Naturalistic Driving Studies: Literature Review and Planning for the Australian Naturalistic Driving Study

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Abstract

The *Naturalistic Driving Study* (NDS) is a research method with great potential to complement existing methods for collecting data on driver performance and behavior in normal, impaired and safety-critical situations. However, to date, no large-scale NDS projects have been undertaken in Australia. In this paper, naturalistic driving studies that have been undertaken previously are reviewed, the advantages for Australia in running large-scale naturalistic driving studies are discussed, and a project, led by the University of New South Wales in Sydney, Australia, is described that will culminate in the country's first large-scale NDS.

Keywords: road safety; naturalistic driving study; data collection; instrumented vehicles

Introduction

It is estimated that, by 2030, road trauma will be the 5th leading cause of death worldwide, ahead of cancer and HIV/AIDS (WHO, 2009), unless immediate action is taken. In Australia, around 1400 people die and 33,000 are seriously injured on average each year on our roads (ATC, 2011). The estimated annual cost of road trauma to the Australian community is $AUD 27 billion (BITRE, 2009). While Australia's annual road fatality rate declined from 22.3 deaths per 100,000 people in 1980 to 6.1 in 2010 (ATC, 2011), the rate of decline has slowed markedly over the last decade. In 2010 Australia slumped to 16th out of 27 OECD countries in terms of road fatalities per capita. The best performing countries (e.g., Sweden, the Netherlands) are presently achieving rates consistently below 4.0.

A cornerstone of Australia's past success in road safety has been the development of road safety strategies with prioritised interventions that are strongly evidence-based. To date, this evidence base has derived primarily from crash data collected by police and Coroners and in-depth investigations, hospital data, exposure data available in licensing and registration databases and Australian Bureau of Statistics (ABS) surveys. However, these data collection methods are limited in the depth and quality of information they provide - especially information about *human* factors (as distinct from vehicle and environmental factors), which are the primary contributing factor in most collisions (Antin et al, 2011) and which can often only be inferred, if at all, from available evidence after a crash. Existing data collection methods rely on limited accuracy of drivers' and witnesses' recall of events; for crashes, on retrospective physical evidence with little or no pre-crash information about other vehicles and road users involved; and for surveys, the unknown 'self-reported' biases (Gordon, 2009). Poor levels of training of investigating personnel, and inadequate design of Police reporting forms, along with other factors, may further compromise the accuracy and quality of information collected, especially on contributing human factors.

The *Naturalistic Driving Study* (NDS) is a research method, pioneered by the Virginia Tech Transportation Institute (VTTI), in the United States, that has potential to overcome many of these limitations. In a NDS, volunteer participants (hundreds or even thousands of them) drive a vehicle (usually their own) for 6 to 12 months, or more, fitted with an unobtrusive Data Acquisition System (DAS) which records continuously their driving behavior (e.g. where they are looking), the behavior of their vehicle (e.g. speed, lane position) and the behavior of other road users with whom they interact (e.g. other drivers, motorcyclists, cyclists and pedestrians), in normal and safety-critical situations. Each DAS, depending on its capabilities, incorporates multiple sensors (video cameras, GPS, radar, accelerometers, etc) – to provide a complete, continuous, picture, of driver, vehicle and road user behavior in all driving situations. Recorded DAS data are uploaded and transferred remotely to a central database for further processing and analysis. The DAS units can be fitted to cars, trucks and motorcycles.

The NDS method overcomes a range of problems associated with traditional approaches to data collection (Backer-Grondahl et al, 2009): it yields information about normal behavior and about all types of crashes, including property damage crashes, which may go unreported, and near-crashes, which are never reported; and it allows for direct observation of driver behaviours, without the previously noted biases and errors of traditional methods. Furthermore, while the extant evidence base is reliant to some extent on experimental data (e.g. from simulators), it has been long known that, for various reasons, drivers do not always behave in simulators as they do in the real world. There, however, some potential methodological and other limitations associated with the NDS method: they are very resource demanding in terms of sample recruitment, data gathering, data storage and data analysis (Backer-Grondahl et al); driver behavior may be influenced by knowledge of the presence of cameras and other sensors; crashes are rare events and thus very large sample sizes are needed to yield sufficient crash events; and, although large-scale studies may yield thousands of near-crash events, the validity of near-crash events as surrogates for crash events remains unresolved.

