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Editorial

The contribution of on-road studies of road user behaviour to improving road safety

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ABSTRACT

For over 40 years transport safety researchers have been using methods of vehicle instrumentation to gain greater insights into the factors that contribute to road user crash risk and the associated crash factors. In the previous decade in particular the widespread availability of lower cost and more advanced methods of vehicle instrumentation and recording technologies are supporting the increasing number of on-road research studies worldwide. The design of these studies ranges from multi-method studies using instrumented test vehicles and defined driving routes, to field operational tests, through to much larger and more naturalistic studies. It is timely to assess the utility of these methods for studying the influences of driver characteristics and states, the design and operation of the road system, and the influences of in-vehicle technologies on behaviour and safety for various road user groups. This special issue considers the extent to which on-road studies using vehicle instrumentation have been used to advance knowledge across these areas of road safety research. The papers included in this issue illustrate how research using instrumented test vehicles continues to generate new knowledge, and how the larger scale United States and European naturalistic and field operational test studies are providing a wealth of data about road user behaviour in real traffic. This is balanced with a number of studies that present methodological developments in data collection and analysis methods that, while promising, need further validation. The use of on-road methods to accurately describe the behaviours occurring in everyday real-world conditions, to quantify risks for safety critical events, and an improved understanding of the factors that contribute to risk, clearly has huge potential to promote further road trauma reductions.

1. The context for this special issue

The road-transport system serves a vital role in the well-being and prosperity of modern societies, yet is a major source of trauma with more than 1.2 million people killed and as many as 50 million injured annually worldwide (WHO, 2009). Journals including *Accident Analysis and Prevention* publish hundreds of articles each year that aim to advance science and practice to make inroads here. In this journal alone in 2012 there have been special issues devoted to specific road safety topics: intelligent speed adaption, safety for vulnerable road users, powered-two-wheeler safety, and cognitive impairment and driving safety. This present issue continues the focus on road safety issues through considering the developments in the use of on-road methods to better understand road safety crash risks and risk factors.

Studies using instrumented vehicles to measure behaviour on-road, and debating the merits of direct and indirect measures of safety have been published for many decades (e.g., Helander and Hagvall, 1976; Pahl, 1970; O'Hanlon et al., 1982). The widespread availability of lower cost and more advanced methods of vehicle instrumentation and recording technologies is supporting the increasing number of on-road research studies worldwide. Using varying levels of vehicle instrumentation, the design of these studies typically range from those employing instrumented test vehicles and defined driving routes, to larger scale field operational tests, through to naturalistic studies typically involving participants' own vehicles. The instrumentation of cars, powered-two-wheelers (PTWs), bicycles, and heavy vehicles offers a platform to potentially support further leaps forward in our understanding of road user behaviour. It is important to assess the extent to which the investments in these approaches are contributing to this goal.

There is currently much excitement across the road safety research and practitioner community concerning the use of naturalistic methods to assess road user behaviour. Studying behaviour in its natural setting is inherently attractive and by definition overcomes many of the limitations of more traditional laboratory based methodologies. The naturalistic driving methods developed, and studies conducted, in the United States in the previous decade have stimulated significant growth in the application of this method. The impact that these studies are having on the road safety field is clear. The 100 car reports have received many hundreds of citations (Dingus et al., 2006; Klauer et al., 2006), with well over 20 additional reports and publications by other authors using the dataset. Incredibly substantive investments in research funding continue to be made in the United States (e.g., Hallmark et al., 2013) and Europe (e.g., UDRIVE, 2013), and increasingly in other regions including Australia. Importantly, over the last two years a larger number of journal publications that are based on naturalistic data sets have emerged, many within *Accident Analysis and Prevention* (Eby et al.,

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2012; Hickman and Hanowski, 2012; Peng et al., 2013; Guo and Fang, 2013; Lee et al., 2011; Wu and Jovanis, 2012). It is both expected and hoped that this trend will continue in the coming years.

Clearly many of the ethical and logistical challenges differ substantively across the different methods for studying on-road behaviour. These issues are previously discussed by Klauer et al. (2011) and others in recent texts such as the Handbook of Traffic Psychology (Porter, 2011), and are further discussed in papers within this issue. However some of the fundamental research issues and processes should be similar across these on-road methods. What performance measures should be used, what technology can support the collection of these measures across the different designs, how can other methods and performance measures be integrated to complement vehicle-based data, and how should behaviours be coded and the units of analysis defined? Importantly, what is the utility of these methods for studying the influences of driver characteristics and states, the design and operation of the road system, and the influences of in-vehicle technologies on behaviour and safety for various road user groups?

Given the significant investments being made in on-road research it is timely to ask questions around the contribution of these approaches to road safety. What are the key developments in the study of road user behaviour using on-road methods, in terms of the developments in methodologies, analysis, and research platforms that will advance our understanding of crash risks and risk factors? These questions are the focus of this special issue.

