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Driving self-regulation and risky driving outcomes

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A R T I C L E I N F O

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A B S T R A C T

Self-regulation has been associated with risky driving outcomes in the past but there are no available measures to assess driving-specific self-regulatory capacity. The present study assessed the association of a newly developed driving self-regulation measure with driving violations, errors, and lapses. Overall, 330 UK drivers completed measures of risky driving outcomes, driving anger, trait impulsivity, sensation seeking, normlessness, domain-general trait self-regulation plus a new unidimensional measure of Driving Self-Regulation Questionnaire (DSRQ-16). Bivariate correlation analysis indicated that the DSRQ-16 showed expected associations with both driving-related outcomes and factors, as well as with impulsivity traits and general self-regulation. Bootstrapped hierarchical linear regression models showed that the DSRQ-16 was significantly associated with driving violations, errors, and lapses after controlling for the effects of other relevant predictors. This is the first study to demonstrate the association of driving-specific self-regulation with risky driving behaviour, driving anger, impulsivity and related personality traits. Driving-specific self-regulation may present a novel target for road safety interventions, as well as a theoretically relevant component of models of risky driving behaviour.

1. Introduction

According to the World Health Organisation (WHO, 2022) over a million people die in road traffic crashes (RTCs) every year, RTCs represent the leading cause of death for children and young people aged 5–29 years, and they can cost up to 3% of the national gross domestic product in certain countries. The 2019 United Nations' Road Safety Strategy recognises driver behaviour as an important factor for RTCs and related injuries and fatalities and calls for interventions to develop safer road users by promoting safe driving practices and reducing the risk for risky driving. Indeed, research in different countries has shown that speeding and other driver behaviours, such as road traffic violations, errors, and lapses are associated with higher RTC involvement (de Winter and Dodou, 2010; Mohamed & Lotfi, 2016; Pawłowski, Goniewicz, Schwebel, Shen, & Goniewicz, 2019; Petridou & Moustaki, 2000). Behavioural science research in risky driving has focused on the social and psychological factors associated with aberrant and risky driving outcomes, such as personality and attitudes towards road safety (e.g., Rowe, Andrews, Harris, Armitage, McKenna, & Norman, 2016; Ulleberg & Rundmo, 2003). To this end, individual differences in driving anger, impulsiveness, as well as in impulsivity-related traits, such as

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sensation seeking and normlessness, have been positively associated with different risky driving outcomes in both professional (Cheng, Ting, Liu, & Ba, 2016; Mallia, Lazuras, Violani, & Lucidi, 2015) and non-professional drivers (Dahlen, Martin, Ragan, & Kuhlman, 2005), across age groups (Chen, 2009; Lucidi, Mallia, Lazuras, & Violani, 2014). Personality traits have been also associated with cognitive processes that relate to driving ability, such as motor, reaction, and perceptual speed (Tinella et al., 2021) and with safe driving performance in professional drivers (Vetter et al., 2018). Moreover, positive attitudes towards road safety have been associated with reduced risky driving tendencies and outcomes in drivers of cars and other motor vehicles (Iversen, 2004; Lucidi et al., 2019; Rowe, Maughan, Gregory, & Eley, 2013).

Self-regulation broadly reflects the capacity to set goals and pursue them successfully, while at the same time resisting impulses and temptations that would hamper goal attainment (Carver & Scheier, 2016). This is a complex process involving different cognitive and behavioural mechanisms, such as the ability to retrieve long-term goals from memory, staying focused on the goal, inhibiting goal-incongruent impulsive responses, and regulating responses to external influences on behaviour and goal attainment (Heatherton & Wagner, 2011; Hofmann, Schmeichel, & Baddeley, 2012). Scholars have purported that successful self-regulation is, at least partly, dependent on executive functions, such as working memory updating, inhibition of impulsive behaviour, and attention shifting between tasks (Dohle, Diel, & Hofmann, 2018; Hoffman et al., 2012). In support of this approach, neurophysiological research has shown that brain areas associated with executive functions (e.g., left inferior frontal gyrus), are also implicated in self-regulation (Lopez et al., 2014).

In the context of driving, self-regulation can serve as a protective factor against RTCs by mitigating the effects of risk-conducive external influences (e.g., peer pressure, driving behaviour of others), as well as the effects of individual differences in risk-taking tendencies, such as sensation seeking, impulsivity, and driving anger (e.g., Cascio et al., 2015; Dahlen et al., 2005; Lazuras et al., 2019; Zhang & Chan, 2016). Research on driving and self-regulation has been diverse and involved different populations. For example, self-regulation has been studied in relation to older drivers' ability to change their driving patterns by selecting risk-free routes and engaging in other risk-avoidant practices, such as refraining from driving at night or in bad weather (e.g., Baldock, Mathias, McLean, & Berndt, 2006; Okonkwo, Crowe, Wadley, & Ball, 2008). Other research with prospective taxi drivers showed that lab-based measures of cognitive inhibition, a component of self-regulation, were associated with driving errors (Sani, Tabibi, Fadardi, & Stavrinos, 2017). Another study with novice drivers used self-reports of attitudinal beliefs and driving safety self-perceptions (e.g., "*driving safely is important to me*" and "*how safe driver do you think you are*") as proxy measures of driving self-regulation and indicated that these were significantly associated with risky driving behaviour (Watson-Brown, Senserrick, Freeman, Davey, & Scott-Parker, 2021).

