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From fear to forecast: The role of simulators, accompanied driving, age, gender, and information-processing style in driver training and beyond

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A B S T R A C T

Background: Even though accompanied driving and simulator training are common, clarity on their usage trends and effectiveness is lacking. This research aimed to deepen the understanding of the relationships between personal characteristics, pre-licence accompanied driving, self-reported post-licence driving behaviour, and driving performance scores during simulator lessons.
Methods: We used data from a questionnaire completed by simulator and non-simulator students (total $n = 3{,}761$). Data were analysed by dividing the sample into two groups based on variables such as gender, age at licensure, education level, fear of driving a car when starting driver education, information-processing style, participation in accompanied driving, and the number of driving simulator lessons completed.
Results: Males took fewer on-road lessons and reported lower fear, but they had poorer simulator safety scores than females. Younger learners required fewer lessons and test attempts, were less fearful, and violated traffic rules more than older respondents. Higher-educated respondents had more fear and safer driving scores in the simulator. Thinkers, who were typically more educated, showed more caution in the simulator and on the road, and were older at licensure. Compared to regular students, students participating in accompanied driving were younger at licensure. Moreover, students with a higher driving skill score in the simulator were less fearful and needed slightly fewer attempts to pass the road driving test.
Discussion and conclusion: The fear towards driving, which is strongly linked to personal characteristics, provides a logical explanation for the progression of students through driver education. Furthermore, this study illustrated the possibility of considering information-processing styles, education level, and driving simulator performance in driving education. However, in order to conclusively study the safety-effectiveness of accompanied driving and simulator training, further research in the form of a randomised controlled trial is necessary.

1. Introduction

In high-income nations, road collisions outrank crime and violence as the predominant threat to personal safety (Lloyd's Register Foundation, 2022). The 'young driver problem', which refers to the overrepresentation of young drivers in these accidents (Drummond, 1989; OECD, 2006), emerges as a daunting issue that is hard to solve (Elvik, 2010). Reinforcing this concern, the World Health Organization (2018) reports that road traffic accidents are the leading cause of death for those aged between 5 and 29.

In 2020, the EU set a renewed target to reduce road fatalities and serious injuries by half before 2030 and ultimately to zero by 2050 (European Commission, 2019). It remains to be seen whether this goal is realistic for countries with relatively low road casualties, such

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Fig. 1. Driving simulator type "Drive Master B".
Source: https://www.greendino.nl

as the Netherlands. In fact, the Netherlands Institute for Road Safety Research expressed concern over a possible *rise* in severe road injuries by 2030 if preventative strategies are not put into place (De Craen et al., 2022).

The traffic safety of young drivers is compromised by their tendency for risk-taking behaviours such as speeding (Ivers et al., 2009; Rolison et al., 2018), as well as their limited driving experience (Laapotti et al., 2001; Rolison et al., 2018), which leaves them with undeveloped hazard perception and attention management skills (Hill et al., 2019; Horswill et al., 2015; Laapotti et al., 2001; Rolison et al., 2018). These factors are recognised in current driver education, such as through accompanied driving (Boets et al., 2016; Christie et al., 2017; Jones et al., 2016; SWOV, 2019), the incorporation of a hazard perception test in the driving examination (Boufous et al., 2011; Moran et al., 2019; SWOV, 2014), and the introduction of training for so-called higher-order skills, i.e., the notion that students should not only master the vehicle and demonstrate traffic insight, but must also reflect on their own skills, and make prudent decisions (Bartl et al., 2010; De Craen et al., 2005; Isler et al., 2011; Kluppels, 2015).

It is commonly known that innovations in driving education are generally hardly evaluated (Beanland et al., 2013; De Winter & Kovácsová, 2016). For example, the concept of training for higher-order skills has received attention in various European projects, such as GADGET (1999), BASIC (2003), ADVANCED (2002), TRAINER (2003), NOVEV (2005), SUPREME (2007), and HERMES (2010), but a rigorous evaluation with a control group is lacking (Beanland et al., 2013).

Since the early 2000s, another factor that has come into play, particularly in a number of countries, including Germany, the Netherlands, and France, is the introduction of simulator-based training (Genschow et al., 2014; Goepp, 2017; Sætren et al., 2018; SWOV, 2019). One of the advantages of driving simulators is that they allow learners to repeatedly practise certain tasks without physically endangering themselves (e.g., Rodwell et al., 2019). Driving simulators also record driving performance, making it possible to automatically provide feedback and evaluations in a consistent manner (Kappé et al., 2010; Wassink et al., 2006). However, similar to general driver training (Groeger & Banks, 2007), questions arise about the extent to which skills acquired in a virtual environment can be transferred to real-world roads (Hirsch & Bellavance, 2017).

Although knowledge on transfer-of-learning is scarce (for an exception, see Hirsch et al., 2017), a variety of studies have shown that simulators can be used for reliable driver assessment (Aksan et al., 2016; Bernstein, 2020; Ju et al., 2022; Lee, 2003; Park et al., 2007). A study of 900 trainees by De Winter et al. (2009) showed that drivers who executed tasks more slowly and drivers who made more steering errors in the simulator took longer to obtain their licence. A subsequent study (De Winter, 2013) surveyed 320 former simulator trainees who had held their licences for an average of 3.4 years. It revealed simulator training behaviour, including errors and violations, to be a robust predictor of self-reported driving behaviour post-licensure. De Winter and Kuipers (2017) reported how a simulator driving style test used at a motor show could assess a person's driving style with a short 6.5-minute drive. They found substantial correlations between years of licensure, driving speed, and the 'total risk score' in the simulator, a finding which corroborates on-road data showing that young drivers are more likely to engage in risky behaviours than older, more experienced drivers. While simulators can provide objective measurements, still little is known about the use of simulators within driver education.

The role of driving style versus driving skill in driver education represents a substantial challenge (Hatakka et al., 2002; Zhang et al., 2018). A risky driving style, typified by close following and speeding, is a danger among young drivers, particularly young males (Clarke et al., 2005; Turner & McClure, 2003). However, driver training and driving tests often see candidates driving as well as they can, thereby exhibiting good driving styles (for further reflection, see Baughan et al., 2005; Driessen et al., 2021). This finding corresponds with another observation: males generally need fewer driving lessons than females and also have a higher first-time driving

test pass rate (Granié & Varet, 2017; Hazevoet & Vissers, 2005; Sexton & Grayson, 2009; Vlakveld, 2006; Wells et al., 2008), implying that they are better drivers. The paradox that arises here is that effective driver training, while preparing students well for their driving tests, might indirectly harm public health. It may allow younger individuals, who may not be fully mature in terms of hormonal regulation and brain development and thus more likely to engage in riskier behaviours, to acquire their driving licences (Dahl, 2008; Glendon, 2011; Lewis-Evans, 2010; Lund et al., 1986; Roberts & Kwan, 2001; Vlakveld, 2006). On the other hand, some drivers who are more anxious and take fewer risks might require a longer period of time to complete their driving education. This issue necessitates further study to improve driver training methods, with the eventual goal of promoting a safer driving style. One potential tool for pre-licence driver assessment could be driving simulation, where students may be less inhibited to speed compared to on-road driving lessons or tests, providing a more realistic assessment of their true driving style (De Winter et al., 2007).

This research aims to gain a deeper understanding of the aforementioned patterns. To this end, we administered an online questionnaire among over 3,000 students who had completed part of their training in a simulator. We examined the relationship between personal characteristics such as gender and age, as well as self-reported driving behaviour and mileage, accident involvement, and experiences such as the fear of driving when starting driving lessons, in relation to driving performance during lessons in the simulator. Even though the questionnaire was conducted some time ago, at the end of 2015, we believe it is important to elaborate on this research, especially given the renewed call to revitalise and objectify driver education in Europe (Roemer, 2021).

2. Methods

2.1. Driving simulators

The dataset for this study originates from Green Dino driving simulators (Fig. 1). Between 2008 and 2015, four different types of driving simulators were used by Dutch driving schools. Key differences lay in image projection methods (projectors or screens) and control mechanisms (car parts or Logitech products). Note that all simulators ran identical software applications and curricula.

The Green Dino simulator provides automated adaptive instruction using a virtual driving instructor (Fikkert et al., 2006; Weevers et al., 2003) and automated performance feedback. The simulator substitutes both the training vehicle and the human driving instructor. The thirty-four 30-minute curriculum lessons address vehicle handling, intersection navigation, highway driving, and manoeuvring. The simulator is typically used early in driver training, that is, before students transition to lessons in an actual vehicle. Driving school owners are advised against having an instructor present during the simulator lessons, as this decreases the economic benefit substantially. De Groot et al. (2007) reported that additional attention from a human driving instructor during lessons on the Green Dino simulator (with automated instruction) resulted in decreased student performance in the simulator.

This research used scores from a summary report, frequently used to brief students and their parents. The report includes various composite scores. In this study, we use the primary scores ‘driving skill score’ and ‘safety score’, in line with earlier findings that driving skill and driving style are two distinct components identifiable in the recorded data from driving simulator training (De Winter et al., 2009). In short, the driving skill score is a composite score derived from combining various task scores. These include instances of excessive braking or collisions, improper use of turn signals, swerving or deviating from the centre of the road, and operating at inconsistent RPMs within the simulator. Contrastingly, the safety score is computed based on the degree to which the driver exceeded speed limits or maintained insufficient distance from the vehicle ahead in the simulator, amongst other safety-related behaviours.

2.2. Questionnaire distribution

Between 9 and 13 November 2015, 22,881 persons were sent an email from Green Dino with an invitation to participate in a questionnaire study. The reported study goal was to examine the effects of simulator training on the lessons needed to obtain a driving licence. The recipients were asked to complete an online questionnaire by clicking the provided link. As a reward, twenty cinema tickets were raffled among interested participants. People could also indicate whether they would like to receive a summary of the results at the end of the study. The raffle and the sending of the summary took place in March 2016.

To increase the sample size, non-simulator students were invited as well. Specifically, several driving schools were contacted in December 2015 with a request to distribute an email message to their current and former learner drivers. The questionnaire was also shared on various social media platforms. The questionnaire was open until February 10, 2016.

