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Why are newly qualified motorists at high crash risk? Modelling driving behaviours across the first six months of driving

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ABSTRACT

Objective: Novice driver crash risk diminishes steeply over the first few months of driving. We explore the characteristics of driving over this period to identify behaviours that might underlie this change in risk.
Methods: We conducted a cross-sectional study of 1456 UK drivers aged 17–21 within six months of gaining their licence. We examined how various forms of driving exposure, such as weekly mileage and driving at night, were related to duration of licencing. We explored the factor structure of the Early Driving Development Questionnaire (EDD-Q); a new instrument designed to measure safety relevant attitudes and behaviours in recently qualified drivers. We examined the relationship of the derived factors to licence duration.
Results: There was little evidence that greater exposure to risky driving situations was more common in those with shorter licence durations. Exploratory and Confirmatory Factor Analyses identified EDD-Q factors measuring risky style (12 items), skill deficiencies (8 items) and driving confidence (4 items). Licence duration was positively correlated with both risky style and confidence, with these relationships stronger for older novices. Licence duration was also negatively related to skill deficiencies (i.e., positively correlated with perceived driving skill development): this relationship was stronger in younger novices.
Conclusions: The negative correlation between license duration and skill deficiencies is consistent with the observation of decreasing novice crash involvement as experience is gained. The EDD-Q offers a new brief measure of aberrant driving that is specifically tailored for newly qualified drivers.

1. Introduction

Road traffic crashes cause approximately 3400 deaths per day globally (Peden et al., 2004; World Health Organisation, 2013). Novice drivers are overrepresented in crash statistics, with both their lack of driving experience and typically young age independently contributing to this vulnerability (see McCartt et al., 2009 for a review). Crash risk is highest when beginning independent driving and declines steeply over the next few months. The effects of age and experience persist in localities enforcing a Graduated Licensing Framework (Chapman et al., 2014; Curry et al., 2015). Curry et al. (2015) found that crash risk decreased more steeply in younger novice drivers. Identifying the factors that underlie this fall in crash risk would be valuable to policy and intervention development but currently the mechanisms are unclear.

One possibility is that exposure changes during the first few months of driving. Toledo et al. (2014) found male Israeli newly qualified novices drove the most in the first weeks after unaccompanied driving was allowed in a graduated licencing framework, with driving frequency diminishing over subsequent weeks. Therefore, their exposure to crash opportunities was highest during their first few weeks of solo driving. In addition, it may be speculated that driving in risky situations, such as with same-age peers, could be more frequent in the early weeks, with more routine and less risky journeys becoming more common subsequently.

Driving quality may also change during early motoring. Driving behaviour is typically discussed in terms of skill and style (Elander et al.,

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1993). Driving skill includes vehicle control, such as steering and braking, and the higher-order cognitive processes underlying comprehension and anticipation of events in the developing traffic environment. These higher-order skills are often referred to as situation awareness (Endsley, 1995) and may be assessed by hazard perception tests (Horswill & McKenna, 2004). Other aspects of driving skill may be measured by self-reported errors scales, which assess behaviours including driving in the wrong lane at roundabouts and missing give-way signs. Driving style refers to violation of accepted safety practices such as speeding and ignoring red lights. Violations are more common in younger drivers and male drivers (de Winter et al., 2015). Measures of both hazard perception (Horswill and McKenna, 2004) and errors and violations (de Winter et al., 2015) are well documented correlates of self-reported crash involvement. Therefore, changes in these factors could explain decreasing crash risk during early driving.

The existing literature indicates that the fall in crash-risk during early driving is not explained by simple reductions in errors or violations, at least as currently measured. Violations have been reported to be more common in more experienced drivers relative to less experienced drivers in both cross-sectional and longitudinal studies (Ozkan et al., 2006; Roman et al., 2015; Rowe et al., 2013). Similarly, self-reported errors become a little more common over the first three years of driving (Roman et al., 2015). One small scale study also found no substantial differences in hazard perception measured one, five and nine months post-licensing (Sagberg & Bjornskau, 2006), although methodological limitations mean that more extensive replication of this result is desirable.

These findings present a paradox; crash risk diminishes over the first months of driving but errors and violations, our best documented indicators of crash risk, become *more* dangerous across this period. Underlying this paradox might be a complex relationship between skill development and violations in predicting crash risk. For example, a skill might develop to mitigate the effect of violations on crash risk. Consistent with this position, McKenna (2019) showed that correlations between crash involvement and violations were stronger after six months of driving than after 36 months.

Many of the above studies, including McKenna (2019) used the Driver Behaviour Questionnaire (DBQ; Reason et al., 1990) to measure errors and violations. This assesses frequency of behaviours over the previous six months. Therefore, it is not ideal to model behavioural changes *within* the first months of driving. Measures sensitive to variations within a shorter timeframe are required. We aim to fill this lacuna by developing a questionnaire sensitive to variations in driving behaviours and attitudes across the first months of driving.

