

Dorn, L. (2005). Professional driver training and driver stress: Effects on simulated driving performance. In G. Underwood. (Ed). Traffic and Transport Psychology, Elsevier.

Professional Driver Training and Driver Stress: Effects on Simulated Driving Performance

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INTRODUCTION

Professional drivers are at increased risk of accident involvement (Broughton, Baughan, Pearce, Smith and Buckle, 2003) and have work-related issues to deal with that are likely to increase driver stress and exposure to risk (Dorn and Brown, 2003). Well-designed training could upgrade driver abilities, yet literature reviews have asserted that driver training may be counter-productive in improving road safety (Christie, 2001; Mayhew and Simpson, 2002). But, studies tend to focus on an extremely unreliable criterion measure - accidents (af Wahlberg, 2003). Perhaps a more useful start to evaluating the effectiveness of driver training might be to consider whether driving performance is qualitatively improved and safer according to the level of training proficiency attained. In a study of real driving, Treffner, Barrett and Petersen (2002) show improved performance amongst trained driving instructors in cornering trajectory, emergency braking strategy and high speed swerve and recovery tasks compared with untrained experienced drivers. In a simulator-based task, Dorn and Barker (in press) report significant differences between trained experienced drivers and non-trained experienced drivers on speed choice in response to hazards, the initiation of safer overtaking and safer vehicle positioning compared with untrained drivers. There are methodological difficulties in using this kind of experimental design to investigate training effects. One might expect there to be driving performance differences between professionally trained and non-professionally trained drivers. This kind of design says little about what aspects of professional driver training could be improved upon to reduce accident risk. The purpose of the present study then is to consider whether there are driver group differences in driving performance between drivers trained to a standard professional level compared with those trained to an advanced professional level of proficiency with a view to informing the content of professional driver training. By comparing two sets of professionally trained drivers but with different levels of proficiency, standard professional drivers operate as a control group for more advanced professional drivers.

Police driver training is a good model to use to investigate driver training effects due to clear differences between standard and advanced police driver training. In addition, generally police drivers receive similar driver training, and work under similar organisational policies and practises. In the UK, the content of standard police driver training broadly includes instruction in safe systematic driving techniques, Highway Code, protection at a road incident scene; attitudinal training, stopping vehicles; skid techniques and manoeuvrability; familiarisation and vehicle care, emergency response driving, night driving, and basic pursuit driving. Advanced police driver training includes all the elements of standard training but is enhanced with practical training in safe, systematic high speed driving techniques to a high degree of all round proficiency. Furthermore, advanced driver training places greater emphasis on hazard awareness and maintaining visual contact following a target vehicle whilst also refining observation skills to anticipate danger. The advanced course is longer than the standard course (about 3 weeks versus about 4-5 weeks but this varies across forces). Both courses instruct in safe overtaking in which trainees overtake by observing the road ahead for layout, road signs, hazards etc, identify a safe gap and then pull out to initiate an overtake at speed. But standard drivers do not get the opportunity to practise these manoeuvres during training to the same extent as advanced drivers do, nor do they have as many hours instruction in developing other driving skills. Given these driver training differences, it is expected that advanced drivers will demonstrate safer driving performance in comparison with standard drivers, especially with regard to speed, overtaking and driving behaviour at particular hazards.

There is a further rationale for this study that has not previously been considered in the literature with respect to driver training proficiency. Stress states can interfere with several distinct components of the driving task including psychomotor control and hazard detection (Matthews, Sparkes and Bygrave, 1996) and not surprisingly, previous research has shown a link between driver stress and accident involvement amongst non-professionally trained (Matthews Dorn and Glendon, 1991) and professionally trained drivers (Dorn and Garwood, in press). There are a number of reasons why this relationship may exist. Firstly, stress might interfere

with attention to driving by generating anxiety, worry and task-irrelevant thoughts that reduce the availability of attentional resources for the driving task. Second, stress could impair the driver's judgement in the selection of coping strategies to deal with a hazardous situation. The implication here is that vehicle handling skills honed during training may not always be well executed under the pressure of day-to-day professional driving - despite superior driving skills. For police drivers, there is little debate that driving is stressful and at times life-threatening. Driving in response or pursuit requires police officers to put themselves in unpredictable traffic situations. They frequently respond to calls where there is little information available about what is occurring at the scene, or chase a suspect at speed under dangerous circumstances. Responses to stress will vary according to individual differences but qualitative research (Dorn and Brown, 2003) reported that over 40% of police drivers interviewed felt that stress-related problems contributed to police collisions.