2.3. Questionnaire content

The following questions were presented in the questionnaire (translated from Dutch). A number of questions are based on previous research into driver education and simulator training, particularly the work of De Winter (2013), Feenstra and Vissers (2002), and Van Schagen et al. (2015):

Q1. “In which driving school did you take your driving lessons?” (multiple choice),

Q2. “Did you have lessons in a driving simulator as part of your driver training?” (Yes, No).

Respondents were also asked to provide their email address, the same one where they received the questionnaire link, thereby granting permission for the researchers to link their answers to the simulator lessons taken.

Q3. “Age” (numeric entry),

Q4. “Gender” (Female, Male),

Q5. “What is your current level of education? If you are not currently studying, mark the level of your highest completed education”

(Primary education, Practical education, Pre-vocational secondary education [VMBO], Higher general continued education [HAVO], Pre-university education [VWO], Secondary vocational education [MBO], University of applied sciences [HBO], University; also option to select: Other, namely).

This was followed by a question about the respondents' preferred way of information-processing during learning:

Q6. "Everyone has their own way of learning. Various types can be distinguished:

1. I like to master theory well before I do something in practice. I think carefully before I make a decision and like to take my time for this,

2. I enjoy trying things out and finding a link between theory and practice. I learn most from making mistakes,

3. Gaining new experiences is important to me. I don't need to know the theory behind things exactly and don't want to think too much, just do.

How would you describe your learning method? (1, 2, or 3)".

Response 1 (referred to as 'Thinkers') aligns with Kolb's (1984) assimilative style, Honey and Mumford's theorist style (Mumford & Honey, 1992), and Gregorc's abstract sequential style (Gregorc & Ward, 1977). Response 2 ('Doers') indicates a preference for practical learning through experience. This relates to Kolb's convergent style, Honey and Mumford's pragmatist style, and Gregorc's concrete sequential style. Response 3 ('Deciders') shows a preference for intuitive and experiential learning, consistent with Kolb's divergent style, Honey and Mumford's activist style, and Gregorc's concrete random style. Although learning styles are often said to lack validity (An & Carr, 2017; Cassidy, 2004; De Bello, 1990), everyday experience shows that driving schools and other educators make extensive use of such categorisations. Note that although Q6 pertains to learning styles, our analysis suggested that the answers to this question seem to relate more with respondents' information-processing in general, without necessarily relating to the style of learning. Hence, in this paper, we use the term 'information-processing style' instead of 'learning style'.

Next, a number of questions about driver's licence acquisition were asked:

Q7. "Do you have a driver's licence?" (Yes, No; students who answered 'No' were led to the end of the questionnaire),

Q8. "Did you get your driver's licence through 2toDrive?" (No, Yes),

Q8a. "You indicated that you obtained your driver's licence via 2toDrive. How often did you drive under supervision before you turned 18?" (Never, Rarely [less than once a month], Sometimes [about once a month], Regularly [about once a week], Very often [multiple times a week], Almost every day).

The 2toDrive accompanied driving programme permits students to start on-road driving lessons at the age of 16.5 and take the driving test at 17, instead of the usual 18 years. Once the driving test is passed at 17, students are allowed to drive under the supervision of an approved coach, typically a parent, until they turn 18. The programme helps young drivers accrue more extensive road experience to potentially lower accident rates, as indicated by international studies (e.g., Williams, 2017). However, a Dutch large-scale questionnaire by Van Schagen et al. (2015) found it inconclusive whether 2toDrive participants were safer drivers compared to those who obtained their licence after 18 because there were group differences in cumulative mileage. Note that traditionally trained students are those who only commence their on-road driving lessons at the age of 18 or later. Enrolment in the 2toDrive programme is not officially registered; the current study relies on self-report to determine whether someone participated in 2toDrive (Q8).

Q9. "How many whole hours (60 min) of practical lessons did you have? This is about the lessons you had from your driving instructor on the road; any lessons on the simulator do not count here" (numeric entry),

Q9a. "Did you know the answer to the previous question for sure, or was this a rough estimate?" (Certain, Estimate),

Q10. "How many times did you take the practical test before you got your driver's licence?" (multiple choice),

Q11. "Since when have you been in possession of your driver's licence? (This is on the licence)" (Date entry).

Subsequently, several questions were asked about accident involvement in the first 12 months after obtaining the driver's licence, introduced with the following text: "The following questions are about your behaviour in traffic, in the first 12 months after obtaining your driver's licence. For each question, indicate how often you displayed the relevant behaviour. These questions are purely to get a picture of motorists in general; there are no consequences for you personally. It is important that you answer honestly." The questions were:

Q12. "How many kilometres have you driven in the first 12 months after getting your driver's licence (approximately)?" (numeric entry),

Q13. "An accident is defined as: a collision with something or someone on a public road resulting in damage. It doesn't matter how severe the accident was, or who was at fault. Have you been involved in an accident in the first 12 months after getting your driver's licence?",

Q13a. "How many accidents have you been involved in during the first 12 months?" (multiple choice),

Q13b. "In how many accidents you were involved in during the first 12 months, did someone have to be treated in the hospital?" (multiple choice).

Next, a small version of the Driver Behaviour Questionnaire (DBQ; Reason et al., 1990) was administered (items based on De Winter, 2013; Van Schagen et al., 2015):

Q14. "For the following questions, only check the 'Can't remember' option if you really cannot estimate. (Never, Rarely [less than once a month], Sometimes [about once a month], Regularly [about once a week], Very often [multiple times a week], Almost every car ride; also option to select: Can't remember). In the first 12 months, how often did you ….

(a) drive more than 10 km per hour over the speed limit within a built-up area?

(b) read/send a message on your mobile phone while driving?

(c) deliberately drive through a red light?

(d) have to make an emergency stop?
(e) drive after drinking one or more glasses of alcohol?
(f) drive without a seatbelt?
(g) go off the road and end up in the shoulder, against the curb, or in the wrong lane?
(h) fail to give way where you should have?".

The questionnaire ended with questions for the last 12 months of driving, complemented with a question about fear of driving: "The following questions are not about the first 12 months after your licence, but about the past 12 months."

Q15. "Have you been involved in an accident in the past 12 months?" (Yes, No),

Q15a. "How often have you been involved in an accident in the past 12 months?" (multiple choice),

Q15b. "How many times did someone have to be treated in the hospital as a result of an accident you were involved in (in the past 12 months)?" (multiple choice).

Finally, the last question was about fear:

Q16. "Were you scared to drive a car when you started your driving lessons?" (Not at all, Barely, A little, Quite, Very much).

At the conclusion of the questionnaire, respondents were thanked for their participation and provided with an email contact for any subsequent questions or comments, and they were asked to click 'Submit' to send their responses.

2.4. Derivation of variables

The following variables were derived from the questionnaire responses.

(a) **Months licenced.** To calculate the length of time a respondent held their driver's licence in months, we subtracted the date when they received their licence (Q11) from the date they completed the questionnaire. This period, initially measured in days, was converted to months by dividing by 30.4375, the average number of days in a month.
(b) **Months simulator to licence.** We computed the duration in days from the last simulator training to the date of acquiring the driver's licence (Q11). This duration was then converted to months by dividing the number of days by 30.4375.
(c) **Age of licensure.** Each respondent's age at the time they obtained their driver's licence was determined by subtracting the reported number of years they had been licensed from their current age (Q3), and adding 0.5 years. The addition of half a year is justified as participants reported their ages in whole numbers (e.g., 17, 18, 19), which inherently lacks precision. For instance, an individual reporting their age as 21 could nearly be 22. To improve the estimation of the age of licensure, we added half a year to this variable.
(d) **Age at last simulator session.** We first calculated the duration from the last recorded driving simulator activity to the date of questionnaire completion, transforming this period from days to years by dividing by 365.25. Next, this value was subtracted from the respondent's age at the time of completing the questionnaire (Q3), and then we added 0.5 years to estimate the age of the respondent at their final simulator session.
(e) **Violations and errors scores.** Using the responses to the Driver Behaviour Questionnaire (Q14), a violations score and an errors score were calculated. Firstly, 'I cannot remember' responses were excluded. The remaining scores were standardised per item so that the mean of the item is 0 and the standard deviation is 1. Subsequently, the violations score was calculated by taking the average across items a, b, e, and f, and the errors were calculated by taking the average across items d, g, and h. The violations and errors scores obtained were then again standardised.
(f) **Number of accidents per 1,000 km for the first 12 months of driving.** We computed the accident rate by dividing the reported number of accidents in the first 12 months of driving (Q13) by the reported mileage in the 12 months of driving in 1,000s of km (Q12). A problem with exposure variables such as this is that drivers who report a small number of kilometres might be identified as having an exceptionally high accident risk (Af Wåhlberg, 2011). For the sake of statistical robustness, we applied a cap of 1 accident per 1,000 km.

2.5. Exclusion of respondents

A total of 5,142 respondents commenced the questionnaire, with 3,761 (73.1 %) completing the full questionnaire. Only participants who completed the full questionnaire were retained.

Additionally, a total of 134 respondents were removed according to several exclusion criteria that indicate impossibilities or implausible responses. More specifically, we removed the following respondents:

- those who had obtained their driving licence before their 16th birthday or before turning 17 while indicating that they did not participate in the 2toDrive programme,
- a respondent who claimed to be 100 years old,
- a respondent who claimed to have driven 123,456 km per year,
- respondents who reported having obtained their driving licence at a later date than when they completed the questionnaire,
- respondents who took simulator lessons after obtaining their driving licence,
- respondents who only followed 0 to 3, or more than 200 hours of road driving lessons. The reason for this exclusion is to remove respondents with implausible data. While it is not illegal in the Netherlands to participate in the driving test without having taken

any or only a few driving lessons, we considered it highly unlikely in practice. Similarly, although it is possible for a student to have taken over 200 hours of on-road driving lessons, such outliers likely represent invalid entries with a certain probability,
- respondents who obtained their driving licence or completed their simulator training before January 1, 2008.[2]

The following analysis was conducted with the remaining 3,627 respondents. Based on Q2, 3,244 of these respondents identified themselves as simulator learner drivers; the remaining 383 respondents were traditional learner drivers (i.e., non-simulator drivers).

