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Cross-cultural differences in driving behaviours: A comparison of six countries

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Abstract

The first aim of the present study was to investigate the applicability of the three-factor structure (aggressive violations, ordinary violations, and errors) of the Manchester Driver Behaviour Questionnaire (DBQ) and then to compare these driving behaviours across the six countries (Finland, Great Britain, Greece, Iran, The Netherlands, and Turkey). The third aim of the present study was to evaluate the role of driving styles in the relationship between traffic cultures (countries) and the number of traffic accidents utilizing a mediational framework. The fourth aim of this paper was to investigate the relationship between the three factors of DBQ and the number of traffic accidents in each country. Two hundred and forty-two drivers were chosen from each of the six countries, matched for age and sex. The results of confirmatory factor analyses showed that the fit of the three-factor model of DBQ was partially satisfactory in each country. Exploratory factor analyses together with target (Procrustes) rotation and factorial agreement indexes showed that the "ordinary violations" factor was fully congruent and the "errors" factor was fairly congruent across countries. Reliabilities of the scales were at the same level as in the original British data. ANOVA results revealed differences between drivers from "safe" Western/Northern European and Southern European/Middle Eastern countries on DBQ items and scales. Results demonstrated that driving style mediates the relationship between traffic culture (i.e. country) and the number of accidents. Poisson and negative binomial regression analyses also showed that the importance of driver characteristics and behaviours in predicting the number of traffic accidents varies from country to country.

Keywords: Driver behaviours; Cross-cultural differences; Regional differences; Traffic accidents; Mediational model

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1. Introduction

It has been estimated that annually two million people die worldwide in road traffic accidents. In addition to human misery and suffering, the total cost of road accidents, including the economic value of lost quality of life, has ranged from 0.5% to 5.7% of GNP of countries (Elvik, 2000). Although road traffic accidents are a large problem everywhere, there are considerable regional differences between countries. In 2001, 9.1 Finns, 8.9 Dutch, and 7.5 Britons per 1 billion vehicle-kilometer were killed in traffic accidents whereas the corresponding figures for Turks and Greeks were 73 and 26.7, respectively (IRTAD, 2003). Despite this inequality between Southern and Western Europe, the reasons for different accident risk figures have remained mainly unexamined.

Most road traffic accidents can be directly attributed to human factors as a sole or a contributory factor (Lewin, 1982). Human factors in driving can be seen as being composed of two separate components: driving skills and driving style or, in other words, driver performance and behaviour (Elander, West, & French, 1993; Evans, 1991; Näätänen & Summala, 1976). Driving skills include information processing and motor skills, which improve with practice and training, i.e. with driving experience. Driving style refers to the ways drivers choose to drive or habitually drive, including, for example, the choice of driving speed, habitual level of general attentiveness, and gap acceptance (Elander et al., 1993). Because of the evident relevance of driving style to accident risk, dozens of self-report instruments have been developed for measuring driving style.

1.1. The Driver Behaviour Questionnaire (DBQ) and its theoretical basis

The Driver Behaviour Questionnaire (DBQ) (Reason, Manstead, Stradling, Baxter, & Campbell, 1990) is one of the most widely used instruments for measuring driving style. The DBQ is based on a theoretical taxonomy of aberrant behaviours (Reason, 1990) and the main idea in the DBQ being the distinction between errors and violations (Reason et al., 1990). Errors were defined as "generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency" (Reason, 1990, p. 9). Hence, errors are unwanted results of involuntary actions whereas violations are based on conscious deviation from a rule or safe practice. Errors were further divided into slips and lapses (resulting from action) and mistakes (errors of intention). Slips (attention deficits) and lapses (memory failures) are results of cognitive processing problems.

Mistakes were further divided into two subcategories, which were based on Rasmussen's "skill-rule-knowledge" taxonomy of human performance levels (for comprehensive review see Rasmussen, 1980): rule-based mistakes and knowledge-based mistakes (Reason, 1999). Violations can be located in the "rule-based mistakes" category. They can be associated with the misapplication of normally good rules, the application of bad rules, a failure to apply a good rule, or erroneous performance in a no-rules situation. A further distinction has been suggested between two kinds of violations according to the reason why drivers violate (Lawton, Parker, Manstead, & Stradling, 1997). The first violation type, named as ordinary violations, involves deliberate breaking the Highway Code (e.g., speeding). The second violation type involves overtly aggressive acts (e.g., showing hostility by chasing other vehicles). In this way, contextual and motivational demands influence violations. Errors can be located in the "knowledge-based mistakes" category. They emerge when pre-existing solutions do not work and a trial-and-error learning process is needed for finding new feasible solutions (see Reason, 1999).

1.2. Factor solutions of the DBQ in empirical studies

In their first study about DBQ, Reason et al. (1990) found that driver errors and violations are two empirically distinct classes of behaviour containing three factors (deliberate violations, dangerous errors, and 'silly' errors). Later, Parker, Reason, Manstead, and Stradling (1995) confirmed the three-factor structure of the DBQ. Åberg and Rimmö (1998) re-confirmed the three-factor solution with 44 of the 50 original items in their study conducted in Sweden. In contrast to the British and Swedish results, Blockey and Hartley (1995) could not find the same three-factor solution in Australia and, consequently, named their DBQ factors differently as

general errors, dangerous errors and violations. Åberg and Rimmö (1998) also identified two different types of errors, i.e. inattention and inexperience errors by using 104-item form of the DBQ in a large sample of Swedish drivers.

Later Lawton et al. (1997) introduced a further distinction between two kinds of violations as ordinary (i.e., speeding) and aggressive violations (i.e., showing hostility). Occasionally, a higher number of DBQ factors have been reported (e.g. five factors among elderly drivers in Parker, McDonald, Rabbitt, & Sutcliffe, 2000; six factors in work context in Dimmer & Parker, 1999; in Chapman, Roberts, & Underwood, 2000), and rarely, a smaller number of DBQ factors have been found (e.g. two factors among professional drivers in Sümer, 2003). In general, the main distinction between errors and violations seems to be the most stable in all studies in spite of some dissimilarity in factor structures. Lajunen, Parker, and Summala (2004) studied the DBQ factor structure among British, Dutch, and Finnish drivers. The results of this study supported the idea of two second-order factors, named as errors and violations. A more recent follow-up study by Özkan, Lajunen, and Summala (2006), the two-factor solution emerged as the most applicable and stable one over three years follow-up period among possible factor solutions (two to six factors) of the DBQ.

