Risking the road: How drivers perceive risk

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Abstract

We have long assumed that drivers' perceptions of risk play an important role in guiding their on-road behaviour. The goal of this research was to examine how accurately drivers perceive risk while driving. To do this, we compared drivers' continuous perceptions of risk to an independent measure of the risk associated with those roads (using road protection scores from the KiwiRAP database). High-definition videos of rural roads, filmed from the drivers' perspective, were presented to 69 participants seated in a driving simulator while they indicated the momentary level of risk they were experiencing by moving a risk meter mounted on the steering wheel. Results showed that drivers' perceptions of risk were generally in agreement with the objective risk, but that certain road situations were perceived 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 under-rated objects. 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. The identification of situations with under-and over-rated risks has clear implications for rural highway design.

Introduction

In an early study of drivers' perceptions of risk, Pelz and Krupat (1974) showed 60 undergraduate men a 5 minute film of highway driving as seen from the driver's seat and recorded their 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. Participants with a safe driving record had the highest baseline level of caution between hazards and the longest duration of elevated caution for each hazard; i.e., they recognized driving risk sooner and longer.

Watts and Quimby (1980) asked 60 drivers to rate risk along a 16 mile (25.75 km) route and compared the participants' risk ratings to objective risk (calculated from crash data). The correlation between the objective risk and the participants' risk ratings was only moderate (Spearman's rho = 0.37) with many locations where 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 et al., (1994, 2000) compared drivers' ratings of risk to the objective risk of several sections of a four-lane divided arterial road in Athens. Volunteer drivers drove the road in each direction and gave verbal risk ratings. Measurement of objective risk was calculated by filming the road 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 (Spearman's rho = 0.78) and the authors suggested that differences between actual risk and perceived risk were associated with increased accident frequency, and that where subjective risk is viewed lower than the objective risk the presence of warning signs becomes most important in maintaining adequate safety margins.

The goal of the present research was to assess the degree of correspondence between drivers' perceived risk and the objective risk associated with a wide range of New Zealand (NZ) road types. The present research used a combination of video, still photographs, and on-road driving at the same road locations and employing the same risk rating scale to explicitly compare differences in methods in stimulus presentation and provide a better understanding of how drivers' risk perceptions are formed. Finally, the collection of risk perceptions across a wide range of road types allowed us to identify hazardous road situations that are under-recognised by drivers (i.e., show the greatest discordance between objective and subjective risk).

Experiment 1

Method

Participants

Seventy-four participants with full (unrestricted) NZ driving licences were recruited to take part in the study, 69 of whom completed the full test protocol (five participants did not complete the testing due to equipment difficulties or other reasons). The 69 participants (31 males; 38 females) had an average age of 33.7 years (range 17-69 years), and reported an average of 15.7 years since receiving their full NZ licence (range 1.6-50 years). Ethical approval for the recruitment and test protocols was received from the School of Psychology Research Ethics Committee at the University of Waikato. Each of the participants received a $20 gift voucher for participating.

Apparatus

Participants were seated in the TARS driving simulator consisting of a complete automobile (BMW 314i) positioned in front of a projection surface on which the test stimuli were projected 2.64 m wide by 2.10 m high (at a resolution of 1920 by 1200 pixels). Details of the TARS simulator have been described elsewhere (Charlton & Starkey, 2011).

Stimulus selection

A set of rural roads from the state highway system were selected such that they were representative of a range of objective risk. The measure of objective risk used was the Road Protection Score from KiwiRAP (the New Zealand Road Assessment Programme). Road Protection Scores (RPS) are calculated for each 100m section of state highway based on a formula incorporating the road design features most likely to influence the occurrence of three primary crash types (run-off road, head-on and intersection) (Waibl, Tate, & Brodie, 2012). Thirteen road design features are rated every 100m and used in the calculation of RPS: lane width, shoulder width, terrain (gradient), horizontal alignment, run-off road risk score, head-on risk score, intersection risk score, left roadside risk score, right roadside risk score, roadside hazard offset left, roadside hazard offset right, roadside hazard severity left, and roadside hazard severity right.

