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A study at the level of drivers and districts

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Short communication

Correlates of self-reported driving aberrations in Tehran: A study at the level of drivers and districts

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ABSTRACT

There are relatively few comprehensive studies on driving errors and violations in Iran, a non-Western country with a high traffic fatality rate. In this study, 712 drivers completed a questionnaire at technical inspection centres and carwashes in Tehran, Iran. Respondents were asked about their demographic characteristics, accident involvement, traffic fines, and driving aberrations in the form of the Driver Behaviour Questionnaire (DBQ). The results of a principal component analysis of the DBQ showed a distinction between errors and two types of violations: speeding and non-speeding violations. Correlation analyses showed that DBQ violations were associated with a higher driving mileage, a higher education level (for DBQ speeding violations in particular), and younger age. DBQ errors were associated with risk perception, that is, the belief that one has a high probability of becoming involved in a car accident. Regression analyses showed that the DBQ speeding violations score was predictive of the number of speeding tickets and that the DBQ non-speeding violations score was predictive of involvement in minor accidents in the past three years. A correlation analysis at the level of municipal districts showed that drivers from districts with lower education and literacy levels and lower car ownership were more likely to report driving a low-cost car and had lower DBQ violations scores. These results can be interpreted as indicating that affluence enables deviant driving. We conclude that the error-violation distinction is of relevance to road safety in Tehran, both at the level of individual drivers and at the level of districts.

1. Introduction

According to a report of the World Health Organization (WHO, 2015), Iran has the eighth highest traffic fatality rate in the world. Despite gradual improvements in the last decade, the number of fatal accidents in Iran remains substantial. The latest report of the Iranian Legal Medicine Organization (ILMO, 2018) states that, during a one-year period from March 21, 2017 to March 21, 2018, about 16,200 out of the 80 million inhabitants of Iran lost their lives in road accidents. Iran is a country with a majority Muslim population and an Islamic government; Iran is not characterized by liberalism, but by high levels of fatalism among its population (Şimşekoğlu et al., 2013). Because of the high number of traffic fatalities in Iran, research is needed into the behavioural determinants of accidents in this country.

It is widely held that aberrant driving behaviours can be classified into errors and violations (e.g., Lajunen, Parker, & Summala, 2004; Reason, Manstead, Stradling, Baxter, & Campbell, 1990). Errors can be defined as actions that fail to attain

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their intended outcome. Violations, on the other hand, are defined as intentional deviations from safe driving practices. According to Lawton, Parker, Manstead, and Stradling (1997), violations can be divided into aggressive violations, which include an interpersonally aggressive component, and ordinary violations, such as speeding. While errors arise from poor driving skills and information-processing limitations, violations arise from motivational sources and personal predispositions (Elander, West, & French, 1993; Reason et al., 1990).

Errors and violations are the two main factors of the widely used Driver Behaviour Questionnaire (DBQ), a questionnaire in which drivers are asked how often they make specific aberrations in traffic (De Winter, Dodou, & Stanton, 2015; Reason et al., 1990). DBQ violations scores are positively correlated with self-reported accident involvement (De Winter et al., 2018; Gras et al., 2006; Kontogiannis, Kossiavelou, & Marmaras, 2002; Özkan, Lajunen, Chliaoutakis, Parker, & Summala, 2006), a finding which is consistent with road safety statistics showing that drivers who make more violations are more likely to be involved in accidents (e.g., Cooper, 1997; Factor, 2014) and with the fact that many accidents, especially those involving young drivers, are due to recklessness and speeding (Clarke, Ward, & Truman, 2005). DBQ errors, on the other hand, exhibit a somewhat weaker, or even non-significant, correlation with accident involvement (De Winter et al., 2018; Özkan & Lajunen, 2005; Parker, West, Stradling, & Manstead, 1995; Warner, Özkan, Lajunen, & Tzamalouka, 2011), perhaps because drivers are not well able to memorize their own errors. Based on a meta-analysis, De Winter et al. (2015) concluded that: "When judging the totality of evidence in this article, it appears that DBQ errors correlate less strongly with accidents than DBQ violations" (p. 1759).

Questionnaire research using the DBQ has shown that the error-violation distinction also exists in Iran (Alavi et al., 2016; Bazzaz, Zarifian, Emadzadeh, & Vakili, 2015; Hezaveh, Nordfjærn, Mamdoohi, & Nordfjærn, 2017; Kalhori, Foroughinia, & Ziapour, 2017; Mamdoohi, Hazaveh, & Zavareh, 2014; Moghaddam, Tabibi, Sadeghi, Ayati, & Ravandi, 2017; Nordfjærn, Hezaveh, & Mamdoohi, 2015; Özkan et al., 2006; Tabibi, 2011; Tavakoli Kashani, Sokouni Ravasani, & Ayazi, 2016; Varmazyar, Mortazavi, Arghami, & Hajizadeh, 2014) and nearby countries such as Qatar (Bener et al., 2013). These DBQ studies have confirmed several well-known findings that have also been identified in Western countries, such as the fact that older drivers commit fewer violations than younger drivers (Bazzaz et al., 2015; Tavakoli Kashani et al., 2016) and that violations are predictive of accidents (Hezaveh et al., 2017; Moghaddam et al., 2017; Özkan et al., 2006). Even though a fair number of DBQ studies from Iran are available, knowledge about the association between driving behaviour and road safety in Iran is still scarce.

Studies have shown that in addition to errors, violations, and demographic variables (e.g., gender, age, driving experience), the driver's education level is a predictor of road traffic accidents (Whitley et al., 2010). An important safety issue in Iran is the overall low quality of cars (Saberi, 2017). More highly educated drivers may drive in safer environments and in safer cars, which in turn may cause risk compensation behaviours: According to risk compensation theories, a driver compares the perceived level of risk with his or her target risk level (Wilde, 1982). If a driver's perceived risk level is lower than his/her target risk level, then the driver is likely to drive in a more risky manner to reduce the difference between the two levels (Zavareh, Mamdoohi, & Nordfjærn, 2017). A more specific, yet critical factor associated with unsafe driving behaviour is driver sleepiness (Maycock, 1997; Radun, Radun, Wahde, Watling, & Kecklund, 2015; Sadeghniiat-Haghighi, Yazdi, Moradinia, Aminian, & Esmaili, 2015). Although sleepiness is known to be a frequent contributor to accidents, its relationship with self-reported errors and violations is less clear. That is, it would be interesting to examine whether drivers with poor sleep quality are involved in a high number of errors (perhaps because sleep evokes lapses in attention) or a high number of violations (perhaps because sleep deprivation weakens the inhibition of aggression; Kahn-Greene, Lipizzi, Conrad, Kamimori, & Killgore, 2006; Kamphuis, Meerlo, Koolhaas, & Lancel, 2012).

