DRIVER BELIEFS REGARDING THE BENEFITS OF REDUCED SPEEDS

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ABSTRACT

Despite many studies of the benefits of reducing driving speeds for safety, vehicular emissions, and stress in driving, little is known regarding how drivers perceive these benefits and the factors influencing their beliefs. This paper examines the factors influencing driver perceptions of the benefits attainable by reducing travel speeds. Driver perceptions of the extent to which reducing speed would lead to improved safety, lower emissions, and reduced stress and road rage were collected in an online survey of 3538 drivers in Queensland, Australia. An analysis using seemingly unrelated regression showed that drivers of automatic cars and bicycle commuters more strongly agreed that lower speeds would provide these benefits than other drivers, while drivers who used premium fuel thought otherwise. Users of ethanol blended fuel believed more strongly that reductions in speeds would reduce emissions. Young drivers less strongly agreed regarding both emissions and stress than older. Females, drivers of small cars, and those who drive frequently with passengers agreed more strongly that speed reductions would improve safety and reduce stress and road rage. These findings indicate a need to develop targeted educational and training programs to help drivers better understand these benefits to improve their willingness to reduce speeds.

Keywords: Driver perceptions; Speed choice; Safety; Vehicle emissions; Stress and road rage; Seemingly unrelated regression.

1. INTRODUCTION

Improved safety, reduced vehicular emissions, and lowered driving stress are the three important benefits of traveling at slower and consistent speeds. Past research has demonstrated that higher safety levels can be obtained by lowering speed limits (Finch et al., 1994; Kockelman and Bottom, 2006) and that traveling above posted speed limits and driving aggressively results in increased fuel consumption, vehicular emissions, and driving stress and road rage (e.g., Dukes et al., 2001; Eerens et al., 1993; LAT, 2006).

A large number of studies have demonstrated the benefits attainable by reducing travel speeds through field studies and analysis of safety and emissions data (see a brief review of the literature in Section 2). While these studies have provided objective evidence of the benefits of speed reductions, little is known about driver beliefs of the benefits and the factors that influence their beliefs. Without a proper understanding of drivers' beliefs of the benefits and of their influencing factors, speed control measures (e.g., speed limit signage, speed camera, enforcement) targeted to improve the benefits might be less effective. For example, a reduction in speed limits (because of roadworks or a bottleneck, for example) might not attract good compliance rates from drivers (Debnath et al., 2014a; 2014b). Drivers are likely to drive at speeds they perceive to be suitable, or with which they are comfortable, regardless of the reductions in posted speed limits (Brewer et al., 2006). Therefore, it is reasonable to argue that drivers would be more likely to choose driving at posted limits when they correctly understand the benefits of reducing travel speeds. These arguments support the assertions that understanding driver perceptions of speed reduction benefits and their influential factors is important for achieving better results from speed control measures.

This paper examines the factors influencing driver perceptions of the benefits attainable by reducing travel speeds. Driver perceptions of the extent to which reducing speed would lead to improved road safety, lower vehicular emissions, and reduced driving stress and road rage were collected using an online survey of drivers in the state of Queensland, Australia. The three benefits of speed reduction are modeled using a simultaneous equations modeling technique. Since each driver perceived the benefits simultaneously, the perceptions are likely to be correlated within individuals due to shared unobserved characteristics of drivers. Interrelated systems of equations like the technique applied here is an appropriate choice to properly account for the unobserved and within-driver correlations. The technique is illustrated for modeling the perceived benefits of speed reduction in order to understand how driver perceptions vary according to characteristics of drivers, their cars, and their travel behavior.

The reminder of the paper first presents a brief review of literature related to the benefits of speed reduction, followed by the survey methodology and a description of the collected data. The modeling technique is described then, before presenting the model results and discussions.

2. LITERATURE REVIEW OF SPEED REDUCTION BENEFITS

Driving speed and speed limits have significant influences on road safety. A number of studies (Elvik et al., 2004; Nilsson, 2004) have shown that speed not only affects the likelihood of being involved in crashes, but also influences crash severity. Aarts and van Schagen (2006) concluded from a review of studies which examined the relationships between speed and crash risk that crash rate increases with increase in travel speed. In addition, changes in posted speed limits are associated with changes in the likelihood of crash and fatality. Finch et al. (1994) reported a 3% decrease in crash rate in response to 1 km/h reduction in speed. Similarly, Kockelman and Bottom (2006) found a 3% increase in crash rate and 24% increase in the probability of a fatality if a crash occurred when speed limit was increased from 55 to 65 mph (88.5 to 104.6 km/h). Furthermore, larger speed variance among vehicles in a road section is associated with higher crash rates, possibly because the variance influences the rate of overtaking in a traffic stream (Hauer, 1971). Aarts and van Schagen (2006) showed that there is a higher risk of being involved in crash when a driver drives faster than the surrounding traffic. The effects of driving slower than surrounding traffic were inconclusive though.

Influence of speed limits on drivers' speed choice and perception of safety has also been a subject of considerable research. For example, Mannering (2009) studied drivers' perception of the relationships between speed limits and safety among 988 drivers in Indiana. Drivers were found to link their perceptions of safety to the likelihood of being booked for speeding, suggesting that their perception of safety is influenced by enforcement (or perceived enforcement). Perceptions of safety were also found to be correlated with driver-reported speeding behavior. However, other research suggests that drivers' perception of safety and willingness to comply with posted speed limits are interrelated. For example, Kanellaidis et al. (1995) showed from a study among Greek drivers that those who believe speed limits contribute to reduction in crashes are generally more likely to be compliant with posted speed limits. While these studies looked at driver beliefs about safety benefits generated from reduced speeds, the potential benefits related to vehicular emissions and driving stress were not among the foci of these studies.