Lazuras et al. (2019) presented a dual-process model of risky driving where domain-general (i.e., unrelated to driving) self-regulation was negatively associated with driving violations, errors, and lapses, and positively with road safety attitudes, in bivariate correlation analysis. Furthermore, the same study showed that, in a multivariate model, self-regulation significantly mediated the effects of trait impulsiveness on risky driving outcomes. This evidence suggests that individual differences in domain-general self-regulation may partly account for the variance in risky driving outcomes and mediate the association between impulsiveness and risky driving. Nevertheless, the bivariate correlations between domain-general self-regulation and risky driving outcomes reported by Lazuras et al. (2019) ranged from −0.16 to −0.24, indicating small-to-moderate effect sizes. Lazuras et al. further argued that having used a driving-specific measure of self-regulation, instead of a domain-general one, could have yielded stronger associations between self-regulatory capacities and risky driving outcomes (i.e., violations, errors, and lapses). However, to date research in risky driving has relied upon general self-regulation instruments rather than domain-specific measures. The self-reports of driving safety (Watson-Brown et al., 2021) and avoiding driving in risky conditions in older drivers (Balock et al., 2006) that were used in previous research reflect behavioural beliefs and tendencies to engage in safe driving practices, but do not tap individual differences in driving-specific self-regulation. This is a notable shortcoming because domain-specific measures may provide a better understanding of contextualised behaviours, such as driving. Evidence from other domains of research, including self-regulation, impulsivity, and risk-taking, has indicated that domain-specific measures can be more predictive of risk-taking behaviour than domain-general ones (e.g., Tsukayama, Duckworth, & Kim, 2012).

Following on from Lazuras et al. (2019), the present study set out to develop a driving-specific measure of self-regulation and examine its association with protective factors, such as attitudes to driving safety (Iversen, 2004), and with driving-specific outcomes and characteristics that have been associated with higher RTC risk, including risky driving behaviour (de Winter et al., 2015), driving anger (Zhang & Chan, 2016), and impulsiveness traits (Dahlen et al., 2005; Lazuras et al., 2019). Accordingly, the following hypotheses were formed: higher levels of driving-specific self-regulation will be associated positively with domain-general self-regulation and driving safety attitudes, and negatively with driving anger, sensation-seeking, normlessness, trait impulsivity, and risky driving outcomes, such as violations, errors, and lapses. Driving self-regulation was also expected to be associated with risky driving outcomes, over and above the effects of domain-general self-regulation.

2. Methods

2.1. Participants

Participants were recruited via Prolific (prolific.co), an online platform that facilitates participation in research studies. Overall, 330 participants from across the UK took part in the survey between March and October 2020. Eligibility criteria included age ≥ 18 years and holding a valid UK driving licence. To ensure that participants were engaging with the survey we embedded an "attention checker" item which prompted participants to select a specific response (i.e., somewhat disagree) if they were paying attention. Three hundred and one (i.e., 92.9% of the initial sample) participants selected the correct answer, and their data was retained for further

Table 1
Inter-correlations, internal consistency reliability, mean and standard deviation scores of the measures used in the study.

	1	2	3	4	5	6	7	8	9	10	11	12
1. DSRQ-16	–	0.62***	0.48***	0.37***	0.45***	−0.46***	0.13*	0.33***	−0.52***	0.44***	0.46***	0.24***
2. DBQ violations		–	0.52***	0.36***	0.34***	−0.58***	0.20***	0.38***	−0.33***	0.25***	0.40***	0.18***
3. DBQ errors			–	0.66***	0.30***	−0.30***	0.04	0.26***	−0.22***	0.11	0.18***	0.07
4. DBQ lapses				–	0.16**	−0.14*	-0.04	0.10	−0.21***	0.11	0.11*	−0.00
5. Driving anger					–	−0.21***	0.11	0.28***	−0.39***	0.23***	0.34***	0.11*
6. Safety attitudes						–	−0.17**	−0.50***	0.33***	−0.27***	−0.37***	−0.26***
7. Sensation seeking							–	0.23***	-0.15*	0.07	0.33***	0.12*
8. Normlessness								–	−0.35***	0.28***	0.40***	0.18**
9. SCS									–	−0.73***	−0.65***	−0.53***
10. ABIS attentional										–	0.56***	0.57***
11. ABIS motor											–	0.38***
12. ABIS planning												–
M	31.51	1.79	1.51	2.05	2.47	3.79	3.40	2.40	118.09	2.05	1.83	1.94
SD	9.49	0.54	0.43	0.54	0.60	0.58	0.69	0.84	19.67	0.50	0.58	0.59
Cronbach's α	0.86	0.80	0.79	0.74	0.85	0.84	0.66	0.70	0.90	0.73	0.80	0.72

Note. DSRQ = Driving Self-Regulation Questionnaire; DBQ = Driver Behaviour Questionnaire; SCS = Self-Control Scale; ABIS = Abbreviated Impulsiveness Scale; $^{***}p \leq 0.001$; $^{**}p \leq 0.005$ $^{*}p \leq 0.05$.

analysis. In the final sample ($N = 301$), the mean age of participants was 28.89 years ($SD = 13.20$), 66.1% were females, the average (median) weekly mileage was 40 miles, and 59.1% of the participants had obtained their driving licence within 5 years (i.e., since 2015). The study protocol was designed to adhere to the Code of Human Research Ethics of the British Psychological Society. Only participants who explicitly provided their informed consent, by selecting the respective option in the online survey, were eligible to complete the survey. Ethical approval for the study protocol was provided by the Research Ethics Committee of the Department of Psychology, University of Sheffield.