Large regional socioeconomic differences exist in Iran (Asadi-Lari & Vaez-Mahdavi, 2008), which in turn may correlate with driving behaviour and accident risk. In addition to studying driver behaviour at the level of individual drivers, this paper examines the correlates of self-reported driving aberrations at the level of city districts. This district-level analysis addresses a knowledge gap in transport planning research, which traditionally relies on regional characteristics, such as socioeconomic, road network, and land use variables (Lovegrove & Sayed, 2006; Naderan & Shahi, 2010; Wegman, 2004). Previous studies have found that there exist regional differences in driving errors (e.g., distraction) and violations (e.g., close following) (e.g., Sharda, Wang, & Ward, 2017), suggesting that safety-conscious transport planning could benefit from including regional differences in driving behaviours. Therefore, besides the analysis of correlations between the DBQ and drivers' individual characteristics, municipal differences were examined.

Summarizing, this study aimed to explore the associations between self-reported driving aberrations (DBQ) and self-reported accidents, together with various variables that were thought to relate to road safety, such as education level, risk perception, and sleep quality. The study was performed in Tehran, the densely populated capital of Iran with close to 9 million citizens, and analyses were performed at the level of Tehran's drivers and districts.

2. Methods

2.1. Questionnaire procedure

A self-report questionnaire was administered in five technical inspection centres and carwashes in Tehran. According to law, vehicles older than five years must annually visit technical inspection and receive a sticker indicating their emission and safety level. To prevent being fined during their New Year's vacation trips, large numbers of drivers visit the technical inspection centres during the first half of March, leading to queues of vehicles. We used theses queues in March 2016 (12th month of the year 1394 according to the Solar Hijri calendar) as an opportunity for asking drivers to complete our questionnaire. To also poll drivers with vehicles newer than five years, we recruited participants from carwashes.

A total of 772 volunteers participated in this research. The experimenters were students from Sharif University who had received training from the first author. The experimenter introduced him/herself to the driver by presenting a business card with the Sharif University logo and the text "Study to improve driving safety." The experimenter asked whether the driver was willing to spend about 15 min to complete the questionnaire and informed the driver that participation would help develop a prediction model of the risk of accidents. At the top of the questionnaire, it was stated that the questionnaire was created by the Sharif University of Technology to help reduce traffic accidents. The questionnaire also stated that the respondents' data would be kept anonymous.

2.2. Questionnaire content

The questionnaire consisted of six parts: driving experience and risk perception, at-fault accidents, traffic tickets, sleep quality, sociodemographic information, and driving behaviour (DBQ). For this paper, the questionnaire was translated by an ISO-17100 certified company from Persian to English.

2.2.1. Driving experience and risk perception

The first part of the questionnaire consisted of 12 questions (Q1–Q12) about driving experience and risk perception (Table 1). In short, Q1 to Q7 were about the respondents' vehicle and vehicle usage, Q8 was about the respondents' usual driving purpose (derived from Tseng, 2013), Q9 was about the amount of driving on country roads, Q10 was about common driving speeds, and Q11 and Q12 were about risk perception (based on Ulleberg & Rundmo, 2003). Additionally, Q18 asked the respondents how many times over the last year they drove their private car out of town for short (less than 100 km) and long (more than 100 km) trips.

2.2.2. At-fault accidents and tickets

Respondents were asked how many times in the last three years (Q13) and in the last year (Q14) they were recognized as being at-fault in minor and damage accidents. Furthermore, they were asked how many times in the last three years (Q15) and in the last year (Q16) they were recognized as being at-fault in fatal or injury accidents. For these questions, the respondents could tick one of seven options, namely one accident, two accidents, three accidents, four accidents, five accidents, more than five accidents, or no accidents. Minor accidents were defined as "accidents as a result of which you paid money or insurance coupons to the other driver."

Q17 asked respondents how many times they were issued a traffic ticket for traffic violations during the last three years, for five types of traffic violations, namely, exceeding the speed limit, illegal overtaking, technical defects of the vehicle, not fastening the seat belt, and talking on the phone while driving. The respondents could tick one of the following options: one ticket, two tickets, three or four tickets, five to ten tickets, more than ten tickets, or no tickets. The respondents were further asked (Q19) how many times in a year they usually get a speeding ticket and (Q20) whether their driving license has ever been confiscated by the police.

2.2.3. Sleep quality

The shortest instrument for assessing driver's sleep problems is the Global Sleep Dissatisfaction (GSD), which includes only one question (Ohayon & Zulley, 2001; Radun et al., 2015). This question (Q21) assessed the respondents' overall quality of sleep on a five-point Likert scale from 'I have very bad sleep' to 'I sleep well'.

Table 1
Questionnaire items regarding driving experience and habits.

Q1	What is the brand of the vehicle you usually drive:
Q2	Year of manufacture:
Q3	Purchased in the year:
Q4	Vehicle use (Private, Taxi, Transfer of goods, Public, Out-of-town trips)
Q5	How many days in a week do you usually drive? (1 to 7)
Q6	How many hours do you drive during the day? (1 = Less than half an hour, 6 = More than 8 hours)
Q7	How many kilometres approximately do you drive per year?
Q8	What is the usual purpose of your driving? (Business, Education, Shopping, Excursion, Picking up family members)
Q9	In percentages, how much of your driving takes place on country roads? (1 = 0–20%, 5 = 80–100%)
Q10	How much faster is your driving speed usually, compared with that of others? (1 = Much slower, 6 = Much faster)
Q11	What do you think is the probability of you having a car accident? (1 = Very low, 5 = Very high)
Q12	If you, as a driver, have an accident, what do you think is the probability of it being fatal or causing severe injury? (1 = Very low, 5 = Very high)

2.2.4. Sociodemographic information

The questionnaire asked respondents to report several demographic characteristics, namely, (Q22) their marital status (married, never married, or widowed/divorced), (Q23) their education level (reading and writing, middle school, high school diploma, Bachelor's degree, Master's degree, or PhD), (Q24) whether the vehicle they usually drive is their own, their father's, their mother's, their spouse's, other family members', or an organization/company's, (Q25) the number of vehicles they own, (Q26) the year of birth, (Q27) their gender, (Q28) municipal district, (Q29) the year they obtained their driving license, and (Q30) the year since which they have been actually driving. In Q31, respondents were asked whether they had been involved in any fatal accident in the last three years.

2.2.5. Driver Behaviour Questionnaire (DBQ)

The last part of the questionnaire consisted of 29 questions (Q32–Q60) regarding the frequency of aberrations while driving. Respondents were asked on a six-point Likert scale from 'never' to 'always' how often particular situations happen to them while driving. Items described different types of aberrations such as speeding, not noticing a priority sign, texting while driving, and not checking the mirrors. The questions were based on existing DBQs (Rowe, Roman, McKenna, Barker, & Poulter, 2015), speeding behaviour questions (Eiksund, 2009; Iversen & Rundmo, 2004), and typical reckless driving behaviours in Iran.

