will be recorded while you are driving. The video includes an image of your face, so that we can determine where you are normally looking. The video will be treated with confidentiality and kept secure. It will be shared only with other qualified researchers, and not published except as noted in the following paragraph.

If at a later time we wish to use the video information for other than research purposes, say, for public education, or if we wish to publish (for research or for other purposes) your likeness or other information from the study that identifies you either directly or indirectly, we will only do so after we have contacted you again and obtained your permission.

VI. Compensation

You will be paid $20 per hour for the time you actually spend in the experiment. It is estimated that the entire session, including orientation, driving, and debriefing will be 2 hours. Payment will be made immediately after you have finished your participation.

VII. Freedom to Withdraw

You are free to withdraw at any time without penalty. If you choose to withdraw from this study you will be compensated for your time up until that point.

VIII. Medical Treatment and Insurance

If you should become injured in an accident, the medical treatment available to you would be that provided to any driver or passenger by emergency medical services in the vicinity where the accident occurs. The vehicle you will be driving is insured for automobile liability and collision/comprehensive through Virginia Tech and the Commonwealth of Virginia. There is medical coverage for you under this policy. The total policy amount per occurrence is $2,000,000. This coverage would apply in case of an accident, except as noted below.

Under certain circumstances, you may be deemed to be driving in the course of your employment, and your employer's worker's compensation provisions may apply in lieu of the Virginia Tech and Commonwealth of Virginia insurance provisions, in case of an accident. The particular circumstances under which worker's compensation would apply are specified in Virginia law. If worker's compensation provisions do not apply in a particular situation, the Virginia Tech and Commonwealth of Virginia insurance provisions will provide coverage.

Briefly, worker's compensation would apply if your driving for this research can be considered as part of the duties you perform in your regular job. If it is not considered as part of your regular job, then the insurance policy would apply.

IX. Approval of Research

This research project has been approved, as required by the Institutional Review Board for Research Involving Human Participants at Virginia Polytechnic Institute and State University, and the Virginia Tech Transportation Institution.

X. Participant's Responsibilities
I voluntarily agree to participate in this study. I have the following responsibilities:

1) I should not participate in this study if I do not have a valid driver's license or if I am not in good health.

2) I should notify the experimenter if at any time I do not want to continue my participation.

3) I should operate the instrumented vehicle in a safe and responsible manner.

4) I should answer all questions truthfully.

XI. Participant's Permission

Check one of the following:

____ I have **not** had an eye injury/eye surgery (including, but not limited to, LASIK, Radial Keratotomy, and cataract surgery.

____ I **have** had eye injury/eye surgery and I have been informed of the possible risks to participants who have had eye surgery. I choose to accept this possible risk to participate in this study.

I have read and understand the Informed Consent and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty. I agree to abide by the rules of this project.

____

Signature **Date**

Should I have any questions about this research project or its conduct, I may contact:

Dr. Suzanne E. Lee, Principal Investigator	(540) 231-1511
Erik C. B. Olsen, Graduate Research Assistant	(540) 231-1536
David Moore, Chair of the Virginia Tech Institutional Review Board	(540) 231-4991

Participants must be given a complete copy (or duplicate original) of the signed Informed Consent.

Participant #_____

Appendix C. Post Driving Questionnaire

Thank you for participating in this driving study. We would appreciate if you would respond to the following items. All information will remain confidential.

1. Please circle either "Familiar" (driven at least once a week) or "Not Familiar" (driven less than one time a week) for the following roadway sections:

Along I-85 to I-77	Familiar	Not Familiar
From I-77 to Tyvola Road	Familiar	Not Familiar
Tyvola Road, South Blvd, and Downtown Charlotte	Familiar	Not Familiar
Independence Blvd (74/27)	Familiar	Not Familiar
Albemarle Road (24/27)	Familiar	Not Familiar
Harris Blvd	Familiar	Not Familiar

2. For the following systems, please mark what you liked or disliked:

Seating	like	neutral	dislike
Air conditioning	like	neutral	dislike
Engine power	like	neutral	dislike
Visibility	like	neutral	dislike
Steering	like	neutral	dislike

3. Please check the top five items that most caught your attention during your drive:
   Surrounding traffic
   Other drivers
   Construction areas
   Road/street signs
   Emergency vehicles
   Buildings
   Landmarks
   Walls
   Landscaping/scenery
   Gas Stations
   Restaurants
   Motels/Hotels
   Billboards
   Towers
   Highway/Exit Signs
   Smoke Stacks
   Apartments/housing
   Other_______________

Did you experience any problems while following the written directions? If so, please describe.

4. What was most memorable about the drive? For example, where there any objects that stood out?

5. What other activities do you typically engage in while driving?

6. Does anything about other drivers bother you? If so, please briefly describe:

7. Please provide any other input about this study:

1. In what city do you live? ______________________________

2. In what city do you work? ______________________________

3. What level of education have you completed?

_____ Elementary/Secondary
_____ Junior High School
_____ High School degree
_____ 2-yr Associate degree
_____ Bachelor's degree
_____ Master's degree
_____ Doctoral/Professional degree

4. Please indicate your marital status:

single married widowed divorced separated

5. Which of the following groups best represent your ethnicity?

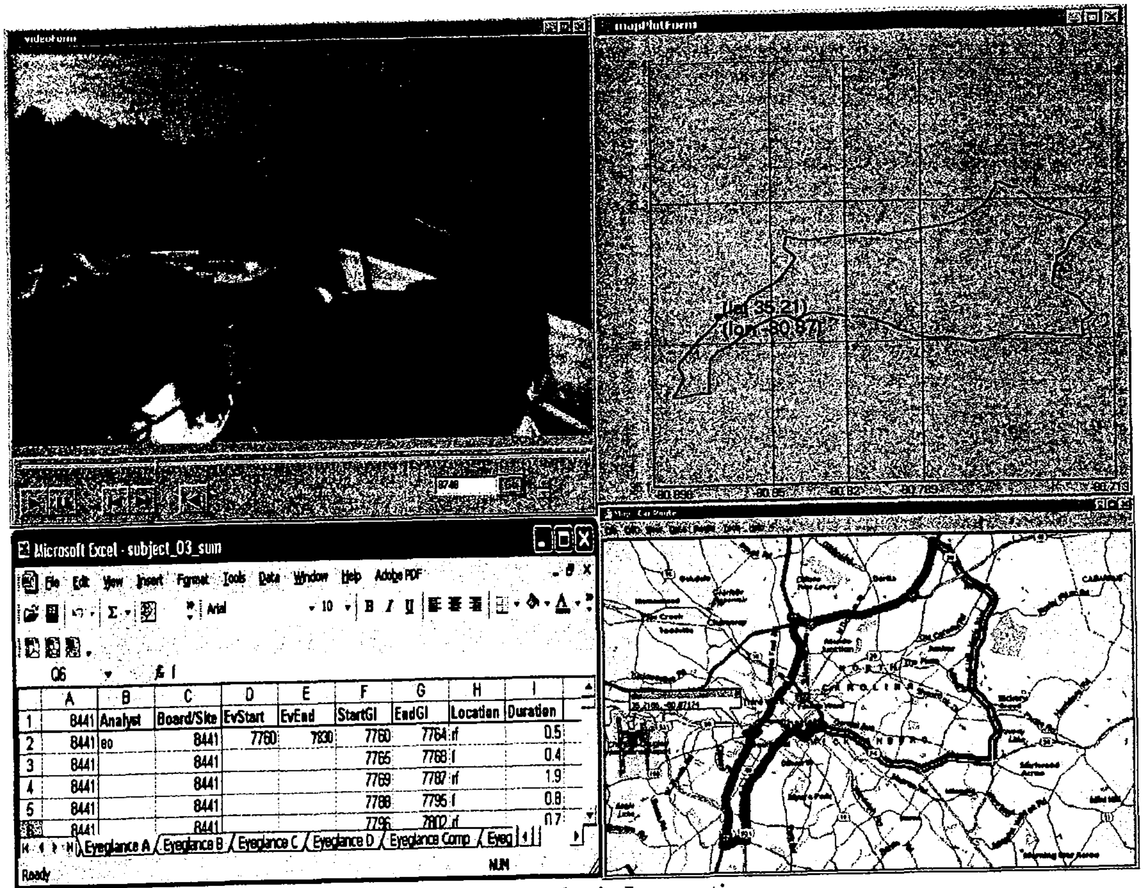
_____ African American
_____ Hispanic (Latino)
_____ Asian
_____ Native American (American Indian)
_____ European (Caucasian, White)
_____ Multi-racial

6. Which of the following best represents your annual household income?

_____ $0-$24,999
_____ $25,000-$49,999
_____ $50,000-$74,999
_____ $75,000-$99,999
_____ > $100,000

What was the purpose of this study?

Appendix D. Analyst Training Manual



Billboard Analysis Instructions
5/27/03

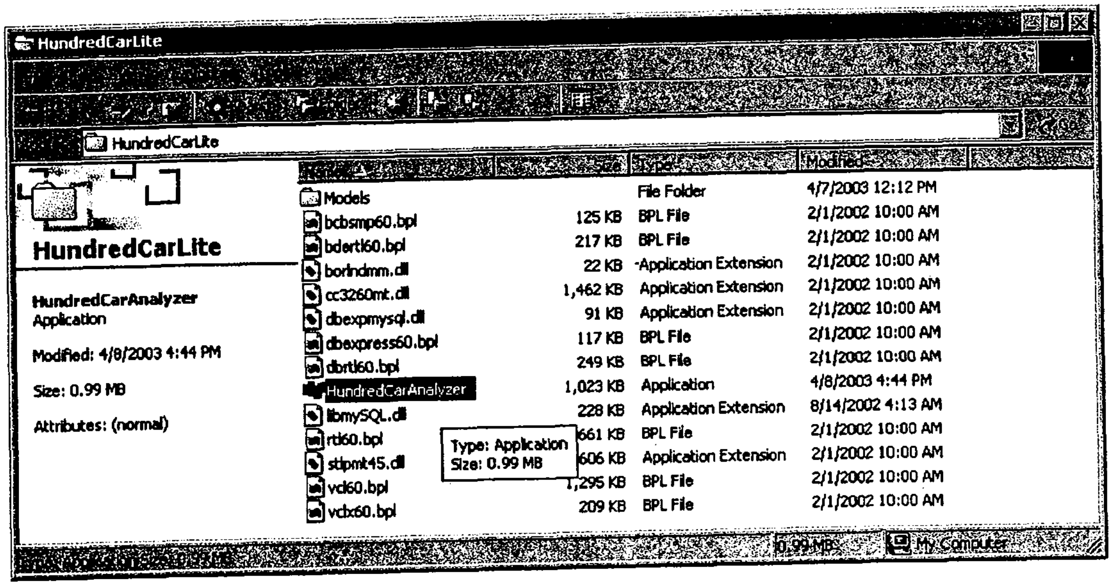
This document describes how to manually analyze data files for the billboard project. Analysis includes identifying events by start and end time (synch numbers), and then recording GPS coordinates (latitude and longitude) and if the driver performed a lane change maneuver, talked on the phone, or was stopped in traffic during the event. Preliminarily, data will be entered into an Excel spreadsheet for each participant and saved for later access. For these instructions, subject_03 (with image on experimenter) will be used for the examples. NOTE: The application works best if all other applications are closed. The files used are VERY large and all available computing power will allow the application to work most efficiently. The MapPoint application must also be installed for the analysis program to work properly.

The sections covered are the following:

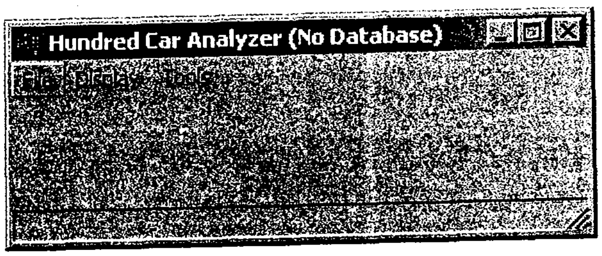
- Software Preparation
- Event Identification
- Eye glance Analysis

Software Preparation

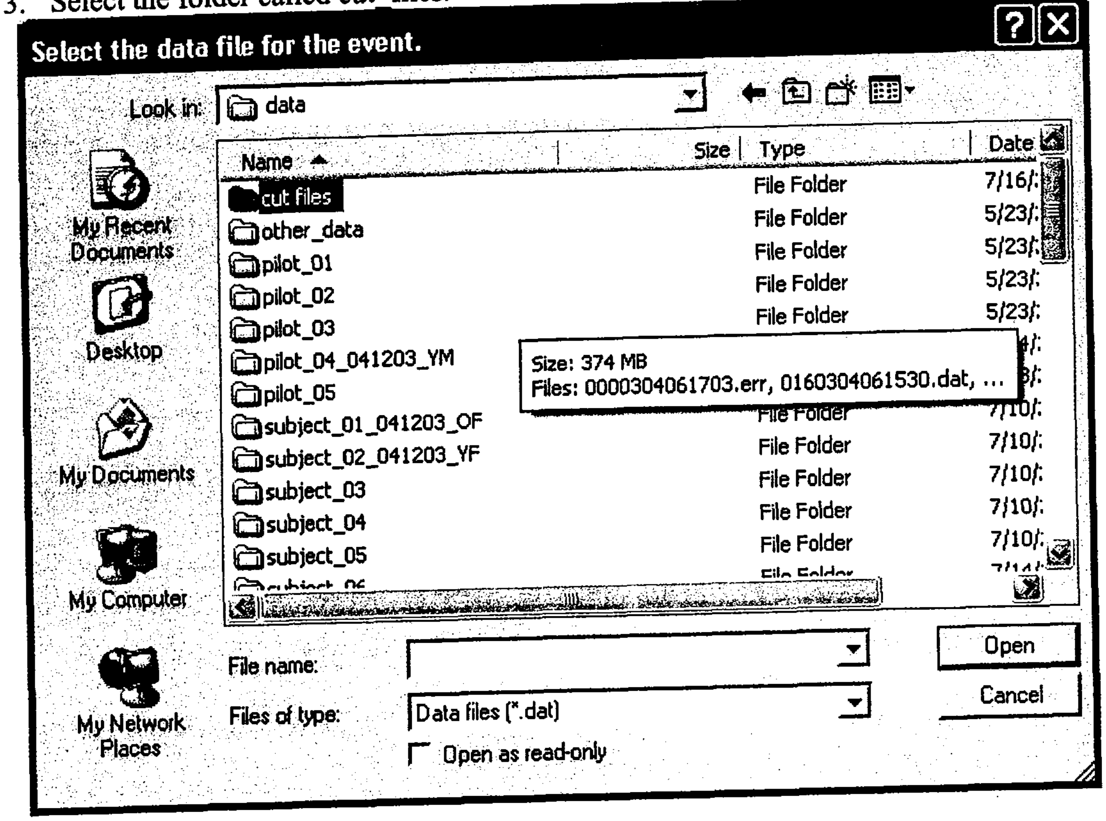
1. Open the HundredCarLite application. (A short cut can be created on the desktop for easy access later).



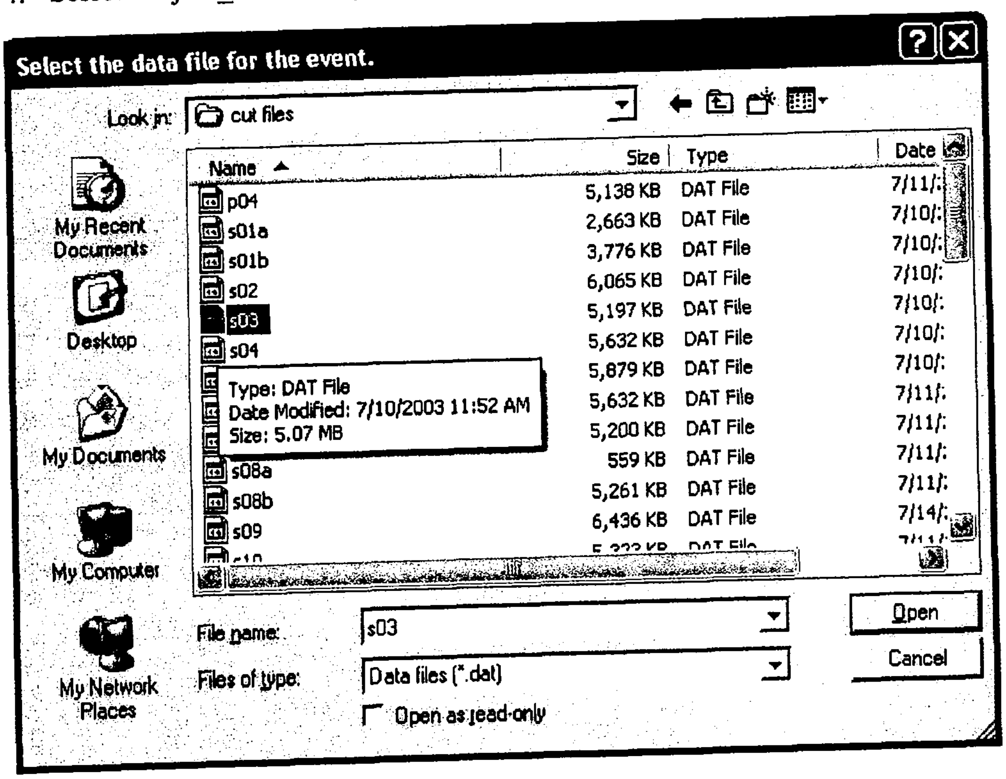
1. From the File menu, select Admin Tools.



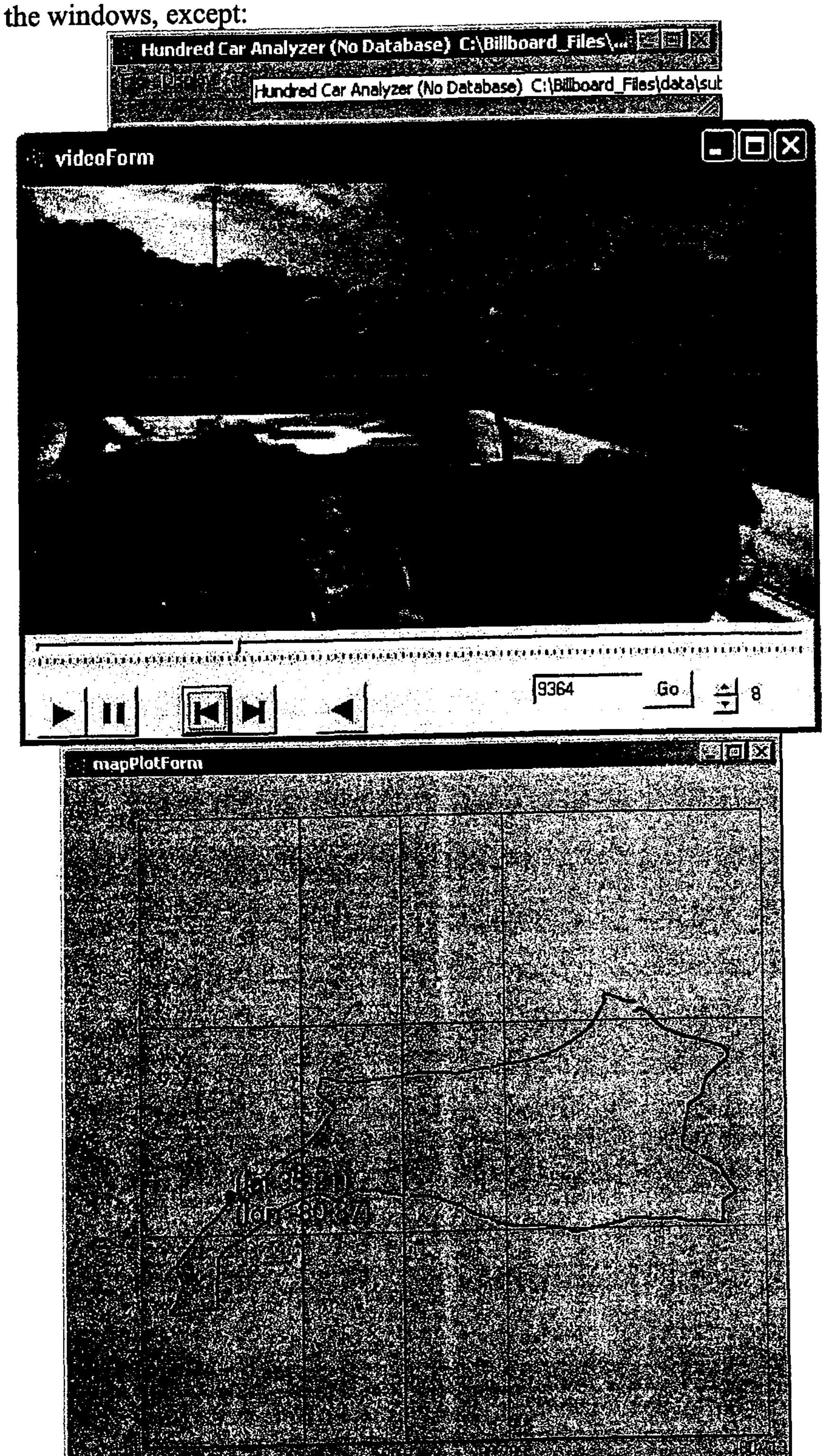
2. From Admin Tools, select Open Trip. The data files are in the "data" folder.
3. Select the folder called cut_files.



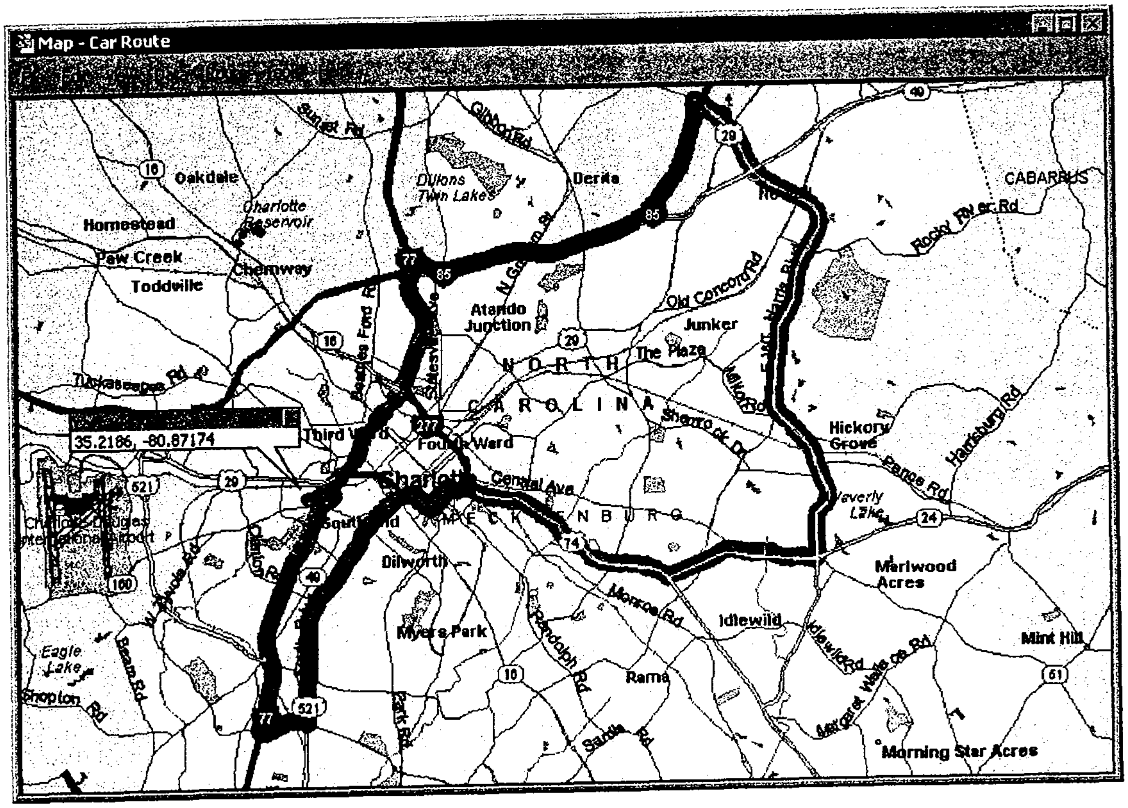
4. Select subject_03. The system will take a few minutes to open all the windows.