Driver stress can be conceptualised as a continual interaction of factors both intrinsic and extrinsic to driving, mediated by an individual's appraisal of the driving task (Gulian, Matthews, Glendon, Davies and Debney, 1989a). Matthews (2001) proposed that driver stress vulnerability relates to cognitive processes of appraisal and coping specified by transactional models of stress (Lazarus and Folkman, 1984). In this way, driver stress is generated by cognitive appraisals that demands of the driving task exceed the driver's capabilities and coping resources. The Driver Stress Inventory (DSI; Gulian, et al, 1989a) aims to measure an individual's vulnerability to stress reactions during driving and is a reliable measure of driver stress (Glendon, Dorn, Matthews, Gulian, Davies and Debney, 1993). The DSI includes five dimensions of driver stress, Thrill Seeking, Aggression, Dislike of Driving, Hazard Monitoring, and Fatigue Proneness (Matthews, et al, 1991; Dorn and Matthews, 1995; Matthews, Desmond, Joyner and Carcardy, 1997; Matthews, Tsuda, Xin and Ozeki, 1999).

The present research aimed to test the relationship between the DSI factors and driving performance. It is expected that different factors might relate to specific aspects of driving task performance amongst police drivers in the same way as that shown in previous studies with non-professionally trained drivers (Matthews, et al, 1996; Matthews Dorn, Hoyes, Glendon, Davies and Taylor 1998; Matthews, 2001). There are several *a priori* reasons why established links might also be found amongst police drivers. Firstly, police drivers may be attracted to the thrill of driving so high scores on Thrill Seeking are expected to be associated with more risky decision making to satisfy sensation seeking motivations whilst driving. Secondly, police drivers are trained to drive with confidence and maintain a 'presence' on the road when the situation demands it. They are regularly exposed to other non-paced drivers who often respond inappropriately to the 'Blues and Twos'. Previous research has shown that Aggression is characterised by negative appraisals of other drivers expressed through intimidation and is associated with tailgating, frequent overtaking, higher frequencies of driving errors and deliberate violations such as speeding (Matthews, 1993; Matthews et al, 1997). It is reasonable to suggest then that increased Aggression may be associated with unsafe driving manoeuvres amongst police drivers as well. Thirdly, Dislike of Driving is associated with negative self-appraisal, and these cognitions generate negative mood states and worries which tend to interfere with task performance (Matthews, 2001). Given that personal safety is threatened during overtaking manoeuvres it is anticipated that high scores on Dislike is associated with more risky overtaking. Fourthly, increased scores on Hazard Monitoring are associated with active attempts to anticipate danger that may in part be linked to visual search strategies. Crundall and Underwood (1998) found that experienced drivers adapt their visual search according to roadway demands whereas novice drivers adopt a less flexible strategy. In a study of police drivers, Crundall, Chapman, Phelps and Underwood (2003) reported that police drivers demonstrated greater visual sampling rate and spread of search and increased electrodermal activity when viewing pursuits compared with novice drivers and age-matched controls. It is hypothesised then that increased Hazard Monitoring scores may be associated with safer driving performance at hazards. Finally, police drivers drive for long periods and may suffer from fatigue (Matthews and Desmond, 1996). The Fatigue Proneness dimension measures an individual's vulnerability to experience driver fatigue after several hours of prolonged driving. It relates to drowsiness, day dreaming, boredom and may be correlated with slower reactions and reduced attention to components of the driving task.

The DSI also measures specific driver stress coping strategies based on cognitive appraisals of the driving task, including, Emotion-focused Coping, Confrontive Coping, Task-focus Coping, Avoidance and Reappraisal Coping (Matthews, 1993). Poor driver stress coping strategies would not only fail to manage the experience of driver stress but also may intensify it. Taking these in turn, Emotion-focused Coping refers to self-criticism as a driver and may impair driving performance through distraction and self-focus, whereas Confrontive Coping involves mastery of the driving challenge through self-assertion or conflict and are clearly dangerous driver coping strategies. Task-focus Coping refers to active attempts to change the external environment via a behavioural response, for example, reducing speed when driving conditions are dangerous and is therefore an effective coping strategy in the face of driver stress. Similarly, Reappraisal Coping is an attempt to deal with driver stress by re-appraising one's emotional and cognitive reactions and tends to have a more positive influence on driving behaviour. Avoidance Coping, on the other hand, is the attempt to ignore the stressor often through self-distraction and diverting attention away from driving and in this way performance could be

impaired. It is expected that these specific coping strategies are associated with components of driving task performance such that Emotion-focused coping, Confrontive Coping and Avoidance are expected to relate to risk taking whereas Task Focus and Reappraisal are expected to relate to safer driving performance.

