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3 The development of risky attitudes from pre-driving to fully-qualified driving

4

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1 **ABSTRACT**

2 **Objective:** Young drivers are at increased crash risk as a result of adopting risky driving  
3 styles. This paper examines the development of risky attitudes from pre-driving to fully qualified  
4 driving, focussing on speed related attitudes.

5 **Design:** Data are drawn from a UK longitudinal study of adolescent behaviour  
6 development in the general population (the G1219 study).

7 **Subjects:** At baseline (modal age 17 years) there were 1596 participants only 18% of  
8 whom were fully qualified drivers. At follow-up (modal age 20 years) 64% were fully qualified  
9 drivers.

10 **Main Outcome measures:** Attitudes to driving violations, particularly speeding, were  
11 measured in all participants at both assessments. Self-reported driving violations, also related to  
12 speeding, were measured in fully qualified drivers at follow-up.

13 **Results:** Attitudes became riskier with driver training/experience. Baseline attitudes  
14 measured in pre-drivers did not independently predict violations in those that had become fully-  
15 qualified drivers at follow-up. The attitudes of learner and fully qualified drivers at baseline  
16 independently predicted violations at follow-up.

17 **Conclusions:** These results indicate that the driver training period offers a promising  
18 opportunity for interventions to develop safer driving attitudes.

19

1 **WHAT IS ALREADY KNOWN**

2 • Risky attitudes and behaviours are linked to crash involvement in young drivers

3 • Risky attitudes may develop during the pre-driving period

4

5 **WHAT THIS STUDY ADDS**

6 • Attitudes to violations focussing on speed become riskier during driver training

7 • Attitudes in pre-drivers do not independently predict risky driving behaviour 3 years later

8 • Attitudes in learner drivers do predict risky driving 3 years later

9

10

1 Road traffic crashes provide a major public health challenge. In 2010 there were 1,850 fatalities  
2 on UK roads and 22,690 serious injuries.(1) Young drivers, particularly males, are over-  
3 represented in many crash types(2). For example adolescent drivers (aged 15-19 years) were  
4 more vulnerable to single vehicle fatalities than adults aged 45-64 (odds-ratio =1.64 for males  
5 and 1.45 for females) in the US, 2005-2009(2). Inexperience performs a role here(3), with faulty  
6 risk and hazard perception likely to be involved.(4) However, choice of risky behaviours such as  
7 speeding and dangerous overtaking, is also important.(5-9)

8         The antecedents of risky driving can be found before fully qualified driving begins. In the  
9 UK pre-drivers include people with no licence, who are prohibited from driving on public roads  
10 and those who hold a provisional licence (available from age 17) allowing supervised driving  
11 (learners). Drivers become fully qualified on completion of the UK driving test that can be taken  
12 from age 17, with no minimum period holding a provisional licence. Longitudinal studies  
13 showing adolescent behavioural difficulties predict driving risk(10) show that characteristics  
14 present before training begins influence driving behaviour. Further evidence shows driving  
15 attitudes have similar correlates in pre-drivers and full licence holders.(11)

16         Pre-driving is an attractive period for intervention as attitudes may be more malleable  
17 before habits form.(12) If driving experience results in attitude change then interventions may be  
18 targeted at key points to prevent negative changes and accentuate positive ones. A full  
19 understanding of attitude development across training is required to target interventions most  
20 effectively. Risky driving becomes more frequent as novice drivers gain experience(9) and this  
21 effect may begin when experience starts to accrue during training. Not all studies find an effect  
22 of experience prior to fully licensed driving(12, 13) However, one unpublished study indicates  
23 that attitudes to driving violations (largely focussed on speed)(14) are riskier in fully qualified

1 drivers than in learners and riskier in learners than non-drivers (Rowe, Andrews & Harris,  
2 manuscript submitted). This unpublished study also found that a measure of willingness to  
3 commit a wider range of violations showed the opposite relationship with driving experience.  
4 Therefore further studies are required to clarify the relationship between driving experience and  
5 attitudes during pre-driving.

6 A further issue in effectively delivering interventions is to target stages where attitudes  
7 optimally predict future behaviour. For example, learner drivers' attitudes might predict later  
8 behaviour more accurately than non-drivers' attitudes as training experience may have already  
9 started to shape attitudes. One study found a correlation of .28 between pre-driver speeding  
10 attitudes and risky driving behaviour 12 months later.(13) This study did not test whether  
11 prediction of future behaviour was similar for non-drivers and learner drivers at baseline.