Our questionnaire was based on a longitudinal qualitative study exploring behavioural changes across the first three months of driving (Day et al., 2018). As in the quantitative literature, the qualitative study highlighted perceived increases in risk-taking and improvements in driving skills and situation awareness across early driving. Some participants felt this reflected automation of their car control skills allowing them to allocate attention to the traffic situation. In addition, the interviews also highlighted the perceived importance of social status to newly qualified drivers. They reported concerns regarding both the opinions of their passengers and of other drivers regarding their driving skills. When very newly qualified, they reported difficulties keeping up with traffic flow and that they believed other drivers looked down on them as a result. They felt that this led them to drive faster than they would have preferred. Over time their concerns dissipated, partly because they perceived their driving skills improved. Perceived social status has been identified in other qualitative work (Fleiter et al., 2010; Scott-Parker, 2018) but its relationship with driver behaviour over early driving has not been quantitatively addressed.

We aimed to recruit a sample of young UK drivers within six months of passing their UK driving test (which permits independent driving). Our first goal was to examine the association between licence duration and driving exposure, indexed by self-reported mileage over the preceding two weeks and frequency of driving in specific contexts. If simple driving exposure explains the association between driving experience and reduced crash involvement then it would be expected that total mileage, or frequency of driving in particularly dangerous situations, would be negatively associated with licensure duration.

Our second aim was to design and validate a new self-report questionnaire (the Early Driving Development Questionnaire [EDD-Q]) to measure the aspects of risky driving, skills and status that Day et al. (2018) identified as potentially developing during early driving. The EDD-Q addressed driving in the preceding two weeks, thus assessing a timescale sensitive to variations across the earliest months of driving. To validate the EDD-Q we planned to identify its factor structure and to examine the external (concurrent) validity of the emerging factors by estimating their relationships with other previously identified correlates of aberrant driving.

Given EDD-Q items were chosen to address risky driving and skill development, we expected emergent factors that would show similar correlates to the DBQ violations and errors subscales. We expected emergent factor(s) measuring risky driving to be more common in males and younger drivers while skill deficiencies would be more commonly reported by females and to decline with age less strongly than violations, on the basis of De Winter and Dodou's (2010) *meta*-analysis. In addition, risky driver factor(s) were expected to correlate positively with higher weekly mileage. The prediction regarding skill development is less clear as de Winter and Dodou found the direction of the relationship between DBQ errors and mileage varied across different analysis approaches. On the basis of existing literature, risky driving and skill development were predicted to correlate with self-reported crash involvement (de Winter et al., 2015), risky driving attitudes (e.g., Lazuras et al., 2019) and sensation seeking (Zhang et al., 2019). Additionally, we designed EDD-Q items to address driving status and therefore expected a related factor to emerge. Driving status shares some conceptual relationships with driving confidence so predictions of the correlates of social status may be based on the literature investigating confidence. McKenna (2018) showed that confidence is positively related to violations, so similar correlates might be predicted for social status and risk-taking.

Our final aim was to examine the relationships between the emerging EDD-Q factors and licence duration. We posited that any factors contributing to the decrease in crash liability over the early months of driving would be negatively correlated with licence duration. Following Curry et al.'s (2015) finding that the effect of experience may be greater for younger drivers, we tested whether age moderated the relationships between extracted factors and licence duration.

2. Method

2.1. Participants

Study inclusion criteria required participants to be aged 21 or less, to have passed the full UK driving test (allowing unrestricted independent driving on public roads) between two weeks and six months previously, and to have driven during the previous two weeks. In order to contact and recruit this specific population, emails were circulated to schools and colleges across the UK, distributed by members of the Driving Instructors Association to their pupils who had recently passed the UK practical driving test, and sent to subscribers of FirstCar, a commercial organization for learner and newly qualified drivers. Participants were also recruited from the University of Sheffield volunteers email list, and via the social media pages of road safety charity IAM Roadsmart. The questionnaire was hosted by the Qualtrics (https://www.qualtrics.com) online platform and was completed remotely by all participants. Various incentives were trialled including voluntary participation, entry into a prize draw for a £50 shopping voucher and receiving a £5 shopping voucher in return for study completion. Most participants received a £5 voucher. We received $>$ 1500 fraudulent responses with the intention of triggering unearned voucher payments. Suspicious responses were

identified and removed by an algorithm which considered uniqueness of quoted email address and time spent completing the survey amongst other factors.

We targeted a sample of 1507 participants. Power calculation in GPower 3.1.9.2 (Faul et al., 2007) indicated that this sample size would provide 95 % power to detect relationships between crash involvement (count outcome) and continuous predictors in Poisson regression models, assuming an Incidence Rate Ratio (IRR) of 1.3 for a standard deviation change in the predictor variable. This IRR was based on unpublished analysis of the relationship between crash involvement and the DBQ violations scale as measured in the Genesis1219 study (McAdams et al., 2013). The final dataset contained 1456 drivers (52 % male, 85 % White British ethnic background). The mean age was 18.16 years (range 17–21, SD = 1.19 years). The average licence duration was 2.79 months (range 0.46–5.88, SD = 1.47 months). Median mileage in the previous two weeks was 70 miles (IQR = 120). Participants provided informed consent and study procedures were approved by the Research Ethics Committee of the Department of Psychology, University of Sheffield (Reference numbers 011465/011830).

