Predicting driver safety: A methodology for small samples

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ABSTRACT

Research suggests that driver safety is reduced by driver fatigue, risk-taking and inappropriate driver behaviour. These effects can be combined to produce a single strong predictor. The present study examined whether this approach was sensitive enough to detect effects in a small sample (N = 103) who had a low annual mileage (about 5000 miles). The study identified correlated attributes of the main predictors and examined whether these added to the model. The results confirmed the predictive power of driver fatigue, risk-taking and inappropriate driver behaviour. They also showed that the effects of other correlated variables did not add to the predictive power of the model. Other important features of the approach included the development and use of short measuring instruments, adjustment for the social desirability bias and use of an outcome measure combining road traffic collisions and near misses.

KEYWORDS

Road safety, driver fatigue risk-taking, driving behaviour, small sample, short measures, social desirability bias

Introduction

The present article examined prediction of road traffic collisions (RTCs). The term RTC is used rather than road traffic accident, because the term 'road accident' could suggest tolerance of road danger. Use of the term accident does not hold drivers accountable for their actions, implying instead it was a matter of chance. Considerable research has shown associations between fatigue and road traffic collisions (see Moradi, Nazari & Rahmani, 2018 for a review). Other individual differences which are predictive of road traffic collisions include risk-taking behaviour and driving behaviour (Smith, 2016). The Driver Behaviour Questionnaire (DBQ; Reason, Manstead, Stradling, Baxter & Campbell, 1990) categorises driving behaviour into two distinct components: errors and violations. Errors reflect performance deficits such as those related to attentional, perceptual and information processing abilities. Violations, on the other hand, represent the driving style and includes actions such as speeding or showing hostility to other road users. Smith (2016) showed that driver safety is reduced by driver fatigue, risk-taking and inappropriate driver behaviour. The combination of these factors yielded strong associations with reduced safety.

A recent systematic review (Bowen, Budden & Smith, 2020) has identified other variables associated with predictors of road safety. Anxiety, stress and depression were predictive of unfavourable driving (e.g. risk-taking, aggression, poor driving behaviour.) Driving discourtesy was found to not only induce stress reactions in drivers, but also led to riskier driving practice, such as deliberately engaging in intimidating driving behaviour. Negative personality traits were related to negative driving behaviours, with higher levels of well-being and life satisfaction appearing to safeguard drivers against deliberate driving violations. The review also revealed that most studies examine only a few

predictors. Indeed, large epidemiological databases are required to identify the small effects of some predictors. Previous research often used commercial drivers with a high annual mileage. The present study aimed to test a model of driver safety that could be used with a small sample of university students whose driving habits led to a low annual mileage (it was difficult to access a student sample with high mileage). A sample of students were recruited and although they might be considered low risk because of their low mileage, insurance claims show they have a high risk of having an RTC. The key feature of the research was to examine whether a combined driver fatigue/poor driving behaviour/risk taking variable would predict driver safety in this sample. Other predictors, such as personality and measures from the wellbeing process, have been considered in previous research (see Bowen, Budden & Smith, 2020) and were also included here to determine whether they could add to the model. The 'wellbeing process model' is a holistic approach to wellbeing and provides a theoretical framework that led to the development of a measuring instrument that would be useful in practice and policy. The initial approach was based on the Demands-Resources-Individual Effects (DRIVE) model which was developed for use in occupational stress research (Mark & Smith, 2008). This model included work characteristics, perceived stress, personal characteristics such as coping styles and negative outcomes (e.g. anxiety and depression). The next versions of the model (Smith, et al., 2010; Wadsworth, et al., 2009) also included positive factors such as psychological capital (self-esteem, self-efficacy and optimism), positive appraisals (e.g. job satisfaction) and outcomes (e.g. positive affect and happiness).

Previous research has identified a problem in using the wellbeing process model, in that it requires measurement of many variables and the use of long scales led to a questionnaire that was very lengthy and not very acceptable to the respondents. In order to remove this problem, short scales were developed and these were found to be significantly correlated with the longer scales from which they were derived. The Wellbeing Process Questionnaire (WPQ - Williams & Smith; Williams, Pendlebury & Smith, 2017; Williams, Thomas & Smith, 2017) was developed using this approach. The questionnaires have been modified for use in research with students (Williams, Pendlebury, Thomas & Smith, 2017) and a short form has been developed (the Short Smith Wellbeing questionnaire, Smith & Smith, 2017) which has also been used with students (Nor & Smith, 2019; Alharbi & Smith, 2019; Alheneidi & Smith, 2020). The main differences between the WPQ for workers and students reflect the type of stressors the two groups are exposed to.