5. Close all the windows, except:

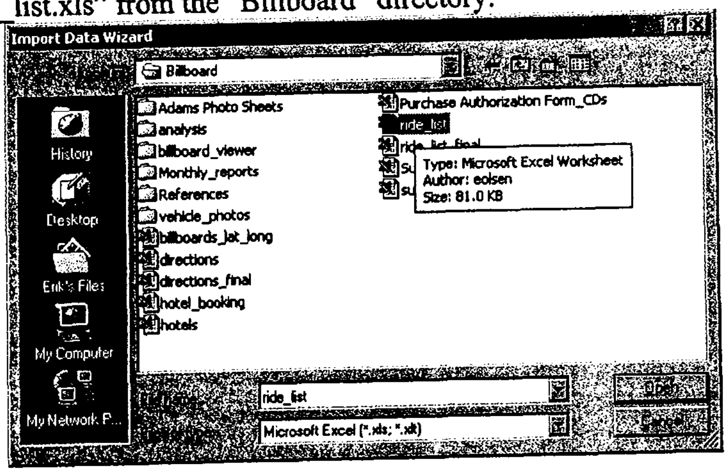


6. From the Display menu select "MapPoint." Wait a minute for the application to launch completely.
7. Zoom in to the Charlotte, NC area (the blue area on the right side of the USA map) by using the "+" key. The map should look something like this:

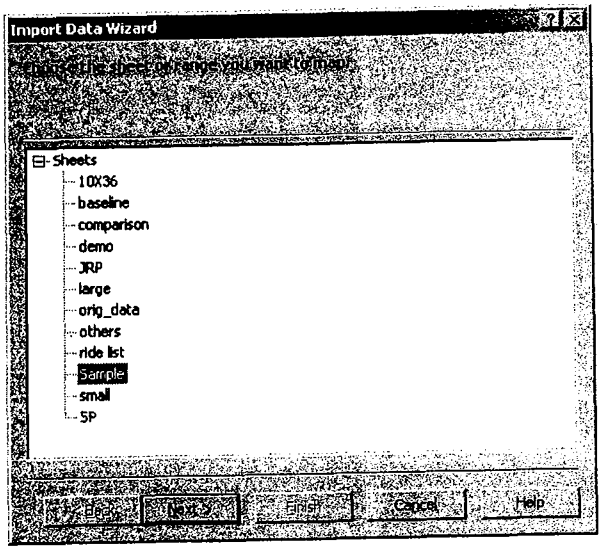


Now you can see that that MapPoint map and the mapPlotForm (in the Hundred Car Analyzer application) window correspond to the same route. The MapPoint map will be used to read the GPS coordinates. The mapPlotForm is used to move the position of the vehicle along the map.

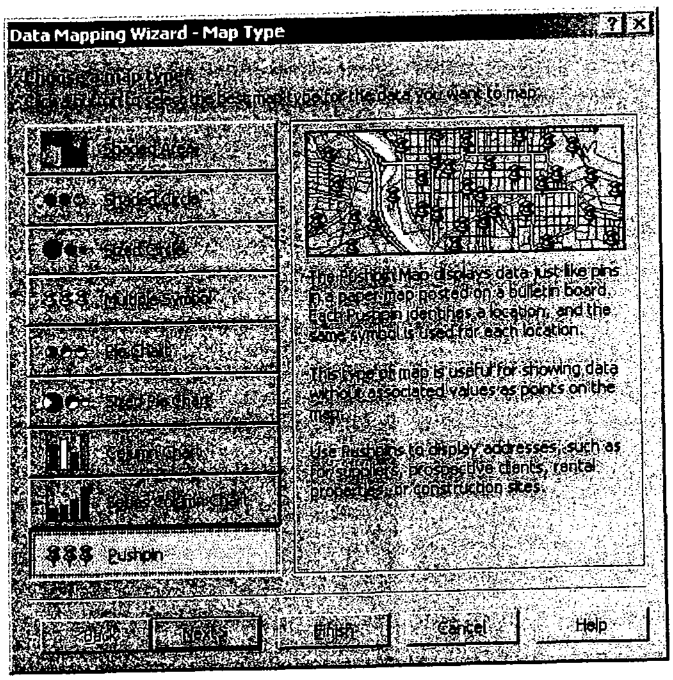
8. Within MapPoint, go to the Data menu and select "Import Data Wizard"
9. Select "ride_list.xls" from the "Billboard" directory.



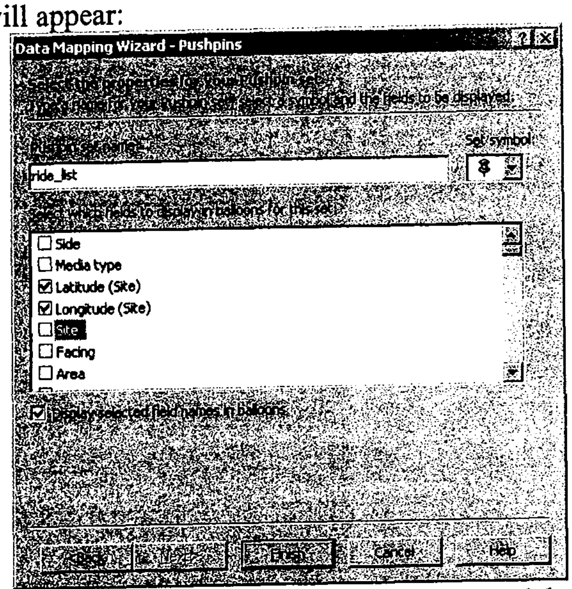
10. From “ride_list.xls” select “Sample”



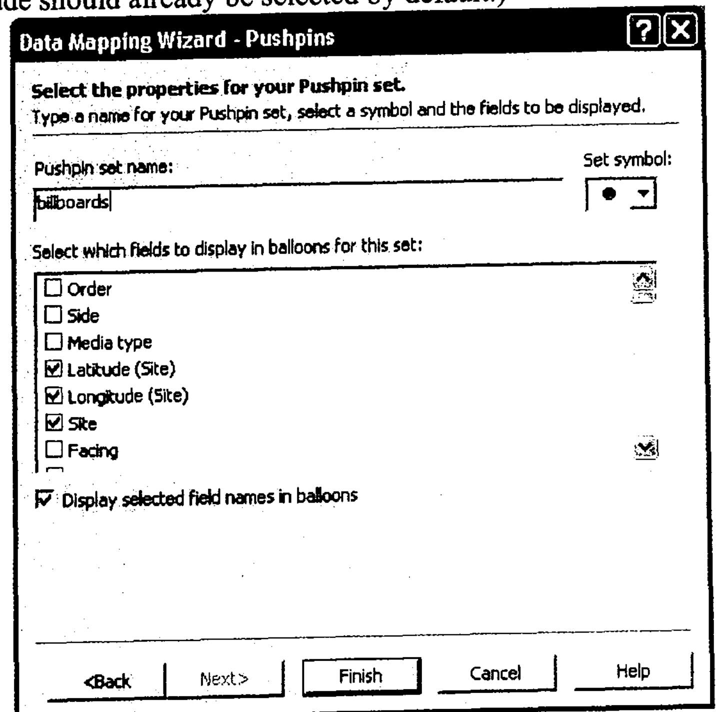
11. Select “Next >”
12. Select “Finish”
13. At the bottom of the next window, select “Pushpin”



The following window will appear:



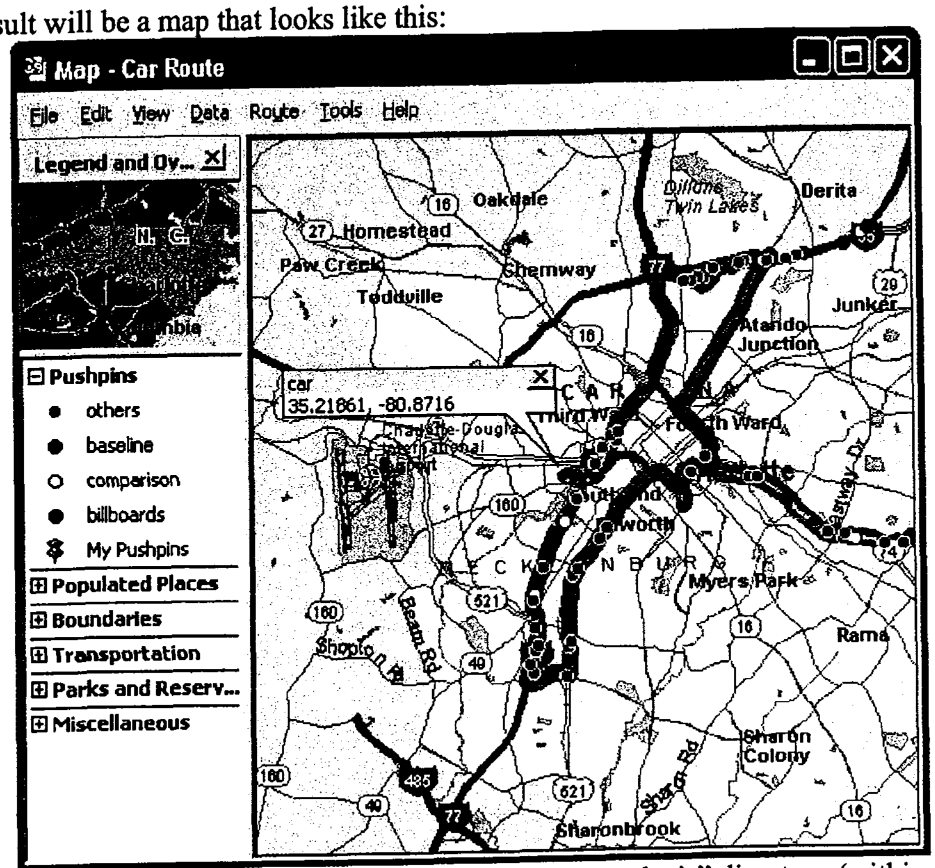
14. Set the symbol to a aqua blue dot using the pull down menu labeled "Set symbol"
15. Then select "site" under "Select which fields to display in balloons for this set." (Latitude and Longitude should already be selected by default.)



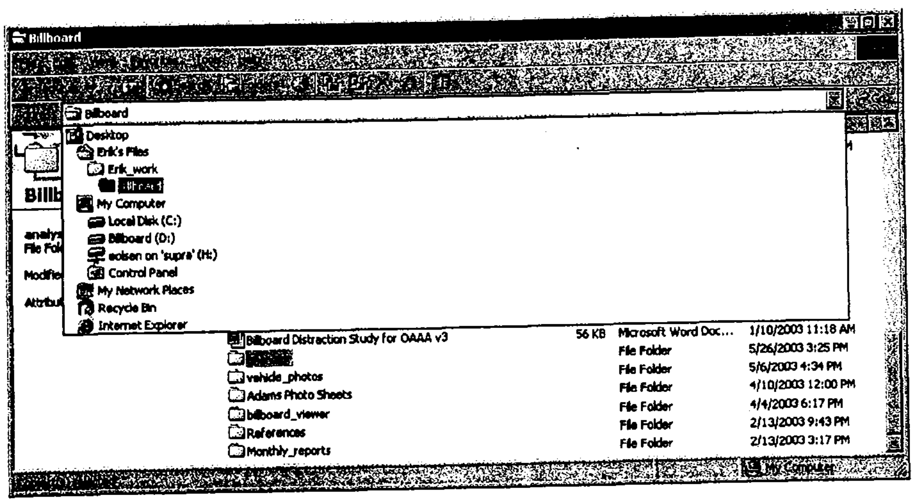
16. Hit the "Finish" button. The map will now show 30 aqua blue dots. These represent the 30 billboard locations.
17. Now repeat the process for:
    - "others" as black dots
    - "baseline" as red dots
    - "comparison" as yellow dots.

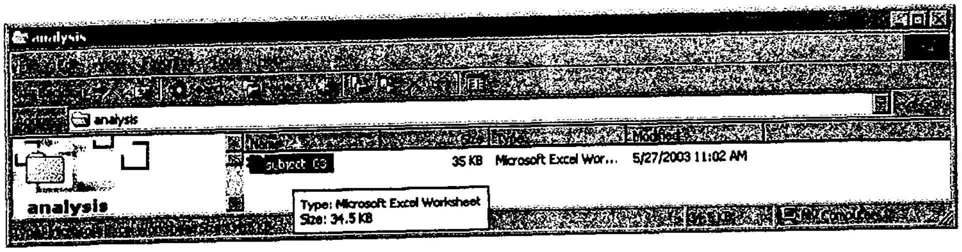
18. Rename each set of push pins listed as shown (ride_list becomes "sample," ride_list_2 becomes "others" and so on)

The final result will be a map that looks like this:



19. Now, open the Excel file"subject_03.xls" file in the "analysis" directory (within the "Billboard" directory)



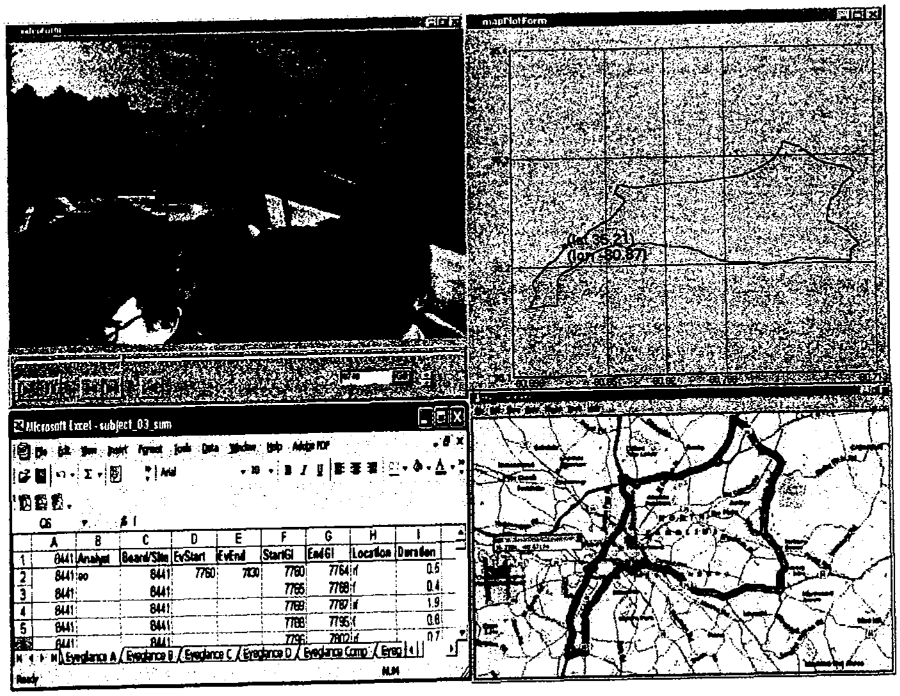


This data will be entered and saved in Excel. The file will look like this:

Lat	Long	Start	End	Name	Side	Media Type
35.28432	-80.7773	7065	7165	8441	R	14 X 48
35.28174	-80.78312	7302	7402	8489	R	Jr. P.
35.27822	-80.796	7728	7828	12239	L	14 X 48
35.27715	-80.81296	8263	8363	13652	L	14 X 48

etc.

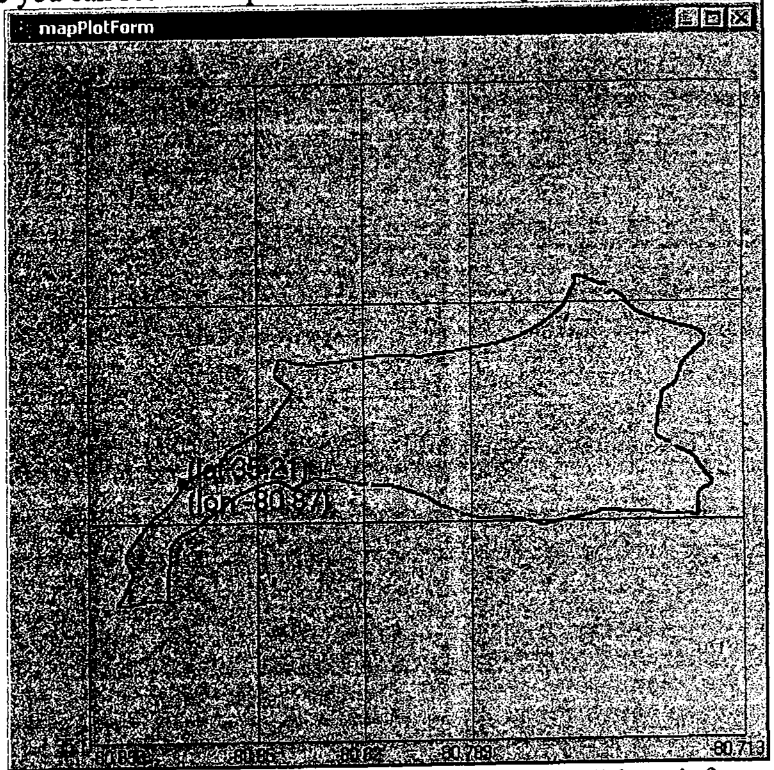
20. Arrange all the windows in the screen so it has the Excel file in the bottom left corner and the MapPoint file on the bottom right corner like this:



Event Identification

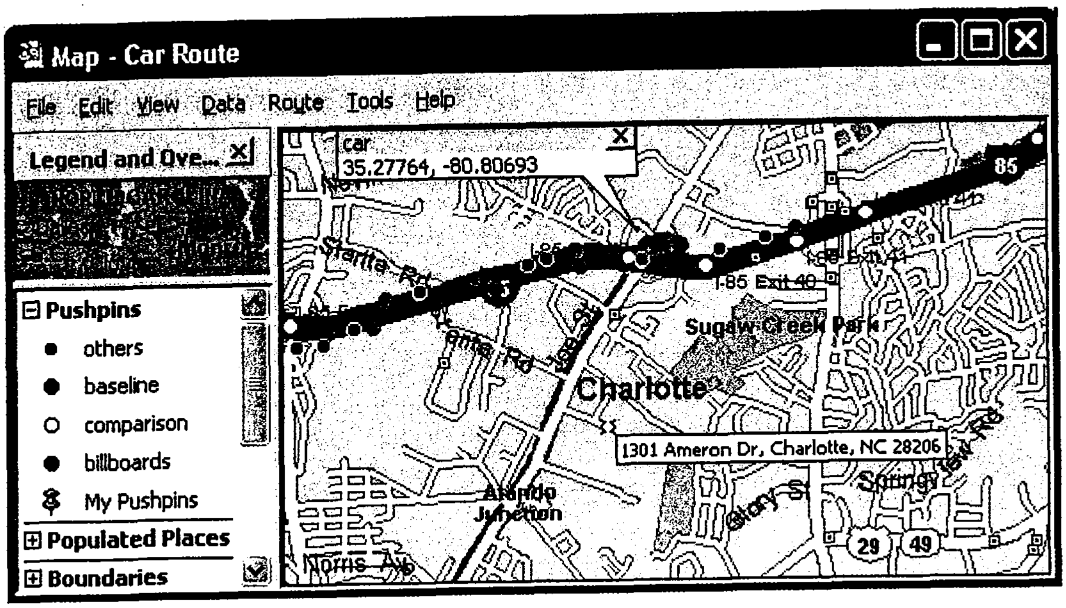
The first step in the analysis is the Event Identification process. This involves forwarding the video using the mapPlotForm.

