Roadside aesthetic appeal, driver behaviour and safety

Gerald J.S. Wilde

Address for correspondence: Gerald Wilde, Queen's University, 99 University Avenue, Kingston, ON K7L 3N6 Canada; wildeg@queensu.ca.

Abstract

Earlier publications report that on average the accident rate per hour of driver exposure is virtually the same across samples of different road sections. Both physiological and cognitive measures of the level of risk perceived, taken from drivers while passing different road sections, have shown substantial positive correlations with the police-recorded accident rate per km of the road sections in which the driving was done. Taken together, these studies indicate that where the historical accident rate is high, drivers on average maintain lower speeds, and vice versa. Apparently then, drivers are sensitive to environmental features that are associated with the accident rate per km driven, and they adjust their behaviour accordingly.

This paper presents an analytical discussion of pertinent literature. Attention is drawn to the psychological effects of roadside scenery as documented in the literature. In contrast with the assumption that roadside trees distract travellers from the driving task and thus add to collision risk, several studies actually support the notion that the presence of trees along the roadside has a calming and restorative effect on the state of mind of passing drivers and leads them to lower moving speeds. Moreover, there is evidence that both driver (semi-permanent) traits and (temporary) states have an effect on their choice between more or less scenic roads.

In order to overcome some of the limitations of the evidence gathered so far (simulation, quasi-experimentation in the field, and small sample sizes), this paper proposes that a time-based accident rate for different road sections be determined, and this with the ultimate aim to identify the distinctive geometric and scenic road features that make drivers run more risk per hour in certain road sections, and less in others than they do on average.

Acknowledgement

Paper based on an invited presentation at the SIIV International Workshop on Human-Centred Infrastructure Design, Faculty of Engineering, University of Naples Federico II, Oct. 1-2, 2009 (proceedings not published).

Travel support from the Faculty of Engineering, University of Naples (Italy) Federico II is gratefully acknowledged.

Date of receipt of final manuscript: July 2010

1.0 Different (pre)conceptions

The topic of roadside aesthetic appeal, driver behaviour and traffic safety is characterized by a variety of problems due to different opinions among both professionals and in the general public, different methods of assessing aesthetic experience, conflicting empirical evidence on how drivers respond, and different methodologies in study design. This paper is obviously not the appropriate place for an elaborate discussion of the psychology of aesthetics. For reasons of simplicity and in line with the popular dictum that "beauty is in the eye of the beholder," the term aesthetic appeal is used here to indicate what people say is aesthetically pleasing. It will be seen that green environments ‒ trees, shrubs, scenery ‒ fall in that rubric.

The traditional attitude of traffic engineers and municipal authorities seems to be that roadside landscaping creates traffic hazards; first because of the potential collisions with trees (which are an integral part of roadside greening), and second because of the distraction that roadside scenery may produce and thus interfere with the driving task (Virginia Crash Investigation Team, 2001; Glaze and Ellis, 2003; Dixon and Wolf, 2007; CBC News, 2008).

One example of this type of thinking is a Swedish study according to which "fixed roadside objects [lamp posts and other hard obstacles] cause 100 fatalities each year;" the authors suggest that that number of lives could be saved by removal of these objects (Nilsson and Wenäll, 1998). This study does not report on the number of fatalities that would have occurred anyway, when drivers who lose control and hit a fixed object, even if that fixed object had not been there (roll-over, ditching in a canal, head-on collision with opposing traffic or whatever). Although that number is unknown, it would not seem reasonable to assume it were zero. Therefore, the estimate of 100 is likely too high.

Visibility is also a frequently expressed concern. It may be argued, however, that the implications of improved visibility for accident prevention are not obvious. For example, in the past, researchers have been surprised by the fact that poor visibility at unprotected railway crossings does not seem to add to the accident rate at these crossings. As some have said in an older but very well documented report: "This does not seem logical: sight distance should be one of the most important variables. If a driver cannot see the crossing and down the track at an adequate distance, then he and his vehicle are being expected to perform beyond their physical limitations." (Schoppert and Hoyt, 1968).

What is patently obvious, however, is that drivers at these locations *can see that they cannot see* and are thus likely to adjust their approach behaviour. This was clearly bone out in field experiment with external controls conducted in Canada in which lateral sight distances were improved by removing bush and trees between the road and the railroad (and not so at the comparison site). Motorists responded to the improved lateral sight distance by searching for trains earlier, that is, more upstream from the crossing, and by moving at a higher approach speed. The proportion of passing drivers deemed safe or unsafe on the basis of their approach behaviour and the hypothetical arrival of a train from the farthest observable point along the track remained the same.