2.2. Measures

2.2.1. Early driving development questionnaire

The EDD-Q was based on Day et al.'s (2018) qualitative analysis which identified three broad themes; (1) improvement in car control skills and situation awareness, (2) increasing levels of violation and (3) increasing comfort with the status of being an independent driver. Eighty-six items (Electronic Appendix) were constructed to address these themes across a range of driving situations potentially relevant to novice driver crash vulnerability. These included (1) passengers in the car, (2) roadcraft and situation awareness, (3) perceptions of other drivers, (4) identity as a driver, (5) driving with distraction, (6) night driving, (7) close following, (8) speed, and (9) car control. All questions addressed driving over the previous 14 days, and were phrased as statements with which participants rated agreement on a five-point scale labelled Strongly disagree (scoring 1) to Strongly agree (scoring 5).

2.2.2. Attitudes to driving violations

The Attitudes to Driving Violations Scale (ADVS, West & Hall, 1997) contains seven statements such as "Decreasing the speed limits on motorways is a good idea". Responses are made on a five-point scale labelled Strongly Disagree (scoring 5) to Strongly Agree (scoring 1), meaning higher scores indicate riskier responses. In a sample of 406 drivers the ADVS had a Cronbach's alpha of 0.76 and correlated with self-reported speeding and crash involvement (West & Hall, 1997).

2.2.3. Sensation seeking

Sensation seeking was measured using the Brief Sensation Seeking Scale (BSSS, Hoyle et al., 2002). This contains eight items such as "I like to do frightening things" with responses on a five-point scale labelled Strongly Disagree (scoring 1) to Strongly Agree (scoring 5); higher scores indicate greater sensation seeking. Hoyle et al. (2002) reported a Cronbach's alpha of 0.76 and that scores correlated with adolescent substance use.

2.2.4. Driving experience and exposure

Licence duration was measured as days since passing test, which, to aid coefficient interpretability, was converted to months by dividing by 30.417. We measured driving exposure as the number of miles driven in the previous 14 days via free numerical response. Mileage was log-transformed due to a heavily skewed distribution. Participants were also asked about the context of their driving over the last 14 days. Separate questions addressed frequency of driving after dark, for pleasure, in busy town centres, on country roads, on fast dual carriageways/motorways, in poor weather conditions, for commuting, for work and on unfamiliar roads. Each question was answered on a five-point scale labelled 'none', 'a little', 'about half', 'a lot', and 'all'. Participants were asked how many crashes (involving injury or property damage) they had been involved in as a driver since passing their test. More than one crash was rare (16 cases), so crash involvement was treated as a dichotomous variable indicating any crash involvement which was endorsed by 8.5 % of the sample.

2.3. Statistical analyses

First, we tested whether licence duration was negatively associated with driving exposure, using zero-order Pearson correlations estimated in Stata 16.1 (StataCorp., 2019). All inferential analyses calculated two-tailed tests, reporting exact p-values and 95 % confidence intervals.

Second, we explored and then validated the factor structure of the 86 EDD-Q items. To avoid overfitting caused by model building and testing using the same cases (Fokkema and Greiff, 2017), we split the dataset randomly into 'construction' and 'validation' halves each containing 728 observations. Using the construction half of the dataset we checked the suitability of the item-set for factor analysis using the Kaiser-Meyer-Oklin measure of the proportion of variance that might be due to underlying factors (Kaiser, 1974). Next, we built a measurement model using Exploratory Factor Analysis (EFA). This was conducted in Stata, using Principal Axis Factoring extraction. Oblique (Oblimin) rotation was used when interpreting the factors, thus recognizing that they may be correlated.

We then tested the fit of the emergent EDD-Q measurement model on the validation dataset, via Confirmatory Factor Analysis (CFA). EDD-Q items were modelled as ordinal (i.e., ordered categories), using the Weighted Least Mean Squares Means and Variances adjusted (WLSMV) estimator within Mplus software, v7.3 (Muthen & Muthen, 1998–2018). Model fit was assessed using the Comparative Fit Index (CFI) and Root Mean Square Error of Approximation (RMSEA) statistics. CFI values ≥ 0.95 and RMSEA values ≤ 0.06 indicate good fit (Hu and Bentler, 1999). WLSMV estimation results in scaled model chi-square statistics so nested models were compared using adjusted chi-square difference tests (Satorra & Bentler, 2010) computed using the Mplus DIFFTEST function.

The internal convergent validity and discriminant validity of the emergent factors was examined using Average Variance Extracted (AVE) scores. Fornell and Larcker (1981) note that a factor's internal convergent validity is satisfactory if AVE > 0.5. Discriminant validity was indicated when a factor's AVE score exceeded its squared correlations with other factors. Emergent factor reliability was examined using an approach to coefficient alpha suitable for ordinal response items based on polychoric inter-item correlations (Gadermann et al., 2012), estimated in R (R Core Team, 2021).

