Chapter

Piloting a telemetric data tracking system to assess post-training real driving performance of young novice drivers

Robert B. Isler, Nicola J. Starkey, Peter Sheppard* and Chris Yu[#]
University of Waikato,
*AA Driver Education Foundation,
[#]SmarTrak,
New Zealand

Introduction

Evaluating the effects of driver training interventions is a difficult research task. The ultimate goal of such interventions is to make the driver safer and therefore less likely to be involved in a road crash. A particular driver training intervention can only be considered to be effective if it can show a significant reduction in the number crashes for the driver, or a significant change in driver behaviour that clearly implies safer driving. Getting accurate and comprehensive crash records is difficult and to measure post training behavioural driving changes based on self-reports (e.g., log books) may not be accurate enough to be statistically meaningful.

The majority of driver training evaluation studies in the last thirty years concluded that driver education and training contributes little to reduce crash risk / involvement for road users (pre-licence, defensive, advanced, or driver improvement). And even more puzzling and paradoxical is the fact that there was no evidence that professional driver training is effective in reducing crash risk.

However, failing to find a driver training effect does not necessarily mean that it does not exist. In fact, there has been a heated scientific debate about the usefulness of the hypothesis testing procedures employed by most of these evaluation studies (Shrout, P.E., 1997). For example, the fact that statistical procedures are generally geared towards preventing type 1 errors (claiming an

effect when there is in fact no effect) but at the same time are quite likely to lead to type 2 errors (failing to detect an effect when there is an effect) biases results towards non-significance. Furthermore, Crick and McKenna (1991) maintained that the lack of evidence for the benefits of road safety education / training may be ascribed to a lack of methodological soundness in previous evaluations and / or to the content of the course.

It is indeed interesting to note that many driver training evaluations have been published as technical reports and therefore were not subject to peer review. Often, evaluation studies have failed to use appropriate control groups and used hypothesis testing procedures inappropriately, with very little statistical power to detect any effects.

The content of the driver training courses that have been evaluated in the past tended to emphasise the teaching of vehicle control skills or alternatively, were classroom based. Since then, research has shown that increasing driver skills does not necessarily lead to safer drivers. For example, skid training may lead to drivers overestimating their own driving ability, without actually improving the way they manoeuvre the car (Gregersen, 1996). Furthermore, studies suggest that crash involvement is more often the result of risk taking behaviour, rather than poor driving ability (Clarke, Ward and Truman, 2005). Thus, driver training programmes which concentrate on vehicle handling skills, may actually lead to increased risk taking due to learners' inflated self-confidence and self-rated skills.

Consequently, a growing consensus among driver training and road safety researchers is that greater emphasis should be placed on higher level cognitive functions underlying driving skills (Senserrick, 2007). Some researchers have argued further that there is an urgent need for a holistic and structured plan of education and training that addresses all goals of driver education, as outlined in the 'Goals for Driver Education' (GDE) model (see Engstroem, Gregerson, Hernetkostki, Keeskinen, & Nyberg, 2003 for a comprehensive review on young drivers, driver education and training). At the same time there is a call for employing more sensitive and objective behavioural outcome measures, so that their accuracy can be increased and at the same time the probability for committing a type 2 error can be minimised.

We recently conducted a large scale driver training study (Isler, Starkey, Charlton & Sheppard, 2007) in New Zealand to compare the effects of training in higher level driving skills (such as eye scanning, hazard detection and risk management) and vehicle control skills (such as manoeuvring, braking and parking) on teenagers' real driving and risk taking behaviour, confidence levels and self-rated driving skills. Thirty-six teenage drivers (across a range of ethnic and social backgrounds) on a restricted driver licence were recruited via 500 secondary schools.

After the driver training camp, we installed telemetric data trackers in the vehicles of eight participants to pilot how well this technology measured post-training real driving behaviour. We tracked the driving behaviour of the participants for 32 weeks in order to evaluate if such data acquisition could help fill a methodological gap in driver training evaluations. From the outset, we knew

that the number of data trackers would be too small for making conclusive claims about any potential long-term effects of the driver training in our study. The idea was to test this new and promising evaluation technology and report on our findings.

Method

Participants

From a total of 36 participants who attended the driver training study, eight participants (4 males and 4 females) who brought their private vehicles to the training were selected to participate in this pilot study. They were all 16 years old and were required to hold a current New Zealand restricted driver's licence. This ensured that they all had some unsupervised driving experience. Their vehicles were fitted with a telemetric data tracking system and their driving behaviour was monitored on-line via the internet over a 32-week period.

