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Modelling Ghanaian Road Crash Risk using the Manchester Driver Behaviour Questionnaire

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Highlights

- The DBQ is a well documented measure of crash liability in the developed world.
- How well the DBQ applies to motoring in low and middle income countries is unknown.
- A 28-item version of the DBQ was examined in Ghana.
- The established broad distinction between errors and violations was identified.
- Both violations and errors were correlated with self-reported crash involvement.
- Both violations and errors were higher in Ghana than typically reported in the UK.
- Results are consistent with using the DBQ to measure risky driving in Ghana.
- The findings point to targets for intervention to reduce crash risk.

ABSTRACT

Little is known about how well models of driver crash risks from the developed world apply to motoring in African low and middle income countries. The Manchester Driver Behaviour Questionnaire (DBQ; Reason et al., 1990), which distinguishes deliberate violations of accepted safety practices and unintentional errors in its measurement of risky driving has been demonstrated to measure crash liability across a range of cultures. However, its applicability to Africa is currently unknown. The present study examines the psychometric properties of the DBQ in a sample of 453 Ghanaian drivers. A combination of exploratory and confirmatory factor analyses produced a 24 item 2-factor model of the DBQ with mainly violation items loading onto one factor and error items loading onto the other. Both violations and errors were independently correlated with self-reported crash involvement and violations correlated with self-reported traffic citations. Higher frequencies of violations and errors were reported by the Ghanaian sample than typically observed in the UK. The findings are consistent with the usefulness of the DBQ in characterising behaviours underlying crash risk in Ghana. The extent to which these risky behaviours may be targeted by behavioural, enforcement and engineering interventions is discussed.

Keywords: Driver Behaviour Questionnaire, violations, errors, crash, Ghana

1 Introduction

Road crashes kill over 1.35 million people annually. African has the highest fatality-rate; 28.6 deaths per 100,000 population compared to 9.3 in Europe and 15.6 in North America (World Health Organisation [WHO], 2018). We focus on Ghana (population 28 million), where road crashes account for 29.6% of all deaths (WHO, 2018) with the rate growing 12-15% annually since 2008 (National Road Safety Commission [NRSC], 2016). Therefore, addressing this public health challenge is particularly timely. Driver behaviour has been established as a substantial contributor to crash causation (Petridou & Moustaki, 2000]). Self-reported driving behaviour questionnaires have been helpful in understanding this behavioural contribution to crash risk in the developed world but their validity in African contexts has received little research attention. If existing measures may be used in Africa then they can be influential in identifying the behavioural contribution to the high crash risk in these contexts and informing policies to address this public health challenge.

The Driver Behaviour Questionnaire (DBQ) (Reason, Manstead, Stradling, Baxter, & Campbell, 1990) is a well-documented measure of risky driving in the developed world (de Winter, Dodou, & Stanton, 2015) that may also be applicable to Africa. Many studies use different versions of the DBQ in terms of the number and nature of the items presented which leads to varied factor structures but most DBQ studies categorise risky driving behaviours into violations and errors. These are hypothesised to have different psychological origins (Reason et al., 1990). Violations constitute 'acts that contravene safe driving practices (e.g., disregarding the speed limit on a motorway) while errors represent the failure of a planned action to achieve their intended consequences' (e.g., underestimating the speed of an oncoming vehicle when overtaking) (Reason et al., 1990, p. 1316). Further development of the DBQ often involves sub-dividing violations into ordinary and aggressive violations (Lawton, Parker, Manstead, & Stradling, 1997). Ordinary violations include deliberately engaging in behaviours that deviate from accepted safe driving conventions without specific aggressive intent (e.g., disregarding the

speed limit). Aggressive violations involve interpersonal aggression (e.g., becoming angered by another driver and giving a chase). Errors may also be subdivided, with slips/lapses, defined as memory failures (e.g., 'get into the wrong lane approaching a roundabout or a junction'), seen as a distinct subset (Reason et al., 1990, p. 1316). However, these sub-divisions are less fundamental than the errors/violations distinction (de-Winter &Dodou, 2010).

External validity of the DBQ has been demonstrated through correlation with driving performance measures. De Winter (2013) showed that self-reported violations correlate with violations and speeding in a driving simulator. Helman and Reed (2015) also found that the DBQ violations scale correlated with objectively measured speed in an instrumented vehicle and in a driving simulator (r =.38 in two reported studies). In terms of association with real-world behaviour, a sub-set of violations (described as dangerous by the authors) correlated positively with traffic citations (Blockley& Hartley, 1995). A crucial test for a behavioural measure of risky driving is to measure crash liability. de Winter et al.'s (2015) meta-analysis identified significant relationships between self-reported crash involvement and violations (r=.13 based on 57,480 participants from 67 samples) and errors (r=.09 based on 66,028 participants from 56 samples). External validity is also supported by links to demographic factors, many of which are correlated with crash involvement. Across a range of studies, it has been found that males report more violations while females report more errors (e.g., de Winter &Dodou, 2010, 2016) and younger drivers report more violations than older drivers (Cordazzo, Scialfa, Bubrick, & Ross, 2014; de Winter &Dodou, 2010) and that higher mileage is positively associated with violations (de Winter &Dodou, 2010).