2.2. Design and measures

A cross-sectional, correlational design was used. The online survey was operated via Qualtrics and included basic demographic and background measures (i.e., age, gender, weekly mileage, and year of obtaining driving licence) which were assessed with corresponding single items. The following measures were also completed.

Risky driving behaviour was assessed with a 27-item version (Lajunen, Parker, & Summala, 2004) of the Driver Behaviour Questionnaire (DBQ; Reason, Manstead, Stradling, Baxter, & Campbell, 1990), that measures ordinary and aggressive violations (total of 11 items, e.g., "*become angered by another driver and give chase with the intention of giving hm/her a piece of your mind*"), errors (8 items, e.g., "*fail to check your rear-view mirror before pulling out, changing lanes, etc*"), and lapses (8 items, e.g., "*hit something when reversing that you had not previously seen*"). Responses were recorded on a 6-point frequency scale from "*Never*" to "*Nearly all the time*", with higher scores reflecting more frequent violations, errors, and lapses respectively for each sub-component of the DBQ.

Attitudes to driving safety were assessed with Iversen's (2004) 16-item measure. Items included statements relevant to traffic rule conformity (e.g., "*Traffic rules must be respected regardless of road and weather conditions*") and violations (e.g., "*Many traffic rules must be ignored to ensure traffic flow*"), and other aspects of risky driving behaviours (e.g., "*It's ok to ride with someone who speeds if others do*" and "*I would never drive after drinking alcohol*"). Responses were recorded on a 5-point "*Strongly Agree/Strongly Disagree*" Likert scale. According to Iversen's (2004) scoring instructions, items indicating attitudes to driving safety were reversed scored so higher scores reflected safer attitudes.

Driving Anger was measured with the short form of the Driving Anger Scale (DAS; Deffenbacher, Oetting, & Lynch, 1994). This 14-item measure reflects different anger-eliciting driving situation (e.g., "*A police officer pulls you over*" and "*someone speeds up when you try to pass them*"), and respondents indicate the amount of anger elicited from each situation on a 5-point continuous scale, from "*Not at all*" to "*Very much anger*". A mean score was computed with higher scores reflecting greater anger.

Driving-specific self-regulation was assessed with the newly developed Driving Self-Regulation Questionnaire (DSRQ). Seventeen items were adapted from questions in domain-general, trait self-regulation measures, such as the Short Self-Regulation Questionnaire (SSRQ; Carey, Neal, & Collins, 2004) and the Self-Control Scale (SCS; Tangney, Baumeister, & Boone, 2004) to the context of driving. The items include statements reflecting both self-regulation failure (e.g., "*I get easily distracted by my thoughts when I'm driving*" and "*When I'm driving, I lose my temper too easily*") and successful enactment of self-regulation (e.g., "*I usually keep track of my speed when I'm driving*" and "*I am able to resist my impulses when I'm driving*"). A full list of items is presented in Appendix 1. The responses were recorded on a 5-point "*Strongly Disagree/Strongly Agree*" Likert scale and a total score was computed after reverse-scoring positive items (i.e., self-regulation enactment). Higher scores reflect lower driving self-regulatory capacity.

Domain-general self-regulation was assessed with the Self-Control Scale (SCS; Tangney et al., 2004), a 36-item measure of individual differences in self-regulatory capacity. Items in the SCS reflect both successful self-regulation (e.g., "*I am able to work effectively towards long-term goals*") and self-regulation failure (e.g., "*pleasure and fun sometimes keep me from getting work done*"). Responses are recorded on a 5-point continuous scale ranging from "*Not at all like me*" to "*Very much like me*". After the negative items (i.e., self-regulation failure) were reverse scored, a total score was computed where higher scores reflect greater self-regulatory capacity.

Trait impulsivity was assessed with the Abbreviated Impulsiveness Scale (ABIS; Coutlee, Politzer, Hoyle, & Huettel, 2014), an 11-item measure assessing individual differences in impulsiveness. This measure includes three sub-scales reflecting attentional (e.g., "*I don't pay attention*"), motor (e.g., "*I do things without thinking*"), and planning (e.g., "*I plan tasks carefully*") impulsivity. Items reflect both high and low impulsivity, and the low impulsivity items are reverse scored to calculate the total mean score. Responses are anchored on a 4-point continuous scale from "*Almost Never/Never*" to "*Almost always/always*", and higher scores reflect higher levels of impulsivity.