2.3. Treatment of missing values

When reviewing the data, we found that there were missing data, which across items ranged between 0.3% and 34.5%. It is important to understand the causes of the missing data, to decide on the treatment of the remaining data and avoid having a biased analysis. There were respondents who answered only some questions at the beginning of the questionnaire and left the rest of the questionnaire blank. Furthermore, given the non-ordinal item response format of Q13–Q19, we suspected that the large number of nonresponses for these items could be explained by the fact that respondents often left the question unanswered if they were not involved in an accident/ticket/trip. If these missing data were treated as missing values, the mean number of accidents/tickets/trips would increase compared to the true value. We processed the data as follows. First, we excluded all respondents who did not complete the last two questions of the questionnaire (60 of 772 respondents). Next, we created an 'imputed dataset', by imputing a zero value (no accident/no ticket/never) if there was no entry (Q13–Q19). Also, if the reported number of accidents in the last year exceeded the reported number of accidents in the last three years, a missing value was imputed. This approach left 712 respondents and changed the missing values between the items to a minimum of 0% and a maximum of 18.5%. The maximum number of missing values (18.5%, 132 out of 712) occurred for mileage.

2.4. Statistical analyses

First, all the responses were rank-transformed per item, to account for skewed distributions (Conover & Iman, 1981). Thus, all correlations and regression analyses in this work are based on rank-transformed data. Next, missing values of the 29 DBQ items were imputed using the 'nearest neighbour' respondent on that item (Euclidean distance).

Because DBQ items are usually correlated and therefore exhibit redundancy, a principal component analysis was performed. Principal component analysis usually yields scores that are practically indistinguishable from those obtained with exploratory factor analysis (De Winter & Dodou, 2016a, 2016b; Velicer and Jackson, 1990). Principal component analysis is a simple and tractable method and suits our goal of dimensionality reduction. Factor analysis is a more computationally intensive method, which suffers from some theoretical issues, such as factor indeterminacy (Velicer & Jackson, 1990). Hence, we opted for principal component analysis instead of factor analysis.

The 29 items of the DBQ were reduced to three components. The decision to retain three components was based on the scree plot and the interpretability of the loading pattern after oblique rotation (Promax) (Floyd & Widaman, 1995). The decision to apply oblique rather than orthogonal rotation was based on previous DBQ research showing that the errors and violations components are substantially correlated (e.g., Martinussen, Møller, & Prato, 2014). Oblique rotation is also in agreement with a review by Fabrigar, Wegener, MacCallum, and Strahan (1999), which stated that "oblique rotations provide a more accurate and realistic representation of how constructs are likely to be related to one another" (p. 282). We interpreted the meaning of the components based on the items that loaded stronger than 0.4. According to Hair, Anderson, Tatham, and Black (2010), loadings of 0.3 to 0.4 meet the minimal level for interpreting a factor structure.

Next, correlation coefficients were calculated between the DBQ scores on the one hand, and driving experience, risk perception, at-fault accidents, traffic tickets, and sociodemographic information, on the other. For a sample size of 712, correlations of 0.08 or higher, and −0.08 or lower are significantly different from zero, $p < 0.05$. Correlations were assessed for the imputed dataset as reported in Section 2.3. As a countercheck, correlations for the non-imputed dataset are reported in the supplementary material.

A problem with interpreting zero-order correlations is that the DBQ scores are correlated with each other. These positive correlations may be due to response style, self-esteem, or social desirability (Af Wåhlberg, 2010; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Because of the overlapping variance between the DBQ components, the distinctiveness of each DBQ component may not properly come forward when assessing the DBQ's criterion validity. Partial correlations are a suggested remedy to the issue of common method variance (Lindell & Whitney, 2001). Accordingly, in addition to zero-order correlations between the DBQ component scores and item scores, we calculated correlation coefficients between each DBQ component score and the item scores with the other DBQ component scores partialled out. For example, we calculated a correlation between DBQ errors and the participants' age, while partialling out DBQ speeding violations and DBQ non-speeding violations.

A linear regression analysis was performed for predicting two criterion variables: the number of speeding tickets in the past three years (Q17) and the number of minor and damage accidents in the past three years (Q13) using the three DBQ scores, age, and education level as predictor variables. We performed a linear regression analysis because its regression coefficients are more intuitively interpretable than the regression coefficients of a logistic regression analysis, while the *p* values for both types of regression analysis are highly similar (Hellevik, 2009). To verify whether the results of linear and logistic regression analysis are indeed similar, we also performed a logistic regression analysis using an ordinal response model (proportional odds model) for the criterion variable Q13. We used a significance level of 0.05 for determining which predictor variables significantly contribute to the regression model.

Finally, we performed a correlation analysis at the level of Tehran's districts, using only those districts with 10 or more respondents. Correlations were computed between the mean DBQ component scores and socioeconomic indexes of the districts.

3. Results

3.1. Driving experience and risk perception

More than half of the 712 respondents selected cars of IKCO (Iran Khodro Corporation) and SAIPA (Société Anonyme Iranienne de Production Automobile), Iran's two largest automobile manufacturers (Q1). IKCO and SAIPA have a large share in the Iranian automotive market as a joint venture with several automobile manufacturers, particularly Peugeot and Kia Motors. Pride (25%), Peugeot 206 (17%), and Peugeot 405 (16%) were the most reported car models. Most respondents usually drove a vehicle older than five years (84%; Q2) and more than half of them had purchased a new vehicle (54%; i.e., the year of purchase [Q3] and the year of manufacture [Q2] were identical). Most of the respondents used their vehicles as a private car (97%; Q4).

Most of the respondents usually drove more than three days per week (56%; Q5), and less than two hours during the day (64%; Q6). Respondents on average estimated their annual mileage to be 18,400 km (Q7). The majority of respondents drove for business purposes (55%); 32% drove the car for business purposes only (Q8). 52% of the respondents were driving on country roads for less than 20% of their driving time (Q9). Furthermore, 52% of respondents indicated that their usual driving speed was higher than that of other drivers (Q10). Most of the respondents thought that the probability of them having a car accident is less than 'high' or 'very high' (91%; Q11). Also, the respondents felt the likelihood of such accident being fatal or causing severe injury is 'low' or 'very low' (72%; Q12). 54% of the respondents drove their private car out of town for short (less than 100 km) trips during the last year (Q18). Also, most drove their private car for long (>100 km) trips during the last year (77%; Q18). The mean, standard deviation, and distribution for each item are available in the supplementary material.

3.2. At-fault accidents and tickets

The majority of respondents were not at fault in any minor accidents in the last three years (76%; Q13). Of those who were at fault in an accident in the previous three years, 132 respondents reported one, 23 respondents reported two, and 9 respondents reported three or more accidents. Twenty-four out of 712 respondents reported being at fault in one or more injury accidents in the last three years (Q15). None of the respondents indicated that they had been involved in a fatal accident in the previous three years (Q31).

The results for the traffic ticket questions are shown in Table 2. More than half of the respondents were not issued any traffic ticket for exceeding the speed limit, illegal overtaking, a technical defect, not fastening the seat belt, or talking on the phone while driving.

Table 2
Frequency distribution of self-reported traffic tickets (Q17).

