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The Effects of Driver Training on Simulated Driving Performance

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Abstract

Given that the beneficial effects of driver training on accident risk may not be an appropriate criterion measure, this study investigates whether professionally trained and experienced drivers exhibit safer driving behaviour in a simulated driving task compared with drivers without professional driver training. A sample of 54 police trained drivers and a sample of 56 non-police trained drivers were required to complete two tasks. Firstly to overtake a slow-moving bus on a hazardous stretch of single-lane road with bends and hills and secondly to follow a lead vehicle travelling at 55mph in a built-up section with a speed limit of 30mph. Results showed that in comparison with non-police trained drivers; police drivers were significantly less likely to cross the central division of the road at unsafe locations during the overtaking task and reduced their speed on approach to pedestrians at the roadside in the following task to a greater extent. Police drivers also adopted a more central lane position compared with non-police trained drivers on urban roads and at traffic lights during the following task. Driver group differences in simulated driving performance are discussed with reference to the implications for driver training assessment and skill development.

Keywords: Driving behaviour, driving simulator, hazard perception, driver training

Introduction

The effectiveness of driver training on road safety is a controversial issue. Early research has demonstrated improvements in accident risk (Anderson, Ford and Peck, 1980) but many more studies report no significant difference in crash risk post-training (Kaestner, 1968; Nichols, 1970; and Struckman-Johnson, 1989; Manders and Rennie, 1984; Lund and Williams, 1985). Whilst there may be some evidence for an initial improvement, road safety effects are not always long-lived (Stock, Weaver, Ray, Brink and Sadoff, 1983). Even specific skills training such as skid control and braking techniques have failed to find measurable improvements in slippery road accident rates (Lynam and Twisk, 1995; Gregersen, 1991; Katila, Keskinen, Hatakka and Laapotti, 2003). When considering the road safety benefits for accident-involved drivers, still no significant reduction on crash involvement post training has been found for at risk groups (Brown, Groeger and Biehl, 1987; Stuckman-Johnson, Lund, Williams and Osborne, 1989). Several studies have suggested that higher order skills such as hazard perception contribute more to reducing crash risk than advanced driving skills and knowledge *per se* (Lyman, 1995; McKenna and Crick, 1992) and greater emphasis on hazard awareness may improve the effect of training on road safety (Gregersen, 1995). Other studies suggest that accident reductions are possible provided a package of safety measures is in place (Gray 1990; Gregersen, Brehmer and Moren, 1996).

Whilst one of the goals of driver training is to improve road safety, reduction in accident rates may not be a reliable indicator of driver training effectiveness. Firstly, there are well-established problems in the reliability of accident records that lead to difficulties in using accident rates as a criterion measure (Wahlberg, 2003). Secondly, an accident may be the result of several events that might be due to factors not considered during the driver-training course under study. Thirdly, accident frequency is an unreliable criterion given the fact that accidents are comparatively rare events when considering the prevalence of everyday risk taking. Perhaps a more fruitful avenue would be to consider whether post-test professional driver training leads to reduced risk taking behaviour which may ultimately improve road safety whilst not necessarily influencing individual accident risk.

Police driver training provides a good model for studying the effects of professional driver training especially given that it often forms the basis of many post-test driver training courses in the UK. Police driver training follows core course texts including 'Roadcraft: The Police Drivers Handbook' involving 3-5 weeks of classroom-based and in-vehicle instruction and leads to a written theory test and driving test. Police drivers are trained either to a standard or advanced level with both courses based on The System of Car Control outlined in Roadcraft. 'The System' emphasises observation and focuses on road cues to potential hazards. Observation is seen as particularly critical for the development of high speed driving skills. There is also an element of off-road training dealing with skid recovery, understeer, oversteer and general manoeuvring. The advanced course is longer and designed to equip police drivers with the skills required to drive in pursuit situations in far higher powered cars, or to drive in firearms based situations. Overtaking is also a primary focus, using the increased observational skills already established. Trainees are trained to overtake by observing the road ahead for layout, road signs, hazards and any obstruction to their view and then identify a safe gap before initiating an overtake. Trainees then observe speed and the position of vehicles behind them, and move up close to the vehicle ahead, pull out to facilitate good observation and accelerate past the vehicle if there are no hazards. During training general driving skills such as positional techniques are also introduced, in particular straddling the centre white line when there is no opposing traffic in order to minimise effects of kerbside pot-holes at speed and to allow better positioning and observation on entry to a bend.