21. Make sure you can see the mapPlotForm and the MapPoint map at the same time.



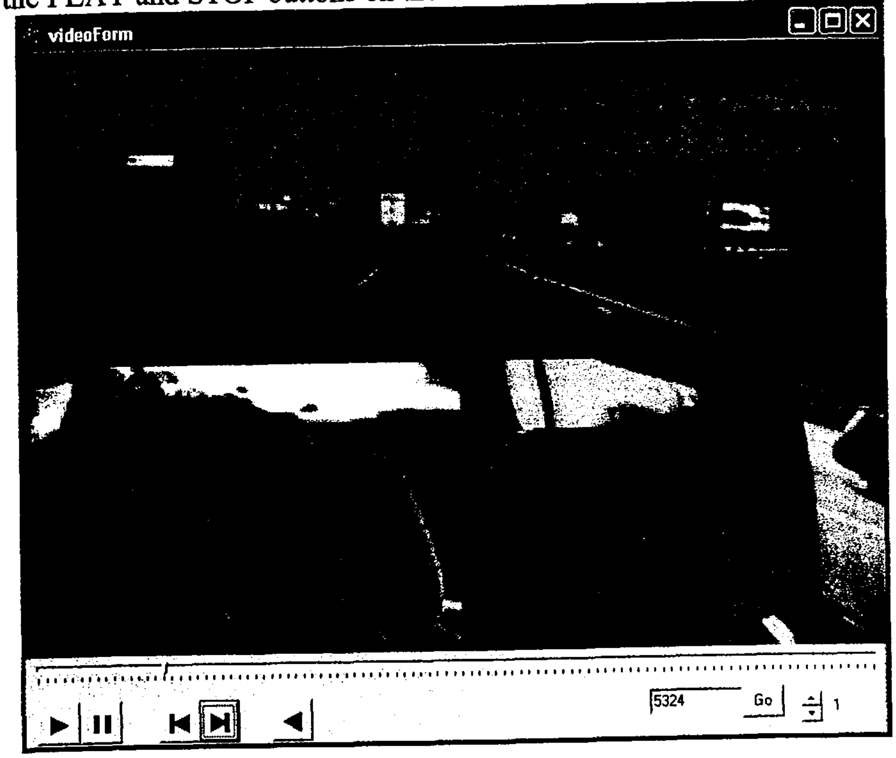
22. Locate the location, a yellow circle (right click and select "show information" to see the info on the map about this location). This is comparison site #2

23. Click on the mapPlotForm at a location just before (to the right of) the aqua blue circle. After you click on the mapPlotForm, the Map Point map should look like this:

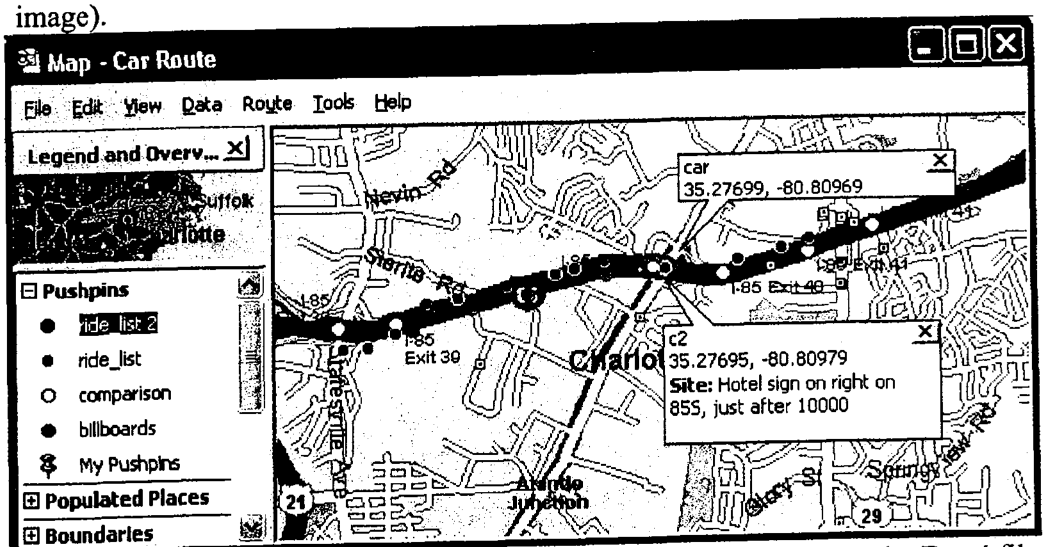


Map - Car Route
File
Edit
View
Data
Route
Tools
Help
Legend and Ove...
Pushpins
others
baseline
comparison
billboards
My Pushpins
Populated Places
Boundaries
car
35.27764, -80.80693
I-85 Exit 40
Sugaw Creek Park
Charlotte
1301 Ameron Dr, Charlotte, NC 28206
Norris Av
85
29
49

24. Use the PLAY and STOP buttons on the Video window to let the video play.



25. Stop the video just as the car lines up with the yellow circle. The lat/long values should be very close (if not exactly) the same for both the car and the location. (Notice also the 2 aqua blue dots on the map corresponding to billboards that are also visible on the video image).



26. Record (cut and paste) the lat/long values (35.27699, -80.80969) into the Excel file in the first 2 columns.
27. Record the Sync value (7165) in the "End" column
   - The Start value will automatically be filled in (7165-70=7095)
   - Each 10 sync units = 1 second of time

Repeat this process for all 42 locations. There are:

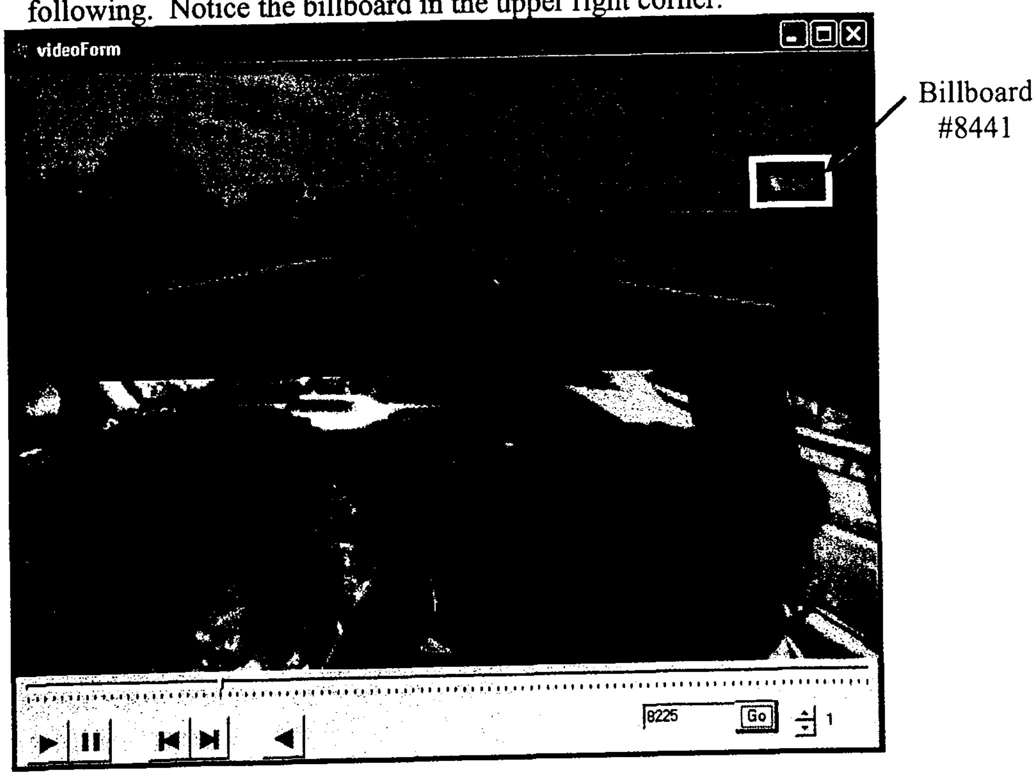
- 30 Billboards (aqua blue dots)
- 7 comparison sites (yellow dots)
- 7 baseline sites (red dots)

NOTE: DO NOT ANALYZE BLACK DOTS. These are other billboards that will not be analyzed (there are 43 black dots). These are included only so that billboard identification is easier during the event identification process.

If you go past a location and need to "go back," stop the video before doing so.

- Then use the mapPlotForm window and click on a location further back on the map to move the video back.

28. For billboard, comparison, and baseline analysis, stop the video on the first sync at which the vehicle icon actually touches the site dot when the map is at the closest zoom level. If the vehicle does not touch the dot at any point, record the last sync before the vehicle passes the dot. Double check the video to be sure the participant is passing the appropriate billboard at the identified time.
    - For example, for the first aqua dot (board #8441), the video will look like the following. Notice the billboard in the upper right corner.

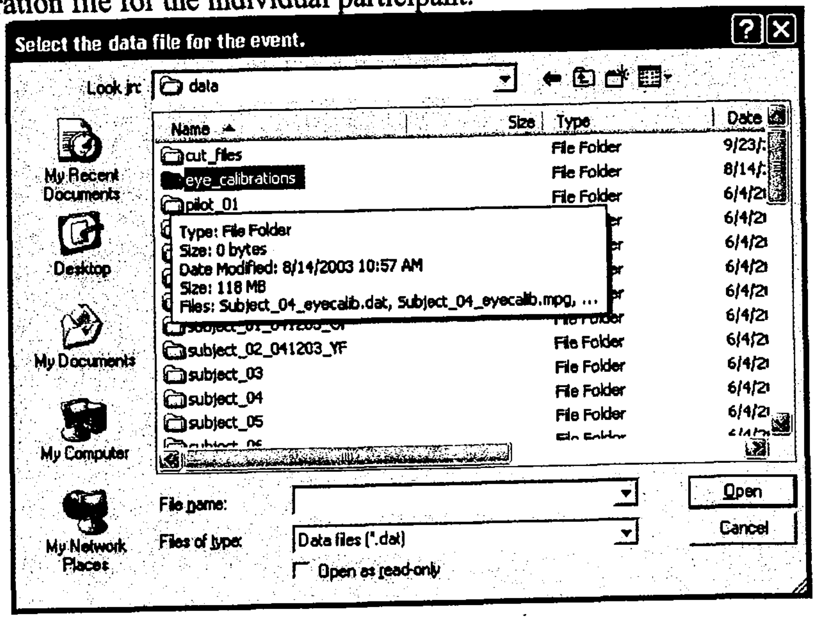


This completes the event identification process. Repeat this process for all events.

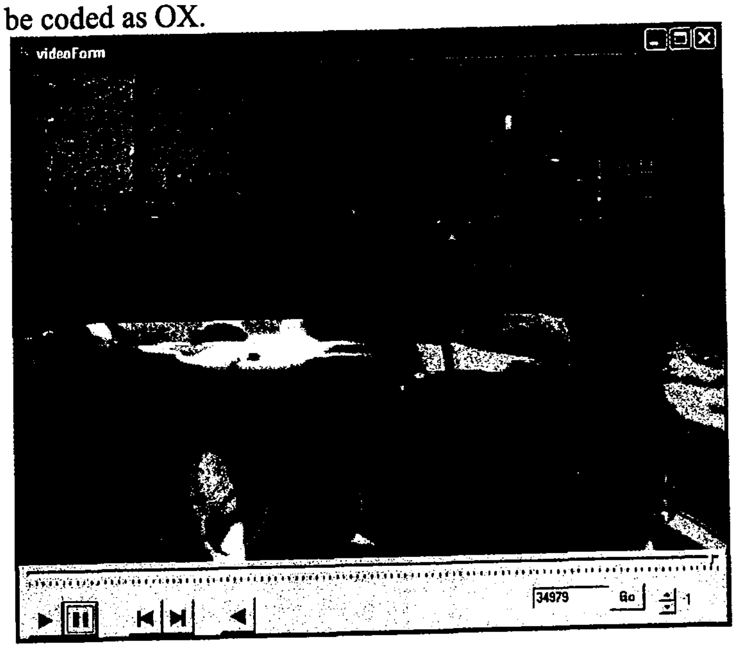
Eye glance Analysis

The second step in analysis is recording the direction the participant is looking at each 10th of a second. Before actual analysis, familiarize yourself with that participant's individual eye glance calibrations.

29. By using Admin Tools from the File menu of HundredCarLite application, open the EyeCalibration file for the individual participant.



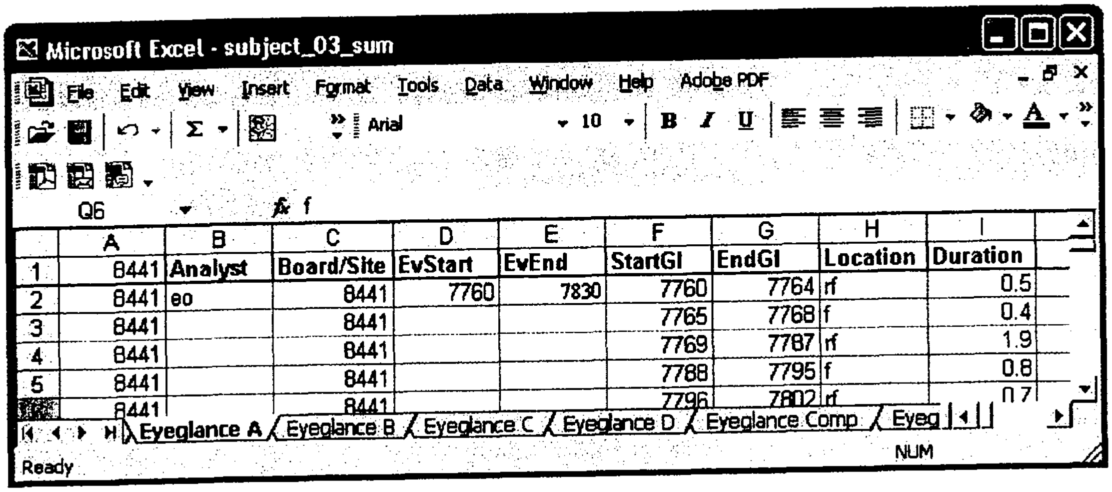
30. Review the eye calibrations several times. Follow the protocol script so you know when the subject is looking in each direction. This subject is looking at the driver's side mirror, which would be coded as OX.



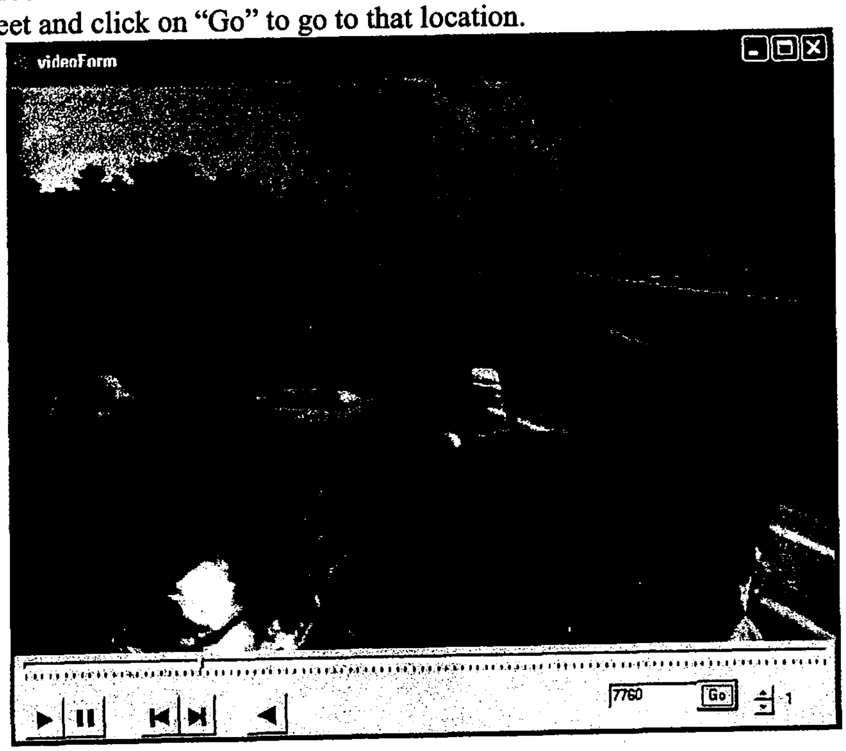
31. By using Admin Tools from the File menu of HundredCarLite application, open the Cut_files file for the individual participant.

32. Be sure the correct participant's analysis spreadsheet is open.

33. In each participant's spreadsheet there are 6 event analysis tabs, named Eye glance A through D for the 30 primary billboards, Comp for comparison sites, and Base for baseline. Start with Eye glance A and go to the first board (#8441).



34. Enter your initials in the "Analyst" column.
35. In the videoForm window of Hundred Car Analyzer, enter in the EvStart value from the Excel sheet and click on "Go" to go to that location.

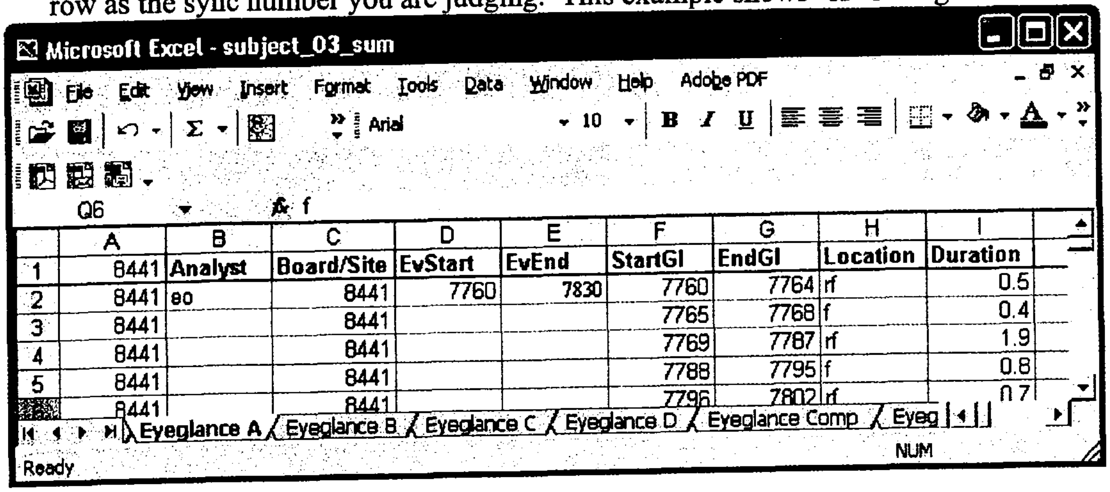


36. Play video until sync in videoForm window reaches EvEnd value in spreadsheet. Review the event several times, forward and backward, to become familiar with the basic eye glance pattern.

37. Note now if the event has a lane change, involves cell phone use, or occurs stopped in traffic. Highlight the analysis master sheet with the appropriate color if necessary. Use yellow for cell phone, green for lane change, and blue for stopped in traffic.

38. Put videoForm on EvStart Sync again. Decide which direction the participant is looking.

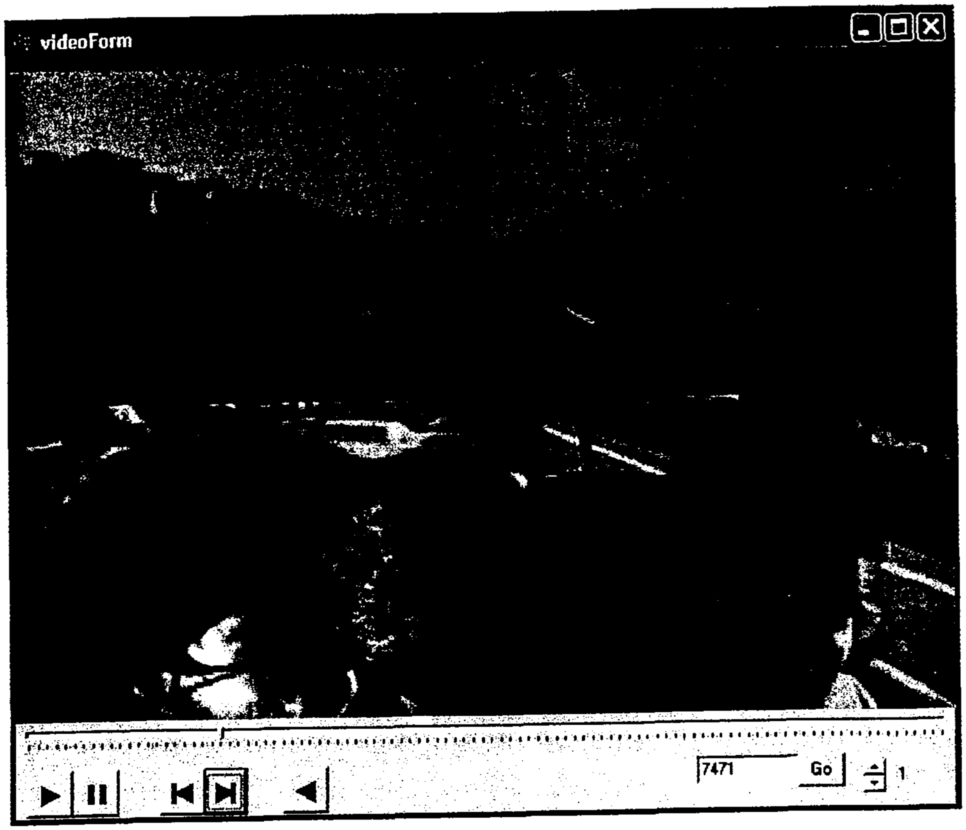
39. Enter the corresponding code into the "Location" column. Be sure to put it in the same row as the sync number you are judging. This example shows "rf" for right forward.



	A	B	C	D	E	F	G	H	I
1	8441	Analyst	Board/Site	EvStart	EvEnd	StartGl	EndGl	Location	Duration
2	8441	eo	8441	7760	7830	7760	7764	rf	0.5
3	8441		8441			7765	7768	f	0.4
4	8441		8441			7769	7787	rf	1.9
5	8441		8441			7788	7795	f	0.8
	8441		8441			7796	7802	rf	0.7

40. The directions and corresponding codes are as follows:
   - F: forward
   - LF: left forward
   - RF: right forward
   - RVM: rear view mirror
   - OX: other exterior (side windows, left and right mirrors etc.)
   - DIR: directions
   - OINT: other interior (speedometer etc.)

41. Advance the video one sync at a time. When the participant's eyes rest on a different location, enter that sync below the previous one in the StartGl column. That is, the transition time from one location to another is included in the duration calculation for the first location.



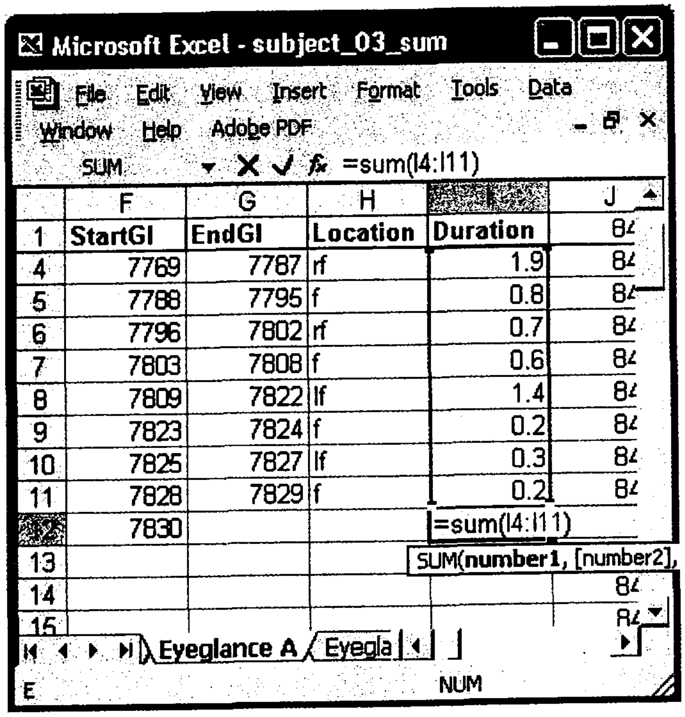
42. The EndGl and Duration values will be calculated automatically.

43. Enter the new glance direction in the Location column. Be sure to stay in the appropriate row.

44. Repeat this process until EvEnd sync has been reached. Do not record a direction for the EvEnd sync.

45. When complete, check duration column to make sure it adds up to 7.

– Erase the 7 and color the cell green to indicate that it has been checked.



46. Mark your initials and the date with a check mark on the master sheet in the square for that subject, that event.

47. Continue analyzing events, about 1 of every four, until your share of that subject has been completed.

48. Move on to the next subject and repeat.

This is the end of the eye glance analysis process.