12 We address the development of driving attitudes across training in a UK cohort  
13 study.(15) We use the attitudes to driving violations scale(14) as our primary attitudes measure.  
14 As noted above, this scale focuses primarily on speed which is a key contributor to crash  
15 involvement.(16) First we examine whether this measure changes with driving experience, using  
16 cross-sectional and longitudinal analyses. Second, we examine the longitudinal prediction from  
17 attitudes to behaviour, testing whether the strength of the relationship varies depending upon  
18 baseline driving experience. Given that males are riskier drivers than females(9), we test whether  
19 identified associations were moderated by sex throughout our analyses.

## 20 **METHODS**

### 21 **Study population**

22 G1219 includes participants from two sources, a community sample of siblings and a  
23 random selection of live twin births (between 1985 and 1988) identified by the UK Office of

1 National Statistics. Sample recruitment and retention is fully described elsewhere.(17) At wave 1  
2 3,640 respondents aged 12 to 19 years participated. Wave 3 (collected in 2004) was the first  
3 contact to include driving measures and is referred to as the baseline here. This wave contained  
4 1,596 adolescents (44% of the Wave 1 sample) with modal age 17 years (range 14-23) and 60%  
5 were female. The next contact (Wave 4, referred to here as the follow-up) was conducted  
6 approximately 3 years later (2007) and there were 1,556 participants (including 74% of wave 3  
7 respondents as well as additional study members who had participated at wave 2 but not at wave  
8 3). At this point the modal age was 20 years (range 18-27 years). Informed consent was obtained  
9 from parents/guardians of all study members under 16 years, and from study members  
10 themselves when over 16. Ethical approval for different stages of this study has been provided by  
11 the Research Ethics Committees of the Institute of Psychiatry, South London and Maudsley NHS  
12 Trust, and Goldsmiths, University of London. At wave 1, levels of parental education were  
13 somewhat higher (39% educated to A-level [US equivalent High School Diploma] or above)  
14 than in a large nationally represented sample of parents where 32% were educated to this level.  
15 Throughout the study, loss to follow up was associated with being male, higher on antisocial  
16 behaviour, living in rented accommodation and lower maternal education.

17 The characteristics of the sample at baseline and follow-up contacts are shown in Table 1  
18 including the distribution of driving licences at each stage. At follow-up, fully-qualified drivers  
19 reported that they had held their licence for 2.69 years (sd=1.88) on average and their weekly  
20 mileage was most commonly reported as 1-50 miles (39%), with 51-100 miles (25%) next most  
21 common.

22 <Table 1>

23 **Measures**

## 1 Attitudes to Driving Violations

2           The Attitudes to Driving Violations Scale(14) was presented to all participants at baseline  
3 and follow-up. Items are shown in Table 2. Responses are made on a 5-point scale labelled  
4 Strongly Disagree (scoring 5) to Strongly Agree (scoring 1). The scale is usually scored as the  
5 total of the 7 items providing a potential range of 7-35 with higher scores indicating riskier  
6 attitudes. The original validation study recruited a sample of 406 drivers and found the scale had  
7 a Cronbach's alpha of .76 and correlated with self-reported speeding and crash involvement.(14)  
8 In our sample, alpha reliabilities were .72 at both baseline and follow-up.

9 <Table 2>

## 10 Driving Behaviour

11           Driving violations were measured at follow-up in fully qualified drivers using items from  
12 the ordinary violations sub-scale of the Driver Behaviour Questionnaire (DBQ).(18) The  
13 questionnaire addresses violation frequency during the previous year on a 6-point scale ranging  
14 from never (scoring 0) to nearly all the time (scoring 5).(5) A recent meta-analysis including 70  
15 DBQ studies found a correlation of .13 between violations and crash involvement.(9) This study  
16 also reported new analyses of a large-scale UK sample of novice drivers showing DBQ  
17 violations measured at 6 months after licensing correlated with crash history at .15 and predicted  
18 future crash involvement over the next 6 ( $r=.14$ ), 18 ( $r=.14$ ) and 30 ( $r=.12$ ) months.(9) Space  
19 restrictions in the G1219 mail-out meant only four of the usual seven items were included. These  
20 were chosen as the strongest loading items in a factor analysis based on a large UK sample(19)  
21 and they showed good alpha reliability (.73) in our sample. The DBQ is usually scored as the  
22 mean of responses, with higher scores indicating more frequent violations.