To date, around 40 naturalistic driving studies have been undertaken around the world, almost all of them in the United States. These have focused on cars, trucks and (to a far lesser extent) motorcycles and bicycles, have varied widely in terms of number of participants (from less than 10 to more than a thousand; e.g., Antin, et al., 2011; the US Strategic Highway Research Program [SHRP 2] NDS) and in elapsed recorded driving time (from less than a week to up to 2 years). While there have been some research studies undertaken in Australia using instrumented vehicles to record driver and vehicle behavior (e.g., Regan et al., 2006, for understanding driver interactions with advanced driver assistance systems; Koppell et al., 2011, to understand driver distraction from child occupants), we have not conducted in this country a large-scale NDS. In this paper, we (a) review naturalistic driving studies that have been undertaken previously in other countries, (b) outline what we see as the key advantages for Australia in running large-scale naturalistic driving studies (in addition to those previously described), and (c) describe a project, created and led by Transport and Road Safety (TARS) Research, at the University of New South Wales in Sydney, Australia, which will culminate in Australia's first large-scale NDS ("The Australian Naturalistic Driving Study") and provide the springboard for many follow-on studies.

Review of previous naturalistic driving studies

Around 40 naturalistic driving studies have been undertaken, almost all of them in the United States. In this section of the paper they are reviewed briefly under seven broad headings:

Driver Characteristics; Driver Error; Driver Distraction/Inattention; Driver Fatigue/Sleep Deprivation; Interactions between Vehicles; Driver Assistance Systems; and Eco-Driving. This is not a critical review, but rather a survey of studies undertaken which illustrates the limited range of issues that have been addressed, and highlights the fact that such studies are becoming in other parts of the world a routine method for data collection.

Driver characteristics

Crashes and near-crashes involving novice teen drivers and experienced adult drivers were examined in an NDS undertaken by Lee et al., (2011). The vehicles of 42 teen and parent pairs were instrumented with DAS units that collected video and kinematic sensor data continuously, over a period of 18 months, commencing within three weeks of licensure for the teen drivers. It was found that crash and near-crash rates were higher for the novice teen drivers than for the adult drivers. Furthermore, crash and near-crash rates among teen drivers were highest during the first six months of the monitoring period, and declined steadily and significantly during the following 12 months.

Prato et al (2010) investigated the driving behaviour of teen drivers in the first year after licensure in the Israeli Graduated Driver Licensing (GDL) program. A key component of that program is an accompanied driving period in the first three months after licensure. Sixty two novice young drivers were monitored over a period of 12 months immediately following licensure, including three months of accompanied driving and nine months of solo driving. Each of the drivers' vehicles was instrumented with DAS units that collected continuously driving data including speed, acceleration, driver manoeuvres, and trip start and end times. Prato et al. (2010) found that people with higher sensation seeking tendencies were more inclined toward risky driving behaviour, and were most likely to exhibit such inclinations after being allowed to drive without supervision. It was also reported that a higher level of experience acquired during the accompanied driving period led to lower risk taking behaviour during the solo driving period, highlighting the importance of GDL for young drivers.

The NDS method has been used to evaluate the effects of providing feedback to novice young drivers and their parents in promoting safe driving behaviours. In a study investigating the effects of video and graphical review feedback, a group of 26 novice young drivers was monitored over a period of 12 months (McGehee, et al, 2007). Participants' vehicles were equipped with an event-triggered video recording system, which recorded 20 seconds of data when sensor values exceeded a safety limit threshold. Feedback to drivers was provided immediately in the form of an LED light that blinked when acceleration threshold values were exceeded, and in a weekly mentoring session involving parents in the form of graphical report cards and video reviews. Similarly, Lotan and Toledo (2005) provided feedback to drivers using NDS data. A total of 120 novice young drivers were monitored over 8 months, using in-vehicle DAS units that continuously recorded driving behaviours and manoeuvres, acceleration, and speed. Feedback was provided in real time, in the form of SMS text messages to parents or on in-vehicle displays, or off-line, in the form of a monthly driver report. Overall, the data showed that providing feedback to novice young drivers and their parents was helpful in reducing unsafe driving behaviours. Video feedback with parental mentoring produced a significant decrease in the number of safety-relevant driving events in novice teen drivers, and this decrease was evident within the first nine weeks of the feedback intervention.