Appendix E. Descriptive Statistics for Eyeglance Measures

Table E1. Baseline Site Glance Statistics

# of Glances	b1	b2	b3	b4	b5	b6		Avg	SD	Min	Max	Range
Forward	3.47	3.89	3.17	3.14	3.47	3.64		3.46	0.28	3.14	3.89	0.75
Left Forward	0.97	0.72	0.50	0.69	0.85	0.50		0.71	0.19	0.50	0.97	0.47
Right Forward	1.28	1.42	0.86	0.86	1.41	2.11		1.32	0.46	0.86	2.11	1.25
Avg Glance Dur.	**b1**	**b2**	**b3**	**b4**	**b5**	**b6**		**Avg**	**SD**	**Min**	**Max**	**Range**
Forward	1.84	1.67	2.00	2.37	1.78	1.65		1.88	0.27	1.65	2.37	0.73
Left Forward	0.22	0.26	0.23	0.33	0.23	0.14		0.23	0.06	0.14	0.33	0.18
Right Forward	0.36	0.34	0.29	0.31	0.51	0.47		0.38	0.09	0.29	0.51	0.22
Total Glance Dur.	**b1**	**b2**	**b3**	**b4**	**b5**	**b6**		**Avg**	**SD**	**Min**	**Max**	**Range**
Forward	4.46	4.79	4.47	4.94	4.83	4.22		4.62	0.28	4.22	4.94	0.72
Left Forward	0.46	0.43	0.29	0.45	0.40	0.23		0.38	0.09	0.23	0.46	0.23
Right Forward	0.73	0.65	0.51	0.44	0.82	1.29		0.74	0.31	0.44	1.29	0.85

Table E2. Comparison Site Glance Statistics

# of Glances	c1	c2	c3	c4	c5	c6		Avg	SD	Min	Max	Range
Forward	3.86	3.06	2.97	3.40	3.32	3.33		3.32	0.31	2.97	3.86	0.89
Left Forward	0.78	0.53	0.47	1.23	1.06	0.86		0.82	0.29	0.47	1.23	0.76
Right Forward	1.31	1.03	0.92	1.34	1.74	1.53		1.31	0.30	0.92	1.74	0.82
Avg Glance Dur.	**c1**	**c2**	**c3**	**c4**	**c5**	**c6**		**Avg**	**SD**	**Min**	**Max**	**Range**
Forward	1.56	2.13	2.39	1.86	2.13	2.35		2.07	0.31	1.56	2.39	0.82
Left Forward	0.28	0.13	0.20	0.79	0.34	0.47		0.37	0.24	0.13	0.79	0.65
Right Forward	0.40	0.32	0.30	0.42	0.70	0.40		0.42	0.15	0.30	0.70	0.40
Total Glance Dur.	**c1**	**c2**	**c3**	**c4**	**c5**	**c6**		**Avg**	**SD**	**Min**	**Max**	**Range**
Forward	4.40	4.77	4.72	4.16	4.49	5.29		4.64	0.39	4.16	5.29	1.13
Left Forward	0.43	0.23	0.34	1.21	0.57	0.63		0.57	0.35	0.23	1.21	0.98
Right Forward	0.81	0.64	0.59	0.83	1.46	0.84		0.86	0.31	0.59	1.46	0.88

Table E3. Billboard Glance Statistics (first 15 boards)

# of Glances	12209	13052	13200	13346	13351	13353	1856	1895	3068	3130	3197	3240	7194	7245	7716
Forward	3.75	3.26	3.61	3.54	4.06	3.97	3.79	3.62	4.26	4.00	3.69	4.08	3.92	3.53	3.86
Left Forward	1.11	0.68	1.06	1.20	1.21	1.18	1.18	1.44	1.32	1.06	1.06	1.39	1.39	1.32	1.14
Right Forward	1.44	1.62	1.92	1.00	1.56	1.97	1.71	1.26	1.88	1.59	1.39	1.58	1.61	1.24	1.71
Avg Glance Dur.	**12209**	**13052**	**13200**	**13346**	**13351**	**13353**	**1856**	**1895**	**3068**	**3130**	**3197**	**3240**	**7194**	**7245**	**7716**
Forward	1.89	1.56	1.64	1.93	1.40	1.72	1.66	1.79	1.29	1.50	1.69	1.17	1.36	2.01	1.91
Left Forward	0.32	0.44	0.31	0.31	0.32	0.37	0.25	0.45	0.36	0.39	0.33	0.32	0.44	0.38	0.27
Right Forward	0.32	0.53	0.59	0.26	0.44	0.39	0.53	0.42	0.52	0.41	0.57	0.60	0.50	0.52	0.45
Total Glance Dur.	**12209**	**13052**	**13200**	**13346**	**13351**	**13353**	**1856**	**1895**	**3068**	**3130**	**3197**	**3240**	**7194**	**7245**	**7716**
Forward	4.59	3.25	4.03	4.71	4.46	4.63	3.85	4.61	4.09	4.32	4.66	4.06	4.15	4.54	4.63
Left Forward	0.65	0.52	0.58	0.64	0.63	0.61	0.59	0.89	0.79	0.70	0.59	0.67	0.85	0.76	0.59
Right Forward	0.71	1.16	1.27	0.44	0.87	0.99	1.26	0.84	1.20	0.91	0.98	1.09	1.04	0.92	0.97

Table E4. Billboard Glance Statistics (last 15 boards)

# of Glances	**7723**	**8441**	**8489**	**8532**	**8537**	**8568**	**8574**	**8960**	**8998**	**9027**	**9034**	**9071**	**9106**	**9128**	**9159**
Forward	3.60	3.56	3.94	3.23	3.56	3.31	2.94	3.03	4.14	3.25	3.06	3.33	3.34	3.03	3.09
Left Forward	1.00	0.56	1.31	0.63	0.67	0.94	0.83	1.03	1.26	0.75	0.75	0.56	0.80	0.43	0.86
Right Forward	1.74	1.67	1.53	1.46	1.36	1.31	1.11	1.03	1.91	1.08	1.33	0.92	1.09	0.94	1.17
Avg Glance Dur.	**7723**	**8441**	**8489**	**8532**	**8537**	**8568**	**8574**	**8960**	**8998**	**9027**	**9034**	**9071**	**9106**	**9128**	**9159**
Forward	1.99	1.69	1.66	2.02	1.90	2.00	2.53	2.37	1.84	1.94	2.81	1.86	2.07	2.71	2.17
Left Forward	0.29	0.20	0.55	0.23	0.20	0.38	0.34	0.42	0.27	0.33	0.27	0.22	0.27	0.17	0.26
Right Forward	0.60	0.43	0.35	0.49	0.35	0.53	0.35	0.42	0.61	0.47	0.44	0.44	0.29	0.27	0.38
Total Glance Dur.	**7723**	**8441**	**8489**	**8532**	**8537**	**8568**	**8574**	**8960**	**8998**	**9027**	**9034**	**9071**	**9106**	**9128**	**9159**
Forward	4.38	4.51	4.24	4.38	4.86	4.26	4.90	4.95	4.60	4.84	4.83	4.68	5.09	5.31	4.61
Left Forward	0.41	0.34	0.88	0.36	0.29	0.56	0.51	0.67	0.67	0.50	0.39	0.34	0.41	0.20	0.50
Right Forward	1.51	1.05	0.77	0.94	0.72	0.96	0.71	0.64	1.16	0.73	0.85	0.65	0.57	0.59	0.86

Table E5. Billboard Glance Statistics (summary for all billboards)

# of Glances	Avg	SD	Min	Max	Range
Forward	3.58	0.37	2.94	4.26	1.32
Left Forward	1.00	0.28	0.43	1.44	1.01
Right Forward	1.44	0.31	0.92	1.97	1.05
Avg Glance Dur.	**Avg**	**SD**	**Min**	**Max**	**Range**
Forward	1.87	0.38	1.17	2.81	1.63
Left Forward	0.32	0.08	0.17	0.55	0.38
Right Forward	0.45	0.10	0.26	0.61	0.35
Total Glance Dur.	**Avg**	**SD**	**Min**	**Max**	**Range**
Forward	4.50	0.41	3.25	5.31	2.06
Left Forward	0.57	0.17	0.20	0.89	0.69
Right Forward	0.91	0.24	0.44	1.51	1.08

Table E6. Glance Statistics for Baseline, Comparison, and Billboards

	Baseline		Comparison		Billboard	
# of Glances	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Forward	3.46	0.28	3.32	0.31	3.58	0.37
Left Forward	0.71	0.19	0.82	0.29	1.00	0.28
Right Forward	1.32	0.46	1.31	0.30	1.44	0.31
Avg Glance Dur.	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Forward	1.88	0.27	2.07	0.31	1.87	0.38
Left Forward	0.23	0.06	0.37	0.24	0.32	0.08
Right Forward	0.38	0.09	0.42	0.15	0.45	0.10
Total Glance Dur.	**Avg**	**SD**	**Avg**	**SD**	**Avg**	**SD**
Forward	4.62	0.28	4.64	0.39	4.50	0.41
Left Forward	0.38	0.09	0.57	0.35	0.57	0.17
Right Forward	0.74	0.31	0.86	0.31	0.91	0.24

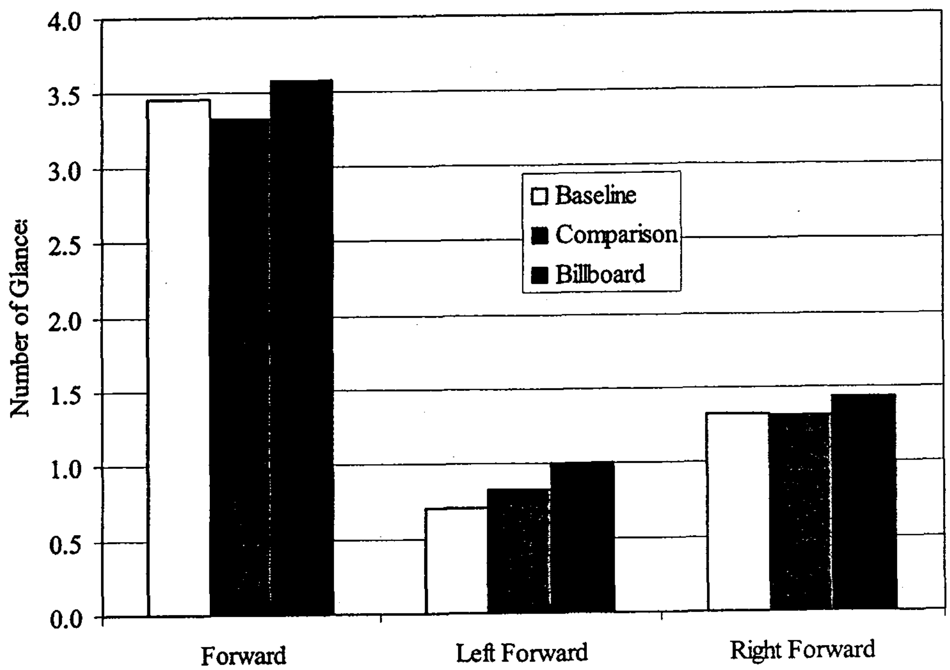


Figure E1. Number of Glances (Averaged) for Baseline, Comparison, and Billboard Sites.

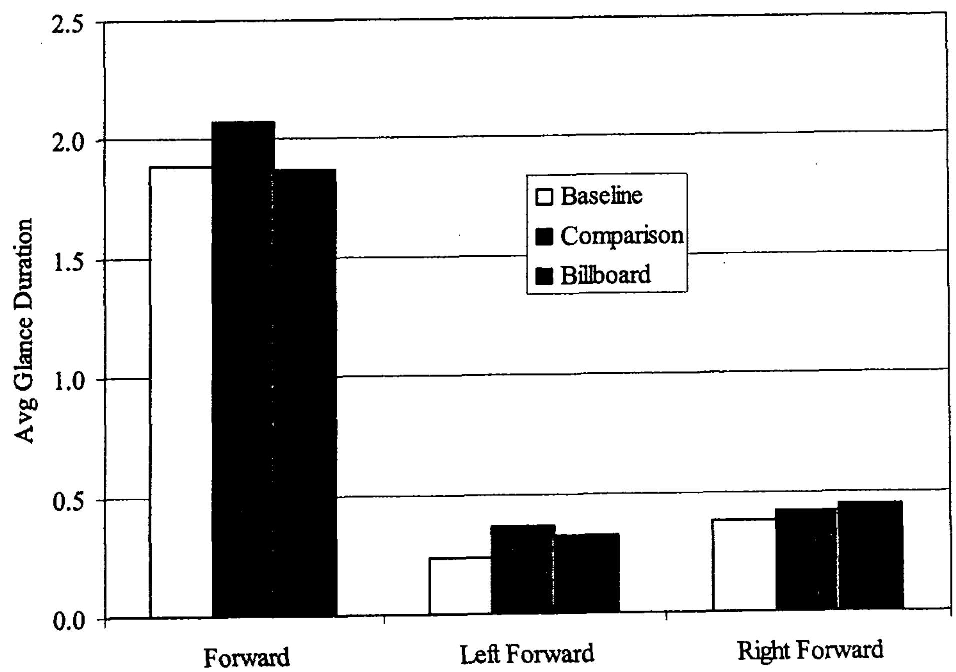


Figure E2. Mean Glance Duration (Averaged) for Baseline, Comparison, and Billboard Sites.

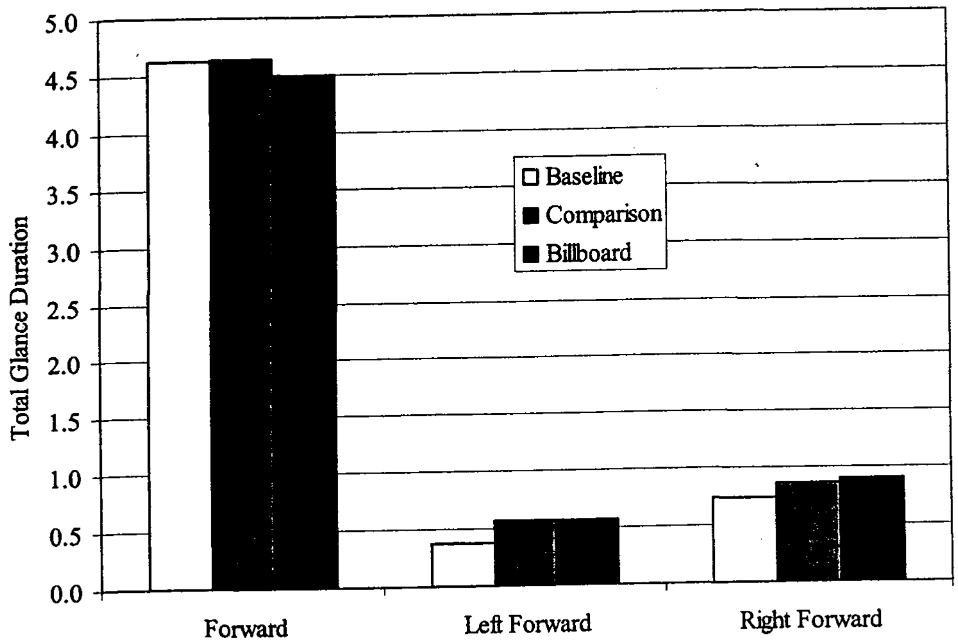


Figure E3. Total Glance Duration (Averaged) for Baseline, Comparison, and Billboard Sites.

Bellavance - 2003

Étude sur les panneaux-réclame le long des routes et l'incidence des accidents dans le voisinage immédiat de ces panneaux

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SOMMAIRE

Problématique et objectif

Depuis le milieu des années 1990, nous avons observé une augmentation importante des panneaux-réclame le long des voies rapides, près des ponts et dans les échangeurs dans les régions urbaines. Le ministère des Transports du Québec considère que la présence de ces panneaux-réclame nuie à la sécurité routière et a fait adopté par l'Assemblée nationale, le 20 décembre 2000, le projet de loi 129 intitulé *Loi interdisant l'Affichage publicitaire de certaines voies de circulation* (L.Q. 2000, c. 58) (ci-après désigné la «Loi 129»). Cette loi vise à réglementer les publicités situées à 200 mètres ou moins du bord de la chaussée de certaines routes et des ponts se trouvant sur le territoire des communautés urbaines et des municipalités régies par la *Loi sur les cités et villes* (L.R.Q., c. C-19).

Cette intervention législative amène la question suivante : Les publicités que vise à prohiber la Loi 129 ont-elles un impact significatif sur la sécurité routière ? Il y a très peu d'études avec des données empiriques sur le sujet, et les quelques études recensées ont été publiées il y a déjà plus de vingt ans. La principale conclusion que l'on peut en tirer est qu'à ce jour il n'y a aucune évidence empirique pour soutenir l'hypothèse d'un lien de cause à effet significatif entre la présence de panneaux-réclame en bordure des routes et le risque d'accidents de la route. L'objectif du présent projet de recherche est donc d'étudier empiriquement s'il existe un lien significatif entre l'incidence des accidents et la présence de panneaux-réclame maintenant prohibés par la Loi 129.

Méthodologie

Pour répondre à cet objectif, nous avons obtenu de la Société d'assurance automobile du Québec (SAAQ), un fichier de données contenant tous les accidents rapportés par un policier et qui sont survenus sur l'île de Montréal entre le 1er janvier 1992 et le 31 décembre 1998. Dans un premier temps, nous avons identifié huit zones ou tronçons de routes sur l'île de Montréal : trois zones où des panneaux-réclame ont été aménagés entre le 1er janvier 1992 et le 31 décembre 1998 et qui ne pourraient aujourd'hui être installés aux mêmes endroits en vertu de la Loi 129, et cinq autres zones où il n'y avait aucun panneau-réclame prohibé par cette loi dans la période de temps considérée pour l'étude. Les zones sans panneau-réclame prohibé par la Loi 129 ont été choisies comme zones témoins pour évaluer l'évolution dans le temps du nombre d'accidents sur des tronçons de route ou échangeurs ayant une architecture similaire aux zones avec des panneaux-réclame qui sont maintenant prohibés par la Loi 129. Les trois zones avec panneaux-réclame sont: l'échangeur Décarie, jonction des autoroutes 15 et 40; l'échangeur Turcot, jonction des autoroutes 15, 20 et 720; le tronçon de l'autoroute 40 secteur Est, section comprise entre l'avenue Broadway et le boulevard Tricentenaire, incluant les voies de service. Les cinq zones sans panneau-réclame sont: l'échangeur Anjou, jonction des autoroutes 25 et 40; l'échangeur autoroutes 13 et 40, jonction des autoroutes 13 et 40; le tronçon de l'autoroute 40 secteur Ouest, section comprise entre la rue Tecumseh à l'ouest et le boulevard Sunnybrooke à l'est (inclusivement), incluant les voies de service; le tronçon de l'autoroute 40 secteur Ouest, section comprise entre l'avenue Stillview à l'ouest (inclus) et la rue Tecumseh à l'est (exclus), incluant les

voies de service; le tronçon de l'autoroute 40 secteur Ouest, section comprise entre le chemin Ste-Marie à l'ouest (inclusivement) et l'avenue Stillview à l'est (exclusivement), incluant les voies de service.

L'extraction des données pour les analyses statistiques consistait à identifier tous les accidents répertoriés dans les fichiers de la SAAQ qui sont survenus dans chacune des huit zones retenues. Ce travail a été effectué par des spécialistes en systèmes d'information géographique de la firme Géomatique SIGISCO Inc. Nous avons par la suite calculé et analysé le nombre annuel d'accidents survenus dans chacune des huit zones considérées, selon la gravité et au total. Nous avons également analysé les nombres mensuels d'accidents survenus dans chacune des huit zones à l'aide de cartes de contrôle et de modèles statistiques pour l'analyse de séries chronologiques.

Résultats

Le fichier de données reçu de la SAAQ contenait 263 967 enregistrements d'accidents survenus sur l'île de Montréal entre le 1er janvier 1992 et le 31 décembre 1998. De ce nombre, 10 096 accidents ont été identifiés comme ayant eu lieu dans l'une des huit zones considérées. La grande majorité de ces accidents (81,8%) ont été des accidents avec dommages matériels seulement (DMS). Il y a eu très peu d'accidents mortels (0,2%) ou avec blessés graves (2%) et un peu plus d'accidents avec blessés légers (16%).

Les analyses descriptives et de cartes de contrôle montrent que, durant la période de l'étude, il n'y a eu aucune différence significative entre le nombre d'accidents survenus avant et après l'apparition de plusieurs publicités désormais prohibées par la Loi 129 dans les trois zones retenues. Aussi, l'évolution des nombres annuels et mensuels d'accidents dans ces trois zones est tout à fait comparable à celle des cinq zones témoins où il n'y avait aucun panneau-réclame prohibé par la Loi 129 durant cette même période. De même, les modèles de séries chronologiques des nombres mensuels d'accidents ne montrent aucun lien significatif entre l'apparition massive de panneaux-réclame, qui sont maintenant prohibés par la Loi 129, et l'incidence d'accidents de la route.

Conclusion

Les résultats de cette étude empirique vont dans le même sens que l'ensemble des autres études empiriques publiées il y a plusieurs années. Nous n'avons trouvé aucun lien significatif entre l'apparition de panneaux-réclame désormais prohibés par la Loi 129 et l'incidence d'accidents survenus dans les échangeurs et sur des tronçons d'autoroute en milieu urbain où la circulation routière est dense et la géométrie des échangeurs est complexe.

Introduction

Les panneaux-réclame le long des routes ont fait leur apparition il y a plusieurs décennies au Québec. Ces panneaux visent généralement à attirer l'attention des conducteurs et passagers des véhicules pour annoncer des commerces, des produits ou des services. Il existe plusieurs formes de publicité destinée aux usagers de la route (Andreassen, 1985):

1) La publicité sur les véhicules routiers eux-mêmes; par exemple sur les autos et camions pour annoncer le nom d'entreprise et les services offerts; sur les autobus pour annoncer toutes sortes de produits ou services. La grandeur des affiches publicitaires sur les véhicules est limitée par la grandeur du véhicule.
2) Les affiches identifiant les différents commerces qui sont établis le long des routes : restaurants, stations services, hôtels, etc. La grandeur de ces affiches varient beaucoup. Elles sont généralement localisées sur les édifices ou les terrains où se trouvent les commerces.
3) Les panneaux-réclame annonçant des produits ou services à des endroits éloignés des commerces. Ces panneaux le long des routes sont généralement de grande dimension et peuvent prendre la forme d'affiches, de panneaux illuminés ou électroniques avec messages variables ou animés.

Depuis le milieu des années 1990, nous avons observé une augmentation importante des panneaux-réclame le long des routes au Québec, particulièrement le long des voies rapides, près des ponts et dans les échangeurs dans les régions urbaines. Le ministère des Transports du Québec considère que la présence de ces panneaux-réclame nuie à la sécurité routière et a fait adopté par l'Assemblée nationale, le 20 décembre 2000, le projet de loi 129 intitulé *Loi interdisant l'Affichage publicitaire de certaines voies de circulation* (L.Q. 2000, c. 58) (ci-après désigné la «Loi 129»). Cette loi vise à réglementer les publicités situées à 200 mètres ou moins du bord de la chaussée de certaines routes et des ponts se trouvant sur le territoire des communautés urbaines et des municipalités régies par la *Loi sur les cités et villes* (L.R.Q., c. C-19).