The potential applicability of the DBQ to Africa is demonstrated by its adaptability to other cultures across the world. Examples include: Turkey (Sumer, 2003), China (e.g., Qu, Zhang, Zhao, Zhang, & Ge, 2016) and Iran (Ozkan, Lajunen, Chliaoutakis, Parker, &Summala, 2006). The major distinction

between violations and errors is consistent across cultures. However, variations in the factor structure have been observed. For example, in Qatar, Bener, Ozkan and Lajunan (2008) found four factors, including a speeding factor that included close following, with crossing red traffic lights loading onto an errors factor. Another example is that driving under the influence of alcohol does not load on any factor in some cultures (Lajunen, Parker, &Summala, 2004;) but loaded onto the ordinary violation factor in Finland (Mattsson, 2012). Differences in societal norms and rules may influence the relationship between underlying psychological processes and manifesting risky driving behaviours (Bjorklund, 2005) and therefore influence factor loadings. It is also possible that there are cultural differences in the interpretation of the behaviours measured in the DBQ (Stephens &Fitzharris, 2016).

Cultural differences have been found in the frequency of violations and errors (Ozkan et al., 2006). For instance, aggressive violations such as indicating annoyance and hostility to other road users were more common among Greek drivers than Dutch and Finnish drivers. Finnish driver, however, reported more ordinary violations (e.g., speeding on a motorway) (Ozkan et al., 2006). Regarding errors, drivers from South-eastern European countries (e.g., Greece and Turkey) reported more errors than those from North-western European countries (e.g., UK and Finland).

While the DBQ has been demonstrated to measure crash liability in High Income Countries (HICs) (e.g., de-Winter &Dodou, 2010) less is known about its performance in Low and Middle Income Countries (LMICs), particularly in Africa, in terms of factor structure and reliability, and in terms of external validity, most importantly its association with crash involvement. An exploratory qualitative study conducted in Ghana (Dotse, Nicolson, & Rowe, 2018) provided some basis for expecting that the DBQ may be a useful measure in this context. For example, risky driving behaviours of the sort measured in the DBQ, such as speeding, disregarding traffic signals and dangerous overtaking were reported to be common in Ghana. The sample reported that these behaviours were linked to being

younger, male and high in sensation seeking. This indicates that the factors underlying risky driving in Ghana may be similar to those observed in HICs. However, Dotse et al. also found evidence that there may be differences in the psychological processes underlying some driving behaviours between Ghana and HICs. For instance, there was evidence of substantial training deficits, partly as a result of licences being obtained through bribery. There was also evidence of extremely risky driving practices in commercial drivers including very risky approaches to racing other drivers to passenger pick-up points. Road crashes were also partly attributed to spiritual influences. The importance of factors of this sort may mean that the DBQ provides a less comprehensive assessment of risky driving behaviours in Ghana and similar cultures than in HICs.

The current study explored the usefulness of the DBQ in Ghana. Given that commercial passenger vehicles are common on Ghana's roads and are involved in 40% of fatal crashes (NRSC, 2017), we ensured both commercial drivers and private car drivers were represented in our sample. First we tested the factor structure in Ghana using a combination of exploratory and confirmatory approaches. We expected that the distinction between errors and violations would be maintained in Ghana, but predicted that the precise loadings of items of onto factors may show some nuances in Ghana compared to general findings in HICs. External validity was assessed by examining the correlates of the extracted factors with measures documented to correlate with the DBQ in literature from HICs.Based on findings from HICs (de-Winter &Dodou, 2010), it was predicted that both violations and errors would be correlated with crash involvement and higher mileage. Violations were predicted to additionally correlate with traffic citations, younger age and being male. Errors were predicted to relate to being female and older age. We also compared the level of risky driving behaviour reported in Ghana with a large scale UK sample reported by Lajunen et al. (2004). We expected that levels of aberrant driving would be higher in Ghana, on the basis that crashes are more common there than in the UK.

2 Method

2.1 Sample

Data were collected by a team of researchers from the Department of Psychology, University of Ghana. Initial contacts were made with the individual participants through personal approaches and mutual acquaintance. Commercial drivers were approached at lorry parks and stations within Accra where they loaded and discharged passengers. Other categories of drivers were approached in the premises of public and private organisations (e.g., University of Ghana and the Very Important Person bus depot in Accra). Participants provided informed consent. Ethical approval was obtained from The Department of Psychology Ethics Committee at University of Sheffield (UK) and University of Ghana Ethics Committee for the Humanities. Participants were paid GHS 15.00 (£3) for expenses.