	No tickets	1 ticket	2 tickets	3 or 4 tickets	5–10 tickets	>10 tickets
Exceeding the speed limit	400 (56%)	147 (21%)	81 (11%)	67 (9%)	14 (2%)	3 (0%)
Illegal overtaking	636 (89%)	59 (8%)	9 (1%)	5 (1%)	1 (0%)	2 (0%)
Technical defect	656 (92%)	44 (6%)	7 (1%)	3 (0%)	0 (0%)	2 (0%)
Not fastening the seat belt	535 (75%)	126 (18%)	30 (4%)	15 (2%)	4 (1%)	2 (0%)
Talking on the phone while driving	554 (78%)	111 (16%)	25 (4%)	13 (2%)	5 (1%)	4 (1%)

3.3. Sleep quality and sociodemographic information

Most of the respondents indicated sleeping 'well' or 'almost satisfactorily' (90%; Q21). The majority of respondents were married (78%); only 2% of them were widowed or divorced (Q22). 71% of respondents had a Bachelor's degree or higher (Q23). Most respondents indicated that the vehicle they usually drove was their own (80%; Q24). 12% of respondents stated that they did not own a car, and 77% owned one car (Q25). Respondents had an average age of 41 years, with a minimum and maximum of 18 and 77 years, respectively (Q26). The sample consisted predominantly of males (89%; Q27). Respondents had their driving license for more than three years (96%; Q29) and had more than three years of actual driving experience (91%; Q30).

3.4. Driver Behaviour Questionnaire (DBQ) and dimensionality reduction

Table 3 shows that driving under the influence of drugs or running red lights to overtake other drivers were rare aberrations, whereas talking on the phone, suddenly encountering a motorcycle or bicycle while turning right, horn-honking,

Table 3
Means, standard deviations, and kurtosis of the non-transformed responses of the Driver Behaviour Questionnaire (DBQ) and principal component loadings (after Promax rotation) of the rank-transformed items of the DBQ.

		Mean	SD	Kurtosis	Principal component loadings		
					Speeding violations	Errors	Non-speeding violations
Q32	Your traffic violations remain unnoticed by the police.	2.17	1.09	4.11	**0.80**	−0.14	−0.01
Q33	You get angry with certain types of drivers and show them your annoyance by any means.	2.38	1.03	3.88	0.13	0.07	0.27
Q34	You use your vehicle's horn to show that you are annoyed or angry with the way people drive.	2.34	1.03	3.80	0.16	0.00	0.36
Q35	You get angry at people's way of driving and follow them to take revenge in some way.	1.36	0.68	9.95	−0.15	−0.12	**0.73**
Q36	You run red lights when trying to overtake other drivers.	1.09	0.39	28.82	−0.33	0.06	**0.70**
Q37	You exceed the speed limit on highways or motorways.	1.69	0.88	6.22	**0.81**	−0.13	−0.03
Q38	You exceed the speed limit in residential areas.	1.65	0.84	6.80	**0.61**	0.01	0.06
Q39	You misread the exit board on highways or in squares.	1.89	0.87	3.91	−0.07	**0.67**	−0.08
Q40	You turn in the wrong direction on crossroads or in squares.	1.75	0.81	3.63	−0.10	**0.65**	−0.01
Q41	You aim to go to destination A but you suddenly find yourself on the road to destination B.	1.82	0.76	3.74	−0.26	**0.57**	0.15
Q42	You overtake drivers who are signalling their intention to turn left.	1.34	0.64	8.68	0.03	0.22	0.37
Q43	When turning right, you suddenly encounter a motorcycle or bicycle.	2.32	1.02	3.97	0.04	**0.64**	−0.21
Q44	You do not notice the "priority sign" and you face the risk of colliding with the vehicles which have the right of way.	1.73	0.70	4.73	0.14	**0.59**	−0.12
Q45	Your distance to the vehicle in front of you is so little that it makes it difficult for you to stop urgently.	1.91	0.82	3.93	0.23	**0.51**	−0.05
Q46	You overtake from the right.	1.76	0.85	6.21	0.39	0.16	0.17
Q47	You drive after taking drugs that alter your state of consciousness, such as sleep medications, painkillers, etc.	1.25	0.57	11.23	−0.03	−0.07	**0.62**
Q48	You talk on the phone when driving.	2.26	1.00	4.20	**0.47**	0.09	0.20
Q49	You read text messages while driving.	1.78	0.93	4.60	0.20	−0.03	**0.62**
Q50	You send text messages while driving.	1.57	0.86	6.45	0.11	−0.12	**0.74**
Q51	You drive on the lines instead of between them.	1.90	0.76	3.95	0.27	0.40	−0.02
Q52	You drive in zig zags.	1.28	0.59	10.07	0.23	−0.05	**0.46**
Q53	You drive without fastening your seat belt.	1.47	0.80	8.80	0.12	0.09	0.30
Q54	You drive with a speed exceeding 60 km/h in an area with a speed limit of 50 km/h.	2.12	0.93	4.73	**0.73**	0.14	−0.07
Q55	You drive with a speed exceeding 100 km/h in an area with a speed limit of 90 km/h.	2.01	0.95	4.24	**0.83**	0.03	−0.07
Q56	You overtake vehicles that drive within the speed limit.	2.01	0.96	4.78	**0.77**	0.01	−0.03
Q57	You do not respect the speed limit to avoid being late for an important appointment.	2.10	1.07	4.65	**0.73**	−0.01	0.09
Q58	You do not check your side mirror when changing lanes.	1.57	1.15	10.44	−0.11	0.36	0.21
Q59	You do not notice vehicles intending to merge into your lane from the right.	2.00	0.89	7.76	0.00	**0.58**	−0.07
Q60	Due to being lost in thought, you fail to notice that the vehicle in front has slowed down and consequently you must hit the brakes to avoid a crash.	2.01	0.94	6.91	−0.07	**0.59**	0.04

Note. The DBQ responses were coded on a scale from 1 (never) to 6 (always). The kurtosis of a normal distribution equals 3. Loadings greater than 0.40 are indicated in boldface.

and getting angry at others were relatively common. The responses showed a tailed distribution, in line with the literature (Mattsson, 2012).

The first five eigenvalues of the correlation matrix of the 29 DBQ items were 7.91, 2.05, 1.50, 1.39, and 1.27. A principal component analysis was used to reduce the 29 DBQ items to three components. The scree plot (Fig. 1) did not provide a clear indication regarding the number of components to retain, but a three-component solution was found to be the most interpretable based on an inspection of the rotated loadings. The Kaiser-Meyer-Olkin (KMO) index of sampling adequacy, calculated from the correlation matrix, was 0.910. This KMO value suggests that the data are suitable for factor-analytic purposes (Kaiser, 1970).

The obliquely rotated principal component loadings of the items of the DBQ are shown in Table 3. The first component, explaining 27.3% of the variance, was interpreted as *Speeding violations*. The strongest loadings (>0.8) occurred for speeding violations that remain unnoticed by the police (Q32; $\lambda = 0.80$), exceeding the speed limit on highways or motorways (Q37; $\lambda = 0.81$), and driving with a speed exceeding 100 km/h in an area with a speed limit of 90 km/h (Q55; $\lambda = 0.83$).

The second component, explaining 7.1% of the variance, was interpreted as *Errors* with the strongest loadings (>0.6) for misreading an exit board (Q39; $\lambda = 0.67$), turning in the wrong direction (Q40; $\lambda = 0.65$), and suddenly encountering a motorcycle or bicycle when turning right (Q43, $\lambda = 0.64$).