La Loi 129 prohibe d'abord toute publicité le long d'un pont. Pour les fins de cette Loi, un pont inclut ses voies d'entrée et de sortie sur une distance de 300 mètres.

La Loi 129 prohibe, sans égard à la vitesse permise, les publicités situées dans les échangeurs et les intersections sur une distance de 200 mètres avant et après chacun de ces endroits. Elle prohibe également la publicité, sans égard à la vitesse permise, dans les zones scolaires et les courbes prononcées sur une distance de 100 mètres avant et après chacun de ces endroits.

Ailleurs qu'à ces endroits, la Loi 129 interdit toute publicité le long des routes où la vitesse maximale permise est de 70 km/h ou plus, à moins qu'elle ne respecte les dispositions suivantes :

1° Il ne s'agit pas d'un message publicitaire animé ou électriquement variable ;

2° Dans un périmètre d'urbanisation :

a) la publicité doit être à au moins 50 mètres d'un panneau de signalisation et à plus de 100 mètres d'une autre publicité qui a moins de 40 mètres carrés ou à plus de 200 mètres d'une autre publicité qui a 40 mètres carrés ou plus ;

b) la publicité doit être à plus de 15 mètres du bord de la chaussée et avoir une dimension maximale de 20 mètres carrés si elle est placée à moins de 30 mètres du bord de la chaussée ou de 65 mètres carrés si elle est placée à 30 mètres et plus du bord de la chaussée ;

3° À l'extérieur d'un périmètre d'urbanisation, la publicité doit respecter les distances minimales et les dimensions maximales prescrites par la *Loi sur la publicité le long des routes* (L.R.Q., c. P-44) et par tout règlement édicté en vertu de celle-ci.

Finalement, la Loi 129 ne s'applique pas à l'égard des inscriptions se trouvant sur l'emplacement d'un édifice du culte ou d'un cimetière, ainsi qu'à l'égard de la publicité placée sur les lieux où s'exerce une entreprise, une profession ou un art et qui ne contient que des informations sur le nom de l'occupant, ses activités, ses produits ou services ou ses installations physiques.

Cette intervention législative amène la question suivante : Les publicités que vise à prohiber la Loi 129 ont-elles un impact significatif sur la sécurité routière ?

Dans une étude récente préparée pour le Ministère des Transports du Québec et intitulée « Évaluation de l'influence de la publicité le long des routes sur la sécurité routière », l'auteur (Bergeron, J., 1996) fait une recension des écrits portant sur les relations entre l'affichage publicitaire en bordure des routes et la sécurité routière. Dans un premier temps, il constate qu'il y a très peu d'études avec des données empiriques sur le sujet, et que les quelques études recensées ont été publiées il y a déjà plus de vingt ans. Andreassen (1985) avait déjà recensé ces études. La principale conclusion que l'on peut en tirer est qu'à ce jour il n'y a aucune évidence empirique pour soutenir l'hypothèse d'un lien de cause à effet significatif entre la présence de panneaux-réclame en bordure des routes et les accidents (pour plus de détails voir Bergeron, 1996 et Andreassen, 1985). Il y a par contre un grand nombre d'études publiées sur la conduite automobile et le traitement de l'information comme la signalisation routière, et plus récemment sur les formes de distractions qui sont possiblement la cause de plusieurs accidents. Parmi ces distractions, mentionnons l'ajustement de la radio, cassette ou CD, parler au téléphone, porter son attention sur une personne ou un objet ou un événement à l'extérieur du véhicule, etc. Par contre les panneaux-réclame ne sont pas mentionnés explicitement dans la liste des distractions les plus fréquentes qui seraient la cause d'accidents de la route (Stutts et al. 2001).

Il y a eu des changements importants au cours des dernières années au niveau de la forme et de la grandeur des messages publicitaires sur les panneaux (ex .: couleur des images, longueur et grosseur des textes, éclairage) pour les rendre plus attrayants. Les panneaux le long des routes se sont également multipliés et il y a eu une augmentation des débits routiers. Puisque les dernières études empiriques ont été réalisées il y a très longtemps et que les conditions ont beaucoup changées depuis, il est important d'actualiser nos connaissances sur la présence de panneaux-réclame et la sécurité routière.

L'objectif du présent projet de recherche est donc d'étudier empiriquement s'il existe un lien significatif entre l'incidence des accidents et la présence de panneaux-réclame maintenant prohibés par la Loi 129. Nous décrivons dans la prochaine section la méthodologie utilisée qui comprend la source des données et les différentes analyses statistiques effectuées. Les résultats des analyses et la discussion de ces derniers forment les deux dernières sections de ce rapport.

Méthodologie

Source des données :

Les données sur les accidents proviennent des fichiers informatisés de la Société de l'assurance automobile du Québec (SAAQ), qui sont construits à partir des rapports de police d'accidents. Ainsi, seuls les accidents ayant fait l'objet d'un rapport de police sont inclus dans les analyses statistiques de cette étude. Tous les accidents avec dommages matériels mineurs qui ont simplement fait l'objet d'un constat à l'amiable, ne sont pas inclus dans les bases de données de la SAAQ.

À la demande des commanditaires de cette étude, la SAAQ a fourni un fichier de données contenant tous les accidents, rapportés par la police, survenus sur l'île de Montréal entre le 1er janvier 1992 et le 31 décembre 1998. Pour préserver la confidentialité des victimes des accidents, le fichier de données ne contient aucune information nominale permettant d'identifier les individus. Les champs disponibles dans le fichier de données reçu de la SAAQ sont : le numéro d'événement, la date de l'accident, la gravité de l'accident (mortelle, blessés graves, blessés légers, dommages matériels seulement), le code de municipalité, le numéro de route, les intersections les plus proches du lieu de l'accident, la distance du lieu de l'accident et des intersections, la direction des véhicules, le nombre de véhicules impliqués dans l'accident, le nombre de morts, de blessés graves et de blessés légers.

Pour répondre à l'objectif de notre étude, nous avons identifié avant même de voir les données, huit zones ou tronçons de routes sur l'île de Montréal, trois zones où il y a des panneaux-réclame qui ne pourraient aujourd'hui être installés aux mêmes endroits en vertu de la Loi 129 et cinq autres zones où il n'y a aucun panneau-réclame prohibé par cette loi dans la période de temps considérée pour l'étude. Les zones sans panneau-réclame prohibé par la Loi 129 ont été choisies comme zones témoins pour évaluer l'évolution dans le temps du nombre d'accidents sur des tronçons de route ou échangeurs ayant une architecture similaire aux zones avec des panneaux-réclame qui sont maintenant prohibés par la Loi 129. Dans le choix de ces zones échantillons, nous avons bénéficié de la collaboration des quatre principales entreprises d'affichage au Québec (Affichage Astral Media, Pattison, Viacom et Claude Néon) relativement à la localisation, les dimensions et la date de construction de leurs panneaux-réclame. Les zones retenues pour les analyses statistiques sont les suivantes :

- Zone 1 : Échangeur Décarie : jonction des autoroutes 15 et 40. Cette zone comportait déjà quatre panneaux-réclame avant le 1er janvier 1992, pour un total de 9 faces dont plusieurs d'au moins 20 m^2, en place depuis une quinzaine d'années. Parmi ces faces, il y avait un centre de message, un trivision et deux faces intégrant chacune un indicateur de l'heure et de la température. Durant la période de 1992 à 1998, deux nouveaux panneaux-réclame sont apparus dans cette zone. D'abord, il a été érigé un panneau-réclame à trois faces composé d'une première face de dimension 24" x 48" qui a reçu sa première publicité en novembre 1993, suivi d'une deuxième face avec publicité électroniquement variable de dimension 20" x 40" qui est entrée en fonction en décembre 1994, et finalement une troisième face de dimension 29" x 47" ayant reçu sa première publicité en février 1995. Ensuite, un deuxième panneau-réclame à trois faces a été aménagé en novembre 1996. Chacune de ces trois faces était de dimension 10" x 20". Tous ces panneaux sont maintenant prohibés par la Loi 129 parce qu'ils sont situés dans un échangeur. Quant à la face publicitaire projetant des messages électroniquement variables, cela est spécifiquement interdit par la Loi 129. De plus, le panneau-réclame soutenant cette face électronique est située à moins de 30 mètres de la chaussée et à moins de 200 mètres d'une autre publicité.
- Zone 2 : Échangeur Turcot: jonction des autoroutes 15, 20 et 720. Cette zone comportait déjà trois panneaux-réclame pour un total de quatre faces publicitaires et un centre de message avant le 1er janvier 1992. Cependant sept panneaux-réclame à deux faces (3 faces de dimension 10" x 20" et 11 faces de dimension 14" x 48" dont 2 trivisions) sont apparus dans cette zone entre les mois de juillet 1995 et novembre 1997. Tous ces nouveaux panneaux seraient maintenant prohibés par la Loi 129 parce que situés dans un échangeur. La quasi totalité des faces de dimension 14" x 48" sont à moins de 30 mètres de la chaussée et plusieurs sont à moins de 200 mètres les unes des autres. Par ailleurs, les faces de dimensions 10" x 20" sont toutes à moins de 100 mètres d'une autre face publicitaire.
- Zone 3 : Tronçon de l'autoroute 40 secteur Est: section comprise entre l'avenue Broadway et le boulevard Tricentenaire, incluant les voies de service. Pendant la période de l'étude, six panneaux-réclame à deux faces de dimension 10" x 20" sont apparus, quatre au mois de mai 1995 et deux au mois d'octobre 1997. La quasi-totalité de ces faces seraient maintenant prohibées par la Loi 129 parce que situées trop près d'une intersection ou encore parce que situées à moins de 100 mètres d'une autre publicité ou à moins de 50 mètres d'une signalisation.
- Zone 4 : Échangeur Anjou: jonction des autoroutes 25 et 40. Cette zone ne comporte aucun panneau-réclame qui serait maintenant prohibé par la Loi 129 et servira de zone témoin.
- Zone 5 : Échangeur autoroutes 13 et 40: jonction des autoroutes 13 et 40. Cette zone ne comporte aucun panneau-réclame qui serait maintenant prohibé par la Loi 129 et servira de zone témoin.
- Zone 6 : Tronçon de l'autoroute 40 secteur Ouest: section comprise entre la rue Tecumseh à l'ouest et le boulevard Sunnybrooke à l'est (inclusivement), incluant les voies de service. Ce tronçon comporte un échangeur similaire à celui du tronçon Broadway et Tricentenaire

sur l'autoroute 40 Est, mais ne comporte aucun panneau-réclame qui serait maintenant prohibé par la Loi 129 et servira de zone témoin.

- Zone 7 : Tronçon de l'autoroute 40 secteur Ouest: section comprise entre l'avenue Stillview à l'ouest (inclus) et la rue Tecumseh à l'est (exclus), incluant les voies de service. Ce tronçon comporte un échangeur similaire à celui du tronçon Broadway et Tricentenaire sur l'autoroute 40 Est, mais ne comporte aucun panneau-réclame qui serait maintenant prohibé par la Loi 129 et servira de zone témoin.
- Zone 8 : Tronçon de l'autoroute 40 secteur Ouest: section comprise entre le chemin Ste-Marie à l'ouest (inclusivement) et l'avenue Stillview à l'est (exclusivement), incluant les voies de service. Ce tronçon comporte un échangeur similaire à celui du tronçon Broadway et Tricentenaire sur l'autoroute 40 Est, mais ne comporte aucun panneau-réclame qui serait maintenant prohibé par la Loi 129 et servira de zone témoin.

Il est à noter qu'il est plus que probable que des publicités, autres que celles appartenant à des entreprises d'affichage, étaient présentes dans ces zones afin d'annoncer des commerces situés sur des terrains contigus. Nous n'avons pas répertorié ces autres panneaux publicitaires car nous nous intéressons uniquement dans cette étude à l'effet sur la sécurité routière des panneaux-réclame maintenant prohibés par la Loi 129.

L'extraction des données consistait à identifier tous les accidents survenus sur l'un ou l'autre des tronçons retenus en leur attribuant le bon numéro de zone ainsi qu'un code de probabilité d'appartenance à cette zone. Le code 1 correspond à un accident qui doit, selon toute vraisemblance, appartenir à la zone attribuée. Le code 2 correspond à un accident qui doit probablement appartenir à la zone attribuée mais pour lequel il subsiste un léger doute d'appartenance à une autre zone. Finalement le code 3 correspond à un accident qui pourrait appartenir à la zone attribuée mais où l'information disponible dans le fichier de données ne permet ni d'éliminer l'accident, ni de l'attribuer à la zone de manière certaine. Pour ce qui est des quatre tronçons de l'autoroute 40, nous avons également séparé les accidents survenus sur l'autoroute de ceux survenus sur la voie de service.

Le travail d'identification des accidents qui sont survenus dans chacune des huit zones retenues, et répertoriés dans les fichiers de la SAAQ, a été effectué par des spécialistes en systèmes d'information géographique de la firme Géomatique SIGISCO Inc. (www.sigisco.com). Plusieurs rencontres ont eu lieu entre le chercheur principal de cette étude et le responsable de l'extraction des données chez Géomatique SIGISCO Inc. afin de s'assurer de la qualité et de l'uniformité des critères utilisés pour l'identification du lieu des accidents. Le responsable de l'extraction des données a procédé à la reconnaissance terrain des zones d'accidents retenues. Il a ainsi été en mesure d'évaluer l'information visuelle disponible aux policiers qui remplissent les rapports d'accidents afin de mieux comprendre la manière dont celle-ci est saisie.

Le fichier de données reçu de la SAAQ contenait 263 967 enregistrements d'accidents survenus sur l'île de Montréal entre le 1er janvier 1992 et le 31 décembre 1998. À partir de cartes de l'île de Montréal (papier et informatisée), tous les noms de rue pouvant correspondre à une ou l'autre des intersections à l'étude pour chacune des huit zones retenues, ont été identifiés. Tous les enregistrements du fichier de données ont été examinés un à un. Le fichier de données comporte un champ indiquant dans quelle municipalité s'est produit l'accident. Toutefois, des tests ont démontré que nous ne pouvions utiliser le code de municipalité pour obtenir un pré-filtrage fiable des enregistrements. En effet, si nous n'avions retenu que les enregistrements ayant un code de municipalité correspondant à celui où se trouve effectivement un échangeur ou un segment de route retenu, nous aurions éliminé des accidents qui, selon la description, se trouvait bien à l'intersection recherchée. Le code de municipalité a toutefois aidé par la suite à valider l'identification du lieu de certains accidents dans les zones retenues.

Dans un premier temps, tous les accidents où le champ numéro de route n'était pas vide ont été classifiés (40 881 accidents). Les accidents s'étant produit sur des routes se trouvant dans les zones retenues à partir de ce champ ont été identifiés. Les accidents attribués à un numéro de route ne se trouvant pas dans l'une des zones retenues ont également été examinés pour s'assurer qu'il ne s'y trouvait aucun accident survenu dans une zone sélectionnée. Ce premier traitement a permis d'obtenir un sous-échantillon dont le traitement était plus facile à effectuer à cause de la pré-classification représentée par l'inscription du numéro de route. Pour les enregistrements ne contenant aucun numéro de route (223 086 accidents), toutes les occurrences d'une intersection avec une autre ont été examinées une à une afin de sélectionner celles correspondant aux zones retenues.

Après la classification de chacun des enregistrements, une centaine de requêtes informatisées ont été effectuées en recherchant des sous-ensembles de chaînes de caractères correspondant aux rues formant les intersections retenues afin de s'assurer qu'aucun accident n'avait été éliminé par inadvertance. Par exemple, l'occurrence de la chaîne "TR" a été recherché pour vérifier si des enregistrements sur la "TRANSCANADIENNE" avaient été oubliés, ou encore la chaîne "DEC" pour l'autoroute "DECARIE".

Les accidents retenus ont finalement été réexaminés dans leur ensemble de manière successive à une quinzaine de reprises. Ceci a permis de valider l'appartenance des événements à une zone donnée et de s'assurer que les codes de probabilité attribués correspondaient à des situations similaires à l'intérieur d'une même zone ainsi qu'entre les zones.

Enfin, des estimations du débit journalier moyen annuel pour certaines des zones retenues ont été obtenues du Ministère des Transports du Québec. Cette information auxiliaire permettra d'évaluer l'effet d'une augmentation du débit routier sur le nombre d'accidents dans les zones analysées, et d'ajuster, si nécessaire, l'effet des panneaux-réclame dans les modèles d'analyses statistiques pour expliquer le nombre d'accidents.

Analyses statistiques

1. Analyses descriptives :

Dans un premier temps, nous avons calculé le nombre annuel d'accidents survenus dans chacune des huit zones considérées, selon la gravité et au total. Nous avons également calculé le pourcentage d'augmentation du nombre d'accidents par rapport à l'année 1992. Ainsi, si la présence de panneaux-réclame à un lien de cause à effet significatif avec l'incidence d'accidents, nous nous attendons à ce que le nombre d'accidents augmente de façon beaucoup plus importante et reste relativement élevé à partir de l'année 1994 pour l'échangeur Décarie, et de 1995 pour l'échangeur Turcot et le tronçon de la 40 Est entre Broadway et Tricentenaire, où plusieurs nouveaux panneaux-réclame ont été érigés, comparativement aux autres zones où aucun nouveau panneau-réclame prohibé par la Loi 129 n'est apparu entre le 1er janvier 1992 et le 31 décembre 1998.

2. Cartes de contrôle :

Les cartes de contrôle sont surtout utilisées dans les industries manufacturières pour assurer le contrôle de la qualité des produits fabriqués et détecter rapidement les problèmes (Montgomery, 1996). Pour ce qui est de notre étude, d'un mois à l'autre on peut s'attendre à observer un certain nombre d'accidents dans une zone donnée. Ce nombre variera d'un mois à l'autre autour d'une moyenne, la moyenne du nombre d'accidents généralement observée dans cette zone durant un mois. Si les conditions dans la zone donnée ne changent pas beaucoup dans la période de temps étudiée, le nombre d'accidents devrait normalement varier à l'intérieur de certaines limites autour de la moyenne attendue d'accidents dans cette zone. Les cartes de contrôle servent à calculer ces limites et à identifier les périodes où le nombre d'accidents est hors de ces limites, indiquant ainsi qu'une cause autre que les conditions normales est fort probablement à l'origine de ce dépassement c.-à-d. « le processus n'est plus sous contrôle ».

Pour cette analyse, nous avons considéré le nombre mensuel d'accidents entre le 1er janvier 1992 et le 31 décembre 1998. Nous n'avons pas utilisé le nombre annuel d'accidents car nous n'aurions eu que sept points, ce qui est très peu pour construire une carte de contrôle et évaluer l'effet de l'apparition de panneaux-réclame sur le nombre d'accidents. À partir des nombres d'accidents mensuels, nous avons calculé la moyenne mensuelle d'accidents pour chacune des zones et les limites entre lesquelles le nombre mensuel d'accidents devrait normalement varier (Montgomery, 1996, p. 223).

Pour l'échangeur Décarie, la moyenne mensuelle et les limites servant à construire la carte de contrôle ont été calculées à partir des nombres mensuels d'accidents de janvier 1992 à octobre 1993, soient les mois juste avant l'apparition de la première nouvelle face publicitaire dans cette zone durant la période de l'étude. De même pour l'échangeur Turcot, la moyenne mensuelle et les limites servant à construire la carte de contrôle ont été calculées à partir des nombres mensuels d'accidents de janvier 1992 à juin 1995, soient les mois juste avant l'apparition des nouveaux panneaux-réclame dans cette zone durant la période de l'étude. Similairement, pour le tronçon de la 40 Est entre Broadway et Tricentenaire, les nombres mensuels d'accidents de janvier 1992 à avril 1995 ont été utilisés pour le calcul de la moyenne et des limites de la carte de contrôle. Ainsi, si la présence de panneaux-réclame le long des routes a un effet significatif sur l'incidence d'accidents, nous devrions nous attendre à ce que les nombres mensuels observés d'accidents pour les mois de novembre 1993 à décembre 1998 pour l'échangeur Décarie, de juillet 1995 à décembre 1998 pour l'échangeur Turcot, et de mai 1995 à décembre 1998 pour le tronçon de la 40 Est entre Broadway et Tricentenaire, soient majoritairement au-dessus de la limite supérieure de la carte de contrôle, ou à tout le moins que de longues séquences avec huit points ou plus qui sont tous supérieurs à la moyenne (Montgomery, 1996, p. 148). Pour ce qui est des cinq autres zones ou aucun nouveau panneau-réclame n'est apparu durant la période considérée, on doit s'attendre à ce que la majorité des points se situent à l'intérieur des limites de la carte de contrôle.

3. Modèles de séries chronologiques et inférence statistique

Les données mensuelles sont des séries chronologiques telles que discutées dans Box et Jenkins (1976) ou Brockwell et Davis (1996). Les données portant sur le nombre mensuel d'accidents se prêtent particulièrement bien à une formulation avec des modèles de séries chronologiques de type autorégressifs et moyennes-mobiles (modèles ARMA). Nous avons modélisé individuellement chacune des huit séries selon la méthodologie de la méthode itérative en trois étapes de Box-Jenkins, où un modèle est proposé dans un premier temps (phase d'identification), estimé dans un second temps (phase d'estimation) et finalement diagnostiqué (phase finale de validation).

Pour la série chronologique correspondant à l'échangeur Décarie, une nouvelle face publicitaire prohibée par la Loi 129 est apparue en novembre 1993 (événement 1), une deuxième face, électronique cette fois, en décembre 1994 (événement 2), une troisième face en février 1995 (événement 3), et finalement, un dernier panneau-réclame à trois faces a été aménagé en novembre 1996 (événement 4). Nous postulons un modèle autorégressif d'ordre un pour cette série. Nous insérons dans ce modèle quatre variables indicatrices qui tiennent compte des événements de l'apparition de nouvelles faces publicitaires à différents moments dans cette zone durant la période de l'étude. Plus précisément le modèle statistique pour expliquer la variabilité du nombre d'accidents au mois t (t = janvier 1992 à décembre 1998) est le suivant :

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \gamma_{2t} + \gamma_{3t} + \gamma_{4t} + \phi_1 ACCIDENTS_{t-1} + \varepsilon_t .$$

La variable indicatrice γ_{1t} prend la valeur 0 lorsque t = janvier 1992 à octobre 1993 et la valeur 1 lorsque t = novembre 1993 à décembre 1998, γ_{2t} prend la valeur 0 lorsque t = janvier 1992 à novembre 1994 et la valeur 1 lorsque t = décembre 1994 à décembre 1998, γ_{3t} prend la valeur 0 lorsque t = janvier 1992 à janvier 1995 et la valeur 1 lorsque t = février 1995 à décembre 1998, et γ_{4t} prend la valeur 0 lorsque t = janvier 1992 à octobre 1996 et la valeur 1 lorsque t = novembre 1996 à décembre 1998. Le modèle précédent est un cas particulier de modèles de régression généraux étudiés dans Fuller (1996, Section 9.8). Le nombre d'accidents au mois t peut être modélisé par une moyenne générale représentée par la variable γ dans le modèle, les variables indicatrices pour l'apparition des panneaux-réclame et le nombre d'accidents qui sont survenus le mois précédent c.-à-d. le mois t-1. La variable ε_t représente l'erreur aléatoire (ou la valeur résiduelle) dans le modèle autorégressif. Si au moins une des quatre variables indicatrices est positive et statistiquement significative dans le modèle, ceci indiquera alors que le nombre d'accidents aura augmenté de façon significative après l'apparition des faces publicitaires correspondants aux variables indicatrices significatives du modèle. Si aucune des quatre variables indicatrices n'est statistiquement significative, nous ne pourrons conclure que l'apparition de nouvelles faces publicitaires dans l'échangeur Décarie aura eu un effet sur l'incidence des accidents survenus dans cette zone durant la période de l'étude.