Some researchers have studied the relationships between fuel consumption and driving behavior. A number of studies (e.g., Eerens et al., 1993; LAT, 2006; Nie and Li, 2013) showed that high speed and aggressive driving (e.g., sudden acceleration and braking, frequent lane shifting) result in sharp increases in fuel consumption and emissions. An aggressive driver generally consumes 12-40% more fuel and produces 1-8 times more carbon monoxide (CO), 15-400% more volatile organic compounds (VOC), and 20-150% more oxides of nitrogen (NO_x) than a non-aggressive driver (De Vlieger et al., 2000). Significant fuel savings and emissions reductions can be achieved by encouraging drivers to drive at consistent speeds, imposing lower speed limits, and enforcing current speed limits. The European Environment Agency (EEA, 2011) reported from a simulation study that a 10 km/h reduction in motorway speed limits (from 120 km/h to 110 km/h) would reduce fuel consumption by 12-18% for passenger cars at a full compliance rate.

While it is evident from the literature that fuel consumption could be effectively reduced by adopting good driving behavior, it is not known whether drivers believe that they could reduce vehicular emissions by driving at lower and consistent speeds. Results from a public poll (EEA, 2011) indicate a general willingness to reduce speeds in order to reduce emissions, though this may not necessarily translate to compliant behavior. Non-compliance with posted speed limits is common in most road sections (Debnath et al., 2014a; 2014b; OECD, 2006) and speeding is often cited as one of the major contributory factors of crashes (Clarke et al., 2002). Despite the demonstrated benefits of improved safety and reduced fuel consumption and emissions, there are a range of cognitive, motivational and emotional factors that might militate against drivers adopting lower speeds.

From the cognitive perspective, drivers generally do not have a proper understanding of the changes in travel time due to change in driving speeds. A series of studies (Fuller et al., 2006; 2008; Fuller et al., 2009; Svenson, 2008; 2009) consistently reported that drivers misjudge the amount of time saved when increasing speeds or the amount of time lost when decreasing speeds. Generally, the amount of time saved is underestimated when increasing from a low speed and overestimated when increasing from a high speed. On the other hand, the amount of time lost is underestimated when decreasing from a low speed and overestimated when decreasing from a high speed. Furthermore, Cœugnet et al. (2013) showed from a laboratory study that time pressure leads to both underestimation of speed and trip duration.

Research have also suggests that drivers have incorrect perceptions about their own speeds and the speeds of others. For example, Walton and Bathhurst (1998) showed from a study among New Zealand drivers that 85-90% of drivers perceived that they drive slower than the average driver. A Swedish study (Haglund and Aberg, 2000) found that drivers perceived 50.7% of other drivers as non-compliant with posted speed limit with a margin of more than 10 km/h over the limit, whereas in reality only 22.9% drivers were observed speeding by this margin. Cœugnet et al. (2013) found that underestimation of speed is influenced by the state of being on time-pressure.

Driver motivations may influence the speeds they choose to drive at and other unsafe driving behaviors. Many studies from around the world (see Peer, 2011 for a discussion) have reported that drivers are often in a hurry when driving. Furthermore, McKenna (2005) showed that citing time pressure or being in a hurry are among the common reasons drivers give to explain delinquent behavior. Hurry in driving is also often associated with speeding, faster acceleration, sudden braking, aggressive driving, and feeling more stress in driving (Oliveras et al., 2002).

The emotions of frustration and impatience can occur when traffic congestion or slow moving vehicles force drivers to travel more slowly than they want to, and this can lead them to select routes and speeds that they believe would shorten their travel time (Fuller, 2005; Tarko, 2009). Shinar (1998) proposed that frustrating on-road events, such as traffic congestion or delays, can act as a trigger to aggressive behaviors which are moderated by both person-related and situational factors. Frustration in driving and aggressive driving could also lead to increased road rage. Dukes et al. (2001) reported that aggressive driving produces more road rage than impeding traffic does.

While there is a common perception that aggressive driving and road rage essentially refer to similar types of driving offences, these two terms actually carry different meanings. In literature, aggressive driving is defined in terms of deliberate traffic offences (e.g., failure to give way, cutting off other vehicles). The term “road rage” is mostly used by the media and members of the public (and some writers) to refer to aggressive driving, but many researchers reserve this term for extreme cases of aggressive driving that usually involved goal-oriented acts of violence which are criminal offences (Goehring, 2000; Joint, 1995).

The foregoing review shows that many studies have demonstrated the benefits attainable by reducing travel speeds. However, specific focus of these studies did not simultaneously account for all three benefits of reduced-speed travel, namely improved safety, reduced vehicular emissions, and lowered driving stress. While the reviewed studies primarily focused on objectively understanding the benefits of speed reductions (as well as of other driving behavior, such as aggressive driving), limited emphasis have been given on understanding driver beliefs about the benefits and which factors influence their beliefs. The current study fills this important gap in the literature.

3. DATA

3.1 Perception Survey

Driver perceptions of the benefits of reducing driving speeds were collected using an online survey. The survey entitled "Driving Costs, Attitudes and Behaviours study" was designed to assess the suitability of respondents for later participation in an eco-driving training program, conducted by the Royal Automobile Club of Queensland (RACQ) and partly funded by the Queensland Government. The Centre for Accident Research and Road Safety – Queensland (CARRS-Q) provided advice on development and analysis of the study.