Given these specific driver training instructions, it is expected that police drivers in comparison to non police trained drivers will exhibit different simulated driving performance during overtaking, in lane positioning choice and at particular hazards.

Method

Participants

Fifty-four male police drivers were recruited as volunteers from two large UK urban Police Services via newsletter, website and direct contact. The average age was 36.7 (SD = 5.7). They had held a full driving licence on average for 18.4 years (SD = 6.1). A group of 56 non-police trained drivers were recruited via opportunity sampling. The average age was 34. 3 (SD 8.4). The non-police trained driver group had held a full driving licence on average for 15.6 years (SD = 8.4) and were paid for their participation.

Table 1 here

Design

All participants were asked to take part in a driving simulator-based experimental trial in which they were required to drive at their preferred speed along a scenario partitioned into three sections (but running smoothly into each section without a break in the appearance of the roads presented). Firstly participants were presented with a 'rural' section, representing single lane country roads with hills and bends with occasional traffic. Secondly a 'link' section, representing a stretch of single-lane, fairly straight, open road, relatively free of traffic. Finally an 'urban' section representing driving through a built-up area, with traffic lights, pedestrians and a single and dual carriageway with heavy traffic. A between-subjects design was used with driver group (non-police and police trained drivers) as between-subjects factors. To test for risk taking propensity the participants were required to perform two tasks. Firstly, overtaking a slow-moving bus and secondly following a lead vehicle at speed in the urban section. During the following task, participants encountered a parked bus from which passengers were alighting, and this hazardous event was selected for detailed analysis. The main dependent variables selected were scenario completion time (measured as the total number of seconds taken to complete the entire simulation from start to finish), speed (measured in mph), lane positioning (measured in metres from the centre line), lane positioning variability (measured in standard deviations from the mean position). For the overtaking task, overtaking risk is measured as the number of occasions that the driver crossed the roadway division when there were double white lines indicating 'no overtaking'. For the following task, a measure of lateral separation was recorded (measured as the distance from a parked bus and the driver's vehicle measured in feet).

Further dependent variables were selected for performance on approach to the traffic lights. At distances of 450 feet, 300 feet and 150 feet from the first set of traffic lights, speed, positioning and positioning variability was recorded and averaged at each of these distances. The same measures were also 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 passed). Finally, the vehicle's speed and positioning at the point of passing the traffic light itself were recorded. The scenario was 9.12 miles in length and took about 15 minutes to complete, depending on preferred speed.

Procedure

The participants were seated in the driving simulator at a distance of one metre (35 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 practise trial on the driving simulator. During the practise session they were asked to drive along the road in order to get used to the feel of the simulator and 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. Vehicles behind the driver never overtook the driver, although they could be viewed in a rear-view mirror. Participants were asked to overtake a slow-moving bus during the link section and to maintain visual contact with a lead vehicle in the urban section without seriously compromising safety.

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 such as a modular accelerator and brake pedal unit, and speed sensitive steering feel provided by computer controlled torque motor (360° steering capability). The simulator incorporated 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. 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, in accordance with the British Highway code.

Results

Age, Driving Experience and Driving Exposure

Results showed that age and driving experience did not significantly differ between the two driver groups (Age: t=1.73, D.F. = 97.14, p>0.05; Experience: t=1.95, D.F.=99.86, p>0.05). Drivers' age was significantly correlated with driving experience (r=0.94, n=110, P<0.001), with increasing age being associated with greater driving experience.