Older drivers have also been observed using the NDS method. Blanchard et al (2010) monitored 61 older adult drivers over a one-week period. Each participant's vehicle was instrumented with a DAS unit that recorded continuously driving trip information including time of day, distance, duration, roadways, turns, and manoeuvres. Myers et al (2011) used a similar system of data recording devices to monitor a group of 47 older adult drivers over two weeks. Both studies found that older adult drivers often mis-estimate their driving exposure and travel patterns, and that they may not regulate or adjust their driving as much as they indicate they do in self-report measures. In addition, a number of factors were found to influence older adults' driving exposure and travel patterns, including gender, season, weather and road conditions, self-ratings of driving comfort, and self-ratings of perceived driving abilities (Myers et al., 2011).

People with early stage or developing dementia represent another group of high-risk drivers. Dementia affects many critical skills needed for driving. However, many people with Alzheimer's disease continue to drive, especially in the initial stages of the condition when cognitive deficits are mild. The driving behaviour of a group of 17 drivers with early stage dementia was monitored over one month (Eby et al., in press). Data acquisition systems and sensors were used to collect video, audio, relative speed and distances to other vehicles and objects in front, acceleration, yaw rate, GPS position, heading, speed, and time of day. Compared to older drivers without dementia, those with dementia were found to be more likely to follow too closely, drive slower than surrounding traffic more often, and use seat belts less often. Drivers with dementia also had significantly less driving activity, where they drove shorter distances, to fewer destinations, and avoided freeways. Most only drove during daytime. In a related NDS, Silverstein et al. (2009) monitored the driving behaviours of a group of 12 drivers with dementia for at least one month. Results showed that in-vehicle data collection could be useful for comparing with and determining the validity of the recommendations of clinicians, family, and self-screening for drivers with dementia. Thus, using in-vehicle devices to monitor driving behaviours of people with dementia could yield greater insights to inform decision-makers about driving competency and appropriate intervals for on-going assessment. The driving of people with visual impairments has also been examined using the NDS (Luo & Peli, 2011).

Driver error

A number of studies have used the NDS method to examine the impact of driver errors on safety outcomes. Uchida et al. (2010) used instrumented vehicles to study accident causation in Japan. Incident data were recorded and analysed by monitoring a group of 60 drivers over a period of 18 months to two years. In-vehicle DAS units were used to record video, audio, and kinematic sensor data when triggered by sensor threshold values of acceleration and deceleration. To identify and examine specific key contributing factors, incidents at intersections involving vehicles turning right and motorcycles going straight ahead were analysed. Results showed that drivers who experienced near-crashes with motorcycles at intersections initiated the right turn despite there being obstructed view caused by an oncoming right turning vehicle. Furthermore, the longer the drivers' gaze was directed away from the opposite lane, the greater was their delay in detecting the motorcycle going forward, and consequently the more pronounced was the near-miss.

In a study by Toledo et al (2008), a group of 191 drivers who drove compact pickup trucks was monitored for eight weeks. Their vehicles were instrumented with sensors, accelerometers, and a data recording unit that continuously recorded speed, acceleration, location, and other trip details. It was found that risk indices for drivers were associated with their actual accident history, and that driving behaviour (measured as risk indices) changed following exposure to feedback. There was a reduction in crash rate from the period before to after exposure to feedback, although the same pattern was not found when only looking at at-fault crashes. In another study, 109 car drivers were monitored for approximately one year in the seminal “100-Car NDS” in the US (Klauer et al., 2006). In-vehicle data acquisition devices recorded sensor and video data continuously. Four behaviours or driving states were found to be associated with an increased risk of being involved in a crash or near-crash, including driving at inappropriate speeds, driving while drowsy, eye glances away from the forward roadway for greater than two seconds, and aggressive driving behaviours. In addition, high-risk drivers were less likely to wear a safety belt, more likely to drive while drowsy, and have critical incident rates of more than 100 times greater than that of low-risk drivers. Finally, older drivers were found to have lower risk of involvement in critical incidents than younger drivers.