Other features of the present approach included the use of a more sensitive measure of driver safety than RTC occurrence. This new outcome included incidents which involved collisions requiring medical treatment, collisions requiring no medical treatment and near misses. The dynamics of near-miss involvement and its subsequent impact on driving are mixed in the literature to date, with some researchers pointing to an increase in caution, whilst others report a boost in confidence in one's ability, referred to as 'near-miss bias' (Terum & Svartdal, 2019). A second feature of the approach is the use of short measures so that a lot of different concepts could be investigated without producing a long questionnaire that would have a negative effect on engagement and compliance. Another feature was the addition of concepts that were identified as important in the literature review but which had not been combined with the present model. Impulsivity and hostility were identified as having a significant effect on driving outcomes, and, as such, the present study included short-item measurements of these constructs.

Finally, a key limitation in research using self-report is that of the potential influence of Social Desirability Bias (SDB) defined as participants' propensity to provide 'desirable' answers to questionnaires in order to appear more socially acceptable, which may impact reliability and external validity of the data. Several studies have assessed this issue in the remit of driving behaviour (for example, Sullman & Taylor, 2010), finding that the DBQ is not particularly vulnerable to socially

desirable responding. However, SDB has not yet been explored in the context of risk-taking, driver fatigue, near-misses, driver retraining and RTC involvement. Therefore, the present purpose is to assess whether these measures are subject to SDB.

Method

Participants

The study was approved by the Ethics Committee, School of Psychology, Cardiff University prior to the recruitment of participants. Data were collected from 103 (85.4% female; age range 18-40, M_{age} = 20) undergraduate psychology students, all of whom had driven a motor vehicle in the last twelve months (Mean annual mileage = 5413; *SD* = 4259). The sample were recruited via the School's Experimental Management System (EMS) in return for partial course credit. The use of this convenience sample meant that data collection was rapid and inexpensive. However, the bias towards female participants is something that should be rectified in future research.

Measures

The 67 - item questionnaire (Bowen & Smith, 2020) comprised five sections, briefly detailed below.

Section 1: Student short version of the Smith Wellbeing (SWELL) scale (Smith & Smith, 2017), consisting of four established predictors of well-being: positive personality (high self-efficacy; self-esteem; optimism); healthy lifestyle; course demands; and academic control/support. The outcome measures were negative and positive well-being. Responses were recorded on a 10-point Likert scale (1= not at all; 10 = very much so).

Section 2: Ten-item personality scale (TIPI) measuring extraversion, openness, neuroticism, agreeableness and conscientiousness (Gosling et al., 2003). Responses were recorded on a 7-point Likert scale (1 = disagree strongly; 7 agree strongly).

Section 3: Impulsivity and hostility scale - short item scale measuring impulsivity, cynicism, anger and aggression. Responses were recorded on a 10-point Likert scale (1= not at all; 10= very much so). The scale returned satisfactory Cronbach Alpha reliability in the present study: $\alpha = .710$.

Section 4: Social desirability bias (SDB), was measured using the Brief Social Desirability Scale (BSDS; Haghighat, 2007). Comprising four questions, each item requires a yes/no response, of which only one is considered socially desirable.

Section 5: Questions relating to driving (e.g. mileage; motorway driving; see Smith, 2016) measured via a 5-point Likert scale (1= never, 5= very often).

Design and Procedure

Delivered via the Qualtrics survey platform, this cross-sectional study involved an online survey. All questions were counterbalanced (achieved by way of randomisation within the software) to alleviate any potential order effects. The predictor variables were initially explored for associations with the outcome variables using univariate analyses, those returning significant chi-squares were then combined and entered into logistic regressions to assess multi-variate effects. The reliability of the short-items was assessed using correlations and Cronbach Alpha analyses.

A detailed information sheet outlining the aims and procedure of the study for participants to give informed consent to take part was provided at study sign up. At the end of the survey the participants were thanked for their time, shown a debrief statement and awarded course credits for their participation.

Results

Driving behaviour, driver fatigue, risk-taking and driver safety

Univariate analyses showed that driver behaviour, frequency of driving when fatigued and risk-taking were the only variables associated with driver safety. Logistic regressions examined dose-response by splitting the combined predictors score (sum of driving when fatigue, risk-taking and inappropriate driving behaviour) into tertiles. The full model significantly predicted driver safety (omnibus $\chi 2 = 15.81$; $df = 2$, $p = .001$). The model accounted for between 15 and 20 percent of the variance in driver safety. Overall 70% of predictions were accurate, a 14.4% increase on the intercept model.

