



## Age, gender, mileage and the DBQ: The validity of the Driver Behavior Questionnaire in different driver groups

Martinussen, Laila Marianne; Hakamies-Blomqvist, Liisa; Møller, Mette; Özkan, Türker ; Lajunen, Timo

*Published in:*  
Accident Analysis & Prevention

*Link to article, DOI:*  
[10.1016/j.aap.2012.12.036](https://doi.org/10.1016/j.aap.2012.12.036)

*Publication date:*  
2013

*Document Version*  
Peer reviewed version

[Link back to DTU Orbit](#)

*Citation (APA):*  
Martinussen, L. M., Hakamies-Blomqvist, L., Møller, M., Özkan, T., & Lajunen, T. (2013). Age, gender, mileage and the DBQ: The validity of the Driver Behavior Questionnaire in different driver groups. *Accident Analysis & Prevention*, 52, 228-236. <https://doi.org/10.1016/j.aap.2012.12.036>

---

### General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

# **Age, gender, mileage and the DBQ: the validity of the Driver Behaviour Questionnaire in different driver groups**

Laila M. Martinussen<sup>a\*</sup>, Liisa Hakamies-Blomqvist<sup>b</sup>, Mette Møller<sup>a</sup>, Türker Özkan<sup>c</sup>,

Timo Lajunen<sup>c,d</sup>

<sup>a</sup> DTU Transport, Bygningstorvet 115, DK-2800 Kgs, Lyngby, Denmark

<sup>b</sup> Culture and Society, Academy of Finland, Hakaniemenranta 6, POB 131, FI-00531 Helsinki,  
Finland

<sup>c</sup> Department of Psychology, Middle East Technical University (ODTÜ), Inonu Bulvari, 06531  
Ankara, Turkey

<sup>d</sup> Department of Psychology, Norwegian University of Science and Technology (NTNU), 7491  
Trondheim, Norway

---

\*Corresponding author. Tel. +45 45 25 65 00; fax: +45 45 93 65 33

*E-mail address:* laima@transport.dtu.dk (L. M. Martinussen).

## **Abstract**

The Driver Behavior Questionnaire (DBQ) is one of the most widely used instruments for measuring self-reported driving behaviors. Despite the popularity of the DBQ, the applicability of the DBQ in different driver groups has remained mostly unexamined. The present study measured aberrant driving behavior using the original DBQ (Reason, J. T., Manstead, A., Stradling, S G., Baxter, J., Campbell, K., 1990. Errors and violations on the road – a real distinction. *Ergonomics*, 33 (10/11), 1315-1332) to test the factorial validity and reliability of the instrument across different subgroups of Danish drivers. The survey was conducted among 11,004 Danish driving license holders of whom 2250 male and 2190 female drivers completed the questionnaire containing background variables and the DBQ. Exploratory and confirmatory factor analysis showed that the original three-factor solution, a four-factor solution and a two-factor solution had acceptable fit when using the whole sample. However, fit indices of these solutions varied across subgroups. The presents study illustrates that both the original DBQ and a Danish four-factor DBQ structure is relatively stable across subgroups, indicating factorial validity and reliability of the DBQ. However, as the Danish DBQ structure has an overall better fit, the present study highlights the importance of performing an explorative analysis when applying the DBQ in order to assess the problem areas within a driving population.

*Keywords:* Driver Behavior Questionnaire (DBQ); factor structure; gender; age; mileage

## 1. Introduction

The classification of behavioral items in the Driver Behavior Questionnaire (DBQ) is based on Reasons theory, namely "generic error modeling system" (GEMS) (Reason, 1990). The original DBQ was designed and developed by Reason, Manstead, Stradling, Baxter, and Campbell (1990) to measure aberrant driving behavior with 50 items measuring lapses, errors and violations. Since then, it has become one of the most widely used instruments for measuring both driving style (Bener et al., 2006) and the relationship between driving behavior and crash involvement (for a review see: de Winter and Dodou, 2010).

The DBQ has over the years been applied in numerous countries for example; Qatar and United Arab Emirates (Bener et al., 2008), USA (Owsley et al., 2003), China (Xie and Parker, 2002), Australia (Blockey and Hartley, 1995; Davey et al., 2007; Dobson et al., 1999; Lawton et al., 1997), Sweden (Rimmö and Hakamies-Blomqvist, 2002; Åberg and Rimmö, 1998; Åberg and Warner, 2008), Greece (Kontogiannis et al., 2002), The Netherlands (Lajunen et al., 1999), Spain (Gras et al., 2006), France (Obriot-Claudé and Gabaude, 2004), New Zealand (Sullman et al., 2000), Turkey (Özkan and Lajunen, 2005; Sümer, 2003), and UK (Parker et al., 1995; Reason et al., 1990). However, the factorial structures of the DBQ as well as the number of items vary between different driving cultures and nations.

Many studies have found support for the original three-factor structure consisting of *lapses, errors and violations* (Dobson et al., 1999; Kontogiannis et al., 2002; Reason et al., 1990; Åberg and Rimmö, 1998). Others have found that aggressive violations, ordinary violations and lapses were applicable, although not firmly stable across countries (Warner et al., 2011). Similar results have been obtained in Australia by Lawton et al. (1997) and Davey et al. (2007) who found support for errors, highway-code violations and interpersonal aggressive violations. However, also

within Australian drivers Blockey and Hartley (1995) found a different factor structure consisting of general errors, dangerous errors and dangerous violations in their DBQ study.

In addition to the content of the factors, the number of factors has also varied between studies; Hennessy and Wiesenthal (2005) and Sümer (2003) reported fewer factors and Kontogiannis et al., (2002), and Parker et al. (2000) more factors than in the original DBQ, which might partly reflect the number and different item contents. The most common besides the original three-factor structure seems to be the four-factor solution (Mesken et al., 2002; Lajunen et al., 2004; Rimmö, 2002, Xie and Parker, 2002). Despite cross-cultural differences, the important distinction between unintended errors and intended violations has been found in most studies (Warner et al., 2010; Kontogiannis et al., 2002; Blockey and Hartley, 1995; Lajunen et al., 2004; Parker et al., 1998; Rimmö and Hakamies-Blomqvist, 2002; Rimmö and Åberg, 1999; Sullman, Meadows, and Pajo, 2002; Özkan et al., 2006a; Warner, 2006). The distinction between errors and violations also seems to be stable over time (Özkan et al., 2006b). Moreover, the literature also reports variations in driving style among subgroups such as age, gender and annual mileage (Lawton et al., 1997; Reason et al., 1990; Rimmö 2002; Rimmö and Hakamies-Blomqvist, 2002; Åberg and Rimmö, 1998).