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The purpose of the present study then is twofold. Firstly to test the hypothesis that advanced police driver training leads to safer simulated driving performance compared with standard driver training. Secondly to consider the hypothesis that driver stress factors are associated with specific components of simulated driving task performance amongst police drivers in an expected direction, the same as that found for non-professionally trained drivers.

METHOD

Participants

Fifty-three police drivers were recruited as volunteers from two urban police services via newsletter, website and direct contact. Both police services used very similar driver training approaches for both advanced and standard courses and were operationally adjacent in the South East of England. The average age was 36.7 (SD = 5.67). The police drivers had held a full driving licence on average for 18.37 years. Of the sample 67% reported driving over 15,000 miles per annum and all drivers reported driving everyday. There were 14 police officers trained to a standard level of driving proficiency and 39 officers trained to an advanced level of driving proficiency. Of the police drivers trained to an advanced level, 10 had undertaken specialist pursuit training and 3 had been trained on anti-surveillance/anti-ambush courses with 27 of the 39 having also completed other kinds of shorter courses such as driving specialist police vehicles and motorcycle training. The mean age for the advanced drivers was 37.28 and the mean age for the standard drivers was 33.93.

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Design and Procedure

All participants were asked to take part in a driving simulator-based experimental trial in which they were required to drive along a scenario partitioned into a 'rural' section, representing single lane country roads with hills and bends with occasional traffic, a 'link' section, representing a stretch of single-lane, fairly straight, open road, relatively free of traffic, and finally an 'urban' section representing driving through a built-up area, with traffic lights, pedestrians and a single and dual carriageway with occasional traffic. The participants were seated in the driving simulator at a distance of one metre (39 inches) from the screen, resulting in an approximate eye-to-screen distance of seventy-five cm (25 inches). The participant viewed the road ahead on a 22-inch visual display unit. Participants were given a 10-minute practice trial on the driving simulator to get used to the feel of the steering wheel and pedal controls. Next, participants took part in the experimental trial and were instructed to drive the way they would normally drive and deal with the conditions presented as if they are really happening. The scenario was 9.12 miles in length and took about 15 minutes to complete, depending on preferred speed. Vehicles behind the driver never overtook the driver, although they could be viewed in a rear-view mirror. All traffic lights were encountered during the urban section of the scenario. Traffic lights were always set to 'go'.

To test for risk taking propensity, the participants were given two main tasks to complete. Firstly they were asked to overtake a slow-moving bus during the link section. Here, certain sections of the link roads had been programmed with hills and bends and double white lines (indicating in the UK that overtaking is prohibited) in the centre of the road. Oncoming traffic was relatively infrequent. Secondly, they were asked to maintain visual contact with a lead vehicle travelling at 55mph in a 30mph urban section without seriously compromising safety. An independent Measures design was used with police driver group (standard and advanced drivers) as between subjects factors and dependent measures were scenario completion time (the total number of seconds taken to complete the entire simulation from beginning to end); speed (mph), overtaking risk (the number of occasions that the driver crossed the roadway division when there were double white lines indicating 'no overtaking'); and lateral separation (the distance from the parked bus and the driver's vehicle measured in feet). Speed on approach to traffic signals was recorded on three occasions. Firstly, 450 feet, secondly 300 feet and finally 150 feet distance from the traffic lights. Speed was averaged at each of these distances and recorded and averaged over the 1500 feet before the traffic lights (the earliest point at which the traffic lights were visible to the participant) until they were passed. Speed on passing traffic signals was also measured. Participants completed the DSI either before or after the simulated driving task and were also asked to rate their chances of being involved in a road traffic accident in the next 12 months ranging from extremely unlikely (0) to extremely likely (10).

