What's special about Eco-Drivers? Results from an online questionnaire exploring driver habits

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ABSTRACT

Previous research has suggested that fuel usage and emissions can be dramatically reduced should drivers engage in fuel efficient driving practices, commonly referred to as eco-driving. Despite eco-driving being a popular topic for both academic literature and online communities, questions remain regarding whether there are fundamental differences in eco-driving compared to standard driving practices, or whether eco-drivers are repeating standard behaviour more consistently. To address this question, an online questionnaire was developed exploring the extent to which drivers, both those who considered themselves to be eco-drivers and those who did not follow behaviours associated with eco-driving. Results suggest that not only are fuel-efficient driving behaviours known to a greater percentage of the eco-drivers, but also the majority of known fuel-efficient driving behaviours are followed with a significant greater regularity by eco-drivers. Results support the idea that regular drivers need to be made aware of different fuel-efficient driving techniques, and also need assistance to make these behaviours habitual. Future research is also discussed.

KEYWORDS

Eco-driving, Online Questionnaire, Fuel-efficient driving

Introduction

Pollution arising from transportation is considered a critical challenge that must be addressed (Yin & Lawphongpanich, 2006). Transport emissions, primarily greenhouse gasses (GHGs) such as carbon dioxide (CO_2) and Nitrous Oxides (NOx), as a consequence of everyday car use, are currently the leading cause of air pollution in Britain (Department for Environment, Food and Rural Affairs, 2017). Car use contributes to a variety of environmental problems including global warming, acid rain, resource depletion and noise pollution (Lowe, 1990). The evidence that GHGs negatively impact the environment (Ramanathan & Feng, 2009) has led to a prevailing argument that vehicle use is fundamentally linked to anthropogenic climate change and unstable global weather patterns (Karl & Trenberth, 2003; Chapman, 2007). In addition to the negative impact vehicle emissions can have on our environment, they are also harmful to human health and wellbeing, with exposure to vehicle emissions having negative long-term health implications (McCubbin, & Delucchi, 1999). Long term exposure to vehicle emissions are associated with an increase risk of developing a variety of respiratory based disorders, such as asthma, bronchitis, chronic obstructive pulmonary disease, pneumonia and upper respiratory tract infection (Buckeridge et al., 2002). Approaches to reduce such emissions are therefore highly sought after.

Barkenbus (2010) proposed that GHG emissions can be significantly reduced just by altering driving style. Barkenbus argued that by using a more measured driving style, referred to as eco-driving, fuel use and GHG emissions could be dramatically reduced. Eco-driving, the behavioural approach to emissions reduction, has been demonstrated to hold significant potential, with previous research suggesting that emissions could be reduced by 5% - 20% (Stillwater & Kurani, 2013) with fuel usage being reduced by between 5% – 10% (Martin, Chan & Shaheen, 2012). Recent analysis of naturalistic driving carried out as part of the UDRIVE project has indicated that braking, gear shifting and velocity choice on motorways each have effects on fuel consumption of 10% or more for conventional vehicles (Heijne, Ligterink, & Stelwagen, 2017).

Numerous approaches to best achieving eco-driving has been promoted within both academic literature and eco-driving communities. Sivak and Schoettle (2012) suggest that eco-driving comprises of strategic and tactical decisions. Strategic decisions relate to initial vehicle selection, for example choosing a vehicle that maximises fuel economy and on-going vehicle maintenance, such as ensuring tyres are adequately inflated. Conversely, tactical decisions relate to navigational decisions, for example changing route in order to avoid traffic and minimising vehicle load. Barkenbus (2010) proposes that eco-driving is characterised by active behaviours that drivers can engage with such as modest acceleration, early gear changes, limiting the engine to approximately 2,500 revolutions per minute (RPM), anticipating traffic flow to minimise braking, driving below the speed limit, and limiting unnecessary idling. In addition to the academic literature, a variety of online communities have developed promoting ideas relating to eco-driving and fuel efficiency who promote their own tips for achieving best fuel efficiency primarily relating to day to actions a driver can take.

Despite the large corpus of information relating to eco-driving being available, this information is largely dispersed from disparate sources. Additionally, it is unclear the extent to which eco-driving behaviours are independent from everyday driving behaviours, that is to say are eco-drivers engaging with novel behaviours, or just more frequently engaging with good driving practices?