Despite the popularity of the DBQ (de Winter and Dodou, 2010, reports 174 studies using some version of the DBQ), no study so far has tested the fit of the original DBQ model across driver subgroups. Only two studies have employed confirmatory factor analysis (CFA) to test the factorial validity of the DBQ (Rimmö, 2002; Özkan et al., 2006a). Özkan et al. (2006a) used CFA to test the applicability of a three-factor model (aggressive violations, ordinary violations and errors) across six countries. Rimmö (2002) investigated the fit of the Swedish DBQ (DBQ-SWE) across different driver subgroups: new drivers, inexperienced drivers, young drivers and experienced drivers. However, Rimmö focused mainly on young drivers and did not make any

distinction between drivers aged from 28 to 70. In addition, the DBQ-SWE includes only 32 items from Reason et al.'s original 50 item DBQ. It would therefore be pertinent to test the fit of the original DBQ in different drivers groups, as Reason et al.'s DBQ is the original from which all other versions have been derived, and also because it has been suggested that different driver subgroups could best be tested with different DBQ versions (Rimmö, 2002).

The first aim of the present study was to investigate if the distinction between errors and violations were present in the sample of Danish drivers as this structure seems to be the most stable across studies. The second aim was to develop a country specific "Danish DBQ" which could be used in further studies of aberrant driver behavior in Denmark. The third aim was to investigate the applicability of the three different DBQ structures (the two-factor structure, the original three-factor structure and the Danish factor structure) among different driver subgroups.

## **2. Method**

### *2.1. Participants and procedure*

Drivers with a type B driver license (Danish license for personal car) were randomly selected from the Danish Driving License Register. The sample was stratified by age and gender to include 1,572 drivers in each of the following seven age groups; 18-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-84 years (respectively 786 men and women in each age group). The questionnaire together with a cover letter and a freepost return envelope were sent by post to all 11,004 selected participants. A web address that the respondents could use to reply was also included. Two reminders were sent. The total response rate was 44 percent. Of the 4,849 responses, 4,335 persons had fully completed the DBQ. Participants responded to the questionnaire

anonymously. The Danish Data Protection Agency had approved the survey. Sample characteristics can be found in Table 1.

---

Insert Table 1 about here

---

## *2.2. Measures*

The DBQ and demographic measures were combined into one questionnaire as part of a larger study. Respondents answered questions about age and gender, as well as last year's annual driving distance. The original Driver Behavior Questionnaire (Reason et al., 1990) was translated into Danish using the back-translation method. The drivers were asked, using the standard DBQ instructions (see Reason et al., 1990), to indicate on a six-point Likert scale (0 = never and 5 = nearly all the time) how often they performed each of the 50 driving behaviors. Since Reason et al. (1990) only reported items which had factor loadings above 0.50, only 27 of the original 50 items were in the current study used as "the original DBQ".

## *2.3. Statistical analysis*

Exploratory factor analysis (EFA, principal axis with oblimin rotation) and confirmatory factor analyses (CFA, LISREL with maximum likelihood estimation) were performed in order to examine the underlying dimensions and the model fit (see Russell, 2002 for detailed information regarding confirmatory and exploratory analysis). In the EFA, scree plots, interpretability of the factors, and parallel analysis were used to determine the number of factors to be extracted as the Danish DBQ. In addition, an EFA with a forced two-factor solution was performed. A CFA was carried out in order to examine the fit of the model established in the EFA, the simpler two-factor model, as well as the original DBQ (1990) structure in the whole sample and across subgroups. In line with Hu and Bentler (1999) and Bryne (2001) the fit of the models was evaluated by  $\chi^2$ /degree of freedom ratio, root mean square error of approximation (RMSEA), comparative fit index (CFI) and standardized

root mean square residual (SRMR). A good fit model should have 2:1 or 5:1  $\chi^2$ /degree of freedom ratio, CFI > 0.90 (preferably > 0.95), and RMSEA < 0.08 or 0.10 (preferably < 0.05), and SRMR < .08 (preferably < .05) indexes (Bryne, 2001; Hu and Bentler, 1999; Russell, 2002).

### 3. Results

#### 3.1. Factor structure in the current sample

The first analysis was performed using an EFA with principal axis factoring. Direct oblimin (oblique) rotation was used, since the correlation between the factors ranged from 0.318 to 0.578. Parallel analysis revealed either a six- or a four-factor structure while the scree plot indicated a four-factor structure. The four-factor structure was found most interpretable. Thus, the three-factor structure of the original DBQ (Reason et al., 1990) was not supported by these analyses. The four factors explained 34.0% of the variance. Loadings less than 0.3 were omitted for the sake of clarity. Factor loadings of the four-factor structure can be seen in Table 2.

---

Insert Table 2 about here

---

#### 3.2 Fit of the three models

CFA were performed in order to test the fit of the original DBQ model, the Danish four-factor model revealed in the EFA, and the forced two-factor model. The two-, three and four-factor structures used in the analysis are schematically presented in Figures 1, 2 and 3, which respectively show two-, three and four factors that inter-correlate to explain aberrant driver behavior. No items loaded on more than one factor. The goodness of fit indices suggest satisfactory, but not perfect fit for all three structures in the whole sample, with a slightly better fit for the three- and four-factor solutions (*two-factor solution*: CFI 0.828, RMSEA 0.043, SRMR 0.045,  $\chi^2$ /df 7032.75/778; *three-*



*factor solution:* CFI 0.848, RMSEA 0.045, SRMR 0.043;  $\chi^2/df$  3197.76/321; *four-factor solution;* CFI 0.848, RMSEA 0.040; SRMR 0.046,  $\chi^2/df$  6207.81/773; see Table 3).

Furthermore, the three DBQ models were applied to the data consisting of different driver subgroups (see Table 3). Results suggest that the three- and the four-factor models had a reasonably good fit among older drivers (men and women analyzed separately) as well as a good fit in all annual mileage groups. The three- and the four-factor models had the poorest fit among the younger drivers. The two-factor model was generally less fitting than the two other factor models. The two-factor model had the poorest fit among young and middle-aged men and women. Fit indices are presented in Table 3 (correlation matrixes can be obtained upon request from the corresponding author). Looking at Table 3, one can see that the three-factor model had the best fit across sub-groups of drivers according to the CFI statistics, however, when looking at the RMSEA, the four-factor model had the best fit across groups. In general, and in all models, it was better fit among older than younger drivers.

---

Insert Table 3 about here

---

---

Insert Figures 1, 2 and 3 about here

---

### *3.3. Factor interpretability in both EFA and CFA*

In the Danish four-factor solution, mainly error and lapses items loaded on the first factor, which seems to contain an underlying structure of actions performed while unfocused; thus it can be named “unfocused errors/lapses”. The second factor can be labeled “emotional violations” as the loading items were violations triggered by emotional arousal. The third factor included violations and lapses. The underlying structure seems to be reckless behavior, and can thus be called “reckless violations/lapses”. In the fourth factor, the items represent errors and lapses characterized by confusion, and can therefore be called “confused error/lapses” (see Table 2 and Figure 1).

In the two-factor model, factor one contained mostly unintended errors and lapses and can therefore be labeled as “errors”. The second factor contained a mix of emotional and ordinary violations and could be labeled “violations” (see Table 2 and Figure 2).

### *3.4. Inter-correlations and reliability analysis in four- and two-factor solutions*

Correlations between the two violation factors and between the two the lapse factors were higher than between any of the violation factors and lapse factors.