Regarding educational attainment (Q5), the option 'other' permitted participants to provide a response that did not conform to one of the eight predefined categories. These responses were manually coded into one of the eight categories in 29 out of 33 instances; four responses could not be classified and were designated as missing data.

An initial analysis of information-processing styles (Q6) showed that there were no statistically significant differences in the questionnaire results between the doers and deciders. Therefore, we grouped these responses into a single category labelled as 'doers/deciders'.

Accidents that required hospital intervention were not included in the analysis due to their rarity; only 0.4 % and 0.3 % of the respondents in the first and last 12-month intervals reported a hospitalisation accident. The infrequency of these cases rendered the statistical power inadequate for meaningful data analysis.

For variables related to the first 12 months after obtaining a driver's licence (Q12–15), responses were marked as missing values if the respondent had held their driver's licence for less than 12 months at the time of completing the questionnaire.

2.6. Analysis approach

In the analysis of the questionnaire results, various approaches can be taken. One is to examine correlation coefficients between responses or perform a regression analysis to assess the extent to which one variable can be predicted from other variables. A risk with these methods is that interpretation can be challenging, and that the correlations and regression coefficients may be difficult to translate into qualitative insight. We opted for an alternative way of analysing the results, which involves repeatedly dividing the sample into two groups and then comparing these two groups in terms of averages and effect sizes. Although such an approach is not the most statistically powerful in the case of continuous variables such as age (MacCallum et al., 2002), it is a way to achieve clear results (Iacobucci et al., 2015).

In this study, we repeatedly compared the following two groups:

- **Gender.** Men versus women (Q4).
- **Age of licensure.** Respondents who acquired their driver's licence at or before the age of 19 and those who did so later (Q11). For a more balanced comparison, only those respondents who did not participate in the 2toDrive programme (Q8) are included in this analysis.
- **Educational level.** Respondents with a higher education level (university or pre-university education) versus lower education level (primary education, practical education, pre-vocational secondary education [VMBO], secondary vocational education [MBO]) (Q5).
- **Fear.** Respondents who indicated a high fear score (4 or 5) versus respondents who indicated a low score (1 or 2) (Q16).
- **Information-processing style.** Respondents with a thinker versus respondents with a doer/decider information-processing style (Q6).
- **Licence obtained via 2toDrive.** Respondents who have completed the 2toDrive programme versus respondents who have not (Q8). Given that the 2toDrive programme is specifically designed to enable candidates to obtain their driving licences before the age of 18, it poses a challenge to create a controlled comparison with traditionally trained learners, as the age factor will inherently vary. To address this limitation, this analysis is solely focused on those learners who obtained their driving licences before the age of 21. A similar strategy was used by Van Schagen et al. (2015); they evaluated the 2toDrive programme by surveying individuals in a narrow age band, specifically between 18.5 and 20 years old.
- **Number of simulator lessons.** Respondents who had completed a high number of simulator lessons (15 or more) versus respondents who had completed a lower number (0 to 3). Only students with a record in the simulator database were used for this comparison; non-simulator drivers were excluded. Those with 0 simulator lessons may have taken an intake lesson but not actually completed a full lesson.
- **Simulator driving skill score.** Respondents who scored above the 75th percentile versus respondents who scored below the 25th percentile in driving skill in the simulator. This comparison was included to test whether the scores in the simulator were predictive of on-road driver training progression, post-licence behaviours, and accident rates.

In evaluating the magnitude of the difference between two groups, we use the common effect size measure Cohen's *d*. Cohen's

[2] Note that previous studies on driving behaviour recorded in the same type of driving simulators involved students who had their first lesson in the simulator between November 23, 2004 and August 2, 2005 (De Winter et al., 2007, $n = 519$; one student from September 2004 not considered here), between August 1, 2005 and March 6, 2006 (De Winter et al., 2009, $n = 804$) and between May 22, 2007 and March 12, 2009 (De Winter, 2013, $n = 321$). The current sample involves students with a last driving simulator activity between April 26, 2008 and August 10, 2015 ($n = 1,287$, for whom this time stamp was available).

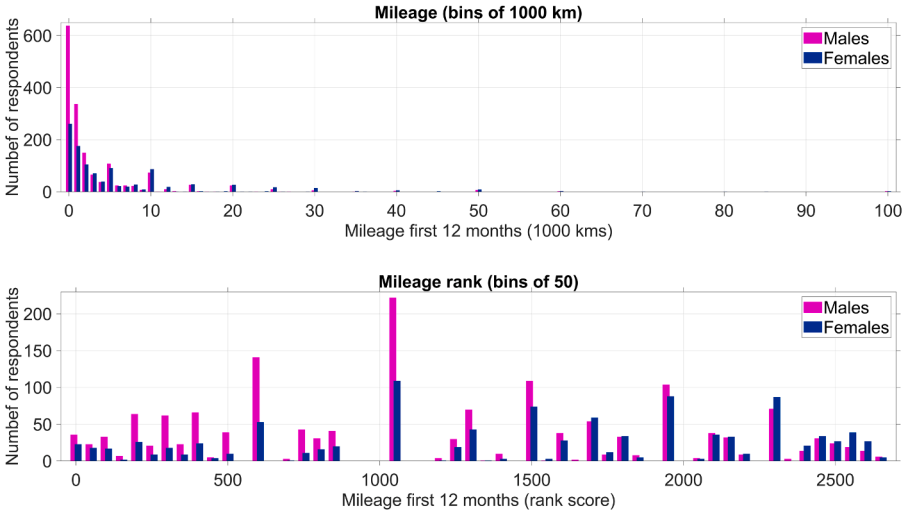

Fig. 2. Histogram of self-reported mileage (Q12) in the first 12 months for male and female respondents (top), and of the same mileage values transformed to ranks (bottom).

Table 1
Means, standard deviations, sample sizes, effect sizes, and *p*-values for males versus females. The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Gender	Males			Females				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's d_r	*p*
Q2. Simulator training (0: no, 1: yes)	0.88	0.33	1410	0.90	0.29	2217	-0.08	1.9E-02
Q3. Age questionnaire (years)	23.14	5.90	1410	23.20	6.24	2217	0.01	8.2E-01
Q4. Gender (0: female, 1: male)	1.00	0.00	1410	0.00	0.00	2217	—	—
Q5. Educational level (0: low, 1: med, 2: high)	1.10	0.77	1407	1.11	0.76	2216	-0.02	5.4E-01
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.70	0.46	1410	0.61	0.49	2217	0.20	**8.6E-09**
Q7. Licence (0: no, 1:yes)	0.89	0.31	1410	0.88	0.32	2217	0.04	2.5E-01
Age of licensure (years)	20.88	5.38	1258	20.83	5.20	1949	-0.05	1.6E-01
Months licensed	36.74	22.12	1258	33.86	21.08	1949	0.13	**4.8E-04**
Q8. Licence via 2toDrive (0: no, 1: yes)	0.17	0.38	1259	0.16	0.36	1951	0.04	2.2E-01
Q8a. 2toDrive frequency (1 to 6)	3.60	1.58	217	3.58	1.60	306	0.01	8.9E-01
Q9. On-road lessons (hours)	36.08	16.95	1258	43.26	22.56	1946	-0.43	**5.4E-32**
Q10. Number of driving test attempts	1.57	0.89	1258	1.66	0.98	1949	-0.08	2.9E-02
Q10. Passed 1st attempt (0: no, 1: yes)	0.62	0.49	1258	0.59	0.49	1949	0.06	7.9E-02
Q12. Mileage first 12 months (1000 kms)	6.73	12.94	1062	3.86	9.65	1598	0.42	**1.0E-25**
Q13. Number of accidents first 12 months	0.12	0.38	1060	0.11	0.34	1598	-0.01	7.2E-01
Q13/Q12. Accidents first 12 months (/1000 km)	0.05	0.19	1058	0.06	0.23	1592	-0.02	5.5E-01
Q15. Number of accidents last 12 months	0.10	0.33	1259	0.08	0.29	1951	0.04	2.2E-01
Q14. Violations (z-score)	0.28	1.26	1061	-0.13	0.78	1598	0.34	**6.7E-18**
Q14. Errors (z-score)	0.03	1.02	1059	0.01	0.98	1593	0.03	5.1E-01
Q16. Fear (1 to 5)	2.11	1.10	1260	2.91	1.23	1956	-0.68	**9.6E-76**
Months simulator to licence	8.16	8.58	480	9.38	9.79	807	-0.16	**4.8E-03**
Age last simulator lesson (years)	21.03	5.17	480	20.83	5.04	807	0.03	5.8E-01
Number of simulator lessons	9.22	7.37	708	10.21	7.30	1168	-0.14	**3.6E-03**
Simulator driving skill score (1 to 10)	5.87	1.51	600	5.75	1.50	1027	0.07	1.6E-01
Simulator safety score (1 to 10)	4.73	0.96	600	5.17	1.00	1027	-0.45	**3.5E-18**

d represents the difference between two means, normalised by the standard deviation. Typically, a *d* value of 0.20 is interpreted as a small effect size, 0.50 represents a medium effect size, and a value of 0.80 or higher is considered to represent a large effect size.