The prerequisites for participating in the eco-driving program included being at least 18 years old, being the main driver of the car driven, the car being privately owned, and agreeing to the conditions of participating in the eco-driving training program (using a fuel card for all fuel purchases from selected brand outlets for about six months, not intending to sell or modify their car during the study period). To support involvement in the survey and the training program, participants were offered two incentives: entry into a draw of 2 cash prizes of $1000 each (open to all survey participants), and 4 cents per liter discount on all fuel purchases during the study period (only for participants of the training program). It should to be noted that while the survey participants were aware that some of them will later be selected for participation in the eco-driving training program based on their responses in the survey, the selection criteria for inclusion in the training program was not revealed to participants. Therefore, the participants did not know specifically which responses might help them to be selected for the training program. Membership of the club who conducted this survey (RACQ) was not a requirement for participation.

The questionnaire included items on driver beliefs regarding the effects of a range of measures on safety, emissions, and stress and road rage. In addition, demographic data and information about vehicle and travel mode usage patterns were collected in the survey. The questions are summarized in Table 1. Among the questions related to driver beliefs, three questions were used in the current study which are I believe I can improve road safety if I reduce my driving speed", "I believe I can reduce my car's emissions if I reduce my driving speed", and "I believe I can reduce stress and road rage if I reduce my driving speed". Respondents indicated their response to each item on a 6 point scale (1=strongly disagree, 2=moderately disagree, 3=slightly disagree, 4=slightly agree, 5=moderately agree, and 6=strongly agree). A detailed description of the survey and preliminary analysis of the data can be found elsewhere (Debnath et al., 2013; Graves and Jeffreys, 2012).

3.2 Recruitment and participants

An email invitation to participate in the survey was sent to 194,662 RACQ members in Queensland for whom RACQ held a valid email address. Email recipients were encouraged to forward the invitation to friends and family who they thought might be interested in participating. The invitation was sent on 12 April 2011. As at 6 May 2011, 6705 potential participants had accessed the survey and 3585 complete and valid responses were received. These responses included all questions completed and agreement with the conditions of the survey. Further examination of the data (removing errors and unrealistic values) resulted in having 3538 responses for the present study.

Participants had an average age of 46.3 (S.D. = 15.7) years with an almost equal share of males and females. About 80% of the participants had more than 11 years driving experience and only 10.5% had less than 5 years experience. About 85% of the respondents lived in urban areas. While the response rate was low (1.8% if the unknown number of surveys passed on to friends and family are ignored), Figure 1 shows that the distribution of participants by age groups reflects the licensed driver population in Queensland reasonably well.

3.3 Data Description

Table 2 lists the variables used in the current study which are a subset of all the variables collected in the survey. The variables and their categories are described, along with their summary statistics and reference categories of categorical variables. Three of the variables—safety benefit, emissions benefit, and stress benefit—represent the outcome variables of the regression models described later in the paper. The other variables in the table are the explanatory variables of the models. The explanatory variables listed here were those hypothesized to be associated with drivers' beliefs about the benefits of speed reductions. Although some of the variables were later found to be non-significant in the calibrated models, it should be noted that the set of explanatory variables reflects an effort to capture the characteristics of driver demographics, their cars, and their travel behavior.

The three demographic characteristics were age, gender, and living area of participants. Age was coded into indicator variables following the classification scheme used by the local road and licensing authority for classifying licensed drivers into age groups (TMR, 2013). Gender and living area (urban or rural) were expressed in dichotomous form.

Characteristics of cars were expressed by six variables. Age of car was coded into indicator variables to reflect new cars (age<3years), cars of intermediate age (3-8 years), old cars (9-13 years) and very old cars (14 years or more). It is to be noted that average age of all vehicles registered in Australia is about 10 years—a value that remained constant over the period 2010-2013 (ABS, 2014). Type of transmission (automatic, manual) and number of cylinders (2-4, 5-8) variables were coded as dichotomous variables. Engine size was classified into four categories: small (1.9 liters or less), medium (2-2.9 liters), large (3 liters or more), and unknown (27% of the respondents reported not knowing their car's engine size). Five categories of type of fuel used were considered including diesel, liquefied petroleum gas (LPG), and three classes of unleaded petrol (ethanol blended gasoline 'E10', regular unleaded, and premium unleaded). About 85% of the participants reported using unleaded petrol (regular: 46%, premium: 20%, and E10: 19%), whereas 19% reported diesel and only 2% reported using LPG. Fuel consumption (in liters per 100 km) was coded into five indicator variables: highly efficient (8 liters or less), efficient (8.1-12 liters), not so efficient (12.1-16 liters), inefficient (more than 16 liters), and unknown. About 40% of the respondents reported that they do not know their car's fuel consumption. The high proportion might indicate that many drivers are generally unaware or uninterested in their car's fuel consumption.

A total of eight variables were used to capture the travel characteristics of the respondents. Number of drivers, as a dichotomy (single driver or multiple drivers of a particular car) measured the extent to which a driver shares driving his/her car with others. Weekly distance driven was categorized into five indicator variables. The other six variables gauged respondents' choice of transportation modes: walk, cycle, public transport, drive with no passengers, drive with passengers, and travel as a passenger in a car. These variables were measured by the number of days each transport mode is used by respondents in an average month. Note that someone who normally cycles to work may also use public transport occasionally. Similarly, someone who uses public transport may also have a significant amount of walking or cycling involved in travelling to and from public transport stop and home.

The outcome variables of the model were measured on a 6 point scale with 1 being 'strongly disagree' and 6 being 'strongly agree'. Therefore, an increase in the scale represents an increase in the positive beliefs of the benefits.