A total of 36 sites were identified on state highways for which RPS scores were available. Each of these sites was selected based on the presence of a particular road characteristic such as lane width, shoulder width, horizontal and vertical curves, and roadside objects such as guard rails, light poles, or drainage ditches. High-definition video (HD resolution, 60 Hz frame rate) of the roads containing the 36 sites were collected from a video capture vehicle driven at the posted speed limits (predominantly 100 km/h) in a safe (i.e., non-aggressive) driving style by an experienced driver. Each of the videos, with accompanying car and road sounds, was edited into a series of 45 sec "clips" or test stimuli and joined into a 1,690 sec (28 min 10 sec) test video in which each clip was separated from adjacent clips by a 2 sec interval which dissolved from the clip to black and then to the next scene. The resulting video contained a total of approximately 45 km of driving across the

36 locations. Three versions of the testing video were created containing the 36 video clips in one of three random orders, each of them beginning with the same clip (used as a control or "warm-up" to start the video). A 188 sec (3 min 8 sec) training video containing four clips not used in the test stimuli video was created and used during participant familiarisation.

In addition to the test videos, 12 still photos (1920 by 1200 pixels) were taken from frames of the test videos, and 14 other photos taken from the raw video (not contained in the 36 test clips or at locations near them). Two of the "new" photos were designated as practice stimuli, and the remaining 24 photos were put into three random orders for presentation to participants.

Procedure

Following informed consent and completion of a brief demographic questionnaire the participants were seated in the simulator and shown the 3 min training video. During the training video the participants were asked to engage in a steering task in which they were instructed to use the steering wheel to keep a yellow dot lined up on the centre of their lane front of them. The steering task was introduced to make the visual and attentional demands of the situation more representative of driving a car. During the test video the yellow dot was removed from the screen so as not to produce a distraction although participants were still instructed to "steer" appropriate to the road direction. During both the training and test videos participants were also instructed to provide moment-to-moment judgments of driving risk by means of a risk meter (an analogue to Pelz & Krupat's apprehension meter, 1974). The risk meter consisted of a thumbwheel mounted on the right side of the steering wheel that controlled a pointer which moved along an on-screen scale anchored with the words "Safe" at the bottom and "Unsafe" at the top with nine calibration lines between. The instructions to the participants were to report how safe or unsafe they felt as the driver with the "Safe" end of the scale referring to feeling completely at ease such as while being at rest or parked while "Unsafe" referred to feeling extremely threatened or in immediate danger of being involved in a serious accident. Participants were also asked to move the risk meter all the way down to the "Safe" end during the 2 sec dark intervals separating the different scenes.

After completion of the training video, the participants were shown the full 28 min test video during which they provided moment-to-moment risk ratings for the 36 video clips and "steered" the car in the appropriate direction (albeit without the yellow dot target). At the end of the video the participants were invited to take a short (2-3 min) rest break and get out of the car to stretch. The participants were then given instructions about the self-paced recognition and risk rating task for the still photos. Participants were asked to indicate whether they recalled seeing each photo location in the video they just watched using the turn indicator (moving it up for yes, down for no) and then rating the risk of each location using the risk meter.

Data analysis

For analysis of the video ratings, 35 specific points were identified beforehand (1 location per clip, excluding the warm-up clip) based on the presence of particular road features of interest (e.g., poles, ditches, vertical or horizontal curves). Another 22 points were identified from the participants' risk ratings (where ratings were high or large changes in ratings occurred). Points of interest that included other road users such as vehicles parked at the roadside, oncoming trucks, and pedestrians were excluded. In addition there were 20 locations depicted in the videos that were selected on the basis of their high RPS (objective risk), yielding a total of 77 locations of interest/points in the video for the analysis of participants' risk ratings. The locations depicted in the 12 still photos were all drawn from the initial 35 points of interest in the video clips such that the road types and situations were representative of the range of locations shown in the video clips.

Results

Participants' risk ratings during the videos ranged the entire risk rating scale (where "Safe" = 1 and "Unsafe" = 10); the point in the video with the highest risk rating had a mean of 6.68 (SD = 2.60) and the point with the lowest risk rating had a mean of 1.93 (SD = 0.91). Risk ratings for the 24 photos showed a very similar pattern, with the mean of the participants' ratings ranging from a high of 5.96 (SD = 2.19) to a low of 2.06 (SD = 1.18). No significant differences in risk ratings were identified as resulting from participant gender or age.