1           At follow-up, drivers were also asked the date they obtained their full licence and to  
2 report their usual weekly mileage as 0, 1-50, 51-100, 101-200 or 200+. Mileage was treated as a  
3 continuous variable, scored 0 to 4.

#### 4 **Analyses**

5 The G1219 sample contains sibling pairs of differing genetic relatedness (identical twins, non-  
6 identical twins and full siblings) for the purpose of identifying genetic and environmental  
7 contributions to variance in behavioural traits. The current analyses address relationships  
8 between variables at the phenotypic level and therefore do not utilise the twin/family design. All  
9 analyses were conducted using the survey models of Stata 10.1(20) which adjust results for the  
10 non-independence of observations taken from the same family. These models are also robust to  
11 minor violations of some of the usual regression assumptions, including the normality  
12 assumption in linear regression. Linear regression models were used when predicting attitudes  
13 and behaviours with licence status coded as a categorical predictor using dummy variables.  
14 Within participants at each contact, missing data on the variables of interest was limited to  
15 between .5% and 1.5% of cases. There were slightly more missing responses for duration licence  
16 held (6%). Individuals without complete data on key variables were omitted from all analyses. In  
17 order to use as much of the available data as possible, analyses at single time points included all  
18 available participants irrespective of whether they participated at the other wave. Longitudinal  
19 analyses required participants to be present at both time points.

#### 20 **RESULTS**

##### 21 **Driving attitudes and behaviour**

22           Table 3 shows descriptive statistics regarding the driving-related variables and their  
23 relationship with age, sex and driving experience. Attitudes to driving violations were

1 significantly riskier in males than females and riskier attitudes were positively associated with  
2 age at baseline but not follow-up. In fully qualified drivers riskier attitudes were associated with  
3 higher mileage and with licence duration. Violations were more common in males than females,  
4 negatively correlated with age and positively correlated with driving exposure. After controlling  
5 for the effects of age, sex and driving exposure, riskier attitudes were associated with more  
6 frequent violations ( $\beta=.43$ , 95% CI: .36, .49,  $p<.001$ ).

### 7 **Are driving attitudes associated with licence status?**

8 Figure 1 shows mean attitude scores at each licence stage. We conducted regression  
9 models predicting standardised attitudes from licence status (coded with dummy variables),  
10 controlling for age and sex. At baseline, fully qualified drivers had riskier attitudes than non-  
11 drivers ( $b=.59$ , 95% CI: .41, .76,  $p<.001$ ) and learner drivers ( $b=.36$ , 95% CI: .20, .52,  $p<.001$ ).  
12 Learners had significantly riskier attitudes than non-drivers ( $b=.23$ , 95% CI: .09, .36,  $p=.001$ ). An  
13 additional interaction term between licence status and sex was non-significant ( $F(2, 860)=.00$   
14  $p=.998$ ).

15 We repeated the analysis using the follow-up data and found the interaction between sex  
16 and licence status was significant ( $F(2, 890)=3.46$ ,  $p=.032$ ). In males the pattern was similar to  
17 baseline: fully qualified drivers reported riskier attitudes than non-drivers ( $b=.75$ , 95% CI: .49,  
18 1.00,  $p<.001$ ) and learner drivers ( $b=.33$ , 95% CI: .10, .56,  $p=.005$ ), and learners had riskier  
19 attitudes than non-drivers ( $b=.42$ , 95% CI: .11, .72,  $p=.008$ ). For females, fully licenced drivers  
20 had riskier attitudes than non-drivers ( $b=.45$ , 95% CI: .27, .64,  $p<.001$ ) and learners ( $b=.54$ , 95%  
21 CI: .38, .70,  $p<.001$ ) but there was no difference between learners and non-drivers ( $b=-.08$ , 95%  
22 CI: -.29, .12,  $p=.423$ ). Age was not associated with attitude once licence status was accounted

1 for, at baseline ( $\beta=-.06$ , 95% CI:  $-.13, .01$ ,  $p=.109$ ) or follow-up ( $\beta=.01$ , 95% CI:  $-.04, .06$ ,  
2  $p=.710$ ).