Ergo, behavioural adaptation (Wilde, 2001) to a condition of better visibility did occur, but no apparent safety gain (Ward and Wilde, 1996). Similarly, cutting, clearing and mowing of vegetation along Swedish roadways was found to lead to improved sight distances as intended, but also to changes in lateral positioning and increased vehicle speeds (Sävenhed and Wretling, 1997).

Others, as will be seen in Section 3, have argued that natural roadside vegetation may be beneficial to safety, because it creates a feeling of well-being in passing travellers, reduces their aggressive tendencies and reminds them of the beauty of being alive, and thus reinforces their desire to preserve life and limb, and act accordingly.

An interesting parallel issue, although not obviously akin to roadside aesthetics (apart from the frequent display of flowers), but no less contentious, is the placement of roadside memorials at locations where people were killed (Churchill and Tay, 2008). While it is often realized that these memorials may act as a warning against potential danger in these locations, some professionals and laymen see them as sources of dangerous distraction (City-data.com, 2009). Others view these signs as a "*memento mori,*" thus articulating in passing drivers their awareness of being alive and thus the desire to stay that way; in other words: "*memento vivere*." Very little empirical evidence is available on the issue as to whether such memorials affect safety. There is, however, a recent report on the effect on driver behaviour.

In an on-street experiment conducted in a Canadian city, the installation of (fake) roadside memorials for a 6-week period at intersections produced an almost 30% reduction in red-light violations in comparison with control intersections (Tay, 2009). The absence of accident data in this experiment is not surprising because of its rather short duration. It should also be noted, that some drivers, who are fully aware of the traffic light being red, may decide to violate it because they see no traffic on the crossroad. Running a red light is not dangerous *eo ipso,* although it may be followed by a fine for violating the traffic rule. For a collision to happen, there has to be traffic on the crossroad at least, and even that condition is not sufficient, as it depends on the actions of drivers on the crossroad.

Accident data were collected in a subsequent larger-scale investigation, conducted on rural roads in the province of Alberta (Canada). The authors concluded from the data collected that "The effects of the roadside memorials on speed and following distance were found to be negligible. Similarly, the effect on collision history was found to be neutral, with only one site showing a reduction in collisions of 8.7%. These findings suggest that roadside memorials are not detrimental to safety and may provide some benefits." (Churchill, Tay and McGregor, 2010)

2.0 Some empirical studies and their limitations

One of the better known empirical studies on behavioural effects of roadside scenery, carried out in the field, was conducted in Sweden. The author observed that at cherry-blossom time drivers moved at lower speeds in streets lined with cherry trees. The average speed was about 3 km/h lower than in comparison environments used for control (Drottenborg, 1999). No data on speed variance or accident data were reported.

Accident data were included in a quasi field-experiment conducted in Texas. The authors compared accident rates per traffic volume before and after landscape improvements on urban streets, and reported substantial reductions in injury accidents per vehicle-kilometre travelled on the modified streets. (Mok *et al.,* 2006). There were no external control data, however, and any possible changes in vehicle-kilometres travelled or in driver route choice were not reported That these factors may have major implications for the interpretation of the findings will be discussed below.

The authors of this Texas *quasi*-experiment mention an earlier, and indeed seminal, study on the effect of urban scenic streetscaping in Germany (Topp, 1990). The report of that study, however, does not give information either on (changes in) volumes or the states or traits of the drivers (and other road users, pedestrians or bicyclists) who opted to travel the modified streets before and after the alterations.

This, unfortunately, is true too for the extant evaluations of the “shared space” or “naked streets” projects. These originated in the Province of Friesland in the northern Netherlands and spread to many other towns and villages in that part of the world and subsequently to other countries in Europe as well as elsewhere. One of the several stated aims of these projects is to improve the appearance of the built-up environment by removing the clutter of traffic lights, other prohibitive and permissive signs, and barriers (Quimby and Castle, 2006). These modifications are often accompanied by further reductions in allowed speed (*e.g.*, from 50 to 30 km/h).

In passing, it should be noted that in some of these towns in the Netherlands, the “shared space” features have more recently been curtailed because of (subjective) safety concerns expressed, especially among elderly pedestrians. The irony of this partial reversal is that the shared space concept has, among other things, the very purpose of enhancing traffic risk awareness, and thus greater carefulness in using the streets on the part of all road users. Elderly citizens, however, complained to the town authorities about the behaviour of bicyclists in the shared space context, especially about the young bicyclists, and they are the ones the elderly feared most (van der Molen, 2008).

