The Australian Naturalistic Driving Study: from beginnings to launch

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Abstract

The Australian Naturalistic Driving Study (ANDS), a ground-breaking study of Australian driver behaviour and performance, was officially launched on April 21st, 2015 at UNSW. The ANDS project will provide a realistic perspective on the causes of vehicle crashes and near miss crash events, along with the roles speeding, distraction and other factors have on such events. A total of 360 volunteer drivers across NSW and Victoria - 180 in NSW and 180 in Victoria - will be monitored by a Data Acquisition System (DAS) recording continuously for 4 months their driving behaviour using a suite of cameras and sensors. Participants' driving behaviour (e.g. gaze), the behaviour of their vehicle (e.g. speed, lane position) and the behaviour of other road users with whom they interact in normal and safety-critical situations will be recorded. Planning of the ANDS commenced over two years ago in June 2013 when the Multi-Institutional Agreement for a grant supporting the equipment purchase and assembly phase was signed by parties involved in this large scale $4 million study (5 university accident research centres, 3 government regulators, 2 third party insurers and 2 industry partners). The program's second development phase commenced a year later in June 2014 after a second grant was awarded. This paper presents an insider's view into that two year process leading up to the launch, and outlines issues that arose in the set-up phase of the study and how these were addressed. This information will be useful to other organisations considering setting up an NDS.

Background

Naturalistic driving studies (NDS) are one of the most exciting developments in road safety in recent years. In an NDS, volunteer participants drive an instrumented vehicle (usually their own) fitted with an unobtrusive Data Acquisition System (DAS) for a period of months. The system continuously records their driving behaviour (e.g. where they are looking), the behaviour of their vehicle (e.g. speed, lane position) and the behaviour of other road users with whom they interact (e.g. other drivers, motorcyclists, cyclists and pedestrians). When the first 100-car study conducted by Virginia Tech Transportation Institute (VTTI) was made public, the excitement about the possibilities that had opened up was palpable (Dingus et al, 2006). There was general consensus that studying 'natural' driving would provide a range of new insights into how drivers manage the demands of driving in the real world.

Traditionally, road safety has focussed on crashes and fatalities, derived primarily from crash data collected by police, in-depth crash investigations, Coroners' and hospital data and from data from surveys on driver exposures to risk as this has been the best available data. These data sources are

severely limited in the depth and quality of 'real-world' information they provide about driver and road user behaviour and performance, which are primary contributing factors in most collisions (Antin et al, 2011). Furthermore causal characteristics can often only be inferred, if at all, from available evidence after a crash or from surveys with confounding from unknown self-reported biases (Gordon and Regan, 2013). Existing data collection methods rely on the limited post-crash accuracy and biases of driver and witness recall of events and on retrospective physical evidence from crash scenes - with little or no pre-crash information about other vehicles and road users involved. Naturalistic driving studies provide the opportunity to study what drivers do and how they handle the broad range of components of the road system: their vehicle, the road, road infrastructure and road regulations. These studies also open up new opportunities for understanding how drivers interact with these various components, how they deal with hazards of driving and the conditions in which risky driving occurs as well as how drivers adapt to risky driving situations and, most importantly, about how drivers avoid crashes.

The development of the Australian Naturalistic Driving Study

The first large scale NDSs were conducted in the USA. Australia was not far behind. Currently naturalistic driving studies are being conducted in Canada, China and the EU. In Australia, the impetus was taken by a consortium of university researchers, who combined with road safety authorities, partners and organisations to develop a proposal to conduct a naturalistic study in Australia. One of the main reasons these studies are occurring at this time is that the technology is emerging that can collect the data about the driver, vehicle and environment that are needed, and that can store and analyse the enormous amount of data generated. However, these studies are expensive. The consortium was successful in attracting Australian Research Council funding, first for the equipment, and then for conducting the project, in partnership with funding from road authorities, industry partners and universities.

With studies springing up all over the world now, it is reasonable to ask: why do we need one in Australia? Primarily, it is because our driving conditions, environment, composition of our vehicle fleet and driving regulations and culture are different from other parts of the world. A considerable number of studies have shown that country and even regional differences like population density (Eksler et al, 2008), structure and culture (Wegman and Oppe, 2010) and socioeconomic factors (Hollo, et al., 2010) play a role in road safety outcomes. Furthermore, while previous NDS projects have yielded some valuable insights into driver and road user behaviour in general, their applicability to the Australian context is questionable for several reasons. First, they have not yet explored many of the high priority, and intractable, road safety problems identified in the Australian National Road Safety Strategy (ATC, 2011). Speed choice and vulnerable road user interactions, in different situations, and in urban versus regional areas, are good examples (ATC, 2011). Second, it is not clear how well the findings translate to Australian conditions. Differences in cultural and societal norms, road laws, enforcement, vehicle fleets, road environments, distances travelled, environmental conditions and mix of road users may threaten the transferability of data across countries.