Normlessness was assessed with three items (e.g., "*It is ok to get round laws and rules as long as you do not break them directly*") from the Kohn and Schooler (1983) normlessness scale. Responses were anchored on a 5-point "*Strongly Disagree/Strongly Agree*" Likert scale and a mean score was computed. Higher scores reflected higher levels of normlessness.

Sensation-seeking was assessed with the respective 5-item measure taken from the NEO Personality Inventory (Costa and McCrae, 1992). Responses were anchored on a 5-point "*Strongly Disagree/Strongly Agree*" Likert scale and a mean score was computed. Higher scores reflected higher sensation-seeking tendency.

3. Results

3.1. Psychometric properties of the DSRQ-16

As shown in Table 1, the internal consistency reliability was satisfactory and above acceptable levels (>0.70) for the majority of the measures used, except sensation seeking (Cronbach's $\alpha = 0.66$). Importantly, the newly developed driving self-regulation measure had high internal consistency reliability (Cronbach's $\alpha = 0.85$). Nevertheless, one item (Item 11 "*I plan my journey to ensure I am always on* *time*") was dropped because it did not correlate highly with the other items of the measure, item-total correlation was $r = 0.12$. The poor fit of this item was also supported by Rasch analysis, and more specifically the INFIT statistic and the person-item map. The reliability coefficient of the 16-item DSRQ (i.e., DSRQ-16) was slightly improved (Cronbach's $\alpha = 0.86$).

Pearson correlation was used to assess the convergent and construct validity of the DSRQ-16. With regards to convergent validity, the DSRQ-16 measure, where higher scores reflected lower driving self-regulation, was significantly and negatively correlated with domain-general self-regulation (r = -0.52, p <.001). We further assessed the construct validity of the DSRQ-16, that is, whether the new measure was associated with theoretically relevant constructs in the expected direction. The analysis showed that higher scores in DSRQ-16 (indicative of low levels of driving self-regulation) were negatively associated with attitudes towards driving safety (r = -0.46, p <.001), and positively correlated with driving anger (r = 0.45, p <.001), sensation seeking (r = 0.13, p =.02), normlessness (r = 0.33, p <.001), and motor (r = 0.46, p <.001), planning (r = 0.24, p <.001), and attentional impulsivity (r = 0.44, p <.001). The DSRQ-16 was also positively associated with driving violations (r = 0.62, p <.001), errors (r = 0.48, p <.001), and lapses (r = 0.37, p <.001). It is noteworthy that there were moderate-to-strong correlations with the DBQ dimensions, according to Cohen's (1992) conventions. Finally, the DSRQ-16 was associated with age (r = -0.13, p = 01) and gender (r = −0.12, p = 03), so that being older and female driver was associated with better driving self-regulation, but DSRQ scores were unrelated to weekly mileage (r = 0.04, p > 05). The means, standard deviation scores, internal consistency reliability coefficients, and the inter-correlations among the study variables are presented in Table 1.

3.2. Multivariate associations between driving self-regulation and risky driving outcomes

Three separate hierarchical regression models were used to respectively assess the multivariate predictors of driving-specific self-regulation (DSRQ-16) with driving violations, errors, and lapses. The bootstrapping method with 1000 resamples and 95% Bias Corrected and Accelerated (BCa) Confidence Intervals were used. Compared to more traditional computational approaches in regression modelling, bootstrapping offers a robust and useful alternative because it does not require distributional assumptions. Rather sampling distributions are developed through multiple resampling of the dataset (Fox, 2016).

All the bootstrapped regression models were completed in three steps to allow examination of the unique variance explained by the addition of driving self-regulation over and above the effects of other predictors of risky driving outcomes. Tolerance levels were at acceptable levels (>0.30) in all three models, thus, indicating low multicollinearity among the predictor variables. The first step included background and demographic characteristics (i.e., age, gender, and weekly mileage), driving anger, sensation seeking, normlessness, and the three dimensions of trait impulsivity (i.e., attentional, motor, and planning). The second step included domain-general, trait self-regulation and attitudes towards driving safety. Finally, the last step included driving self-regulation (DSRQ-16).

The model predicting driving violations[1] (see Table 2) accounted for 53.1% of the variance (Adjusted R^2, F = 28.43, p <.001) – a large multivariate effect size, f^2 = 1.13, according to Cohen (1992). In the first step, driving violations were significantly associated with age (β = 0.159, p =.003), driving anger (β = 0.238, p <.001), normlessness (β = 0.240, p <.001), and motor impulsivity (β = 0.168, p =.01). In the second step, driving violations were significantly associated with driving anger (β = 0.201, p <.001) and sensation seeking (β = 0.104, p =.04), but the effects of normlessness and motor impulsivity were no longer significant. Attitudes to driving safety (β = -0.472, p <.001) were also significantly associated with driving violations, but the association with domain-general, trait self-regulation was non-significant. In the last step of the analysis, adding driving self-regulation (DSRQ-16) significantly increased predicted variance in driving violations by 10.1% (F_{change} = 62.38, p <.001). The effect of driving anger turned non-significant, but the effect of sensation seeking remained marginally significant (β = 0.099, p =.03). Attitudes to driving safety (β = -0.349, p <.001) and driving self-regulation (β = 0.432, p <.001) were both significantly associated with driving violations – with driving self-regulation having a stronger multivariate association with driving violations, as indicated by the value of the corresponding standardised beta coefficient.