Factor one, i.e., unfocused error/lapses, showed the highest internal consistency, whereas the factor three, reckless violations/lapses, had the lowest internal consistency. Factor two and four, emotional violations and confused error/lapses, respectively, both had acceptably high alpha values, 0.730 and 0.724 (Cortina, 1993), showing good internal consistency. Alpha values are also in line with the original study and other previous studies (Lajunen et al., 2004; Özkan et al., 2006a; Reason et al., 1990). Inter-correlations and alpha values for all three factor models can be seen in Table 5.

---

Insert Table 5 about here

---

## **4. Discussion**

Firstly, the EFA revealed a distinction between error/lapses and violations, thus clearly showing the difference between intended and unintended aberrant driving behavior. Secondly, the EFA revealed a Danish DBQ structure consisting of four factors: two error/lapses factors named confused- and unfocused errors/lapses, one emotional violation factor and one reckless violation/lapses factor. Further, the fit of the original DBQ, the Danish DBQ, and the forced two-factor DBQ structure was tested with CFA. Acceptable fit was found for both the original DBQ three-factor model and the

four-factor model in the whole sample. Lastly, fit of the three models were tested across subgroups differing in gender, age and annual mileage. The original three-factor model and the Danish four-factor model had the best fit across all subgroups compared to the two-factor solution. However, in the whole sample, the older sample as well as in gender groups separately, the fit of the two-factor model could be considered acceptable. In general, the fit was better among the older drivers compared to the younger ones. The present results show validity and reliability of the original DBQ model, as well as for the Danish DBQ model, thus supporting the further use of both models.

#### *4.1. The two-factor model*

The distinction between intended behavior (violations) and unintended behavior (errors and lapses) was salient in the Danish population, as lapses and errors items loaded together and violation items together. This distinction was expected due to earlier findings (see Wallén Warner, 2006 p. 27-28 for an overview) and the different psychological processes behind lapses and errors, and violations, as highlighted by Reason et al. (1990). Violations is motivational and/or contextual based, while errors are cognitive based. The difference of the two behavioral classes was validated using CFA. This further supports the theory behind DBQ, that aberrant driving behavior can be separated into two broad behavioral classes of unintentional errors/lapses and intentional violations.

#### *4.2. The Danish DBQ factor model*

In Reason et al. (1990), a cut-off point of 0.50 for the factor loadings was applied. In the present study, the cut-off point of 0.50 was found too high resulting in many deleted items and low interpretability of factors, so a lower (0.30) cut-off point was applied (see Costello and Osborn,

2005; Field, 2009; Kline, 1994) and a different factorial solution than presented in Reason et al. (1990) was revealed.

There are important differences between the principal component analysis (PCA) used by Reason et al. (1990) and the principal axis factoring (PAF) used in the present study. Different factor extraction methods (PCA vs. PAF), and rotation techniques (varimax vs. oblimin) may explain the differences between the results of Reason et al. (1990) and the present study. When applying PCA, loadings become higher than in PAF because of higher communality estimates (Russell, 2002). The PCA has been the most common method in the DBQ literature; which is somewhat peculiar since the literature in the field of factor analysis generally recommends PAF over PCA (Reise et al., 2000; Russell, 2002; Widaman, 1993).

The current EFA revealed a four-factor structure containing two factors explained by both error and lapses items and two factors containing violations items. The factors could be said to resemble other studies four-factor solutions. The unfocused lapses/ errors factor resembles Rimmö's (2002) mistake factor, Lajunen et al.'s (2004) errors factor and Mesken et al.'s (2002) errors factor. Further, the emotional violations factor resembles Meskens's (2002) interpersonal violations and Lajunen et al.'s (2004) aggressive violations. The present reckless violations/lapses factor consists of both violations and lapses, but does not resemble previous factor solutions in the literature. The confused lapses/errors resemble Rimmö's (2002) inattention errors factor and Mesken's (2002) lapses factor. However, the present factor structure does not seem to separate between errors and lapses, as both behaviors load together. Thus, the distinction between errors and lapses is not present in the Danish sample. The implication of this is that the broad distinction of behavioral classes in the DBQ between errors/lapses and violations, thus intended versus unintended behavior, is further supported. Additionally, the distinction between the aberrant behavioral classes is not stable, as different underlying structures do seem to appear when applying the DBQ in different

countries. Originally, the DBQ was thought to consist of five factors or behavioral classes (mistakes, lapses, slips, unintended violations and deliberate violations). However, Reason et al.'s study (1990) did not find such a structure, but found a three-factor structure instead. Other previous studies have also found different factor structures of the DBQ (Blockey & Hartley, 1995; Lawton et al., 1997; Reason et al., 1990; Åberg & Rimmö, 1998). This is not surprising as the driving style is formed by personal factors such as age, gender and cognitive biases, as well as by the social context (Reason 1990; Reason et al., 1990). The fact that the present four-factor structure resembles previously obtained factor structures, although not completely, confirms the need to apply explorative analysis when the DBQ is applied in a population with the purpose to identify relevant preventive efforts. The different factors found are indicative of the relevant preventive strategy. Drivers who perform many emotional violations need other means to change their driving style than drivers performing reckless driving violations as there is different underlying mechanism and different motivational mechanisms behind. Further, errors and lapses caused by confusion are different than errors/lapses caused by voluntary engagement in distracting behaviors. The current study, as well as previous studies (Wallén Warner et al., 2011), find that different countries have different problems with regard to aberrant driving behavior. A country or population's factor structure is a good indicator of where preventive efforts should be targeted.

#### *4.3. Fit of the three DBQ models*

Results showed that the original three-factor structure and the Danish four-factor structure had an acceptable fit in the whole sample whereas the forced two-factor structure showed a somewhat lower fit. This could reflect the complexity of the driver tasks, thus a more complex model explains driver behavior to a greater degree. On the other hand, the difference between the fit indexes of the

three models was small, indicative of stable DBQ structures across driver groups. Overall a slightly better fit was obtained by the Danish four-factor structure than by the original three-factor structure.

Further, the fit of the three DBQ models was tested across subgroups. The three-factor model had the best fit across sub-groups of drivers according to the CFI statistics, however when looking at the RMSEA, the four-factor model had the best fit across groups. Since the CFI statistics in general are below the recommended value (good fit  $>0.90$ ) and the RMSEA statistics are in the recommended end (good fit  $< 0.05$ ) across sub-groups, and that the literature does not recommend one over the other, the four-factor model seems slightly better fitting. This is not surprising as the EFA did not reveal a three-factor structure, thus the four-factor structure represents the present sample better. As for the whole population, the three- and four-factor models revealed a slightly better fit than the two-factor model across all subgroups. Overall, the fit indexes were higher in the older driver groups than in the younger groups. The fit indexes were about at the same level among men and women, and in all annual mileage groups. This could be indicative of gender neutral and mileage neutral DBQ models. One explanation for less fit among the young drivers could be that younger persons have not developed stable driving skills and style yet. Since driver behaviors or style of less experienced and younger drivers are not as consistent as those of experienced drivers, the younger drivers might still be in a learning stage in which skills are acquired and a personal driving style formed (Hatakka et al., 2002). This leads to more variance within the group, thus a more heterogenic group, and this makes it harder to represent the sample with the model. Another reason for lower fit among young drivers might be estimation of own behavior. Younger and less experienced drivers might find it harder to actually remember their own behavior as it is not fully stable yet, thus it might be harder to report their behavior. Previous studies have also performed a CFA of the DBQ across driver age groups (Rimmö, 2002 using DBQ-SWE). In contrast to current findings, better fit among young and inexperienced drivers than among older drivers was found.