Five hundred questionnaires were distributed and 453 were returned completed (90.6%), 339 were from commercial drivers and 114 from private vehicle drivers. There was occasional missing demographic data but all theDBQ, and crashes items were completed. All participants were proficient in English and had at least basic formal education (Primary School). In Ghana, the adult English literacy rate was 76.67% in 2017 (WHO, 2018). The participants held driving licences with classes that included *'B'* (cars and cross-country vehicles not exceeding 3000kg)*;* 25.3%, '*C'* (goods carrying vehicles, buses/coaches of between 3000-5500kg or 1-33passengers)*;* 40.2%, '*D'* (goods carrying vehicles, buses/coaches not exceeding 8000kg)*;* 28.7%, '*E'* (graders, loaders, forklifts, tractors, bulldozers, dumpers and rollers)*;* 2.7%, and '*F'* (goods carrying vehicles, buses/coaches and articulator vehicles over 8000kg)*;* 3.1%. The majority held full licences (96.9%). Eleven held provisional licences (2.4%) that allow independent driving in Ghana. Three (0.7%) indicated that they did not hold a licence and were therefore driving illegally.

The sample was predominantly male (77.5%) and was aged between 21 - 67 years (M = 40.93, SD = 9.93). Their driving experience was 1- 43 years (M = 9.53, SD = 7.14). Participants reported weekly mileage of 2 - 686 km (M = 102.22, SD = 118.72). A total of 152 (33.6%) reported being involved in a crash as a driver during their driving careers. Of these, 115 (75.66%) had crashed once, 31 (20.40%) had crashed twice and 6 (3.94%) had crashed three times. Within the past 12 months 35 (7.7%) indicated being cited for traffic offences, 13 (2.9%) were cited twice and 1 (0.2%) had three convictions.

2.2 Measures

We used a 28item version of the Manchester DBQ which included the 27 item version used by Lajunen et al. (2004) and an additional 'drink and drive' item taken from Mattsson (2012). Typically this version of the DBQ distinguish ordinary violations (8 items, e.g., overtake a slow driver on the inside), aggressive violations (3 items, e.g., sound your horn to indicate your annoyance to another road user), errors (8 items, e.g., failed to check the rear-view mirror before pulling out or changing lanes, etc.) and lapses (8 items, e.g., get into the wrong lane approaching roundabout or a junction) (Lajunen et al., 2004). The drink and drive item has been found to load onto the ordinary violation component (Mattsson, 2012). Respondents indicate how often they engage in each of the behaviours on a six-point Likert scale (never = 0, hardly ever = 1, occasionally = 2, quite often = 3, frequently = 4, nearly all the time = 5). Minor changes were made to three DBQ items to recognise that drivers drive on the right in Ghana. Crash involvement (crash resulting in injury, death or damage to property and which involve at least one vehicle"while you were driving") was measured through self-report as in previous studies (Iverson &Rudmo, 2004; Ulleberg&Rudmo, 2003).

2.3. Analytic Strategy

First, we tested the applicability of the 2-4 factor structures that are commonly applied to DBQ data in HICs using Confirmatory Factor Analysis (CFA) in our full sample (n=453). As this produced unsatisfactory fitwe followed Byrne's (2013) approach to exploratory analysis by splitting the sample into two random halves, and using one for exploratory model building and the other for independently validating the model constructed. Therefore, we used Exploratory Factor Analysis (EFA) to identify the DBQ factor structure in one half of our sample (228 observations). We then cross-validated this model in the second half of the data (225 observations) using Confirmatory Factor Analysis (CFA). The EFA was conducted using IBM SPSS version 20. Principal axis factoring with oblique rotation was employed given that DBQ factors are usually correlated (de Winter &Dodou, 2010). The CFA models were estimated using the WLSMV-estimator (Weighted Least Squares with Mean and Variance correction) in Mplus 7.11 (Muthen & Muthen, 2012) with responses treated as ordinal. The adequacy of models was assessed using three fit indices; Root Mean Square Error of Approximation (RMSEA), the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI). Values of RMSEA; ≤ .08, and CFI and TLI; ≥ .90 indicate adequate model fit (Hu &Bentler, 1999) while RMSEA; ≤ .06, and CFI and TLI; ≥ .95 indicate excellent model fit (Bentler, 1990).

Our sample size did not allow us to formally investigate whether the factor structure differed between commercial and private drivers, and the number of private drivers was too small to support splitting the sample or fitting confirmatory models. However, we did conduct an EFA separately in commercial and private drivers in order to provide some indication of whether the factor structure was consistent across these groups.

External validity was tested using Pearson correlations to identify the associations of the extracted DBQ factors with age, sex, experience and mileage in the full sample. Negative Binomial Regression

tested the association between the DBQ factors and crash involvement given that this count distribution has an overdispersed Poison distribution (Hauer, 2001).The levels of reported errors and violations between Ghana and data from the UK reported by Lajunen et al. (2004) were compared with the immediate form of the t-test using STATA version 13 (StataCorp, 2013).

3. Results

3.1. Confirmatory Factor Analysis

The initial CFAs fitting 2-factor (violations and errors; χ^2*= 831.98 (118) p<.01, RMSEA = .11, CFI = .86; TLI = .85*), 3-factor (violations, errors and lapses; χ^2*= 853.57 (151) p<.01, RMSEA = .10, CFI = .78; TLI = .77*) and 4-factor (ordinary violations, aggressive violations, errors and lapses; χ^2*= 1110.42 (169), p<.01; RMSEA = .17, CFI = .80; TLI = .81*) models that are commonly applied in HICs (e.g., Lajunen et al., 2004) did not fit the data well. Therefore we proceeded to build an exploratory factor model in a random half the data and then to cross-validate this model in the other half of the data.