As regards to automobile drivers, speed limit reduction may lead them to travel elsewhere, as is suggested by a German study that reported a 21% reduction on an expressway following the introduction of a speed limit where no limit had previously existed. A stretch of expressway running parallel to the one with the new speed limit experienced a 29% increase in accidents, apparently as the result of the fact that drivers who did not want to forgo speedy progress simply took the alternative expressway route (Pfafferott and Huguenin, 1991). Motorized travel migrated elsewhere and so did the accidents.

For the purpose of identifying the effects of roadside scenery and the appreciation thereof, driving simulators have also been used. Inviting participants, and using an Italian simulator, a Polish experimenter had them “drive” a variety of road scenarios (with posted speed limits 50, 80 and 100 km/h) and rate the aesthetic appeal of the road sections (Zakowska, 2009). Although the scenic features of the road stretches were not intentionally manipulated, the data revealed some gender differences in small sample sizes. Women rated natural-looking environments higher on aesthetic appeal than men, while males and females both maintained lower driving speeds in motorway road sections that they rated to be more aesthetically appealing. As one is dealing here with computer simulation, there were no accident data to be reported and no proxy measure of accidents was included in the study. Nor does this study shed light on any association between speed variance and mean aesthetic evaluation ratings of the road sections in question.

Another simulator experiment involved deliberate manipulation of the presence or absence of curbside trees along streets in otherwise identical urban and suburban environment. Participants, in this four-fold repeated-measures experimental design (with the same drivers in the same two roadside environments, urban and suburban, either with or without trees), rated the degree of safety they perceived as well as the clarity of road edge delineation. Their moving speeds were also recorded. The results indicated reduced speeds of both fast and slow drivers in the *presence* of roadside trees and the participants judged these environments to be safer than the identical ones without the trees. The presence of trees also aided a clearer perception of road delineation, while the extent to which the participants acknowledged this improvement correlated significantly with their safety ratings in the urban as well as the suburban environment (Naderi *et al*., 2008). The apparent inconsistency here (feeling safer, yet driving more slowly) can be resolved if green environments change the state of mind of travellers with the effect that their willingness to take risks is reduced. The plausibility of this explanation is exactly what this paper attempts to point out. The authors of the Naderi *et al*. experiment make note of the fact that their findings conflict with the doctrines of the road-safety engineering officialdom in the USA which are generally opposed to trees in close proximity of the roadway (ASSHTO, 2001; NCHRP, 2008).

3.0 On the restorative effect of roadside landscaping

The effect of intentional changes in roadside scenery on driver response has been studied in a number of computer simulations. In two of these it was observed that driver fatigue was greater when the roadside vegetation was rather monotonous (only rows of trees) than where the scenery was more enriched (Thiffault and Bergeron, 2003a), while personality traits such as sensation seeking and extraversion enhanced the effect of monotony on driver fatigue (Thiffault and Bergeron, 2003b). Another study concluded that “Engaging roadside scenery may delay the onset of ‘passive fatigue’ during automated driving [such as driving assisted by “intelligent traffic systems, [...].”(Saxby *et al*., 2008). Passive fatigue is the consequence of under-stimulation, as opposed to “active fatigue” caused by prolonged heavy task demand. Thus, choosing scenic routes may not only have *restorative* effects, but be *prophylactic* as well.

So far in this discussion, no empirical evidence has been encountered to show that roadside scenery has a negative effect on safety, despite the presumed increase in driver distraction and collisions with trees. In fact, there are several studies suggesting that scenic landscaping may actually enhance safety, because of the relaxing and restorative effect of greenery. “Roadside nature is associated with driving stress reduction, and trees contribute to positive place perceptions [sometimes called *topophilia*]” (Wolf, 2005).

In another study (Dixon and Wolf, 2007), a sample of drivers was asked to evaluate a series of 36 photographs of streetscapes with low or high levels of greenery on 13 rating scales. Factor analysis yielded five categories of evaluation responses, and in all categories the ratings were significantly more positive for the streetscape photos with more green. These evaluation categories were: (1) local shopper appeal, (2) inviting to visitors, (3) high quality of business in the area, (4) business leaders seen as leading corporate citizens, and (5) perceived economic prosperity. Respondents reported to be willing to pay a higher price for various purchases in the areas with a greener landscape character, including trees.

In general, respondent characteristics showed few differences in the ratings given, although older drivers were more likely to view trees as a safety hazard and higher-income individuals reported paying more attention to the roadside and less concern about trees as a threat to safety (Wolf, 2006).