A disadvantage of Cohen's *d* is that it is less suitable for describing effect sizes when the underlying data is heavily skewed or contains outliers. This is illustrated by Fig. 2 (top), which shows the distribution of self-reported mileage (Q12) in the first 12 months for male (n = 1,598) and female (n = 1,062) respondents. The mean (*SD*) mileages of males and females are 6,732 km (12,945) and 3,861 km (9,646), resulting in a Cohen's *d* of 0.26, which suggests that the gender difference in mileage is fairly small. To make a more accurate estimate of the effect size, the data was transformed into ranks, where in the case of equal values (ties), the average rank was taken (Fig. 2, bottom). Inspired by earlier research on the *t*-test on ranks (Zimmerman & Zumbo, 1993), Cohen's *d* on ranks was determined, henceforth referred to as Cohen's d_r. In this case, the effect size is 0.42. The primary reason for the stronger effect after rank transformation is that all values are now constrained to a range from 1 to the number of respondents, which in turn limits the

Table 2
Means, standard deviations, sample sizes, effect sizes, and *p*-values for respondents who obtained their driving licence at a younger versus older age (Q3). The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Age	Younger			Older				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's d_r	*p*
Q2. Simulator training (0: no, 1: yes)	0.93	0.26	1262	0.83	0.37	1422	0.29	**1.4E-13**
Q3. Age questionnaire (years)	21.27	1.92	1262	26.29	6.70	1422	-1.19	**3.5E-179**
Q4. Gender (0: female, 1: male)	0.41	0.49	1262	0.37	0.48	1422	0.08	4.3E-02
Q5. Educational level (0: low, 1: med, 2: high)	1.09	0.75	1261	1.16	0.75	1420	-0.10	9.2E-03
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.68	0.47	1262	0.60	0.49	1422	0.17	**1.4E-05**
Q7. Licence (0: no, 1:yes)	1.00	0.00	1262	1.00	0.00	1422	—	—
Age of licensure (years)	18.32	0.43	1262	24.00	6.43	1422	-3.44	**0.0E+00**
Months licensed	41.34	21.81	1262	33.53	21.01	1422	0.36	**1.8E-20**
Q8. Licence via 2toDrive (0: no, 1: yes)	0.00	0.00	1262	0.00	0.00	1422	—	—
Q8a. 2toDrive frequency (1 to 6)	—	—	0	—	—	0	—	—
Q9. On-road lessons (hours)	36.44	14.57	1261	45.21	25.42	1421	-0.41	**7.5E-26**
Q10. Number of driving test attempts	1.50	0.81	1262	1.79	1.06	1422	-0.27	**2.2E-12**
Q10. Passed 1st attempt (0: no, 1: yes)	0.65	0.48	1262	0.53	0.50	1422	0.24	**9.8E-10**
Q12. Mileage first 12 months (1000 kms)	4.97	10.39	1114	5.24	12.30	1165	0.10	1.2E-02
Q13. Number of accidents first 12 months	0.12	0.36	1114	0.11	0.36	1163	0.03	5.0E-01
Q13/Q12. Accidents first 12 months (/1000 km)	0.06	0.22	1113	0.05	0.20	1157	0.03	5.1E-01
Q15. Number of accidents last 12 months	0.09	0.31	1261	0.09	0.31	1422	0.00	9.9E-01
Q14. Violations (z-score)	0.19	1.13	1115	-0.12	0.87	1162	0.34	**3.3E-16**
Q14. Errors (z-score)	0.06	1.01	1112	0.01	0.99	1159	0.06	1.6E-01
Q16. Fear (1 to 5)	2.37	1.17	1260	2.88	1.25	1422	-0.42	**1.4E-26**
Months simulator to licence	6.59	4.15	313	10.30	11.03	786	-0.27	**5.4E-05**
Age last simulator lesson (years)	18.13	0.36	313	22.66	5.70	786	-1.88	**6.4E-132**
Number of simulator lessons	9.01	7.46	481	9.80	7.40	1099	-0.11	4.5E-02
Simulator driving skill score (1 to 10)	5.96	1.59	398	5.74	1.44	947	0.16	7.5E-03
Simulator safety score (1 to 10)	5.02	1.02	398	5.05	1.00	947	-0.03	5.6E-01

Table 3
Means, standard deviations, sample sizes, effect sizes, and *p*-values for respondents with higher versus lower levels of education (Q5). The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Educational level	Higher			Lower				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's d_r	*p*
Q2. Simulator training (0: no, 1: yes)	0.88	0.32	1278	0.91	0.29	890	-0.09	3.1E-02
Q3. Age questionnaire (years)	23.41	6.04	1278	22.83	6.33	890	0.20	**5.1E-06**
Q4. Gender (0: female, 1: male)	0.39	0.49	1278	0.40	0.49	890	-0.03	4.5E-01
Q5. Educational level (0: low, 1: med, 2: high)	2.00	0.00	1278	0.00	0.00	890	—	—
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.50	0.50	1278	0.78	0.41	890	-0.61	**1.0E-42**
Q7. Licence (0: no, 1:yes)	0.89	0.31	1278	0.84	0.37	890	0.16	**2.6E-04**
Age of licensure (years)	21.07	5.16	1140	20.84	5.56	745	0.10	3.0E-02
Months licensed	35.25	21.97	1140	32.48	21.32	745	0.12	9.2E-03
Q8. Licence via 2toDrive (0: no, 1: yes)	0.16	0.37	1141	0.18	0.39	746	-0.06	2.2E-01
Q8a. 2toDrive frequency (1 to 6)	3.65	1.49	185	3.50	1.76	137	0.02	8.4E-01
Q9. On-road lessons (hours)	40.61	17.14	1140	40.80	24.02	743	0.13	6.2E-03
Q10. Number of driving test attempts	1.60	0.94	1140	1.68	0.97	745	-0.10	3.8E-02
Q10. Passed 1st attempt (0: no, 1: yes)	0.62	0.49	1140	0.57	0.50	745	0.11	2.1E-02
Q12. Mileage first 12 months (1000 kms)	3.16	5.58	945	8.01	15.04	592	-0.39	**2.3E-13**
Q13. Number of accidents first 12 months	0.10	0.34	944	0.18	0.42	591	-0.24	**7.9E-06**
Q13/Q12. Accidents first 12 months (/1000 km)	0.06	0.21	941	0.08	0.24	589	-0.22	**2.1E-05**
Q15. Number of accidents last 12 months	0.06	0.25	1141	0.13	0.36	747	-0.21	**6.3E-06**
Q14. Violations (z-score)	-0.17	0.82	944	0.21	1.25	592	-0.32	**1.2E-09**
Q14. Errors (z-score)	0.03	1.02	942	0.03	1.02	591	-0.01	8.4E-01
Q16. Fear (1 to 5)	2.78	1.22	1145	2.46	1.25	749	0.27	**1.9E-08**
Months simulator to licence	8.56	9.08	508	9.89	9.80	276	-0.23	**2.3E-03**
Age last simulator lesson (years)	21.42	5.37	508	20.66	5.49	276	0.29	**8.8E-05**
Number of simulator lessons	9.78	7.16	676	10.77	7.32	432	-0.16	8.7E-03
Simulator driving skill score (1 to 10)	5.72	1.45	584	5.80	1.45	386	-0.08	2.5E-01
Simulator safety score (1 to 10)	5.09	0.96	584	4.86	0.98	386	0.23	**4.1E-04**

standard deviation.

In our results, we display Cohen's d_r and the corresponding *p*-value as calculated on the rank-transformed data, an approach that corresponds with the Mann-Whitney-Wilcoxon test (Conover & Iman, 1981). A *p*-value smaller than 0.005 is considered statistically significant (Benjamin et al., 2018). We have chosen a more conservative *p*-value than the usual 0.05 because we are performing a large number of statistical tests.

Table 4
Means, standard deviations, sample sizes, effect sizes, and *p*-values for respondents with higher versus lower self-reported fear levels (Q16). The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Fear	Higher			Lower				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's *d* / *r*	*p*
Q2. Simulator training (0: no, 1: yes)	0.91	0.29	748	0.87	0.34	1529	0.13	**4.3E-03**
Q3. Age questionnaire (years)	24.86	6.78	748	22.64	5.00	1529	0.39	**2.5E-18**
Q4. Gender (0: female, 1: male)	0.19	0.39	748	0.53	0.50	1529	-0.74	**4.7E-58**
Q5. Educational level (0: low, 1: med, 2: high)	1.23	0.75	748	1.06	0.74	1527	0.24	**4.9E-08**
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.45	0.50	748	0.74	0.44	1529	-0.64	**3.0E-45**
Q7. Licence (0: no, 1:yes)	0.99	0.07	748	1.00	0.04	1529	-0.08	7.7E-02
Age of licensure (years)	22.50	6.40	743	20.10	4.66	1525	0.63	**1.1E-42**
Months licensed	33.69	20.68	743	36.33	21.78	1525	-0.12	8.0E-03
Q8. Licence via 2toDrive (0: no, 1: yes)	0.11	0.32	744	0.19	0.39	1526	-0.21	**3.2E-06**
Q8a. 2toDrive frequency (1 to 6)	2.89	1.62	84	3.78	1.57	289	-0.58	**4.1E-06**
Q9. On-road lessons (hours)	47.59	26.25	742	35.46	16.13	1523	0.71	**2.8E-53**
Q10. Number of driving test attempts	1.73	0.99	743	1.56	0.90	1525	0.19	**2.3E-05**
Q10. Passed 1st attempt (0: no, 1: yes)	0.55	0.50	743	0.63	0.48	1525	-0.16	**3.0E-04**
Q12. Mileage first 12 months (1000 kms)	2.88	5.58	613	6.48	12.63	1289	-0.58	**3.8E-31**
Q13. Number of accidents first 12 months	0.11	0.34	612	0.13	0.38	1288	-0.04	4.5E-01
Q13/Q12. Accidents first 12 months (/1000 km)	0.06	0.23	609	0.06	0.21	1286	-0.03	5.6E-01
Q15. Number of accidents last 12 months	0.08	0.30	744	0.10	0.32	1526	-0.06	1.9E-01
Q14. Violations (z-score)	-0.24	0.81	614	0.23	1.14	1288	-0.50	**7.8E-24**
Q14. Errors (z-score)	0.13	1.12	610	-0.07	0.93	1286	0.16	**8.1E-04**
Q16. Fear (1 to 5)	4.37	0.48	748	1.48	0.50	1529	3.45	**0.0E+00**
Months simulator to licence	9.99	9.50	374	8.32	9.27	525	0.29	**1.5E-05**
Age last simulator lesson (years)	22.33	6.07	374	19.96	4.28	525	0.57	**1.2E-16**
Number of simulator lessons	10.29	7.53	522	9.38	7.31	784	0.12	3.1E-02
Simulator driving skill score (1 to 10)	5.59	1.41	457	5.95	1.53	674	-0.25	**3.7E-05**
Simulator safety score (1 to 10)	5.13	0.97	457	4.89	1.01	674	0.25	**3.6E-05**

3. Results

3.1. Gender

The gender comparison shown in Table 1 indicates that males and females reported comparable age, licensure status, and age of licensure. However, noteworthy differences were found in on-road lessons, mileage during the first 12 months, and fear when starting their driver education: Males completed fewer on-road lessons but had higher mileage in the first 12 months and reported a lower fear level, with substantial effect sizes of −0.43, 0.42, and −0.68, respectively. For DBQ violations, males exhibited significantly higher scores, with a moderate effect size of 0.34. Males also took fewer simulator lessons than women (−0.16), and they had a substantially poorer safety score in the simulator than women (−0.45).