3.2. Exploratory model building

The suitability of data for EFA was supported in three ways. First, the correlation matrix showed many coefficients above .3. Second, factorability of the correlation matrix was supported by a Kaiser-Meyer-Oklin measure of sampling adequacy of .82, meeting the commonly recommended value of .6 and above (Kaiser, 1974). Third, Bartlett's Test of Sphericity (Bartlett, 1954) was highly significant (χ^2 (378) = 5.68, p < .001), indicating suitability for data reduction. The initial EFA identified seven components with eigenvalues exceeding 1, explaining 77.43% of the variance. The scree plot (Appendix A) revealed a clear break (elbow) after the second component. Therefore, two components were retained for further analysis.

Following oblique rotation the extracted factors were substantially correlated (r=.70). The two-factor solution explained 51.7% of the variance (component one contributing 32.5% and component two contributing 19.2%). As shown in Table 1, the majority of items that loaded most strongly onto factor one are usually identified as violations (e.g., Lajunan et al., 2004), so this was labelled 'violations'. However, five error items (*E1, E2, E3, E4 and E5*) and one lapse item (*L1*) also loaded onto this factor. The items loading onto the second factor included the rest of the items that typically form the errors and lapses sub-scales of the DBQ so we labelled this an 'errors' factor. In addition, one typical violation item regarding overtaking on the inside (*OV8*) also loaded onto this second factor. Four items which had loadings below .50 on both factors (E8, L7, L8 and OV9) were dropped.

Table 1: Factor loadings from Exploratory and Confirmatory Factor Analyses and descriptive statistics for the Driver Behaviour Questionnaire items in Ghana and UK

	Item	EFA (GH) (*n*=228)		Non-commercial drivers (N=114)		Commercial drivers (N=339)		CFA (GH)	GH (*n* = 453)		UK (*n* = 831)		GH vs UK Effect size
		Viol	Error	Viol	Error	Viol	Error		Mean	SD	Mean	SD	
AV1	Become angered by another driver and give chase with the intention of giving him/her a piece of your mind	.85		.71		.87		.82	1.53	1.26	.20	.59	1.35***
OV1	Race away from traffic lights with the intention of beating the driver next to you	.78		.74		.78		.82	1.21	1.30	.99	1.15	.18**
E1	Attempt to overtake someone that you had not noticed to be signaling a left turn	.75		.69		.74		.83	1.26	1.09	.24	.47	1.26***
OV2	Disregard the speed limit on a motorway	.75		.70		.77		.93	1.76	1.26	1.87	1.61	.08
AV2	Become angered by a certain type of a driver and indicate your hostility by whatever means you can	.74		.73		.77		.80	1.73	1.31	.85	.96	.77***
OV3	Disregard the speed limit on a residential road	.73		.68		.73		.83	1.45	1.33	1.38	1.21	.08
AV3	Sound your horn to indicate your annoyance to another road user	.73		.70		.73		.52	2.11	1.13	1.06	1.08	.95***
OV4	Cross a junction knowing that the traffic lights have already turned against you	.70		.70		.75		.75	1.27	1.13	.78	.84	.49***
L1	Attempt to drive away from the traffic lights in third gear	.69		.66		.71		.78	1.06	1.12	.69	.86	.37***
OV5	Drive so close to the car in front that it would be difficult to stop in an emergency	.69		.66		.71		.85	1.23	1.17	.80	.86	.42***
OV6	Pull out of a junction so far that the driver with right of way has to stop and let you out	.66		.67		.67		.73	1.17	1.03	.82	.99	.35***
OV7	Stay in a motorway lane that you know will be closed ahead until the last minute before forcing your way into the other lane	.59		.62		.66		.81	1.11	1.09	.52	.85	.60***
E2	Underestimate the speed of an oncoming vehicle when overtaking	.58		.56		.61		.83	1.49	1.19	.74	.70	.79***
E3	Brake too quickly on a slippery road or steer the wrong way in a skid	.56		.56		.65		.71	.87	1.02	.68	.70	.22***
E4	Miss "Give Way" signs and narrowly avoid colliding with traffic having right of way	.55		.54		.60		.72	.98	.96	.24	.47	.98***
E5	Fail to check your rear-view mirror before pulling out, changing lanes, etc	.54		.52		.59		.74	1.34	1.26	.71	.82	.60***
L2	Realise that you have no clear recollection of the road along which you have just been travelling		.72		.70		.75	.63	1.18	.97	1.17	1.03	.01
L3	Switch on one thing, such as the headlights, when you meant to switch on something else, such as the wipers		.66		.61		.72	.84	1.19	1.22	.89	.89	.28***
E6	Fail to notice that pedestrians are crossing when turning into a side street from the main road		.61		.60		.65	.79	1.13	1.02	.44	.61	.82***
L4	Misread the signs and exit from a roundabout on the wrong road		.61		.60		.60	.86	.81	.96	1.03	.78	-.25***
L5	Forget where you left your car in a car park		.59		.55		.59	.63	.72	.92	1.16	1.09	-.44***
OV8	Overtake a slow driver on the inside		.56		.54		.63	.62	1.36	1.16	.70	.95	.62***
E7	On turning left nearly hit a cyclist who has come up on your inside		.56		.55		.59	.68	.79	.86	.31	.55	.66***
L6	Get into the wrong lane approaching a roundabout or a junction		.53		.51		.60	.65	.85	.86	1.45	.82	-.71***
E8	Queuing to turn right onto a main road, you pay such close attention to the mainstream of traffic that you nearly hit the car in front								1.11	1.11	.63	.71	1.02***
L7	Hit something when reversing that you had not previously seen								.52	.68	.45	.62	.11*
L8	Intending to drive to destination A, you 'wake up' to find yourself on the road to destination 'B'.								.51	.81	.86	.92	-.39***
OV9	Drink and drive								.62	.91	-	-	-