To start to understand what makes eco-drivers more fuel-efficient than non eco-drivers, academic literature concerned with the topic of eco-driving and online communities dedicated to eco-driving were consulted to generate an online questionnaire to start to understand the habits of all drivers, including those who consider themselves as eco-drivers and those who do not.

Method

To begin to understand the different behaviours associated with eco-driving, an extensive literature search was conducted on the topic of “eco-driving”, “fuel-efficient driving” and similar search terms on portals including “Web of Science”, “Scopus” and “Google Scholar”. This was supplemented by consultation with Subject Matter Experts found on eco-driving online communities. Following this consultation, a web-based questionnaire was developed to adequately capture respondents’ attitudes and behaviours relating to eco-driving. This questionnaire was hosted using isurvey, the University of Southampton’s bespoke online questionnaire system.

The questionnaire comprised of eight main sections which participants were required to complete as part of the research investigation. Section I focused on participant demographics; Section II enquired about participants’ current vehicle; Section III examined participants’ driving habits; Section IV explored participants’ eco-driving motivation and strategies that they use; Section V explored the extent to which participants followed documented eco-driving behaviours; Section VI

explored participants' opinions of future vehicle technologies; Section VII explored participants' level of environmental concern and; Section VIII enquired about participants' willingness to become involved within future research studies exploring driving behaviours. The sections were always presented to participants in the same order but the sequencing of questions within each section was randomised. The questionnaire took approximately 30 minutes to complete. Data was automatically saved within the isurvey database following participants' completion of the study. All participants were required to hold a full driving license, own and have access to a vehicle, have at least 3 months driving experience using their current vehicle and be able to provide the research team with data relating to their current fuel economy as measured in miles per gallon (MPG). No specific requirements relating to the concept of eco-driving were put in place in order to examine the motivations and behaviours of typical drivers rather than just individuals who identify themselves as eco-drivers. Participants were not compensated for their time completing this research study.

The study was advertised via the use of social media, including Twitter and Facebook and a variety of online fora, including specialist eco-driving websites and reddit. Advertisements were also disseminated across The University of Southampton's Highfield and Boldrewood campuses.

As an exploratory study, the questionnaire collected a variety of information beyond the scope of the current paper and as such this paper will focus only on Section I (demographics) and Section V. Section V was a block of 28 questions exploring participants' likelihood of following established eco-driving behaviours. Participants were required to respond to each question using a five point likert scale response, ranging from "Never" to "All the Time".

A total of 196 participants completed the questionnaire. Of these, 138 were male (70%) and 55 were female (28%), 3 participants (2%) chose not to disclose their gender. Participants were aged between 17 years – 75 years (*M* = 34 years, *S.D.* = 14 years, aged M = 37.39 years, S.D. = 15.34 years, driving licences held M = 18.26 years, S.D. = 15.82 years). Within the questionaire, participants were asked whether they consider themselves an eco-driver; this was a yes/ no closed response question. Of the respondents, 72 considered themselves eco-drivers (60 male, 11 female, 1 undisclosed), the remaining 124 drivers (78 male, 44 female, 2 undisclosed, aged M = 32.56 years, S.D. = 13.36 years, driving licences held M = 14.24 years, S.D. = 12.94 years) did not consider themselves eco-drivers. This reponse was used as a grouping variable for subsequent analysis.

Results

For the first stage of analysis, participants' responses were simplified to understand the percentage of drivers, from both groups, who complied with the eco-driving behaviour at least some of the time, i.e. recorded a score of 2 or more on the corresponding Likert scale. The list of eco-driving behaviour, alongside the percentage of drivers from each grouping followed the behaviours is presented in Table 1. It can be seen that the percentage of eco-drivers who follow the behaviours is consistently higher for all behaviours other than the use of cruise control systems.

To extend this analysis, the likelihood of each participant following the different behaviours was compared between eco-drivers and non-eco-drivers, using a series of Mann-Whitney tests. The results of these tests are presented in Table 2. It was clear that participants who considered themselves as eco-drivers engaged with the vast majority of fuel-efficient behaviours with significantly greater regularity than drivers who did not consider themselves to be an eco-driver. Noticeable exceptions to this were "I attend eco-driving workshops and events to support my eco-driving" whereby too few participants recorded attending such an event to enable the identification

of differences and "I use my vehicles on-board cruise control where possible to control my speed" which displayed no differences between the groups.