The relationship between the participants' ratings of risk and the objective risk for the 77 locations of interest in the video can be seen in Figure 1. In the left panel of the figure are the mean risk ratings plotted against their corresponding RPS scores for all 77 locations of interest. The correlation between risk ratings and RPS scores overall was rather low; Pearson's $r(68) = .081$, $p = .486$. Because of the way RPS scores are calculated from objective risk components, the 20 points with high RPS scores were all located at intersections. In the right panel of the figure are the mean risk ratings and RPS scores for the 57 locations of interest excluding the 20 intersections. The correlation for this subset of locations was strong and positive; Pearson's $r(68) = .771$, $p <$ 001. In other words, the participants' risk ratings agreed quite well with the objective risk scores, with the exception of the ratings of intersections, which although having high risk RPS scores, were not rated as high risk by the participants.

The right panel of the figure also shows some locations where the risk ratings were above the 95% confidence intervals, and others that fell well below the confidence intervals. The locations lying above the interval represent situations that the participants perceived as riskier than the objective risk in the situation. All of the points associated with over-rated risks were instances of narrow lane width, horizontal curves, and wire rope barriers. In contrast, every location with narrow road shoulders, ditches, and poles in close proximity to the road were under-rated as risks by the participants. The remaining four (of 17 total) under-rated risks included banks on the roadside, wide (dual) centre lines, and one location with a grass median (but no barrier).

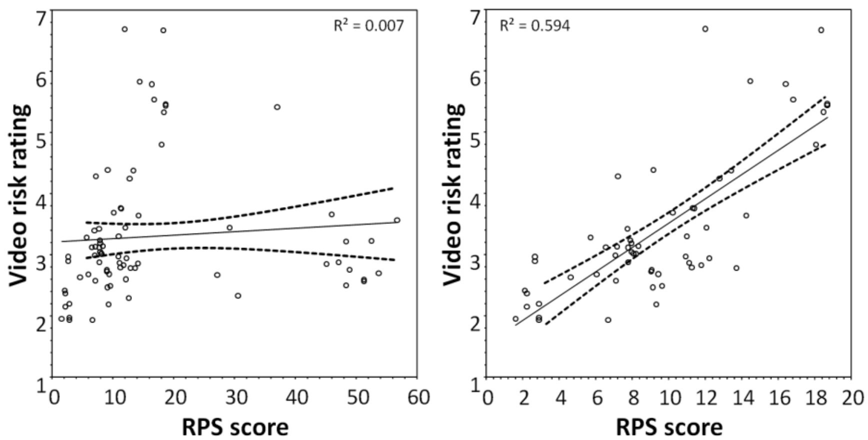

Figure 1. Mean risk ratings and RPS scores for video scenes including (left panel) and excluding the 20 intersections (right panel). Dashed lines show 95% confidence intervals.

A multiple regression analysis predicting the mean risk ratings for each of the 77 locations from the 13 components of the RPS scores at those locations revealed that the single largest predictor of the participants' ratings was the horizontal alignment score; Adj $R^2 = .532$, $F(1,73) = 85.00$, p < .001. The best combination of RPS components predicting the risk ratings was horizontal alignment, lane width, shoulder width, terrain (gradient), and right roadside risk; Adj $R^2 = .785$, $F(1,69) = 54.97$, $p < .001$. These 5 RPS components together accounted for nearly 80% of the variance in the participants' risk ratings; none of the other component measures were significant predictors of the risk ratings. (It should be noted that in this context the RPS component right roadside risk was essentially a measure of whether or not the opposing lanes were separated by a physical barrier.)

Comparison of the risk ratings of the 12 photos presented to participants in the second stage of the driving simulator testing compared to the risk ratings for the corresponding locations in the video indicated a strong positive correlation; Pearson's $r(68) = .926$, $p < .001$. Overall, there was a slight tendency for the participants to rate the photos as being riskier than the corresponding locations in the video ($M = 3.74$, $SD = 1.18$; $M = 3.52$, $SD = 1.45$; for photos and video respectively). Two locations (both of them bridges) fell above the 95% confidence interval indicating that they appeared riskier in the photos than they did during the video.