However, it is reasonable to suspect that this might be because the stratification of the age was broad for the older group (27-70 years of age). Based on the results of the current study, one can expect significant differences in driver behaviors within such a broad age spectrum, even within older drivers (Rimmö and Hakamies-Blomqvist, 2002).

Due to variability in driver behavior among driver subgroups (Lawton et al., 1997; Parker et al., 1995; Reason et al., 1990; Åberg and Rimmo, 1998; Rimmo, 2002), it has been suggested that it might be a good idea to apply different DBQ structures in order to replicate different driver groups (Rimmö, 2002). The current results suggest that this may not be necessary, with an exception of different age groups, because the fit of the current four-factor model as well as the original three-factor model was acceptable in all driver groups. Thus, the items included in the four- and three-factor structure seem to explain aberrant behavior across subgroups. The lower fit of the younger groups should though be examined further to better understand the reasons for this.

Lastly, as all three models have relatively good fit, all three factor structures seem to explain the data well. The difference between unintended errors and deliberate violations is apparent in the current sample, although the least fitting factor model. The distinction between violations on the one hand and the errors and lapses on the other is important because it has shown to be the most stable DBQ structure across previous studies (Özkan et al., 2006b) and therefore one could expect that this DBQ structure would be the most fitting across sub-groups. However, across subgroups this structure is the least fitting, which indicates that the population cannot be replicated by the simpler two-factor model. Moreover, the original DBQ factor structure was supported as that structure fits the data nearly as good as the Danish four-factor structure. One reason for the good fit of the original DBQ structure could be that Reason et al.'s structure contains what can be called "marker items" of the DBQ. These items seem to be core items that have the highest loadings, i.e., the behaviors that explain the most of aberrant driver behavior, both in lapses, errors and violations.

This gives support for the GEMS theory behind the DBQ and shows construct validity (Reason, 1990; Reason et al., 1990). However, the fact that the four-factor structure has the best fit indicates that this model adds something more, a country specific structure. Previously it has been suggested that it could be better if countries separated between national items (country specific additional DBQ items developed by the researcher in a given country) and international items (core original DBQ items) in order to both represent the national driving style and to be able to compare across nations (Lajunen et al., 2004). This would be a good idea if the DBQ factor models showed bad fit to the data. However, the current study's good fit indicate that this might not be necessary. The present results shows validity and reliability of the DBQ, thus supports the further use of the instrument. Nevertheless, it also highlights that it is important to perform explorative analysis in order to see what and where the problem areas in a driving population are. This is crucial in order to identify which driver subgroups should be targeted in interventions, and what intervention should be performed. In short, the DBQ seems to represent the driving population across subgroups both with the use of the original factor structure and the Danish DBQ structure, the difference between the two being a more country specific replication of the population.

### **Acknowledgements**

Financial support from by the Danish Council for Strategic Research (Det Strategiske Forskningsråd) is greatly acknowledged.

### **References**

Bener, A., Özkan, T., Lajunen, T., 2008. The driver behaviour questionnaire in Arab gulf countries: Qatar and United Emirates. *Accident Analysis and Prevention*, 40, 1411-1417.