Annual mileage (using five tick-box categories ranging from less than 5,000 to over 20,000 miles per annum) and driving frequency (using four tick-box categories ranging from everyday to never) were found to differ according to driver group (Mileage: $\chi 2$ = 12.56, DF=1, p<0.001; Driving Frequency: ($\chi 2$ = 5.2, DF=1, p<0.05). Police drivers were more than twice as likely as non-police trained drivers to have driven in excess of 15,000 miles in the last year and were more likely to have reported driving every day when compared with non-police trained drivers (see Table 2 and 3 below).

Table 2 and 3 here

In the result presented in the following sections, all analysis controls for driving experience via age, given the highly significant relationship between age and driving experience.

Driver Group Differences in Speed

Overall scenario completion time (dependent upon preferred speed) was significantly correlated with age (r=0.18, n=110, p<0.05) but not with driving experience (r=0.15, n =110, p>0.05) suggesting that age and not experience is associated with speed. Furthermore, the partial correlation between driving experience and scenario completion time, with the effects of age partialled out, was very small ($r_{time(experience.age)} = -0.05$, DF=107, $p>0.05$). Analysis of variance showed that there was no significant difference in scenario completion time between the two driver groups ($F_{1,107} = 0.3$, $p>0.05$) controlling for age (see table 4 below) with both driver groups adopting similar overall speeds.

Table 4 here

In an analysis of variance considering driver group and scenario section differences in speed, controlling for age, results showed that there was a significant main effect of scenario section on speed ($F_{2,214} = 6.9$, $p<0.005$). Post hoc test revealed that drivers were significantly slower in the rural section compared with both the link and urban sections, and that they were significantly faster in the link section compared with the urban section. Given that the link section is an open road, in contrast to the speed limit imposed on rural driving and the speed required to complete the following task in the urban section, these findings were expected. There was no significant main effect of driver group ($F_{1,107} = 1.2$, $p>0.05$) or a significant interactive effect of driver group by scenario section ($F_{2,214} = 0.43$, $p>0.05$) on speed (see Figure 1 below) indicating that both non-police trained drivers and police drivers adopt similar speeds across each section of the scenario.

Figure 1 here

<u>Driver Group Differences in Overtaking</u>

For the link section, drivers were required to drive along an open country road relatively free of traffic and hazards and overtake a slow-moving bus. Chi Square analysis of driving performance for this task shows that non-police trained drivers were significantly more likely to cross the roadway division at potentially unsafe locations when compared with police drivers ($\chi 2 = 9.2$, DF = 1, $p<0.005$). Non-police trained drivers were over three times more likely than police drivers to 'pull' on to the oncoming carriageway when it was potentially dangerous to do so.

<u>Driver Group Differences in Lane Positioning and Positioning Variability</u>

(a) Lane Positioning

Analysis of variance revealed driver group and scenario section differences in lane positioning, controlling for experience ($F_{2,214} = 110.4$, $p<0.001$). Bonferonni post hoc test revealed that drivers were significantly closer to the central roadway division in both the rural and link sections compared with the urban section lane positioning, and that they were significantly closer to the central roadway division in the rural section compared with the link section. There was no significant main effect of driver group ($F_{1,107}$ =3.1, p>0.05) but there was significant interactive effect of driver group by scenario section on lane positioning ($F_{2,214}$ =8.3, p>0.001), controlling for driving experience. Police drivers, when compared with non-police trained drivers, were positioned closer to the central roadway division to a greater extent in the urban section, compared with the rural and link sections (see Figure 2 below). In response to the task to follow the lead vehicle, police drivers are inclined to maintain a more central position in the road compared with non-police trained drivers.

Figure 2 here

(b) *Variability in Lane Positioning*

Analysis of variance was conducted to consider driver group and scenario section differences in lane positioning variability. The results showed that there was a significant main effect of scenario section on lane positioning ($F_{2,216}$ = 118.2, p<0.001). Bonferonni post hoc test revealed that drivers were significantly more varied in lane positioning in both the link and urban scenarios when compared with the rural section but there was not a significant difference in variability between the link and urban sections. There was no significant main effect of driver group ($F_{1,108}$ =0.16, p>0.05) but there was a significant interactive effect of driver group by scenario section on variability in lane positioning ($F_{2,216}$ =7.1, p<0.005). Non-police trained drivers, when compared with police drivers, demonstrated more variability in lane positioning within the urban section, but police drivers demonstrated more variability in lane positioning, when compared with non-police trained drivers within the link section (see Figure 3 below).