1.3. Possible reasons of the different factor structures of the DBQ

Driving style is supposed to vary in degree to which it is shaped by both intrinsic (e.g., age, sex, and cognitive biases) and extrinsic (e.g., social context) factors (Reason, 1990; Reason et al., 1990). Similarly, Blockey and Hartley (1995) suggested that age, gender, socio-economic and cultural differences between British and Australian samples could have caused the dissimilarities in factor structures found in their study. In DBQ literature, it has also been reported that men and young drivers tend to commit violations more frequently than women and older drivers, and that those who drive frequently violate traffic rules more often than those who drive less frequently (Åberg & Rimmö, 1998; Lawton et al., 1997; Mesken, Lajunen, & Summala, 2002; Parker, Reason et al., 1995; Reason et al., 1990). In addition, social environment including other road users, general social norms as well as formal and informal traffic rules, influence every individual driver (Björklund, 2005; Zaidel, 1992). It is likely that traffic culture or context determines the criteria and both formal and informal rules for acceptable driving style. It could be hypothesized, therefore, that the vast difference between the Southern and Northern Europe in traffic culture and level of safety would be reflected in the drivers' driving behaviours. Southern European and Iranian drivers should have higher scores on the three factors of DBQ than drivers in Northern European countries. It has been found, for example, that drivers score differently on DBQ items or scales in different countries (e.g., Sweden by Åberg & Rimmö, 1998; Australia by Blockey & Hartley, 1995; UK by Reason et al., 1990). However, comparative research about DBQ factor structure and drivers' conceptualisation of driving in general has not been conducted between countries with low level of motorization and safety and countries with high level of motorization and safety. The first aim of the present study was, therefore, to investigate the applicability of the three-factor structure (aggressive violations, ordinary violations, and errors) of DBQ in the six countries (Great Britain, The Netherlands, Finland, Greece, Iran, and Turkey) and, secondly, to compare driving styles cross-culturally.

1.4. Relationship between the DBQ and traffic accidents

Errors and violations are potentially dangerous and could lead to a crash. According to previous findings, violations predict accident involvement, both retrospectively and prospectively (Parker, Reason et al., 1995; Parker, West, Stradling, & Manstead, 1995). Specifically, violations have been reported to be associated with active loss-of-control and passive right-of-way accidents (Parker, West et al., 1995) as well as with speeding and parking offences (Mesken et al., 2002). Although both slips (attention deficits) and lapses (memory failures) can cause embarrassment, they are unlikely to have an impact on driving safety (Parker, Reason et al., 1995). It should be noted, however, that passive accident involvement was associated with high scores on the lapses factor among elderly drivers (Parker et al., 2000). In addition to the characteristics of samples, it is also possible that the relationship between driving styles and driving outcomes vary from country to country. Lajunen and his colleagues (1998), for example, showed that driving skills, the other main component of human factors in driving, is related to culture. They found that Australian drivers were less safety-oriented and had

more accidents than Finnish drivers. However, it has not been investigated whether different driving styles could explain differences in accident risk across different countries. The third aim of the present study was, therefore, to evaluate the role of driving styles in the relationship between traffic cultures (countries) and the number of traffic accidents utilizing a mediational framework. The fourth aim of this paper was to investigate the relationship between the three factors of DBQ and the number of traffic accidents among British, Dutch, Finnish, Greek, Iranian, and Turkish drivers.

2. Method

2.1. Participants and procedure

The participants from Finland (1120), Great Britain (840), and the Netherlands (700) were obtained from data collected in a previous study (see Lajunen et al., 2004 for detailed information). The Turkish data reported in this study initially consisted of four previous data sets including more than two thousand drivers across different age groups (see, for instance, Sümer, Özkan, & Lajunen, in press for information about the data collection procedure). In Greece (Crete), stratified random sampling using information from the National Statistics Department was performed to collect data from 342 participants in the targeted households (see Chliaoutakis, Koukouli, & Lajunen, 2005 for detailed information). In Iran, two research assistants trained in data collection approached drivers and only those who agreed to fill out the questionnaire were included in the study. Research assistants also used their own social network to find eligible drivers. They collected data from 311 participants, of which, 242 drivers were then eligible to be included in the present study.

Since the Iranian sample was smaller compared to the other datasets, a total number of 242 drivers (matched by age and sex) were sampled from each country. In all studies, participation was voluntary but having a driving license was obligatory. Participants were assured of anonymity and confidentiality. Characteristics for the whole sample as well as for male and female drivers in each country are presented in Table 1.

2.2. Measures

2.2.1. The Driver Behaviour Questionnaire (DBQ)

The extended version of the DBQ (Lawton et al., 1997; Parker, Lajunen, & Stradling, 1998) was used to measure aberrant driver behaviours. In the present study, only "errors" (eight items), "ordinary violations" (eight items), and "aggressive violations" (three items) scales were used (see Appendix for DBQ items), because "slips and lapses" are largely irrelevant to safety or they have been critical only for elderly drivers (Parker et al., 2000). The aggressive violation item "driving when you suspect you might be over the legal blood alcohol limit" was excluded in the present study because of two reasons. First, previous studies show that answers to "drinking and driving" questions are generally affected by socially desirable responding (Lajunen & Summala, 2003). Second, this question is not applicable in Iran where drinking alcohol is a crime and leads to punishment delivered in different forms (e.g., flogging). The DBQ items were translated from English into other languages by at least one psychologist and the correctness of the translations of the scale was evaluated by using back translation. Participants were asked to indicate how often they committed each of the 19 behaviours in the previous year on a six-point scale (0 = never, 5 = nearly all the time).

2.2.2. Demographic measures

Respondents answered questions about their age, sex, the number and types of accidents (active and passive accidents) and offences (parking, speeding, and other) during last three years, the number of years a full driving license held, and their annual mileage.