3.2. Age

According to Table 2, respondents who obtained their driving licence at a younger age were logically of a younger age at the time of administering the questionnaire and when completing the simulator training, and they also took less on-road training and fewer attempts to pass the on-road driving test.

Furthermore, they exhibited lower levels of fear of driving when starting their driver education (−0.42), took fewer simulator lessons (−0.27), and reported a higher frequency of traffic violations (0.34) compared to respondents who completed their simulator training at an older age. A younger age of licensure was also associated with an increased likelihood of simulator-based training (0.29).

3.3. Educational level

Table 3 shows the results for the differentiation between educational levels. Substantial effects are seen in information-processing style, violations, fear, number of accidents in the last 12 months, mileage in the first year of licensure, age at the final simulator lesson, and simulator safety score. Respondents with lower education levels tended to be more doer/decider-oriented (−0.61), have a higher number of self-reported violations (−0.32), and more accidents (−0.24, −0.21). The difference in accident rates can partially be explained by the fact that less educated individuals drove more (8,010 km compared to 3,160 km annually). The number of accidents in the first 12 months (Q13) was 83 % higher for respondents with lower educational levels compared to those with higher educational levels. However, when expressed per 1,000 km (Q13/Q12), the rate was 39 % higher.

Conversely, those with higher education levels reported higher fear levels (0.27), tended to be older at their last simulator lesson (0.29), and had better simulator safety scores (0.23). However, individuals with a higher level of education spent less time obtaining their driver's licence since their last simulator lesson (−0.23) and had a higher chance of holding a valid driver's licence at the time of completing the questionnaire (0.16).

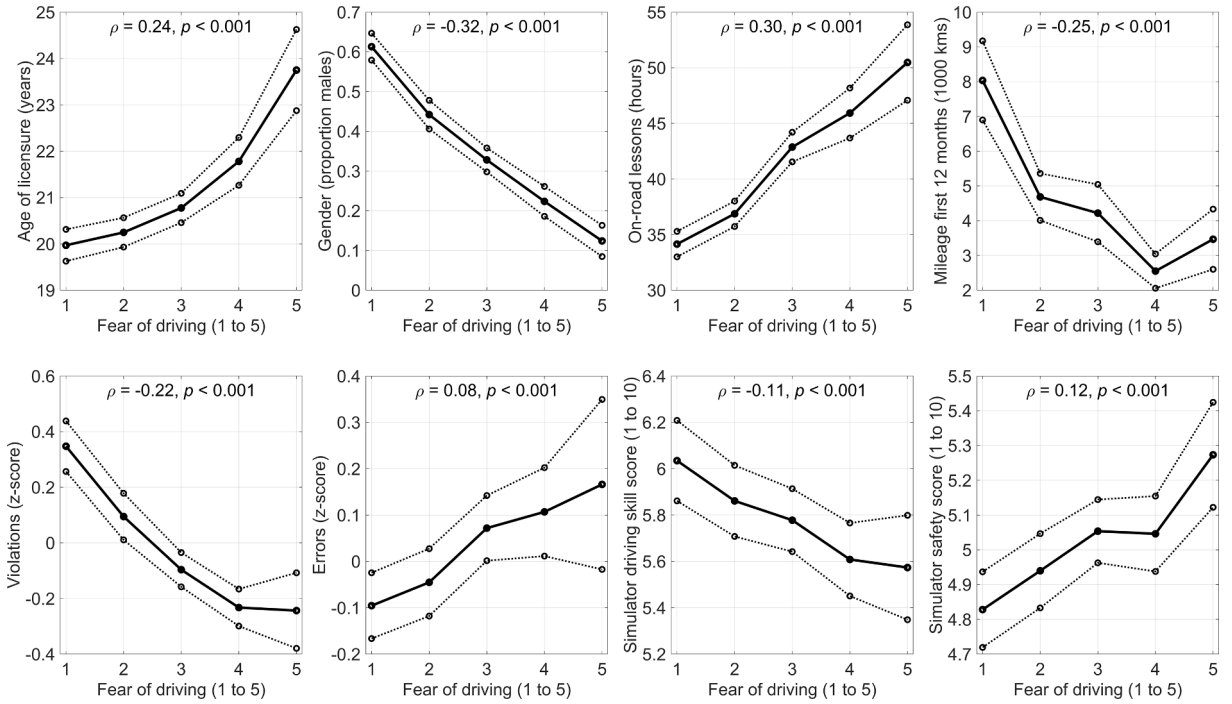

Fig. 3. Mean score and 95 % confidence intervals for eight selected dependent variables as a function of self-reported fear to drive a car when starting driving lessons (n = 796, 733, 939, 474, 274, for fear levels 1, 2, 3, 4, and 5, respectively). At the top of each figure, the Spearman rank-order correlation coefficient between the fear level and the variable is also displayed.

Table 5
Means, standard deviations, sample sizes, effect sizes, and *p*-values for respondents with a thinker information-processing style versus a doer/decider information-processing style (Q6). The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Information-processing style	Thinker			Doer/decider				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's *d* / *r*	*p*
Q2. Simulator training (0: no, 1: yes)	0.91	0.29	1280	0.89	0.32	2347	0.06	8.6E-02
Q3. Age questionnaire (years)	23.76	6.52	1280	22.86	5.86	2347	0.17	**1.0E-06**
Q4. Gender (0: female, 1: male)	0.33	0.47	1280	0.42	0.49	2347	-0.20	**8.6E-09**
Q5. Educational level (0: low, 1: med, 2: high)	1.35	0.73	1279	0.97	0.75	2344	0.51	**9.9E-48**
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.00	0.00	1280	1.00	0.00	2347	—	—
Q7. Licence (0: no, 1:yes)	0.91	0.28	1280	0.87	0.33	2347	0.12	**3.4E-04**
Age of licensure (years)	21.24	5.45	1164	20.63	5.16	2043	0.17	**5.5E-06**
Months licensed	34.59	21.49	1164	35.22	21.57	2043	-0.03	4.6E-01
Q8. Licence via 2toDrive (0: no, 1: yes)	0.16	0.37	1165	0.16	0.37	2045	0.00	9.1E-01
Q8a. 2toDrive frequency (1 to 6)	3.57	1.58	190	3.60	1.59	333	-0.02	8.2E-01
Q9. On-road lessons (hours)	42.42	21.33	1163	39.32	20.47	2041	0.23	**5.6E-10**
Q10. Number of driving test attempts	1.65	0.97	1164	1.61	0.93	2043	0.03	4.6E-01
Q10. Passed 1st attempt (0: no, 1: yes)	0.59	0.49	1164	0.60	0.49	2043	-0.02	6.6E-01
Q12. Mileage first 12 months (1000 kms)	3.75	7.96	958	5.71	12.57	1702	-0.24	**2.9E-09**
Q13. Number of accidents first 12 months	0.10	0.36	958	0.12	0.35	1700	-0.08	4.1E-02
Q13/Q12. Accidents first 12 months (/1000 km)	0.05	0.21	955	0.06	0.22	1695	-0.08	4.9E-02
Q15. Number of accidents last 12 months	0.06	0.27	1166	0.10	0.33	2044	-0.15	**4.9E-05**
Q14. Violations (z-score)	-0.21	0.78	958	0.16	1.11	1701	-0.41	**7.8E-24**
Q14. Errors (z-score)	0.06	0.98	954	-0.01	1.00	1698	0.07	7.1E-02
Q16. Fear (1 to 5)	3.00	1.26	1169	2.36	1.17	2047	0.52	**6.3E-45**
Months simulator to licence	8.89	9.55	536	8.95	9.24	751	-0.06	3.1E-01
Age last simulator lesson (years)	21.40	5.51	536	20.56	4.74	751	0.21	**1.6E-04**
Number of simulator lessons	10.05	7.48	735	9.69	7.25	1141	0.04	4.0E-01
Simulator driving skill score (1 to 10)	5.76	1.50	644	5.82	1.51	983	-0.03	5.1E-01
Simulator safety score (1 to 10)	5.20	1.01	644	4.88	0.99	983	0.32	**4.7E-10**

Table 6
Means, standard deviations, sample sizes, effect sizes, and *p*-values for respondents who partook in the 2toDrive programme versus those who did not (Q8). The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