Experiment 2

The results of the driving simulator experiment showed that the participants rated roadside hazards such as power poles and ditches as low risk even though the objective risk (RPS) is high. A useful question to ask is whether or not drivers noticed these hazards or looked at them. To answer this question a second sample of participants was recruited to have their eye movements recorded while rating the risk of the video and still photos.

Method

Participants

A total of 10 participants were recruited to take part in the eye-tracking testing. Ethical approval for the recruitment and test protocols was received from the School of Psychology Research Ethics Committee at the University of Waikato. Each of the participants received a $20 gift voucher. The 10 participants (4 males; 6 females) had an average age of 24.4 years (range 19-30 years), and reported an average of 8.4 years since receiving their full NZ Licence (range 4-13 years).

Apparatus

An SR Research EyeLink II eyetracker set for monocular recording (participant's preferred eye) at a sample rate of 250 Hz was used to monitor eye movements whilst participants viewed a flat-panel display screen (93cm x 52cm, 1920 x 1080 pixels) from a distance of 90cm (field of view = 55° horizontal x 32° vertical). The stimulus presentation software and on-screen risk scale were the same as used in the driving simulator testing. The risk scale was superimposed over the right hand side of the video display (15° to the right of the centre of the road) and eye position data was analysed for points of interest in the central or left region of the screen only, to avoid the saccades or fixations towards the on-screen risk rating scale.

Procedure

The same informed consent, participant instructions, and training procedure used in Experiment 1 were used for the eye-tracking testing. As with the driving simulator testing, the participants rated the perceived risk of the road video using a thumbwheel attached to a steering wheel in front of them. To minimise discomfort (the eye-tracking equipment becomes uncomfortable if worn for extended periods), a subset of 20 of the video clips used in the driving simulator was selected for the eye-tracking testing. The clips were selected to provide a range of different road types and hazards. These clips, plus the same initial clip used for practice, resulted in a test video 984 sec (16 min 24 sec) in length. The same 3 min 8 sec training video containing 4 clips used in simulator testing was used for instructing the eye-tracking participants. The same photos used in the driving simulator were used for the eye-tracking testing.

Results

To confirm that the participants in the eye tracking experiment were perceiving the same level of risk as those in the driving simulator, we compared the average rating for each of the 20 locations in the test video against the average rating for the corresponding locations in the driving simulator video. (The risk rating data from one of the participants was not recorded because of a computer software problem and so only 9 participants' data were included in this comparison.) The correspondence between the video risk ratings obtained for the two types of testing was high and statistical analysis indicated a strong positive correlation; Pearson's $r(19) = .778$, $p < .001$. The overall average of the risk ratings for the two test protocols were very close ($M = 3.41$ for the driving simulator, $M = 3.49$ for the eye-tracking test), although the variability was higher in the simulator ($SD = 1.15$, $SD = 0.76$, for the simulator and eye-tracking test respectively). Statistical analysis also indicated a strong positive correlation for the risk ratings of the still photos; Pearson's $r(23) = .947$, $p < .001$. The overall risk ratings of the photos in the two test protocols were also very close ($M = 3.72$ for the driving simulator, $M = 3.92$ for the eye-tracking test), although the variability was higher in the eye-tracking experiment ($SD = 1.01$, $SD = 1.19$, for the simulator and eye-tracking test respectively).

A video clip containing a straight piece of road with a series of power poles close to the edge of the road was selected for detailed analysis. In the video clips, the poles appear to move from the centre of the screen to the left edge over a period of about 2.5 sec as the driver approaches and passes a pole. For each pole the location at the start and end of a series of 2.5 sec segments from the video was located. An example of pole locations for three of these video segments is shown as bold diagonal lines in the three panels of Figure 2. For these three example segments, the position of the poles were measured as beginning at image pixel location 866 and ended up at a point 32 pixels from the left edge of the screen. The mean eye location across all 10 participants over these 2.5 sec segments of the video clip were calculated from a series of 4 msec time samples, along with the 95% confidence intervals for the mean as shown in Figure 2. As can be seen in the figure, except for the very start of the segment, where the poles were close to the centre of the road in the video image, on average the participants' gaze did not include the position of the poles.