Finally, having established the EDD-Q factor structure, we extended the measurement model to a Structural Equation Model (SEM), fitted to the combined construction and validation datasets (see Fig. 1). Specifically, we added the observed ADVS and BSSS scale means and self-reported crash involvement as correlates of the EDD-Q factors in order to test concurrent validity. Participant's licence duration, age, sex, and mileage were added as predictors of the EDD-Q factors and of the additional correlates. This both tested their relationships with the EDD-Q factors and also ensured that relationships observed between EDD-Q factors and other variables were not confounded by shared relationships with demographic and mileage variables. To test whether driver age moderated the relationship between licence duration and the EDD-Q factors, interactions between licence duration and age were included as predictors of each factor. Identified moderation effects were probed by calculating the conditional effects (i.e. simple slopes) of licence duration on each factor at each year of age included in the study. EDD-Q factor variances were fixed to 1 to aid coefficient interpretability.

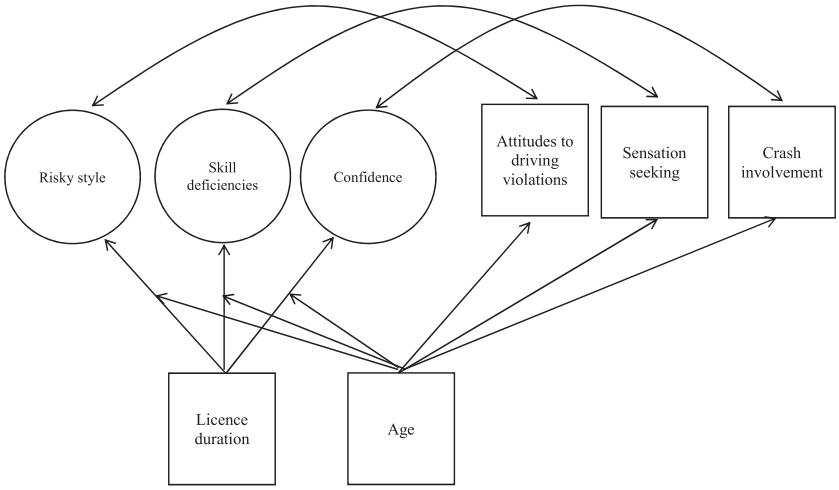

Fig. 1. Structural equation model. Sex, mileage and licence duration were modelled as predictors of all scales and factors. Some components have been omitted from the figure to aid presentation.

Table 1
Correlations (and 95% confidence intervals) between driving exposure and licence duration.

Driving exposure	Correlation with licence duration	p-value
Mileage	0.09 (0.04, 0.14)	<0.001
Driving…		
…after dark	0.11 (0.06, 0.16)	<0.001
…with friends	0.04 (-0.02, 0.09)	0.169
…for pleasure	-0.03 (-0.08, 0.02)	0.289
…in town centres	0.03 (-0.03, 0.08)	0.338
…on country roads	0.09 (0.04, 0.14)	0.001
…dual carriageways/motorways	0.09 (0.04, 0.14)	<0.001
…in poor weather conditions	0.05 (-0.00, 0.10)	0.062
…for commuting	0.13 (0.08, 0.18)	<0.001
…for work	0.09 (0.04, 0.14)	<0.001
…on unfamiliar roads	-0.02 (-0.07, 0.03)	0.505

N = 1455–1453.

3. Results

3.1. Driving exposure across the first 6 months of driving

Table 1 summarises correlations between driving exposure (both absolute mileage and frequency of driving in varied contexts) and licence duration. There was no compelling evidence that licence duration was substantively related to exposure. While some correlations reached statistical significance, many were in the opposite direction predicted. If greater exposure explains high crash risk in early driving then a negative association between exposure and licence duration would be expected. In contrast we found greater licence duration was related to higher total mileage and more commonly driving in many risky contexts including after dark, and on country roads. Driving for commuting, that may be a relatively safe form of driving, was positively

Table 2
Factor loadings from the final factor analysis models of the Early Driving Development Questionnaire items run in construction and validation datasets.