Table 1. Established eco-driving behaviours and percentage of respondents who follow the behaviours.

	Non Eco-Drivers	Eco-Drivers
I ensure there is no unnecessary weight in my vehicle	75.8	86.1
I avoid the use of air conditioning in my vehicle	60.5	77.8
I turn my vehicle's engine off if I am going to the stopped for longer than 30 seconds	51.6	87.5
I calculate my fuel efficiency every time I refuel my vehicle	57.3	87.5
I avoid the use of brakes whenever possible	88.7	93.1
I limit my top speed to 65mph when driving on motorways	37.9	75.0
I use my vehicles on-board cruise control where possible to control my speed	50.8	47.2
I attend eco-driving workshops and events to support my eco-driving	4.8	11.1
I use park and ride systems where ever possible to avoid traffic	33.9	45.8
If multiple licensed drivers are present in the vehicle, I recommend the most fuel efficient driver drives	12.9	31.9
I remove the roof rack from my vehicle when it is not is use	51.6	77.8
I check my tyre pressure	87.9	94.4
I consider travelling longer distance routes when shorter routes have a considerable presence of traffic	89.5	91.7
I always ensure I leave for my destination in plenty of time to avoid feeling pressured to drive faster	84.7	95.8
I avoid the use of drive-through restaurants due to the idling required in their use	42.7	75.0
I avoid driving in the rain and snow due to the negative impact this has on fuel economy	24.2	47.2
Wherever possible I drive at off-peak times to avoid heavy traffic	81.5	93.1
I consider traveling through car parks and exiting and returning on motorway slip lanes if it means avoiding traffic	33.9	40.3
I avoid short trips in my vehicle	61.3	86.1
I switch off the daylight running light of my vehicle to save fuel	31.5	40.3
I close the windows and sunroof of my vehicle when traveling at higher speeds to save fuel	74.2	95.8
I make my fuel economy a game and try to better my previous results	40.3	83.3
I compare my fuel economy to other drivers	37.1	72.2
If I only have to move my car a very short distance I consider pushing it rather than using the engine	23.4	45.8
When driving a manual vehicle I select the highest possible gear	79.8	88.9
I avoid the use of my in-vehicle heater due to reduction in fuel economy	36.3	72.2
I listen to slow paced music in my car to assist in achieving a calm relaxed driving style	39.5	50.0

Table 2. Z-Scores and Significance level for the Mann-Whitney U-Test differences between non-eco-drivers and eco-drivers. Asterix (*) marks indicate significant differences between the two group at $p < .05$ level.

	z-Score	Significance
I ensure there is no unnecessary weight in my vehicle	-2.55	.011*
I avoid the use of air conditioning in my vehicle	-3.29	.001*
I turn my vehicle's engine off if I am going to the stopped for longer than 30 seconds	-5.83	.001*
I calculate my fuel efficiency every time I refuel my vehicle	-4.92	.001*
I avoid the use of brakes whenever possible	-3.77	.001*
I limit my top speed to 65mph when driving on motorways	-5.77	.001*
I use my vehicles on-board cruise control where possible to control my speed	.148	.88
I attend eco-driving workshops and events to support my eco-driving	-1.61	.108
I use park and ride systems where ever possible to avoid traffic	-2.07	.039*
If multiple licensed drivers are present in the vehicle, I recommend the most fuel efficient driver drives	-3.23	.001*
I remove the roof rack from my vehicle when it is not is use	-3.31	.001*
I check my tyre pressure	-2.66	.008*
I consider travelling longer distance routes when shorter routes have a considerable presence of traffic	-1.83	.067
I always ensure I leave for my destination in plenty of time to avoid feeling pressured to drive faster	-4.24	.001*
I avoid the use of drive-through restaurants due to the idling required in their use	-4.62	.001*
I avoid driving in the rain and snow due to the negative impact this has on fuel economy	-3.33	.001*
Wherever possible I drive at off-peak times to avoid heavy traffic	-1.50	.133
I consider traveling through car parks and exiting and returning on motorway slip lanes if it means avoiding traffic	-1.24	.216
I avoid short trips in my vehicle	-4.50	.001*
I switch off the daylight running light of my vehicle to save fuel	-1.67	.094
I close the windows and sunroof of my vehicle when traveling at higher speeds to save fuel	-3.57	.001*
I make my fuel economy a game and try to better my previous results	-7.27	.001*
I compare my fuel economy to other drivers	-5.69	.001*
If I only have to move my car a very short distance I consider pushing it rather than using the engine	-3.51	.001*
When driving a manual vehicle I select the highest possible gear	-3.72	.001*
I avoid the use of my in-vehicle heater due to reduction in fuel economy	-4.17	.001*
I listen to slow paced music in my car to assist in achieving a calm relaxed driving style	-1.36	.174