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The Driving Simulator

The driving simulator was built using the STISIM PC-based interactive driving simulator model 100. The simulation included vehicle dynamics, visual and auditory feedback and performance measurement system, full sized driving controls including a modular accelerator and brake pedal unit, and speed sensitive steering feel

provided by computer controlled torque motor (360° steering capability). The simulator incorporates a high-resolution digital-optical control input sensors, an audio amplified stereo speaker set and sound card (sound blaster Live PCI) and graphics card (3D voodoo2, 24 MB RAM; resolution: 1024 X 768). The scenario was presented on a 22" VGA colour monitor. The hardware and software were housed in a frame with a car seat built from the dimensions of a Ford Escort car. The screen update was set to produce between 10-30 frames per second depending on the complexity of the view, leading to a moderately smooth apparent motion. The road was represented within a rectangle that was 1024 pixels wide and 768 pixels high with the screen representing the sky above, a speedometer below, and a rear-view mirror in the top left-hand corner. The simulator displayed realistic three-dimensional scenes at 135° field view including pedestrians, buildings, road signs and oncoming traffic. The participant viewed objects up to 1500 feet away appropriately scaled in size and perspective. In accordance with the British Highway code, relevant road signs and markings were included in the scenario such as speed limit signs, signs warning of impending bends in the road approaching, and double/dashed white lines in the centre of the road.

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RESULTS AND DISCUSSION

Age, Experience and Driver Training Differences

Advanced drivers report driving more miles annually and weekly and have been driving as a police officer for nearly twice as long as standard drivers. Standard drivers had received police driver training more recently than advanced drivers. However, Table 1 shows no significant differences for age, mileage and experience between the two police driver groups.

(Table 1 about here)

Hypothesis 1: Driver Group Difference in Driving Performance

Speed

Analysis revealed that standard drivers were faster on approach to Signal 1, 2 and 3 (Signal 1; $t = 2.20$, $p < 0.05$, Signal 2; $t = 2.00$, $p < 0.05$, Signal 3; $t = 2.21$, $p < 0.05$) and on passing Signal 1 ($t = 1.70$, $p < 0.05$) compared with advanced drivers. Results also showed that standard drivers were faster during both the rural ($t = 1.91$, $p < 0.05$) and the 'link' sections ($t = 1.92$, $p < 0.05$) and faster overall, completing the driving simulator component of the study in less time than advanced drivers ($t = 1.95$, $p < 0.05$) (see Table 2 below). In comparison to standard drivers, advanced drivers exhibited lower speeds in both the rural and link sections and took longer to complete the simulated scenario overall.

(Table 2 about here)

The characteristic speed differentials between the police driver groups indicate a consistent pattern of speed choice with standard drivers adopting significantly higher speeds across a range of different road and traffic contexts compared with advanced drivers. These findings suggest that advanced driver training may indeed be influential in making safer speed choice decisions in comparison to drivers who have only? received training to a standard level of proficiency.

Overtaking

Analysis revealed that standard drivers were over five times ($n = 4$, 26.4%) more likely to cross the roadway division at unsafe locations during the overtaking manoeuvre than advanced drivers ($n = 2$, 5.1%) ($\chi^2 = 5.6$, D.F. = 1, $p < 0.05$). It should be noted that the total number of risky roadway crossings across the total driver sample was small ($n=6$). Perhaps additional advanced driver training in overtaking is exerting an influence on decision making when initiating an overtaking manoeuvre.

Risk Perception

Interestingly, standard drivers rate their chances of being involved in an accident in the next 12 months significantly lower than advanced drivers do ($t = 9.53$, $p < 0.01$; $\bar{x} = 1.25$ Vs $\bar{x} = 2.50$) suggesting an illusory sense of optimism in comparison with advanced drivers. This may help explain differences between the police driver groups in risk taking. Perhaps standard drivers drive at increased risk compared with advanced drivers because they believe they are unlikely to be involved in an accident.

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With respect to the first hypothesis then, driver group differences in simulated driving performance were found in the expected direction. Advanced drivers showed greater caution in speed choice, at traffic signal hazards and during overtaking compared with standard drivers. Standard drivers also rated their chances of being involved in an accident significantly lower than did advanced drivers.