4. ANALYSIS METHOD

The three outcome variables were measured simultaneously from each individual participant in the sample. Therefore, these outcomes are likely to be correlated within individuals and unobserved driver characteristics might influence their beliefs in a similar way across the three variables. Modeling the outcomes without appropriately treating the interrelated structure would result in erroneous model estimates (Washington et al., 2011). If ordinary least squares (OLS) regression is used, it would violate a key assumption of the OLS regressions that the correlation between the regressors and disturbances is zero. If ignored, this endogeneity of errors will result in erroneous conclusions and inferences from the empirical models. Furthermore, OLS assumes that the calibrated model has all necessary information relating to the model and its variables so the estimated model parameters are unbiased and efficient. However, if not all information are taken into account—for example, not knowing that the disturbance terms of the three regression equations are likely to be correlated because of potentially correlated unobserved driver characteristics that influence their beliefs—then the unbiasedness and efficiency of estimated parameters are questionable.

A popular and robust approach for modeling such interrelated data and endogeneity is the three-stage least squares (3SLS) estimation, where one endogenous variable serves as a predictor of another. For example, driver beliefs of the safety benefits may serve as a good predictor of the emissions benefits beliefs. In this approach, endogenous variables (those variables whose variations are caused by the other variables in a model) serve as predictors of other outcome variables. A variation of the approach, called seemingly unrelated regression (SUR), is that only the exogenous variables (those variables which vary independently of other variables in a model) serve as predictors. The disturbance terms for the outcomes are correlated with each other due to shared unobserved characteristics, i.e., any unobserved factors that determine the outcome variables are likely to be correlated.

In order to decide which approach of interrelated systems of equations suits the data, endogeneity was tested first using the Durbin WU Hausman (DWH) test. The test examines endogeneity in data by estimating the significance of the residuals of an outcome variable for which endogeneity is being tested in a linear model with another outcome variable as the response variable.

In the absence of significant endogeneity (as found later in the analysis), the SUR approach is an appropriate choice. The three outcome variables of driver perceptions—improve safety (IS), reduce emissions (RE), and reduce stress and road rage (RSRG)—can be written in the form of a system of simultaneous equations:

$$IS = \alpha_{IS} + \boldsymbol{\beta}_{IS}\boldsymbol{X} + \boldsymbol{\gamma}_{IS}\boldsymbol{Y} + \boldsymbol{\delta}_{IS}\boldsymbol{Z} + \varepsilon_{IS} \quad (1)$$
$$RE = \alpha_{RE} + \boldsymbol{\beta}_{RE}\boldsymbol{X} + \boldsymbol{\gamma}_{RE}\boldsymbol{Y} + \boldsymbol{\delta}_{RE}\boldsymbol{Z} + \varepsilon_{RE} \quad (2)$$
$$RSRS = \alpha_{RSRG} + \boldsymbol{\beta}_{RSRG}\boldsymbol{X} + \boldsymbol{\gamma}_{RSRG}\boldsymbol{Y} + \boldsymbol{\delta}_{RSRG}\boldsymbol{Z} + \varepsilon_{RSRG} \quad (3)$$

where IS, RE and $RSRS$ are the perceived benefits for improving safety, reducing emissions, and reducing stress and road rage, respectively; $\boldsymbol{X}$ is the vector of driver demographics characteristics; $\boldsymbol{Y}$ is the vector of the characteristics of cars; $\boldsymbol{Z}$ is the vector of driver travel behavior characteristics; α, $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$, and $\boldsymbol{\delta}$ are the vectors of estimable parameters in the model, and ε are the correlated disturbance terms within individual respondents. The three equations (eq. 1-3) are seemingly unrelated but there is contemporaneous correlation of disturbance terms. If the three equations are estimated separately by OLS, then consistent but inefficient estimates of coefficients would be obtained. By considering the contemporaneous correlation of the disturbance terms, efficient estimates of coefficients can be obtained. Interested readers are referred to Washington et al. (2011) for a detailed description of the SUR modeling approach.

5. RESULTS AND DISCUSSION

Before estimating the parameters of the models, the DWH test was conducted to examine if endogeneity exists in the system of equations. Endogeneity was not found to be statistically significant in any of the models. Therefore, the SUR estimation approach is an appropriate choice to estimate the model parameters.

The formulated SUR models were calibrated to examine the trends in driver beliefs regarding speed reduction benefits and how these beliefs vary with different characteristics of drivers and their cars and travel characteristics. Three linear regression equations, each with one of the three outcome variables specified earlier, were estimated simultaneously using the iterative estimation command "*isure*", which iterates until the maximum likelihood result is obtained, in the software STATA 11.2. The most parsimonious models were obtained by minimizing the values of Akaike Information Criteria (AIC). The parameter estimates, their statistical significance, and the fitness statistics of the models are presented in Table 3.

Fitness statistics of the estimated models showed that all three models are superior to models with only a constant term. The Chi-square test statistics and associated p-values indicate that the test statistics were significant at 99% confidence level. These suggest that the outcome variables are functions of various explanatory variables.

Turning to the specific estimation results, several explanatory variables were found to be significant in the models. The variables, both those found statistically significant and those omitted due to lack of statistical significance (where appropriate), are discussed in the subsequent sections.

5.1 Driver demographics

Driver's age was not found to be a significant predictor of the perceived safety benefits of reducing their speeds. However, in the case of the beliefs regarding the other two benefits, significant differences were observed among different age groups of drivers. Drivers aged between 18 and 29 years less strongly agreed that reducing their driving speed would result in reduced emissions or reduced stress and road rage than drivers aged between 50 and 59 years. Drivers aged 30-39 years had beliefs similar to those aged 18-29 years, but the results were significant at the 90% confidence level only. Regression coefficients for other age groups were not statistically significant. These results are consistent with earlier research findings regarding associations between driving speeds and aggressive driving. For example, Fildes et al. (1991) found that younger drivers (under 34 years of age) were more likely to exceed the 85th percentile speed, whereas drivers aged over 45 years were more likely to be the excessively slow drivers. Studies (e.g., AAA, 1997) have reported that the majority of aggressive drivers are men aged between 18 and 26 years. Age of driver was also proved to be the most significant factor in crashes related to aggressive driving (Arnett, 1994). Aggressive driving and thrill-seeking results in risky driving behaviors like speeding, sudden acceleration, and hard braking (Öz et al., 2010). While such behaviors are definite safety hazards, they also result in increased fuel consumption and emissions (Joumard et al., 1995) as well as in increased stress and road rage (Dukes et al., 2001; Oliveras et al., 2002).