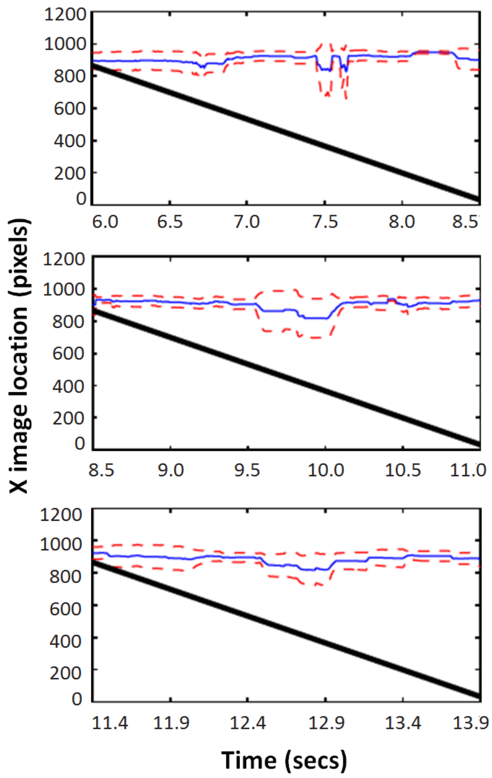

Figure 2. Participants' mean eye fixations (solid line) compared to roadside pole locations (bold diagonal lines) at three locations. Dashed lines indicate 95% confidence intervals for eye fixations.

Roadside ditches were also underrated (relative to RPS scores) by the participants. We carried out a similar analysis to that used for the power poles and examined participants' average fixation locations relative to the position of a ditch to determine whether or not they fixated roadside ditches. This analysis revealed that none of the participants made eye fixations in the location of the roadside ditch. To investigate whether the above results could be a consequence of the participants simply not fixating any roadside objects, a similar 2.5 section of straight road containing an advance curve warning with a supplementary speed advisory was selected from the video. The results of this analysis showed that a substantial number of eye fixations did occur to the roadside area containing the sign. Thus, it is apparent that the participants' functional field of view did include roadside objects, however, the roadside poles and ditch did not attract fixations to the degree that the example curve advisory sign did.

Experiment 3

Another sample of participants was recruited to drive an actual car over a subset of the roads contained in the videos presented to participants in Experiments 1 and 2 and provide verbal risk ratings at 13 locations. This was followed by an interview session in which participants watched a video recording of their drive and provided reasons for their risk ratings which provided an explicit narrative to aid in interpretation of the data collected.

Method

Participants

A sample of 15 participants over 25 years of age, with a full New Zealand driving licence was recruited via flyers posted on noticeboards around the University. Ethical approval for the recruitment and test protocols was received from the School of Psychology Research Ethics Committee at the University of Waikato. Fourteen participants (8 males, 6 females, average age = 41.6 years, range 25-50 years) completed the drive (the remaining participant was recruited to test the procedure). Each participant received a $40 gift voucher after the drive and another $10 voucher after the interview session.

Apparatus

A Suzuki SX4 vehicle, was fitted with two video cameras; one attached via suction cups to the front windscreen recording the road scene ahead; another attached to the window on the passenger side of the vehicle to record the driver’s behaviour. A laptop computer generated a tone to prompt the participant to provide a verbal risk rating at predetermined GPS coordinates (points of interest) along the route. During the post-drive interview participants viewed 35 sec sections of the video containing the locations of their risk ratings on a flat-panel display screen (93cm x 52cm, 1920 x 1080 pixels).

Procedure

Each participant was first taken on a short test drive (15-20 mins) to familiarise them with the vehicle and the tone that prompted them to provide a verbal risk rating. The risk ratings were recorded by a research assistant in the vehicle and as part of the video recording of each drive. The risk rating scale and definitions were the same as used during Experiment 1. The participants then drove a route containing 13 of the locations shown in the driving simulator. The route (approximately 180 km round trip) was selected as it was close to the University of Waikato and could be completed within a reasonable time (2 - 2.5 hr). Participants were asked to comply with all normal roads rules and regulations and drive as they would in their own car.