Pour tenir compte d'un effet possible de saisonnalité dans les données, nous avons également considéré un deuxième modèle où nous avons ajouté comme variable explicative pour le nombre d'accidents survenus au mois t, le nombre d'accidents qui ont eu lieu au même mois l'année précédente, c.-à-d. au mois t-12. Le deuxième modèle considéré pour l'échangeur Décarie est donc le suivant :

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \gamma_{2t} + \gamma_{3t} + \gamma_{4t} + \phi_1 ACCIDENTS_{t-1} + \phi_2 ACCIDENTS_{t-12} + \varepsilon_t .$$

Finalement, nous avons considéré les deux derniers modèles auxquels nous avons enlevé la variable indicatrice des événements 2, 3 et 4. La seule variable indicatrice γ_{1t} dans ces deux modèles nous indiquera si le nombre moyen d'accidents pour toute la période de l'étude qui suit l'apparition de la première nouvelle face publicitaire dans l'échangeur Décarie est significativement supérieur au nombre moyen d'accidents observés avant le premier événement.

Pour la série chronologique correspondant à l'échangeur Turcot, un nouveau panneau-réclame fut installé en juillet 1995 (événement 1), un autre en novembre 1995 (événement 2), un autre en décembre 1995 (événement 3), un autre en mai 1996 (événement 4), deux panneaux en octobre 1996 (événement 5) et finalement un septième panneau fut installé en novembre 1997 (événement 6). Rappelons que ces nouveaux panneaux-réclame sont tous à deux faces. Similairement à l'échangeur Décarie, nous postulons un modèle autorégressif d'ordre un pour cette série. Nous insérons dans ce modèle des variables indicatrices qui tiennent compte des événements de l'apparition des panneaux-réclame à différents moments dans cette zone durant la période de l'étude. Plus précisément le modèle statistique pour expliquer la variabilité du nombre d'accidents au mois t (t = janvier 1992 à décembre 1998) est le suivant :

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \gamma_{2t} + \gamma_{3t} + \gamma_{4t} + \gamma_{5t} + \gamma_{6t} + \phi_1 ACCIDENTS_{t-1} + \varepsilon_t .$$

Les variables indicatrices $\gamma_{1t},\ldots,\gamma_{6t}$ prennent la valeur 0 pour tous les mois t avant le mois correspondant à l'événement 1, 2, ..., et 6 respectivement, et la valeur 1 à partir du mois où il y a eu l'installation des panneaux correspondant à chacun des six événements. Le nombre d'accidents au mois t peut être modélisé par une moyenne générale représentée par la variable γ dans le modèle, les variables indicatrices pour l'apparition des panneaux-réclame et le nombre d'accidents qui sont survenus le mois précédent c.-à-d. le mois t-1. La variable ε_t représente l'erreur aléatoire (ou la valeur résiduelle) dans le modèle autorégressif. Si au moins une des variables indicatrices est positive et statistiquement significative dans le modèle, ceci indiquera alors que le nombre d'accidents aura augmenté de façon significative après l'apparition des panneaux-réclame correspondants aux variables indicatrices significatives du modèle. Si aucune des variables indicatrices n'est statistiquement significative, nous ne pourrons conclure que l'apparition de nouveaux panneaux-réclame dans l'échangeur Turcot aura eu un effet sur l'incidence des accidents survenus dans cette zone durant la période de l'étude.

Pour tenir compte d'un effet possible de saisonnalité dans les données, nous avons également considéré un deuxième modèle où nous avons ajouté comme variable explicative pour le nombre d'accidents survenus au mois t, le nombre d'accidents qui ont eu lieu au même mois l'année précédente, c.-à-d. au mois t-12. Le deuxième modèle considéré pour l'échangeur Turcot est donc le suivant :

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \gamma_{2t} + \gamma_{3t} + \gamma_{4t} + \gamma_{5t} + \gamma_{6t} + \phi_1 ACCIDENTS_{t-1} + \phi_2 ACCIDENTS_{t-12} + \varepsilon_t .$$

Finalement, nous avons considéré les deux derniers modèles auxquels nous avons enlevé les variables indicatrices des événements 2 à 6. La seule variable indicatrice γ_{1t} dans ces deux modèles nous indiquera si le nombre moyen d'accidents pour toute la période de l'étude qui suit l'apparition des premiers panneaux-réclame dans l'échangeur Turcot est significativement supérieur au nombre moyen d'accidents observés avant le premier événement.

Nous avons considéré des modèles similaires pour la série chronologique du nombre mensuel d'accidents correspondant à l'autoroute 40 Est entre Broadway et Tricentenaire. Dans ce tronçon de route, quatre panneaux-réclame à deux faces ont été installés en mai 1995 (événement 1) et deux autres panneaux à deux faces ont été installés en octobre 1997 (événement 2). Les quatre modèles ajustés pour cette zone sont les suivants :

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \gamma_{2t} + \phi_1 ACCIDENTS_{t-1} + \varepsilon_t ,$$

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \gamma_{2t} + \phi_1 ACCIDENTS_{t-1} + \phi_2 ACCIDENTS_{t-12} + \varepsilon_t ,$$

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \phi_1 ACCIDENTS_{t-1} + \varepsilon_t ,$$

$$ACCIDENTS_t = \gamma + \gamma_{1t} + \phi_1 ACCIDENTS_{t-1} + \phi_2 ACCIDENTS_{t-12} + \varepsilon_t ,$$

où la variable indicatrice γ_{1t} prend la valeur 0 lorsque t = janvier 1992 à avril 1995 et la valeur 1 lorsque t = mai 1995 à décembre 1998, et γ_{2t} prend la valeur 0 lorsque t = janvier 1992 à septembre 1997 et la valeur 1 lorsque t = octobre 1997 à décembre 1998. De la même façon, si les variables indicatrices sont positives et statistiquement significatives, ceci indiquera alors que le nombre d'accidents aura augmenté de façon significative après l'apparition des panneaux-réclame correspondants.

Pour ce qui est des cinq autres zones retenues, puisqu'elle ne contenaient pas de panneau-réclame prohibé par la Loi 129, nous avons simplement ajusté à chacune des séries chronologiques du nombre mensuel d'accidents, les deux modèles autorégressifs suivants :

$$ACCIDENTS_t = \gamma + \phi_1 ACCIDENTS_{t-1} + \varepsilon_t,$$

$$ACCIDENTS_t = \gamma + \phi_1 ACCIDENTS_{t-1} + \phi_2 ACCIDENTS_{t-12} + \varepsilon_t.$$

Pour les analyses des séries chronologiques, nous utiliserons le niveau 5% pour établir la signification statistique des paramètres des modèles.

Résultats

10 096 accidents ont été identifiés au total pour l'ensemble des huit zones considérées entre 1992 et 1998. De ce nombre, 10% ont été codés comme devant probablement appartenir à la zone attribuée mais pour lequel il subsiste un léger doute d'appartenance à une autre zone (code 2) et seulement 2% des accidents attribués aux huit zones manquaient d'information pour être éliminés ou être attribués de manière certaine aux zones retenues (code 3). Ainsi, 88% des accidents identifiés étaient survenus selon toute vraisemblance dans l'une des huit zones à l'étude (code 1). De plus, les distributions des accidents codés 2 ou 3 sont similaires pour chacune des années et des zones considérées dans cette étude. Ces résultats concernant l'identification des accidents dans les huit zones retenues justifient de ne pas tenir compte des codes 1, 2 et 3 dans les analyses statistiques, c.-à-d. les analyses sont basées sur la somme des accidents codés 1, 2 et 3.

1. Analyses descriptives

Le Tableau 1 présente les nombres d'accidents, selon la gravité et au total, pour chacune des zones et des années retenues dans l'étude. Les accidents mortels ou avec blessés graves ont été très rares sur ces tronçons de routes. Il y a eu seulement 20 accidents mortels (0,2%) pour l'ensemble des huit zones et des sept années considérées et 204 accidents avec blessés graves (2%). La grande majorité des accidents (81,8%) survenus à ces endroits entre le 1er janvier 1992 et le 31 décembre 1998 ont été des accidents avec dommages matériels seulement (DMS) ou dans une moins grande proportion (16%) des accidents avec blessés légers. Nous présenterons donc dans ce rapport que les résultats des analyses pour le nombre total d'accidents car le nombre trop peu élevé d'accidents mortels ou avec blessés graves rendraient invalides les calculs des limites pour les cartes de contrôle et les tests d'hypothèse dans les modèles de séries chronologiques si nous analysions les accidents séparément selon la gravité.

La Figure 1 présente l'évolution des nombres annuels d'accidents survenus dans les quatre échangeurs pour lesquels les données ont été recueillies, et la Figure 2 présente les pourcentages d'augmentation du nombre annuel d'accidents par rapport à l'année 1992. Le nombre total annuel maximum d'accidents dans l'échangeur Décarie a été de 421 enregistré en 1993, année où une nouvelle face publicitaire désormais prohibée par la Loi 129 est apparue, mais ce à la toute fin de l'année en novembre. Par contre, ce nombre a ensuite diminué à 352 l'année suivante, année où une seule nouvelle face publicitaire a été aménagé également en fin d'année, soit en décembre 1994. Ce nombre a ensuite varié à la hausse puis à la baisse pour atteindre en 1998 un niveau légèrement inférieur à 1992. Pour ce qui est de l'échangeur Turcot, il y a eu une baisse du nombre annuel d'accidents entre 1993 et 1995, année de l'apparition des premiers panneaux-réclame, prohibés par la Loi 129, pendant la période de l'étude dans cette zone, pour ensuite augmenter jusqu'en 1998 et atteindre exactement le même niveau que 1992 (0% d'augmentation en 1998 par rapport à 1992; voir Figure 2 et Tableau 2). Seul l'échangeur 13 & 40, où aucun panneau-réclame prohibé par la Loi 129 n'a été érigé durant la période de l'étude, a connu une augmentation plus importante du nombre annuel d'accidents entre 1995 et 1998 par rapport à 1992 (voir Figure 2 et Tableau 2). Les estimations des débits journaliers moyens annuels pour l'échangeur Turcot sont passés de 167 030 en 1992 à 184 000 en 1996 (voir Tableau 3) et de 147 150 en 1992 à 158 000 en 1996 pour l'échangeur Décarie. Les estimations des débits journaliers moyens annuels pour les deux autres échangeurs n'étaient disponibles que pour 1995 et 1996 et moins fiable car les compteurs étaient localisés à des endroits un peu plus éloignés des zones à l'étude (voir Tableau 3). Nous pouvons cependant faire l'hypothèse que les débits ont similairement augmenté dans ces zones entre 1992 et 1998.

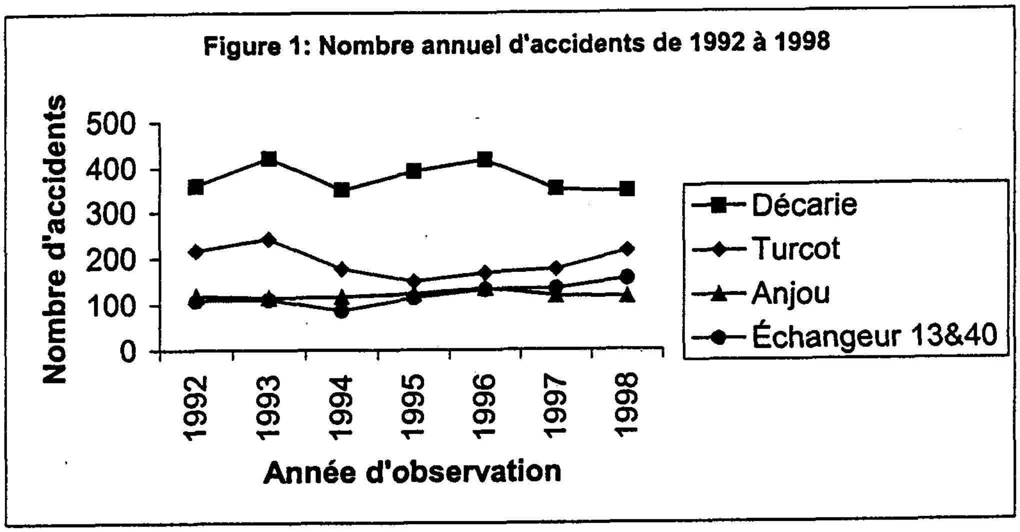
Tableau 1: Nombre d'accidents entre 1992 et 1998

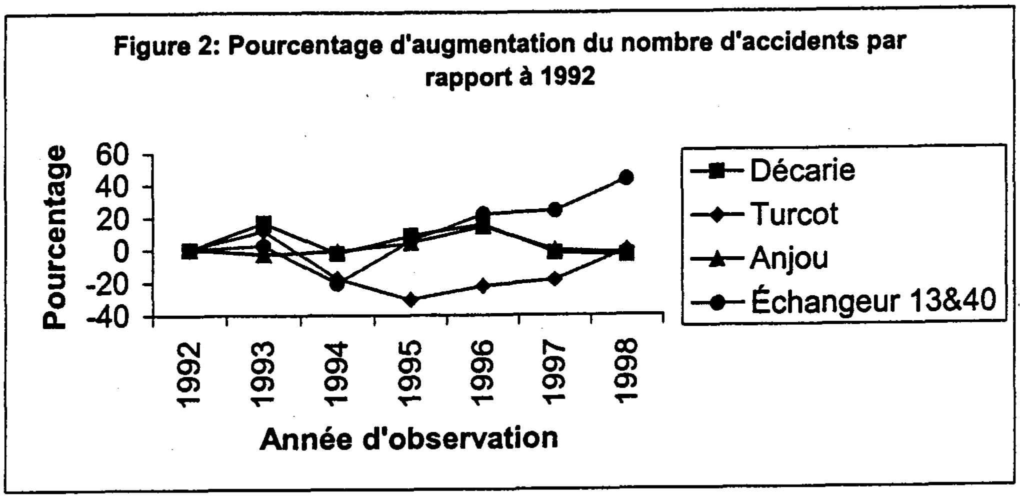
Zone	1992					1993					1994					1995				
	Mortel	Grave	Léger	DMS	Total	Mortel	Grave	Léger	DMS	Total	Mortel	Grave	Léger	DMS	Total	Mortel	Grave	Léger	DMS	Total
Échangeur Décarie	0	11	54	295	360	0	12	50	359	421	1	9	41	301	352	0	8	57	327	392
Échangeur Turcot	0	5	34	177	216	0	7	41	194	242	1	5	28	144	178	0	2	17	131	150
Échangeur Anjou	0	5	14	99	118	0	3	20	95	115	0	6	17	94	117	0	2	18	103	123
Échangeur 13&40	0	1	15	92	108	0	6	19	86	111	0	2	8	76	86	0	4	18	92	114
Autoroute 40 Est Broadway&tricentenaire	2	6	52	151	211	0	6	34	134	174	0	4	41	142	187	0	3	34	153	190
Autoroute 40 Ouest Sunnybrooke&Tecumseh	0	4	26	115	145	0	3	25	91	119	2	2	28	124	156	1	4	26	108	139
Autoroute 40 Ouest Tecumseh&Stillview	0	5	24	169	198	1	7	26	181	215	0	4	24	166	194	0	5	20	176	201
Autoroute 40 Ouest Stillview&Ste-Marie	1	2	28	97	128	1	4	20	94	119	1	3	16	87	107	0	1	24	83	108

Zone	1996					1997					1998				
	Mortel	Grave	Léger	DMS	Total	Mortel	Grave	Léger	DMS	Total	Mortel	Grave	Léger	DMS	Total
Échangeur Décarie	0	0	65	352	417	0	4	42	307	353	0	4	56	288	348
Échangeur Turcot	1	4	31	132	168	0	5	31	140	176	0	1	48	167	216
Échangeur Anjou	0	1	16	118	135	0	2	17	99	118	1	0	19	96	116
Échangeur 13&40	0	5	15	112	132	1	3	26	104	134	1	1	29	124	155
Autoroute 40 Est Broadway&tricentenaire	1	4	30	121	156	0	1	45	127	173	1	2	38	115	156
Autoroute 40 Ouest Sunnybrooke&Tecumseh	0	2	20	95	117	0	3	30	112	145	1	2	21	114	138
Autoroute 40 Ouest Tecumseh&Stillview	1	2	24	166	193	1	2	22	174	199	0	4	31	193	228
Autoroute 40 Ouest Stillview&Ste-Marie	0	0	12	92	104	0	0	23	88	111	0	1	23	90	114

Tableau 2 : Nombre total d'accidents par année de 1992 à 1998 et pourcentage d'augmentation par rapport à 1992

Secteur	1992	1993		1994		1995		1996		1997		1998	
	nombre d'accidents	nombre d'accidents	% p.r. 1992	nombre d'accidents	% p.r. 1992	nombre d'accidents	% p.r. 1992	nombre d'accidents	% p.r. 1992	nombre d'accidents	% p.r. 1992	nombre d'accidents	% p.r. 1992
Échangeur Décarie	360	421	16,9%	352	-2,2%	392	8,9%	417	15,8%	353	-1,9%	348	-3,3%
Échangeur Turcot	216	242	12,0%	178	-17,6%	150	-30,6%	168	-22,2%	176	-18,5%	216	0,0%
Échangeur Anjou	118	115	-2,5%	117	-0,8%	123	4,2%	135	14,4%	118	0,0%	116	-1,7%
Échangeur 13&40	108	111	2,8%	86	-20,4%	114	5,6%	132	22,2%	134	24,1%	155	43,5%
Autoroute 40 Est Broadway-tricentenaire													
Voie de service	23	29		38		38		43		39		34	
Autoroute	188	145		149		152		113		134		122	
Total	211	174	-17,5%	187	-11,4%	190	-10,0%	156	-26,1%	173	-18,0%	156	-26,1%
Autoroute 40 Ouest Sunnybrooke-Tecumseh													
Voie de service	42	20		35		33		26		25		23	
Autoroute	103	99		121		106		91		120		115	
Total	145	119	-17,9%	156	7,6%	139	-4,1%	117	-19,3%	145	0,0%	138	-4,8%
Autoroute 40 Ouest Tecumseh-Stillview													
Voie de service	25	28		17		24		35		15		24	
Autoroute	173	187		177		177		158		184		204	
Total	198	215	8,6%	194	-2,0%	201	1,5%	193	-2,5%	199	0,5%	228	15,2%
Autoroute 40 Ouest Stillview&Ste-Marie													
Voie de service	34	34		23		17		20		19		20	
Autoroute	94	85		84		91		84		92		94	
Total	128	119	-7,0%	107	-16,4%	108	-15,6%	104	-18,8%	111	-13,3%	114	-10,9%





Les nombres annuels d'accidents survenus dans les quatre tronçons de l'autoroute 40 pour lesquels les données ont été recueillies sont présentés dans la partie du bas du Tableau 2. Les nombres d'accidents ayant eu lieu sur l'autoroute et sur la voie de service sont donnés séparément et pour le total. De façon générale, plus du trois quart des accidents sont survenus sur l'autoroute. Les Figures 3 et 4 présentent l'évolution des nombres annuels totaux d'accidents dans ces quatre zones, et des pourcentages d'augmentation par rapport à l'année 1992, respectivement. Le nombre total d'accidents survenus sur l'autoroute 40 entre Broadway et Tricentenaire est passé de 211 en 1992 à 190 en 1995, année où sont apparus quatre panneaux-réclame à deux faces, pour ensuite diminuer jusqu'à 156 accidents en 1998. Parmi les quatre tronçons retenus de l'autoroute 40, c'est le tronçon entre Broadway et Tricentenaire, le seul où des panneaux maintenant prohibés par la Loi 129 ont été érigés, qui a connu le plus grand pourcentage de diminution du nombre d'accidents entre 1992 et 1998. Les estimations des débits journaliers moyens annuels pour le tronçon de l'autoroute 40 entre

Broadway et Tricentenaire sont passées de 82 340 en 1992 à 94 000 en 1996 (voir Tableau 3). Donc, malgré une augmentation relativement importante de l'estimation du débit routier dans cette zone, le nombre total annuel d'accidents répertoriés dans les bases de données de la SAAQ a diminué sur cette période. Les estimations des débits journaliers moyens annuels pour les deux tronçons entre Sunnybrooke et Stillview sont passés de 118 000 en 1993 à 126 000 en 1996 et de 99 000 en 1993 à 98 000 en 1995 pour le tronçon entre Stillview et Ste-Marie.

En résumé, les analyses descriptives ne montrent aucun lien significatif entre l'apparition massive de panneaux-réclame qui sont maintenant prohibés par la Loi 129, et l'incidence d'accidents de la route. En effet, s'il existait un lien de cause à effet significatif entre la présence de panneaux-réclame prohibés par la Loi 129 et l'incidence d'accidents de la route, nous devrions retrouver dans les analyses descriptives, des nombres annuels d'accidents beaucoup plus élevés pour les années 1994 à 1998 dans l'échangeur Décarie (zone 1) et pour les années 1995 à 1998 dans l'échangeur Turcot (zone 2) et le tronçon de la 40 Est entre Broadway et Tricentenaire (zone 3), comparativement aux nombres d'accidents observés dans ces zones durant les premières années de l'étude. Aussi, nous devrions retrouver des courbes très différentes des courbes des cinq autres zones témoins dans les Figures 1 à 4. Or, ce n'est pas le cas. Les analyses descriptives montrent plutôt que l'évolution des nombres annuels d'accidents dans les zones 1, 2 et 3 où plusieurs publicités désormais prohibées par la Loi 129 sont apparues entre 1993 et 1997, est tout à fait comparable à celle des zones témoins où il n'y avait aucun panneau-réclame prohibé par la Loi 129 durant la période de l'étude.