In terms of the magnitude of influence, young drivers (18-24 years) had the least agreement that speed reduction reduces vehicular emissions and driving stress among all driver age groups. These drivers are mostly the new and novice drivers who either have started driving recently or have been driving only for few years. Perhaps, lack of driving experience in combination with the tendency of overrating own driving skills by this group of drivers might underpin young drivers perceiving the speed reduction benefits less positively than their senior counterparts. Furthermore, young drivers are prone to faster driving than others (Quimby et al., 1999) and young males are the most aggressive drivers (AAA, 1997). Deliberate risk-taking behaviors, such as speeding, drink-driving, and reckless or negligent driving are also cited to contribute to about half of the crashes involving young drivers (Clarke et al., 2005). These findings in literature support the finding of the current study that young drivers had the least agreement with speed reduction benefits.

Compared to male drivers, females agreed more strongly that reducing driving speeds improves safety and reduces stress and road rage. This finding, again, is consistent with the findings discussed from literature on the association between aggressive driving and crash risk. However, no significant differences were found regarding the perceived benefits of speed reductions in reducing emissions reduction between males and females. Interestingly, where drivers live (urban/rural) did not show significant influence on their benefit perceptions either.

The above findings of this study have important implications for improving driver behavior with regard to reducing travel speeds. Since male drivers under the age of 40 years, particularly the young novices, had relatively less strong beliefs than other driver groups about the speed-reduction benefits, transportation and enforcement authorities should target this driver group in order to improve their beliefs through education campaigns. On the other hand, the other groups of drivers who showed positive attitude to speed reduction may be better targets for educational campaigns targeted at encouraging drivers to reduce travel speeds.

5.2 Characteristics of cars

Age of the car was found to be a significant predictor of perceived benefits in terms of emission reductions. The drivers of the very old cars (14 years or more) perceived the benefits less positively than the drivers of cars of intermediate age (3-9 years). Older cars are likely to be less fuel efficient and produce more emissions, thus it is not surprising to observe such beliefs from the drivers of older cars.

Drivers of small-engined cars (1.9 liters or less) believed that they can improve their safety and reduce stress and road rage in driving by travelling slower to a greater extent than the drivers of cars with 2-2.9 liters engines. This result can be explained by a finding of Quimby et al. (1999) that the fastest drivers are usually the younger people, drivers who drive large cars, and those who have high annual mileages.

Drivers of automatic cars had higher levels of agreement that speed reduction improves safety, reduces vehicular emissions (significant at 92% confidence level), and reduces stress and road rage. However, Larue et al. (2014) contended that eco-driving instructions (e.g., driving at consistent speed, avoiding jerky braking and acceleration) may be less effective for automatic car drivers. They found that the instructions did not result in lower fuel consumption or CO_2 and NO_x emissions than in normal driving of an automatic car (although there were reductions of about 20% in CO and HC emissions). This suggests a need to develop tailored and effective eco-driving instructions for drivers of automatic cars, given their positive beliefs related to speed reductions.

Drivers who use premium quality unleaded fuel perceived that they can improve safety, reduce emissions, and reduce stress and road rage to a lesser extent by driving at slower speeds than the drivers who use regular unleaded fuel. The premium fuels are richer in octane rating than the regular unleaded fuel and therefore drivers expect better engine performance and possibly more fuel efficiency. Many cars which require premium fuel are high performance cars and research (Clarke et al., 2002; Horswill and Coster, 2002) showed that drivers of high performance vehicles are more likely to travel at higher speeds. Debnath et al. (2013) also showed that drivers of high performance vehicles are more likely to be involved in minor road rage acts (e.g., shouting and threatening without assault or property damage) than drivers of other cars. Perceptions of the drivers who use premium fuels (which are costlier than regular unleaded) indicate that they care for their cars or ready to pay higher fuel prices, but perhaps not so when it comes to their safety or protecting the environment. Interestingly, drivers who use ethanol blended unleaded fuel (E10) believed more strongly than the regular unleaded users that reducing driving speed would produce less emissions. It is known that quality of fuel has direct effects on vehicular emission levels and fuel economy (Graves and Jeffreys, 2012; Perry and Gee, 1995). In comparison with regular unleaded fuel, E10 reduces CO, CO_2, and NO_x emissions but increases fuel consumption rate (Graves and Jeffreys, 2012; Larue et al., 2014). Drivers seem to perceive correctly that use of E10 would reduce vehicular emissions.

The above findings could be utilized by transportation and enforcement agencies to target driver groups for relevant education campaigns. Drivers of large-sized old cars with manual transmission might be better targets for campaigns to improve driver beliefs about speed reduction benefits, whereas the new and automatic transmission car drivers who use premium quality unleaded fuel might be better targets for speed-reduction related campaigns.

5.3 Travel behavior

Drivers who reported driving fewer kilometers per week (up to 200 km) believed that they could reduce driving stress and road rage to a greater extent by reducing speeds than the drivers who reported driving 201-400 km/week. A possible plausible explanation of this finding is that shorter distance drivers might have lower time pressure or be in a hurry less often than the longer distance drivers. This is because the former group requires less travel time than the other group in everyday travel (for example, commuting), so a reduction in speed would not affect their travel time as greatly as it would affect the travel time of longer distance drivers. Furthermore, the shorter distance drivers might be regular users of alternative modes of transport (e.g., walk, cycle), thus a reduction in speed is seen as a positive approach from the viewpoint of a pedestrian or cyclist.