The participants were invited back to the laboratory within 5 days to view the video clips from their drive. Each clip was preceded by a 5 second on-screen countdown and ended with a blank screen. At the end of each clip participants were given the opportunity to change the risk ratings they gave during their drive (or leave them unchanged) and comment on road features that contributed to their ratings. The interview sessions took approximately one hour and were recorded (audio and video) for subsequent analysis. The participants’ comments were reviewed and post-hoc categories of road features contained in the videos and/or mentioned in the comments (curves, visibility, traffic, terrain, narrow road, signs, straight road, bridge, road markings, junction, banks, weather, no shoulder) were derived by two scorers. The number of comments in each category were counted, regardless of whether participants mentioned the particular road feature to justify a high or low risk rating (the focus was on identifying features that informed risk ratings generally, rather than focusing on high risk features only).

Results

The mean risk ratings were lower for the on-road drive (M = 3.44, SD = 0.97) compared to the ratings obtained for the same roads viewed in the driving simulator (M = 4.03, SD = 1.58), but this difference was not statistically reliable; $t(24) = -1.159$, p = .258. There was a strong positive relationship between the risk ratings from the on-road drive and the video-based ratings; Pearson's $r(13) = .791$, p =.001.

In regard to the road features that participants reported as contributing to their risk ratings (Figure 3) the most commonly mentioned related to curves (e.g., swerving corner), visibility (e.g., can't see ahead), traffic (e.g., idiot on motorbike; oncoming traffic) and terrain (e.g., brow of hill). The road width was also noted, as were speed advisory signs, particularly heading into curves (e.g., 35 km/h sign close to corner). Road markings (e.g., yellow lines; no overtaking), junctions, banks, weather and the lack of a shoulder were mentioned less frequently. The presence of poles and ditches did not appear to contribute to the participants' risk ratings.

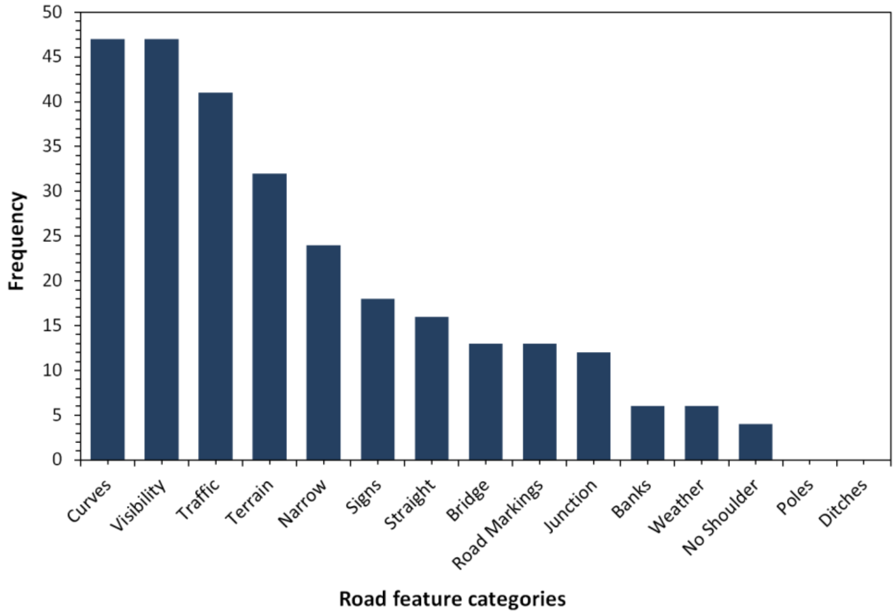

Figure 3. The frequency of reporting of specific road features as contributing to participants' risk ratings.