	Construction (EFA)			Validation (CFA)		
Item	Risk	Skill	Con	Risk	Skill	Con
I use a phone with my hands while driving (e.g. for talking, texting, social media)	**0.80**	-0.04	-0.11	**0.84**		
Speeding makes me look cool	**0.78**	0.03	0.01	**0.85**		
I sometimes drive under the influence of alcohol or other drugs that might impair my driving	**0.77**	-0.05	-0.27	**0.89**		
Sometimes I drive close behind slow vehicles to make them speed up	**0.76**	0.01	0.02	**0.81**		
I try to test how fast I can drive round bends without losing control	**0.73**	0.06	0.06	**0.79**		
I think my friends are impressed when I drive fast round bends	**0.72**	0.13	0.13	**0.79**		
I have driven with more passengers than my car is meant to hold	**0.72**	-0.07	-0.17	**0.75**		
Sometimes I compete with other drivers	**0.72**	0.01	0.11	**0.80**		
I enjoy driving round bends quickly	**0.70**	0.01	0.24	**0.69**		
I sometimes make illegal U-turns	**0.58**	0.03	0.02	**0.61**		
Skilful drivers can drive fast round bends	**0.56**	0.18	0.19	**0.62**		
I wear my seatbelt while driving*	**0.55**	-0.07	-0.24	**0.71**		
I found it difficult to… manage busy junctions	0.01	**0.78**	-0.01		**0.83**	
I found it difficult to… negotiate roundabouts	0.06	**0.75**	0.02		**0.85**	
I found it difficult to… drive at night	-0.02	**0.69**	-0.10		**0.76**	
I found it difficult to… anticipate potential hazards	0.17	**0.69**	0.08		**0.83**	
I found it difficult to… judge the speed of oncoming vehicles	-0.03	**0.62**	0.02		**0.64**	
I found it difficult to… do hill starts	-0.07	**0.57**	0.06		**0.68**	
I found it difficult to… drive on a motorway	-0.06	**0.52**	-0.16		**0.57**	
I found it difficult to… judge the gaps my car will fit into on narrow roads	-0.13	**0.56**	-0.17		**0.66**	
I feel more vulnerable now I am driving without my instructor*	-0.01	-0.11	**0.64**			**0.69**
I find driving stressful*	-0.12	-0.12	**0.57**			**0.72**
I still feel like a learner driver*	-0.09	-0.15	**0.57**			**0.81**
I find being able to drive without supervision… difficult*	0.09	-0.20	**0.52**			**0.72**

EFA: Exploratory Factor Analysis; CFA: Confirmatory Factor Analysis; Risk: Risky style; Skill: Skill deficiencies; Con: Confidence.
*Item reverse coded.
Bold indicates factor loadings > 0.5.

Table 3
Model fit indices from Confirmatory Factor Analyses of Early Driving Development Questionnaire items in the validation dataset.

Model	Chi-square[1]	Df	CFI	RMSEA	Chi-square[1,2] difference vs 3 factor model	Df
Three factor model (Risk, skill, confidence as separate factors)	1198.25	249	0.95	0.07	–	–
Two factor models						
Risk and skill merged, confidence	5310.24	251	0.71	0.17	567.74	2
Risk and confidence merged, skill	3799.97	251	0.80	0.14	471.76	2
Skill and confidence merged, risk	1665.53	251	0.92	0.09	115.91	2
One factor model	6229.65	252	0.66	0.18	814.50	3

Df: Degrees of Freedom; CFI: Comparative Fit Index; RMSEA: Root Mean Square Error of Approximation; Risk: Risky style; Skill: Skill deficiencies.
[1] All chi-square tests significant at $p < 0.001$. [2]Model comparisons made with adjusted chi-square difference tests.

correlated with licence duration.

3.2. EDD-Q factor structure

The initial EFA including all 86 EDD-Q items was fitted to the construction half of the dataset. The Kaiser-Meyer-Olkin statistic of 0.92 demonstrated suitability for factor analysis. Seven factors with eigenvalues > 1 were identified, but we fitted a five factor solution based on inspection of the scree plot. This model was modified in three iterations; (1) 59 items were removed because they loaded < 0.5 onto all factors or they were part of factors that featured less than three items loading > 0.5. This resulted in two factors being removed from the model. (2) Two further items were dropped as they loaded at < 0.5 in the revised three factor solution and (3) a further item was dropped as its uniqueness was > 0.7, indicating that it was not well explained by the model. As shown in Table 2, items loading strongly onto factor 1 addressed risky style, factor 2 reflected skill deficiencies and factor 3 measured driving confidence.

The three factor measurement model that emerged from the EFA of the construction dataset was fitted to the validation dataset using CFA. This model provided acceptable fit (See Table 3). Table 2 shows standardised item-factor loadings. Factors were correlated, but remained distinct: risky style correlated with skill deficiencies $r = 0.32$ and confidence $r = -0.15$, skill deficiencies correlated with confidence, $r = -0.57$. The AVE score for each factor exceeded the Fornell and Larcker (1981) criterion for internal convergent validity, i.e. AVEs were>0.5 (risky style: 0.59, skill deficiencies: 0.54, confidence: 0.54). Discriminant validity was supported by each factor's AVE exceeding its squared correlations with other factors and by the three factor solution providing a better fit to the data than either a one factor model or alternative two factor solutions (see Table 3). Ordinal alpha coefficients demonstrated the internal reliability of risky style (0.94), errors (0.90) and confidence (0.82).

3.3. Characteristics of the EDD-Q factors

We examined the predictors and correlates of the three factor EDD-Q measurement model by extending it to an SEM (Fig. 1) fitted to the full dataset (combining construction and validation subsets). This model provided adequate fit (chi-square = 2142.40 df = 420, $p < 0.001$, RMSEA = 0.05, CFI = 0.95). Table 4 summarises relationships between the EDD-Q factors and sensation-seeking, attitudes to violations and

Table 4
Parameter estimates (and 95% confidence intervals) from our Structural Equation Model (Fig. 1).