The restorative effect of natural scenery has been documented, not only in road environments, but elsewhere as well (Kaplan and Kaplan, 1989). Remarkably, recovering patients whose gallbladder had been removed and were assigned to rooms with windows looking out on a natural scene had shorter post-operative hospital stays, received fewer negative evaluative comments in nurses' notes, and took fewer potent analgesics than patients assigned to similar rooms with windows facing a brick building wall (Ulrich, 1984).

In an effort to test the effects of roadside scenery on people's moods by experiment, respondents with varying degrees of anger and frustration tolerance, as measured by Spielberger's (1996) self-report questionnaire, were assigned randomly to one of three videos which varied in the amount of vegetation versus man-made objects. Anger and frustration tolerance, as assessed by the amount of time subjects were willing to spend on an unsolvable word puzzle (anagrams), were measured before and after exposure to the videos. No significant effect on anger emerged, but the results showed increased frustration tolerance (as indicated by respondents spending more time on unsolvable anagrams) after exposure to videotapes with more vegetation. The authors concluded from their findings that "Parkway design and roadside vegetation appear to have restorative effects in reducing frustration." (Cackowsky and Nasar, 2003); hence the expression *vitamin G* (with G for greenery).

Other researchers, who also demonstrated the restorative effect of green scenes following (imagined) exposure to prolonged and heavy mental load, have called attention to the fact that as yet little information is available on individual differences in environmental preferences for prophylactic or remedial restoration (Staats *et al*., 2003). There are, however, some indications that these inter-individual differences do exist, as seen already in the factor-analytic study mentioned above.

Furthermore, a survey of the driving tourist's information needs and preferences in the United States showed that, when planning a route to a destination on an overnight automobile trip, driving tourists are most concerned with factors related to the actual driving of the route, such as the directness, safety, amount of congestion, and distance. However, secondary factors are also important and these include factors that make the route entertaining or pleasant to drive, and include whether or not the route is a scenic byway. Analysis of the importance of scenic byways by several demographic factors showed little difference in importance ratings except for age and household income (Eby and Molnar, 2002).

Thus, it would seem fair to infer from the available literature that there are marked within-individual differences in the preference for scenery as a function of their degree of mental fatigue, while the between-individual differences in preferences for scenery appear to be less salient .

4.0 The issue of route choice

Given the above findings, it is not surprising that several studies have found differential route preferences among road users with different temporary or more lasting traits and states. For instance, it has been observed that drivers on shopping trips do not always use the fastest route, but often prefer a scenic itinerary although it is slower and covers a longer distance (Ulrich, 1974).

Almost one-half of all travel is due to weekend, holiday and leisure trips (Bouladon, 1979). As Goethe (1749-1832) wrote on one of his frequent journeys: "One does not travel only to arrive, but to be on the way," and according to observations in more recent days: "Trip time is part of destination activity in some ways — [and] may be the source of various satisfactions: self-discovery, reflection, daydreams, reaching outside work and family context—we could list numerous examples which would clearly show that the minimization of distance covered or time spent is not what is sought — [but] pleasure in driving, speed, physical effort, a special relationship with the environment." (Matalon, 1978).

According to an investigator in California, the four highest ranking of criteria most often used in route selection are: (1) shortest distance, (2) least time, (3) fewest turns, and (4) most scenic/aesthetic (Golledge, 1995). It is noteworthy that the aesthetic experience is among the dominant factors of route choice. Significant deviations from the shortest route have been documented by others as well (Parkany *et al*., 2006).

The importance of aesthetic appeal seems to hold not only for drivers, but also for pedestrian mobility. A study conducted in the province of Ontario in Canada, in which a sample of residents was asked to keep a log of their walking trips over a 7-day period, found that aesthetic appeal (such as "trees along the streets in my neighbourhood") was the only walking route characteristic that was significantly and positively associated with the frequency of walking for purposes of transportation, as well as recreation (Kaczynski, 2010).

An effort by researchers at the University of Wisconsin to systematize the determining factors in route choice has been depicted in Table 1. However, as if this tabulation were not exhaustive enough, from a psychological point of view it would also seem desirable to make room in the traveller category (Category 1) for both more or less lasting traits and momentary states. Depending upon their personality traits and transient states, road users may well opt for driving routes of different physical features, including roadside scenery, as may be inferred from the studies mentioned above.