3 <Figure 1>

#### 4 **Do attitudes change as a result of training/experience?**

5       These analyses focussed on the 659 non-drivers at baseline. Of these participants 323 had  
6 become fully qualified drivers at follow-up, 199 were learning to drive and 137 remained non-  
7 drivers. As shown in Figure 2, attitudes became riskier in those who became fully qualified  
8 drivers between baseline and follow-up (Cohen's  $D=.33$ ). There was no evidence of change in  
9 those who remained non-drivers ( $D=.01$ ) or began learning to drive ( $D=.11$ ). Controlling for age  
10 and sex, there were no differences in baseline attitudes between participants who did not learn to  
11 drive before follow-up and those that began learning to drive or became fully qualified before the  
12 follow-up assessment ( $F(2, 420)=.45$   $p=.636$ ). Significant differences only emerged at follow-up  
13 ( $F(2, 420)=8.94$ ,  $p<.001$ ). In order to test whether learning to drive between baseline and follow-  
14 up predicted change in attitude, we ran a regression model predicting standardised follow-up  
15 attitudes with licence status at wave 4 (coded with dummy variables), controlling for baseline  
16 attitude, age and sex. In this model those who learnt to drive had significantly riskier attitudes at  
17 follow-up than participants who remained non-drivers ( $b=.34$ , 95% CI:  $.15, .54$ ,  $p=.001$ ) and  
18 participants who had started training but not completed it ( $b=.29$ , 95% CI:  $.13, .45$ ,  $p<.001$ ). The  
19 comparison of those who remained non-drivers and those who had begun driver training was  
20 non-significant ( $b=.06$ , 95% CI:  $-.15, .26$ ,  $p=.593$ ). An additional interaction term between sex  
21 and licence status was non-significant ( $F(2, 420)=1.22$ ,  $p=.300$ ), indicating the effect of learning  
22 to drive was not significantly different for males and females. These results are consistent with

1 the hypothesis that driving experience influences attitudes rather than that those with riskier  
2 attitudes start to drive earlier.

3 <Figure 2>

4 The above analyses did not indicate whether change in attitudes happened immediately  
5 after gaining a full licence or gradually with the acquisition of experience. Next we examined  
6 whether attitudes were linearly related to the time since qualifying to drive at follow-up. The  
7 zero-order correlation between attitudes and time since acquiring a full licence was .13 ( $p < .001$ ).  
8 Mean attitude scores were 18.74 ( $SD=4.17$ ) for participants in their first year of fully qualified  
9 driving, 19.61 ( $SD=4.06$ ) in the second year and 20.45 ( $SD=4.10$ ) in the third year and beyond.  
10 Therefore it appears there was a linear relationship between driving experience and attitude.

### 11 **Do pre-licence attitudes predict fully qualified driving behaviour?**

12 We tested the longitudinal prediction of violations from attitudes using only fully  
13 qualified drivers at follow-up ( $N=775$ ). Table 4 shows that these participants were most  
14 commonly non-drivers at baseline (41%), 30% were learners and 29% were fully qualified  
15 drivers. As Table 4 shows, violations were more strongly correlated with the prior attitudes of  
16 full and provisional licence holders than they were with non-licence holders. We ran a multiple  
17 regression model predicting violations from baseline attitudes, licence status, and their  
18 interaction. Sex, age and regular mileage were also included as covariates<sup>1</sup>. The model showed a  
19 significant interaction between baseline licence status and attitude ( $F(2, 519)=3.55$   $p=.029$ ). As  
20 shown in Table 4, attitudes significantly predicted violations in those who were fully qualified  
21 drivers at baseline and in those who were learners, but not in those who were non-drivers at

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<sup>1</sup> Duration licence held was not included as a covariate as this was closely related to licence status at baseline, although the pattern of results was similar when this covariate was included.

1 baseline. Sex did not moderate the prediction of violations from baseline attitudes in non-drivers  
2 ( $p=.586$ ), learners ( $p=.689$ ) or fully qualified drivers ( $p=.223$ ).