Tableau 3 : débit journalier moyen annuel

Année	Échangeur Décarie	Échangeur Turcot	Échangeur Anjou	Échangeur 13 & 40	40 Est Broadway Tricentenaire	40 Ouest Sunnybrooke Tecumseh	40 Ouest Tecumseh Stillvew	40 Ouest Stillvew Ste-Marie
1992	147150	167030			82340			
1993	147600	165000		-	86000	118000	118000	99000
1994	153800	166318			86102	113000	113000	96000
1995	156000	178000	128000	141000	87000	119000	119000	98000
1996	158000	184000	125000	150000	94000	126000	126000	
1997	155000							
1998								
(RTS)*	(0040-02-111)	(0015-02-070)	(0025-01-020)	(0040-02-090)	(0040-03-101)	(0040-02-080)	(0040-02-080)	(0040-02-070)

* Source des données : Route - Tronçon – Section (RTS) dans les recueils du Ministère des Transports du Québec

0040-02-111: compteur localisé sur la 40 à la hauteur de la rue Sunset en face de l'ONF
0015-02-070: compteur localisé sur la 15 à la hauteur de la sortie Atwater
0040-03-101: compteur localisé sur la 40 à la hauteur du viaduc Marien
0025-01-020: compteur localisé sur la 25 à 1 km au sud de l'échangeur Anjou
0040-02-090: compteur localisé sur la 40 à 1 km à l'ouest de l'autoroute 13
0040-02-080: compteur localisé sur la 40 entre les boulevards St-Jean et Des Sources
0040-02-070: compteur localisé sur la 40 à 1 km à l'ouest du boulevard St-Charles

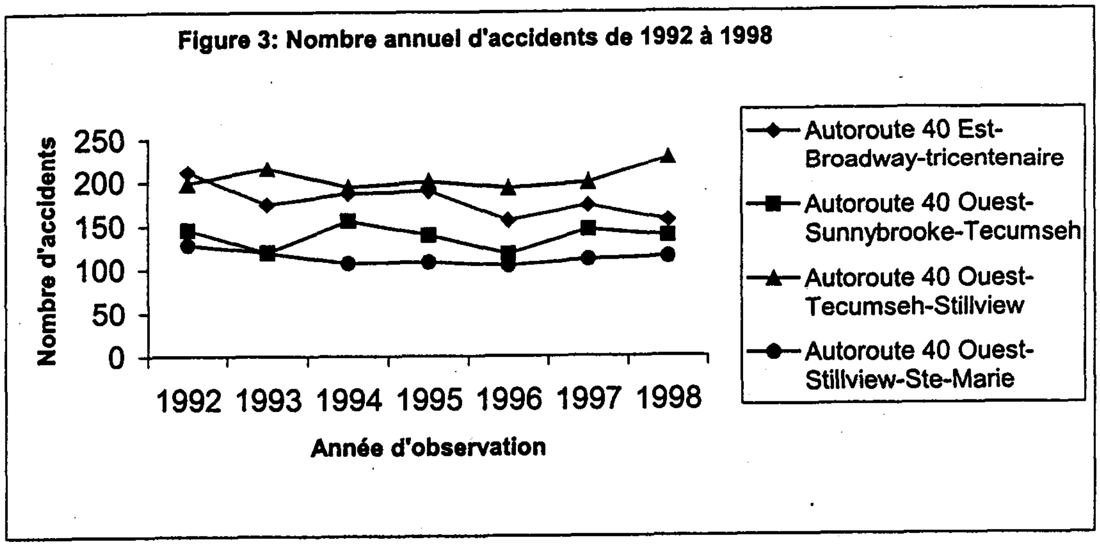


Figure 3: Nombre annuel d'accidents de 1992 à 1998
Nombre d'accidents
250
200
150
100
50
0
1992 1993 1994 1995 1996 1997 1998
Année d'observation
Autoroute 40 Est-Broadway-tricentenaire
Autoroute 40 Ouest-Sunnybrooke-Tecumseh
Autoroute 40 Ouest-Tecumseh-Stillview
Autoroute 40 Ouest-Stillview-Ste-Marie

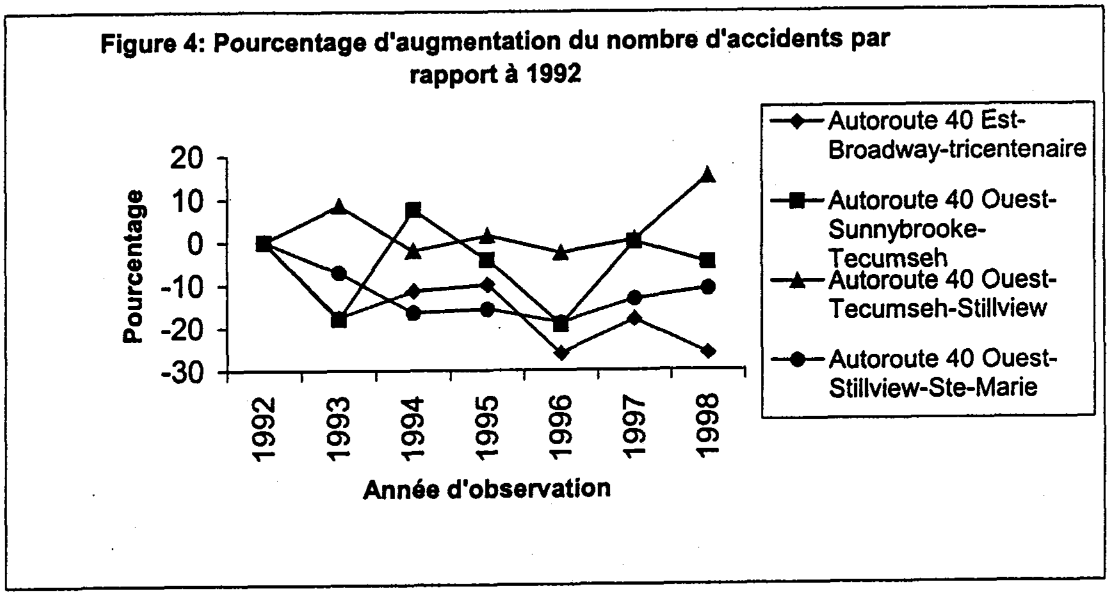


Figure 4: Pourcentage d'augmentation du nombre d'accidents par rapport à 1992
Pourcentage
20
10
0
-10
-20
-30
1992
1993
1994
1995
1996
1997
1998
Année d'observation
Autoroute 40 Est-Broadway-tricentenaire
Autoroute 40 Ouest-Sunnybrooke-Tecumseh
Autoroute 40 Ouest-Tecumseh-Stillview
Autoroute 40 Ouest-Stillview-Ste-Marie

2. Cartes de contrôle

Les Figures 5 à 12 présentent les nombres mensuels d'accidents et les limites des cartes de contrôle pour les huit zones à l'étude respectivement. Les trois zones qui nous intéressent plus particulièrement sont l'échangeur Décarie (Figure 5), l'échangeur Turcot (Figure 6) et le tronçon de l'autoroute 40 Est entre Broadway et Tricentenaire (Figure 9).

Rappelons qu'entre le 1er janvier 1992 et le 31 décembre 1998, la première nouvelle face publicitaire a été aménagé au mois de novembre 1993 dans l'échangeur Décarie, une face avec publicité électroniquement variable est entrée en fonction en décembre 1994 et une troisième face a reçu sa première publicité en février 1995. Enfin, un dernier panneau-réclame à trois faces a été aménagé en novembre 1996. Il y a deux points qui dépassent légèrement la limite supérieure de la carte de contrôle pour l'échangeur Décarie (Figure 5). Ces deux points correspondent aux mois d'octobre 1995 et septembre 1996. Aucune nouvelle face publicitaire n'a été aménagé juste avant ces deux mois problématiques. De plus, à chaque fois les nombres d'accidents reviennent vers la moyenne les mois suivants. Il n'y a aucune tendance soutenue avec des nombres mensuels d'accidents au-dessus de la moyenne après les mois de novembre 1993, décembre 1994, février 1995 ou novembre 1996, soit juste après l'apparition de nouvelles faces publicitaires dans l'échangeur Décarie.

Dans la zone de l'échangeur Turcot, le premier nouveau panneau-réclame est apparu en juillet 1995 et six autres ont été érigés entre les mois de novembre 1995 et novembre 1997. Aucun point de la Figure 6 ne dépasse la limite supérieure de la carte de contrôle après le mois de juillet 1995. En fait, la majorité des nombres mensuels d'accidents entre le mois de juillet 1995 et le mois de décembre 1998 sont sous la moyenne du nombre mensuel d'accidents observés dans l'Échangeur Turcot entre les mois de janvier 1992 et juin 1995. Un seul point, le nombre d'accidents en février 1992, est au-dessus de la limite supérieure de la carte de contrôle. Similairement, aucun nombre mensuel d'accidents ne dépasse la limite supérieure de la carte de contrôle présenté à la Figure 9 pour le tronçon de l'autoroute 40 Est entre Broadway et Tricentenaire.

Pour ce qui est des cartes de contrôle des cinq autres zones retenues dans l'étude comme zones témoins, il y a quelques points qui à l'occasion atteignent ou dépassent les limites supérieures des cartes de contrôle, mais à chaque fois les nombres d'accidents sont revenus à l'intérieur des limites les mois suivants. Dans l'ensemble, les cartes de contrôle n'indiquent aucune tendance à la hausse, comme à la baisse, dans les nombres d'accidents survenus entre le 1er janvier 1992 et le 31 décembre 1998, et ce pour les huit zones retenues dans cette étude.

Notons enfin qu'il ne semble pas y avoir une augmentation ou une diminution de la variabilité des nombres mensuels d'accidents dans le temps pour chacune des huit séries. Cette dernière observation est importante pour la validité des modèles de séries chronologiques dans la prochaine section.

En résumé, les analyses des nombres mensuels d'accidents avec les cartes de contrôle ne montrent aucun lien significatif entre l'apparition massive de panneaux-réclame, qui sont maintenant prohibés par la Loi 129, et l'incidence d'accidents de la route. En effet, s'il existait un lien de cause à effet significatif entre la présence de panneaux-réclame prohibés par la Loi 129 et l'incidence d'accidents de la route, nous devrions retrouver plusieurs nombres mensuels d'accidents au-dessus de la limite supérieure de la carte de contrôle entre les mois de novembre 1993 et décembre 1998 pour l'échangeur Décarie (zone 1, Figure 5), entre les mois de juillet 1995 et décembre 1998 pour l'échangeur Turcot (zone 2, Figure 6), et entre les mois de mai 1995 et décembre 1998 pour le tronçon de la 40 Est entre Broadway et Tricentenaire (zone 3, Figure 9), ou alternativement, nous devrions retrouver de longues séquences avec huit points ou plus qui seraient tous supérieurs à la moyenne dans la période suivant l'apparition des premières publicités dans les zones 1, 2 et 3. Or, ce n'est pas le cas. Les analyses des nombres mensuels d'accidents avec les cartes de contrôle montrent que les nombres mensuels d'accidents dans les zones 1, 2 et 3, où plusieurs publicités prohibées par la Loi 129 sont apparues entre novembre 1993 et novembre 1997, sont presque tous à l'intérieur des limites de contrôle pour la zone 1, et tous à l'intérieur des limites de contrôle pour les zones 2 et 3. Nous pouvons même observer dans les zones 2 et 3 (Figures 6 et 9) que les nombres mensuels d'accidents se retrouvent plus souvent sous la moyenne après l'apparition des premiers panneaux-réclame.

Bref, les analyses avec les cartes de contrôle montrent que l'évolution des nombres mensuels d'accidents dans les zones 1, 2 et 3 où plusieurs publicités désormais prohibées par la Loi 129 sont apparues entre 1993 et 1997, est tout à fait comparable à celle des zones témoins où il n'y avait aucun panneau-réclame prohibé par la Loi 129 durant la période de l'étude.

Figure 5: Échangeur Décarie

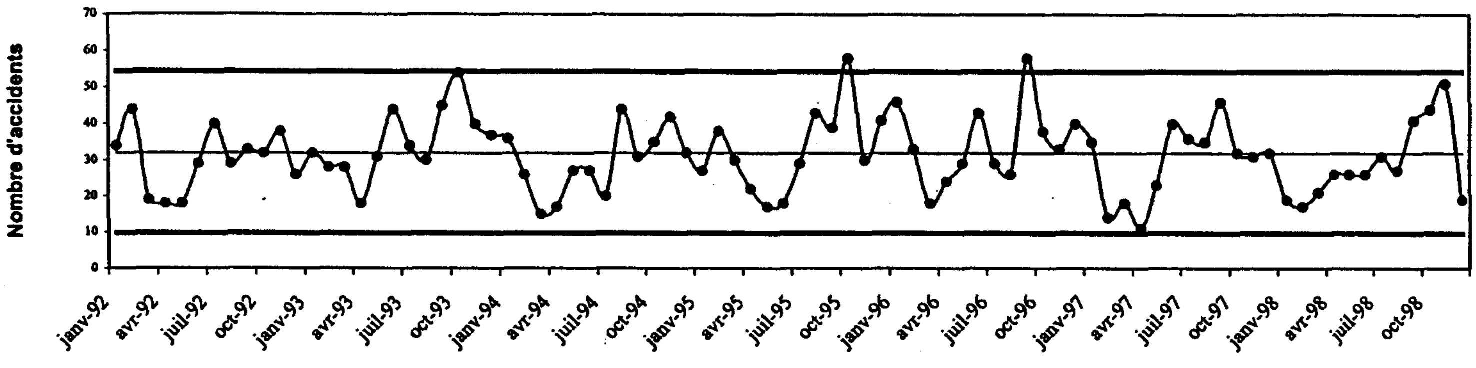
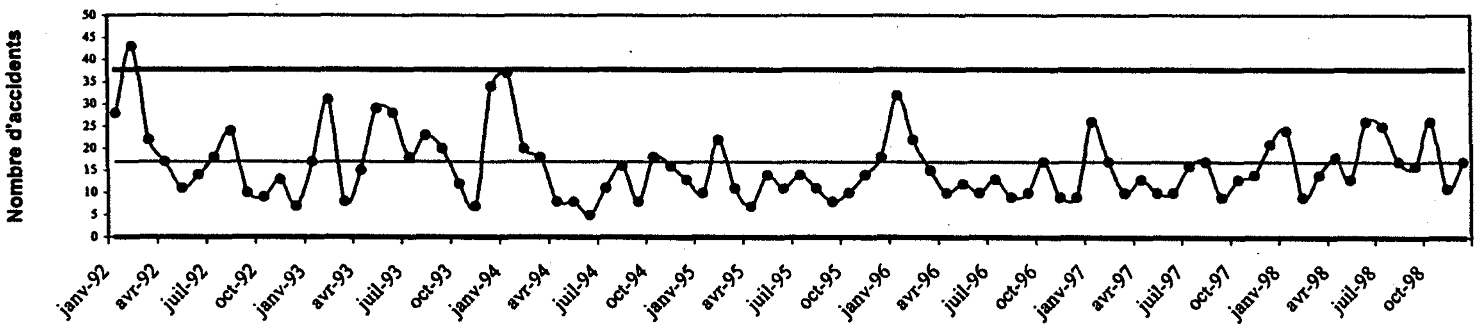


Figure 6: Échangeur Turcot



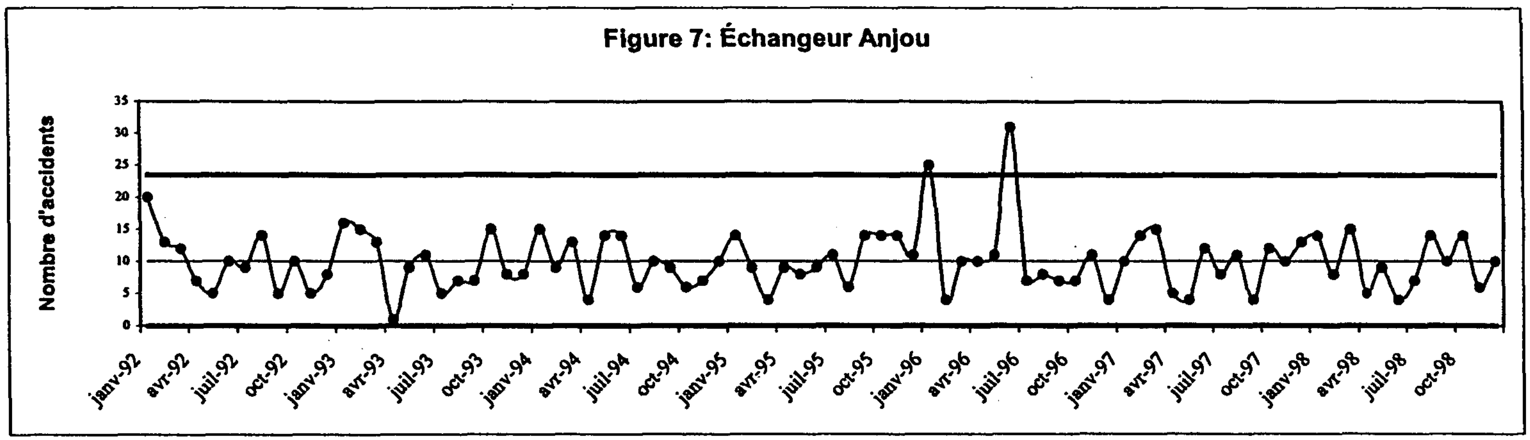


Figure 7: Échangeur Anjou
Nombre d'accidents
35
30
25
20
15
10
5
0
janv-92
avr-92
juil-92
oct-92
janv-93
avr-93
juil-93
oct-93
janv-94
avr-94
juil-94
oct-94
janv-95
avr-95
juil-95
oct-95
janv-96
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avr-98
juil-98
oct-98

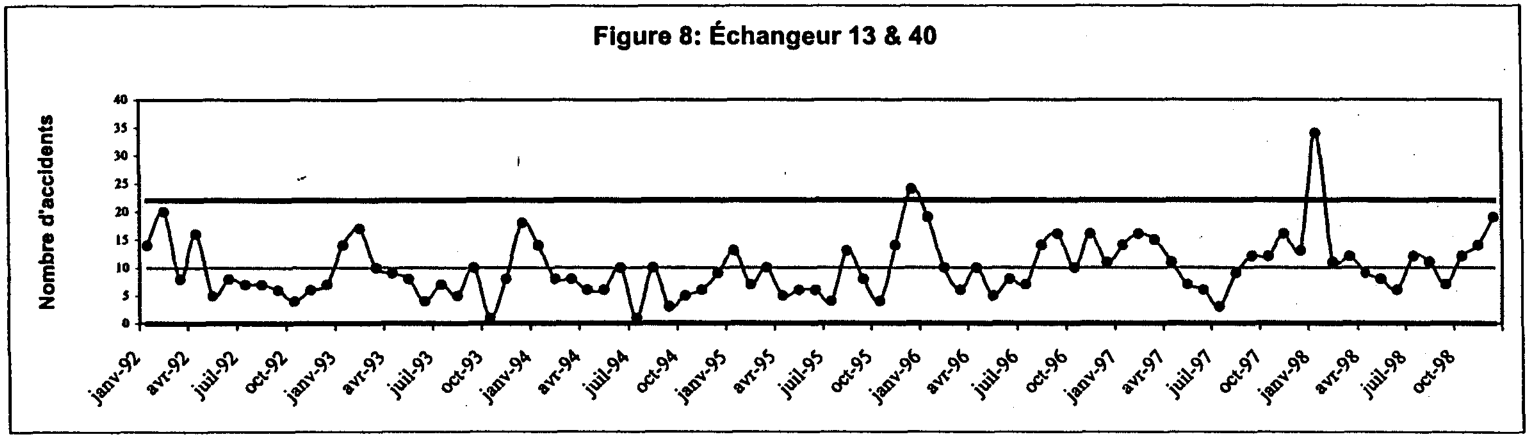


Figure 8: Échangeur 13 & 40
Nombre d'accidents
40
35
30
25
20
15
10
5
0
janv-92
avr-92
juil-92
oct-92
janv-93
avr-93
juil-93
oct-93
janv-94
avr-94
juil-94
oct-94
janv-95
avr-95
juil-95
oct-95
janv-96
avr-96
juil-96
oct-96
janv-97
avr-97
juil-97
oct-97
janv-98
avr-98
juil-98
oct-98

