Transportation Research Part F 25 (2014) 50–64

Contents lists available at ScienceDirect

Transportation Research Part F

journal homepage: www.elsevier.com/locate/trf

What's the risk? A comparison of actual and perceived driving risk

Samuel G. Charlton *, Nicola J. Starkey, John A. Perrone, Robert B. Isler

Traffic and Road Safety Research Group, University of Waikato, New Zealand

ARTICLE INFO

Article history:
Received 22 January 2014
Received in revised form 21 March 2014
Accepted 12 May 2014

Keywords:
Risk perception
Road design
Driving simulator
Eye-tracking

ABSTRACT

It has long been presumed that drivers' perceptions of risk play an important role in guiding on-road behaviour. The answer to how accurately drivers perceive the momentary risk of a driving situation, however, is unknown. This research compared drivers' perceptions of the momentary risk for a range of roads to the objective risk associated with those roads. Videos of rural roads, filmed from the drivers' perspective, were presented to 69 participants seated in a driving simulator while they indicated the momentary levels of risk they were experiencing by moving a risk meter mounted on the steering wheel. Estimates of the objective levels of risk for the roads were calculated using road protection scores from the KiwiRAP database (part of the International Road Assessment Programme). Subsequently, the participants also provided risk estimates for still photos taken from the videos. Another group of 10 participants viewed the videos and photos while their eye movements and fixations were recorded. In a third experiment, 14 participants drove a subset of the roads in a car while providing risk ratings at selected points of interest. Results showed a high degree of consistency across the different methods. Certain road situations were rated as being riskier than the objective risk, and perhaps more importantly, the risk of other situations was significantly under-rated. Horizontal curves and narrow lanes were associated with over-rated risk estimates, while intersections and roadside hazards such as narrow road shoulders, power poles and ditches were significantly under-rated. Analysis of eye movements indicated that drivers did not fixate these features and that the spread of fixations, pupil size and eye blinks were significantly correlated with the risk ratings. An analysis of the road design elements at 77 locations in the video revealed five road characteristics that predicted nearly 80% of the variance in drivers' risk perceptions; horizontal curvature, lane and shoulder width, gradient, and the presence of median barriers.

1. Introduction

Since the earliest days of research into driver behaviour, it has been reported that drivers modify their behaviour according to the risk they perceive (Fuller, 2005; Gibson & Crooks, 1938; Näätänen & Summala, 1974; Taylor, 1964; Watts & Quimby, 1980; Wilde, 1982). It has even been proposed that this behavioural factor is the most important of the three main factors associated with road crashes: behavioural, vehicular, and environmental (Armsby, Boyle, & Wright,

* Corresponding author. Address: Traffic and Road Safety Research Group, School of Psychology, University of Waikato, Private Bag 3105, Hamilton, New Zealand. Tel.: +64 7 838 4466x6534; fax: +64 7 858 5132.
E-mail address: samiam@waikato.ac.nz (S.G. Charlton).

http://dx.doi.org/10.1016/j.trf.2014.05.003
1369-8478/

1989). Unfortunately, drivers do not always accurately perceive hazards and risks, and as a result, their behaviour may not be appropriate to the circumstances.

In an early study of drivers' perceptions of risk, Pelz and Krupat (1974) showed 60 undergraduate men a 5 min film of highway driving as seen from the driver's seat and recorded moment-to-moment judgments of risk by means of an "apprehension meter". While watching the film, the participants moved a lever with a scale marked SAFE at one end and UNSAFE at the other according to how safe or unsafe they felt as a driver throughout the film. The participants were divided into three groups based on their driving records: Safe Record, Accidents only, and Violations-or-both groups. The Safe Record group had the highest baseline level of caution between hazards and the longest duration of elevated caution for each hazard; i.e., the participants in this group recognised driving risk sooner and longer.