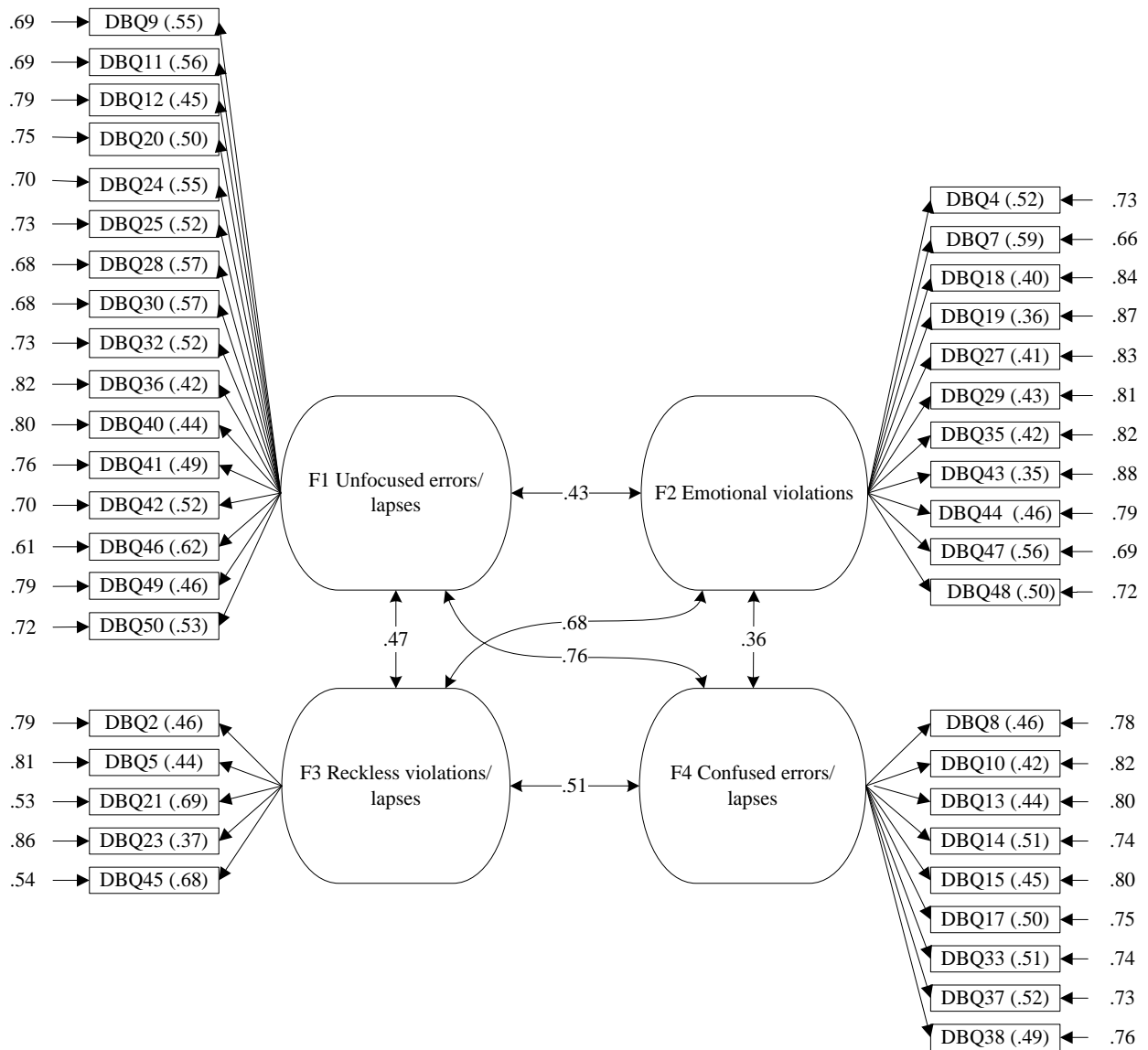


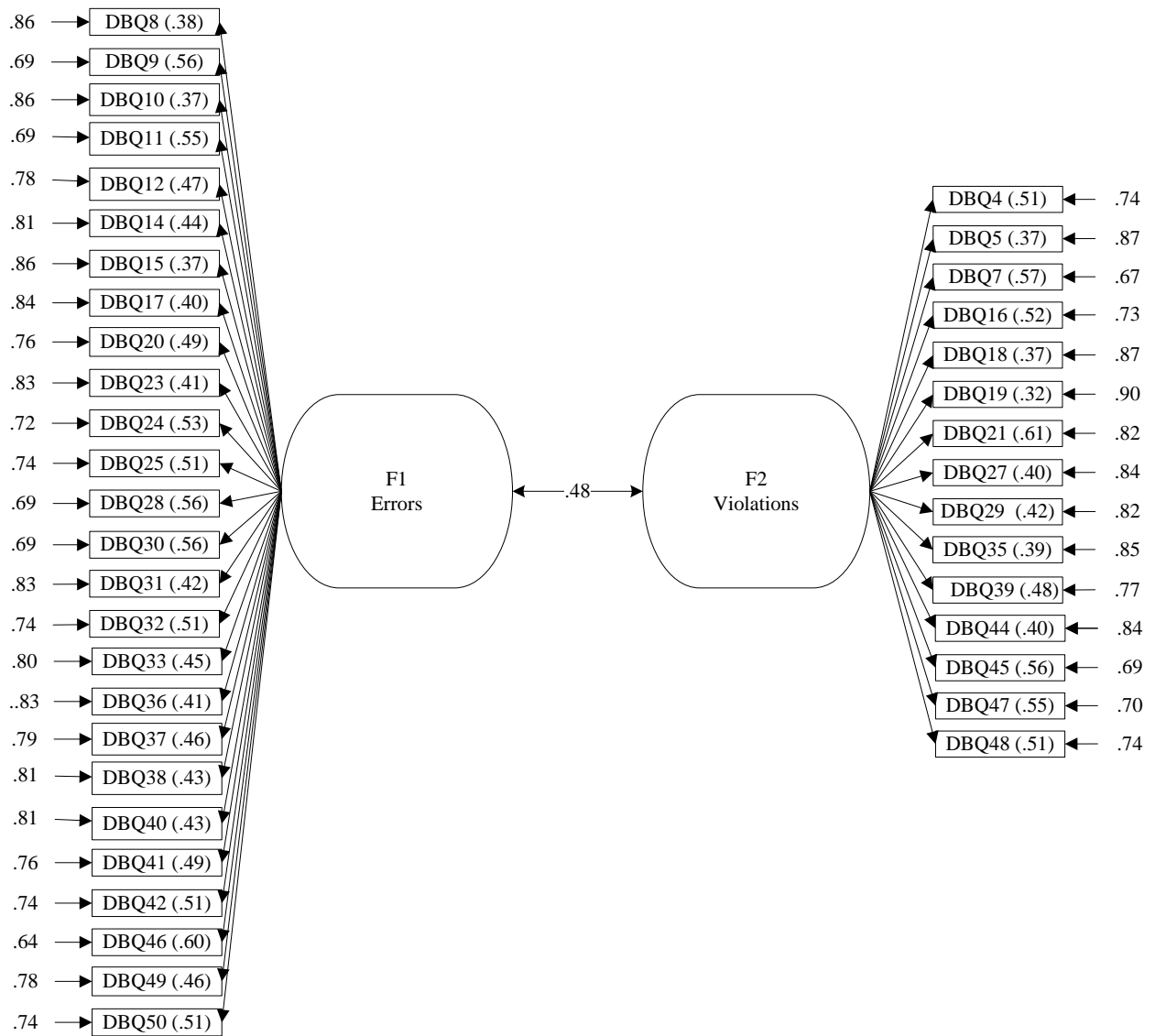
- Bener, A., Lajunen, T., Özkan, T., Haigney, D., 2006. The effect of mobile phone use on driving style and driving skills. *International Journal of Crashworthiness*, 11 (5), 459-466.
- Blockey, P. N., Hartley, L. R., 1995. Aberrant driving behavior: errors and violations. *Ergonomics*, 38 (9), 1759-1771.
- Bryne, B. M., 2001. *Structural Equation Modeling with AMOS: Basic Concepts, Applications, and Programming*. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Cortina, J. M., 1993. What is coefficient alpha? An examination of theory and applications. *Journal of Applied Psychology*, 78, 98-104.
- Costello, A. B., Osborn, J. B., 2005. Best practices in exploratory factor analysis: four recommendations for getting the most out of your analysis. *Practical Assessment, Research and Evaluation*, 10 (7).
- Davey, J., Wishart, D., Freeman, J., Watson, B., 2007. An application of the driver behaviours questionnaire in an Australian organizational fleet setting. *Transportation Research Part F: Traffic Psychology and Behaviour*, 10 (1), 11-21.
- De Winter, J.C.F., Dodou, D., 2010. The driver behavior questionnaire as a predictor of accidents: a meta-analysis. *Journal of safety research* 41, 463-470.
- Dobson, A., Brown, W., Ball, J., Powers, J., McFadden, M., 1999. Women drivers' behavior, socio-demographic characteristics and accidents. *Accident Analysis and Prevention*, 31 (5), 525-535.
- Field, A., 2009. *Discovering statistics using SPSS (3th ed.)*. London: SAGE Publications Ltd.
- Gras, E. M., Sullman, M. J. M., Cunill, M., Planes, M., Aymerich, M., Font-Mayolas, S., 2006. Spanish drivers and their aberrant driving behaviours. *Transportation Part F: Traffic Psychology and Behaviour*, 9, 129-137.
- Hatakka, M., Keskinen, E., Gregersen, N.P., Glad, A., Hernetkoski, K., 2002. From control of the vehicle to personal self-control; broadening the perspectives to driver education. *Transport Research Part F: Traffic Psychology and Behaviour*, 5, 201-215.
- Hennessy, A., Wiesenthal, D. L., 2005. Driving vengeance and willful violations: clustering of problem driving attitudes. *Journal of Applied Social Psychology*, 35 (1), 61-79.
- Hu, L., Bentler, P. M., 1999. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling*, 6, 1-55.
- Kline, P., 1994. *An easy guide to factor analysis*. London: Routledge.