Table 3 shows that the predictors accounted for 25.3% of the variance (Adjusted R^2, F = 9.20, p <.001) in driving errors – a medium-to-large multivariate effect size, f^2 = 0.33, according to Cohen (1992). Tolerance levels were acceptable (>0.30), indicating low levels of multicollinearity among the predictor variables. In the first step, driving errors were significantly associated driving anger (β = 0.256, p <.001) and normlessness (β = 0.206, p =.001). In the second step, driving errors were significantly associated with driving anger (β = 0.220, p <.001) and attitudes to driving safety (β = -0.215, p =.001), and no other significant multivariate association was observed. In the last step, adding driving self-regulation (DSRQ-16) significantly increased predicted variance in driving errors by 10.7% (F_{change} = 41.70, p <.001). Driving self-regulation was significantly associated with driving errors, over and above the effects of the other predictors (β = 0.445, p <.001).

Table 4 shows that the model predicting driving lapses accounted for 19.4% of the variance (Adjusted R^2, F = 6.82, p <.001) – a medium multivariate effect size, f^2 = 0.24 (Cohen, 1992). In the first step of the analysis, driving lapses were significantly associated with being female (β = 0.216, p <.001), and a marginally significant association was observed with driving anger (β = 0.122, p =.050). In the second step, driving lapses were significantly associated with being female (β = 0.217, p <.001), planning impulsivity (β = -0.147, p =.040), attitudes to driving safety (β = -0.144, p =.034), and domain-general, trait self-regulation (β = -0.295, p =.003). In

[1] We also run a separate model only for ordinary driving violations that do not entail self-regulation failures, as aggressive violations do. The results are largely the same with regards to the multivariate effect size (Adj. R^2 = 52.4%) and the association of the DSRQ with the criterion variable (β = 0.452, p <.001). Therefore, we decided to report the model that uses the composite measure of (i.e., ordinary and aggressive) driving violations.

Table 2
Predictors of Driving Violations.

	B	*β*	95% CIs for B	Adjusted R^2
Step 1				27.4%
Age	0.007	0.159**	0.002 – 0.011	
Gender	−0.039	−0.035	−0.154 – 0.076	
Weekly mileage	0.001	0.097	0.000 – 0.001	
Driving anger	0.221	0.238***	0.121 – 0.320	
Sensation seeking	0.081	0.102	−0.007 – 0.168	
Normlessness	0.156	0.240***	0.083 – 0.230	
ABIS attention	0.036	0.033	−0.119 – 0.190	
ABIS motor	0.160	0.168*	0.028 – 0.292	
ABIS planning	0.013	0.014	−0.100 – 0.127	
Step 2				42.8%
Age	0.008	0.194***	0.004 – 0.012	
Gender	0.020	0.018	−0.084 – 0.123	
Weekly mileage	0.000	0.088	0.000 – 0.001	
Driving anger	0.186	0.201***	0.094 – 0.278	
Sensation seeking	0.082	0.104*	0.004 – 0.161	
Normlessness	0.035	0.054	−0.035 – 0.106	
ABIS attention	−0.008	−0.008	−0.163 – 0.147	
ABIS motor	0.090	0.095	−0.035 – 0.216	
ABIS planning	−0.056	−0.061	−0.160 – 0.048	
Driving safety attitudes	−0.448	−0.472***	−0.549 – −0.347	
General self-regulation	−0.002	−0.075	−0.007 – 0.002	
Step 3				53.1%
Age	0.008	0.184***	0.004 – 0.011	
Gender	0.047	0.042	−0.047 – 0.142	
Weekly mileage	0.000	0.080	0.000 – 0.001	
Driving anger	0.074	0.080	−0.014 – 0.161	
Sensation seeking	0.078	0.099*	0.008 – 0.149	
Normlessness	0.043	0.066	−0.021 – 0.107	
ABIS attention	−0.095	−0.087	−0.237 – 0.047	
ABIS motor	0.072	0.076	−0.042 – 0.186	
ABIS planning	−0.009	−0.010	−0.104 – 0.086	
Driving safety attitudes	−0.332	−0.349***	−0.428 – −0.236	
General self-regulation	0.001	0.025	−0.003 – 0.005	
DSRQ-16	0.026	0.432***	0.019 – 0.032	

Note. DSRQ = Driving Self-Regulation Questionnaire; ABIS = Abbreviated Impulsiveness Scale; ***$p \leq 0.001$; **$p \leq 0.005$ *$p \leq 0.05$.

the last step of the analysis, adding driving self-regulation (DSRQ-16) significantly increased predicted variance in driving lapses by 8.8% ($F_{change} = 31.73$, $p < .001$), and was significantly associated with driving lapses, having the strongest multivariate association as indicated by the value of the corresponding standardised beta coefficient. The results are summarised in Table 4.