Number of days cycled per month showed significant positive associations with perceptions of improving safety, reducing emissions, and reducing stress and road rage by traveling at slower speeds. Positive beliefs of the associations were found to increase with increasing numbers of days cycled as an alternative mode of transport. Being cyclists, the drivers might understand that reducing car speeds could improve the safety of bicyclists. Cycling, being an emission free transport mode, could also help these drivers to become aware of the adverse effects of vehicular emissions.

Drivers who frequently drive with passengers perceived that they can improve safety and reduce stress and road rage by reducing driving speed. Driver who commute alone in a car are likely to drive at higher speeds than others (Quimby et al., 1999) and those who drive with passengers are more likely to have family members (e.g., driving children to school) in their cars. These issues might influence drivers to travel at slower speeds, remain relaxed, and not become involved in any forms of road rage.

While the number of days public transport is used was found to be positively associated with positive perceptions of improving safety by reducing speeds, it was not found to be significant in the other models. Number of days in a month a person uses the travel modes—walking, driving with no passengers, and traveling as a passenger—was also found to be non-significant in all three models.

The above results have important implications for transportation and enforcement authorities. As the results show, drivers who frequently drive with passengers, drive for a short distance per week, or often ride a bicycle showed greater beliefs about speed reduction benefits than other drivers. These groups of drivers might be better targets for speed reduction related campaigns.

5.4 Limitations

While this study has produced useful insights into understanding driver beliefs of speed reduction benefits, it has some limitations. The response rate was low (1.8%, although the total number of observations was sufficiently large: 3538) and the survey sample consists of mostly RACQ members who are residents of Queensland (note that about 35% of licensed drivers in Queensland are RACQ members). Thus, the results may be less generalizable to general driver population and residents of other parts of Australia and of other countries. Another limitation is that some participants might have confused ‘speeding’ and ‘driving speed’ when the survey questions were stated as “... if I reduce my driving speed”. This could have potentially resulted in some drivers who do not speed, not agreeing that reducing their speed would result in safety or environmental benefits. Having said this, an examination of the issue was not possible with the current data.

6. CONCLUSIONS

The results of the SUR models suggest that there are significant associations between drivers' perceived benefits and the characteristics of drivers, their cars, and their travel behavior. While driver age was not a significant predictor of safety benefits, drivers under the age of 29 years perceived the benefits of reducing emissions, and stress and road rage less strongly than the older drivers. Female drivers and those who drive small cars had stronger beliefs than other drivers that reducing speed would improve safety and reduce stress and road rage. Drivers of automatic cars and drivers who are bicycle commuters perceived the three benefits more positively than other drivers. On the other hand, drivers who use premium quality unleaded fuel perceived the three benefits less positively than those who use regular quality unleaded fuel. However, those who use ethanol-blended unleaded fuel perceived the benefit of emissions reductions more strongly that the regular unleaded users. Driving with one or more passengers seem to had positive effects on drivers' speed reduction benefit beliefs for improving safety and reducing stress and road rage. Drivers who drive fewer kilometers per week felt that reducing speed would help them to reduce stress and road rage. Apart from cycling and driving with passengers, use of other forms of transport modes, such as walking, public transport, driving alone, and being a passenger in a car were not found to be associated with drivers' speed reduction benefits perceptions.

The finding that some driver groups perceived the benefits of speed reduction positively holds promise for making road transport safer, less damaging to the environment, and less stressful to drivers. However, there remains a greater need for convincing some groups of drivers about the costs and benefits of reducing travel speeds. In particular, education programs targeted to young male drivers could help them to better understand the benefits of driving at lower speeds. Findings of the current study, in conjunction with the findings of existing research that drivers generally misjudge the travel time savings or losses resulting from changes in travel speeds, indicate that driver perceptions may not truly reflect the actual benefits achievable from reducing speeds. Therefore, correcting the misperceptions and encouraging more positive perceptions of speed reduction benefits should be among the targets of driver education and licensing programs. Evaluation of the effectiveness of such programs could be an important subject of future research.

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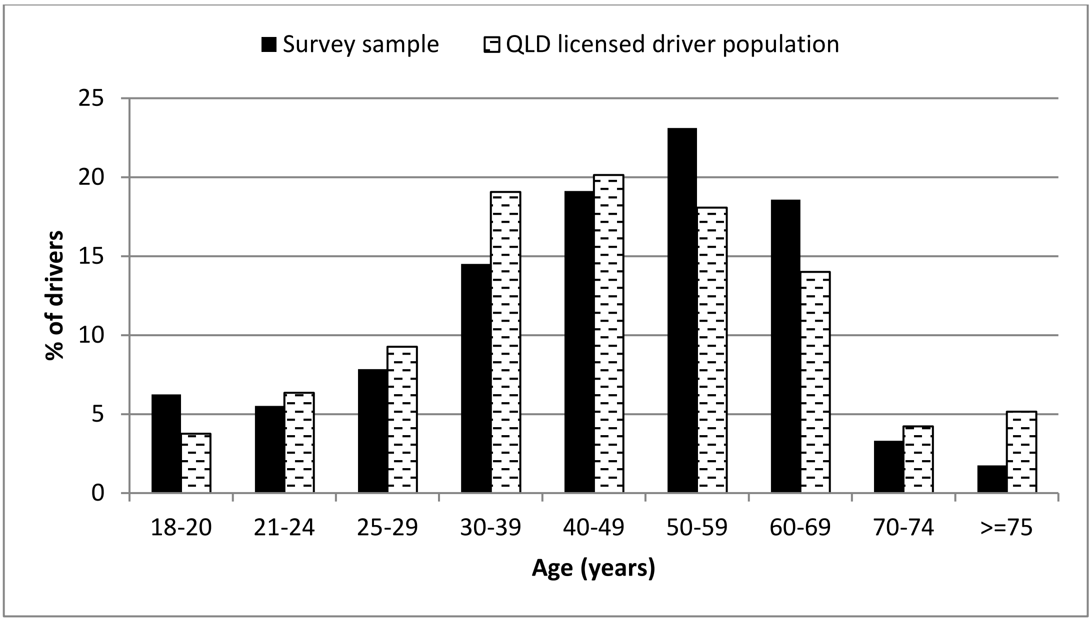