Driver distraction/inattention

A number of studies have used the NDS to investigate the causes and impacts of driver distraction or inattention. Data derived from the “100-Car NDS” (Klauer et al., 2006) showed that “inattention” (defined as including secondary task distraction, driving-related eye glances [e.g. checking blind spot], moderate to extreme drowsiness, and other non-driving-related eye glances) was involved in a vast majority of lead-vehicle crash and collision events, and that the majority of crashes and near-crashes involved the driver looking away from the forward roadway just prior to event onset (Dingus et al. 2006). Furthermore, engaging in complex secondary tasks and driving while drowsy increased a driver’s crash and near-crash risk by two to six times, respectively, compared to normal baseline driving (Klauer et al., 2006).

To examine the occurrence and impact of events and activities that can draw a driver’s attention away from activities critical for safe driving, 70 drivers were monitored for one week using a continuous in-vehicle video recording system (Stutts et al, 2005). Driver distraction from child occupants has also been examined using similar methods. Twelve drivers with young children were monitored by Koppel et al (2011) for three weeks using a continuous video recording system that captured front seat passenger and child occupant activities. Both studies observed that engaging in one or more potentially distracting activity (excluding any time spent simply conversing with other passengers) is a frequent occurrence in everyday driving. Children and front seat passengers were found to be large sources of distraction to drivers; drivers were often distracted by child occupants for three seconds or more (Koppel et al., 2011). Distractions can negatively affect driving performance, as measured by higher rates of drivers having no hands on the steering wheel, eyes directed inside rather than outside the vehicle, and vehicles wandering and crossing lane lines (Stutts et al., 2005).

Truck driver distraction has also been examined. Barr et al (2003) monitored six truck drivers for two weeks using a continuous in-vehicle video recording system, while Hanowski et al (2005) collected in-vehicle video and driving performance data from 33 truck drivers. Olsen et al (2009) reported data from two studies characterising truck driver inattention in safety critical events, where 103 truck drivers were monitored for 12 weeks in the first study, and a separate group of 100 truck drivers were monitored for four weeks in the second study. Data acquisition devices were used in trucks to record kinematic, video and audio data. As for car drivers, engaging in potentially distracting activities was found to be a common occurrence for truck drivers (Barr et al., 2003). Moreover, truck drivers engaging in any complex secondary task had an increased risk of being involved in a safety-critical event, and this effect held true across different environmental conditions (Olson et al., 2009). Finally, task characteristics including frequency and duration of glances, and visual demand, were found to contribute in combination to the prevalence of critical incidents (Hanowski et al., 2005).

Driver fatigue/sleep deprivation

To assess safety-related fatigue issues among long haul (LH) truck drivers, in-vehicle devices were used to collect sensor and video data from 56 drivers, including 30 single drivers and 26 team drivers comprising 13 teams (Dingus et al., 2006). Single drivers, compared to team drivers, were found to have many more critical incidents, at all levels of severity, and this difference could not be accounted for by age, experience, or hours driven alone. Further, the frequency of fatigue-related critical incidents varied significantly by hour of the day. However, the largest number of cases of very drowsy single drivers occurred in the late afternoon and early evening hours, indicating that interaction with heavier traffic had a greater impact on the occurrence of incidents than did fatigue due to circadian rhythm effects.

The hours-of-service regulation for LH truck drivers in the US was revised in 2003 to include a two-hour extension of off-duty time from 8 to 10 hours, and a one-hour extension of allowable driving time from 10 to 11 hours. To determine the effects of extended off-duty time on sleep quantity and involvement in critical incidents, 82 LH truck drivers were monitored for 16 weeks using instrumented vehicles and sleep monitors (Hanowski et al 2007). Results showed that drivers appeared to be getting more sleep under the revised regulations. However, fatigue-related critical incidents still occurred. Importantly, in the period before a critical incident, driver sleep quantity was significantly less than the overall average, even for incidents where the driver was not at fault. To determine whether there was an increase in risk associated with the increase in allowable driving time, data from 103 LH truck drivers who were monitored for 12 weeks in a previously mentioned study were analysed (Hanowski et al., 2009). The first driving hour was found to be associated with higher frequency of critical incidents relative to other driving hours, while the second through eleventh driving hours were not consistently different from each other. Consistent with Dingus et al. (2006), critical incident occurrence was found to vary as a function of time of day, where incident frequency by hour had a strong positive relationship with traffic density by hour. Data from the same 103 LH truck drivers were analysed to examine differences in the frequency of fatigued driving episodes based on body mass index (BMI) among LH truck drivers (Wiegand et al., 2009). Obesity was found to be a safety issue in LH truck drivers, with a higher risk for driving while fatigued for obese drivers relative to non-obese drivers, and greater likelihood to experience a safety-critical incident.