Developing the Australian Naturalistic Driving Study (ANDS) has involved researchers from four Australian universities (TARS Research at UNSW, MUARC at Monash University, CASR at Adelaide and CARRS-Q at QUT), representatives of road authorities (Centre for Road Safety in NSW, VicRoads and Office of Road Safety at Main Roads Western Australia) and insurers (Transport Accident Commission or TAC in Victoria, Motor Accident Commissions or MAC in South Australia) as well as the National Roads and Motorist Association (NRMA). Recently Hyundai and Seeing Machines have joined the consortium. Much of the initial discussions were about the best approaches to large-scale instrumentation of vehicles. After weighing up many options, it was decided to purchase the Data Acquisition Systems (DAS) developed by Virginia

Tech Transport Institute (VTTI). This decision was based on the following: VTTI had the most experience with studies similar to the one planned for Australia, their DAS was judged at the time to be the most capable for the price and readily available for installation and, most importantly, they had extensive expertise in analysis of the large datasets that are generated by the video and sensor equipment installed in each vehicle.

The final design of the ANDS project involves recruitment of 360 volunteer drivers (180 from New South Wales and 180 from Victoria) who will have their private vehicle equipped with the instrumentation for 4 months. The system silently records each participant's driving behaviour (e.g. where they are looking; engagement with secondary tasks), the behaviour of their vehicle (e.g. speed, lane position) and the behaviour of other road users with whom they interact (e.g. other drivers, motorcyclists, cyclists and pedestrians) in normal and safety-critical situations. Each data collection system incorporates multiple sensors (video cameras, a still camera, GPS, radar, accelerometers, etc.) to provide a complete picture of driver, vehicle and road user behaviour in all driving situations they encounter.

The ANDS differs from previous naturalistic studies in other countries in a number of ways. These differences include:

Vehicles will be instrumented for a shorter period: As in all naturalistic studies, drivers will have their own car instrumented with data recording equipment, allowing continuous recording of the participating drivers' behaviour and those of others with whom they interact. However, unlike other studies that instrument each vehicle for 12 months, in the ANDS each vehicle is instrumented for 4 months. This has the benefit of increasing the number of drivers and vehicles that can be included in the study. However, instead of studying 100 driver/vehicles for 12 months, ANDS is recruiting 360 driver/vehicles for 4 months. Longer study periods for each driver are needed in northern hemisphere studies because many locations have major seasonal fluctuations in weather (e.g. snow) over the year that must be controlled by studying each driver across all seasonal challenges. In most parts of Australia, major weather fluctuations are not an issue. Moreover, by increasing the number of participants, the ANDS is likely to detect more safety critical events, e.g. near misses and crashes. Evidence from the 100-car NDS in the US (Klauer et al., 2006A) found individual differences in the likelihood of crashing with 35 percent of drivers having at least one crash and 14 percent accounting for around half of all crashes. By increasing the number of drivers in the study, the ANDS study may pick up a larger sample of crashes: the least frequent safety critical event. Less severe safety incidents occurred very frequently in the 100-car study with 761 near crashes and 8,295 safety incidents over 12 months so they are expected to be common in the ANDS as well.

The driver sample will be experienced drivers: The ANDS is recruiting to the study only drivers who have a full driver's licence in the 20 to 70 years age range. Many other naturalistic studies have recruited drivers from across the age range, including novices. While understanding the driving behaviour of novice drivers is of great importance to road safety, the ANDS took the view that the sample size in the Australian study was too small to allow for study of small subgroups. The issue of novice driving will be explored in subsequent naturalistic driving studies in Australia in which this driver group is the primary focus.

Expanded vehicle/driver monitoring: The ANDS has taken the opportunity to increase the scope of driver and vehicle monitoring by including additional technologies, ones that both look outwards to the external environment (Mobileye) and inwards toward the driver (Seeing Machines).