If this reasoning is correct, road volume is not a truly independent variable, although it has commonly been used as one of the predictor variables in estimating to-be-expected accident rates. Thus, traffic volume, and this in contrast with various aspects of road geometry and other physical features, does not seem to belong in the list of independent variables. Moreover, the very availability of roads attracts automobile drivers (Marchetti, 1983). Different roads, because of their various physical characteristics, draw drivers in different numbers and with different (semi)permanent or transient characteristics. In other words, volumes of drivers, their trait and state characteristics and their ensuing behaviours are a function of road features, and it would thus seem more appropriate to treat them as dependent variables.

Table 1

Factors in path choice (expanded after Jan et al., 2000)

(1) Traveller	Age, sex, life cycle, income level, education, household structure, race, profession, length of residence, number of drivers in family, number of cars in family, personality traits and transient mood states, etc.
(2) Route	*Road:* Travel time, travel cost, speed limits, waiting time, type of road, width, length, number of lanes, angularity, intersections, bridges, slopes, etc.
	Traffic: Traffic density, congestion, number of turns, stop signs and traffic lights, travel speed, parking, probability of accident, reliability and variability in travel time, etc.
	Environment: Aesthetics, land use along route, scenery, easy pick-up/drop-off, etc.
(3) Trip	Trip purpose, time budget, time of the trip, mode use, number of travelers
(4) Circumstances	Weather conditions, day/night, accident en-route, route and traffic information, etc.

5.0 Proposal for yet another research procedure

Earlier studies have seen that, when the same individuals are observed in different road sections, average driving speed is higher in those road sections where the historical accident rate per vehicle-mile is lower. A British study found a correlation coefficient **r** = -0.67 in a sample of 20 drivers (Taylor, 1964), and a later Canadian study found correlations **r** = -0.73 and **r** = -0.74 in a sample of eleven drivers, each of whom drove the route twice (Moran, 1982). In these studies, either cognitive or physiological indicators of perceived risk while driving were obtained and these were found to be strongly correlated with moving speed (negatively) and the historical accident record per unit distance driven (positively).

Apparently then, drivers are sensitive to environmental features that are associated with the accident rate per km driven, and they adjust their behaviour accordingly. A more detailed description of methods, findings and their implications has been published elsewhere (Wilde, 2001). In road sections where the historical spatial accident rate is high, drivers perceive higher levels of accident risk, and move more slowly, thereby keeping the temporal accident rate comparatively constant, more or less *regardless of where the driving is done*.

This adjustment, however, seems to be imperfect, as there are some road sections where drivers on average move too slow or too fast for a constant accident risk per hour to be maintained. The correlation coefficients cited above, while sizable, are far from unity. Deviations from temporal constancy can also be seen in the results from another researcher, who did not observe the same drivers in each road section, but followed a somewhat different method of data collection. Accident rates for 40 different road sections in and around Detroit, Michigan, were gathered from police records over a two-year period. Accident severity was not considered, only their numbers (May, 1959).

For each road section, the number of passing vehicles was counted over a period of 48 hours, and the average driving speeds were determined over 84 hours, using a method that may have been more convenient than leading to reliable and representative observations. As can be seen in Figure 1, its author related the accident rate (A) per million vehicle miles of each of the road sections to total travel time per road section (T), in an exponential function instead of a simple linear one, the product-moment correlation coefficient being in the order of **r** = 0.6 (outliers included).

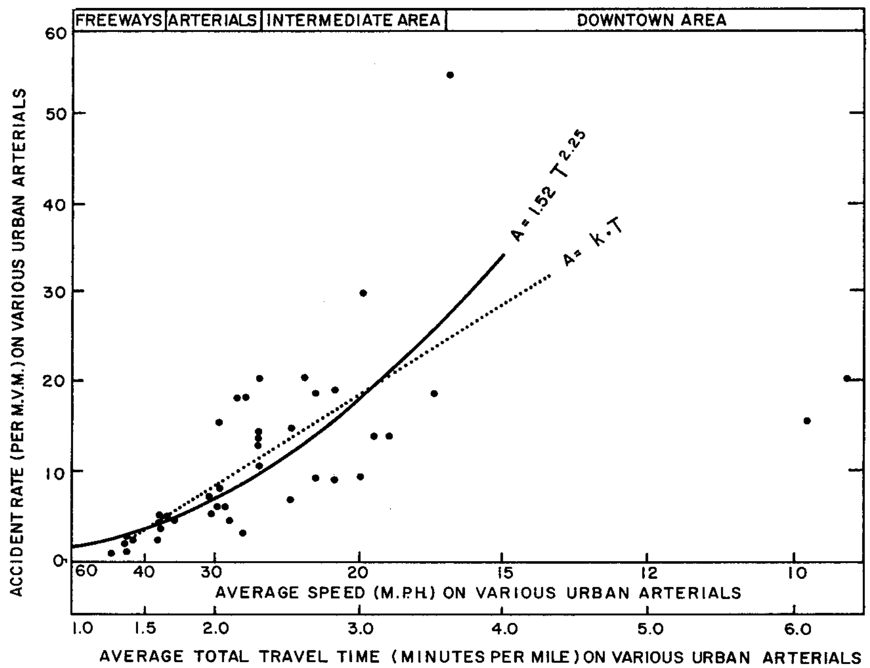
Additional calculations, made from the graphed data by the current author, however, indicate that the non-linear component, reflected in the curved solid line, is in statistical terms not significantly different from a simple linear relationship. Thus, it appears that, *on average*, where the previously recorded spatial accident rate was half as high, people subsequently drove approximately twice as fast on the aggregate of the 40 road sections. This relationship is represented by the dotted line in Figure 1. In other words, *on average*, the accident rate per time unit of exposure remained essentially constant across this sample of 40 road and street sections.