The third component, explaining 5.2% of the variance, was interpreted as *Non-speeding violations*. The strongest loadings (>0.7) occurred for getting angry at people's way of driving and following them to take revenge in some way (Q35; $\lambda = 0.73$), and sending text messages while driving (Q50; $\lambda = 0.74$).

The Cronbach's alpha values for DBQ speeding violations, DBQ errors, and DBQ non-speeding violations were 0.883, 0.729, and 0.720, respectively, if selecting the 8, 8, and 6 items that loaded stronger than 0.4 on the respective component.

3.5. Correlates of the DBQ

3.5.1. Driving experience/risk perception

Correlation coefficients between the DBQ scores and the other questionnaire items are shown in Table 4. It can be seen that driving exposure was associated with DBQ violations. In particular, respondents who drove more days per week ($r = 0.13$, Q5), respondents who estimated their usual driving speed as faster compared to other drivers ($r = 0.44$, Q10), and respondents who made more short ($r = 0.12$, Q18) and long ($r = 0.20$, Q18) trips had a higher DBQ speeding violations score. Respondents who had a higher driving exposure in terms of driving days per week ($r = 0.11$, Q5), driving hours per day ($r = 0.12$, Q6), or annual mileage ($r = 0.15$, Q7), and who estimated their usual driving speed faster as compared to other drivers ($r = 0.23$, Q10) had a higher DBQ non-speeding violations score. Furthermore, respondents who thought they had a higher probability of having a car accident (Q11) showed a higher DBQ speeding violations score ($r = 0.15$), errors score ($r = 0.29$), and non-speeding violations score ($r = 0.19$).

3.5.2. At-fault accidents/tickets

DBQ speeding violations, DBQ errors, and DBQ non-speeding violations correlated with the number of at-fault minor accidents ($r = 0.14$, 0.16, and 0.19, respectively, Q13). Respondents who were issued more tickets for exceeding the speed limit

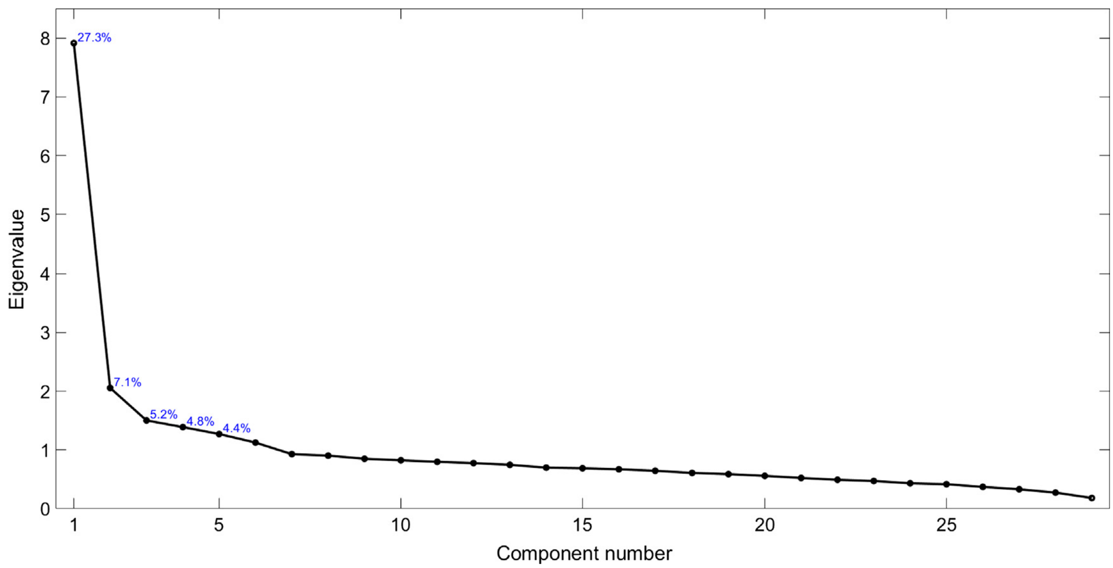

Fig. 1. Eigenvalues of the correlation matrix of the Driver Behaviour Questionnaire (DBQ), sorted in descending order ("scree plot"). Also shown are the percentages of variance explained (being proportional to the eigenvalue) for the first five components.

Table 4
Zero-order correlations (r) between the Driver Behaviour Questionnaire (DBQ) component scores and the questionnaire items which are expressed on an ordinal scale, and correlations (r_p) between the DBQ component scores and the questionnaire items, where the other two DBQ component scores are partialled out.