4. Discussion

Previous research has shown that domain-general (i.e., unrelated to driving) self-regulation was associated with less risky driving outcomes, such as road traffic violations, errors, and lapses (Lazuras et al., 2019; Sani et al., 2017), but there has been little research on the role of driving-specific self-regulation in risky motoring. The present study developed a novel self-report measure of driving-specific self-regulation (DSRQ-16) and examined its bivariate and multivariate associations with individual differences in domain-general self-regulation and impulsiveness, risky driving (i.e., errors, lapses, and violations) and related psychological variables, such as driving safety attitudes and driving anger. The results indicated that the DSRQ-16 had good psychometric properties in terms of high internal consistency reliability, construct, and convergent validity. Furthermore, and consistent with our hypothesis, higher driving-specific self-regulation was associated with protective factors against risky driving, such as domain-general self-regulation and driving safety attitudes. This supports previous research on the role of self-regulation in risky driving (Lazuras et al., 2019).

Notably, our results indicate that the driving-specific self-regulation measure may tap general self-regulatory capacity, but also reflect dimensions that are specifically relevant to the context of driving. In support of this argument, the effect sizes of the bivariate associations between the driving-specific and domain-general self-regulation indicate moderate associations. Moreover, the findings of the multivariate models showed that driving-specific self-regulation was independently associated with risky driving outcomes, such as driving violations, errors, and lapses, over and above the effects of domain-general self-regulation, and this is consistent with the hypothesis of the study. In fact, in only one of the regression models (i.e., predicting lapses) was domain-general self-regulation associated with risky driving outcomes, when driving-specific self-regulation was included in the model.

Moreover, driving-specific self-regulation was significantly associated with all the risky driving outcomes (i.e., violations, errors, and lapses) over and above the effects of well-established protective factors, such as attitudes to driving safety (Iversen, 2004; Lucidi et al., 2019; Rowe et al., 2013), thus supporting our hypotheses. Importantly, the addition of driving-specific self-regulation in the regression models significantly increased predicted variance in the respective criterion variables by at least 8.8%. More specifically,

Table 3
Predictors of Driving Errors.

	B	*β*	95% CIs for B	Adjusted R^2
Step 1				11.0%
Age	0.002	0.063	−0.002 – 0.006	
Gender	0.010	0.012	−0.091 – 0.112	
Weekly mileage	0.000	−0.040	−0.001 – 0.000	
Driving anger	0.188	0.256***	0.101 – 0.275	
Sensation seeking	−0.014	−0.022	−0.091– 0.063	
Normlessness	0.107	0.206***	0.042 – 0.171	
ABIS attention	−0.033	−0.037	−0.168 – 0.103	
ABIS motor	0.037	0.049	−−0.079 – 0.153	
ABIS planning	0.009	0.012	−0.090 – 0.109	
Step 2				14.4%
Age	0.003	0.092	−0.001 – 0.007	
Gender	0.026	0.030	−0.074 – 0.127	
Weekly mileage	0.000	−0.044	−0.001 – 0.000	
Driving anger	0.162	0.220***	0.073 – 0.251	
Sensation seeking	−0.009	−0.014	−0.085– 0.067	
Normlessness	0.061	0.119	−0.007 – 0.130	
ABIS attention	−0.089	−0.102	−0.239 – 0.061	
ABIS motor	−0.013	−0.017	−0.135 – 0.109	
ABIS planning	−0.029	−0.040	−0.130 – 0.072	
Driving safety attitudes	−0.162	−0.215***	−0.260 – −0.064	
General self-regulation	−0.003	−0.144	−0.008 – 0.001	
Step 3				25.3%
Age	0.003	0.082	−0.001 – 0.006	
Gender	0.049	0.055	−0.045 – 0.143	
Weekly mileage	0.000	−0.053	−0.001 – 0.000	
Driving anger	0.070	0.096	−0.017 – 0.158	
Sensation seeking	−0.012	−0.019	−0.083– 0.059	
Normlessness	0.068	0.131*	0.004 – 0.132	
ABIS attention	−0.160	−0.184*	−0.302 – −0.018	
ABIS motor	−0.028	−0.037	−0.141 – 0.086	
ABIS planning	0.009	0.013	−0.086 – 0.104	
Driving safety attitudes	−0.066	−0.088	−0.162 – 0.030	
General self-regulation	−0.001	−0.040	−0.005 – 0.003	
DSRQ-16	0.021	0.445***	0.015 – 0.027	

Note. DSRQ = Driving Self-Regulation Questionnaire; ABIS = Abbreviated Impulsiveness Scale; ***$p \leq 0.001$; **$p \leq 0.005$ *$p \leq 0.05$.

driving-specific self-regulation predicted almost 1/3 of the variance in the multivariate models of driving errors and lapses, and 1/5 of the variance in the model of traffic rule violations. Lastly, in further support of our hypotheses, higher levels of driving-specific self-regulation were significantly and negatively associated with general traits that have been found to increase risk for RCTs and risky driving, such as trait impulsivity, sensation seeking, and normlessness (Cheng et al., 2016; Lucidi et al., 2014; Mallia et al., 2015).