A noted above, the severity of accident was not considered. It is conceivable that the magnitude of accident loss (frequency times severity) was greater in the south-west area of the graph, i.e., where moving speeds were higher. If this is correct, the Y intercept shown in the graph might disappear.

Although the accident rate per time unit of exposure remained essentially constant, this is true only *on average* across the sample of road sections involved. Figure 1 indicates that drivers' speed adjustment was not perfect. The graph suggests that in some road sections drivers moved either too slow or too fast for a constant accident risk per hour to be maintained. The data points above the regression line **A = k.T** indicate those road sections where drivers moved too fast, and data points below the regression line indicate where drivers moved at speeds too low for equilibrium between time spent and the historical accident rate per unit distance driven to be maintained. What might explain these deviations?

Figure 1

Accident rates per million vehicle miles (m.v.m.) related to average total travel time per mile in various road sections of different road design (graph adapted from the original; May, 1959).



Although the accident rate per time unit of exposure remained essentially constant, this is true only *on average* across the sample of road sections involved. Figure 1 indicates that drivers' speed adjustment was not perfect. The graph suggests that in some road sections drivers moved either too slow or too fast for a constant accident risk per hour to be maintained. The data points above the regression line **A = k.T** indicate those road sections where drivers moved too fast, and data points below the regression line indicate where drivers moved at speeds too low for equilibrium between time spent and the historical accident rate per unit distance driven to be maintained. What might explain these deviations?

The first issue emerging for future research that arises is whether such deviations are reliable, either over time or within randomly split parts of the road sections involved. Modern technology makes it possible to include many more drivers, assess time spent over much longer periods and over many more roads and streets than was possible in the days the Detroit study was carried out. If the deviations from **A = k.T** turn out to be reliable, then the following questions arise:

1) Are the differences due to different traits or states of drivers passing? Do these drivers differ in their perception of accident risk and/or willingness to accept it?

2) Are the deviations from **A = k.T** related to differences in the physical road characteristics, such as geometry and roadside scenery (or any other features such as the ones listed in Table 1 above)?

Answers to these two questions can be obtained by roadside surveys of drivers in selected road sections, and by applying the same type of simplified driving commentary (i.e., ongoing risk rating) or physiological techniques that were used to determine risk perception in the British and Canadian studies mentioned above.

6.0 Conclusion

First, scenery, along the roadside and elsewhere, has been found to have a restorative effect on individuals after the stress of surgery or mental fatigue due to attentional overload. Green scenery may also serve a prophylactic function. There are indications that road users frequently choose itineraries that serve to provide them with these benefits, and thereby forego the option of going the shortest route, while there seem to be differences in the preference for scenic route between drivers depending on their momentary mental state, but also in relation to attributes such as gender, age and income level. Problems regarding ecological validity have been noted: simulation, deficient experimental design, and small sample sizes. The available research evidence, however, does not clearly identify reasons for assuming that roadside scenery actually leads to more accidents. Instead, it seems to have beneficial effects on a safety-oriented state of mind of drivers and is generally positively appreciated. An argument can thus be made in favour of more liberal use of this form of roadside shaping.

Second, an important inference from the evidence on drivers' route choice is that, in efforts to predict the accident rate in different road sections, road volumes (such as ADT or AADT) should, contrary to common practice, not be treated as an independent variable. Different roads, because of their various physical characteristics, draw drivers in greater or smaller numbers and with different (semi)permanent or transient characteristics. In other words, driver volumes and trait and state characteristics, and consequently their ensuing behaviours, are a function of road features as they perceive them, and it would seem more appropriate to treat them as dependent variables. A different methodology would thus seem to be in order.