- Kontogiannis, T., Kossiavelou, Z., Marmaras, N., 2002. Self-reports of aberrant behavior on the roads: error and violations in sample of Greek drivers. *Accident Analysis and Prevention*, 34 (3), 381-399.
- Lajunen, T., Parker, D., Summala, H., 1999. Does traffic congestion increase driver aggression? *Transport Research Part F: Traffic Psychology and Behaviour*, 2, 225-236.
- Lajunen, T., Parker, D., Summala, H., 2004. The Manchester driver behaviour questionnaire: a cross-cultural study. *Accident Analysis and Prevention*, 36 (2), 231-238.
- Lawton, R., Parker, D., Manstead, A., Stradling, S. G., 1997. The role of affect in predicting social behaviours: the case of road traffic violations. *Journal of Applied Social Psychology*, 27, 1258-1276.
- Mesken, J., Lajunen T., Summala, H., 2002. Interpersonal violations, speeding, violations and their relation to accident involvement in Finland. *Ergonomics*, 45 (7), 469-489.
- Obriot-Claudiel, F, Gabaude, C., 2004, September. The driver behaviour questionnaire: A French study applied to elderly drivers. Paper presented at the 3<sup>rd</sup> International Conference on Traffic & Transport Psychology, Nottingham, UK.
- Owsley, C., McGwin, G., Jr., McNeal, S. F., 2003. Impact of impulsiveness, venturesomeness, and empathy on driving by older adults. *Journal of Safety Research*, 34, 353-359.
- Özkan, T., Lajunen, T., 2005. A new addition to DBQ: Positive driver behavior scale. *Transportation Part F: Traffic Psychology and Behaviour*, 8 (4-5), 355-368.
- Özkan, T., Lajunen, T., Chliaoutakis, J., Parker, D., Summala, H., 2006a. Cross-cultural differences in driving behaviours: a comparison of six countries. *Transportation Part F: Traffic Psychology and Behaviour*, 9 (3), 227-242.
- Özkan, T., Lajunen, T., Summala, H., 2006b. Driver behaviour questionnaire: a follow-up study. *Accident Analysis and Prevention*, 38, 386-395.
- Parker, D., Lajunen, T., Stradling, S. G., 1998. Attitudinal predictors of interpersonally aggressive violations on the road. *Transportation Part F: Traffic Psychology and Behaviour*, 1 (1), 11-24.
- Parker, D., McDonald, L., Rabbit, P., Sutcliffe, P., 2000. Elderly drivers and their accidents: the aging driver questionnaire. *Accident Analysis and Prevention*, 32 (6), 751-759.
- Parker, D., Reason, J. T., Manstead, A, Stradling, S. G., 1995. Driver errors, driving violations, and accident involvement. *Ergonomics*, 38 (5), 1036-1048.
- Reason, J. T., 1990. *Human errors*. Cambridge; Cambridge University Press.

- Reason, J. T., Manstead, A., Stradling, S G., Baxter, J., Campbell, K., 1990. Errors and violations on the road – a real distinction. *Ergonomics*, 33 (10/11), 1315-1332.
- Reise, S. P., Waller, N. G., Comrey, A. L., 2000. Factor analysis and scale revision. *Psychological Assessment*, 12 (3), 287-297.
- Rimmö, P.-A., 2002. Aberrant driving behaviour: homogeneity of a four-factor structure in samples differing in age and gender. *Ergonomics*, 4 (8), 569-582.
- Rimmö, P.-A., Hakamies-Blomqvist, L., 2002. Older drivers' aberrant driving behaviour impaired activity, and health as reasons for self-imposed driving limitations. *Transportation Research Part F: Traffic Psychology and Behaviour*, 5 (1), 47-62.
- Russell, D. W., 2002. In search of underlying dimensions: the use (and abuse) of factor analysis in *Personality and Social Psychological Bulletin* (2002). *Personality and Social Psychological Bulletin*, 28, 1629–1646.
- Sullman, M., Meadows, M., Pajo, K., 2000. *Traffic and transport psychology. Theory and application*. Amsterdam: Elsevier.
- Sullman, M., Meadows, M., Pajo, K., 2002. Aberrant driving behaviours amongst New Zealand truck drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, 5 (3), 217-232.
- Sümer, N., 2003. Personality and behavioral predictors of traffic accidents: testing a contextual mediated model. *Accident Analysis and Prevention*, 35 (6), 949-964.
- Wallén W. H., 2006. Factors influencing drivers' speeding behaviour. Doctoral dissertation. *Acta Universitatis Upsaliensis. Digital comprehensive summaries of Uppsala dissertations from the Faculty of Social Sciences* (p. 21). Uppsala, Sweden. <<http://uu.diva-portal.org/smash/record.jsf?searchId=1&pid=diva2:169263>> (Accessed 07.06.11).
- Wallén W. H., Özkan, T., Lajunen, T., Tzamalouka, G., 2011. Cross-cultural comparison of drivers' tendency to commit different aberrant driving behaviours. *Transportation Research Part F*, 14, 390-399.
- Widaman, K. F., 1993. Common factor analysis versus principal component analysis: differential bias in representing model parameters? *Multivariate Behavioral Research*, 28 (3), 263-311.
- Xie, C-qiu., Parker, D., 2002. A social psychological approach to driving violations in two Chinese cities. *Transportation Part F: Traffic Psychology and Behaviour*, 5 (4), 293-308.
- Åberg, L., Rimmö, P.-A., 1998. Dimensions of aberrant driver behaviour. *Ergonomics*, 41 (1), 39-56.

Åberg, L., Warner, H., 2008. Speeding- deliberate violations or involuntary mistake? European Review of Applied Psychology, 58 (1), 23-30.