Figure 1 Comparison of survey sample and Queensland's (QLD) licensed driver population

Table 1 Summary of survey questions

Survey questions	Measurement unit
Driver beliefs related questions	
I believe I can improve road safety if I drive a car with the newest technology	1 to 6*
I believe I can improve road safety if roads were smoother and wider	1 to 6*
I believe I can improve road safety if I follow the road rules	1 to 6*
I believe I can improve road safety if I walk, cycle or use public transport	1 to 6*
I believe I can improve road safety if I reduce my driving speed[#]	1 to 6*
I believe I can reduce my car's emissions if I change my driving style	1 to 6*
I believe I can reduce my car's emissions if I have my car serviced at least once per year	1 to 6*
I believe I can reduce my car's emissions if I plan my trips in advance	1 to 6*
I believe I can reduce my car's emissions if I reduce my driving speed[#]	1 to 6*
I believe I can reduce my car's emissions if I use alternative fuels e.g., ethanol/ biodiesel	1 to 6*
I believe I can reduce stress and road rage if I drive a car with the newest technology	1 to 6*
I believe I can reduce stress and road rage if I change my driving style	1 to 6*
I believe I can reduce stress and road rage if I follow the road rules	1 to 6*
I believe I can reduce stress and road rage if I walk, cycle or use public transport	1 to 6*
I believe I can reduce stress and road rage if I reduce my driving speed[#]	1 to 6*
I believe I can reduce stress and road rage if I plan my trips in advance	1 to 6*
Driver demographics related questions	
Age (What is your birth year?)[#]	Years
Gender (What is your gender?)[#]	Male/Female
Living area (where do you live?)[#]	Post code
Driving experience (How many years of driving experience you have?)	Years
Car characteristics related questions	
Car age (What is the year of manufacture of your car?)[#]	Years
No of cylinders (How many cylinders your car's engine has?)[#]	No of cylinders
Displacement (What is the engine size of your car?)[#]	Litres
Fuel type (Which type of fuel you regularly use?)[#]	Regular unleaded/ Premium unleaded/ LGP/ E10/ Diesel
Fuel consumption (What is the average fuel consumption rate of your car?)[#]	Litres per 100 Km
Transmission type (What is the type of transmission of your car?)[#]	Auto/Manual
Travel characteristics related questions	
How many kilometres you drive per week?[#]	Km
How many drivers usually drive your car?[#]	No of drivers
How many days per month you use other modes of transport – Walk?[#]	Days/month
How many days per month you use other modes of transport – Cycle?[#]	Days/month
How many days per month you use other modes of transport – Public transport?[#]	Days/month
How many days per month you use drive your car with passenger(s)?[#]	Days/month
How many days per month you use drive your car without passenger(s)?[#]	Days/month
How many days per month you travel as a passenger in a car?[#]	Days/month

[#] questions used in this study; * 1=strongly disagree, 2=moderately disagree, 3=slightly disagree, 4=slightly agree, 5=moderately agree, and 6=strongly agree.