GH – Ghana, EFA - Exploratory Factor Analyses (only loadings > .50 are shown), CFA = Confirmatory Factor Analyses

Viol – violations, AV- aggressive violation, OV – ordinary violation, E – error and L – lapse

CFA loads AV2-E3 on a violations factor and L9 to L4 onto an errors factor

**** p<.001, ** p<.01, * p<.05*

3.3. Factor structure validation

The 2 factor model (violations and errors) including 24 items identified in the exploratory phase was cross-validated in the second random half of the data using CFA. Table 2 shows that this 2-factor model fitted the data well. The CFI and TLI were above .95, and while the RMSEA was a little higher than desirable, across the three indices the fit was acceptable, and substantially better than the fit of plausible competing models also shown in Table 2.

Table 2: *Comparison of fit statistics from Confirmatory Factor Analysis of the Driver Behaviour Questionnaire. The preferred model is highlighted in bold.*

Model	χ^2	***RMSEA***	***CFI***	***TLI***
1 Aberrant driving (single factor)	1460.24	.18	.94	.93
2 Violations & errors	**1357.56**	**.10**	**.97**	**.96**
3 Violations, errors, & lapses	1691.37	.11	.94	.93
4 Ordinary viol, aggressive viol, errors, & lapses	1794.40	.18	.84	.83

All χ^2 are significant at p<.001 on df = 349

3.4 Comparison of commercial and private drivers

EFAs were conducted separately in commercial and private drivers. In both cases the scree plot was consistent with a 2 factor solution. Appendix B shows the pattern of loadings was similar across the two groups.

3.5. Reliability and the relationship among the study variables

Using the full dataset, scales for violations and errors in Ghana were calculated by totalling the strongly loading items. The violations, and errors scales showed good reliabilities; violations (α = *.95*), errors (α = *.86*). A computed generalised Cook's distance statistic (Bollen & Jackman, 1990) for each of the variables revealed no outliers. As shown in Table 3, a significant positive correlation was found

between self-reported traffic citations over the last 12 months and violations but not errors. Table 3 also shows sex was significantly correlated with violations with males scoring higher than females. There was no significant correlation between sex and errors. Similarly, higher mileage related positively to violations but not errors.

Table 3: *Correlations among study variables (n =453)*

	1	*2*	*3*
1. Violations	-		
2. Errors	.34***	-	
3. Crash Involvement	.31***	.28***	-
4. Age	.08	.06	.14**
5. Sex	.11*	.03	.16**
6. Experience	.08	.03	.13**
7. Mileage	17**	.06	.28***
8. Traffic citation	.10*	.09	.16**

*** p<.001(2-tailed), ** p<.01 (2-tailed), * p<0.05 level (2-tailed)
Sex (female = 0, male = 1)

3.6. Association of the DBQ factors with crash involvement

We investigated the associations of the DBQ factors (violations and errors) with self-reported crash involvement using Negative Binomial Regression, entering the demographic factors and driving experience as covariates. The overall model was statistically significant *($\chi 2$= 67.74. (6), p< .001)*. As shown in Table 4, both violations and errors were independently associated with crash involvement.

Table 4: Negative Binomial Regression model of the association between violations, errors and crash involvement (N = 453)

Variable	**Std. Error**	**Wald Chi-Square**	**Sig**	**Exp(B)**	**95% CI (Lower)**	**95% CI (Upper)**
Sex	.26	.92	.34	.78	.47	1.30
Age	.01	.31	.58	1.01	.98	1.03
Experience	.02	.00	.95	1.00	.97	1.04
Mileage	.01	19.00	**.00**	1.00	1.00	1.00
Violation	.01	12.80	**.00**	1.02	1.01	1.03
Error	.01	11.00	**.00**	1.05	1.02	1.08

** p < .05, ** p < .01, *** p < .001*
Sex (female = 0, male = 1)

3.7. The level of aberrant driving in Ghana compared to UK

Given that the factors structures of the DBQ differ in Ghana and UK, the cross-cultural comparison was made at the item level. The drink-drive item was omitted as it was not measured in the UK sample (Lajunen et al., 2004). As shown in Table 1, 20 items were reported significantly more frequently by Ghanaian drivers than UK drivers with effect sizes ranging from .11 to 1.35. This included all the violation items except two (OV2, OV3; that concern disregarding speed limits); No significant difference between Ghana and UK was found on one lapse item (L2; have no clear recollection of the road along which you have just been travelling). Four lapse items (L4, L5, L6, and L8) were reported to be more common in the UK than in Ghana with effect sizes ranging from .25 to .71.