3 <Table 4>

#### 4 **DISCUSSION**

5 G1219 provides a unique opportunity to study the development of driving attitudes from  
6 pre-driving to fully-qualified driving in a large general population sample. We found driving  
7 attitudes were riskier in fully qualified drivers than in learners and non-drivers, independently of  
8 age and sex at baseline and follow-up. Learners had riskier attitudes than non-drivers at baseline.  
9 At follow-up learners were riskier than non-drivers in males but not females. The reasons for this  
10 minor discrepancy between data collection waves are unclear. Further analyses did not identify  
11 any other evidence that sex moderated prediction of attitudes and behaviour. Therefore, overall,  
12 our results provide little evidence that the processes underlying risky driving differ substantially  
13 by sex. .

14 The longitudinal design of G1219 allows us to examine the mechanisms underlying the  
15 cross-sectional association we identified between licence status and risky attitudes. At baseline  
16 there were no differences between those who would go on to gain driving experience in the  
17 follow-up period and those who would not. Attitudes became riskier in those who became fully  
18 qualified drivers between baseline and follow-up whereas there was no change in attitudes for  
19 those who remained non-drivers or had become learners at follow-up. These analyses indicate  
20 that attitudes become riskier with experience rather than that people with riskier attitudes learn to  
21 drive earlier.

22 It may be that the development of riskier attitudes with driving experience is specifically  
23 related to speed. As noted above, the association between riskier scores on the Attitudes to

1 Driving Violations Scale(14) and licence status has been observed elsewhere (Rowe, Andrews &  
2 Harris, submitted), but a different pattern of results was reported for a measure addressing  
3 violations more widely. This does not diminish the importance of the results reported here,  
4 however, given that driving speed is an important contributor to crash involvement.(16) Our data  
5 do not directly address why attitudes become riskier with experience. One possibility is that  
6 confidence in the ability to handle speed and experience of the relatively forgiving nature of the  
7 road environment makes drivers feel that speeding is less risky than they thought initially.

8 Our findings regarding longitudinal prediction of violations from attitudes also indicate  
9 that attitudes change with training and experience. In learners and fully qualified drivers at  
10 baseline there was significant prediction from attitudes to violation behaviour at follow-up. In  
11 non-drivers at baseline who became fully qualified drivers before follow-up, the prediction from  
12 attitudes to behaviour was not independently significant. We are aware of only one other  
13 longitudinal study that has predicted driving behaviour from pre-driving attitudes. This study did  
14 find a correlation between attitudes in pre-drivers and their driving behaviour over a one year  
15 period(13) rather than the three year follow-up of our study. A key strength of our study is the  
16 comparison of prediction of violations from attitudes at different baseline stages of driver  
17 training. Our results show that prediction is stronger in those who are currently driving and in  
18 learners than in non-drivers and this has implications for injury prevention initiatives as  
19 discussed below.

20 Our results must, however, be considered in the context of some limitations. The  
21 retention of participants from baseline to follow-up was incomplete, as is inevitable in studies of  
22 this nature. Loss of observations will lead to lower statistical precision and may also introduce  
23 bias. We rely upon self-report for all measures, although it should be noted that self-report

1 measures of this sort have been well validated in comparison with performance data.(9) It would  
2 be helpful for replications to include measures from other reporters who are familiar with the  
3 participants' driving behaviour and also take more objective measures of risky driving behaviour  
4 such as criminal and medical records.

## 5 **Implications for prevention**

6         The high costs associated with risk-taking in young drivers makes developing  
7 preventative measures a priority. This might involve a range of different approaches including  
8 tougher legislation for violating motoring laws and graduated licensing programmes to reduce  
9 unsupervised driving during the early stages of novice driving. Interventions aiming to improve  
10 attitudes and behaviour in young drivers are likely to continue to perform a central role in these  
11 efforts, in part due to their public acceptability and relatively small cost. Our findings have  
12 implications for identifying the best developmental stage in which to target such interventions.  
13 We found that attitudes only predict driving behaviour independently when driver training has  
14 begun. This has implications for the utility of targeting non-drivers with attitude  
15 interventions.(11) As the attitudes of non-drivers were not independently predictive of violations  
16 during fully qualified driving it seems less plausible that manipulating non-drivers' attitudes will  
17 modify future driving behaviour. This study did not manipulate attitudes directly however. We  
18 believe randomised control trials of the effectiveness of non-driver attitude modification remain  
19 a priority for future research. In the absence of this evidence, our results offer a cautionary  
20 message to organisations considering investing in non-driver attitude training.