The telemetric data tracking system

The tracking system consisted of a small credit card sized global positioning module (SmarTrak Lite GPRS / GPS) fitted with an accelerometer (Figure 1). The system was powered by the vehicles' battery (16 Volt). It took approximately 30 minutes to install the system in a vehicle. In order to obtain accurate data, the device had to be pointing forward and on a flat surface. In most cases it was installed below the driver's seat.

Figure 1. The telemetric data tracking system used in this study

This system uses a GPS receiver and provides reliable and accurate navigational data. The software for the tracking and reporting interface via the internet was developed by SmarTrak Ltd (www.smartrak.co.nz). It allowed us to monitor, in real time, the driving performance (updated every 2 seconds) of the eight participants on the computer screen (see Figure 4 as an example of a map

based online tracking). The built-in accelerometer also provided g-force data from the vehicles. Daily, weekly and monthly reports of the driving measures for each participant could be produced and downloaded as a Microsoft Office EXCEL spreadsheet.

The following driving measures were used as dependent variables in this study:

Distance driven:
> Number of kilometres driven for each trip

Number of trips:
> A trip started from a 'key on' event (starting the engine of the vehicle) to a 'key off' event (shutting down the engine).

Mean Speed per trip:
> Every 4 kilometres the current speed was recorded and the mean speed for each trip was calculated.

Maximum Speed: The maximum speed was recorded for each trip.

Speeding Violation: Each time a participant exceeded 100 km/h (62 mph), which is the maximum speed limit for New Zealand. Lower speed limit violations (e.g., driving 60km/h on a road with a 50km/h speed limit) were not monitored.

Large G-force: Each time the vehicle created a g-force (longitudinal or lateral) that was larger than 0.50 an event was triggered. The threshold setting was the same as that used by McGehee, Raby, Carney, Lee and Reyes (2007) for their event-triggered video driver intervention trial. Negative longitudinal g-force events indicated hard braking while positive events indicated levels of acceleration that would be difficult to reach without external impacts (e.g., rear end collision). The system did not allow differentiation between longitudinal g-forces created by hard braking and those created by hard cornering or swerving.

Results

Thirty six participants (15 females, 21 males) attended the driver training study where they were first assessed on a number of psychometric tests and asked to fill in a variety of driver behaviour questionnaires. The data from these pre-assessments are currently being analysed.

Participants were asked to rate how safe they felt driving in a variety of situations on a 5-point Likert scale (1=Very Safe to 5 = Very Unsafe; adapted from Bergdahl, 2005). The responses from the eight participants in this pilot study did not differ significantly from the responses of the other participants in the driver training camp, and therefore the results from all participants (N=36) are presented in Figure 2.

Most participants felt safe in the majority of driving situations, except after drinking (rated between unsafe and very unsafe), when they are sleepy or tired, and when they are angry or being tailgated (rated as between 'neither safe nor unsafe'

and 'unsafe'). Interestingly, they felt quite safe speeding at 120 km/h even though they indicated in a different questionnaire that speeding is one of the most frequent causes of young driver crashes.

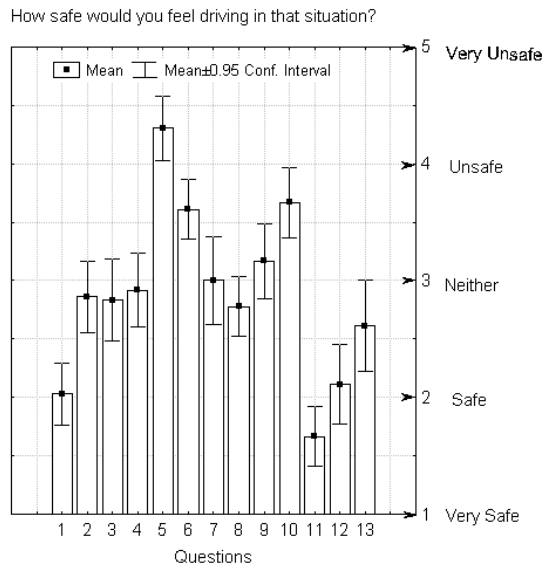How safe would you feel driving in that situation?

Figure 2. Mean responses and 95% confidence intervals of the participants in the driver training study (N=36) for the question: How safe do you feel driving 1) at night? 2) in an unfamiliar area? 3) in the city? 4) in bad weather? 5) after drinking? 6) sleepy or tired? 7) towing a trailer? 8) an unfamiliar car? 9) when angry? 10) when being tailgated? 11) at 100 km/h? 12) at 110 km/h? 13) at 120 km/h?