Two reviews set the scene for this special issue. The first by Carsten et al. seeks to outline the opportunities and limitations of three classes of on-road method: the use of instrumented vehicles with relatively short test routes; the use of field operational tests (FOT); and the use of naturalistic driving studies. A definition of each approach is provided, along with examples of the types of road safety issues that have been examined with each approach, the type of performance metrics collected, and the utility of the findings from each approach. Some of the logistical issues associated with each approach are also discussed. Valero-Mora et al. discuss similar issues in their paper reviewing recent European experiences with on-road studies and discuss some of the supporting technologies used in data collection, indicative classes of research question that can be addressed using different levels of vehicle instrumentation, and some of the logistical challenges associated with the conduct of on-road research. The second major review by Taylor et al. describes the transition of head and eye tracking out of the laboratory and onto the road. Capturing head and eye movement data offers tremendous insights into how road users direct attention and those features of the environment that capture attention. However the processes of capturing these data reliably, and in a range of real-world conditions, are varied and can be problematic. Taylor et al. review the range of measurement approaches and their utility across a range of issues that are longstanding road safety problems such as hazard perception, novice drivers and driver distraction arising from both in-vehicle and out-of-vehicle sources. It is clear that the on-road measurement of visual behaviour contributes substantially to interpretations of driver workload and attention across many problem areas. Importantly, however, these authors also reflect on some the limitations in both the method and the supporting technologies.

2. Studies using instrumented test vehicles

A large number of papers presented in this issue use instrumented test vehicles to assess aspects of driver behaviour and performance on discrete fixed routes. Such studies can be criticised because they do not collect data over a longer time period and in response to selected interventions, as in FOTs, or in more naturalistic settings as in naturalistic driving studies. Another methodological issue is that the studies utilising instrumented test vehicles typically have at least one researcher present, at the very least, to give navigation directions. On other occasions a second researcher is present to make other observations about the driver's behaviour. However, these types of studies do offer unique data collection opportunities with respect to the concurrent use of multiple methods.

For example, the use of verbal protocol analysis (VPA) can provide unique insights into driver situation awareness while driving. Salmon et al. use this approach to better understand the situation awareness of novice and experienced drivers at rail level crossings. While objective performance data such as vehicle speed are valuable, analysed using network analysis, the verbal protocol data show the influence of situation awareness in directing behaviour. This analysis suggests that the situation awareness for experienced drivers was more connected, and contained fewer concepts, than for novice drivers, meaning that the experienced drivers extracted the more salient information and established a stronger situation awareness for safe negotiation of rail level crossings. Such findings provide a broader framework within which to interpret some of the traditional metrics around vehicle speed and position. Aupetit et al. use verbal data in a different way to assess the efficacy of motorcycle rider training in France. Using observation on both test tracks and in real traffic, the authors analysed verbal data during rides together with post-ride interview data to conclude that rider training in France is in need of significant enhancement as it currently lacks sufficient opportunity for trainees to formally develop non-technical skills. The authors note that the findings are being used by French authorities to place an increased emphasis on the training of non-technical skills such as hazard perception.

While in-vehicle observation of behaviour in itself is not new, the use of this approach to gain information into driver errors offers new insights. Young, Salmon and Cornelissen used an instrumented test vehicle over an hour long test route to examine the number and nature of errors committed by drivers in distracted and undistracted states. Distracted drivers made a larger number of speeding, misjudgement and action-based errors than when not distracted by a visual task. This study noted that a substantial number of errors were also recorded when drivers were not distracted, a finding also noted by Young, Salmon and Lenné when examining the influence of the road network on error occurrence. Using a similar methodology this latter study found that a great number of critical errors occurred at intersections compared to mid-block segments of a test route. When combined with other methods such as VPA and vehicle data, in-vehicle observation can help gain greater insights into how the various components of the road system can better support performance in a range of driver states and road environments.

Instrumented vehicles have also been used to benchmark the performance of experienced drivers to aid driver training. Underwood argues that novice drivers could be trained to emulate the driving styles of more experienced drivers and that this would help accelerate novice driver progression towards safer drivers. Underwood tested groups of drivers at three different time points: immediately after obtaining a license, three months later and at six months post licensing. Two groups of novice drivers were tested, a young novice group aged 17–19 years, and an older novice group aged over 23 years. Underwood reported similar driving behaviours by the young novices and an experienced driver group in terms of vehicle handling and headway, suggesting that teaching novice drivers to a follow the standards of experienced drivers, with the performance measures used in this study, is not fruitful at this time. The results of the study suggest, however, that the higher self-reported crash involvement of the older novices shapes subsequent