	Item	Mean	*SD*	Speeding violations		Errors		Non-speeding violations	
				r	r_p	r	r_p	r	r_p
Q2	Year of manufacture	2007.7	3.25	0.08	0.12	−0.03	−0.04	−0.03	−0.07
Q3	Purchased in the year	2009.7	3.53	0.10	0.11	0.03	0.00	0.01	−0.05
Q5	How many days in a week do you usually drive? *(1 to 7)*	4.26	2.15	0.13	0.10	0.03	−0.05	0.11	0.05
Q6	How many hours do you drive during the day? (The average number of hours on the days you drive)? *(1 = Less than half an hour, 6 = More than 8 hours)*	3.15	1.11	0.03	−0.04	0.06	0.01	0.12	0.11
Q7	How many kilometres approximately do you drive per year?	18,400	15,438	0.15	0.09	0.07	−0.03	0.15	0.09
Q8	Purpose of driving: Business *(1 = No, 2 = Yes)*	1.55	0.50	0.10	0.06	0.04	−0.02	0.08	0.04
Q8	Purpose of driving: Education *(1 = No, 2 = Yes)*	1.07	0.25	0.01	−0.03	0.04	0.01	0.07	0.07
Q8	Purpose of driving: Shopping *(1 = No, 2 = Yes)*	1.31	0.46	−0.04	0.01	−0.09	−0.06	−0.06	−0.02
Q8	Purpose of driving: Excursion *(1 = No, 2 = Yes)*	1.36	0.48	0.09	0.07	0.02	−0.04	0.06	0.03
Q8	Purpose of driving: Picking up family members *(1 = No, 2 = Yes)*	1.36	0.48	0.00	0.05	−0.01	0.03	−0.09	−0.11
Q9	In percentages, how much of your driving takes place on country roads? *(1 = 0–20%, 5 = 80–100%)*	1.93	1.22	0.01	0.07	−0.05	−0.03	−0.07	−0.08
Q10	How much faster is your driving speed usually, compared with that of others? *(1 = Much slower, 6 = Much faster)*	3.48	0.90	0.44	0.40	0.10	−0.14	0.23	0.03
Q11	What do you think is the probability of you having a car accident? *(1 = Very low, 5 = Very high)*	2.30	1.00	0.15	0.00	0.29	0.22	0.19	0.04
Q12	If you, as a driver, have an accident, what do you think is the probability of it being fatal or causing severe injury? *(1 = Very low, 5 = Very high)*	1.92	0.91	0.19	0.12	0.19	0.13	0.11	−0.04
Q13	In the last three years, how many times were you recognised as being at fault in minor and damage accidents? *(1 = No accidents, 7 = More than 5)*	1.29	0.60	0.14	0.02	0.16	0.06	0.19	0.10
Q14	How many of the accidents mentioned in the previous question occurred in the last year? *(1 = No accidents, 7 = More than 5)*	1.13	0.38	0.12	0.01	0.15	0.07	0.16	0.08
Q15	In the last three years, how many times were you recognised as being at fault in fatal or injury accidents? *(1 = No accidents, 7 = More than 5)*	1.04	0.20	0.04	−0.01	0.08	0.06	0.06	0.02
Q16	How many of the accidents mentioned in the previous question occurred in the last year? *(1 = No accidents, 7 = More than 5)*	1.03	0.18	0.04	−0.01	0.11	0.11	0.04	−0.02
Q17	Exceeding the speed limit *(1 = No tickets, 6 = More than 10 tickets)*	1.82	1.12	0.35	0.32	0.07	−0.11	0.17	0.01
Q17	Illegal overtaking *(1 = No tickets, 6 = More than 10 tickets)*	1.15	0.52	0.14	0.08	0.04	−0.06	0.14	0.10
Q17	Technical defect *(1 = No tickets, 6 = More than 10 tickets)*	1.11	0.44	0.07	−0.04	0.15	0.09	0.15	0.09
Q17	Not fastening the seat belt *(1 = No tickets, 6 = More than 10 tickets)*	1.36	0.75	0.17	0.06	0.15	0.03	0.21	0.12
Q17	Talking on the phone while driving *(1 = No tickets, 6 = More than 10 tickets)*	1.34	0.78	0.25	0.13	0.17	0.00	0.25	0.13
Q18	Trips more than 100 km *(1 = Never, 5 = More than 12 times)*	2.21	1.40	0.12	0.13	0.00	−0.06	0.05	0.00
Q18	Trips more than 100 km *(1 = Never, 5 = More than 12 times)*	2.51	1.18	0.20	0.25	−0.07	−0.17	0.05	−0.02
Q19	How many times in a year do you usually get a speeding ticket? *(1 = Never, 5 = More than 12 times)*	1.63	0.72	0.36	0.31	0.15	−0.02	0.19	−0.02
Q20	Has your driving license ever been confiscated by the police? *(1 = No, 2 = Yes)*	1.01	0.12	0.06	0.02	0.04	0.00	0.07	0.04
Q21	How do you assess the overall quality of your sleep? *(1 = I have very bad sleep, 5 = I sleep well)*	4.29	0.75	−0.10	−0.01	−0.14	−0.06	−0.15	−0.07
Q22	Marital status *(1 = Single, never married or divorced, 2 = Married)*	1.78	0.41	−0.14	−0.09	−0.07	0.02	−0.13	−0.06
Q23	What is your education level? *(1 = Reading and writing, 6 = PhD)*	3.99	0.96	0.27	0.24	0.08	−0.05	0.14	0.00
Q25	How may vehicles do you own? *(1 = I do not own any vehicles, 5 = More than three)*	2.01	0.53	0.02	0.04	−0.07	−0.09	0.01	0.04
Q29	In what year did you obtain your driving license? *(converted to years of driving experience)*	18.30	11.53	−0.20	−0.13	−0.03	0.12	−0.20	−0.14
Q26	Year of birth *(converted to age)*	41.37	11.92	−0.33	−0.21	−0.10	0.15	−0.34	−0.23
Q27	Gender *(1 = Female, 2 = Male)*	1.89	0.32	0.05	0.05	−0.01	−0.05	0.03	0.02
Q30	Since what year have you been actually driving? *(converted to years of driving experience)*	15.98	11.21	−0.14	−0.11	−0.03	0.06	−0.12	−0.07

Note. For a sample size of 712, correlations of 0.08 or higher, and −0.08 or lower are significantly different from zero ($p < 0.05$), and correlations of 0.13 and higher, and −0.13 or lower are strongly significant ($p < 0.001$). For Q22, 'divorced' was recoded as 'single'. Q31 'Have you been involved in any fatal accidents in the last three years?' was omitted from this table since nobody answered 'yes' to this question.

(Q17) had a higher DBQ speeding violations score ($r = 0.35$). DBQ errors, on the other hand, did not correlate significantly with the number of speeding tickets ($r = 0.07$). DBQ violations and errors were also correlated with receiving tickets for not fastening the seat belt and for talking on the phone while driving ($r \sim 0.20$).

3.5.3. Sleep quality

Respondents who assessed their overall sleep quality as better (Q21) had a lower DBQ speeding violations, errors, and non-speeding violations score ($r = -0.10$, -0.14, and -0.15, respectively).

3.5.4. Sociodemographic Information

Married drivers had a lower DBQ speeding violations, errors, and non-speeding violations score than unmarried drivers (r = -0.14, -0.07, and -0.13, respectively, Q22). Respondents who had a higher education level had a higher DBQ speeding violations score ($r = 0.27$, Q23). There were no significant gender differences in the DBQ scores (Q27).

3.5.5. Partial correlations

The above results showed that the DBQ components are related to various personal characteristics and traffic safety outcomes. In particular, DBQ violations are correlated with driving exposure, young age, and the number of speeding tickets. DBQ errors, on the other hand, are related to risk perception, that is, believing that one has a high probability of being involved in an accident. However, the DBQ scores were correlated with each other ($r = 0.57$ between speeding and non-speeding violations, $r = 0.48$ between speeding violations and errors, and $r = 0.53$ between non-speeding violations and errors), which means that there is overlapping variance. Partial correlations were therefore computed as a complement to the zero-order correlations. The results in Table 4 show that the partial correlation coefficients are more clearly differentiated from each other than the zero-order correlations. For example, the zero-order correlations between DBQ speeding violations, DBQ errors, and DBQ non-speeding violations and self-reported driving speed (Q10) were 0.44, 0.10, and 0.23, respectively, whereas the corresponding partial correlation coefficients were 0.40, -0.14, and 0.03. Thus, the DBQ errors score was negatively associated with driving speed when the variance of DBQ violations was removed. Similarly, the zero-order correlations between DBQ speeding violations, DBQ errors, and DBQ non-speeding violations and education level were 0.27, 0.08, and 0.14, whereas the corresponding partial correlation coefficients were 0.24, -0.05, and 0.00. Thus, speeding violations were associated with a high education level. Also, the partial correlations show that the DBQ errors score was positively correlated with age ($r_p = 0.15$), whereas the zero-order correlation was negative (r = -0.10).

3.6. Regression analyses with the DBQ scores as predictor variables

We performed a regression analysis to predict the respondents' self-reported number of speeding tickets in the past three years (Q17), using age, education, and the three DBQ scores as predictor variables. The results in Table 5 show that self-reported number of speeding tickets in the past three years was predicted by a higher DBQ speeding violations score ($\beta = 0.41$) and a lower DBQ errors score ($\beta = -0.12$).