Table 2 Variables included in Seemingly Unrelated Regression Models

Variables	Description	Mean	S.D.	Min	Max
Dependent variables					
Safety benefit	Strongly disagree (1) to Strongly agree (6)	4.44	1.41	1	6
Emissions benefit	As above	4.30	1.31	1	6
Stress benefit	As above	4.00	1.39	1	6
Explanatory variables					
Driver demographics					
Participant age: 18-20 years	1: Yes, 0: No	0.06	0.24	0	1
Participant age: 21-24 years	1: Yes, 0: No	0.06	0.23	0	1
Participant age: 25-29 years	1: Yes, 0: No	0.08	0.27	0	1
Participant age: 30-39 years	1: Yes, 0: No	0.14	0.35	0	1
Participant age: 40-49 years	1: Yes, 0: No	0.19	0.39	0	1
Participant age: 50-59 years*	1: Yes, 0: No	0.23	0.42	0	1
Participant age: 60-69 years	1: Yes, 0: No	0.19	0.39	0	1
Participant age: 70-74 years	1: Yes, 0: No	0.03	0.18	0	1
Participant age: >=75 years	1: Yes, 0: No	0.02	0.13	0	1
Gender	1: Female, 0: Male	0.50	0.50	0	1
Living area	1: Rural, 0: Urban	0.15	0.36	0	1
Car characteristics					
Car age: <3 years	1: Yes, 0: No	0.19	0.39	0	1
Car age: 3-8 years	1: Yes, 0: No	0.46	0.50	0	1
Car age: 9-13 years*	1: Yes, 0: No	0.22	0.41	0	1
Car age: >=14 years	1: Yes, 0: No	0.13	0.34	0	1
Number of cylinders	1: 2-4, 0: 5-8	0.73	0.45	0	1
Engine size: <=1.9 litres	1: Yes, 0: No	0.23	0.42	0	1
Engine size: 2-2.9 litres*	1: Yes, 0: No	0.28	0.45	0	1
Engine size: >=3 litres	1: Yes, 0: No	0.22	0.41	0	1
Engine size: unsure/don't know	1: Yes, 0: No	0.27	0.44	0	1
Transmission type	1: Automatic, 0: Manual	0.62	0.48	0	1
Fuel type: Diesel	1: Yes, 0: No	0.13	0.34	0	1
Fuel type: E10 unleaded	1: Yes, 0: No	0.19	0.40	0	1
Fuel type: LGP	1: Yes, 0: No	0.02	0.13	0	1
Fuel type: Premium unleaded	1: Yes, 0: No	0.20	0.40	0	1
Fuel type: Regular unleaded*	1: Yes, 0: No	0.46	0.50	0	1
Fuel consumption: <=8L/100km	1: Yes, 0: No	0.15	0.36	0	1
Fuel consumption: 8.1-12L/100km*	1: Yes, 0: No	0.34	0.47	0	1
Fuel consumption: 12.1-16L/100km	1: Yes, 0: No	0.09	0.29	0	1
Fuel consumption: >16L/100km	1: Yes, 0: No	0.02	0.14	0	1
Fuel consumption: Don't know	1: Yes, 0: No	0.40	0.49	0	1
Travel characteristics					
Distance driven/week: <=100km	1: Yes, 0: No	0.14	0.35	0	1
Distance driven/week: 101-200km	1: Yes, 0: No	0.32	0.47	0	1
Distance driven/week: 201-400km*	1: Yes, 0: No	0.37	0.48	0	1
Distance driven/week: 401-600km	1: Yes, 0: No	0.14	0.34	0	1
Distance driven/week: >600km	1: Yes, 0: No	0.03	0.17	0	1
Number of drivers	1: Multiple, 0: Single	0.53	0.50	0	1
Walk	No of days/month	7.72	9.71	0	31
Cycle	No of days/month	1.12	3.72	0	31
Public transport	No of days/month	3.61	6.49	0	31
Dive with no passenger	No of days/month	18.40	9.38	0	31
Drive with passenger(s)	No of days/month	10.91	9.02	0	31
As passenger in car	No of days/month	3.77	4.68	0	31

* Reference category

Table 3 Estimation results and fitness statistics of Seemingly Unrelated Regression Models

Explanatory variables	Coeff.	Std. Err.	z	P>z
Safety model				
Female driver	0.282	0.047	5.98	<0.001
Engine Size: <=1.9 litres[a]	0.157	0.060	2.63	0.009
Engine Size: Unsure/Don't know[a]	0.106	0.060	1.77	0.076
Automatic transmission	0.101	0.050	2.02	0.044
Premium unleaded fuel[b]	-0.280	0.063	-4.46	<0.001
Cycle (days/month)	0.012	0.006	1.94	0.053
Public Transport (days/month)	0.005	0.003	1.66	0.096
Drive with passenger (days/month)	0.008	0.002	3.35	0.001
Constant	4.122	0.068	60.32	0.000
Emissions model				
Participant age: 18-20 years[c]	-0.472	0.088	-5.35	<0.001
Participant age: 21-24 years[c]	-0.417	0.092	-4.55	<0.001
Participant age: 25-29 years[c]	-0.317	0.080	-3.98	<0.001
Participant age: 30-39 years[c]	-0.119	0.064	-1.85	0.064
Participant age: 70-74 years[c]	-0.318	0.113	-2.81	0.005
Car age: <3 years[d]	-0.091	0.049	-1.86	0.063
Car age: >=14 years[d]	-0.134	0.057	-2.33	0.020
Automatic transmission	0.082	0.046	1.77	0.077
E10 Unleaded fuel[b]	0.116	0.059	1.96	0.050
Premium unleaded fuel[b]	-0.147	0.058	-2.52	0.012
Cycle (days/month)	0.017	0.006	2.90	0.004
Constant	4.365	0.060	72.20	<0.001
Stress model				
Participant age: 18-20 years[c]	-0.273	0.088	-3.12	0.002
Participant age: 21-24 years[c]	-0.316	0.091	-3.47	0.001
Participant age: 25-29 years[c]	-0.212	0.079	-2.68	0.007
Participant age: 30-39 years[c]	-0.113	0.064	-1.77	0.077
Participant age: 60-69 years[c]	0.229	0.060	3.84	<0.001
Participant age: 70-74 years[c]	0.231	0.113	2.05	0.040
Female driver	0.175	0.045	3.84	<0.001
Engine Size: <=1.9 litres[a]	0.174	0.057	3.07	0.002
Automatic transmission	0.113	0.050	2.27	0.023
Premium unleaded fuel[b]	-0.201	0.062	-3.26	0.001
Weekly drive distance: <=100 km[e]	0.170	0.057	3.00	0.003
Weekly drive distance: 101-200 km[e]	0.081	0.043	1.86	0.062
Cycle (days/month)	0.018	0.006	2.88	0.004
Drive with passenger (days/month)	0.005	0.002	2.27	0.023
Constant	3.712	0.076	48.66	<0.001
Model Fitness statistics	**Obs**	**Parameters**	**Chi-sq**	**p-value**
Safety model	3538	12	131.4	<0.001
Emissions model	3538	17	126.7	<0.001
Stress model	3538	23	162.4	<0.001

[a] Ref category: 2-2.9 litres; [b] Ref category: regular unleaded; [c] Ref category: 50-59 years; [d] Ref category: 3-8 years; [e] Ref category: 201-400 km; Only the variables with p<0.1 in the most parsimonious model are shown in the table.