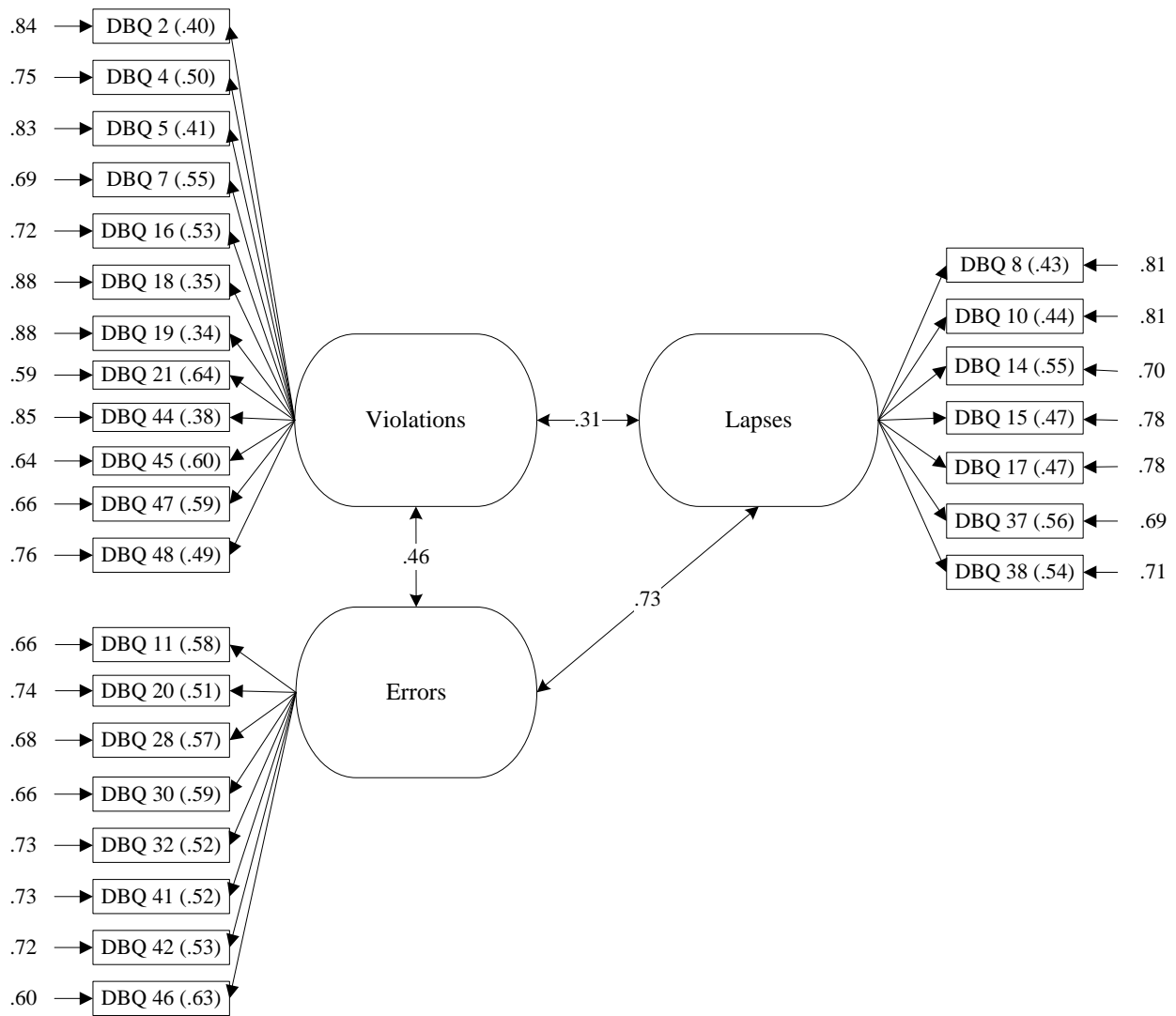


Table 1. Sample characteristics

|                            | Total  | Males  | Females |
|----------------------------|--------|--------|---------|
| N                          | 4335   | 2204   | 2131    |
| <i>Age</i>                 |        |        |         |
| Mean                       | 50.9   | 53.25  | 48.5    |
| St. D                      | 18.886 | 19.049 | 18.416  |
| <i>Annual mileage (km)</i> |        |        |         |

Table 2. Factor structure and loadings of the DBQ items.

|       |          |          |          |
|-------|----------|----------|----------|
| Mean  | 16251.56 | 20204.88 | 11971.41 |
| St. D | 28401.28 | 29001.27 | 27100.97 |

---

| DBQ items   | Factors |      |   |   |
|---|---------|------|---|---|
|   | 1       | 2    | 3 | 4 |
| 46. Fail to notice pedestrians crossing when turning into a side-street from a main road  | .659    |      |   |   |
| 24. On turning right (left), nearly hit a cyclist who has come up on your inside  | .586    |      |   |   |
| 28. Lost in thought or distracted, you fail to notice someone waiting at a zebra crossing, or a pelican crossing light that has just turned red                                   | .568    |      |   |   |
| 50. Misjudge your crossing interval when turning right and narrowly miss collision  | .547    |      |   |   |
| 30. Misjudge speed of oncoming vehicle when overtaking  | .541    |      |   |   |
| 32. Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late   | .532    |      |   |   |
| 42. Attempt to overtake a vehicle that you hadn't noticed was signaling its intention to turn left (right)  | .520    |      |   |   |
| 25. In a queue of vehicles turning right (left) on to a main road, pay such close attention to the traffic approaching from the left (right) that you nearly hit the car in front | .502    |      |   |   |
| 20. Try to overtake without first checking your mirror, and then get hooted at by the car behind which has already begun its overtaking manoeuvre                                 | .489    |      |   |   |
| 11. Turn right (left) on to a main road into the path of an oncoming vehicle that you hadn't seen, or whose speed you had misjudged   | .480    |      |   |   |
| 40. Ignore "give way" signs, and narrowly avoid colliding with traffic having right of way  | .439    |      |   |   |
| 41. Fail to check your mirror before pulling out, changing lanes, turning etc.  | .421    |      |   |   |
| 36. Cut the corner on a left (right)- hand turn and have to swerve violently to avoid an oncoming vehicle   | .395    |      |   |   |
| 49. Brake too quickly on a slippery road and/or steer the wrong way in a skid   | .350    |      |   |   |
| 12. Misjudge your gap in a car park and nearly (or actually) hit adjoining vehicle  | .330    |      |   |   |
| 9. Distracted or preoccupied, realize belatedly that the vehicle ahead has slowed. and have to slam on the breaks to avoid a collision  | .323    |      |   |   |
| 4. Become impatient with a slow driver in the outer lane and overtake on the inside   |         | .516 |   |   |
| 44. Disregard red lights when driving late at night along empty roads   |         | .499 |   |   |
| 7. Drive especially close or "flash" the car in front as a signal for that driver to go faster  |         | .475 |   |   |



|   |       |
|---|-------|
| or get out of your way  |       |
| 35. Overtake a slow-moving vehicle on the inside lane or hard shoulder of a motorway  | .440  |
| 18. Take a chance and cross on lights that have turned red  | .422  |
| 47. Get involved in unofficial “races” with other car drivers   | .392  |
| 19. Angered by another drivers behavior, you give chase with the intention of giving him/her a piece of your mind                 | .356  |
| 27. Have an aversion to a particular class of road user. and indicate your hostility by whatever means you can                    | .354  |
| 29. Park on a double-yellow line and risk a fine  | .346  |
| 43. Deliberately drive the wrong way down a deserted one-way street   | .330  |
| 48. “Race” oncoming vehicle for a one-car gap on a narrow or obstructed road  | .306  |
| 21. Deliberately disregard the speed limits late at night or very early in the morning  | -.621 |
| 45. Drive with only “half-an-eye” on the road while looking at a map, changing a cassette or radio channel etc.                   | -.563 |
| 5. Drive as fast along country roads at night on dipped lights as on full beam  | -.461 |
| 2. Check your speedometer and discover that you are unknowingly travelling faster than the legal limit                            | -.347 |
| 23. Lost in thought, you forget that your lights are in full beam until “flashed” by other motorists                              | -.335 |
| 8. Forget where you left your car in a multi-level car park   | .501  |
| 15. Forget which gear you are currently in and have to check with your hand   | .470  |
| 17. Intending to drive to destination A, you “wake up” to find yourself en to route B, where the latter is the more usual journey | .466  |
| 14. Miss your exit on a motorway and have to make a lengthy detour  | .448  |
| 10. Intend to switch on the windscreen wipers, but switch on the lights instead. or vice versa                                    | .405  |
| 33. Plan your route badly, so that you meet traffic congestion you could have avoided   | .381  |
| 37. Get into the wrong lane at a roundabout or approaching a road junction  | .363  |
| 38. Fail to read the signs correctly, and exit from a roundabout on the wrong road  | .314  |