2.3. Statistical analyses

The sub-samples of British, Dutch, Finnish, Greek, and Turkish datasets and Iranian data were used in all analyses. By using LISREL with maximum likelihood estimation, confirmatory factor analyses (see Russell, 2002 for detailed information about the use of confirmatory and exploratory factor analyses) and were run

Table 1
Sample characteristics

Variables	Total sample						Male sample						Female sample					
	FIN	GB	GR	IRN	NL	TR	FIN	GB	GR	IRN	NL	TR	FIN	GB	GR	IRN	NL	TR
N	242	242	242	242	242	242	146	146	146	146	146	146	96	96	96	96	96	96
Age																		
Mean	29.69	29.48	30.47	29.50	32.25	30.03	31.24	29.73	31.06	31.00	33.06	31.08	27.34	29.09	29.57	27.20	31.02	28.42
SD	10.84	11.10	9.71	10.63	8.26	10.36	11.81	11.93	10.66	11.47	8.81	11.39	8.70	9.76	8.01	8.79	7.22	8.37
Driving experience																		
Mean	10.96	10.52	8.84	9.00	12.00	8.77	12.70	11.28	10.42	10.61	13.11	10.18	8.33	9.35	6.44	6.52	10.31	6.63
SD	9.74	9.69	8.08	9.36	7.85	8.37	10.60	10.78	9.04	9.99	8.47	9.39	7.58	7.64	5.61	7.70	6.49	5.97
Annual mileage																		
Mean	22.21	10.99	87.18	45.77	25.99	13.90	26.97	12.56	103.51	63.17	30.79	17.01	14.96	8.59	62.35	19.31	18.69	9.17
SD	17.76	9.87	97.29	78.78	32.92	19.13	19.68	10.75	106.18	90.00	38.52	21.52	11.03	7.81	75.97	46.98	18.97	13.58
Total accidents																		
Mean	0.38	0.51	1.55	2.68	0.55	1.01	0.42	0.50	1.79	3.16	0.64	1.05	0.34	0.53	1.20	1.95	0.43	0.96
SD	0.80	0.79	2.07	3.28	0.97	1.34	0.86	0.82	2.31	3.63	1.05	1.40	0.71	0.74	1.59	2.53	0.83	1.24

to test the fit of the three-factor model of DBQ in six different countries. The fit of the model was evaluated by χ^2/degree of freedom ratio, root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and the root mean square residual (RMR). In general, good fit of model should have 2:1 or 5:1 χ^2/degree of freedom ratio, GFI > 0.90, AGFI > 0.90, CFI > 0.90 (preferably > 0.95), and RMSEA and RMR < 0.08 or 0.10 (preferably < 0.06) indexes (Byrne, 1998; Hu & Bentler, 1995, 1998, 1999; Russell, 2002).

The equivalence of the three-factor solution of DBQ in six countries were then assessed by comparing the rotated factor matrices by using Procrustes target rotation techniques and factorial agreement coefficients. In the present study, the British drivers were used as a target group and separate principal axis factoring with varimax rotation was run for each sample before calculating factorial agreement coefficients (see Lajunen et al., 2004 for detailed information). In general, values higher than 0.95 indicate factorial similarity, whereas values lower than 0.90 (van de Vijver & Leung, 1997) or 0.85 (ten Berge, 1986) are taken as a sign of non-negligible incongruities.

Cronbach's alpha reliability coefficients were calculated for assessing the internal consistency of the DBQ scale scores. The analysis of variance (ANOVA) was run to study whether there were significant differences between countries on DBQ item and scale scores after controlling the effect of age, sex, and annual mileage within the sample. In order to investigate the relationship between driving style and the number of traffic accidents across countries, the mediational hypothesis was tested using a series of regression models. Poisson and Poisson-gamma (or negative binomial) regression analyses were performed by using forward stepwise procedure (see Lord, Washington, & Ivan, 2005) in order to examine the relationship between driving style and the number of traffic accidents in each country. The level of $p < 0.05$ was considered as the cut-off value for significance. In each of the analyses, age, sex, and annual mileage were forced into the model to control for their effect. Then, DBQ subscales (aggressive violations, ordinary violations, and errors) were entered.

3. Results

3.1. Confirmatory factor analyses

Confirmatory factor analyses were run to test the fit of the three-factor model (or construct validity) of DBQ in six different countries. The model used in confirmatory factor analyses is presented schematically for the British sample in Fig. 1 and the same model was also used for other samples. Fig. 1 shows that driving style can be explained by three inter-correlated factors including 19 observed variables. Each observed variable loaded only on one single factor in the following pattern: items 3, 11, and 17 loaded on aggressive violations, items 1, 2, 4, 5, 8, 9, 10, and 18 loaded on errors, and items 6, 7, 12, 13, 14, 15, 16, and 19 loaded on ordinary violations. Measurement errors related to each observed variable were uncorrelated in the model (see Fig. 1). The fit indices and 'item loadings' for six countries are listed in Table 2. In the British sample, for instance, the item loadings for three items on the aggressive violations factor ranged from 0.59 to 0.79. For errors factor, the item loadings ranged from 0.42 to 0.63, and from 0.48 to 0.68 for the aggressive violations factor (see Table 2 and for also other samples). As presented in Table 2, some values of fit indexes are, in general, low except for Great Britain and Netherlands. The results indicated that items 4 (E3) and 6 (OV1) had generally the lowest item loadings across the six countries.

It should be noted, however, that it would have been possible to improve the fit of the three-factor model of DBQ in each country by taking into account modification indices. However, re-specification or re-estimation of the model with modifications would belong to an exploratory rather than a confirmatory approach, and, therefore, were considered inappropriate for this study in which the fit of the original "global" structure was of interest.

3.2. Target rotation and agreement coefficients

Factorial agreement coefficients for the rotated factor matrices were calculated to assess the equivalence of the three-factor solution of DBQ (or content validity) in six countries. The values of these indexes are listed in Table 3. It shows that the most widely applied index, i.e. coefficient of proportionality (Tucker's phi), and the