Discussion

The findings of the present study indicate that drivers do experience a range of risk levels for different road situations. This finding is in line with previous research indicating that drivers can and do form judgements about driving risk (Fuller, 2005; Groeger & Chapman, 1996; Pelz & Krupat. 1974; Watts & Quimby, 1980). The regression analysis of risk ratings from the driving simulator revealed that the participants used curves, hills, road width, and the presence or absence of a divided median to judge the risk of a road. These features alone predicted nearly 80% of the variation in the participants' ratings and, notable by their absence, none of the other road features making up RPS scores contributed to drivers' perceptions of risk. This finding is similar to the four road engineering factors predicting drivers' ratings of risk reported by Kanellaidis (1995): separation of opposing traffic, cross-section characteristics, alignment, and signing.

In the present study the level of risk experienced was, in general terms, commensurate with the objective risk for the roads. In other words, locations with high objective risk were correctly perceived as high risk and locations with low objective risk were perceived as low risk. As with previous studies, however, there were some notable exceptions; situations where the participants' perceived risk either over- or under-estimated the objective risk. 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. The finding that drivers rated the risk associated with curves as high (and in some cases over-rated the risk) is perhaps not surprising given the previous findings that have shown horizontal alignment to be an important dimension of drivers' perceived risk (Kanellaidis & Dimitropoulos, 1994) and that most, if not all, curves are accompanied by warning signage (Charlton, 2007). Similarly, the finding that drivers view bridges and narrow lanes as high risk has also been reported previously (Watts & Quimby, 1980) and may in part be due to an increase in perceived speed at these locations (Lewis-Evans & Charlton, 2006). In the present study, the presence of wire rope barriers and bridge rails tended to increase participants' ratings of perceived risk, particularly for the still photos in the case of bridge rails. The data collected during the post-drive interviews supported these findings, with curves, terrain and road width being three of the most commonly reported features that influenced drivers' risk ratings

The finding that drivers under-rated the risk associated with roadside hazards such as power poles and ditches (as compared to their objective risk) has not been previously studied or reported to the same extent. It has been suggested, however, that drivers appear to focus on factors contributing to the risk of crash occurrence rather than risk factors associated with the severity of a crash. For example, Lund and O'Neil (1986) proposed that behavioural adaptation would be more likely to occur for changes that affect crash probability (studded tyres) than changes that affect injury probability (seat belts). They argued that this was because changes that reduce the likelihood of a crash also often provide more direct and immediate feedback to the driver (as compared to injury-reducing measures) (Lund and O'Neil, 1986). In the case of the present study, the road locations containing power poles and ditches can be thought of as severity magnifiers rather than directly contributing to crash occurrence. The RPS scores correctly take into account the additional risk posed by these hazards, but drivers apparently do not view their presence as contributing to risk.

The finding that intersections were also significantly under-rated by our participants requires a different explanation. The potential for conflict with other vehicles at intersections does contribute to crash likelihood rather than magnifying the severity of crashes. Intersections were mentioned by some of the participants during the interviews as contributing to their risk ratings, particularly when other vehicles were present, but the risk ratings remained moderately low. Unlike roadside ditches and poles, which were not mentioned by any of the participants, the risks associated with intersections were under-rated rather than simply not considered. It may be that because intersections do not place any additional demands on drivers' vehicle control skills they do not contribute to an increased sense of risk. Groeger and Chapman (1996) reported that perceived difficulty and degree of controllability were important constituents of drivers' feelings of risk and Fuller (2005) has suggested that driving difficulty may be conflated with feelings of risk to some degree. In the present experiments, the risk ratings of the photos were slightly (but significantly) higher than those from the videos, which in turn were slightly higher than those from the on-road experiment. The different sense of controllability associated with these methods (low controllability for photos and high for on-road) could help account for differences in the ratings.

There are several safety implications of the present research that are worth considering. For example, the finding that narrow shoulders, poles, and ditches were not noticed by participants suggests that investment in eliminating or reducing these roadside hazards should be given a high priority. In contrast, intersections were noticed by the participants, but their risk was still under-rated compared to RPS risk estimates. This suggests making the risks associated with intersections more apparent to drivers would be a valuable contribution to road safety. As noted by earlier researchers, roads with low perceived risk may actually contribute to higher levels of objective risk because drivers are not taking due care at these locations.

Acknowledgements

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