Figure 9: 40 Est entre Broadway & Tricentenaire

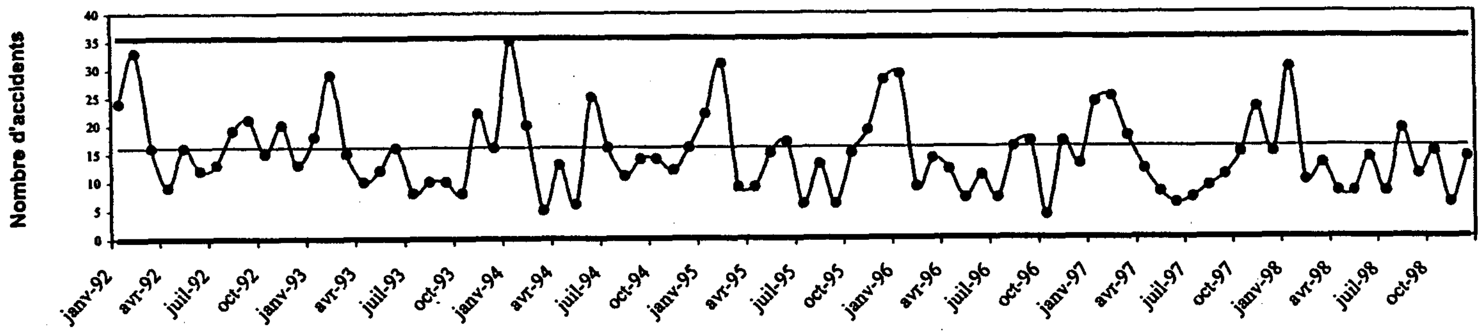


Figure 10: 40 Ouest entre Sunnybrooke & Tecumseh

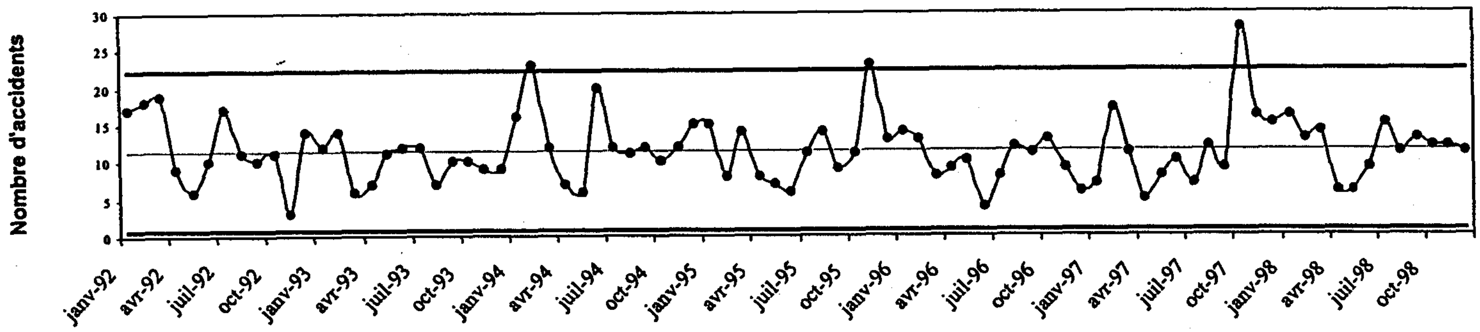


Figure 11: 40 Ouest entre Tecumseh & Stillvew

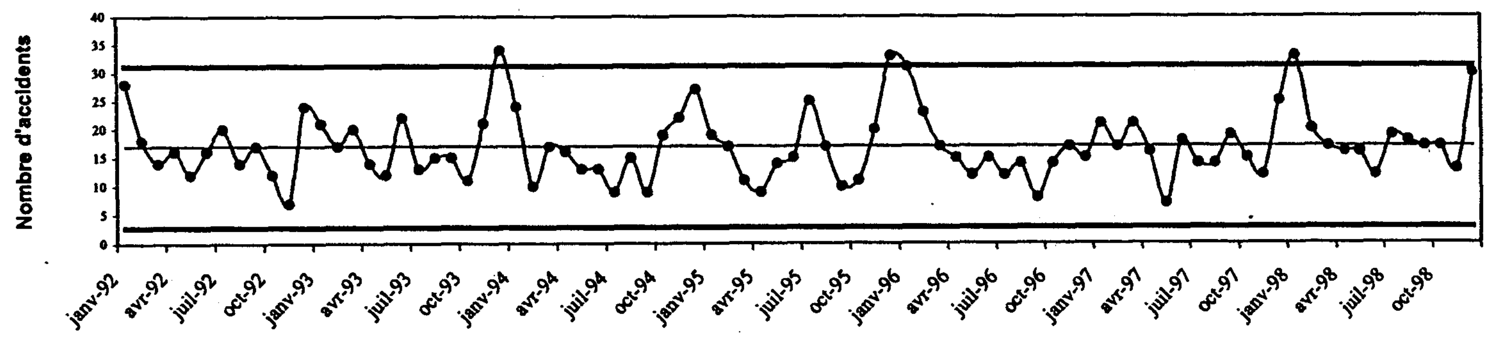
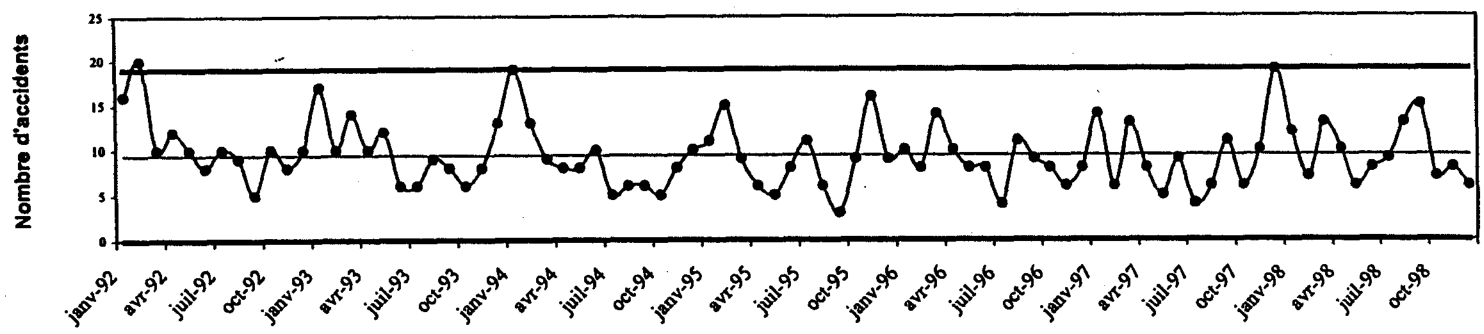


Figure 12: 40 Ouest entre Stillvew & Ste-Marie



3. Modèles de séries chronologiques et inférence statistique

Le Tableau 4 présente les résultats pour les quatre différents modèles de séries chronologiques ajustés à la série des nombres mensuels d'accidents pour l'échangeur Décarie. Les coefficients des variables indicatrices γ_{1t} , γ_{2t} , γ_{3t} et γ_{4t} évaluant l'effet des nouveaux panneaux-réclame sur le nombre mensuel d'accidents dans cette zone, ne sont pas statistiquement significatifs. Les seuils expérimentaux pour ces quatre paramètres sont largement supérieurs à 5%. Le nombre mensuel d'accidents survenus le mois précédent est statistiquement significatif au niveau 5% pour prédire le nombre d'accidents au mois t dans les quatre modèles. Le nombre mensuel d'accidents survenus au même mois l'année précédente est aussi une bonne variable explicative car elle prédit de façon significative le nombre mensuel d'accidents au mois t. Les seuils expérimentaux du coefficient ϕ_2 sont respectivement de 2% et 4% dans les modèles 2 et 4.

Tableau 4 : Modèles de séries chronologiques pour l'échangeur Décarie

paramètre	modèle 1			modèle 2			modèle 3			modèle 4		
	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value
γ	20,51	3,93	0,00	17,63	5,00	<0,01	20,30	3,87	0,00	17,90	4,97	<0,01
γ_{1t}	-1,55	3,44	0,65	-5,32	4,06	0,19	-0,96	2,44	0,69	-3,90	3,26	0,24
γ_{2t}	-3,08	7,42	0,68	-3,01	7,26	0,68						
γ_{3t}	5,65	7,22	0,44	7,07	7,09	0,32						
γ_{4t}	-2,98	2,87	0,30	-3,94	2,84	0,17						
ϕ_1	0,37	0,11	<0,01	0,24	0,12	0,05	0,38	0,10	<0,01	0,27	0,12	0,03
ϕ_2				0,31	0,13	0,02				0,27	0,13	0,04

Le Tableau 5 présente les résultats pour les quatre différents modèles de séries chronologiques ajustés à la série des nombres mensuels d'accidents pour l'échangeur Turcot. Aucun des coefficients des variables indicatrices $\gamma_{1t},\ldots,\gamma_{6t}$ évaluant l'effet des panneaux-réclame sur le nombre mensuel d'accidents, n'est statistiquement significatif. Tous les seuils expérimentaux (p-value) pour ces paramètres sont largement supérieurs à 5%. Seul le nombre mensuel d'accidents survenus le mois précédent est statistiquement significatif au niveau 5% pour prédire le nombre d'accidents au mois t. En effet les seuils expérimentaux pour le coefficient ϕ_1 sont inférieurs à 5% pour les modèles 1, 3 et 4.

Tableau 5 : Modèles de séries chronologiques pour l'échangeur Turcot

paramètre	modèle 1			modèle 2			modèle 3			modèle 4		
	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value
γ	12,09	2,19	0,00	12,47	2,99	0,00	11,01	2,10	0,00	11,07	2,91	0,00
γ_{1t}	-4,28	3,81	0,26	-4,48	3,76	0,24	-0,85	1,58	0,59	-0,76	1,73	0,66
γ_{2t}	3,52	8,01	0,66	3,27	7,72	0,67						
γ_{3t}	2,67	7,93	0,74	3,74	7,68	0,63						
γ_{4t}	-6,09	4,65	0,19	-6,83	4,51	0,14						
γ_{5t}	2,07	3,78	0,59	2,10	3,66	0,57						
γ_{6t}	3,23	2,80	0,25	3,65	2,71	0,18						
ϕ_1	0,27	0,11	0,02	0,18	0,12	0,15	0,33	0,10	0,00	0,28	0,12	0,02
ϕ_2				0,06	0,11	0,61				0,05	0,11	0,66

Le Tableau 6 présente les résultats pour les quatre différents modèles de séries chronologiques ajustés à la série des nombres mensuels d'accidents pour le tronçon de l'autoroute 40 Est entre Broadway et Tricentenaire. Les coefficients des variables indicatrices γ_{1t} et γ_{2t} évaluant l'effet des panneaux-réclame sur le nombre mensuel d'accidents dans cette zone, ne sont pas statistiquement significatifs. Les seuils expérimentaux pour ces deux paramètres sont largement supérieurs à 5%. Le nombre mensuel d'accidents survenus le mois précédent est près d'être statistiquement significatif au niveau 5% pour prédire le nombre d'accidents au mois *t* dans les modèles 1 et 3. Les seuils expérimentaux pour le coefficient ϕ_1 sont de 8% pour les deux modèles. Par contre, le nombre mensuel d'accidents survenus au même mois l'année précédente semble être une meilleure variable explicative car elle prédit de façon significative le nombre mensuel d'accidents au mois *t*. Le seuil expérimental du coefficient ϕ_2 est de 0,01 dans les modèles 2 et 4.

Finalement, le Tableau 7 présente les résultats pour les deux différents modèles de séries chronologiques ajustés aux séries des nombres mensuels d'accidents pour les cinq zones témoins où aucun nouveau panneau-réclame n'a été érigé durant la période de l'étude. Le nombre mensuel d'accidents survenus le mois précédent est significatif au niveau 5% pour prédire les nombres d'accidents au mois *t* (modèle 1) pour l'échangeur des autoroutes 13 & 40, ainsi que pour les trois tronçons de la 40 Ouest. Le nombre mensuel d'accidents survenus au même mois l'année précédente prédit de façon statistiquement significative (p-value < 5% pour le coefficient ϕ_2 dans le modèle 2) les nombres mensuels d'accidents au mois *t* pour l'échangeur des autoroutes 13 & 40, ainsi que pour les tronçons de la 40 Ouest entre Stillview et Tecumseh et entre Ste-Marie et Stillview.

Tableau 6 : Modèles de séries chronologiques pour la 40 Est entre Broadway et Tricentenaire

paramètre	modèle 1			modèle 2			modèle 3			modèle 4		
	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value
γ	12,71	2,09	0,00	8,66	2,62	0,00	12,71	2,08	0,00	8,68	2,60	0,00
γ_{1t}	-1,73	1,70	0,31	-1,08	1,78	0,55	-1,63	1,52	0,29	-0,88	1,62	0,59
γ_{2t}	0,28	2,17	0,90	0,58	2,11	0,78						
ϕ_1	0,19	0,11	0,08	0,10	0,12	0,41	0,19	0,11	0,08	0,10	0,12	0,40
ϕ_2				0,32	0,12	0,01				0,32	0,12	0,01

Tableau 7 : Modèles de séries chronologiques pour les cinq zones où aucun nouveau panneau-réclame n'a été érigé entre le 1er janvier 1992 et le 31 décembre 1998

paramètre	échangeur Anjou						échangeur autoroutes 13 & 40					
	modèle 1			modèle 2			modèle 1			modèle 2		
	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value
γ	10,57	1,19	0,00	9,19	1,86	0,00	6,62	1,19	0,00	4,28	1,46	0,00
ϕ_1	-0,07	0,11	0,54	-0,08	0,12	0,53	0,34	0,11	0,00	0,21	0,12	0,07
ϕ_2				0,16	0,12	0,18				0,39	0,13	0,00

paramètre	40 Ouest entre Tecumseh et Sunnybrooke						40 Ouest entre Stillview et Tecumseh					
	modèle 1			modèle 2			modèle 1			modèle 2		
	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value	coefficient	écart type	p-value
γ	8,94	1,31	0,00	8,20	1,82	0,00	11,33	1,88	0,00	6,70	2,36	0,01
ϕ_1	0,21	0,11	0,05	0,20	0,12	0,09	0,33	0,11	0,00	0,28	0,11	0,02
ϕ_2				0,07	0,11	0,51				0,34	0,11	0,00

paramètre	40 Ouest entre Ste-Marie et Stillview					
	modèle 1			modèle 2		
	coefficient	écart type	p-value	coefficient	écart type	p-value
γ	6,89	1,07	0,00	5,30	1,38	0,00
ϕ_1	0,26	0,11	0,02	0,17	0,12	0,15
ϕ_2				0,25	0,11	0,03

En résumé, les modèles de séries chronologiques des nombres mensuels d'accidents ne montrent aucun lien significatif entre l'apparition massive de panneaux-réclame, qui sont maintenant prohibés par la Loi 129, et l'incidence d'accidents de la route. En effet, s'il existait un lien de cause à effet significatif entre la présence de panneaux-réclame prohibés par la Loi 129 et l'incidence d'accidents de la route, certains des coefficients des variables indicatrices des modèles de séries chronologiques considérés pour les échangeurs Décarie et Turcot (zones 1 et 2), et pour le tronçon de la 40 Est entre Broadway et Tricentenaire (zone 3) seraient statistiquement significatifs et positifs. Or, ce n'est pas le cas. Tous les coefficients des variables indicatrices associées à l'apparition des panneaux-réclame prohibés par la Loi 129 pendant la période de l'étude dans les modèles de séries chronologiques, pour les zones 1, 2 et 3, sont tous non significatif.

Discussion

La littérature traitant du lien entre les panneaux-réclame en bordure des routes et la sécurité routière est peu nombreuse. Les quelques études empiriques sur le sujet ont été publiées il y a plus de vingt ans et de façon générale ces études n'ont pu démontrer qu'il y avait un lien significatif entre la présence de panneaux-réclame sur le bord des routes et l'incidence d'accidents (voir Bergeron, 1996, et Andreassen, 1985). De plus, aucune de ces études publiées étaient du type « avant – après » où les nombres d'accidents ont été analysés avant et après l'apparition de panneaux-réclame dans une même zone. La présente étude avait pour objectif d'actualiser les connaissances sur l'effet de la présence de panneaux-réclame sur le bord des routes et la sécurité routière et plus particulièrement d'évaluer empiriquement l'effet réel de la présence des publicités que vient désormais prohiber la Loi 129 sur l'incidence d'accidents. De plus, l'aspect méthodologique a été amélioré en utilisant un devis expérimental de type « avant – après » pour trois zones où sont apparus dans la période de l'étude des panneaux-réclame qui sont maintenant prohibés par la Loi 129. De plus, nous avons aussi analysé cinq autres zones similaires où il n'y avait aucun panneau-réclame désormais prohibé par la Loi 129.

Les résultats de cette étude empirique sur le terrain vont dans le même sens que l'ensemble des autres études empiriques publiées il y a plusieurs années. Nous n'avons trouvé aucun lien significatif entre l'apparition de panneaux-réclame et le nombre d'accidents survenus dans les échangeurs Décarie et Turcot et sur le tronçon de la 40 Est entre Broadway et Tricentenaire. Les profils du nombre d'accidents dans le temps pour ces trois zones où sont apparus des panneaux-réclame vers le milieu de la période d'étude sont semblables aux profils des cinq autres zones témoins. Notons que les zones choisies pour cette étude sont des voies rapides en milieu urbain où la circulation est dense et la géométrie complexe, surtout dans le cas des échangeurs. Ces zones sont considérées comme des endroits où la charge mentale des conducteurs est très élevée et où l'apparition de panneaux-réclame pourrait, en théorie, avoir le plus grand effet sur la sécurité routière (Bergeron, 1996). En situation réelle de conduite stressante, le conducteur peut probablement s'adapter et faire le tri entre les différentes sources d'informations se présentant dans son environnement immédiat. Ainsi, selon le niveau de charge mentale du moment, le conducteur pourrait décider de totalement ignorer les panneaux-réclame en bordure de la route afin de ne pas augmenter son risque d'avoir un accident. Cette capacité d'adaptation et de sélection des signaux visuels en situation de conduite réelle pourrait expliquer le fait que nous n'ayons pas observé d'augmentation significative et soutenue du nombre d'accidents après l'apparition de panneaux-réclame désormais prohibés par la Loi 129.

Notons que les résultats négatifs de cette étude empirique, et de la majorité des quelques autres études empiriques recensées, expliquent probablement le fait qu'il n'y ait eu aucune étude empirique récente publiée sur le sujet. En effet, les revues scientifiques ont tendance à ne publier que les études qui trouvent des liens qui sont statistiquement significatifs. Ainsi, nous pouvons conclure qu'il n'existe aucun lien significatif entre la présence de publicités le long de la route et le nombre d'accidents survenant à ces endroits. La présente étude démontre plus particulièrement qu'il n'existe aucun lien significatif entre l'incidence d'accidents et la présence de publicités le long d'échangeurs ou de tronçons d'autoroute ou d'intersections ou à une distance inférieure de 100 ou 200 mètres, selon le cas, d'une autre publicité ou à distance inférieure à 50 mètres d'une signalisation ou à une distance inférieure à 30 mètres de la chaussée pour les faces publicitaires de dimension supérieure à 20 mètres carrés. La présente étude montre également l'absence de lien significatif entre l'incidence d'accidents et la présence d'une publicité comportant un message électroniquement variable dans l'échangeur Décarie.

Nous n'avons pas pu évaluer l'effet de l'apparition de panneaux-réclames sur l'incidence d'accidents le long d'un pont, d'une courbe prononcée ou d'une zone scolaire, car nous n'avons pas pu identifier de zone avec ces caractéristiques et où il y avait eu la présence de panneaux-réclame maintenant prohibés par la Loi 129 depuis assez longtemps pour bien évaluer leur effet sur l'incidence d'accidents à ces endroits. Nous pouvons cependant supposer que les résultats auraient été similaires à ceux trouvés dans la présente étude. Par conséquent, la mise en oeuvre des prohibitions contenues à la Loi 129, dans la mesure où elles visent un objectif de sécurité routière, ne pourront pas en soi générer de diminution du nombre d'accidents.

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Annexe : nombres mensuels d'accidents entre le 1er janvier 1992 et le 31 décembre 1998, pour chacune des huit zones de l'étude, qui ont servi à la construction des cartes de contrôle et des modèles de séries chronologiques.

	Nombre mensuel d'accidents							
Mois	Échangeur Décarie	Échangeur Turcot	Échangeur Anjou	Échangeur 13 & 40	40 Est Broadway Tricentenaire	40 Ouest Sunnybrooke Tecumseh	40 Ouest Tecumseh Stillvew	40 Ouest Stillvew Ste-Marie
janv-92	34	28	20	14	24	17	28	16
févr-92	44	43	13	20	33	18	18	20
mars-92	19	22	12	8	16	19	14	10
avr-92	18	17	7	16	9	9	16	12
mai-92	18	11	5	5	16	6	12	10
juin-92	29	14	10	8	12	10	16	8
juil-92	40	18	9	7	13	17	20	10
août-92	29	24	14	7	19	11	14	9
sept-92	33	10	5	6	21	10	17	5
oct-92	32	9	10	4	15	11	12	10
nov-92	38	13	5	6	20	3	7	8
déc-92	26	7	8	7	13	14	24	10
janv-93	32	17	16	14	18	12	21	17
févr-93	28	31	15	17	29	14	17	10
mars-93	28	8	13	10	15	6	20	14
avr-93	18	15	1	9	10	7	14	10
mai-93	31	29	9	8	12	11	12	12
juin-93	44	28	11	4	16	12	22	6
juil-93	34	18	5	7	8	12	13	6
août-93	30	23	7	5	10	7	15	9
sept-93	45	20	7	10	10	10	15	8
oct-93	54	12	15	1	8	10	11	6
nov-93	40	7	8	8	22	9	21	8
déc-93	37	34	8	18	16	9	34	13
janv-94	36	37	15	14	35	16	24	19
févr-94	26	20	9	8	20	23	10	13
mars-94	15	18	13	8	5	12	17	9
avr-94	17	8	4	6	13	7	16	8
mai-94	27	8	14	6	6	6	13	8
juin-94	27	5	14	10	25	20	13	10
juil-94	20	11	6	1	16	12	9	5
août-94	44	16	10	10	11	11	15	6
sept-94	31	8	9	3	14	12	9	6
oct-94	35	18	6	5	14	10	19	5
nov-94	42	16	7	6	12	12	22	8
déc-94	32	13	10	9	16	15	27	10
janv-95	27	10	14	13	22	15	19	11
févr-95	38	22	9	7	31	8	17	15
mars-95	30	11	4	10	9	14	11	9
avr-95	22	7	9	5	9	8	9	6
mai-95	17	14	8	6	15	7	14	5
juin-95	18	11	9	6	17	6	15	8
juil-95	29	14	11	4	6	11	25	11

Nombre mensuel d'accidents (suite)								
Mois	Échangeur Décarie	Échangeur Turcot	Échangeur Anjou	Échangeur 13 & 40	40 Est Broadway Tricentenaire	40 Ouest Sunnybrooke Tecumseh	40 Ouest Tecumseh Stillvew	40 Ouest Stillvew Ste-Marie
août-95	43	11	6	13	13	14	17	6
sept-95	39	8	14	8	6	9	10	3
oct-95	58	10	14	4	15	11	11	9
nov-95	30	14	14	14	19	23	20	16
déc-95	41	18	11	24	28	13	33	9
janv-96	46	32	25	19	29	14	31	10
févr-96	33	22	4	10	9	13	23	8
mars-96	18	15	10	6	14	8	17	14
avr-96	24	10	10	10	12	9	15	10
mai-96	29	12	11	5	7	10	12	8
juin-96	43	10	31	8	11	4	15	8
juil-96	29	13	7	7	7	8	12	4
août-96	26	9	8	14	16	12	14	11
sept-96	58	10	7	16	17	11	8	9
oct-96	38	17	7	10	4	13	14	8
nov-96	33	9	11	16	17	9	17	6
déc-96	40	9	4	11	13	6	15	8
janv-97	35	26	10	14	24	7	21	14
févr-97	14	17	14	16	25	17	17	6
mars-97	18	10	15	15	18	11	21	13
avr-97	11	13	5	11	12	5	16	8
mai-97	23	10	4	7	8	8	7	5
juin-97	40	10	12	6	6	10	18	9
juil-97	36	16	8	3	7	7	14	4
août-97	35	17	11	9	9	12	14	6
sept-97	46	9	4	12	11	9	19	11
oct-97	32	13	12	12	15	28	15	6
nov-97	31	14	10	16	23	16	12	10
déc-97	32	21	13	13	15	15	25	19
janv-98	19	24	14	34	30	16	33	12
févr-98	17	9	8	11	10	13	20	7
mars-98	21	14	15	12	13	14	17	13
avr-98	26	18	5	9	8	6	16	10
mai-98	26	13	9	8	8	6	16	6
juin-98	26	26	4	6	14	9	12	8
juil-98	31	25	7	12	8	15	19	9
août-98	27	17	14	11	19	11	18	13
sept-98	41	16	10	7	11	13	17	15
oct-98	44	26	14	12	15	12	17	7
nov-98	51	11	6	14	6	12	13	8
déc-98	19	17	10	19	14	11	30	6