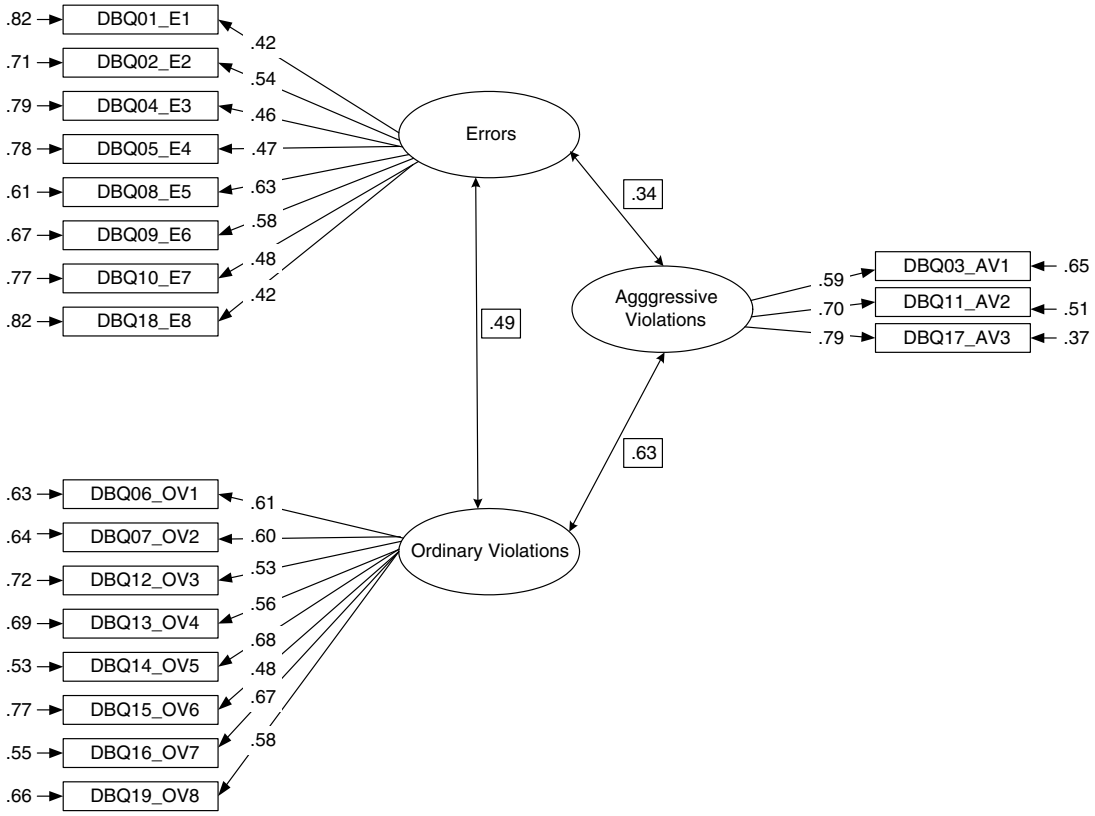

Fig. 1. Original DBQ structure in the British sample.

most stringent index (identity coefficient) both indicated high similarity although not full identity between the British and all other samples especially for ordinary violations (and the errors factor of the Greek DBQ) but not for the aggressive violations. The values for additivity index and correlation coefficient were somewhat lower (even <0.85), especially for the errors and aggressive violations factors.

3.3. Reliability analysis

Alpha reliability coefficients for the DBQ scales for six nationalities were calculated to test internal consistency. They are also listed in Table 2. In all six samples, ''ordinary'' violations scale seemed to be the most internally consistent ($\alpha = 0.73$–0.85) whereas both the ''errors'' ($\alpha = 0.61$–0.75) and ''aggressive'' ($\alpha = 0.59$–0.74) violations scales had the lowest alpha coefficients. DBQ scale scores had the highest reliability coefficients in Great Britain and Turkey and lowest in Iran and the Netherlands.

3.4. Comparison of countries on DBQ item and sub-scale scores

Analysis of variance (ANOVA) was run to test the significant differences between countries on DBQ items and scale scores. The results of ANOVA yielded significant differences between countries on DBQ item and scale scores (see Table 4). Greek drivers reported themselves committing aggressive violations more often than other nationalities, especially behaviours indicating their annoyance and hostility to other road users. British, Dutch, and Finnish drivers had the lowest scores on aggressive violations scale. Iranian and Turkish drivers' scores on aggressive violations scale were between Greeks and British/Dutch/Finnish drivers.

As compared to Greek and Turkish drivers, British, Dutch, Finnish, and Iranian drivers had significantly higher scores on ordinary violations scale. It seems that item 19 (OV8), ''speeding on a motorway'', clearly

Table 2
The results of confirmatory factor analyses of three-factor solution: item loadings, alpha values, fit indexes, chi-square, and degree of freedom values across the six countries

Item No. and factor	FIN	GB	GR	IRN	NL	TR
Aggressive violations						
03_AV1	0.62	0.59	0.64	0.46	0.55	0.43
11_AV2	0.70	0.70	0.58	0.65	0.62	0.80
17_AV3	0.83	0.79	0.77	0.55	0.89	0.74
Cronbach alpha	0.74	0.72	0.69	0.59	0.67	0.67
Errors						
01_E1	0.43	0.42	0.59	0.22	0.49	0.63
02_E2	0.62	0.54	0.47	0.35	0.55	0.67
04_E3	0.50	0.46	0.14	0.29	0.22	0.32
05_E4	0.32	0.47	0.48	0.62	0.35	0.60
08_E5	0.53	0.63	0.49	0.53	0.59	0.71
09_E6	0.63	0.58	0.57	0.61	0.60	0.74
10_E7	0.64	0.48	0.54	0.64	0.54	0.63
18_E8	0.56	0.42	0.42	0.28	0.45	0.54
Cronbach alpha	0.74	0.70	0.67	0.66	0.61	0.75
Ordinary violations						
06_OV1	0.19	0.61	0.54	0.57	0.23	0.69
07_OV2	0.63	0.60	0.70	0.20	0.60	0.69
12_OV3	0.58	0.53	0.40	0.58	0.57	0.61
13_OV4	0.47	0.56	0.55	0.53	0.48	0.63
14_OV5	0.66	0.68	0.70	0.72	0.55	0.70
15_OV6	0.49	0.48	0.74	0.74	0.48	0.70
16_OV7	0.53	0.67	0.66	0.49	0.44	0.61
19_OV8	0.64	0.58	0.57	0.52	0.72	0.63
Cronbach alpha	0.76	0.80	0.82	0.75	0.73	0.85
χ^2 (df = 149)	412.51	303.33	345.13	341.01	249.63	469.31
RMSEA	0.08	0.06	0.07	0.07	0.05	0.09
GFI	0.85	0.88	0.87	0.87	0.90	0.83
AGFI	0.81	0.85	0.83	0.84	0.87	0.78
CFI	0.79	0.86	0.84	0.80	0.87	0.83
RMR	0.08	0.06	0.07	0.07	0.07	0.08

Note: A good fit of model should, in general, have 2:1 or 5:1 χ^2/df, GFI > 0.90, AGFI > 0.90, CFI > 0.90, and RMSEA and RMR < 0.10 (preferably <0.05) indexes.

divided countries into two categories, which could be labelled as ''safe'' and ''dangerous''. British drivers had the highest score both on this item and on item 6 (OV1), ''pulling out, and forcing your way out''. Dutch drivers' committed driving behaviour described in item 14 (OV5: ''racing from traffic lights'') most frequently. Finnish drivers committed driving behaviour described by item 7 (OV2) (''speeding in residential area''), 15 (OV6) (''close following''), and 16 (OV7) (''shooting lights'') most frequently. Iranian drivers committed driving behaviour described by item 12 (OV3) (''pushing in at last minute'') and by item 13 (OV4) (''overtaking a slow driver on the inside'') most frequently.