Taken together, the present findings indicate that driving-specific self-regulation can be highly relevant to people's ability to monitor, control, and adjust their driving behaviour. Future research may further examine whether the self-reported measure of driving-specific self-regulation (DSRQ-16) is also associated with lab-based and other measures of self-regulatory capacity, such as cognitive inhibition (see Sani et al., 2017), as well as with driving behaviour assessed in a driving simulator (e.g., Ouimet et al., 2013) or recorded via other means (e.g., cameras, black box) in naturalistic driving studies (e.g., Freidlin et al., 2018). Future research should also use a larger sample to empirically examine and confirm the factorial validity of the DSRQ-16 (e.g., through Confirmatory Factor Analysis).

Our findings have important theoretical implications. In particular, Ulleberg and Rundmo's (2003) model of risky driving emphasised the role of driving safety attitudes and posited that attitudes can mediate the effects of personality traits and individual differences on risky driving. Other studies have confirmed this mediation effect in different driver populations (e.g., Chen, 2009; Mallia et al., 2015). The present findings further extend the model of Ulleberg and Rundmo (2003) by showing that, when driving-specific individual differences are taken into account, such as driving-specific self-regulation, the effects of driving safety attitudes on risky driving can be attenuated. In fact, in the present study the association between driving safety attitudes and driving errors and lapses turned non-significant when driving-specific self-regulation was added in the model. Driving safety attitudes retained a significant effect after including driving-specific self-regulation only when predicting traffic violations. Even in this case, traffic violations were more strongly associated (as indicated by the absolute values of the respective standardised beta coefficients) with driving-specific self-regulation than with driving safety attitudes. Future research may further extend our findings and revisit the Ulleberg and Rundmo's (2003) mediation hypothesis by considering the effects of driving safety attitudes on the associations of domain-general and driving-specific individual differences with risky driving outcomes. Future research may also examine whether DSRQ scores are associated with driving behaviour measured with other methods, such as driving simulator, as this may also reduce the effects of common method variance.

Another important theoretical implication concerns the rule of domain specificity. In other fields of research, it has been asserted

Table 4
Predictors of Driving Lapses.

	B	*β*	95% CIs for B	Adjusted R^2
Step 1				6.7%
Age	0.001	0.031	−0.004 – 0.006	
Gender	0.241	0.216***	0.111 – 0.371	
Weekly mileage	0.000	0.072	0.000 – 0.001	
Driving anger	0.113	0.122*	0.000 – 0.225	
Sensation seeking	−0.075	−0.095	−0.174 – 0.024	
Normlessness	0.047	0.072	−0.036 – 0.130	
ABIS attention	0.051	0.047	−0.124 – 0.226	
ABIS motor	0.112	0.118	−0.037 – 0.261	
ABIS planning	−0.074	−0.080	−0.202 – 0.055	
Step 2				10.5%
Age	0.003	0.074	−0.002 – 0.008	
Gender	0.242	0.217***	0.112 – 0.371	
Weekly mileage	0.000	0.069	0.000 – 0.001	
Driving anger	0.060	0.065	−0.054 – 0.174	
Sensation seeking	−0.061	−0.078	−0.159 – 0.036	
Normlessness	0.005	0.008	−0.083 – 0.093	
ABIS attention	−0.088	−0.080	−0.281 – 0.105	
ABIS motor	0.014	0.015	−0.143 – 0.171	
ABIS planning	−0.136	−0.147*	−0.266 – −0.006	
Driving safety attitudes	−0.137	−0.144*	−0.263 – −0.010	
General self−regulation	−0.002	−0.295**	−0.014 – −0.003	
Step 3				19.4%
Age	0.003	0.065	−0.002 – 0.007	
Gender	0.268	0.240***	0.145 – 0.391	
Weekly mileage	0.000	0.061	0.000 – 0.001	
Driving anger	−0.045	−0.048	−0.159 – 0.070	
Sensation seeking	−0.065	−0.082	−0.158 – 0.028	
Normlessness	0.012	0.019	−0.071 – 0.096	
ABIS attention	−0.169	−0.155	−0.354 – 0.017	
ABIS motor	−0.003	−0.003	−0.152 – 0.146	
ABIS planning	−0.092	−0.100	−0.216 – 0.032	
Driving safety attitudes	−0.028	−0.029	−0.153 – 0.098	
General self-regulation	−0.006	−0.201*	−0.011 – 0.000	
DSRQ-16	0.024	0.404***	0.016 – 0.032	

Note. DSRQ = Driving Self-Regulation Questionnaire; ABIS = Abbreviated Impulsiveness Scale; ***$p \leq 0.001$; **$p \leq 0.005$ *$p \leq 0.05$.