	Risky style	p	Skill deficiencies	p	Confidence	p
Correlation coefficients						
Crash involvement	0.25 (0.16, 0.33)	<0.001	0.12 (0.03, 0.21)	0.011	0.02 (-0.08, 0.11)	0.729
Attitudes to driving violations	-0.31 (-0.35, -0.26)	<0.001	0.07 (0.02, 0.13)	0.005	-0.06 (-0.12, -0.00)	0.036
Sensation seeking	0.40 (0.36, 0.44)	<0.001	0.03 (-0.02, 0.08)	0.279	0.05 (-0.01, 0.10)	0.121
Regression coefficients (Predictors unstandardised, outcome variances standardised to 1)						
Sex (female = 0 male = 1)	0.66 (0.55, 0.78)	<0.001	-0.04 (-0.15, 0.07)	0.521	0.36 (0.24, 0.48)	<0.001
Mileage in last two weeks (logged)	0.05 (0.00, 0.09)	0.034	-0.10 (-0.14, -0.06)	<0.001	0.31 (0.26, 0.36)	<0.001
Age X licence duration	0.06 (0.02, 0.09)	0.001	0.04 (0.01, 0.08)	0.011	-0.04 (-0.07, -0.00)	0.031

Simple slopes of age at mean months since passing test and months since passing test at each age are reported in the text.

Table 5
Simple slopes (and 95% confidence intervals) of licence duration predicting the Early Driving Development Questionnaire factors at each year of age.

Age	N	Risky style	p	Skill deficiencies	p	Confidence	p
17	512	-0.03 (-0.08, 0.03)	0.349	-0.11 (-0.17, -0.06)	<0.001	0.12 (0.07, 0.18)	<0.001
18	522	0.03 (-0.01, 0.07)	0.102	-0.07 (-0.11, -0.03)	<0.001	0.09 (0.05, 0.13)	<0.001
19	177	0.09 (0.04, 0.14)	0.001	-0.03 (-0.08, 0.02)	0.290	0.05 (-0.00, 0.10)	0.068
20	157	0.15 (0.07, 0.22)	<0.001	0.02 (-0.06, 0.09)	0.662	0.01 (-0.07, 0.09)	0.800
21	86	0.20 (0.10, 0.31)	<0.001	0.06 (-0.05, 0.17)	0.260	-0.03 (-0.14, 0.08)	0.613

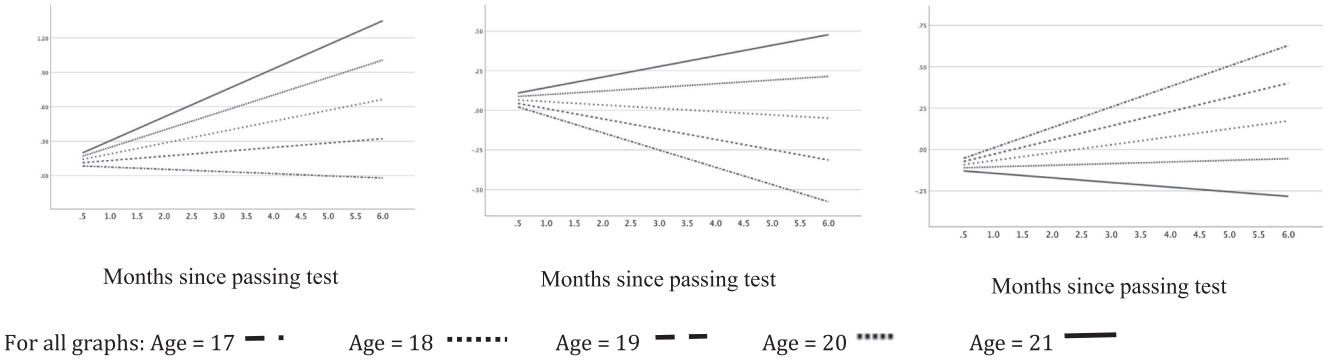

Fig. 2. Simple slopes of licence duration on Early Driving Development Questionnaire factors at each age included in the study.

crash involvement which test concurrent validity. Males were more likely to report higher levels of risky driving style, and to a lesser extent, higher confidence scores, whereas there was no sex difference in skill deficiencies. Mileage was positively correlated with risky style and confidence and negatively correlated with skill deficiencies. Higher scores on the risky style factor were moderately correlated with higher sensation seeking and riskier attitudes to violations and were also related to higher crash involvement. Skill deficiencies and confidence showed weaker correlations with sensation seeking and attitudes to driving violations than risky style. Crash involvement was significantly correlated with skill deficiencies but not confidence.

Table 4 also shows significant interaction effects between age and licence duration on all EDD-Q factors. Simple slopes analyses showed that, at mean licence duration, age was positively associated with risky style ($b = 0.25$, 95 % CI: 0.21, 0.30, $p < 0.001$) and skill deficiencies ($b = 0.20$, 95 % CI: 0.15, 0.25, $p < 0.001$), and negatively associated with confidence ($b = -0.22$, 95 % CI: −0.27, −0.17, $p < 0.001$). Simple slopes of licence duration on each EDD-Q factor at each year of age are reported in Table 5 and illustrated in Fig. 2. Greater licence duration was more strongly associated with riskier driving in older novices. The simple slopes were significant for drivers aged 21, 20 and 19. Greater licence duration was associated with fewer skill deficiencies in younger drivers; the simple slopes were significant at ages 17 and 18 with a non-significant relationship in older novices. Greater licence duration was associated with higher confidence in 17 and 18 year-olds but was non-significant in older drivers.