2toDrive	Yes			No				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's *d* / *r*	*p*
Q2. Simulator training (0: no, 1: yes)	0.93	0.25	490	0.91	0.29	1911	0.08	1.2E-01
Q3. Age questionnaire (years)	19.21	1.57	490	21.55	1.90	1911	-1.29	**1.1E-126**
Q4. Gender (0: female, 1: male)	0.42	0.49	490	0.39	0.49	1911	0.05	2.8E-01
Q5. Educational level (0: low, 1: med, 2: high)	1.09	0.78	489	1.10	0.75	1910	-0.01	8.2E-01
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.65	0.48	490	0.67	0.47	1911	-0.03	5.6E-01
Q7. Licence (0: no, 1:yes)	1.00	0.00	490	1.00	0.00	1911	—	—
Age of licensure (years)	17.81	0.73	490	18.80	0.82	1911	-1.34	**3.6E-136**
Months licensed	22.90	15.34	490	39.02	21.66	1911	-0.80	**1.7E-53**
Q8. Licence via 2toDrive (0: no, 1: yes)	1.00	0.00	490	0.00	0.00	1911	—	—
Q8a. 2toDrive frequency (1 to 6)	3.74	1.50	490	—	—	0	—	—
Q9. On-road lessons (hours)	36.93	15.90	489	39.46	19.40	1910	-0.11	2.7E-02
Q10. Number of driving test attempts	1.47	0.81	490	1.61	0.94	1911	-0.17	**7.8E-04**
Q10. Passed 1st attempt (0: no, 1: yes)	0.68	0.47	490	0.60	0.49	1911	0.17	**1.1E-03**
Q12. Mileage first 12 months (1000 kms)	4.25	9.38	352	4.82	11.58	1658	-0.06	3.0E-01
Q13. Number of accidents first 12 months	0.10	0.32	352	0.11	0.36	1658	-0.02	8.0E-01
Q13/Q12. Accidents first 12 months (/1000 km)	0.07	0.24	351	0.06	0.22	1655	-0.01	9.0E-01
Q15. Number of accidents last 12 months	0.08	0.31	490	0.09	0.31	1910	-0.05	3.6E-01
Q14. Violations (z-score)	0.06	1.08	352	0.12	1.08	1656	-0.06	3.0E-01
Q14. Errors (z-score)	-0.09	0.94	351	0.06	1.02	1652	-0.14	1.7E-02
Q16. Fear (1 to 5)	2.28	1.14	489	2.48	1.20	1909	-0.17	**8.4E-04**
Months simulator to licence	6.79	4.89	172	8.33	6.27	675	-0.23	6.2E-03
Age last simulator lesson (years)	17.58	0.72	172	18.56	0.73	675	-1.44	**4.3E-55**
Number of simulator lessons	11.39	6.67	270	9.46	7.33	1008	0.30	**1.2E-05**
Simulator driving skill score (1 to 10)	5.75	1.57	261	5.92	1.53	860	-0.12	1.0E-01
Simulator safety score (1 to 10)	4.83	0.99	261	4.98	1.02	860	-0.12	9.6E-02

3.4. Fear of driving

Table 4 compares respondents with higher versus lower self-reported fear of driving when they began their driver education. The fear variable was found to have a strong discriminatory capacity. More specifically, respondents with higher fear levels tended to be older (0.39), more likely female (−0.74), and had a higher educational level (0.24). Furthermore, high-fear individuals were more oriented towards a thinker information-processing style (−0.64), were older when they got their licence (0.63), required more on-road lessons (0.71), and were older at their last simulator lesson (0.57).

Behaviourally, individuals with higher fear drove less in their first year of licensure (−0.58), reported fewer violations (−0.50), took more attempts to pass their driving test (0.19), and tended to use the 2toDrive programme less frequently (−0.21). Additionally, they had lower simulator driving skill scores (−0.25) yet higher simulator safety scores (0.25) and took a longer time after their simulator training to acquire their licence (0.29).

Table 4 provided a comparison between respondents who reported high (4 or 5) versus low (1 or 2) fear of driving a car at the commencement of driving training. As fear appeared to have a large distinguishing power on various variables, we further explored the effect of fear by considering the dose–response relationship. Specifically, we examined the effects of fear at levels 1, 2, 3, 4, and 5 separately, rather than just comparing levels 1&2 versus 4&5. The results of this analysis are depicted in Fig. 3, where the mean age, proportion of men, number of hours of instruction on the road, mileage in the first 12 months, self-reported violations and errors, and the objectively determined driving skill score and safe-driving score in the simulator are shown. A clear monotonic relationship can be seen between the level of fear and the variables. Noteworthy here is the convergent validity between the simulator and self-reporting, i.e., high fear is associated with more self-reported errors and lower driving skills in the simulators. Similarly, a high fear is associated with fewer self-reported violations and a higher safety score in the simulator.

3.5. Information-processing style

The results for information-processing styles, depicted in Table 5, show that thinkers were generally higher educated than doers/deciders (0.51) and were more likely to be female (−0.20); they were also more cautious, as demonstrated by a substantially lower DBQ violations score (−0.41), as well as fewer accidents (−0.08, −0.15) and lower mileage (−0.24). Thinkers also completed more on-road lessons than doers/deciders (0.23), and completed their simulator training and obtained their driver's licence at an older age (0.21 and 0.17, respectively). Finally, thinkers exhibited a higher fear to drive a car when starting their driver education (0.52) and drove more safely during simulator-based training than doers/deciders (0.32).

3.6. Accompanied driving (2toDrive programme)

We compared students who completed their driving education through the 2toDrive programme with those who did not (see

Table 7
Means, standard deviations, sample sizes, effect sizes, and *p*-values for respondents who completed many versus few lessons in the driving simulator. The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Number of simulator lessons	Many			Few				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's *d*	*p*
Q2. Simulator training (0: no, 1: yes)	1.00	0.00	485	1.00	0.00	464	—	—
Q3. Age questionnaire (years)	23.22	5.69	485	25.83	6.34	464	-0.71	**3.8E-26**
Q4. Gender (0: female, 1: male)	0.34	0.48	485	0.43	0.50	464	-0.18	**4.9E-03**
Q5. Educational level (0: low, 1: med, 2: high)	1.04	0.80	484	1.14	0.72	464	-0.12	6.8E-02
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.60	0.49	485	0.62	0.49	464	-0.04	5.5E-01
Q7. Licence (0: no, 1:yes)	1.00	0.00	485	1.00	0.00	464	—	—
Age of licensure (years)	21.34	5.56	485	22.28	6.01	464	-0.18	**4.5E-03**
Months licensed	28.63	17.20	485	48.68	23.54	464	-0.95	**7.8E-44**
Q8. Licence via 2toDrive (0: no, 1: yes)	0.22	0.41	485	0.08	0.28	464	0.38	**1.0E-08**
Q8a. 2toDrive frequency (1 to 6)	3.21	1.71	105	3.15	1.83	39	-0.01	9.7E-01
Q9. On-road lessons (hours)	44.48	26.92	484	39.75	21.10	463	0.20	**1.8E-03**
Q10. Number of driving test attempts	1.60	0.93	485	1.69	1.00	464	-0.08	2.0E-01
Q10. Passed 1st attempt (0: no, 1: yes)	0.61	0.49	485	0.57	0.50	464	0.08	2.4E-01
Q12. Mileage first 12 months (1000 kms)	4.17	10.15	382	4.85	10.53	410	-0.09	1.9E-01
Q13. Number of accidents first 12 months	0.12	0.37	382	0.11	0.38	410	0.02	7.4E-01
Q13/Q12. Accidents first 12 months (/1000 km)	0.06	0.23	380	0.06	0.21	410	0.03	7.1E-01
Q15. Number of accidents last 12 months	0.07	0.26	485	0.08	0.30	464	-0.05	4.8E-01
Q14. Violations (z-score)	-0.06	0.92	383	-0.01	0.94	409	-0.07	3.5E-01
Q14. Errors (z-score)	-0.02	1.00	382	-0.04	0.97	408	0.03	7.1E-01
Q16. Fear (1 to 5)	2.81	1.29	485	2.69	1.26	464	0.10	1.4E-01
Months simulator to licence	8.46	7.64	288	11.09	13.13	298	-0.15	6.8E-02
Age last simulator lesson (years)	20.87	5.23	288	21.03	5.66	298	0.03	7.2E-01
Number of simulator lessons	19.28	4.92	485	0.81	1.03	464	3.63	**3.5E-302**
Simulator driving skill score (1 to 10)	5.73	1.68	480	6.20	1.53	262	-0.28	**3.0E-04**
Simulator safety score (1 to 10)	4.97	0.94	480	5.38	1.24	262	-0.34	**1.5E-05**

Table 8
Means, standard deviations, sample sizes, effect sizes, and *p*-values for respondents with a high and low simulator driving skill score. The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Simulator driving skill score	Lower			Higher				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's *d*	*p*
Q2. Simulator training (0: no, 1: yes)	1.00	0.00	407	1.00	0.00	407	—	—
Q3. Age questionnaire (years)	23.09	4.63	407	23.79	5.92	407	-0.04	6.0E-01
Q4. Gender (0: female, 1: male)	0.41	0.49	407	0.35	0.48	407	0.12	8.3E-02
Q5. Educational level (0: low, 1: med, 2: high)	1.07	0.75	406	1.13	0.75	407	-0.07	3.3E-01
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.62	0.49	407	0.60	0.49	407	0.03	7.2E-01
Q7. Licence (0: no, 1:yes)	1.00	0.00	407	1.00	0.00	407	—	—
Age of licensure (years)	20.86	4.41	407	21.98	5.73	407	-0.18	1.1E-02
Months licensed	32.83	18.94	407	27.79	17.85	407	0.27	**1.2E-04**
Q8. Licence via 2toDrive (0: no, 1: yes)	0.16	0.37	406	0.18	0.39	407	-0.06	3.6E-01
Q8a. 2toDrive frequency (1 to 6)	3.71	1.65	66	3.29	1.67	75	0.29	9.3E-02
Q9. On-road lessons (hours)	40.82	22.69	406	43.83	26.71	406	-0.12	8.3E-02
Q10. Number of driving test attempts	1.57	0.96	407	1.81	1.11	407	-0.25	**4.6E-04**
Q10. Passed 1st attempt (0: no, 1: yes)	0.64	0.48	407	0.53	0.50	407	0.22	**1.7E-03**
Q12. Mileage first 12 months (1000 kms)	4.48	9.95	329	4.02	8.09	314	0.17	3.5E-02
Q13. Number of accidents first 12 months	0.12	0.37	329	0.10	0.33	314	0.03	7.3E-01
Q13/Q12. Accidents first 12 months (/1000 km)	0.06	0.23	329	0.05	0.20	313	0.03	7.2E-01
Q15. Number of accidents last 12 months	0.10	0.33	407	0.10	0.31	407	-0.02	8.3E-01
Q14. Violations (z-score)	0.00	0.94	329	-0.07	0.95	313	0.13	8.9E-02
Q14. Errors (z-score)	-0.01	0.98	328	0.02	0.99	311	-0.02	7.8E-01
Q16. Fear (1 to 5)	2.53	1.25	407	2.88	1.27	407	-0.29	**4.9E-05**
Months simulator to licence	9.32	9.73	263	7.86	7.27	297	0.13	1.3E-01
Age last simulator lesson (years)	20.11	4.35	263	21.78	5.94	297	-0.32	**2.0E-04**
Number of simulator lessons	10.53	7.74	407	11.60	6.79	407	-0.16	2.6E-02
Simulator driving skill score (1 to 10)	7.73	0.70	407	3.90	0.76	407	3.46	**1.2E-246**
Simulator safety score (1 to 10)	5.33	0.88	407	4.71	1.22	407	0.60	**4.7E-17**

Table 6). Only those who received their driving licence before the age of 21 were included.