13. "Wake up" to realize that you have no clear recollection of the road along which you  
 have just travelled

.301

Extraction method: Principal axis factoring, rotation method: Oblimin with Kaiser Normalization

Table 3. Fit indexes from confirmatory factor analysis

|                     | <i>2 factors</i> |      |              |     |      | <i>3 factors</i> |      |              |     |      | <i>4 factors</i> |      |              |     |      |
|---------------------|------------------|------|--------------|-----|------|------------------|------|--------------|-----|------|------------------|------|--------------|-----|------|
|                     | C                | RMS  | $\chi^2$ (df | Ra  | SR   | C                | RMS  | $\chi^2$ (df | Ra  | SR   | C                | RMS  | $\chi^2$ (df | Ra  | SR   |
|                     | FI               | EA   | 778)         | tio | MR   | FI               | EA   | 321)         | tio | MR   | FI               | EA   | 773)         | tio | MR   |
| <i>Whole sample</i> | .8               |      | 7032.        | 9.0 |      | .8               |      | 3197.        | 9.9 |      | .8               |      | 6207.        | 8.0 |      |
| (n=4335)            | 28               | .043 | 75           | 4   | .045 | 48               | .045 | 76           | 6   | .043 | 48               | .040 | 81           | 3   | .046 |
| <i>Gender</i>       |                  |      |              |     |      |                  |      |              |     |      |                  |      |              |     |      |
|                     | .8               |      | 3843.        | 4.9 |      | .8               |      | 1810.        | 5.6 |      | .8               |      | 3538.        | 4.5 |      |
| Men (n=2204)        | 39               | .042 | 63           | 4   | .045 | 67               | .046 | 15           | 9   | .044 | 51               | .040 | 82           | 8   | .048 |
|                     | .8               |      | 4079.        | 5.2 |      | .8               |      | 1757.        | 5.4 |      | .8               |      | 3479.        | 4.5 |      |
| Women (n=2131)      | 04               | .045 | 38           | 4   | .047 | 54               | .046 | 95           | 8   | .044 | 40               | .041 | 15           | 0   | .045 |
| <i>Age</i>          |                  |      |              |     |      |                  |      |              |     |      |                  |      |              |     |      |
|                     | .7               |      | 2099.        | 2.6 |      | .8               |      | 1010.        | 3.1 |      | .8               |      | 1954.        | 2.5 |      |
| Young 18-29 (n=779) | 82               | .047 | 51           | 7   | .058 | 17               | .053 | 91           | 5   | .058 | 04               | .044 | 42           | 3   | .056 |
| Middle 30-49        | .7               |      | 3038.        | 3.9 |      | .8               |      | 1336.        | 4.1 |      | .8               |      | 2779.        | 3.6 |      |
| (n=1336)            | 88               | .047 | 55           | 1   | .053 | 32               | .049 | 44           | 6   | .049 | 11               | .044 | 09           | 0   | .052 |
|                     | .8               |      | 3668.        | 4.7 |      | .8               |      | 1522.        | 4.7 |      | .8               |      | 3334.        | 4.3 |      |
| Old 50-85 (n=2220)  | 44               | .041 | 25           | 2   | .044 | 83               | .041 | 98           | 4   | .041 | 59               | .039 | 71           | 1   | .045 |
| <i>Gender*Age</i>   |                  |      |              |     |      |                  |      |              |     |      |                  |      |              |     |      |
| Young men 18-29     | .7               | .051 | 1449.        | 1.8 | .069 | .7               | .059 | 690.2        | 2.1 | .070 | .7               | .049 | 1375.        | 1.7 | .067 |

|                       |    |      |       |     |      |    |      |       |     |      |    |      |       |     |      |
|-----------------------|----|------|-------|-----|------|----|------|-------|-----|------|----|------|-------|-----|------|
| (n=327)               | 49 |      | 72    | 6   |      | 76 |      | 1     | 5   |      | 68 |      | 09    | 8   |      |
| Middle men 30-49      | .7 |      | 1932. | 2.4 |      | .8 |      | 843.1 | 2.6 |      | .7 |      | 1848. | 2.3 |      |
| (n=649)               | 67 | .048 | 32    | 8   | .056 | 13 | .050 | 1     | 3   | .054 | 84 | .046 | 61    | 7   | .056 |
| Old men 50-85         | .8 |      | 2418. | 3.1 |      | .8 |      | 1041. | 3.2 |      | .8 |      | 2217. | 2.8 |      |
| (n=1228)              | 50 | .041 | 91    | 1   | .047 | 80 | .043 | 89    | 5   | .046 | 63 | .048 | 81    | 7   | .045 |
| Young woman 18-29     | .6 |      | 1831. | 2.3 |      | .7 |      | 807.4 | 2.5 |      | .7 |      | 1629. | 2.1 |      |
| (n=452)               | 97 | .055 | 94    | 6   | .065 | 68 | .058 | 7     | 2   | .065 | 54 | .050 | 04    | 1   | .062 |
| Middle women 30-49    | .7 |      | 1970. | 2.5 |      | .8 |      | 876.8 | 2.7 |      | .8 |      | 1818. | 2.3 |      |
| (n= 687)              | 84 | .047 | 58    | 3   | .055 | 22 | .050 | 3     | 3   | .052 | 13 | .044 | 78    | 5   | .055 |
| Old women 50-85       | .7 |      | 2351. | 3.0 |      | .8 |      | 899.5 | 2.8 |      | .8 |      | 2208. | 2.8 |      |
| (n=992)               | 95 | .045 | 35    | 2   | .050 | 62 | .043 | 0     | 0   | .045 | 13 | .043 | 04    | 6   | .051 |
| <hr/>                 |    |      |       |     |      |    |      |       |     |      |    |      |       |     |      |
| <i>Annual driving</i> |    |      |       |     |      |    |      |       |     |      |    |      |       |     |      |
| <i>distance</i>       |    |      |       |     |      |    |      |       |     |      |    |      |       |     |      |
| Low (1-6558 km)       | .8 |      | 2691. | 3.4 |      | .8 |      | 1104. | 3.4 |      | .8 |      | 2286. | 2.9 |      |
| (n=1258)              | 09 | .044 | 03    | 6   | .047 | 67 | .044 | 20    | 4   | .045 | 45 | .039 | 93    | 6   | .045 |
| Middle (6559-15000    | .8 |      | 2531. | 3.2 |      | .8 |      | 1055. | 3.2 |      | .8 |      | 2305. | 2.9 |      |
| km) (n=1060)          | 13 | .046 | 38    | 5   | .050 | 60 | .046 | 24    | 9   | .046 | 32 | .043 | 64    | 8   | .051 |
| High (15001-105000    | .8 |      | 2917. | 2.9 |      | .8 |      | 1314. |     |      | .8 |      | 2816. | 3.6 |      |
| km) (n=1317)          | 01 | .046 | 85    | 6   | .051 | 41 | .049 | 91    | 4.1 | .050 | 10 | .045 | 10    | 4   | .053 |

Note: Criteria for a good fit are 2:1 or 5:1  $\chi^2/df$ , CFI > 0.90, RMSEA < 0.05, and SRMR < 0.08