As compared to British, Dutch, and Finnish drivers, Iranian and Turkish drivers had significantly higher scores on the errors scale. Greek drivers did not differ from any of these groups on the errors scale score. Except for the driving behaviour described by item 4 (E3) (''failing to check your rear-view mirror'') and by item 5 (E4) (''braking too quickly on a slippery road''), Iranian drivers had the highest scores on all errors items.

3.5. Mediational model and regression analyses

As suggested by Baron and Kenny (1986), the mediational hypothesis was tested using a series of regression models in order to investigate whether different driving styles can explain differences in accident risk across the

Table 3
Four identity indexes for three factor solutions of the DBQ in five countries (British sample is the target group)

DBQ factors	Countries	Identity coefficient	Additivity coefficient	Proportionality coefficient	Correlation coefficient
Ordinary violations	FIN	0.93	0.77	0.92	0.77
	GR	0.93	0.78	0.94	0.78
	IRN	0.93	0.78	0.93	0.79
	NL	0.94	0.91	0.95	0.91
	TR	0.91	0.72	0.92	0.72
Errors	FIN	0.82	0.48	0.83	0.49
	GR	0.91	0.68	0.91	0.68
	IRN	0.88	0.64	0.88	0.64
	NL	0.85	0.61	0.86	0.63
	TR	0.83	0.48	0.85	0.49
Aggressive violations	FIN	0.69	0.43	0.70	0.44
	GR	0.59	0.14	0.60	0.14
	IRN	0.87	0.74	0.89	0.77
	NL	0.73	0.50	0.74	0.50
	TR	0.83	0.60	0.83	0.62

Note: In general, values higher than 0.95 indicate factorial similarity, whereas values lower than 0.90 or 0.85 are taken as a sign of non-negligible incongruities.

Table 4
The means of DBQ items after controlling the effects of age, mileage, and sex, and ANOVA results (F) in the six countries

DBQ items (item number)	FIN	GB	GR	IRN	NL	TR	$F(7,1452)$	Eta^2
Aggressive violations	0.78^{a}	0.86^{a}	1.66^{c}	1.33^{b}	0.67^{a}	1.20^{b}	40.69^{***}	0.124
Sound horn to indicate your annoyance (03)	1.00^{a}	1.29^{a}	2.39^{c}	1.75^{b}	1.07^{a}	1.89^{b}	40.73^{***}	0.124
Get angry, give chase (11)	0.71^{cb}	0.32^{ab}	0.56^{b}	1.17^{d}	0.18^{a}	0.61^{cb}	31.61^{***}	0.099
Aversion, indicate hostility (17)	0.64^{a}	0.96^{bc}	2.06^{d}	1.09^{cb}	0.76^{ab}	1.12^{cb}	38.16^{***}	0.117
Ordinary violations	1.21^{b}	1.20^{b}	0.88^{a}	1.21^{b}	1.19^{b}	0.94^{a}	11.33^{***}	0.038
Pull out, force your way out (06)	0.34^{a}	0.99^{d}	0.62^{bc}	0.79^{cd}	0.54^{ba}	0.58^{bc}	16.77^{***}	0.055
Disregard the speed limit on a residential road (07)	2.51^{e}	1.69^{bc}	1.18^{a}	2.12^{d}	1.88^{cd}	1.44^{ab}	29.52^{***}	0.093
Push in at last minute (12)	0.49^{a}	0.60^{a}	0.47^{a}	1.15^{b}	0.73^{a}	0.64^{a}	15.81^{***}	0.052
Overtake a slow driver on the inside (13)	0.32^{a}	0.86^{b}	0.89^{b}	1.45^{c}	1.03^{b}	1.42^{c}	35.20^{***}	0.109
Race from lights (14)	1.35^{bc}	1.31^{b}	1.04^{ba}	0.84^{a}	1.66^{c}	0.83^{a}	17.03^{***}	0.056
Close following (15)	1.40^{b}	0.92^{a}	0.85^{a}	1.21^{b}	0.82^{a}	0.68^{a}	18.12^{***}	0.059
Shooting lights (16)	1.09^{c}	0.85^{bc}	0.66^{ab}	0.77^{ab}	0.55^{a}	0.63^{ab}	10.30^{***}	0.034
Disregard the speed limit on a motorway (19)	2.16^{b}	2.41^{b}	1.31^{a}	1.35^{a}	2.31^{b}	1.29^{a}	33.53^{***}	0.104
Errors	0.53^{a}	0.52^{a}	0.62^{ba}	1.02^{c}	0.56^{a}	73^{b}	35.31^{***}	0.109
Queuing, nearly hit car in front (01)	0.62^{a}	0.68^{a}	0.59^{a}	1.12^{b}	0.55^{a}	0.67^{a}	13.80^{***}	0.046
Fail to see pedestrians crossing (02)	0.80^{b}	0.47^{a}	0.67^{ab}	1.10^{c}	0.59^{ab}	0.63^{ab}	14.73^{***}	0.049
Fail to check your rear-view mirror (04)	0.80^{bac}	0.77^{ba}	0.54^{a}	1.15^{c}	0.94^{bc}	1.50^{dc}	15.03^{***}	0.050
Brake too quickly on a slippery road (05)	0.59^{a}	0.69^{ba}	0.67^{ba}	0.83^{b}	0.66^{ba}	0.83^{b}	3.39^{**}	0.011
Turning right nearly hit cyclist (08)	0.22^{a}	0.30^{ba}	0.51^{b}	0.95^{c}	0.39^{ba}	0.45^{b}	28.32^{***}	0.089
Miss "Give Way" signs (09)	0.26^{a}	0.25^{a}	0.60^{cb}	0.86^{d}	0.32^{ab}	0.47^{b}	22.89^{***}	0.074
Attempt to overtake someone turning left (10)	0.23^{a}	0.24^{a}	0.51^{b}	0.74^{c}	0.34^{ba}	0.48^{b}	16.65^{***}	0.055
Underestimate the speed of an oncoming vehicle (18)	0.74^{a}	0.75^{a}	0.84^{a}	1.45^{b}	0.67^{a}	0.81^{a}	23.34^{***}	0.075