4. Discussion

The DBQ is a well-used measure of aberrant driving behaviour in HICs. The present study addressed its validity in Ghana. The possibility that the structure of the DBQ would differ between HICs and Ghana was expected on the basis of previous findings in LMICs (Bener, Özkan, & Lajunen, 2008) and from a prior exploratory qualitative study (Dotse et al., 2018) that hinted that there may be differences in the psychological processes underlying some driving behaviours between Ghana and HICs. A two-factor structure was identified; the distinction between violations and errors, that has been found to be stable across many settings (Ozkan et al., 2006), was also applicable in Ghana. The errors and violations factors derived in the present study were based on 24 items of the 28 items assessed. The subtler distinctions between aggressive and ordinary violations and between errors and lapses that have been identified in HICs (e.g., Lajunen et al., 2004) were not found in Ghana.

The violation component was made up of 16 items that comprised 10 of the 12 items designed to measure violations from the original 28 item DBQ, as well as 6 error items. The 6 error items could represent deliberate violations in Ghana. For example, overtaking a left-turner (see E1, Table 1) could

be a deliberate method of dangerous overtaking in the Ghanaian context. Underestimating the speed of oncoming traffic when overtaking (E2) could indicate drivers who do a lot of dangerous overtaking exposing them to the potential for this error. Braking too hard (E3) could also be a sign of driving too fast and not checking mirrors (E5) could also be a sign of recklessness that defines violations. The drink-driving item (OV9, Table 1) was expected to load onto the violations factor but it did not. It has been found elsewhere that this item does not always load onto the violations factor (Lajunen et al., 2004). This suggests that drink-driving is independent of general risky driving in some cultures including Ghana. Even though drink-driving is illegal in Ghana (Road Traffic Act 683 of 2004) not all drivers consider that alcohol increases driving risk (Dotse et al., 2018).

The errors factor was made up of 8 items that are usually classed as errors and lapses in the DBQ as well as one violation (overtaking a driver in the inside lane). In the UK this item would usually involve a driver on a motorway becoming frustrated when obstructed by a slower car in their lane and opting to overtake them in an illegal manner. It may be that Ghanaian drivers may pass cars in an inappropriate lane unintentionally rather than as a deliberate violation. There were other behaviours (e.g., nearly hitting a car in front as a result of paying attention to mainstream traffic, hitting something when reversing and selecting the road to the wrong destination) that were endorsed regularly but that did not clearly load onto the violations or errors factor in our Ghanaian sample.

We found the errors and violations scales identified in Ghana had many similar external correlates to those observed in HICs. As expected(de Winter &Dodou, 2010), violations were reported more commonly amongst males than females. We found no sex difference in the reporting of errors contrary to our expectation that these might be more common in females (de Winter &Dodou, 2010; Reason et al., 1990). Non-significant correlations between age and both violations and errors were observed. The non-significant relationship between age and errors was expected based on existing literature (Aberg

&Rimmo, 1998; de Winter &Dodou, 2010). In contrast, violations are more commonly found to be higher in younger drivers in HICs (e.g., de Winter &Dodou, 2010;Ozkan et al., 2006). The discrepancy might be explained by the age distribution of the samples involved. In the developed world the biggest age differences have been found in the teen and early 20s drivers compared to middle aged drivers (e.g., Mallia, Lazuras, Violani, &Lucidi, 2015) but our Ghanaian sample did not include many young people. Reported daily mileage was positively associated with violations but not errors as found in HICs (de Winter &Dodou, 2010).The DBQ was designed to measure the behavioural contribution to crash risk. Therefore, a crucial test of validity is the correlation of the DBQ scales with crash involvement. Replicating findings from HICs (de Winter &Dodou, 2010; de Winter et al., 2015), we found significant relationships of errors and violations with crash involvement.Significant relationships were also found for self-reported traffic citations over the last 12 months and violations but not errors. Both errors and violations were related to crash involvement independently from each other and from demographic and driving experience variables. Taken together, these results indicate that the DBQ is an effective measure of aberrant driving in Ghana.