4. Discussion

This study aimed to identify the behaviours that correlate with licence duration across the first six months of driving; a period when crash risk decreases dramatically. First, we tested whether licence duration was related to mileage. If the high risk of newly qualified drivers is due to high exposure then a negative correlation would be expected. Our results contradicted this hypothesis; we found licence duration was positively correlated with self-reported mileage; those who had held their licence for longer reported higher mileage in the previous two weeks. Similarly, our data did not support the hypothesis that exposure to riskier driving situations, such as driving at night, was concentrated in those who had very recently acquired their licences. In fact, many driving situations that might be expected to increase crash risk, including driving at night and with same age passengers, were more common in those with longer licence durations, while driving for pleasure and driving in unfamiliar situations were unrelated to licence duration. Only commuting, which might be a relatively safe form of driving, was more common in those with longer licence durations. Mileage was found to decrease over time in Israeli drivers once allowed to drive alone in a graduated licensing framework (Toledo et al., 2014). Therefore, there is a basis on which to continue exploring this relationship in future studies. In our data however, there was no compelling evidence that driving exposure could explain the higher crash-risk faced by newly qualified drivers.

Next, we investigated whether different aspects of driving that might underlie crash risk were related to licence duration. First, we validated the EDD-Q as a measure of safety-related driving attitudes and behaviours during the first months of driving. Our psychometric analyses identified EDD-Q factors measuring risky style, skill deficiencies and confidence; broadly matching the themes identified by Day et al.'s (2018) qualitative analysis on which the EDD-Q was based. Overall, our results indicate that the EDD-Q provides an effective measure of aberrant driving in newly qualified drivers. This is illustrated below where we consider the relationship of the EDD-Q constructs with licence duration and their potential to contribute to the decrease in crash risk observed during the early months of driving.

4.1. Driving skill

Of our identified factors, driving skill provided the pattern of results that most closely matched the decrease in crash-risk across the early months of driving. We found a small negative association between skill deficiencies and licence duration such that those who had received their licence more recently reported higher difficulty levels. This relationship was strongest in younger novice drivers (aged 17 and 18), fitting with Curry et al.'s (2015) observation that crash rates improve more quickly for younger than older novices. Further work is required to explore this association, before it can be applied to develop interventions.

It is crucial to specify skill deficiencies more clearly. Our skill deficiencies factor was comprised of items measuring perceived problems in car control (e.g., hill starts) and situation awareness (e.g., managing busy junctions, anticipating hazards). The correlates of this factor showed some similarities to the correlates of DBQ error and lapse scales in young drivers (e.g., Lazuras et al., 2019). These include a positive relation with risky style. The correlation between our skill deficiencies factor and crash involvement was similar in magnitude to the correlation reported between DBQ errors and self-reported crash involvement reported in De Winter et al.'s (2015) meta-analysis.

Not all correlates of the skill deficiencies factor matched those found for DBQ errors. DBQ errors correlate with sensation seeking (Zhang et al., 2019), but we did not find this relationship. The DBQ errors scale has also been reported to correlate with riskier driving attitudes (e.g., Lazuras et al., 2019) whereas our skill deficiencies factor showed a weak but significant correlation in the opposite direction; more skill deficiencies were associated with safer driving attitudes. Perhaps most importantly, DBQ errors become a little more common between six months and four years from passing the test (Roman et al., 2015), whereas we found skill deficiencies were less common in those with higher licence durations, at least in the youngest newly qualified drivers. One explanation may be that many forms of attentional slips and lapses measured in the DBQ, such as completing a journey without remembering it, are hypothesised to *result* from developing automaticity

(Reason, 1990). The skill deficiencies measured here may tap the process of automation itself (e.g., difficulties with hill starts and judging gaps). Therefore, a higher score on our skill deficiencies factor may indicate greater automation of car control skills. This in turn may enable an increasing allocation of attention to maintaining situation awareness.

The correlation of licence duration with skill deficiencies is relatively small, even in younger novices where the relationship is strongest. It is possible that the effect is observed because there is a specific aspect of skill that is correlated with our skill deficiencies factor, which would show a stronger relationship with licence duration. Performance based measures might be more useful in identifying such components of skill than self-report. Immersive simulations may be best placed to measure car control skills and management of complex road situations. Hazard perception may be measured more cheaply in video-based simulations. As mentioned in the introduction, Sagberg and Bjornskau (2006) found little evidence that hazard perception improved substantially over the early months of driving. More exploration of this effect may be warranted, particularly to test the possibility that in-car hazard perception performance improves with experience, as car control skills become automatic. The possibility that improving driving skills interact with style may also be usefully examined, as discussed below.