Figure 3 here

<u>Driver Group Differences in Performance at Traffic Lights</u>

At the time the first set of lights came into view in the urban section, the participants were taking part in their second task of following a speeding lead vehicle. The first set of traffic lights was the only one used for analysis as subsequent signals were always set to ‘go’. The first set of traffic lights appears at the beginning of the urban section located on a single carriageway with heavy oncoming traffic. Cars to the left and right of the junction can be seen waiting for the lights to change.

There was a significant main effect of distance to the traffic lights on speed ($F_{2,216}$ = 26.1, p<0.001). Bonferonni post hoc test showed that drivers were significantly faster in the last 150 feet approaching the signal compared to their speeds at a distance of 300-450 and 150-300 feet from the traffic lights. There was no significant difference in mean speed for the distance of 450-300 feet compared with 300-150 feet. This finding can be interpreted as a function of drivers speeding up just before passing the traffic lights. There was no significant interactive effect of driver group by distance from the traffic lights ($F_{2,216}$ = 0.3, p>0.05) or a significant main effect of driver group ($F_{1,108}$ = 0.4, p>0.05) on approach speed. Age and experience were not significantly related to approach speed (see Table 5 and Figure 4 below).

Table 5 and Figure 4 here

However, analysis of variance shows that police drivers were positioned significantly closer to the central roadway division at traffic lights compared with non-police trained drivers (t=2.82, DF = 108, p<0.01). Non-police trained drivers had a mean positioning from the central roadway division of 6.2 feet, compared to 5.7 feet for police drivers, on their approach to the signal (see table 6 below). Age and driving experience were not related to lane positioning and there were no significant driver group differences in; speed variability, variability in lane positioning, or speed when passing the signals.

Table 6 here

Driver Group Differences in Passing the Parked Bus

During the urban section, drivers were confronted with a parked bus from which passengers were alighting and standing at the roadside waiting to cross. Performance data in response to this hazard showed that mean speed when passing the bus was not significantly correlated with age (r=-0.05, n= 110, p>0.05) or with driving experience (r=-0.06, n=110, p>0.05). Despite police drivers passing the bus more slowly (mean = 41.3 mph, SD = 11.1) when compared with non-police trained drivers (mean = 45.0 mph, SD = 12.7) this difference was not significant (t=1.6, DF=108, p>0.05). Lateral separation (the distance between the driver's vehicle and the parked bus) was significantly correlated with both age (r=0.18, n=110, p<0.05) and driving experience (r=0.20, n=110, p<0.05) showing that increasing age and experience is associated with greater distance from the parked bus. However, the correlation between age and proximity to the bus, controlling for driving experience, was not significant ($r_{Var. Position(age.experience)}$ =-0.02, DF=107, p>0.05). There was not a significant difference in proximity to the parked bus, controlling for driving experience, between police and non-police trained drivers ($F_{1,107}$ = 2.3, p>0.05).

Reduction in speed as drivers approached the parked bus was not significantly correlated with age (r=0.05, n=110, p>0.05) or driving experience (r=-0.03, n=110, p>0.05). However, police drivers significantly reduced their speed, to a greater extent, when compared with non-police trained drivers, on approaching the parked bus (t=3.3, DF=108, p<0.005) (see table 7). There were no significant driver group differences in speed on approach to the parked bus.