21         Our results indicate that the learner driver stage (as indexed by a provisional licence in  
22 the UK) provides the most promising stage in which to foster safer driving attitudes. This period  
23 marks the beginning of a trajectory of increasingly risky attitudes towards violations, at least

1 those involving speed. Variation in the amount and type of driver training received and the  
2 number of driving tests failed may have implications for individual differences in this trajectory.  
3 Interventions that could prevent this change may be particularly helpful, given that we found the  
4 attitudes of learners predicted future driving behaviour. Driving instructors and supervising  
5 adults may already be trying to develop safer attitudes in their pupils at this stage, and our data  
6 are not able to quantify this, or evaluate its effectiveness. While more recent models of driver  
7 education emphasise tuition regarding risky driving style as well as driving skills(21), it is  
8 possible that most UK training is too focussed on the control and higher order driving skills that  
9 will be formally assessed at the expense of developing safer driving attitudes. A focus on skills  
10 may contribute to the development of riskier attitudes as training control skills can lead to over-  
11 confidence(22). While interventions to improve driving behaviour often met with little success in  
12 the past(23), more recent theoretically-based approaches to improving driver risk taking have  
13 shown promise in small scale trials(24). Some approaches to skills training have also shown  
14 benefits for reducing riskiness.(25, 26) All of these approaches to attitude improvement may be  
15 best targeted during the learning phase as risk-taking behaviours may be more malleable before  
16 habits are formed during independent driving. It is also possible that education designed to  
17 improve attitudes during driver training may be most effective in the context of an integrated  
18 programme including pre-driving education. Further research must address this possibility.

19 Targeting attitudes during driver training also has some practical advantages. Attendance  
20 at attitude-training courses may become a formal requirement for licensing. Driving tests also  
21 offer the opportunity to select people for licencing based on their attitude. Implicit attitude  
22 measures, such as the Implicit Association Test(27) may be useful here as they may be less  
23 vulnerable to faking than explicit tests.(28)

24

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9 London.

10

1 **CONTRIBUTORSHIP STATEMENT**

2

3 All authors made a substantial contribution to study conception and design, to data acquisition, to  
4 analysis and interpretation of data and to drafting and revising the article. All authors provided  
5 approval of the final version of the manuscript.

6

1 **COMPETING INTERESTS**

2

3 None of the authors have any competing interests.

## 1 REFERENCES

- 2 1. Department for Transport. Reported Road Casualties Great Britain: 2010. London 2011.
- 3 2. Bingham CR, Ehsani JP. The relative odds of involvement in seven crash configurations  
4 by driver age and sex. *The Journal of adolescent health*. 2012;51(5):484-90.
- 5 3. Groeger JA. Youthfulness, inexperience, and sleep loss: the problems young drivers face  
6 and those they pose for us. *Injury Prevention*. 2006;12:19-24.
- 7 4. Deery HA. Hazard and risk perception among young novice drivers. *Journal of Safety*  
8 *Research*. 1999 Win;30(4):225-36.
- 9 5. Parker D, Reason JT, Manstead ASR, Stradling SG. Driving Errors, Driving Violations  
10 and Accident Involvement. *Ergonomics*. 1995 May;38(5):1036-48.
- 11 6. Clarke DD, Ward P, Truman W. Voluntary risk taking and skill deficits in young driver  
12 accidents in the UK. *Accident Analysis And Prevention*. 2005;37(3):523-9.
- 13 7. Fergusson D, Swain-Campbell N, Horwood J. Risky driving behaviour in young people:  
14 prevalence, personal characteristics and traffic accidents. *Aust N Z Publ Health*. 2003  
15 Jun;27(3):337-42.
- 16 8. Blows S, Ameratunga S, Ivers RQ, Lo SK, Norton R. Risky driving habits and motor  
17 vehicle driver injury. *Accident Analysis And Prevention*. 2005;37(4):619-24.
- 18 9. de Winter JCF, Dodou D. The Driver Behaviour Questionnaire as a predictor of  
19 accidents: A meta-analysis. *Journal of Safety Research*. 2010 Dec;41(6):463-70.
- 20 10. Woodward LJ, Fergusson DM, Horwood LJ. Driving outcomes of young people with  
21 attentional difficulties in adolescence. *Journal of the American Academy of Child and*  
22 *Adolescent Psychiatry*. 2000 May;39(5):627-34.