Note: Bonferroni correction was used for pairwise comparisons. Mean values with different superscripts within rows are statistically different at $p < 0.05$ or better and the scaling of DBQ items are; 0 = never, 1 = hardly ever, 2 = occasionally, 3 = quite often, 4 = frequently, and 5 = nearly all the time.
** $p < 0.01$.
*** $p < 0.001$.

six countries. First, the mediators (aggressive violations, ordinary violations, and errors) were regressed on the independent variable (IV) (country as dummy coded variables for each country) to see whether the IV has a significant effect on the mediator. Second, the dependent variable (DV) (the number of traffic accidents) was

regressed on the IV to check whether the IV has a significant effect on the DV in the absence of the mediator. Third, the DV was regressed on the mediator variable (MV) in order to understand whether the MV has a significant unique effect on the DV. Fourth, the DV was regressed on both the IV and the MV using simultaneous entry in a regression model to see whether the effect of the IV on the DV shrinks when the MV is added into the model (see Preacher & Leonardelli, 2001). Unstandardized b coefficients for each step can be compared by either examining significance values or using Sobel's (1982) test of significance (see Preacher & Hayes, 2004 for SPSS and SAS macros for the calculation).

In order to establish conditions necessary for the mediational model, first, the mediators (aggressive violations, ordinary violations, and errors) were regressed on the IV. Country scores predicted aggressive violations scores [$B = -0.36$, $t(1451) = -5.40$, $p < 0.001$ for Finland; $B = -0.28$, $t(1451) = -4.14$, $p < 0.001$ for Great Britain; $B = 0.73$, $t(1451) = 11.28$, $p < 0.001$ for Greece; $B = 0.32$, $t(1451) = 4.85$, $p < 0.001$ for Iran; $B = -0.55$, $t(1451) = -8.31$, $p < 0.001$ for the Netherlands; $B = 0.13$, $t(1451) = 1.97$, $p < 0.05$ for Turkey], accounting for 2%, 1%, 8%, 1.6%, 4.6%, and 0.5% of the variance, respectively. Country scores predicted ordinary violations scores (except for the Netherlands) [$B = 0.12$, $t(1451) = 2.35$, $p < 0.05$ for Finland; $B = 0.11$, $t(1451) = 2.09$, $p < 0.05$ for Great Britain; $B = -0.21$, $t(1451) = -4.12$, $p < 0.001$ for Greece; $B = 0.32$, $t(1451) = 4.85$, $p < 0.001$ for Iran; $B = -0.22$, $t(1451) = -4.26$, $p < 0.001$ for Turkey], accounting for 0.5%, 0.5%, 1%, 0.6%, and 1.2 of the variance, respectively. Country scores predicted errors scores (except Greece and Turkey) [$B = -0.16$, $t(1451) = -4.31$, $p < 0.001$ for Finland; $B = -0.18$, $t(1451) = -4.92$, $p < 0.001$ for Great Britain; $B = 0.45$, $t(1451) = 12.46$, $p < 0.001$ for Iran; $B = -0.15$, $t(1451) = -3.88$, $p < 0.001$ for the Netherlands], accounting for 1.3%, 1.6%, 10%, and 1% of the variance, respectively.

Second, the number of traffic accidents (DV) was regressed on the country (IV). Country scores predicted the number of traffic accidents (except Turkey) [$B = -0.87$, $t(1451) = -6.45$, $p < 0.001$ for Finland; $B = -0.72$, $t(1451) = -5.33$, $p < 0.001$ for Great Britain; $B = 0.52$, $t(1451) = 3.81$, $p < 0.001$ for Greece; $B = 1.88$, $t(1451) = 14.63$, $p < 0.001$ for Iran; $B = -0.68$, $t(1451) = -4.96$, $p < 0.001$ for the Netherlands], accounting for 2.8%, 1.9%, 1%, 13%, and 1.7% of the variance, respectively.

Third, the number of traffic accidents (DV) was regressed on the MVs (aggressive violations, ordinary violations, and errors). Aggressive violations, ordinary violations, and errors predicted the number of accidents [$B = 0.34$, $t(1451) = 6.38$, $p < 0.001$; $B = 0.18$, $t(1451) = 2.66$, $p < 0.01$; $B = 0.72$, $t(1451) = 7.74$, $p < 0.001$], accounting for 2.7%, 0.5%, and 4% of the variance, respectively.

Fourth, the number of traffic accidents (DV) was regressed on both country (IV) and the MVs (aggressive violations, ordinary violations, and errors) using simultaneous entry in a regression model. It was hypothesized that the relationship between country and the number of traffic accidents would be mediated by driving styles. When both country and aggressive violations were entered into the same model predicting the number of traffic accidents, country scores continued to predict significantly the number of traffic accidents [$B = -0.77$, $t(1452) = -5.66$, $p < 0.001$ for Finland; $B = -0.64$, $t(1451) = -4.72$, $p < 0.001$ for Great Britain; $B = 0.30$, $t(1451) = 2.12$, $p < 0.05$ for Greece; $B = 1.80$, $t(1451) = 14.07$, $p < 0.001$ for Iran; $B = -0.51$, $t(1451) = -3.73$, $p < 0.001$ for the Netherlands]. Sobel test scores indicated that the aggressive violations partially mediated the influence of the country scores on the number of traffic accidents in Finland ($z = -4.11$, $p < 0.001$), in Great Britain ($z = -3.47$, $p < 0.001$), in Greece ($z = 5.53$, $p < 0.001$), in Iran ($z = 3.85$, $p < 0.001$), and in the Netherlands ($z = -5.05$, $p < 0.001$).

When both country and ordinary violations were entered into the same model for predicting the number of traffic accidents, country scores predicted significantly the number of traffic accidents [$B = -0.90$, $t(1452) = -6.65$, $p < 0.001$ for Finland; $B = -0.75$, $t(1451) = -5.50$, $p < 0.001$ for Great Britain; $B = 0.56$, $t(1451) = 4.13$, $p < 0.001$ for Greece; $B = 1.86$, $t(1451) = 14.46$, $p < 0.001$ for Iran; $B = -0.51$, $t(1451) = -3.73$, $p < 0.001$ for the Netherlands]. However, Sobel test scores indicated that the ordinary violations partially mediated the influence of the country scores on the number of traffic accidents only in Greece ($z = -2.23$, $p < 0.05$) and Iran ($z = 2.01$, $p < 0.001$).