Hypothesis 2: Driver Stress and Driving Performance

Hazard Awareness and Driver stress and coping

In the urban section, correlations between the DSI and driving performance revealed that increased scores for Hazard Monitoring ($r=0.29$, $n=53$, $p<0.05$) was significantly associated with reduced speed when passing the parked bus hazard. Here, police drivers high in Hazard Monitoring appear to be aware of their hazardous surroundings and respond appropriately. Sensitivity to the parked bus hazard may have been due to increased visual sampling rate and spread of search as a function of police driver training (Crundall et al, 2003). There was also a significant correlation between speed at passing the bus and scores for Confrontive Coping ($r=0.29$, $n=53$, $p<0.05$) with increased scores being correlated with increased speed at this particular hazard. Clearly, Confrontive Coping is associated with more risky driver decision-making as expected. Proximity to the parked bus was also significantly positively correlated with Task Focus ($r=0.27$, $n=53$, $p<0.05$) with high Task Focus scores being associated with maintaining a greater distance from the parked bus hazard confirming that Task Focus has a beneficial effect on driving performance.

Overtaking and Driver Stress

The results for the overtaking task were found to yield significant differences between overtaking behaviour and elevated scores on the Dislike of Driving dimension of driver stress. Drivers who crossed the centre line at potentially unsafe locations scored higher on Dislike of Driving compared with police drivers who crossed the centre line at safer locations ($t = 2.46$, $P<0.05$) (See Figure 1). This finding confirms previous research showing that high Dislike drivers are more prone to stress when personal safety is threatened (Matthews, 1993).

(Figure 1 about here)

Drivers who crossed the roadway division at potentially unsafe locations scored significantly higher on Thrill Seeking compared to those who did not cross the roadway division at unsafe locations. ($t = 1.8$, $p<0.05$) and this finding confirms that Thrill Seeking is related to sensation seeking amongst police drivers (see Figure 2).

(Figure 2 about here)

There was no evidence that Aggression was associated with unsafe driving performance and Fatigue Proneness was not associated with slower reactions to hazards as found in previous studies (Matthews, et al, 1997). Perhaps this can be explained by reference to the format of the simulated scenario used for this study. The traffic was fairly light, even in the urban section, and drivers high in Aggression may not have mobilised their usual strategies of competing with other drivers under these less demanding driving situations. With regard to Fatigue Proneness, the scenario took about 15 minutes to complete and was therefore not particularly fatiguing (Matthews and Desmond, 1996).

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CONCLUSION

The results show that advanced drivers demonstrate safer driving performance than standard drivers do, and suggest that perhaps advanced police driver training should be extended to include all police drivers. Indeed it is standard police drivers that appear to have an increased exposure to risk of collisions (Rix, Walker and Brown, 1997) compared with advanced police drivers. It also appears that extensive driver training may fail to protect police drivers from the potential deleterious effects of driver stress on driving performance as police drivers do not seem to differ in the effect driver stress has on driving performance compared with non-professionally trained drivers, in spite of their advanced driver training. Confrontive Coping, Thrill Seeking and Dislike are of particular concern. Yet to date, much driver training fails to consider the influence of driver stress and coping despite research for over a decade showing its impairing effects on driving performance. Driver stress management techniques could be trained as part of professional driver training. There are also implications for designing training interventions that aim to minimise potentially hazardous styles of driver appraisal and coping and improve Hazard Monitoring and Task Focus given the beneficial effects reported here. For example, stress management techniques directed towards high Dislike drivers should aim to reduce negative affect without also generating an overly optimistic view of personal competence (Dorn and Brown, 2003). Police driver training should aim to combat an illusory sense of optimism, especially amongst standard police drivers in particular, given the present findings for police driver group differences in risk perception. Furthermore, police driver training should also aim to instruct the trainee in coping strategies for dealing safely with feelings of anger and frustration whilst on duty. Reacting in a confrontational manner is maladaptive and can lead to unsafe decision-making as in the link between Confrontive Coping and hazard awareness shown in the present study. Training in controlling Thrill Seeking tendencies is also recommended. Better driver training can be ultimately evaluated in terms of its effect on accident reduction amongst an extremely vulnerable driver group.

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However, it must be pointed out that advanced drivers' experience post-training will also have undoubtedly influenced driving behaviour sampled for this study. Advanced drivers are likely to have had experience of following a vehicle at speed in a built-up area, whereas standard drivers may have had less experience of this kind of task. Further research would need to examine more closely the effects of professional driving training and experience on driving performance. These findings provide initial support that, whilst on the one hand police drivers trained to a higher level of proficiency demonstrate safer driving performance and driver stress, on the other hand there is evidence that driver stress and coping is associated with increased risk taking. Perhaps strategies that attempt to address appraisal and motivation and effects of emotional state on driving behaviour may be critical in improving police driver training.