We compared levels of aberrant driving in Ghana with those typically found in HICs, as exemplified by the UK sample reported by Lajunen et al. (2004). There was a mixed pattern regarding errors with some items reported to be more common in the UK and some reported more frequently in Ghana. The level of violations reported in Ghana was generally higher than in the UK. There are a number of possible explanations for these findings, including that the response scale is interpreted differently in Ghana and/or that the sample selected here may be unrepresentative of the Ghanaian driving population. However, an alternative possibility is that the frequency of many violations may be genuinely higher in Ghana. The effect sizes were large for aggressive driving behaviours, such as using the horn or giving chase to other drivers. There were also substantial differences in crossing red lights, racing other drivers from traffic lights, close following and pushing into traffic. That these behaviours are frequent in

Ghana is compatible with the results of our qualitative work (Dotse et al., 2018). Given that many of these behaviours are related to wanting to drive faster than current road conditions allow, it was surprising that the violations relating to disregarding speed limits on motorways and residential roads did not differ significantly in the UK and Ghana. This may be more reflective of speeding being a ubiquitous problem rather than being focussed only in LMICs. Therefore, these results do not imply that efforts to reduce driving speed in Ghana cannot lead to road safety benefits.

Overall, it seems plausible that reducing all forms of violations and aggressive driving in Ghana may provide an opportunity to improve road safety. The greatest impact on violations may come from a rigorous programme of traffic law enforcement, although it is possible that driving education informed by theoretical models of behaviour change could also be effective here too (McKenna, 2010). Further research will be required to test this possibility. Engineering solutions may also be helpful in mitigating the consequences of frequent violations in Ghanaian driving. For example, building pavements to keep pedestrians separate from traffic and providing road crossing that pedestrians will use is likely to reduce the impact of driving violations on this vulnerable population. Care must also be taken when improvements are made to road conditions. It is likely that the untarmacked roads which are common in Ghana, have unintended traffic calming effects, reducing the opportunity for drivers to violate. Improving the quality of the road surface is a priority for economic development but must be introduced with training and controls for driver behaviour. Finally, road safety may also be improved by reducing driving errors. Our qualitative work indicated this might be achieved through more structured driving training and assessment (Dotse et al., 2018).

5. Limitations

Our volunteer sample contained a mixture of commercial and private drivers. Commercial drivers are an important Ghanaian motoring group who are involved in 40% of fatal crashes and therefore their

inclusion is important for fully understanding driving behaviour in this context. Our exploratory analyses indicated that factor structure may be broadly similar between the groups. However, our sample size was insufficient to formally test invariance of the DBQ structure across groups. This will be a useful goal for future research. It may be that our sample was not fully representative of the Ghanaian driving population. However, we had a good range of drivers in terms of experience, education and socio-economic background whose responses provided a coherent set of results. The exclusion of non-English speaking drivers may have led to a more highly educated sample of drivers than the full population of Ghana.The inclusion of illiterate participants (adult literacy rate in Ghana is 77% [World Bank, 2015]) will be a challenge for future driving research in Ghana. Our data was self-reported and therefore observed relationships may be inflated by common method variance (Podsakoff,MacKenzie, Lee, & Podsakoff, 2003). However, Lajunen and Summala (2003) concluded that common method variance in the DBQ responses is generally very small. Other researchers (e.g., McDonald, Ingham, Hall, & Rolls, 1991; McGwin, Owsley, & Ball, 1998) found moderate agreement between self-reported and objective (state-recorded) crash measures. Further work validating the DBQ with objective measures of driving behaviour and crash involvement with large samples in LMICs would be useful aims for further research.

6. Conclusion

We found that the DBQ was a useful measure to characterise aberrant driving behaviour in Ghana with the distinction between errors and violations remaining salient in this context. Therefore, the DBQ may have a number of applications in research in Ghana, including being used as an outcome measure in studies that try to improve road safety behaviours. Higher levels violations were reported in Ghana compared to the UK, underscoring the need for more controls on aberrant driving in Ghana. Further, quantitative studies are required to explore whether the psychological factors that underlie violations and errors in Ghana are similar to those identified in HICs.

References

Aberg, L., & Rimmo, P. A. (1998). Dimensions of aberrant driver behaviour. *Ergonomics, 41,* 39–56.

Barron, D. N. (1992). The analysis of count data: Overdispersion and autocorrelation. *Sociological methodology*, 179-220.

Bartlett, M. S. (1954). A note on the multiplying factors for various χ 2 approximations. *Journal of the Royal Statistical Society. Series B (Methodological)*, 296-298.

Bener, A., Özkan, T., & Lajunen, T. (2008). The driver behaviour questionnaire in Arab gulf countries: Qatar and United Arab Emirates. *Accident Analysis & Prevention, 40*(4), 1411-1417.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, *107*(2), 238-246

Bjorklund, G. (2005). *Driver interaction. Informal rules, irritation and aggressive behaviour*. Acta Universitatis Upsaliensis. Digital comprehensive summaries of Uppsala. Dissertations from the faculty of social sciences 8. Uppsala. ISBN 91-554-6354-1.

Blockey, P. N., & Hartley, L. R. (1995). Aberrant driving behaviour: errors and violations. *Ergonomics*, *38*(9), 1759-1771.

Bollen, K.A., & Jackman, R.W. (1990). Regression diagnostics: An expository treatment of outliers and influential cases. In J. Fox & J.S. Long (Eds.), *Modernmethods of data analysis* (pp. 257–291). Thousand Oaks, CA: Sage.