Note that the 2toDrive programme allows students to start taking driving lessons at 16.5 years old, attempt the driving test at 17, and then, if successful, drive under the supervision of an experienced adult until they turn 18. This scheme explains why participants of this programme tend to begin simulator lessons at a younger age, acquire their driving licence earlier, and are generally younger when filling out our questionnaire (see Table 6). It is important to note, however, that while the 2toDrive programme provides this opportunity, not all students may choose to take this path.

Our results further reveal that 2toDrive participants had a higher success rate in obtaining their licence than non-2toDrive students (68 % vs 60 %). Additionally, these students reported lower levels of fear while driving (-0.17) compared to their counterparts who took traditional driving lessons.

3.7. Number of completed lessons in the driving simulator

A distinction was made between students who had a record in the simulator but completed only a few lessons (0, 1, 2, or 3) versus those who completed a high number of lessons (15 or more, with 15 lessons representing the default program).

These results, shown in Table 7, revealed several interesting patterns: students who completed a higher number of simulator lessons followed more hours of on-road lessons subsequently, compared to students who took fewer simulator lessons (44.48 vs. 39.75; effect size: 0.20). The former were also more likely to participate in the 2toDrive programme (22 % vs. 8 %, effect size: 0.38) and obtained their driver's licence at a younger age. Interpreting these findings is challenging, but it may suggest that students who completed a higher number of simulator lessons followed a more intensive, condensed training programme aimed at obtaining their driving licence more rapidly. No significant differences were found regarding self-reported errors and violations.

For the sake of completeness, Appendix A reports a comparison between students who had trained in the simulator and those who had not. From these results, it is clear that students who trained in the simulator tended to be younger; there are only a few other statistically significant differences. These findings should be interpreted with caution as these two groups were recruited separately.

3.8. Predictive value of simulator scores

In addition to comparing students who completed many versus few simulator lessons, it is also relevant to investigate whether scores in the simulator have predictive value. To this end, we have created two groups: one group with a simulator driving skill score higher than the 75th percentile of all students, and a second group with a score lower than the 25th percentile. This division, shown in Table 8, clarifies that students who scored better in the simulator were generally younger while training in the simulator (−0.32) and when obtaining their driving licence (−0.18), reported less fear (−0.29), and had a higher chance of passing the driving test on the first attempt (64 % vs. 53 %; effect size: 0.22). They also had held a driving licence for a longer time at the point of administering the questionnaire (0.27).

4. Discussion

This study aimed to investigate gender and age differences in driving education and explore the relationships between fear of driving and driving behaviour. The study also examined how self-reported information-processing styles may affect driving education outcomes, examining the differences between 'thinkers' and 'doers/deciders'. Finally, this research aimed to evaluate the effectiveness of driving education innovations, such as the Dutch accompanied driving programme, 2toDrive, and the use of simulators in driver training to understand their impact on driving test outcomes, driving behaviour, and accident rates.

Previous studies have examined objective variables such as the correlations between scores recorded in the simulator and scores on driving tests (De Winter et al., 2009) as well as accident records (Allen et al., 2012). Previous research has also used scores recorded in the simulator and self-reported variables (De Winter, 2013). In the current study, conducted with a new and large cohort of students, a more complete picture has been obtained of the complex relationship between performance in the simulator, performance on the driving test, as well as involvement in accidents and errors and violations after obtaining the driving licence, in relation to gender, age, educational level, and information-processing style.

4.1. Age and gender

This study reinforces results from earlier studies which showed that males drive less safely during simulator-based training and on the road and pass their driving test sooner after simulator-based training (De Winter et al., 2009). Our study also found that males need fewer hours of on-road training (36 h) than females (43 h), echoing findings from earlier cohort studies (e.g., Feenstra & Vissers, 2002; Forsyth, 1992; Vlakveld, 2006). Although males, on average, require fewer driving lessons than females, their reduced safety scores in the simulator and higher self-reported violations suggest they are not safer drivers.

One plausible explanation for the observed gender differences could be the lower levels of driving fear among males. A single questionnaire item measuring fear of driving exhibited a large explanatory power in our research. Respondents who indicated being more fearful when starting their driver education participated in simulator training at an older age, were more often female, and took more on-road driving lessons. Furthermore, people who indicated being more fearful when starting their driver education were more likely to have opted for simulator-based training and continued to avoid driving even after obtaining their licence; they tended to avoid risks and commit fewer traffic violations; however, they made more errors, both on the roads (self-reported) and in the simulator (lower skill score; automatically recorded). This latter finding is consistent with findings from an on-road driving assessment of fearful drivers versus a control group (Taylor et al., 2007b).

The present fear-related results align with various theories in traffic psychology, such as the risk homeostasis theory (Melman et al., 2022; Wilde, 2013) and the task-difficulty homeostasis theory (Fuller, 2005). In these theories, emotions such as perceived risk (fear) or perceived task difficulty, exert a regulatory influence on driving speed and decision-making. Fear as an emotion can potentially function as an intrinsic motivator for careful driving (Schmidt-Daffy, 2013) or for avoiding driving altogether (Gwyther & Holland,

2012). Applying this theory to our study, males, due to their diminished levels of fear, might engage more frequently in riskier driving behaviours. This concern mirrors our findings related to age: learners who obtained their driver's licence at a younger age reported less fear of driving as well as more violations, suggesting that those most eager to get their licence quickly may also be the ones less fearful of driving. The emotion of fear may also play a role in classical conditioning, a learning process that may eventually lead to the extinction of these emotions. Conversely, by driving less and avoiding situations, people with greater driving fear also gain less experience in challenging situations. In summary, fear seems to serve as a vital mediating variable in driver education and beyond.

Our study, which measured fear in a broad cohort and which showed clear monotonic trends with various criterion variables (Fig. 3), broadens the discussion in the literature about fear and driving, which has been mostly centred on driving phobia resulting from traumatic traffic accidents (Kuch et al., 1994; Mayou et al., 1993), cognitive-behavioural therapy to mitigate driving phobia (Elphinston et al., 2023; Fischer et al., 2021; Townend & Grant, 2006), the association between fear of driving and anxiety disorders (Ehlers et al., 1994; Taylor et al., 2007a), and fear stemming from the formal nature of driving tests (Fairclough et al., 2006).

4.2. Information-processing style and educational level

Our study revealed substantial differences in outcomes between thinkers and doers/deciders. Specifically, thinkers were typically more highly educated, started their driving lessons later in life, and exhibited more conservative driving behaviours: they reported fewer violations and accidents on the road, reported a higher fear of driving, and had completed more on-road training compared to doers/deciders. Based on these findings, we decided that the term 'information-processing style' might be more appropriate than 'learning style'. The term information-processing style is more generic, and encapsulates whether one tends to reflect on or think about choices, or whether one acts more impulsively.

Despite academic criticism (Kirschner, 2017; Riener & Willingham, 2010), the concept of learning styles remains popular in practice (Cuevas, 2015; Newton & Salvi, 2020), including driving simulator training (Sætren et al., 2021). Note that the present questionnaire did not test whether respondents *learn* in a different manner. This may require an experiment to test the 'meshing hypothesis' (Pashler et al., 2008; Rogowsky et al., 2020), i.e., whether thinkers and doers would benefit differently from specific types of training delivery in the simulator or on the road. Nevertheless, it might be beneficial for driving instructors to consider their students' information-processing styles, as doers indeed appear to 'do' more in terms of faster licence acquisition and more driving post-licensure, while respondents who categorised themselves as 'thinkers', as implied by the term itself, tend to exhibit higher levels of education and a more cautious disposition. The distinction between thinkers and doers/deciders thus provides valuable insight, though it does not inherently relate to a style of learning.

The pattern for education level seems similar to that of information-processing style, in the sense that people with a higher level of education tend to be more often of a 'thinker' type. Respondents with a higher education level were also more anxious, drove more safely in the simulator, committed fewer self-reported errors and violations on the road, and drove less on the road overall. An overarching pattern identifiable here is the apparent convergence between 'thinkers' and being more reflective and analytical prior to taking action. Earlier research into personality, 'learning styles', and average grades (GPA) among students paints a similar picture, wherein positive correlations were found between the personality trait of conscientiousness, more synthetic, elaborative, and methodological learning styles, and GPA (Komarraju et al., 2011). An adjacent explanation could be that respondents with higher levels of education might still be in the course of their studies, hence more prone to using public transportation.

4.3. Accompanied driving

As mentioned in the introduction, innovations in driver education often lack sufficient evaluation. This is similarly the case with 2toDrive, the accompanied driving programme introduced in the Netherlands at the end of 2011. Currently, the only available evaluation study was conducted by Van Schagen et al. (2015), who distributed a questionnaire to all licenced drivers in the Netherlands aged 18.5–20. However, the analysis of the results did not provide clear-cut conclusions. The primary reason was that 2toDrive students were younger and had obtained their licence earlier (in line with the programme's objectives). Consequently, 2toDrive students had more cumulative driving experience, which could explain why they were involved in slightly more accidents than regular students.

Our study faces similar issues in evaluating 2toDrive; 2toDrive students were younger than other students when taking simulator lessons, obtaining their licence, and completing the questionnaire. However, we did collect some additional evidence that 2toDrive students had a higher pass rate for the driving test and that they also took more simulator lessons than regular students. These findings are consistent with the notion that 2toDrive students are keen to obtain their driving licence at an early age.

4.4. Driving simulators

The same pattern can be seen in the analysis of students who only took a few simulator lessons versus students who took many simulator lessons. Here, there were no statistically significant differences in the driving-related variables, such as the number of accidents, between the groups that did or did not make (much) use of the simulator. However, the simulator seems to be relatively popular among younger students and is often used in combination with 2toDrive, especially for students who tend to be fearful of driving in a real vehicle.