When both country and errors were entered into the same model predicting the number of traffic accidents, country scores predicted significantly the number of traffic accidents [$B = -0.77$, $t(1452) = -5.71$, $p < 0.001$ for Finland; $B = -0.60$, $t(1451) = -4.46$, $p < 0.001$ for Great Britain; $B = 1.72$, $t(1451) = 12.79$, $p < 0.001$ for Iran; $B = -0.57$, $t(1451) = -4.28$, $p < 0.001$ for the Netherlands]. Sobel test scores showed that the errors partially mediated the influence of the country scores on the number of traffic accidents in Finland ($z = -3.81$,

Table 5
Poisson and negative binomial regression analyses on the number of accidents with DBQ subscales

Variables	Incidence rate ratios (IRR)	Std. Err.	Z Value	(95% Conf. interval)
FIN			Pseudo $R^2 = 0.13$	
Age	0.95	0.01	-3.31^{***}	0.92–0.98
Annual mileage	1.01	0.00	2.56^{**}	1.00–1.02
Aggressive violations	1.46	0.12	4.57^{***}	1.24–1.71
GB			Pseudo $R^2 = 0.02$	
Age	0.97	0.01	-2.63^{**}	0.95–0.99
GR			Pseudo $R^2 = 0.02$	
Age	1.03	0.01	3.42^{***}	1.01–1.05
IRN			Pseudo $R^2 = 0.06$	
Age	1.03	0.01	4.78^{***}	1.02–1.05
Annual mileage	1.00	0.00	3.17^{**}	1.00–1.00
Aggressive violations	1.25	0.08	3.19^{***}	1.09–1.44
NL			Pseudo $R^2 = 0.03$	
Annual mileage	1.01	0.00	2.77^{**}	1.00–1.02
TR			Pseudo $R^2 = 0.02$	
Errors	1.59	0.22	3.28^{***}	1.20–2.10

** $p < 0.01$.
*** $p < 0.001$.

$p < 0.001$), in Great Britain ($z = -4.18$, $p < 0.001$), in Iran ($z = 6.56$, $p < 0.001$), and in the Netherlands ($z = -3.51$, $p < 0.001$).

3.6. Regression analyses: Poisson and negative binomial regression models

Poisson or negative binomial regression analyses were run to test the relationship driving style and the number of traffic accidents in each country. First, model testing was run to understand which model would fit better to the distribution of the number of accidents in each country. The results of analyses revealed that the Poisson regression model was appropriate for the total number of traffic accidents in British ($\chi^2(238) = 256.56$, $p > 0.05$) and Finnish ($\chi^2(237) = 224.79$, $p > 0.05$) samples. Negative binomial model was, on the other hand, appropriate for the total number of traffic accidents in Dutch ($\chi^2(236) = 301.30$, $p < 0.01$), Greek ($\chi^2(238) = 527.6$, $p < 0.001$), Persian ($\chi^2(237) = 654.42$, $p < 0.001$), and Turkish ($\chi^2(236) = 399.58$, $p < 0.001$) samples.

As shown in Table 5, age was negatively related to the total number of accidents in British and Finnish samples whereas it was positively related to the total number of accidents in Greek and Iranian samples. Annual mileage was significantly associated with the number of accidents in Dutch, Finnish, and Iranian samples. After controlling the effect of age, sex, and annual mileage, results indicated that the accident rate of Finnish and Iranian drivers became 1.46 (increased by 46%) and 1.25 (increased by 25%) times higher with each increment of one unit in aggressive violations, respectively. The accident rate of Turkish drivers became 1.59 (increased by 59%) times higher with each unit increment in errors.

4. Discussion

4.1. DBQ across six countries: factor structure, equivalence, and consistency

In the present study, the results of the confirmatory factor analyses indicated that some values of fit indexes were, in general, low except for Great Britain and The Netherlands. It seems that the three-factor structure of DBQ is applicable but not firmly stable in every country included in the study. It is obvious that the countries

involved in the study represent very different types of traffic cultures, level of motorization, and cultures in general, and matched sample characteristics (e.g., sex and age) in particular. It was assumed that cultural context (Shinar, 1998), or in other words, social context (Reason, 1990; Reason et al., 1990) would influence the driving style. In addition, social context seems to influence different components of driving styles in different degrees. The factorial agreement was incongruent for aggressive violations and errors (except for Greek drivers). The interpretation of errors and aggressive violations factors differs from country to country. Shinar (1998) suggested that aggressive driving would be highly influenced by cultural context. In addition, it is known that violations, in general, are influenced by contextual factors (Reason et al., 1990). By the original definition (Reason et al., 1990), however, errors were seen as mainly related to cognitive processes of the individual. The results of the present study, on the other hand, remind us about the interaction between individual and environment. Errors may occur even in the absence of any cognitive deficiencies because of the lack of supportive social and physical context.

Some alpha reliability coefficients seemed unacceptably low although the reliability coefficients were still at the same level as those found in previous DBQ studies. Low reliability coefficients might be related to the small number of items in some scales (e.g., aggressive violations). Moreover, driving behaviours in general, and questionnaire items in particular, could be interpreted differently in different countries. For example, ''honking'' clearly reflects aggression in Scandinavia whereas in Southern Europe and Iran, drivers use their horn frequently to give a variety of messages, such as thanking other drivers (Lajunen et al., 2004). On the other hand, drivers saw many items in the same way from all six countries included in the study. For instance, the results of factor analyses indicated that DBQ factor structure could be improved by revising and/or replacing item 4 (E3) (''failing to check your rear-view mirror before pulling out, changing lanes, etc.'') and/or 6 (OV1) (''pulling out of a junction so far that the driver with right of way has to stop and let you out'') almost in every country. As suggested by Lajunen et al. (2004), it might be better to develop ''nation-specific items'' and use ''national scoring keys'' together with ''core DBQ items'' for comparisons.

