NATURALISTIC DRIVING STUDIES: THE EFFECTIVENESS OF THE METHODOLOGY IN MONITORING DRIVER BEHAVIOUR

K MURONGA and N RUXWANA*

Tshwane University of Technology, Faculty of ICT, Department of Informatics;
CSIR Built Environment, PO Box 321, Pretoria, 0001
Tel: 012 541 2337, e-mail: kmuronga@gmail.com;
*Tshwane University of Technology, Faculty of ICT, Department of Informatics;
*CSIR Defence Peace Safety & Security, PO Box 321, Pretoria, 0001
*Tel: 012 841 7313, e-mail: nkqubz@yahoo.co.uk;

ABSTRACT

Naturalistic Driving Studies (NDS) is a research methodology that has the potential to improve existing approaches for collecting data about driver behaviour and performance in normal driving conditions. Analysis of naturalistic driving data in normal driving conditions provides a possibility of big data sets that can be used to understand the characteristics that lead to vehicle crashes and/or near crashes. The purpose of this study was to evaluate the effectiveness of NDS to improve driver behaviour and adherence to road rules. Making use of the Theory of Planned Behaviour (TPB) as a theoretical framework, the study managed to illicit responses from both drivers and management, in companies where the technology is used, to show that NDS provides the company and drivers with information that can improve driving ability. Overall, the results provide a clear indication that by making use of the data generated through use of NDS, it is possible to identify risky driver behaviour, which can inform the design and implementation of driver improvement projects.

1. INTRODUCTION

1.1. Background

The right to life and the protection of life is a constitutional right in South Africa. In acknowledgement of this right, the Road Traffic Management Corporation (RTMC) spent about R 800 million on initiatives to encourage road safety in South Africa during the 2012/2013 financial year (Peters, 2014). The main motivation being that the rate of road traffic fatalities had reached unacceptably high levels (Peters, 2014). Peters also confirmed that the National Household Transport Survey (NHTS) of 2013 indicates that the percentage of car ownership had risen from 22.9% in 2003 to 32.6% in 2013; and this

subsequently means more vehicles and more drivers on our roads which could be a contributing factor to the increasing fatal crashes on South African roads.

Recent focus has been on improving driver behaviour as a means to counter road fatalities, and one recent domain which exploits the use of Information and Communication Technologies (ICTs) is the Naturalistic Driving Studies (NDS) methodology - which refers to an unobtrusive approach to studying driver behaviour (Venter, Muronga, 2016), allowing researchers to detect and analyse how the vehicle driver, the vehicle itself, the road and other traffic activities relate to each other in normal circumstances, in conflict situations and in actual crashes (Van Schagen, Welsh, Backer-Grondahl et al., 2011, Shankar, Jovanis, Aguero-Valverde et al., 2008). ICT's technology application in transportation is not a new thing in South Africa as it has being applied in the management of loads control at traffic control centres (Muronga, Sallie, De Franca et al., 2016). Making use of NDS can be beneficial to transport operators, policy makers and commercial organisations (Dozza & González, 2013). NDS is used worldwide as an approach to collect valuable data from drivers. Some of these studies focusing on specifically risky driving practices and road environment factors that can influence driver behaviour.

In South Africa, logistics companies, especially those making use of heavy vehicles to transport goods, have bought into the idea of naturalistic driving studies, as part of the Road Transport Management System (RTMS). RTMS is an industry-led self-regulatory arrangement that encourages heavy vehicle operators to take ownership of road safety programmes and promotes the use of driver monitoring technology to collect data about driving behaviour with the aim of implementing interventions to improve safe driving (Nordengen, Prem & Mai, 2008). South African researchers from the Council for Scientific and Industrial Research (CSIR) have recognised the importance of ICT for road safety research studies and have started making use of NDS as the assertion is that NDS has the capability to significantly improve road safety through a better understanding of South African driver behaviour (Muronga & Venter, 2014).

1.2.   Problem statement

Despite NDS being employed internationally to address different aspects of driver behaviour, there is limited information detailing studies of this nature in developing countries and the potential impact thereof to change driver behaviour and reducing fatalities in South Africa is still not clearly covered in the existing body of knowledge (Venter, 2014). There is thus a need to assess the actual adoption success of NDS as indications are that ICT implementations reportedly fail in achieving their intended objectives (Geels & Smit, 2000)

1.3.   Research rationale (or Significance of the study)

NDS is a new concept in traffic and transportation research, and in South Africa research related to NDS is limited (Venter, 2014). This study aims to contribute to the body of knowledge and could assist in bridging that gap in NDS research by investigating the effectiveness of NDS in learning about South African driver behaviour in relation to road safety.