Driver fatigue has also been investigated among local/short-haul (SH) truck drivers. A group of 42 SH drivers were monitored for two weeks using in-vehicle devices that collected video data, a driver alertness measure, and driver attention and performance measures (Barr et al., 2005; Hanowski et al., 2003). Overall, a significant level of incident involvement was found when signs of fatigue were present immediately prior to an incident where the participant driver was at fault. Drivers involved in at-fault incidents also had less sleep and poorer sleep quality compared to drivers who did not show signs of fatigue (Hanowski et al., 2003). When examining the relationship between driver fatigue and driving condition, it was found that, in the majority of cases, drowsiness occurred during periods of extremely low driver workload, brought on by boredom and monotony. In these cases, drivers often engaged in secondary activities typically associated with driver distraction. Moreover, undivided highways and poor visibility increased driver attention and reduced fatigue (Barr et al., 2005).

Interactions between vehicles

Light vehicles are extremely vulnerable when they interact with large trucks. Two studies have used instrumented vehicles to examine interactions between light and heavy vehicles, one from the perspective of light vehicles (Hanowski et al., 2006), and one from the perspective of heavy vehicles (Hanowski et al., 2007). From the perspective of light vehicles, incident data involving interactions with heavy vehicles from the "100-Car NDS" were analysed (Hanowski et al., 2006). From the perspective of the heavy vehicles, truck drivers, 48 LH and 42 SH drivers, were monitored using the same system of data collection devices as were used in the "100-Car NDS" - for between one and two weeks (Hanowski et al., 2007). In both studies, it was found that the light vehicle driver initiated the critical incident (i.e., were at fault) in the majority of critical incidents involving light vehicle–heavy vehicle interactions, while there were substantially smaller proportions of incidents where the heavy vehicle driver was at fault.

Other NDS studies

It is difficult, in the limited space available here, to review in detail the remaining studies known to the authors that have utilised the NDS method. Several such studies, which can be lumped loosely under the heading "Driver Assistance Technologies", have used the NDS method to investigate the impact and usability of advanced driver assistance systems (Sayer et al., 2005, 2007; Sullivan et al., 2008; McLaughlin et al., 2008). A final cluster of studies, which can be lumped under the heading "Eco-Driving", have used the NDS method to identify driving patterns that have the greatest effects in minimising fuel consumption and vehicle emissions (Ericsson, 2001), and to evaluate in instrumented vehicles the long-term effects of training programs designed to promote economical driving patterns (Beusen et al., 2009, in cars; af Wåhlberg, 2007, in buses).

What are the advantages of the NDS over existing data collection methods?

The NDS offers a new, complementary approach, to existing methods for understanding driver and vehicle behavior in normal, impaired and safety-critical situations. The literature reviewed above is illustrative of how the NDS can be designed to yield data that can support development of new and optimized road safety-related countermeasures. There are several. general, advantages to be gained in running naturalistic driving studies:

- **Exposure**: New and more detailed data can be collected on driver exposure to a wider range of driver, vehicle, road, traffic and environmental factors that increase crash risk; e.g. to speeding, inappropriate vehicle positioning (eg tailgating), being distracted/inattentive, carrying passengers, disobeying road signs and signals, driving at night; driving in poor weather; driving in the country; etc.
- **Crash risk**. Having better exposure data makes it is possible to calculate odds ratios (relative risk) and population attributable risk percentages (proportion of crashes) for a much broader range of risky activities to which drivers expose themselves; and the derivation of odds ratios that are more situational-specific eg "the risk of traveling 5km/hr over the speed limit for a young driver driving at night on a country road, carrying a passenger".