- 1 11. Waylen AE, McKenna FP. Risky attitudes towards road use in pre-drivers. *Accident*  
2 *Analysis and Prevention*. 2008;40(3):905-11.
- 3 12. Harre N, Brandt T, Dawe M. The development of risky driving in adolescence. *Journal of*  
4 *Safety Research*. 2000;31(4):185-94.
- 5 13. Mann HN, Sullman MJM. Pre-driving attitudes and non-driving road-user behaviours:  
6 Does the past predict future driving behaviour? In: Dorn L, editor. *Driver Behaviour and*  
7 *Training: Volume 3*. Aldershot, UK: Ashgate; 2008.
- 8 14. West R, Hall J. The role of personality and attitudes in traffic accident risk. *Applied*  
9 *Psychology-an International Review-Psychologie Appliquee-Revue Internationale*. 1997  
10 Jul;46(3):253-64.
- 11 15. Eley TC, Liang HL, Plomin R, Sham P, Sterne A, Williamson R, et al. Parental familial  
12 vulnerability, family environment, and their interactions as predictors of depressive symptoms in  
13 adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry*.  
14 2004;43:298-306.
- 15 16. Aarts L, van Schagen I. Driving Speed and the Risk of Road Crashes: A Review.  
16 *Accident Analysis and Prevention*. 2006;38(2):215-24.
- 17 17. McAdams T, Gregory AM, Rowe R, Zavos HMS, Barclay NL, Lau JYF, et al. The  
18 Genesis 12–19 (G1219) Study: A Twin and Sibling Study of Gene–Environment Interplay and  
19 Adolescent Development in the UK. *Twin Research and Human Genetics*. Published Online  
20 First: 12 October 2012.
- 21 18. Reason JT, Manstead A, Stradling S, Baxter J, Campbell K. Errors and Violations on the  
22 Roads - a Real Distinction. *Ergonomics*. 1990;33(10-11):1315-32.

- 1 19. Lajunen T, Parker D, Summala H. The Manchester Driver Behaviour Questionnaire: a  
2 cross-cultural study. *Accident Analysis and Prevention*. 2004 Mar;36(2):231-8.
- 3 20. StataCorp. *Stata Statistical Software: Release 10.1*. College Station, TX: Stata  
4 Corporation; 2007.
- 5 21. Hatakka M, Keskinen E, Gregersen NP, Glad A, Hernetkoski K. From control of the  
6 vehicle to personal self-control; broadening the perspectives to driver education. *Transportation  
7 Research Part F*. 2002;5:201-15.
- 8 22. Gregersen NP. Young drivers' overestimation of their own skill - An experiment on the  
9 relation between training strategy and skill. *Accident Analysis and Prevention*. 1996  
10 Mar;28(2):243-50.
- 11 23. Ker K, Roberts IG, Collier T, Beyer FR, Bunn F, Frost C. Strong evidence that advanced  
12 and remedial driver education does not reduce road traffic crashes or injuries. *Cochrane Database  
13 of Systematic Reviews*. 2003.
- 14 24. Elliott MA, Armitage CJ. Promoting drivers' compliance with speed limits: Testing an  
15 intervention based on the theory of planned behaviour. *British Journal of Psychology*.  
16 2009;100:111-32.
- 17 25. Isler RB, Starkey NJ, Sheppard P. Effects of higher-order driving skill training on young,  
18 inexperienced drivers' on-road driving performance. *Accident Analysis and Prevention*. 2011  
19 Sep;43(5):1818-27.
- 20 26. McKenna FP, Horswill MS, Alexander JL. Does anticipation training affect drivers' risk  
21 taking? *Journal of Experimental Psychology-Applied*. 2006 Mar;12(1):1-10.

1 27. Greenwald AG, McGhee DE, Schwartz JLK. Measuring individual differences in implicit  
2 cognition: The implicit association test. *Journal Of Personality And Social Psychology*.  
3 1998;74(6):1464-80.