This study conducted an in-depth examination of the effectiveness of NDS in improving driver behaviour and adherence to road rules in South Africa. If effective, the results can be used in planning approaches that can assist with reducing road fatalities. The findings of this study can support the use of NDS in learning about driver behaviour, and assist in decision-making before government and other institutions invest largely in this technology. This is an important consideration as IT projects, according to Geels & Smit (2000) and Heeks (2010) mostly fail and their return on investment (ROI) cannot be justified due to failure of meeting the intended objectives.

1.4. Research Objectives

The objective of this study was to evaluate the effectiveness of NDS in improving driver behaviour and adherence to road rules, with the aim of recommending means that can improve the success and effective use of NDS in South Africa.

1.5. Limitations

The research study was limited to vehicles that are already fitted with Data Acquisition Systems (DAS) which is used to collect NDS data. The participating organisation on which the case study is based, is South African, but has operations across the South African Development Community (SADC) region. The volume of data collected was very large and the resources needed to analyse the data intense, as the data included both local and cross border delivery vehicles. A sample of data was therefore selected, validated and used to achieve the objectives of the study.

2. RESEARCH METHODOLOGY

2.1. Overview

To achieve the intended objectives of this study, both qualitative and quantitative methodologies were applied in a mixed method approach (Mugenda & Mugenda, 2003; Ross & Israel, 2002). A combination of two data collection methods was used, in other words, a questionnaire for quantitative data collection and content analysis for qualitative data, applied in a case study approach.

2.2. Conceptual framework

NDS focuses its attention on the behaviour of drivers and how they make and alter decisions in relation to the road environment and their behavioural norm; the researcher therefore preferred the elements of Theory of Planned Behaviour (TPB) (see Figure 1) as a suitable framework to explain and monitor driver behaviour and behavioural changes. The TPB was developed by Ajzen in 1988, and its constructs have been used before by other authors to explain pedestrian and driver intentions to violate traffic rules (Guttman & Lotan, 2011).
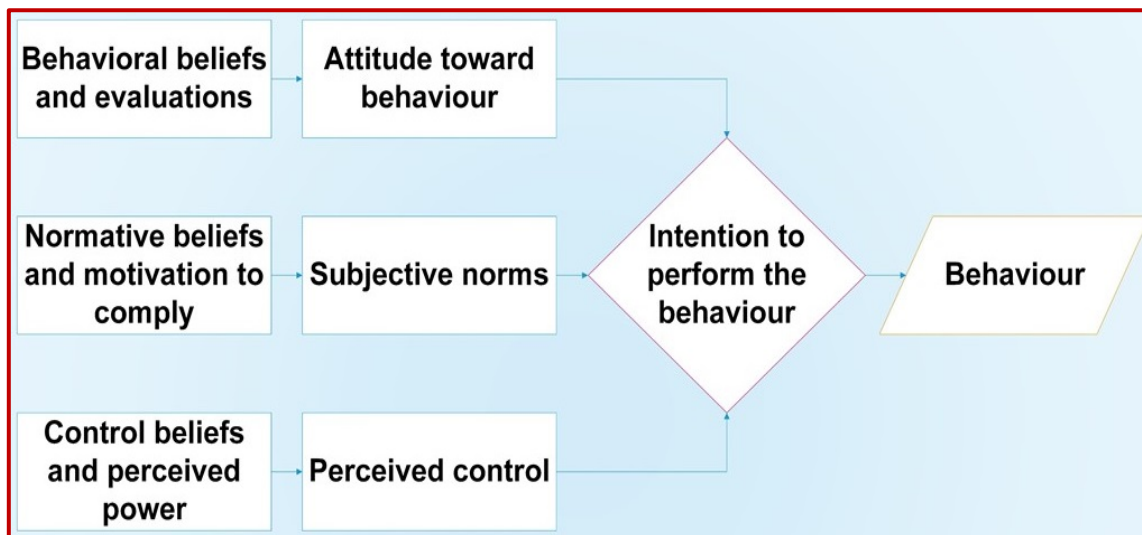
Figure 1: Theory of Planned Behaviour (Ajzen, 1991)

For this study, behavioural change refers to the driver being able to change driver behaviour based on the results of the reports produced by the NDS technology; this behaviour change is analysed by assigning behaviour to a specific TPB construct.

2.3. Population and sampling

The fundamental idea behind sampling is that by choosing some of the elements in a population, conclusions may be drawn about the entire population (Cooper & Schindler, 2006). For this study, purposive sampling was applied. This involves the selection of research attributes to be studied based on the researcher's own judgment about which ones will be the most useful or representative (Babbie, 2005).