Table 7 here

Discussion

It would appear that professional driver training and experiences affects simulated driving performance with trained drivers demonstrating a potentially safer driving style than untrained drivers. The results showed that in comparison to non-police trained drivers, police drivers exhibited greater caution during overtaking and at a particular hazard. Police drivers also tended to position their vehicle more towards the centre of the lane during the following task and at traffic lights, with the magnitude of the driver group differences in simulated driving performance being quite pronounced for some performance variables. The strategy adopted by the police drivers for the overtaking task mirrors the instruction given on safe overtaking during police driver training. For lane positioning variability whilst overtaking, police drivers were repeatedly pulling out behind the slow-moving bus to facilitate observation of the road ahead, as they are instructed to do during training. It is therefore not surprising that police drivers also exhibited less overtaking risk than non-police trained drivers. In contrast, non-police trained drivers were observed to be ‘weaving’ in and out of the lanes of the dual carriageway during the following task whilst police drivers maintained a steadier position in the far lane, presumably to facilitate good observation and maintain a clear view of the speeding lead vehicle ahead during the following task.

However, the effects of driver training and experience on positioning in a simulated driving task should be interpreted with caution given that recent research indicates differences in lateral positioning between real and simulated driving. Blana and Golias (2002) found that in a real driving task, drivers' position their vehicle considerably closer to the centre of the road and kept a relatively constant distance from the road edge in comparison to a similar simulated driving context. They interpreted these findings as an underestimation of risk of hitting the road edge, perhaps due to the reduced environmental cues available in a simulator. However, it is the driver group differences that are of interest here rather than the absolute values discussed by Blana and Golias (2002).

The findings with respect to speed suggest that whilst there is no significant differences in speed choice between the driver groups, significantly more police drivers reduced in response to a pedestrian hazard compared with non-police trained drivers. This may be due to the specialised observation training when driving at speed to help identify potential hazards. Without this training, non-police trained drivers may have been more focused on the study's primary task to maintain visual contact with the lead vehicle during the following task and failed to adjust speed at particular hazards. It is also the case that police drivers compile more mileage and therefore have more experience responding to hazards compared with non-police drivers. Brown (1982) discussed exposure as contributing to driving experience by allowing drivers more opportunity to be confronted with different hazardous events. In the present study, police drivers were more than twice as likely to have driven in excess of 15,000 miles per annum and more likely to report driving everyday compared with non-police trained drivers even though there were no significant driver group differences in driving experience (number of years since being granted a driving licence). Police driving experience will undoubtedly influence driving behaviour and may be responsible for driver group differences in simulated driving performance reported here. Some police drivers in our sample may have had experience of following a vehicle at speed in a built-up area, whereas non-police trained drivers are unlikely to have had experience of this kind of task. Further research would need to examine more closely the differential effects of police driving experience and police driver training.

Anderson (1987) suggests that what is learned with training and practice is not knowledge so much as the use of that knowledge. The findings suggest that skills developed during training may have been retained and practised over time culminating in a somewhat different and potentially safer driving style to that of untrained drivers. The value of a driving simulator to assess the beneficial effects of driver training and experience has been demonstrated. Further research using driving simulators could be particularly useful in facilitating better decisions about the content of driver training and its effect on driving behaviour, rather than attempting to observe the effects of driver training on accident involvement.

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Figure 1: Mean Speed by Driver Group by Scenario Section