We received valid telemetric driving behaviour data from six of the eight participants for the entire 32 weeks' period. The data for one of the six participants (#8) was not analysed, as the tracking system did not provide the data for the variable 'distance driven'. Two of the participants crashed during the study and the GPS system allowed us to examine their driving behaviour just before (and, in one case, during and after) the crash.

Participant #1 crashed in week 19. The tracking system did not transmit any data during the crash as the power supply was disrupted, and we were not able to retrieve any data from the tracker in the crashed car (see Figure 3). The last data we received from the vehicle was two minutes before the crash occurred, indicating that the vehicle was travelling at 75 km/h sometime within that time period.

Figure 3. The crashed car of participant #1

The participant's account of the crash was as follows:

"*Hit a stationary vehicle parked half on / half off road. Was travelling at about 100 km/h when hit the vehicle. I just did not see the car - obviously lack of concentration. I was not text messaging or using phone prior to crash. I did have a passenger though I can't remember all that happened so I don't know what I was doing to not see the car*"

The participant suffered only some minor injuries but was shaken by the experience and decided not to drive for a while.

Participant #2 crashed in week 30. She started her journey at 6.24 a.m., lost control on a bend at 7.22 a.m. and swerved 180 degrees when she was hit by an oncoming car. For this incident we have a complete set of telemetric data available as the car was still functioning after the crash and power was continuously supplied to the data tracker. Figure 4 shows the map function of the on-line monitoring system listing the transmitted driving events on the right side of the map. The map revealed that the crash happened at 7:22 a.m. and was preceded by a large negative g-force (-0.56), probably caused by hard braking. At that time, the vehicle was travelling at 83 km/h when it swerved 180 degrees and hit an oncoming car creating a very large positive g-force (2.85). Within the same minute (7.22 a.m.) the car was decelerated to 1 km/h. We later received the information that the crash occurred during very wet driving conditions.
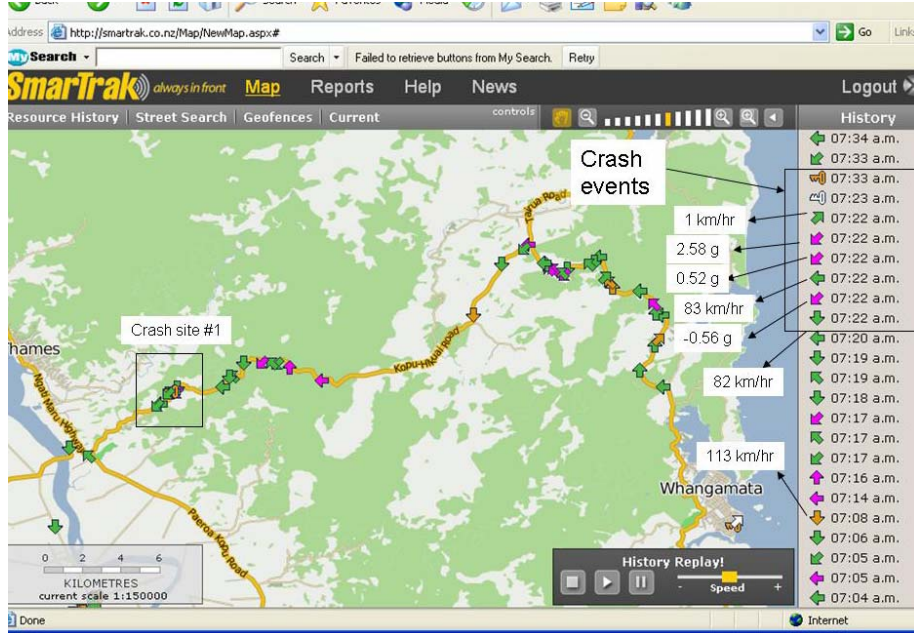
Figure 4. The map function of the on-line monitoring system (see text for explanations)

The vehicle of participant #3 was stolen in week 5, in an early morning at 2.43 a.m. It seems that the vehicle was used for a 'joy ride' that lasted 11 minutes. Telemetric data showed that the car created seven negative large g-forces (up to -0.65), possibly indicating unsafe driving before the data flow was interrupted at 2:54 a.m. We were later informed that the car was found burnt out in a remote parking area.

Table 1 shows the mean weekly distance driven (in kilometres, 1 km=0.62 miles), number of trips and mean speed per trip for 7 participants. As previously mentioned, the data from participant #8 could not be analysed. The table reveals that participants #1 and #2 travelled much longer weekly distances, compared to the other participants. Participant #7 had the smallest mean weekly number of trips. In addition, it is apparent that the weekly mean speeds per trip were by far the highest for participant #1 and #2.