- **Near-Crashes.** Data on the thousands of near-crashes that occur regularly on Australian roads, but which are never reported, would be retrieved, yielding previously unavailable data on how near-crashes come about – between drivers and other road users (pedestrians, motorcycle riders, cyclists, car drivers, truck drivers, etc) – and on how road users prevent near-crashes with other road users from becoming crashes. Such data can be used to, among other things, optimize training and education programs, and optimize the design of advanced driver assistance systems, the traffic management system, and the road environment.
- **Crashes**. Typically, there have been few crashes in naturalistic driving studies, because the number of vehicles/drivers involved in them has been in the order of hundreds (e.g., Klauer et al., 2006) rather than thousands (e.g., Antin et al., 2011). Nevertheless, the crashes that do occur reveal the truth – the factors that actually contribute to crashes. Furthermore, it is possible to discover what factors turn a near-crash into a crash, and hence to understand the critical differences between near-crashes and crashes. Such data can be used, for example, to optimize the design of advanced driver assistance systems, the traffic management system, and the road environment.
- **Normative data**. As noted, the NDS provides normative data for international benchmarking that provides a confirmatory check on the applicability to Australia of other NDS data. The NDS makes it possible to gather fundamental data on how people drive – how they avoid crashes, navigate, maintain speed, adhere to traffic laws; stay within their lane; control the vehicle etc – and how this varies according to age, experience, driver state (eg drunk, distracted), driver condition (impaired; demented, etc) and other factors. This data can be used to build and refine models of driving behavior, refine traffic micro-simulations, develop training and education programs, etc.
- **Violations**. The NDS can provide the road safety community with a better understanding of which traffic laws are violated, by whom (drivers and other road users), where, when (e.g., at night) and in what situations (eg when distracted, drunk). This data can be used to improve traffic laws, optimize Police enforcement regimes, and re-design traffic management practices, among other things.
- **Validation**. Objective data yielded by the NDS can be used to validate findings that emerge from self-report studies of driver behavior, from on-site observational studies and from human-in-the loop simulation studies. Drivers do not always do what they say they do (e.g., Myers et al., 2011) and not all findings from simulators are replicated in real traffic, and vice-versa (e.g. Olson et al, 2009). In the case of crashes, causal factors derived from the NDS can be compared with those cited in Police report forms to validate Police reports. Evidence from NDS studies in the USA indicates that crashes recorded both by DAS units and Police are miscoded routinely by Police.
- **Evaluation**. Traditionally, Australia has placed great emphasis on the need to evaluate countermeasures, to determine whether they are effective and how they can be optimized. The NDS, suitably designed, can be used to derive new data that can be used to evaluate the effectiveness of new and existing countermeasures eg of advanced driver assistance systems; of training programs; of new road design treatments; of new traffic signaling arrangements; of new Police enforcement regimes; of new laws; etc

Findings from naturalistic driving studies are already influencing road safety stakeholders. In the USA, for example, findings from NDSs have informed the Ford and General Motors approaches to managing driver workload and inattention (e.g., Shutko & Tijerina, 2011), and the National Highway Traffic Safety Administration's Driver Distraction Program (NHTSA, 2010); and the SHRP2 NDS, which will involve around 3,000 vehicles (Antin et al., 2011), has been designed specifically to yield data that will be used to improve road safety.

Why run a NDS in Australia?

Given that several large-scale naturalistic driving studies have been undertaken already in other countries, it is reasonable to ask “why run one here in Australia”? There are at least four reasons for doing so.

First, there are many high priority road safety problems identified in the Australian National Road Safety Strategy (ATC, 2011), and in state and territory road safety strategies, that could be better understood (for the reasons discussed previously), by conducting a NDS in Australia, and which have not been explored in any previous NDS studies. These include (at the national level) speeding, drink driving, drugged driving, heavy vehicle crashes, head-on crashes, single vehicle run-off-road crashes, crashes involving pedestrians, cyclists and motorcyclists, failure to wear seatbelts, and differences in driving behavior between people from urban, regional, remote and disadvantaged parts of Australia. Take speeding, for example. It is often said that “speed kills”; but sometimes it does, and sometimes it does not. The NDS provides a means for understanding the driver, vehicle and environmental factors, and the complex interactions between them, that determine in which situations speeding does and does not kill. Secondly, it cannot be assumed without conducting a local NDS that that findings from international NDS studies are valid for Australia. Factors that are likely to threaten transferability of data include differences across countries in cultures and societal norms, road laws, vehicle fleets, road environments, environmental conditions and mix of road users. Thus, if an Australian politician or policy maker were to ask “Are the SHRP 2 data applicable to Australian drivers”, the answer is “we don’t really know”; because we have not run in Australia a NDS to benchmark driving behavior and performance across the two countries.