4.2. Differences in driving style between countries

As hypothesized, the vast difference between the Southern and Northern Europe in traffic culture and level of safety was reflected in driving behaviour. The results of analysis of variance revealed that drivers from ''safe'' Western/Northern European countries scored higher on the ordinary violations, especially on ''speeding on a motorway'' item, than drivers from ''dangerous'' Southern European/Middle Eastern countries. In contrast, drivers from ''dangerous'' countries scored higher on aggressive violations and errors than drivers from ''safe'' countries. Aggressive violations contain an interpersonally aggressive component. It is possible that the Southern traffic context is more prone to interpersonal conflicts, because of less developed infrastructure, lack of respect for rules and problems with enforcement. Ambiguities in traffic environment and enforcement increase the likelihood of conflicts, which in turn, may increase the general stress level and likelihood of errors in traffic, especially in Iran. Western European drivers reported more ordinary violations than Southern Europeans. This might either reflect reality or the fact that drivers in ''safe'' countries with strong enforcement are more aware of their behaviour and ''ordinary violations'' as risky and illegal behaviour. In Turkey, for example, the speed of traffic flow on many roads is much higher than the speed limit. Consequently, drivers do not see their speeding as a serious offence as the Western Europeans might do. It is also likely that enforcement targets different types of violations in different countries. For example, British drivers had the highest score on ''speeding on a motorway'' item 19 (OV8) whereas Dutch drivers' most frequently ''race from lights'' 14 (OV5).

4.3. Mediator role of driving style in accident risk across countries

Findings demonstrated that addition of driving styles (especially aggressive violations and errors) not only improved the models for predicting the number of traffic accidents, but also mediated the relationship between culture/country and accidents. Thus, driving style can explain differences in accident risk across countries to some extend.

4.4. Relationship between demographic characteristics, driving styles, and the number of traffic accidents in each country

Consistent with the previous studies, (e.g., Reason et al., 1990), age emerged as an important factor in accident involvement. However, the findings were mixed. Age was negatively related to the number of accidents in British and Finnish samples whereas its relationship to accidents was positive in Greek and Iranian samples. These differences can be due to different licensing practices and differences in driver populations in terms of age and exposure.

The results of the present study showed that the type of relationship between driving behaviours and the number of traffic accidents varied from country to country. A significant relationship between aggressive violations and the number of accidents was found in Finland and Iran. Errors were significantly related to the number of accidents in Turkey. This might indicate that Turkish drivers drive with smaller safety margins, which do not allow corrective manoeuvres after an error, but rather lead to a crash. In contrast to previous findings (Parker, Reason et al., 1995; Parker, West et al., 1995), none of the DBQ factors predicted accident rates in Great Britain, Greece, and The Netherlands. Although an accident is most commonly an outcome of risky driving style, rather than another cause, it is a relatively rare event. Hence, not all risky behaviours result in an accident. In addition, low level of exposure (e.g., low mileage or short driving history of samples) might be the cause for the lack of relationship between accidents and the DBQ factors.

5. Conclusions

The present study showed that the three-factor structure of DBQ is applicable but not firmly stable in every country and some factors (e.g., aggressive violations) are sensitive to social context. Although two factor structure of DBQ based on errors and violations seems to be cross-culturally valid and stable over time (Lajunen et al., 2004; Özkan et al., 2006), it might still be better to develop both fine-tuned "national scoring keys" for domestic use and keep the "core DBQ items" for cross-cultural comparisons.

The results of the present study indicate that each country has its own problems in its traffic culture in addition to global problems like speeding. Therefore, pan-cultural regulations should also take into account the "local" characteristics and requirements. Southern European and Iranian traffic authorities should, for example, urgently focus on aggressive violations and errors. One of the means to lessen aggressive driver behaviour is to promote "positive driver behaviours" (Özkan & Lajunen, 2005) by media campaigns. Since positive driver behaviours, i.e. polite driving, have been reported to have a negative relationship to aggressive driving (Özkan & Lajunen, 2005), promotion of positive driving might eventually lead to improvement of "positive" traffic culture as well.

6. Limitations of the study

The present study has some methodological limitations that should be taken into account. First, the samples of the study did not represent countries' population, and the sample sizes were small. Second, the data were based solely on self-reports of behaviour. It is possible that some respondents embellished their answers by reporting low levels of violations (e.g., speeding) and errors (e.g., close following). Third, it is also possible that there might have been a larger gap between self-reported and actual driving behaviours in some countries where formal rules are partially replaced by informal ones. Björklund (2005) showed, for instance, that the gap between reported and observed behaviours was larger among experienced drivers than novices because of the "informal rules culture" internalized by the experienced drivers. It is possible, therefore, that drivers might behave according to informal rules in traffic but report according to formal rules. However, the respondents completed the questionnaires anonymously and could not gain anything by giving biased responses. Fourth, these findings also emphasize that great care should be taken when translating instruments, choosing the samples, and collecting data because differences in these procedures can be an important source of cross-cultural differences.

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Appendix. Driver Behaviour Questionnaire (DBQ) items

Aggressive violations

3. Sound your horn to indicate your annoyance to another road user (AV1).
11. Become angered by another driver and give chase with the intention of giving him/her a piece of your mind (AV2).
17. Become angered by a certain type of driver and indicate your hostility by whatever means you can (AV3).

Errors

1. Queuing to turn left onto a main road, you pay such close attention to the main stream of traffic that you nearly hit the car in front (E1).
2. Fail to notice that pedestrians are crossing when turning into a side street from a main road (E2).
4. Fail to your rear-view mirror before pulling out, changing lanes etc. (E3).
5. Brake too quickly on a slippery road, or steer the wrong way in a skid (E4).
8. On turning left, nearly hit a cyclist who has come up on your inside (E5).
9. Miss ''Give Way'' signs, and narrowly avoid colliding with traffic having right of way (E6).
10. Attempt to overtake someone that you hadn't noticed to be signalling a right turn (E7).
18. Underestimate the speed on an oncoming vehicle when overtaking (E8).

Ordinary violations

6. Pull out of a junction so far that the driver with right of way has to stop and let you out (OV1).
7. Disregard the speed limit on a residential road (OV2).
12. Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane (OV3).
13. Overtake a slow driver on the inside (OV4).
14. Race away from traffic lights with the intention of beating the driver next to you (OV5).
15. Drive so close to the car in front that it would be difficult to stop in an emergency (OV6).
16. Cross a junction knowing that the traffic lights have already turned against you (OV7).
19. Disregard the speed limit on a motorway (OV8).

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