Table 1. The mean (M) weekly distance driven (Dist) in kilometres (km), number of trips (Trips) and mean speed per trip (Mean Speed) in kilometres (km/h) for seven of the eight participants. Standard Deviations (SD), minimum (Min) and maximum (Max) values are also given.

Part.	Dist (km)	Trips	Mean Speed	Weeks

	M SD Min Max	M SD Min Max	(km/h) M SD Min Max	
#1	512 290 23 1317	47 14 11 74	81 5.3 60 89	1-32
#2	460 307 0 991	31 25 0 69	84 2.5 0 90	1-18
#3	206 160 5 499	43 19 14 66	51 8.6 40 63	1-6
#4	199 111 59 340	25 12 4 54	69 19.6 18 93	1-32
#5	242 827 0 827	46 32 0 168	65 14.7 0 87	1-32
#6	339 217 0 962	74 45 0 139	54 22.4 0 94	1-32
#7	110 63 0 270	33 11 0 5	69 17.3 0 84	1-32

Table 2 summarises the mean weekly maximum speed, number of speeding violations per 100 km and number of large g-forces per 100km for seven of the eight participants. It shows that participant #1 and #2 had the highest mean weekly maximum speeds. The number of mean weekly speeding violations per 100km was highest for participant #4, followed by participant #1. All participants had a great number of mean weekly large g-forces, with participant #1 and #2 having the two largest numbers. Participant #2, #5, #6, and #7 had some weeks without driving.

Table 2. Weekly means of maximum speed in km/h (Max Speed), number of speeding violations per 100 km (Speeding Viol) and number of large g-forces per 100 km (G-force) for seven of the eight participants

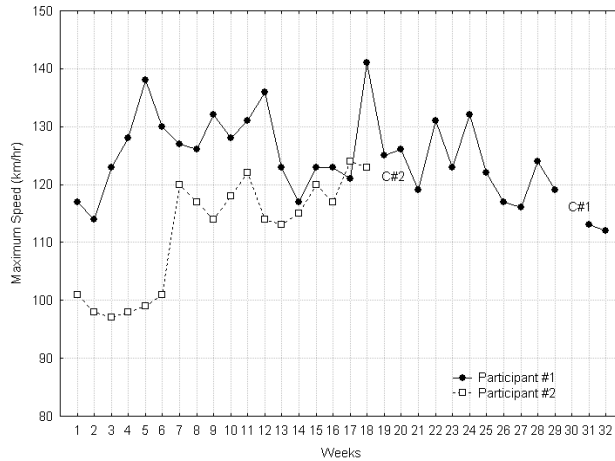| Part.	Max Speed (km/h) M SD Min Max	Speeding Viol M SD Min Max	G-force M SD Min Max	Weeks
#1	123 9.4 89 141	8.7 6.1 1.3 22.8	81 5.3 60 89	1-32
#2	112 9.4 97 124	1.9 3.0 0.0 10.7	84 2.5 0 90	1-18
#3	96 25.5 68 117	0.4 0.4 0.0 1.1	51 8.6 40 63	1-6
#4	98 27.5 27 126	8.9 10.1 0.0 31.4	69 19.6 18 93	1-32
#5	100 19.3 0 111	7.3 10.3 0.0 32.8	65 14.7 0 87	1-32
#6	111 32.9 0 138	3.8 5.4 0.0 23.5	54 22.4 0 94	1-32
#7	86 620 0 121	2.2 5.2 0.0 21.7	69 17.3 0 84	1-32

Figure 5. Mean weekly maximum speeds for participant #1 and #2. Participant #1 crashed in week 30 (C#1) but continued to drive in week 31 and 32. Participant #2 crashed in week 19 (C#2) and stopped driving.