Thirdly, even if the data from previous NDS projects were applicable to Australian drivers, access to that data by Australian researchers and authorities cannot be guaranteed. The data from those studies may not be accessible to Australian researchers for ethical, commercial or other reasons. It is possible, for example, for Australian researchers to obtain access to some of the NDS data collected previously by VTTI in US studies. However, not all data from their studies are accessible, and there is no access to video data, which is the richest data source. Finally, and perhaps most importantly, the NDS is a state-of-the art methodology. If Australia is to regain and maintain its international leadership in road safety, developing a national capability to run such studies is essential.

The Australian Naturalistic Driving Study

Transport and Road Safety (TARS) Research, at the University of New South Wales, in Sydney, Australia, has initiated and is leading a project – “The Australian Naturalistic Driving Study” – that involves development of a national capability to support and run large-scale naturalistic driving studies in Australia, and the running of the first NDS. The first NDS will be an international project that brings together researchers from four leading universities in Australia – the University of NSW (via TARS), Monash University (via MUARC), the University of Adelaide (via CASR) and the Queensland University of Technology (via CARSS-Q) - and one of the leading transport safety research institutes in the United States (The Virginia Tech Transportation Institute; VTTI). The project also brings together key road safety-related stakeholders from government and industry in Australia. Several industry partners have at this time pledged strong support for the project: the Centre for Road Safety at

Transport for NSW; VicRoads; the Transport Accident Commission in Victoria; the Motor Accident Commission in South Australia; and the Office of Road Safety, Government of Western Australia. The overall aim of the project is to create a national facility, like that at VTTI in the USA, that can be used to support the running of naturalistic driving studies in Australia and to use the facility over the coming decade to run multiple naturalistic driving studies in a range of vehicles (cars, trucks, and motorcycles), the first of these being the Australian NDS. The data collected will be comparable, in a technical sense, to that being collected in the SHRP 2 NDS, currently underway in the United States, given that the DAS units to be used in the Australian NDS, and the data management protocols being used to de-encrypt, pre-process and store the data will be the same in both studies.

At this point in time, the design of the first NDS has only just commenced. However, it is envisaged that it will involve the collection of around 200 vehicle years of data over a 2-year period, commencing in mid-2013. The focus of the data collection will be on drivers of passenger cars, and their interactions with their own vehicles, the road environment and other road users. Around 25 DAS units will be deployed in each of 4 Australian states: NSW, Victoria, South Australia and Queensland. In each state, the DAS units will be rotated between the host vehicles on 4 occasions (every 6 months) to enable data to be collected in each state from 100 vehicles. The data collected from the 400 vehicles will be downloaded by the research team in each state, and then transferred to a secure central database located at UNSW. From there it will be sent via the internet to VTTI in the USA for further processing, and stored in a form ready for downloading (via the internet) and analysis by the 4 Australian research teams (TARS, MUARC, CASR and CARRS-Q). A small "pilot" study is being undertaken by TARS in 2012, in conjunction with VTTI and Transport for NSW, to test the interoperability of a sub-set of the VTTI-supplied DAS units to be deployed in 2013, and associated data management systems.

Discussion and Conclusions

An increasing number of naturalistic driving studies are being undertaken around the world, with large-scale studies having been undertaken in the US and Japan. The literature surveyed reveals that, despite the enormous range of issues that might be explored in such studies, relatively few have been explored, and many road safety issues of importance in Australia remain to be explored using this method. We have outlined in this paper what we see as the advantages in running naturalistic driving studies in Australia, and more generally the advantages they could offer in complementing existing techniques for gathering data to support countermeasure development. The first Australian NDS, even on its own, will provide a "living" database of information that can be used for many years to improve countermeasure development, save lives, and improve Australia's road safety performance relative to other OECD countries.

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