The organisation that participated in the study was a convenient selection, as the organisation had already implemented NDS. It was based in the province of residence of the researcher and the organisation was willing to offer its data and participate in the study. The criteria for driver selection revolved around driving experience (two years or more), the presence of the NDS technology installed in the vehicle, and management officials that have been involved in the analysis and interpretation of with the NDS data generated by the NDS technology.

2.4. Data collection

This study used a mixed method approach which included questionnaires, informal interviews and content generated by the technology as primary data collection instruments. Qualitative research can be time consuming, and working with a large data set is often impractical (Mason, 2010). For the qualitative data, a total of 100 vehicles were envisaged for the minimum NDS data collection but 137 vehicles participated - which also meant that data from 137 drivers were analysed. For the quantitative data, a minimum of 15 participants were envisaged, but 19 participated (16 from drivers and 3 from management).

After analysing about 2 533 thesis papers, the study concluded that for content analysis a minimum of 15 participants was a trend and for a naturalistic enquiry a maximum of 26 participants was found to be the trend; the saturation process was also applied in the studies (Mason, 2010; Glaser & Strauss, 2009). Therefore, the sample was deemed to be more than sufficient for this study as it was in line with other research studies.

2.5. Data analysis

Data analysis allows the researcher to organise and bring meaning to a large amount of data (Creswell, 2009). The main method used for the analysis of the NDS data was Content Analysis. To analyse content data, the researcher had to break down the text into units, categorising and giving headings to similar interpretations to develop a coding scheme (Holloway and Wheeler, 2013; Downe-Wamboldt, 1992; Weber, 1990).

The aim was to analyse images, videos, and audios by coding the content into a list of concepts. The concepts were transcribed as coded in the DAS technology, as this technology included a predictive analysis tool that analyses the video images and text files and then produces a spreadsheet containing all the concepts already included as triggers. The process is described as follows (table 1):

Table 1: DAS data analysis process

Phase	Description
Step 1	The system captures risky driving behaviour; this behaviour is pre-defined and therefore could be anything that the management deems risky, from sudden breaking to driving and eating, etc.
Step 2	The triggered event is stored in a storage device located inside the vehicle and at the same time sent over wireless technology from the vehicle to a web-server.
Step 3	When the data is stored in a web-server, predictive analysis is conducted using pre-defined queries and to improve productivity, a team of specialised data analytics also conduct manual reviews, analysis and scoring of events. Scoring of events refers to each event being given a severity or seriousness score, which later is collected as favourable or unfavourable points allocated to each driver.
Step 4	The management of each participating organisation gets access to a confidential website for events, dashboards and reports.
Step 5	The participating organisation is then expected to conduct driver training and couching to improve the driving of those drivers allocated with unfavourable scores.
Step 6	The drivers are expected to return to driving with new knowledge and skills on how to practise safe driving.

Microsoft Excel© was used to analyse the data, by coding the concepts and categories rating information into a spreadsheet. By assigning a column in a table to each concept considered and on each row assigning a case or rating, it was possible to store content data into a spreadsheet for further analysis. Microsoft Excel © can handle multiple attributes and allows for various dashboards or display techniques for qualitative data (Bazeley, 2013; Meyer, Avery, 2009).

3.   RESEARCH FINDINGS AND RESULTS

3.1.   Driver demographics

The results from the questionnaire showed that the drivers were all male of ages between 30 and 45, holding either a code EC driving licence or a foreign driving licence. Most of the drivers had more than 10 years of driving experience and driving more than 500 km per week, which means that they spend a lot of time on the road. These drivers indicated that they are very confident with their driving ability and their self-rating score came at more than 96 %.

3.2.   Driver perception of NDS technology in vehicles

The drivers also indicated that they are concerned with the fact that they are being monitored, however they acknowledged the benefits of the system in providing knowledge that can improve their driving ability and its capability to report on crime-related activities against them, and these were major motivating factors, that made them accept to be monitored.

The main concern of the drivers about being monitored was that they think the information collected from the NDS might be used for punitive measures (a way for managers to get them fired if they don't adhere to the rules). However, results from Section 3 of the questionnaire, which was aimed at eliciting responses from management, indicated that the fears of the drivers were not warranted and unfounded, as the management uses the information from NDS to plan driver improvement interventions, such as driver training programmes. When correlating this with the responses from drivers, the management seem to be correct as more than 83% responses from drivers indicate that they are aware that the information is collected so it can be used to help improve their driving ability.