Next, we performed a regression analysis to predict the respondents' involvement in minor accidents (Q13) using the same predictor variables. The results in Table 6 indicate that accidents are predicted by DBQ non-speeding violations, whereas the other two DBQ components (speeding violations and errors) do not significantly add to the prediction. We also performed a logistic regression analysis to verify whether the results of the linear regression analysis are robust. The logistic analysis confirmed the results of the linear regression analysis in that DBQ non-speeding violations was the only predictor that was statistically significant.

Table 5
Regression analysis for predicting 'How many times have you been issued a traffic ticket for the following traffic violations during the last three years?' (Q17; *1 = No tickets, 7 = More than 10 tickets*) from age, education level, and Driver Behaviour Questionnaire (DBQ) scores ($N = 674$).

Predictor variable	β	95% CI of β	t	p
Age	0.03	−0.05, 0.10	0.69	0.491
Education level	−0.02	−0.09, 0.05	−0.56	0.577
Speeding violations	0.41	0.31, 0.50	8.44	**<0.001**
Errors	−0.12	−0.21, −0.03	−2.72	0.007
Non-speeding violations	0.02	−0.08, 0.11	0.36	0.719

Note. p values < 0.05 are noted in boldface.

Table 6
Regression analysis for predicting 'In the last three years, how many times were you recognised as being at fault in minor and damage accidents?' (Q13; *1 = Never, 6 = More than 5*) from age, education level, and Driver Behaviour Questionnaire (DBQ) scores ($N = 658$).

Predictor variable	β	95% CI of β	t	p	β logistic	p logistic
Age	−0.06	−0.14, 0.03	−1.33	0.184	0.14	0.170
Education level	−0.02	−0.10, 0.06	−0.52	0.606	0.04	0.698
Speeding violations	0.00	−0.10, 0.10	0.07	0.947	−0.02	0.865
Errors	0.08	−0.01, 0.18	1.77	0.078	−0.21	0.066
Non-speeding violations	0.13	0.03, 0.23	2.52	**0.012**	−0.27	**0.023**

Note. p values < 0.05 are noted in boldface.

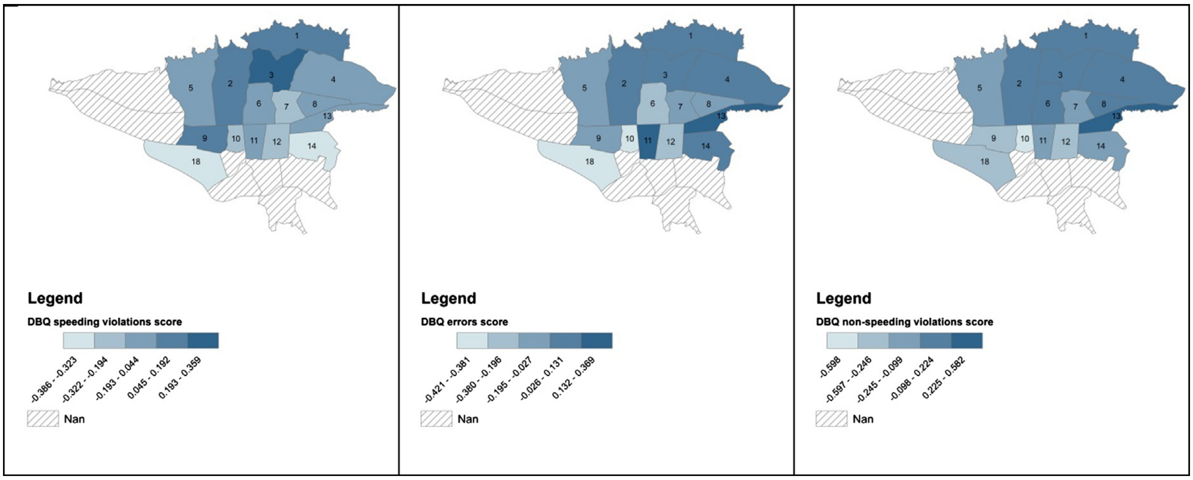

Fig. 2. The geographical distribution of the Driver Behaviour Questionnaire (DBQ) scores. Left: DBQ speeding violations score, Middle: DBQ errors score, Right: DBQ non-speeding violations score.

Table 7
Spearman rank correlation matrix at the level of districts ($N = 15$), and first principal component loading of the correlation matrix.

			1	2	3	4	5	6	7	8	9	Loading
1	Car ownership (% of families)	L										0.95
2	Illiteracy (% of citizens)	L	−0.95									−0.92
3	Higher education (% of citizens)	L	0.94	−0.94								0.94
4	Pride (% of respondents)	Q	−0.86	0.85	−0.88							−0.90
5	Q17. Speeding tickets	Q	0.09	−0.09	0.13	−0.32						0.15
6	Q18. Out of town trips > 100 km	Q	0.29	−0.19	0.24	−0.16	−0.23					0.26
7	Q23. Education level	Q	0.60	−0.65	0.68	−0.65	0.10	0.41				0.75
8	DBQ speeding violations score	Q	0.67	−0.56	0.67	−0.66	0.26	0.37	0.73			0.81
9	DBQ errors score	Q	0.43	−0.34	0.29	−0.35	−0.03	−0.20	0.18	0.51		0.51
10	DBQ non-speeding violations score	Q	0.73	−0.65	0.66	−0.58	−0.15	−0.14	0.34	0.55	0.71	0.75

Note. L = Data retrieved from the literature (Asadi-Lari & Vaez-Mahdavi, 2008). Q = Data from the present questionnaire. The district was available for 630 of 712 respondents. The correlation matrix is based on 15 districts with 10 or more respondents.

3.7. Differences between municipalities

Tehran is divided into 22 municipal districts with diverse socioeconomic characteristics. The geographical distribution of the DBQ scores (speeding violations, errors, and non-speeding violations) is illustrated in Fig. 2. Table 7 shows a correlation matrix at the level of districts for several selected variables. It can be seen that people from more affluent districts (i.e., districts with higher car ownership, lower illiteracy, a higher education level) had higher DBQ scores and were less likely to own a Pride, a low-cost car with a significant share of the Iranian automotive market. A selected association from the correlation matrix is illustrated in Fig. 3.

Because many of the variables in Table 7 show strong correlations, we performed a principal component analysis and retained one component that explained 56.0% of the variance. Based on the component loadings (Table 7), this component can be interpreted as a general socioeconomic component, characterised by high car ownership, low illiteracy, high education, and high DBQ violations scores in particular.

4. Discussion

This study examined self-reported driving aberrations in Tehran, the densely populated capital of Iran. The results of our questionnaire at technical inspection centres and carwashes revealed a distinction between errors and two types of violations: speeding and non-speeding violations.