4 28. Greenwald AG, Poehlman TA, Uhlmann EL, Banaji MR. Understanding and Using the  
5 Implicit Association Test: III. Meta-Analysis of Predictive Validity. *Journal Of Personality And*  
6 *Social Psychology*. 2009;97(1):17-41.

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8

9

1 Table 1. Characteristics of the sample at Baseline and Follow-up.

2

	Baseline	Follow-up
Number of participants	1596	1556
Age	Mode = 17 (range 14-23)	Mode=20 (range 18-27)
Sex	60% female	61.5% female
No licence	55%	13%
Provisional licence	26%	23%
Full licence	18%	64%

3

1 Table 2. Items included in the driving measures.  
2

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Attitudes to Driving Violations Scale(14)

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Decreasing the speed limit on motorways is a good idea

Even at night-time on quiet roads it is important to keep within the speed limit

Drivers who cause accidents by reckless driving should be banned from driving for life

People should drive slower than the speed limit when it is raining

Cars should never overtake on the inside lane even if a slow driver is blocking the outside lane

In towns where there are a lot of pedestrians the speed limit should be 20 miles per hour

Penalties for speeding should be more severe

Violations from the Driver Behaviour Questionnaire(18)

Race away from traffic lights with the intention of beating the driver next to you

Overtake a slow driver on the inside

Disregard the speed limit on a motorway

Disregard the speed limit on a residential road

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3

1 Table 3. Driving related measures: Distribution, sex differences and relationship with age and  
 2 driving experience.

Variable	Skewness	Kurtosis	Mean (SD)		Regression models <sup>1</sup>			
			Male	Female	Sex <sup>2</sup>	Age <sup>3</sup>	Mileage <sup>3</sup>	Driving years <sup>3</sup>
<i>Baseline</i>								
ADVS	.20	3.45	19.63 (4.60)	17.65 (4.09)	.45*** (.35, .56)	.09** (.04, .14)	-	-
<i>Follow-up</i>								
ADVS <sup>4</sup>	.05	3.45	20.25 (4.52)	18.34 (4.23)	.43*** (.32, .54)	.05 (-.00, .10)	-	-
Follow-up: Fully Qualified Drivers Only								
ADVS	-.05	3.14	20.93 (4.20)	19.27 (3.98)	.36*** (.23, .50)	-.05 (-.17, .07)	.12** (.05, .18)	.14* (.03, .26)
DBQ	.78	3.33	1.50 (.99)	1.10 (.84)	.36*** (.23, .50)	-.16* (-.27, -.06)	.24*** (.17, .31)	.24*** (.14, .34)
Violations								

3 ADVS=Attitudes to Driving Violations Scale DBQ =Driver Behaviour Questionnaire  
 4 <sup>1</sup>Regression models predicting the driving variables from sex and age. Mileage and duration  
 5 licence held were also included in models constrained to include only fully qualified drivers.  
 6 <sup>2</sup>b coefficient (and 95% confidence intervals) for male sex predicting standardised outcome  
 7 variables.  
 8 <sup>3</sup>β coefficients (and 95% confidence intervals)  
 9 <sup>4</sup>Includes all participants irrespective of their licence status  
 10 \*p<.05 \*\*p<.01 \*\*\*p<.001

1 Table 4. Prediction of violations at follow-up from attitudes at baseline. Only participants with a  
 2 full licence at follow-up were included in these analyses.

Baseline licence status	N	Simple correlation	Regression $\beta$ coefficient (95% Confidence Interval) <sup>1</sup>
Non-drivers	319	.13*	.08 (-.06, .21)
Learners	232	.33**	.32** (.18, .45)
Fully-qualified drivers	224	.38**	.29** (.17, .41)

3 <sup>1</sup>Model controls for age, sex and mileage.

4 \*p<.05 \*\*p<.001

5

1 Figure Legends.

2 Figure 1. Mean attitudes to violations scores for participants with different forms of driving  
3 licence. Higher scores indicate riskier attitudes towards violations. Error bars show 95%  
4 confidence intervals.

5

6 Figure 2. Development of attitudes to driving violations in non-drivers at baseline, grouped by  
7 licence status at follow-up. Error bars show 95% confidence intervals.