3.3.   Effectiveness of NDS in improving driver behaviour

Results of the TPB constructs making use of the equation: [1]*Constructs = (D Ave + O Ave)/2* showed that the NDS has a rating of 66.7% in terms of its effectiveness to improve driver behaviour.

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[1] D Ave, is the average score of drivers and O Ave is that of officials.

The main research question for this study was: *How effective is NDS in improving driver behaviour and adherence to road rules?* The results from the questionnaires indicated that the NDS is 66.7% effective when it comes to improving driver behaviour and adherence to road rules. More information on the 'how' part of the question was addressed by the results for the NDS technology "DAS".

The DAS technology collected a lot of data and only three attributes triggered by the system were considered and grouped as follows: attributes relating to **driver distractions** (cell phone use, food and drink, passengers); attributes relating to **fundamentals** (failed to keep an Out, too fast for conditions, unsafe lane change); the third one was **traffic violations** (rolling stop, stop sign, red light, speeding, designated roadway).

Table 2: DAS Triger Attributes

Attribute	Points	Description
Distractions: Distractions are common while driving. A driver's attention may be divided between driving, navigating, talking to passengers and other activities. Distractions that cause an event to be activated or lead to a risky situation are scored as distraction.		
Cell phone	3	This is selected if the driver is using a handheld cell phone.
Food and Drink	3	This is selected if attention to food and drink put the driver in a risky situation.
Passenger (s)	3	This is selected if the driver dedicates too much attention to a passenger and it contributes to a risky driving situation.
Fundamentals: These categories involve the fundamentals of safe driving and go to the very root of most crashes.		
Failed to keep an Out	3	Space is the key to avoiding mistakes by other drivers. This behaviour is marked if a risky situation is clearly visible, yet the driver ignores it and positions the vehicle in a space that reduces outs available.
Too fast for Conditions	5	This will be triggered if the driver is driving at a speed that puts the vehicle in a tight spot or if the driver does not slow down for pedestrians looming around.
Unsafe lane change	5	This will be selected if the driver makes a lane change that leads to a risky situation.
Traffic Violations: these refer to traffic violations regulated by the relevant traffic authority and the driver is aware of them.		
Rolling stop	3	(*Yielding at a stop sign*) an instance when a vehicle driver slows down but does not stop at a stop sign.
Stop sign	5	Not stopping at a stop sign and/or not following stop sign rules.
Red light	5	Driving through a red light and/or flashing red light without following the rules.
Speeding	5	Not following set speed limit. Either roadway speed

Attribute	Points	Description
		limit or type of vehicle set speed.
Designated roadway	3	Driving in a wrong lane, without any distractions on the correct lane.

Based on the attributes, local drivers were found to have a 12.6% rating in terms of risky driving behaviour and cross-border drivers, 9.24%, indicating that local drivers violated more of the road rules and tend to drive riskier than the cross-border drivers.

Allocating the attributes of the triggers and linking them to a TPB construct allowed the researcher to identify risky behaviour, as well as to identify top violators. All the top violators were found to have violated mainly the traffic rules, such as speeding and not obeying traffic light rules and were involved in activities that caused driver distractions, such as cell-phone use. The overall results provided a clear indication that from making use of the data from the technology it is possible to identify risky driver behaviour, which can inform management for the implementation of driver improvement projects.

4.   CONCLUSIONS AND RECOMMENDATIONS

The TPB was found suitable for this study, because of its potential to address behavioural attributes that were relevant to the study. The main objective of this study was to evaluate the effectiveness of NDS in improving driver behaviour and adherence to road rules, with the aim of recommending means that can improve the success and effective use of NDS in South Africa.

In conclusion, it can be said that the results were in favour of the NDS and showed that the technology is effective in improving driver behaviour; but care must be given to get consent from drivers when implementing the technology. For NDS to be successful, communication between the management and the drivers is important and drivers must be informed about what the technology is used for and how the information will be shared and what it will be used for.

The results showed that driver distractions were also at the top of violations and, from literature, it is evident that distractions could also come from passengers - some of the heavy vehicle drivers involved in the RTMS programme drive with partners. As a recommendation, the organisation can try and involve relevant measures to reduce driver distractions as part of the safe driving awareness campaigns.

It is further recommended that more logistics organisations make use of naturalistic studies to collect data and analyse it to create more knowledge for the organisation. This study identified that knowledge gained during NDS study could be used to benefit the organisations, and one of the benefits that can be gained by implementing NDS is to identify training needs for drivers and initiate driver training programmes to address the driver behaviour issues.

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