4.2. Driving style

The items forming our risky style factor overlapped with DBQ violations, including both speed preference and close following to make other drivers speed up. Some aspects of driving status were included here, including the belief that speeding looked cool and that passengers were impressed by fast driving around bends. The correlates of our factor showed similarities to the correlates of DBQ violations. Riskier style was related to higher reported weekly mileage, male gender, sensation seeking and risky attitudes to driving violations. We predicted that risky style would be negatively correlated with age as DBQ violations are negatively correlated with age over wide age-ranges (de Winter et al., 2015). The positive relationship that we observed was therefore initially unexpected. However, a close reading of the literature shows that DBQ violations may be positively correlated with age when sampling is restricted to the youngest drivers (de Winter and Dodou, 2010), perhaps reflecting that the relationship between age and violations is curvilinear. Therefore, our results remain consistent with some existing literature on age trends in DBQ violations.

Our risky style factor was positively correlated with licence duration; drivers who had held their licences longer reported riskier style than less experienced drivers. As reviewed in the introduction, there is consistent evidence that riskier driving is more common in more experienced drivers. Our data indicate that this relationship can be detected across the first six months of driving. This provides further evidence that risky style is not *negatively* correlated with experience, as would be expected if development of a less risky driving style explained the safety improvements observed during the first few months of driving in a simple fashion. The relationship between risky style and licence duration was weaker in younger novices and strongest in older novice drivers. One speculative explanation is that younger novices may be more likely to be living with parents and parental influence may dampen the contribution of driving experience to style becoming riskier. This possibility could be usefully addressed in future research.

Risky style/violations may have a stronger relationship with crash involvement in less experienced drivers (McKenna, 2019). Consistent with this possibility our recently qualified sample demonstrated a correlation of 0.25 (95 % CI: 0.16, 0.33) between self-reported crash involvement and risky driving style. This is higher than the correlation of 0.13 between DBQ violations and crash involvement estimated in the de Winter et al. (2015) *meta*-analysis of studies involving drivers across a much wider range of experiences. McKenna (2019) suggested that while violations become more common over the early months of driving, a skill may develop that weakens their relationship with crash involvement. The skill development involved in this effect may be related to our skills deficiencies factor. Exploring this possibility is an important goal for future research. If replicable these results emphasise the importance of targeting interventions and legislation to reduce risky behaviours during the earliest months of driving, including strengthening the case for graduated licencing programmes.

4.3. Driving confidence

Confidence showed a weak positive relationship with licence duration which was stronger in younger novices. The confidence factor contained items addressing concerns about driving without supervision and the opinion of passengers. As such the factor has conceptual overlaps with skill deficiencies, albeit being scored in the opposite direction. The two factors were moderately negatively correlated such that those lower in confidence reported more skill deficiencies. Further research is required to elucidate the role of confidence in novice driving. While we found no significant relationship with crash involvement, longitudinal data would be useful to explore the predictive power of confidence and to test whether confidence interacts with risky style to predict future crash vulnerability.

4.4. Strengths and limitations

Our study has a number of strengths for identifying the correlates of licence duration during early driving. We had an adequate sample size to estimate the strength of relationships and a detailed assessment of driving exposure and behaviours over a two-week time frame. In interpreting the results, however, a number of limitations must be considered. First, a cross-sectional design limits capacity to identify direction of effect. Second, all measures were self-reported meaning associations may be inflated by common-method variance. Third, some aspects of performance may be unavailable to self-report and may be more appropriately assessed via simulators or instrumented vehicles. However, self-report has a crucial role in understanding driving behaviour. Self-reported behaviours correlate with objective driving measures (Helman and Reed, 2014) and are uniquely placed to identify the motivations underlying driving behaviour - for example, in terms of thrill, aggression or misunderstanding the road situation.

Further work would benefit from large-scale longitudinal studies of the development of driving behaviour with multiple multi-modal observations of driving skill and style over the early months of driving. Running sufficiently powered studies of this sort will be expensive - but would provide evidence that can inform road safety policy, specifically with respect to the skills that should be developed to reduce the unacceptably high level of road crash involvement in newly qualified drivers currently observed around the world.

4.5. Conclusions

In terms of theoretical contribution, this work indicates that variations in driving exposure are unlikely to explain the decrease in crash involvement observed over the first few months of driving. Instead, perceptions of driving skill were related to licence duration, providing some evidence that driving skill development may underlie the improvement in road safety over the early stage of driving. To continue to develop theory, it is imperative to understand what the key driving skills are and how they interact with driving style choices in their relationship to crash liability.

Identifying the key behavioural changes underlying the decrease in crash involvement would provide policy-makers with targets for intervention to improve road safety in newly qualified drivers. For example, interventions could take the form of education to help new drivers to perform as if they already have a few months of experience immediately after they pass their tests. While the current work was based in the UK, we believe this issue is pressing across cultures. Errors and violations, as

measured by the DBQ are associated with crash involvement in contexts including Ghana (Dotse and Rowe, 2021), Iran (Nordfjærn et al., 2015) and China (Chu et al., 2019). Therefore, behavioural developments across the early months of driving may be similarly important for crash risk and present an opportunity for interventions to reduce the public health burden of road traffic injuries across the world.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Richard Rowe, Christopher B. Stride, Andrew R. Thompson & Damian R. Poulter reports financial support was provided by Medical Research Council.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.aap.2022.106832.

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