Table 1: Combined effects of driver fatigue, driving behaviour and risk taking on driver safety

	β	Std.Error	Wald Statistic	Odds Ratio Exp (β)	95% Confidence Interval Exp (β)	
					Lower	Upper
	1.40***	.436	10.33	4.06	1.73	9.56
Tertile 1[a]			13.72			
Tertile 2	.492	.594	.688	1.64	.511	5.24
Tertile 3	2.20***	.676	10.56	9.00	2.39	33.87

Note. $N = 103$; * $p = <.05$; *** $p = .001$; [a]= reference category

Psychometrics of other risk factors

Short item: TIPI:

A Cronbach Alpha analysis of the TIPI in the present study returned low reliability for trait conscientiousness ($\alpha = .653$), and moderate-to-strong reliability for extraversion ($\alpha = .819$); agreeableness ($\alpha = .829$); neuroticism ($\alpha = .701$); and openness ($\alpha = .753$).

Short-item: driver fatigue:

The single item driver fatigue measure had a correlation of 0.78 ($p < 0.001$) with the longer driver fatigue scale.

Social desirability:

To assess the potential of social desirability bias in participants' self-report of driving behaviour, driver safety and risk-taking, scores on the social desirability scale were correlated with the outcomes. The correlations revealed no statistically significant association between low levels of poor driving behaviour, driver safety, high levels of risk-taking and high levels of social desirability bias.

Univariate analyses: Other predictors of driver fatigue, driver behaviour and risk taking

Frequency of driving when fatigued was predicted by:

- Frequent driving on the motorway, in heavy traffic and in poor weather
- Others' rating the driver as a good driver
- Driver training course attendance
- Low levels of driver safety

The combined score of the above predictors was significantly correlated with the frequency of driving when fatigued score ($r = 0.56$, $p < 0.001$).

Frequency of risk-taking was predicted by:

- Low levels of course demands
- Engaging with academic work less efficiently
- High levels of illness caused or made worse by university work
- High levels of impulsivity
- Frequently driving on the motorway

The combined score of the above predictors was significantly correlated with the risk-taking score ($r = 0.35$, $p < 0.001$).

Poor driving behaviour was predicted by:

- Lower levels of physical and/or mental tiredness (at university)
- High levels of impulsivity, hostility and risk-taking
- Lower levels of conscientiousness and agreeableness
- Frequently driving on the motorway, in heavy traffic and in poor weather

The combined score of the above predictors was significantly correlated with the driving behaviour score ($r = 0.49$, $p < 0.001$).

Another logistic regression was carried out, with the original combined driver fatigue + driving behaviour + risk-taking score, and the combined univariate predictor scores as the independent variables, and the safety score as the dependent variable. Only the original combined fatigue/behaviour/risk score was significant, showing that the effects of the other variables reflected their association with the established predictors.

Discussion

The present study confirmed the results of Smith (2016), with a combined score of poor driving behaviour, higher frequency of driving when fatigued and high risk-taking being significantly associated with poor driver safety. This was obtained in a small sample of young drivers with a low annual mileage. Part of the sensitivity of the study may reflect the measure of driver safety, namely a combination of RTCs and near misses.

The analyses identified some other variables that predicted poor driving behaviour, high driver fatigue and high risk-taking. However, when these were added to the analyses that included the original combined predictor, they had no significant effect on driver safety. This suggests that previous results obtained with other predictors may also reflect their effects on driving behaviour, driver fatigue and risk-taking.

Further research, preferably with a longitudinal design, is required to replicate and extend the present findings. Other samples should be studied, and it is important to determine whether the present results

only apply to female student cohorts or can be applied more widely. However, based on the present findings one can suggest that we have identified factors that are reliably associated with driver safety, and that this can be measured with a very short survey that could be used on a regular basis. Future research should also use Human Factors and Ergonomics (HFE) methods to develop our understanding of this area of road safety. For example, the use of simulators and telemetry provides other information about driver performance and errors which will be more frequent than RTCs.

Conclusions

Our previous research has suggested that driver safety can be predicted by a combination of frequency of driver fatigue, risk-taking and inappropriate driver behaviour. This was confirmed here in a survey of a small sample of largely female university students. Other variables correlated with the main predictors did not add to the power of the model. The effects did not reflect a social desirability bias. The use of short measuring instruments makes the present approach appropriate for further longitudinal studies with more heterogeneous samples.

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