Younger drivers had higher DBQ violations scores than older drivers (Table 4), a finding that corresponds to literature in Western countries (De Winter et al., 2015; Martinussen et al., 2014). We also showed that both DBQ errors and violations showed positive zero-order correlations with self-reported accident involvement. However, when entered into a regression analysis, only the DBQ non-speeding violations score was significantly predictive (Table 6). Thus, our findings indicate that

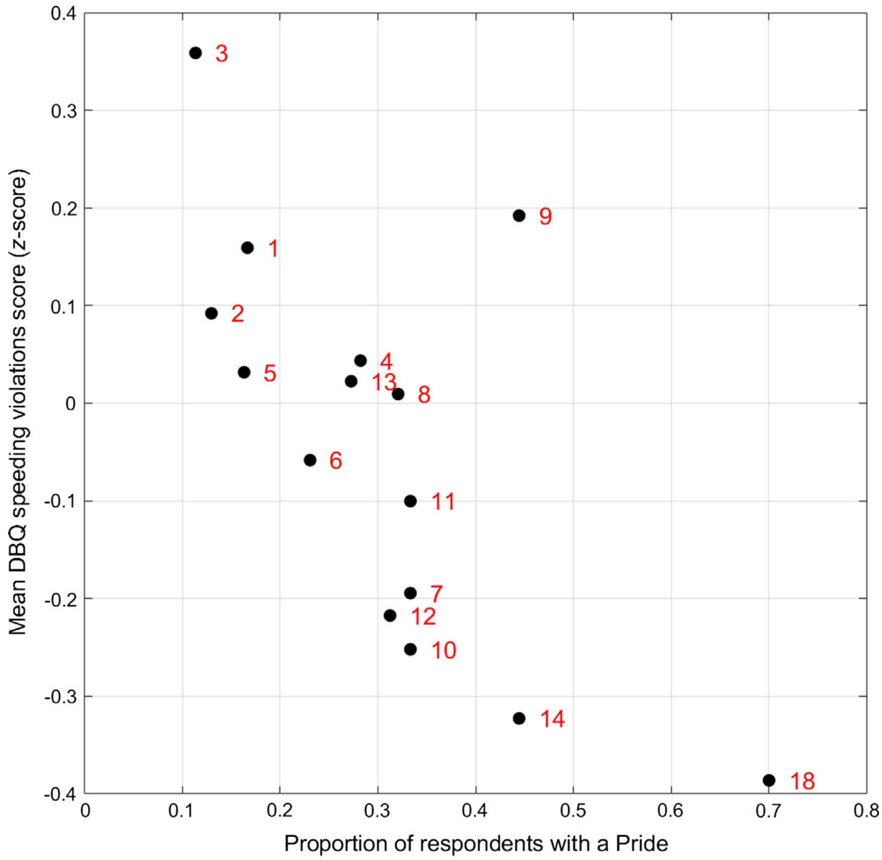

Fig. 3. Scatter plot of the proportion of people who reported to own a Pride car and the mean DBQ speeding violations score, for the 15 districts of Tehran with 10 or more respondents. The numbers next to the markers indicate the district number.

non-speeding violations, such as angry driving, running red lights, and sending text messages while driving, are indicative of self-reported minor accidents.

Results from a regression analysis showed that the number of speeding fines was predicted by a higher DBQ speeding violations score, but a lower DBQ errors score (Table 5). This differentiation between violations and errors can be explained by a compensatory mechanism: It is well established that abilities such as divided attention deteriorate with age (e.g., Sekuler, Bennett, & Mamelak, 2000). Similarly, we found a positive correlation between DBQ errors and age when the two DBQ violations components were partialled out. It is possible that older people, who generally have reduced cognitive abilities, compensate by driving more slowly. A negative correlation between errors and violations has also been found in driving simulator research (De Winter et al., 2009).

At the individual level, we found that drivers with higher DBQ speeding violations scores made more out-of-town trips and had a higher education level. At the level of Tehran's districts, we found a positive manifold between DBQ violations and socioeconomic status, with DBQ violations loading relatively strongly on the general socioeconomic component (Table 7). This positive manifold points to an intricate phenomenon, where it is possible that people with higher income have more access to cars that allow for speeding (as opposed to the low-cost Pride car), and drive more frequently, especially out of town. Given the high traffic congestion in Tehran (Vafa-Arani, Jahani, Dashti, Heydari, & Moazen, 2014), drivers are less likely to speed on urban roads than on highways. Thus, in Tehran, regional wealth may be an enabler of (deviant) driving. Although there is ample support for the fact national wealth is associated with favourable accident statistics (e.g., WHO, 2015), our results show that this association should not be interpreted as implying that wealthy regions necessarily contain the most law-abiding drivers. De Winter and Dodou (2016a, 2016b) previously found that drivers from countries with high developmental status (e.g., Germany) commit fewer non-speeding violations but more speeding violations than drivers from countries with a lower developmental status (e.g., Pakistan).

We found a positive correlation between DBQ scores and drivers' risk perception. In particular, people with a higher DBQ errors score believed that they had a higher probability of becoming involved in an accident. This correlation may represent a genuine effect in the sense that error-prone drivers are dangerous drivers. However, this correlation may also reflect a common cause of individual differences in self-esteem or social desirability (Af Wåhlberg, 2010). That is, some people are more willing to admit their limitations than others, as a result of which these people may report high risk and a high number of errors.

Results indicated that drivers who are more satisfied with their sleep quality reported fewer errors and violations. This finding is consistent with other studies that consider sleepiness as a factor responsible for unsafe driving (e.g., Komada, Asaoka, Abe, & Inoue, 2013; Sadeghniiat-Haghighi et al., 2015). Effect sizes were modest, however, and not statistically significantly different from zero when partial correlations were assessed.

We did not find statistically significant gender differences in DBQ errors and violations, but the effects were in the expected direction, with males reporting more speeding violations but fewer errors than females (Table 4). Previous studies have clearly shown that females report fewer violations than males (De Winter et al., 2015), and ample research has confirmed that males tend to take more risks than females (Evans, 2006; Zuckerman, Eysenck, & Eysenck, 1978). One reason for the lack of significant effect could be that there were only a small number of female drivers in this study, thereby reducing statistical power. The lack of substantial gender differences may also be due to cultural effects: Females in Iran are less likely than males to participate in work-like activities (Koohpayehzadeh et al., 2014) such as taking a car to a technical inspection centre. As a result, the interviewed females were not representative of all Iranian women. That is, it is possible that the surveyed females were more violation-prone than a typical female in Iran. De Winter et al. (2015) argued that it is difficult to study gender differences in DBQ scores in cultures where females typically do not drive a car, such as in Saudi Arabia. It would be interesting to perform longitudinal studies and examine how gender differences in violations and errors scores evolve over time in case a society moves towards higher levels of liberalism.

This study used self-reported data, which causes erroneous responses, and which may have produced common method effects, as evidenced by the fact that DBQ errors correlated with the belief of being involved in a future accident. However, respondents participated anonymously, which should reduce socially desirable responding. Recent research has shown that the DBQ violations score correlates with actual (i.e., non-self-reported) accidents at the level of individual drivers (De Winter et al., 2018) and at the level of countries (De Winter and Dodou, 2016a, 2016b). It should be noted that self-reports are the only practical way to obtain knowledge on the private beliefs and motivations of drivers. We attempted to circumvent method effects by including data from the literature in the same analysis (see Table 7). Future research could use a similar approach whereby data from multiple sources (e.g., regional statistics and self-reports) are combined in a single analysis.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2019.01.001.

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