Using pairs of still photos taken moments apart, Benda and Hoyos (1983) asked participants to sort 39 different traffic situations (that showed various road and weather conditions) according to their "hazardousness". Their results showed that experienced drivers were able to construct a ranked order of the hazardousness of driving scenes but less experienced drivers (roughly half the years' of experience) grouped the photos according to the type of hazard and did not differentiate the different levels of hazardousness shown. The authors also reported that when similar scenes were shown in motion via film clips an equivalent pattern of results was produced and that the participants in each of the experimental conditions tended to separate "comfortable driving" from all other situations. According to Benda and Hoyos, comfortable driving "means driving under good conditions in which drivers do not need to process too much information... relatively few control activities are required. This kind of driving is obviously regarded as fairly nonhazardous" (p. 8). Based on this finding they suggested that drivers' perceptions of hazardousness, or subjective risk, depends on both their amount of experience with various sorts of driving hazards and the information load in the situation, higher information loads leading to higher levels of subjective risk.

Watts et al. (1980) asked 60 drivers to make assessments of risk along a 16 mile (25.75 km) route on a rural road and compared the participants' risk ratings to objective risk (calculated from crash data and the participants' speeds). The correlation between the objective risk and the participants' subjective risk was only moderate (Spearman's rho = .37) and there were many locations where the risks were underestimated or overestimated. Watts and Quimby suggested that the low levels of perceived risk at some sites may have contributed to the high levels of objective risk, and conversely, there was no crash history at the five locations receiving the highest risk ratings, perhaps as a result of the high levels of perceived risk.

Similarly, Kanellaidis and Dimitropoulos (1994) compared drivers' ratings of subjective risk to the objective risk for five curves on a four-lane divided arterial road in Athens. Thirty-four volunteer drivers drove the 3 km section of road in each direction and subjective risk ratings were given verbally at the midpoint of each curve. Measurement of objective risk at the curves was calculated by filming the curves from both directions and rating the road elements according to the German Guide for Traffic Evaluation of Highways. A very good correspondence between the objective and subjective risk values was observed for the curves (Spearman's rho = .78). Two of the curves on the route were generally regarded as accident "black spots" (although no crash history data were provided in the report) and the greatest discrepancy between objective risk and subjective risk ratings occurred at one of these curves.

In a follow-on study, Kanellaidis, Zervas, and Karagioules (2000) used a similar procedure for three different road sections and compared a group of 96 drivers aged 18–64 to a group of 40 drivers aged 65–75 years. The analysis revealed, once again, that differences between actual risk and perceived risk were associated with increased accident frequency, and that in these cases (where subjective risk is viewed lower than the objective risk) the presence of warning signs became most important in maintaining adequate safety margins. The researchers also reported that subjective risk ratings increased with drivers' age, the drivers' familiarity with the roads, and self-assessment of driving skill (the higher the rating of driving skill, the lower the rating of subjective risk).

Groeger and Chapman (1996) showed films of 24 road situations to 64 participants seated at the steering wheel of a partial car. At the conclusion of each scene the participants answered several questions about the level of risk depicted in the scene, how much driving skill was required by a driver in that situation, and the amount of control over the danger they would have as a driver in that situation. Detailed analysis of the participants' ratings indicated that drivers responded to three main characteristics of the situation when considering the road scenes: danger, difficulty, and controllability/abnormality (their level of control and what they would normally expect in that situation). Based on this, and other research, Groeger and Chapman pointed out that although drivers attended to these three factors in their judgements of driving situations, it did not necessarily mean that their judgements of subjective risk were accurate. They argued that, in fact, there was compelling evidence that ratings of subjective risk are highly unreliable and prone to distortions associated with the context in which the judgements are made.

These investigations of drivers' perceptions of risk have shown that drivers do form judgements about the risk of the road and traffic situations they encounter. When compared to the objective risk of the situation, however, the accuracy of those judgements appears to be somewhat variable. Aside from the theoretical interest in the correspondence between drivers' perceptions of risk and the objective risk of various driving situations, there are clear practical reasons for investigating this relationship. Specifically, the published literature suggests that sections of road where drivers' perceived risk is significantly lower than the objective risk (known as risk discordance) may present a significant hazard to drivers (Kanellaidis & Dimitropoulos, 1994; Watts et al., 1980).

There have been very few studies, however, comparing drivers' risk perceptions with some independent estimate of the objective risk, and none of these studies have compared perceived risk and independently estimated objective risk across