Discussion

This work had three primary aims. Firstly, it was sought to capture behaviours associated with eco-driving, based on a search of the academic literature and advice disseminated to eco-drivers within specialist eco-driving website and fora. Secondly, we sought to compare whether any of these behaviours were unique to or more commonplace within eco-drivers. Thirdly, we sought to investigate whether there were differences in the frequency that eco-drivers and non-eco-drivers engaged with the different behaviours. Upon collecting the different behaviours, they were included in part of a wider online questionnaire investigating eco-driving. It was found that for all eco-driving behaviours other than "I use my vehicles on-board cruise control where possible to control my speed" was followed by a greater percentage of eco-drivers. Whilst no behaviours were clearly unique to eco-drivers, the fact that the vast majority were followed by eco-drivers and by fewer non-eco-drivers suggests that there is a need for greater awareness of fuel-efficient behaviours to be promoted to the general driving community. Results also suggested that of the known behaviours, eco-drivers engage with the majority of fuel efficient driving behaviours with significantly greater regularity, suggesting not only a need to promote knowledge of behaviours related to fuel efficiency, but also encourage engagement with such behaviours. It should be noted that that participants did not have the option within the questionnaire to state whether their car had functionality related to each of the discussed features, for example whether their car was equipped with cruise control functionality. Although this may act as a bias when considering what participants would do if they had the option, it does not heavily detract from representing current behaviours. When considering the difference between eco-drivers and non-eco drivers, the concept of gamification was the starkest difference, with eco-drivers attempting to better their previous fuel economy with far greater regularity. Encouraging non-eco drivers to engage with greater gamification presents a large opportunity for engagement with eco-driving more generally, promoting awareness.

Further data analysis is required to explore whether there are experience or gender differences in participants responses. Previous research comparing the eco-driving knowledge of nine older experienced and nine younger, inexperienced, drivers, was completed by Strömberg, Karlsson and Rexfelt (2015), in Sweden. They found that whilst the term 'eco-driving' was know to all bar two experienced drivers, the level of knowledge relating to eco-driving varied greatly both within and between the groups. It is hoped that the data gathered within the current study can add to understanding related to the role of experience in fuel-efficient driving.

A gap in the current work is the inability to directly associate the following of these behaviours to a numerical value for fuel saved. Indeed this is a necessary next step within the research. Whilst participants were asked to provide a measure of fuel efficiency, as measured by miles per gallon (MPG), the majority of non-eco-drivers were unable to provide this information as part of the questionnaire. Combined with differences in vehicles between participants, accurate comparison of MPG, regarding the impact of the different behaviours was not possible. One approach to obtaining an accurate measure of the impact of the different behaviours is to compare the fuel efficiency of participants within a single vehicle or simulator, and compare subsequent fuel usage. Once the impact of each behaviour is known, it will be possible to develop and assess the success of training interventions designed to increase drivers' awareness and use of these different behaviours and consequently, it is hoped improve drivers' fuel efficiency.

In summary, an online study was used to explore the extent to which drivers, including those who consider themselves to be eco-drivers, complied with behaviours associated with fuel-efficient driving, gather from a search of both academic literature and popular online eco-driving resources. Following 196 responses it was found that not only did a greater proportion of eco-drivers engage with the documented behaviours, but eco-drivers engaged with the majority of the different behaviours with much greater regularity. Future work is needed to explore both the relative savings of each of the different behaviours but also ways in which to encourage non-eco-drivers to engage with the different identified behaviours.

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