Third, and for that purpose exactly, a different research approach is being suggested for determining the effect of geometric and other roadside features, including greenery, upon the accident rate. This approach involves the measurement of the accident rate per time unit of road-user exposure, and relating the latter to momentary and more lasting characteristics of passing drivers. In this manner, deviations from average driving risk per hour of driving can be identified and linked to both infrastructure design, roadside aesthetic appeal, as well as to driver states and traits in analyses that may be more robust than has been possible with research approaches that were used in the past.

References

AASHTO, American Association of State Highway and Transportation Officials, (2001). *A policy on geometric design of highways and streets*. Washington, D.C..

Bouladon, G., (1979). Costs and benefits of motor vehicles. In *Urban transport and the environment: background reports*. Paris: Organization for Economic Cooperation and Development, in cooperation with the European Conference of Ministers of Transport, 277-319.

Cackowsky, J.-M. and J.L. Nasar, (2003). Restorative effects of roadside vegetation: implications for automobile driver anger and frustration. *Environment and Behavior*, 35(6): 736-751.

CBC News, (2008). Canadian Broadcasting Corporation. Accessed 16 August 2009.

Churchill, A. and R. Tay, (2008). An assessment of roadside memorial policy and road safety. *Canadian Journal of Transportation*, *2*(1): 1-12. http://etc.hil.unb.ca/ojs/index.php/CJT/article/view/4207/11707. Accessed 26 July, 2010.

Churchill, A., R. Tay, R. and R.V. McGregor, (2010). Effects of roadside memorials on driver behaviour and safety. *Proceedings of the 20th Canadian Multidisciplinary Road Safety Conference*, Niagara Falls, Ontario, Canada,

City-data.com Forum, (2009). Rant on Roadside Memorials (high school, live, fence). http://www.city-data.com/forum/general-u-s/364762-rant-roadside-memorials.html Accessed 15 August 2009.

Dixon, K.K., and K.L. Wolf, (2007). Benefits and risks of urban roadside landscape: finding a liveable, balanced response. *Third Urban Street Symposium*, Seattle, WA. June 24-27.

Drottenborg, H., (1999). *Aesthetics and safety in traffic environments*. Department of Technology and Society, Traffic Planning. Lund, Sweden: Lund Institute of Technology, Bulletin 176.

Eby, D.W. and L.J. Molnar, (2002). Importance of scenic byways in route choice: a survey of driving tourists in the United States. *Transportation Research Part A: Planning and Policy*, 36: 95-106.

Glaze, A. and J. Ellis, (2003). Pilot study of distracted drivers. Virginia Commonwealth University Center for Public Policy.

Golledge, R.G., (1995). Path selection and route preference in human navigation: a progress report. *Conference on Spatial Information theory (COSIT)*, Semmering, Austria, Sept. 21-23.

Jan, O., A. Horowitz, and Z-R. Peng, (2000). Using GPS data to understand variations in path choice. *Transportation Research Record* 1725: 37-44.

Kaczynski, A.T., (2010). Neighborhood walkability perceptions: associations with amount of neighborhood-based physical activity by intensity and purpose. *Journal of Physical Activity and Health*, 7: 3-10.

Kaplan, R. and S. Kaplan, (1989). *The experience of nature: a psychological perspective*, New York: Cambridge University Press.

Marchetti, C., (1983).The automobile in a systems context; the past 80 years and the next 20 years. *Technological Forecasting and Social Change* , 23: 3-23.

Matalon, B., (1978). Do we move for other reasons than going places? *Proceedings, Research Conference on Mobility in Urban Life*, Arc-en-Senans, Sept. 28-30.

May, A.D. (1959). A friction concept of traffic flow. *Proceedings, 30th Annual Meeting of the Highway Research Board*. Washington, DC., 493-510.

Mok, J-H., H.C. Landphair, and J.R. Naderi, (2006). Landscape improvement impacts on roadside safety in Texas. *Landscape and Urban Planning*, 78: 263-274.

Moran, A., (1982). Drivers' mental load and subjective risk estimates while driving road sections of different accident histories. *Proceedings, 15th Annual Meeting of the Human Factors Association of Canada*, 72-75.

Naderi., J.R., B.S. Kweon and P. Maghelal, (2008). The street tree effect and drivers safety. *ITE Journal on the Web*, February: 69-73. http://www.naturewithin.info/Roadside/Tree&Driver_ITE.pdf. Accessed 29 August 2009.

NCHRP, National Cooperative Highway Research Program, (2008). *Safe and aesthetic design of urban roadside treatments.* Transport Research Board, Report 612, Washington, D.C.