The Mobileye is a camera-based Advanced Driver Assistance System (ADAS) and will be installed in all vehicles. It includes a "smart" forward facing camera which, along with proprietary

algorithms, under normal operations provides the driver with alerts when the system detects that the driver is (a) likely to collide with a vulnerable road user (pedestrian, bicyclist or motorcyclist), (b) likely to collide with a forward obstacle (e.g. car), (c) following a vehicle ahead too closely, and (d) likely to drive off the road (e.g. if drowsy). In this study, the system will not be used to provide warnings; rather, it will be used as a sensor input additional to the DAS units. This will provide: (i) an additional automated trigger for detecting in the data recorded by the DAS units potential collisions, especially with vulnerable road users; and (ii) a validation test of the accuracy of algorithms contained in the VTTI DAS units for detecting near-crashes and other safety-critical events. In future NDS studies, Mobileye can be used as both a sensor and as an ADAS system, to understand driver interaction with the system in normal and safety-critical situations.

Real time driver monitoring: The ANDS aims to examine driver states including distraction, inattention, and drowsiness. Examination of these states benefits greatly from an analysis of features including driver head orientation and gaze direction. Assessment of such driver states in research studies has historically been a significant challenge primarily because the analysis of these states has been largely reliant on the post-hoc analysis of video data. While this approach has been fruitful, it necessarily constrains the type of measures that can be collected (via video extraction), while also involving hundreds of hours of manual video coding prior to any data analysis.

A key point of difference with the ANDS is the inclusion of real-time driver monitoring within a subset of the participant vehicles. Real-time driver monitoring offers a number of potential advantages with respect to supporting the collection of a wide range of driver features while also potentially removing the need for hundreds of hours of video analysis. The driver monitoring system (DMS) by Seeing Machines is being included in the ANDS and monitors driver attention state during normal and automated driving. For the purposes of the ANDS, the DMS classifies a driver's direction of attention through a real-time analysis of head pose, gaze and pupil metrics and eyelid opening. The system monitors whether a driver's attention is directed toward the forward roadway, off the road, or inside the vehicle cabin such as on the centre console or the driver's lap, and whether the driver is in a drowsy state. This technology can support a range of research questions including those related to: distraction and behaviour when drivers are, for example, interacting with a centre console or using a mobile phone; drowsiness and the driver behaviours evident in the lead-up to drowsiness events; head-checking behaviour at intersections and during lane changes; and examination of gaze patterns to better understand the impact of driver experience and impairment on driver attention.

Issues encountered in developing the ANDS: getting to launch

The ANDS project was formally launched on 21st April, 2015. Over the two year period between the initial award of funding from the Australian Research Council and the project launch, the Consortium faced a large number of challenges. In most cases, 'if we had known' beforehand, the path to the commencement of the project would have been significantly smoother. It is worthwhile, therefore to document some of these issues so that others may be spared similar problems.

Legal issues: A study that involves video recording of driver behaviour and modifications to participants' vehicles raises a large number of potential issues. A primary concern is the issue of how to handle illegal driving behaviours or crashes involving our participating vehicles that are caught on video. Legal advice was that if serious traffic offences are detected when going through video analysis, they would need to be reported to relevant authorities but that this should be done on a case-by-case basis. Given the very large amount of data that is being collected in ANDS, this is likely to be a very rare occurrence. The question of insurance was also a concern. Again, legal advice was that any installation damage or damage to study equipment was covered by the research institution. Participating vehicles needed to be insured but did not require comprehensive

insurance. The Consortium also sought confirmation that the DAS and other equipment installed in participants' vehicles were within legal requirements by obtaining an Australian Design Rules Engineer Signatory Certificate. All vehicles also carry an official letter detailing the purpose and nature of involvement in the study that can be provided to insurers to confirm this information should the need arise.

Ethics: A large amount of time and resources were invested to ensure that the project met all ethics clearance requirements to commence. The ANDS project has avoided a number of potential ethical issues by only recruiting volunteer participants, and by ensuring that they are fully informed about all aspects of the study, the implications of their participation and that they can withdraw from the study at any time. A significant potential ethical issue that caused a number of concerns relating to privacy was that the person driving the instrumented vehicle was readily identifiable on video. This problem has been solved by pixelation of driver obscuring faces in all images that will be shown publically and ensuring that analysis of video data is conducted by researchers who have signed confidentiality agreements and under conditions in which only authorised researchers have access to the video material.

Attempting to use technology built for US roads: A problem that was recognised early, but which caused considerable delay was the necessity for VTTI to adapt their DAS units to driving on the left hand side of the road and wanting multiple cameras at different angles. This resulted in significant delays in supply of the equipment to Australia and the commencement of the study.