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Acknowledgement

I would like to thank the Police Scientific and Development Branch of the Home Office for their support for this research and all the participants for their assistance. I am also grateful to Cathy Birch for co-ordinating this study.

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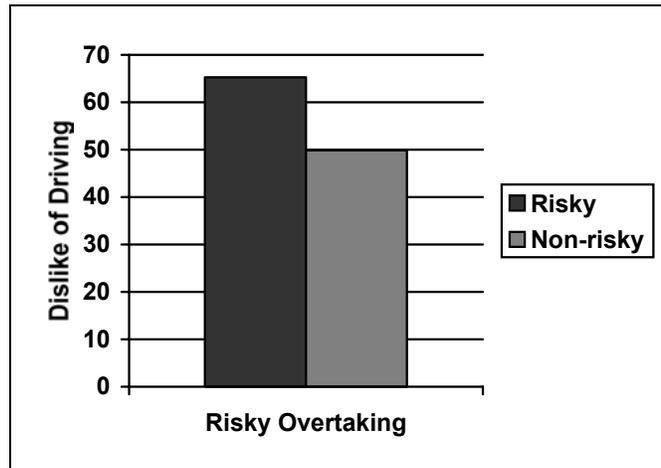
Table 1: Police Driver Group Differences in Age, Experience and Driver Training

Variable	Advanced Drivers Mean and sd	Standard Drivers Mean and sd	t- value	Significance Level (one-tailed)
Age	37.28 (4.98)	33.93 (5.79)	0.552	ns
Annual (work and leisure) mileage	13533 (6217)	10970 (5834)	0.36	ns
Weekly mileage at work	333 (274)	231 (199)	0.493	ns
Number of years since gaining first police driving licence	13.74 (6.28)	7.36 (6.05)	0.011	ns
Number of years since last police driver training course attended	6.12 (5.76)	3.21 (3.20)	3.71	ns

Table 2: Police Driver Group Differences in Simulated Driving Performance

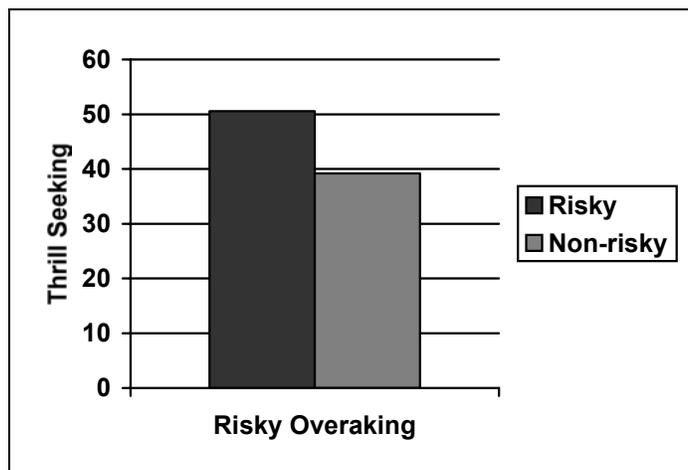
Performance Measure	Advanced Drivers Mean	Standard Drivers Mean	t-value	Significance Level (one-tailed)
Mean speed approaching Signal 1	39.5 mph	45.4 mph	2.20	0.05
Speed passing Signal 1	41.9 mph	46.8 mph	1.70	0.05
Mean speed approaching Signal 2	48.2 mph	54.5 mph	2.00	0.05
Mean speed approaching Signal 3	48.8 mph	58.4 mph	2.21	0.05
Mean speed in rural section	34.1 mph	35.8 mph	1.91	0.05
Mean speed in link section	47.6 mph	49.3 mph	1.92	0.05
Total Time	802.5 s	745.2 s	1.95	0.05

Figure 1: Mean Dislike of Driving Differences between Risky and Non risky Overtaking Manoeuvres



*Note, unequal population variances were assumed in this instance.

Figure 2: Mean Thrill Seeking Differences between Risky and Non risky Overtaking Manoeuvres



*Note, unequal population variances were assumed in this instance.