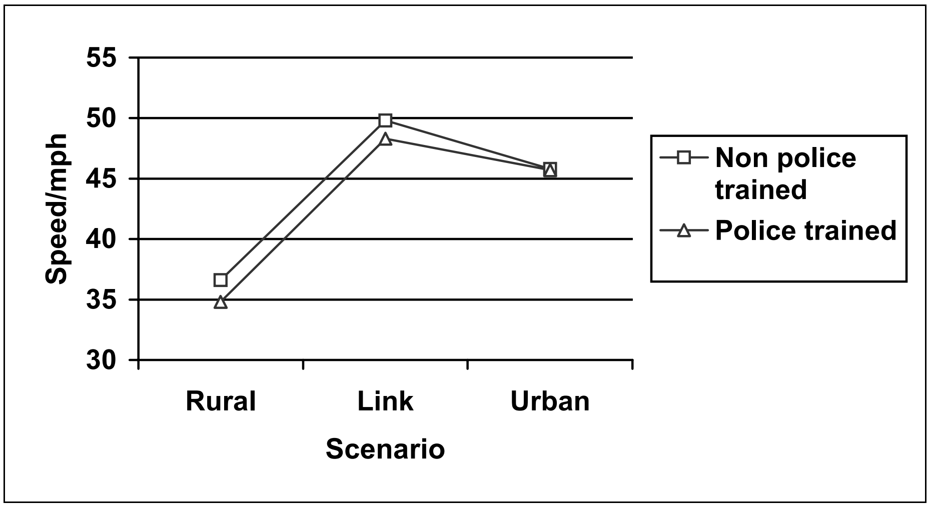

Figure 2: Lane Position by Driver Group by Scenario Section

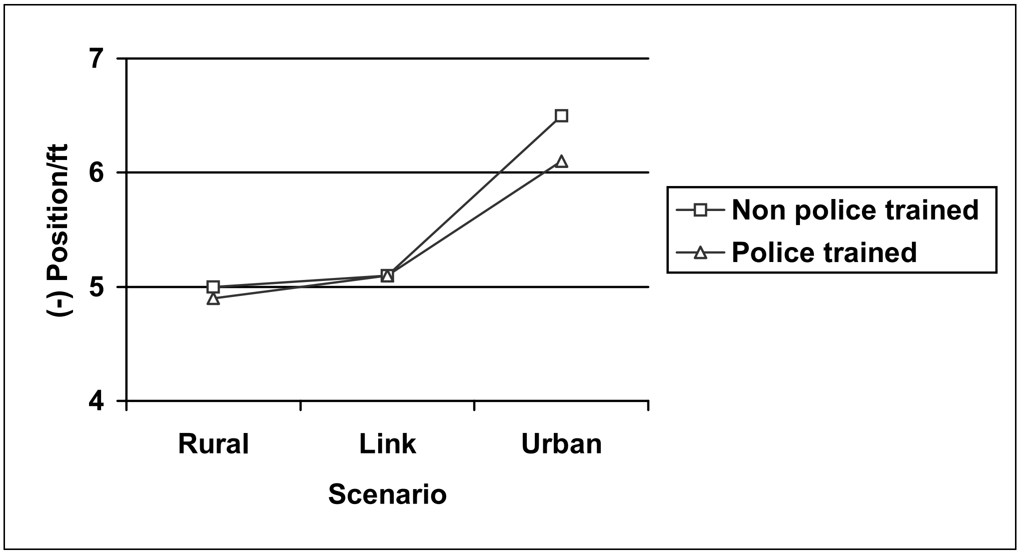

Figure 3: Lane Position by Driver Group by Scenario

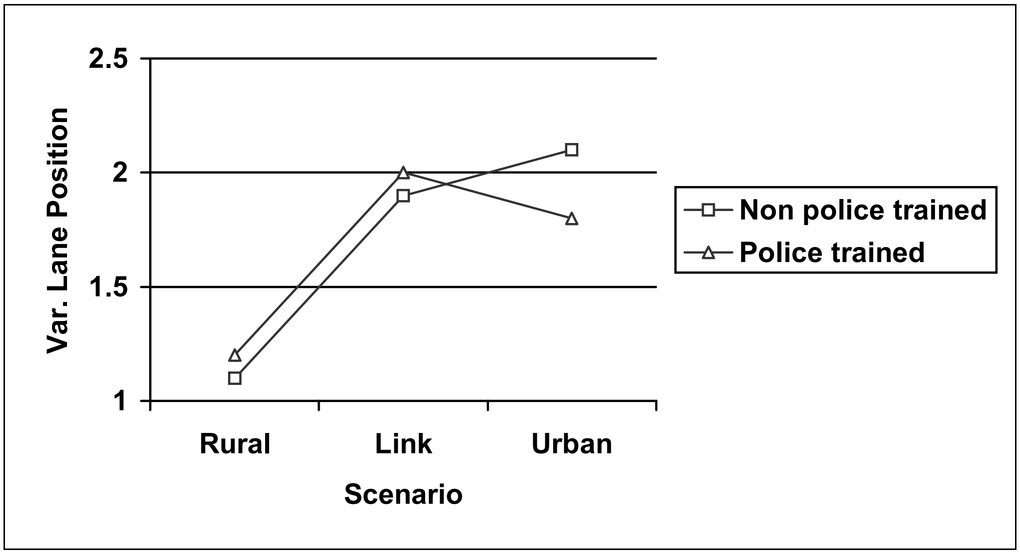

Figure 4: Mean Speed and Distance by Driver group (Traffic Lights)

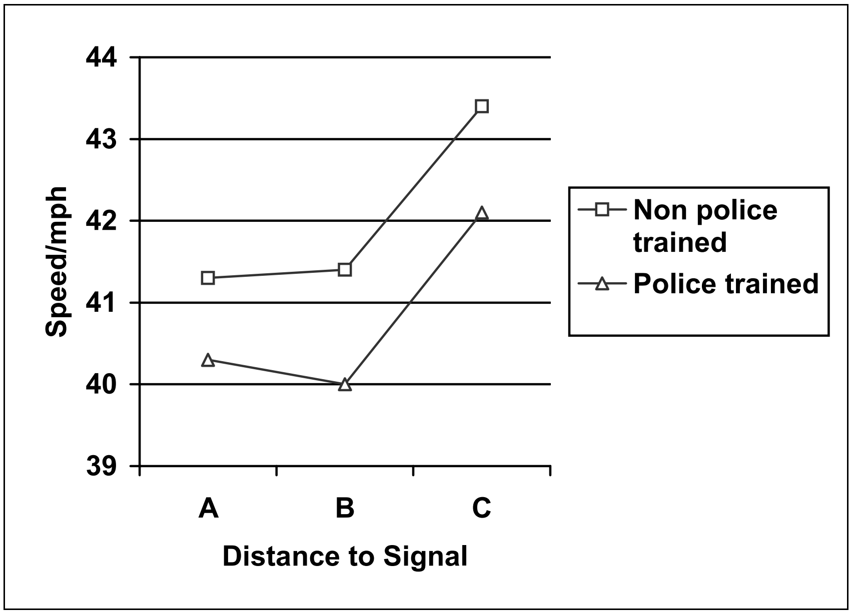

Table 1: Duration of Licence and Age by Driver Type

Driver Group	Age (years)		Licence Duration (years)	
	Mean	Std.Dev	Mean	Std.Dev
Non-police trained drivers	34.3	8.4	15.6	8.4
Police Drivers	36.7	5.7	18.4	6.1

Table 2: Annual Mileage by Driver Group

Driver Group	Percentage Driving Over 15,000 Miles per Annum
Non police trained	33%
Police trained	67%

Table 3: Frequency of Driving by Driver Group

Driver Group	Percentage Driving Everyday
Non police trained	91%
Police trained	100%

Table 4: Scenario Completion Time by Driver Group

Driver Type	Mean Time in seconds*	Std. Dev.
Non police trained	769	134.4
Police trained	788	96.2

*means corrected for age

Table 5: Traffic Lights:Mean Speed, by Distance, by Driver Group

Driver Group	**Mean Speed/mph by Distance from Traffic Lights***			
	450-300 ft (A)	300-150 ft (B)	150-0 ft (C)	Mean
Non police trained	41.3	41.4	43.4	**42.0**
Police trained	40.3	40.0	42.1	**40.8**
Mean	**40.8**	**40.7**	**42.8**	

*means corrected for age

Table 6: Mean Lane Positioning (Traffic Lights) by Driver Group

Driver Type	Mean Position In feet*	Std. Dev.
Ordinary	-6.2	0.90
Police	-5.7	0.87

*means corrected for age

Table 7: Mean Reduction in Speed in response to pedestrian hazard by Driver Group

Driver Group	Mean Speed Reduction	Std. Dev.
Non police trained	9%	1.8
Police trained	20%	1.7