Nilsson, G. and J. Wenäll, (1998). Fixed roadside objects cause 100 fatalities each year. (In Swedish). *Nordic Road and Transport Research*, 10(1): 13-15.

Parkany, E., J. Du, L. Aultman-Hall and R. Gallagher, (2006). Modeling stated and revealed route choice: consideration of consistency, diversion and attitudinal variables. *85th Annual Meeting of the Transportation Research Board*, Washington, D.C., January 22-26. Paper No. 06-0579 on the conference CD.

Pfafferott, I. and R.D. Huguenin, (1991). Adaptation nach Einführung von Sicherheitsmassnahmen. *Zeitschrift für Verkehrssicherheit*, 37: 71-83.

Quimby, A. and J. Castle, (2006). *A review of simplified streetscape schemes*. Transport Research Laboratory, U.K., Project Record TfL/TRL/06/05 http://www.trl.co.uk/online_store/reports_publications/trl_reports/cat_traffic_engineering/report_a_review_of_simplified_streetscape_schemes.htm. Accessed 26 July 2010.

Sävenhed, H. and P. Wretling, (1997). Röjning och slåtter påverkar siktsträcka, hastighet och sidolägesplacering. *VTI aktuellt*, 20(4):18.

Saxby, D., G. Matthews, E.M. Hitchcock and J.S. Warm, Fatigue states are multidimensional : evidence from studies of simulated driving. Quoted in Saxby, D.J., G. Matthews, E.M Hitchcock, J.S. Warm, G.J. Funke .and T. Gantzer, (2008). Effect of active and passive fatigue on performance using a driving simulator**.** *Human Factors and Ergonomics Society Annual Meeting Proceedings, 52*, 1751-1755.

Schoppert, D.W. and D.W. Hoyt, (1968*). Factors influencing safety at highway-rail grade crossings*. NCHRP Report No. 50. Springfield, Virginia: A.M. Voorhees and Associates.

Spielberger, C. D., (1996). *State-Trait Anger Expression Inventory: STAXI professional manual*. Tampa, FL: Psychological Assessment Resources.

Staats, H., A. Kieviet. and T. Hartig, (2003). Where to recover from attentional fatigue: an expectancy-value analysis of environmental preference. *Journal of Environmental Psychology*, 23: 147-157.

Tay, R., (2009). Drivers' perceptions and reactions to roadside memorials. *Accident Analysis and Prevention*, 41: 663-669.

Taylor, D.H., (1964). Driver's galvanic skin response and the risk of accident. *Ergonomics*, 7: 439-451.

Thiffault, P. and J. Bergeron, (2003a). Monotony of road environment and driver fatigue: A simulator study. *Accident Analysis and Prevention*, 35: 381-391.

Thiffault, P., and J. Bergeron, (2003b). The impact of individual differences on driver fatigue. *Personality and Individual Differences*, 34: 159-176.

Topp, H.H., (1990). Traffic safety, usability and streetscape effects of new design principles for major urban roads. *Transportation*, 16: 297-310.

Ulrich, R. S., (1974). *Scenery and the Shopping Trip: The Roadside Environment as a Factor in Route Choice.* Ann Arbor: University of Michigan, Michigan Geographical Publications.

Ulrich, R.S., (1984). View through a window may influence recovery from surgery. *Science, New Series,* 224: 420-421.

van der Molen, H. (2008). Traffic Research Centre, University of Groningen, the Netherlands, *personal communication*.

Virginia Crash Investigation Team, (2001). Driver inattention and driver distraction study, Virginia Commonwealth University, Special Report 15.

Ward, N.J. and G.J.S Wilde, (1996). Driver approach behaviour at railway crossings before and after enhancement of lateral sight distances: An experimental investigation of a risk perception and behavioural compensation hypothesis. *Safety Science*, 22: 63-75.

Wilde, G.J.S., (2001). *Target Risk 2*. Toronto: PDE Publications.

Wolf, K.L., (2005). The urban forest in the roadside: public values and transportation design. *Proceedings of the 9th National Conference of the International Society of Arboriculture*, Launceton, Tasmania.

Wolf, K.L., (2006). Assessing public response to freeway roadsides: urban forestry and context-sensitive solutions. *Proceedings of the 85th Annual Meeting of the Transportation Research Board*, Washington, D.C. Paper 06-1568.

Zakowska, L., (2009). The role of geometric design parameters in driving speed negotiation and safety perception: objective and subjective measures in simulation study. *Advances in Transportation Studies, Section A*, 18: 17-39.