Usage of the simulator was found to have predictive value: Students who took more lessons in the simulator also took more on-road lessons than students who completed only a few lessons in the simulator. Moreover, it was found that a low driving skill score in the

simulator was predictive of success rate on the on-road driving test, which is consistent with previous research for the same simulator (De Winter et al., 2009). That study was based on an earlier cohort of simulator trainees, and used linear regression analysis instead of the group-wise comparisons used in the present study. The capability to predict the results of an on-road driving test using simulator scores is impressive, particularly because the outcome is known to be hard to predict. One of the reasons is that the outcome of the driving test is subject to factors beyond the control of the candidate such as the actions of other drivers and the level of traffic at the time of the test (Baughan et al., 2005).

4.5. Limitations

One of the limitations of our research is that the study was conducted on a select number of students. In total, 22,881 individuals were contacted, of which 3,627 completed the questionnaire in full and without obvious mistakes. Assuming that a portion of the email addresses were no longer valid (in previous research, this was 13 % of the emailed candidates; De Winter, 2013), the response rate would be 18 %. This is more than in previous comparable research on the predictive value of the driving simulator (13 %; De Winter, 2013) but less than in previous questionnaire research on the 2toDrive programme (32 %; Van Schagen et al., 2015).

The average number of on-road driving lesson hours was 36.1 versus 43.3 for men and women, which roughly corresponds with previous cohort studies in the Netherlands (Vlakveld, 2006: 38.0 vs. 46.4 h; Hazevoet & Vissers, 2005: 41.4 h vs. 47.6 h). Furthermore, in our study, 10 % of the 2toDrive participants indicated they were involved in an accident in the first 12 months after obtaining their driving licence, which also aligns with the 9 % reported in Van Schagen et al. (2015). However, other characteristics of our respondent pool do not correspond to national averages. In our research, 61 % of our sample was female, while previous research shows that the percentage of women among simulator students is 55 % (De Winter et al., 2009). Furthermore, 35 % indicated they were highly educated (VWO or University), which is higher than the national average and previous research (CBS, 2015). In summary, while certain outcomes align with other studies and national averages, our study is not representative of the average Dutch person, particularly in terms of educational level.

In addition to this limitation, it must be considered that there is self-selection in the 2toDrive programme and the simulator training. For example, it is possible that participants in the 2toDrive programme or persons attracted to following a large number of simulator lessons already had a different attitude beforehand; the effects we demonstrate, therefore, do not necessarily have to be the result of the simulator or accompanied driving, but could just as well involve reversed causality. The simulator, for instance, might particularly attract candidates who need some extra practice before getting behind the wheel of a real car.

A statistical limitation in the present study lies in the methodology of calculating scores of driving skills and safety in the simulators. These scores were generated by the driving simulator software, which averaged the results across a variety of tasks. This contrasts with our previous research, where we used factor analysis to extract common variance from scores (De Winter et al., 2009; De Winter, 2013). This analytical method may explain why the simulator scores in the earlier studies were more discriminatory, for example, with respect to gender.

5. Conclusions and recommendations

In conclusion, the current study has improved our understanding of various factors influencing driving education outcomes, including age, gender, information-processing styles, fear, and the use of innovative approaches such as the Dutch accompanied driving programme, 2toDrive, and simulator-based training.

The findings reinforce established gender differences in driving education, with males typically requiring fewer on-road training hours but also exhibiting a riskier driving style, possibly due to lower levels of driving fear. Age was found to impact driving behaviour, with younger drivers reporting less fear and committing more violations, potentially linked to their perceived risk. The consideration of information-processing styles might be beneficial in driving education as it could explain certain behaviours and outcomes among learner drivers. More specifically, we observed distinct differences between ‘thinkers’ and ‘doers/deciders’ in relation to their educational level, age of starting driving lessons, driving behaviour, and amount of on-road training.

Our research suggests that fear may play a critical role in driving behaviour and education. While traditionally associated with phobia or anxiety disorders, our research suggests that fear of driving may serve as a vital mediating variable in driving education, associated with the choice of training method, number of lessons, and driving behaviour post-licensure.

In prior research, we found that learner drivers who executed tasks more rapidly tended to make fewer errors in terms of vehicular control (De Winter et al., 2009). This finding, observed at the between-subjects level, appears to be at odds with the speed-accuracy trade-off principle that operates within subjects, and which says that faster driving will induce more errors. This apparent contradiction can be reconciled by considering that between-subjects, speed may reflect lower fear and greater confidence with the task at hand, as opposed to hasty actions typically associated with error-prone behaviour within the speed-accuracy trade-off framework. Simultaneously, error-making is an integral component of learning to drive (e.g., Groeger & Clegg, 2007; Ivancic & Hesketh, 2000). There is potential merit in exploring the correlation between perceived fear, speed selection, and errors, both between-subjects and within-subjects, in relation to the efficacy of driver training. Such research could yield insights into the optimal speeds for executing tasks within a driving simulator and on the road. Moreover, it could lead to a reconsideration of the commonly held belief that smooth driving is invariably synonymous with competent driving.

Driver education innovations of the last decades, such as accompanied driving (2toDrive) and driving simulators, could potentially improve driving test outcomes and affect driving behaviour, although more evaluation is needed to establish their effectiveness. Simulator-trained drivers who scored high on driving skill typically passed their exams with fewer attempts. This finding aligns with

Table A1
Means, standard deviations, sample sizes, effect sizes, and p-values for respondents who were involved in simulator-based driver training versus those who were not (Q2). The coloured bar exhibits a linear scale from −0.5 to 0.5, with negative values in orange and positive values in green.

Simulator training	Yes			No				
	Mean	*SD*	*n*	Mean	*SD*	*n*	Cohen's *d* / *r*	*p*
Q2. Simulator training (0: no, 1: yes)	1.00	0.00	2839	0.00	0.00	368	—	—
Q3. Age questionnaire (years)	23.01	5.37	2839	25.27	6.57	368	-0.44	**2.1E-15**
Q4. Gender (0: female, 1: male)	0.39	0.49	2839	0.45	0.50	368	-0.12	2.6E-02
Q5. Educational level (0: low, 1: med, 2: high)	1.11	0.76	2835	1.21	0.74	368	-0.13	2.1E-02
Q6. Inf-proc. style (0: thinker, 1: doer/decider)	0.63	0.48	2839	0.68	0.47	368	-0.11	5.6E-02
Q7. Licence (0: no, 1:yes)	1.00	0.00	2839	1.00	0.00	368	—	—
Age of licensure (years)	20.58	5.00	2839	22.98	6.68	368	-0.51	**8.1E-20**
Months licensed	35.19	22.06	2839	33.45	16.86	368	0.04	4.2E-01
Q8. Licence via 2toDrive (0: no, 1: yes)	0.17	0.38	2838	0.10	0.30	368	0.19	**5.8E-04**
Q8a. 2toDrive frequency (1 to 6)	3.61	1.58	486	3.30	1.63	37	0.21	2.2E-01
Q9. On-road lessons (hours)	40.55	20.86	2836	39.60	20.61	368	0.09	1.2E-01
Q10. Number of driving test attempts	1.62	0.95	2839	1.67	0.91	368	-0.09	9.8E-02
Q10. Passed 1st attempt (0: no, 1: yes)	0.60	0.49	2839	0.56	0.50	368	0.09	1.1E-01
Q12. Mileage first 12 months (1000 kms)	4.77	10.76	2324	6.51	13.41	333	-0.24	**5.8E-05**
Q13. Number of accidents first 12 months	0.11	0.35	2322	0.13	0.37	333	-0.04	4.5E-01
Q13/Q12. Accidents first 12 months (/1000 km)	0.06	0.22	2315	0.05	0.21	332	-0.04	5.2E-01
Q15. Number of accidents last 12 months	0.09	0.31	2838	0.09	0.32	368	-0.02	6.7E-01
Q14. Violations (z-score)	0.03	1.03	2322	0.00	0.98	333	0.02	7.0E-01
Q14. Errors (z-score)	0.02	1.00	2315	-0.05	0.92	333	0.04	4.6E-01
Q16. Fear (1 to 5)	2.61	1.24	2836	2.42	1.22	368	0.16	**3.8E-03**
Months simulator to licence	8.93	9.37	1287	—	—	0	—	—
Age last simulator lesson (years)	20.91	5.09	1287	—	—	0	—	—
Number of simulator lessons	9.83	7.34	1876	—	—	0	—	—
Simulator driving skill score (1 to 10)	5.80	1.50	1627	—	—	0	—	—
Simulator safety score (1 to 10)	5.01	1.01	1627	—	—	0	—	—

earlier research that showed that simulators could help detect deviant driving styles early in the training process, before on-road driving begins (De Winter, 2013).

Our study had a number of limitations, such as self-selection bias in the 2toDrive programme and simulator training, and the overrepresentation of females and higher-educated individuals in the study sample. Moreover, our work remains cross-sectional, and a randomised controlled trial, as in the classical DeKalb study (Lund et al., 1986; Stock et al., 1983), is still lacking and exceedingly difficult nowadays due to strong regulations and ethical considerations. Consequently, our research could uncover no evidence indicating that either accompanied driving or simulator-based driver training enhances driving safety following the acquisition of a licence. Despite the potential benefits of simulator training, more research is needed to understand its potential to reduce road accidents.

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

The data that has been used is confidential.

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Appendix A:. Analysis of simulator students vs. non-simulator students

Table A1 shows differences between respondents who indicated that they had versus those who had not trained in the simulator, only including respondents who had obtained their driver's licence. The results reveal only a small number of statistically significant differences. It is apparent, however, that simulator students obtained their driver's licence at a younger age than non-simulator students, and more frequently obtained their licence via the 2toDrive programme (17 % vs. 10 %, effect size: 0.19). Furthermore, simulator students tended to be more fearful compared to the reference group of non-simulator students (0.16).

The comparison between simulator and non-simulator students should be interpreted with caution, as non-simulator students were recruited separately. Specifically, simulator students were invited based on their email addresses in a database, while non-simulator

students were recruited on average about one month later (see Methods section).

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2023.10.003.

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