Logistical issues: Instrumentation of large numbers of vehicles over the minimum time presents significant logistical issues. First, it is essential to find staff with appropriate skills and expertise to tackle the problem of installing complex technologies into a very wide range of different types of vehicles without overtly indicating that the vehicle had been instrumented. As these studies become more common, there will be a cohort of people with technical expertise available. The solution for ANDS was to hire a highly skilled technical officer to oversee the installation (and de-installation) part of the project and embark on a significant training program for all other staff. Second, finding suitable installation/de-installation sites were also an issue as a large undercover space and security for tools and instruments is required as well as an environment for interviewing drivers. Unlike the Monash University site there was no suitable space on the UNSW campus. With a great deal of assistance from the Centre for Road Safety this problem was overcome in NSW through the provision of an off-campus facility. Third, it is important the instrumentation requires no more than a single day to install in order to present as little inconvenience for the volunteer drivers as possible. The average time of an install is about 7 hours for the ANDS system.

Recruitment of participants: Feedback from VTTI researchers was that they had experienced considerable difficulty recruiting volunteers, especially amongst younger drivers. The ANDS Consortium put significant effort into designing a recruitment strategy to publicise the study as widely as possible. It was clearly successful as the first wave of instrumentation of vehicles was fully subscribed within a few weeks of the study launch and participants are now on the waiting list for full sample.

A screening questionnaire was set up on the study website to assess key selection criteria including number of trips driven per week, type of vehicle, and city/region of residence. By the end of July 2015, the study received 1,071 expressions of interest through completion of this questionnaire, with 663 potential participants satisfying all key selection criteria (309 in NSW, and 354 in Victoria). This sample included a relatively even spread of males (55%) and females (45%), similar numbers in the defined age groups (20-35 years (28%); 36-50 years (33%); 51-70 years (39%)), and contained mainly sedans (34%), hatchbacks (32%), and four-wheel drives/SUVs (24%). All potential participants drove at least 10 to 14 trips per week (for example, driving one way from

home to work is considered to be one trip). In New South Wales, the most successful recruitment modes so far have been targeting drivers through the National Roads and Motorist Association (NRMA) Open Road magazine and NRMA social media platforms such as Facebook and Twitter. In Victoria, the study flyer sent out with vehicle registration renewal notices by VicRoads attracted the most attention.

By the end of July 2015, twenty-four (24) participant vehicles have been instrumented at the NSW site. There were equal numbers of male and female drivers and of the youngest and oldest driver age groups (38% aged 20-35 years, 38% aged 51-70 years; as well as 25% aged 36-50 years), drivers from Sydney metropolitan areas (75%) compared to regional NSW (25%), and mostly hatchback vehicles (41.7%). Makes of participant vehicles include SsangYong, Kia, Mazda, Hyundai, Toyota, Holden, Nissan, Ford, Mitsubishi, Subaru, and Volkswagen.

So much data and so many research questions: Naturalistic driving studies can potentially answer an enormous range of research questions, but often do not have the resources to do so. The ANDS project proposal laid out seven key research themes, which were selected through consultation with all researchers and participating organisations. Details of their selection were described in Regan et al. (2012 and 2013). In brief, the themes selected were:

- Safety at intersections
- Speed choice
- Interactions with vulnerable road users
- Fatigue
- Distraction and inattention
- Crashes and near-crashes
- Interactions with intelligent transport systems (ITS)

Designing and completing the analysis of the voluminous data available from the ANDS study is likely to be a work-in-progress over the next decade or more. On the one hand, this is one of the most exciting aspects of these studies, but it is also a potential problem. The ANDS study is controlling the problem by establishing an active data analysis group whose task is to investigate strategic approaches to analysis, including automation of the identification of target incidents and driver behaviours. The study will also be using the various technologies (DMS, Mobileye, etc.) as triggers to identify behaviours / events of interest. It is also delegating the analysis task for specific themes to members of the Consortium with expertise in each area and setting up analysis groups for each theme. An important part of this aspect of the project will be seeking additional resources for data analysis, researchers and partners from outside this Consortium to collaborate on analysis and publication of findings.

The next steps

All of these issues have been overcome sufficiently for the project to commence and to be now progressing exceptionally well towards fulfilling its original aims of providing Australia with answers to some intractable, high priority, road safety problems that cannot be solved using currently available methods; creating a new, national, capability for collecting and analysing previously unavailable data and setting up a permanent Australian database that can be added to by future studies and become a public resources that no single university or transport safety authority in Australia on its own could afford; and supporting applied and investigator-driven research. Our ANDS project, unlike previous large-scale NDS projects that have focussed on the detection and characterisation of crashes and near-crashes, will tell us how people drive normally to avoid crashes and minimise risk, and how they modify their behaviour to adapt to conditions of increased crash risk (e.g. when fatigued, distracted, when speeding, in the vicinity of other road users, etc.).

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