Figure 5 shows mean weekly maximum speeds for participant #1 and #2 who crashed during the 32 week period after the driver training study. As the Figure shows, these participants had lower mean maximum speeds right after the driver training study with participant #2 keeping to the New Zealand maximum speed limit of 100 km/h for the first 6 weeks before there was a substantial increase in her maximum speed in week 7, and more or less maintaining it until she crashed in week 19. Participant #1 had much higher mean weekly maximum driving speeds which in some weeks reached up to 140 km/h. She had maximum speeds reaching 120 km/h for most weeks, except for the first two weeks after the driver training study and the two weeks following her crash.
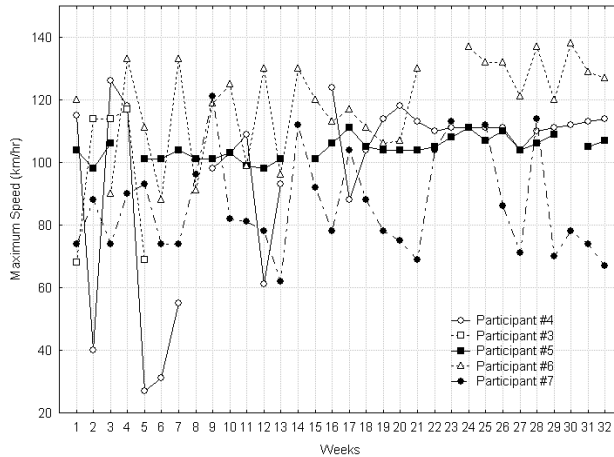
Figure 6. Mean weekly maximum speeds for participants #3 - #7.

Figure 6 shows the mean weekly maximum speeds for participants #3 - #7. The speeds varied considerably for all participants, except for participant #5 who reached maximum speeds at around 100 km/h for most of the monitored weeks. The other participants often reached maximum speeds of up to 120 km/h with participant #6 reaching speeds close to 140 km/h (week 32).

Discussion

Driving behaviour research literature has identified a need for more sensitive and objective intervention outcome measures. Thus, the aim of this pilot study was to test a telemetric data tracking system to measure post-training driving behaviour of young novice drivers. Specifically, this pilot study evaluated a tool that could help close a methodological gap that seems to exist in evaluation research of driver training interventions.

We received valid post-training real driver behaviour data from seven of the eight participants. Two participants, both living in rural areas, crashed their cars within the monitoring period, without being seriously injured. Their telemetric data indicated that they were travelling longer distances, had higher average speeds, and higher maximum speeds than any of the other participants. It is interesting to note that road crash statistics in New Zealand indicate that young drivers in rural areas are at greater risk of being involved in a severe crash, than those who live in urban areas. Consistent with our data, these drivers normally have a higher risk exposure as they typically drive longer distances and more frequently use rural roads that allow for higher speeds than roads in urban areas.

Speeding is known to be one of the most important factors of teenage crashes in New Zealand. However, our participants indicated that they felt relatively safe

when speeding, even at speeds as high as 120 km/h. This is a particularly interesting finding as most of the participants were aware that speeding is one of the most common causes of road crashes. Most participants in this study had maximum speeds reaching 120 km/h and some of them had speeds up to 140 km/h. It seems pertinent that driver training interventions should involve methods that could decrease this high risk behaviour. One of these methods could involve hazard anticipation training, using video simulation, which clearly improved speed choice behaviour (McKenna, Horswill, and Alexander, 2006).

All participants had many large g-force events, either caused by hard braking (longitudinal g-force), and / or hard cornering / swerving (lateral g-force). Our tracking system was not able to differentiate between these events and perhaps recorded also some non risky g-forces caused by hitting a bump / pothole in the road. An event-triggered video recording system manufactured by DriveCam and used by McGehee, Raby Carney, Lee and Reyes (2007), for their event-triggered video driver intervention trial could help verify the cause of each large g-force.

Hard braking events could have been caused by long hazard detection times of the participants which are typically 30% longer in inexperienced novice drivers compared to experienced drivers (Deery, 1999). Hazard detection times have been found to be related strongly to crash risk in young drivers and can be improved using road commentary methods or video based hazard detection training.

In summary, the telemetric data tracking system used in this study seems to be a promising research tool for evaluating post-training effects by providing an objective and sensitive driver behaviour outcome measures. By using the map based tracking function all the recorded driver behaviour events, including crashes could be mapped, replayed and analysed in detail on the internet. It also allowed us to create daily, weekly and monthly reports of important risk-taking behaviour variables (such as speeding, average speed, large g-forces) and could also provide information on risk exposure (driving distance).

In order to improve the system, an event triggered video recording system could help verify each large g-force that was created by the monitored vehicles. It would also be beneficial to record lower speeding events such as driving 60 km/h on a road with a 50 km/h speed limit, but this depends on GPS based speed limit data for all roadways being available.

To fully evaluate the utility of this system and the effects of a driver training intervention, ideally the tracking device would be installed into the vehicles of the participants several months before the driver training programme, in order to obtain data based on the participants real driving behaviour. Baseline driving behaviour in experimental and control participants can then be established, so that any potential changes in the post–training driving behaviour of the experimental group can be clearly attributed to the effect of the driver training.

Acknowledgment

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