that behaviour-specific psychological constructs, such as attitudes and normative beliefs towards a given behaviour, are stronger and more valid predictors of the behaviour, as compared to domain-general personality traits and individual differences (e.g., Ajzen, 1991; Fishbein, 2009). Moreover, scholars who study risk-taking and self-regulation have further argued that people may be generally impulsive (or self-controlled), but certain situations may elicit more risk-taking than others (e.g. effects of peer passengers on risky driving vs. driving alone; Simons-Morton, Lerner, & Singer, 2005), suggesting that domain-specificity can play a role in better understanding how individual differences in self-regulation and impulsivity are associated with risk-taking (Nicholson et al., 2005; Tsukayama, Duckworth, & Kim, 2012; Weber, Blais, & Betz, 2002). Furthermore, Tsukayama et al. (2012) showed that domain-specific traits (e.g., domain-specific impulsivity) can predict additional variance in risk-taking behaviours, over and above the effects of domain-general ones. Lastly, research linking self-regulation to behaviour change has suggested that a context-specific perspective is useful and more ecologically valid, because contextual factors can play an important role in the initiation and maintenance of behaviours and habits (Protogerou, McHugh, & Johnson, 2020). Our assertion is not to dismiss the value and importance of domain-general traits, such as self-regulation or impulsivity, in the context of driving. Rather, our findings highlight the importance of domain-specific, driving-related constructs that can provide additional variance and help us better understand the role of individual differences and personality on risky driving, after controlling for other general characteristics.

With regards to the practical implications, to date, most road safety interventions targeting driver behaviour have focused largely on increasing awareness about the risks of aberrant driving and the severity of the consequences of risky driving and traffic crashes, especially in young and novice drivers (Fylan & Stradling, 2014). Other research has shown that existing education interventions to improve road safety appear rather ineffective, partly because of a lack of understanding of the psychological factors underlying risky driving (Glendon, McNally, Jarvis, Chalmers, & Salisbury, 2014; Ker et al., 2003; Poulter & McKenna, 2010). The present results indicate that driving self-regulation can be a theoretically relevant aspect of risky driving behaviour and can also present a novel target for interventions that might be effective in improving road safety.

In other domains of research, such as health-related behaviour change, different techniques have been shown to improve self-regulation of behaviour and, accordingly, lead to desirable outcomes. Such techniques may encompass effective goal-setting and monitoring strategies, as well as the use of situation-specific action plans (or implementation intentions) that help people regulate their responses and achieve their goals in the face of counteractive influences (Hagger, 2010; Hennessy, Johnson, Acabchuk, McCloskey, & Stewart-James, 2020). Relevant approaches are scarce in the context of road safety interventions, but the existing evidence is promising. For instance, research has shown that having drivers form implementation intentions relevant to attending to the speed limit or reducing mobile phone use behind the wheel respectively led to greater compliance with speed limits and reduced speeding (Brewster, Elliott, McCartan, McGregor, & Kelly, 2016; Elliott & Armitage, 2006) and less use of mobile phones while driving (Elliott et al., 2021). It is theoretically plausible that implementation-intention-based interventions contextualised around driving safety may also enhance self-regulatory capacity, as reflected in DSRQ-16 scores.

Equally, interventions aimed at reducing mind wandering and distracted driving can incorporate driving-specific self-regulation, especially with regards to attention control while driving (Koppel et al., 2019). In support of this argument, research has shown that mind wandering while driving is associated with aberrant driving behaviour (Koppel et al., 2018; Tinella et al., 2021), with greater cognitive control failures, and more driving lapses and violations (Burdett, Charlton, & Starkey, 2016). Cognitive control is subordinate to executive functions (Niendam et al., 2012) and, as such, may be an antecedent or a key component of self-regulatory capacity (Hall & Fong, 2010; Hofmann et al., 2012). Future studies may further explore the links between mind-wandering while driving and measures of both general and driving-specific self-regulation, and their association with risky driving outcomes. It is theoretically plausible that higher levels of driving-specific self-regulation can mitigate the effects of mind-wandering on driving behaviour.

The present study is not free of limitations. Firstly, a cross-sectional design was used, and this prevents modelling temporal associations between variables. Furthermore, female drivers were overrepresented (66.1%) in the present study. The bivariate associations in the present study indicated that being female was associated with greater levels of driving-specific self-regulation. Previous research has also shown that older female drivers regulate their driving behaviour better than older male drivers do (D'Ambrosio, Donorfio, Coughlin, Mohyde, & Meyer, 2008). Lastly, our research was based entirely on self-reports. Future research may explore whether lab-based measures of general self-regulation can provide additional evidence for the convergent validity of the DSRQ-16. Notwithstanding these limitations, the present study provides novel findings about the theoretical relevance and practical importance of utilising measures of driving-specific self-regulation.

5. Conclusions

The present study suggests that a driving-specific measure of self-regulation is more strongly associated with risky driving attitudes and behaviour, than a domain-general measure of self-regulation. Driving-specific self-regulation was associated with risky driving outcomes, over and above the effects of well-established risk factors, including driving safety attitudes, driving anger, impulsivity, and personality traits relevant to risky driving, such as normlessness and sensation-seeking. Driving-specific self-regulation represents a previously untapped psychological aspect of risky driving behaviour, and can be targeted by future road safety interventions.

CRediT authorship contribution statement

Lambros Lazuras: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Project administration, Funding acquisition. **Richard Rowe:** Conceptualization, Writing – original draft, Writing – review & editing. **Antonia Ypsilanti:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Funding acquisition. **Isabelle Smythe:** Data curation, Investigation, Writing – original draft. **Damian Poulter:** Writing – original draft, Writing – review & editing. **John Reidy:** Data curation, Resources, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2022.10.027.

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