Byrne, B. M. (2013). *Structural equation modelling with AMOS: Basic concepts, applications, and programming*. New York: Routledge.

Cordazzo, S. T. D., Scialfa, C. T., Bubrick, K., & Ross, R. J. (2014). The Driver Behavior Questionnaire: a North American analysis. *Journal of Safety Research 50, 99–107.*

de Winter, J. C. F, Dodou, D., & Stanton, N. A. (2015). A quarter of a century of the DBQ: some supplementary notes on its validity with regard to accidents. *Ergonomics*, *58*(10), 1745-1769.

de Winter, J. C. F. (2013). Predicting self-reported violations among novice license drivers using pre-license simulator measures. *Accident Analysis & Prevention*, *52*, 71-79.

de Winter, J. C., & Dodou, D. (2016). National correlates of self-reported traffic violations across 41 countries. *Personality and individual differences*, *98*, 145-152.

de Winter, J.C.F. &Dodou, D. (2010). The Driver Behaviour Questionnaire as a predictor of accidents: A meta-analysis. *Journal of Safety Research 41,* 463–47.

Dotse, J. E., Nicolson, R., & Rowe, R. (2018). Behavioral influences on driver crash risks in Ghana: A qualitative study of commercial passenger drivers. Traffic Injury Prevention … Doi: 10.1080/15389588.2018.1556792.

Hauer, E. (2001). Overdispersion in modelling accidents on road sections and in Empirical Bayes estimation. *Accident Analysis & Prevention*, *33*(6), 799-808.

Helman, S., & Reed, N. (2015). Validation of the driver behaviour questionnaire using behavioural data from an instrumented vehicle and high-fidelity driving simulator. *Accident Analysis & Prevention*, *75*, 245-251.

Hu, L. T., &Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modelling: A Multidisciplinary Journal*, *6*(1), 1-55.

Iversen, H., &Rundmo, T. (2002). Personality, risky driving and accident involvement among Norwegian drivers. *Personality and Individual Differences*, *33*(8), 1251-1263.

Iversen, H., &Rundmo, T. (2004). Attitudes towards traffic safety, driving behaviour and accident involvement among the Norwegian public. *Ergonomics*, *47*(5), 555-572.

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31-36.

Kontogiannis, T., Kossiavelou, Z., &Marmaras, N. (2002). Self-reports of aberrant behaviour on the roads: Errors and violations in a sample of Greek drivers. *Accident Analysis and Prevention, 34, 381–399.*

Lagarde, E. (2007). Road traffic injury is an escalating burden in Africa and deserves proportionate research efforts. *PLoS medicine*, *4*(6), e170-e175.

Lajunen, T., &Summala, H. (2003). Can we trust self-reports of driving? Effects of impression management on driver behaviour questionnaire responses. *Transportation Research Part F: Traffic Psychology and Behaviour*, *6*(2), 97-107.

Lajunen, T., Parker, D., & Stradling, S. G. (1999). Dimensions of driver anger, aggressive, Highway Code violations and their mediation by safety orientation in Drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, *1, 107–121.*

Lajunen, T., Parker, D., &Summala, H. (2003). The Manchester Driver Behaviour Questionnaire: a cross-cultural study. *Accident Analysis and Prevention, 942, 1–8.*

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. S., & Stradling, S. G. (1997). The role of affect in predicting social behaviors: the case of road traffic violations. *Journal of Applied Social Psychology*, *27*(14), 1258-1276.

Lee, I. A., & Preacher, K. J. (2013). Calculation for the test of the difference between two dependent correlations with one variable in common [Computer software]. Available from http://quantpsy.org.

Mallia, L., Lazuras, L., Violani, C., &Lucidi, F. (2015). Crash risk and aberrant driving behaviors among bus drivers: the role of personality and attitudes towards traffic safety. *Accident Analysis & Prevention*, *79*, 145-151.

Mattsson, M. (2012). Investigating the factorial invariance of the 28-item DBQ across genders and age groups: an exploratory structural equation modelling study. *Accident Analysis and Prevention,48,* 379–396.

McDonald, M., Ingham, R., Hall, R. D., & Rolls, G. W. P. (1991). *Accident risk and behavioural patterns of younger drivers* Basingstoke, GB. Automobile Association Foundation for Road Safety Research.

McGwin Jr, G., Owsley, C., & Ball, K. (1998). Identifying crash involvement among older drivers: agreement between self-report and state records. *Accident Analysis & Prevention*, *30*(6), 781-791.

McKenna, F. P. (2010). *Education in Road Safety: Are we getting it right?* (10/113). RAC Foundation Report. RAC Foundation: London.

Mesken, J., Lajunen, T., &Summala, H. (2002). Interpersonal violations, speeding violations and their relation to accident involvement in Finland. *Ergonomics 7, 469–483*.

Muthen, L.K., &Muthen, B.O. (2012). *Mplus User's Guide, Seventh ed*. Los Angeles, CA: Muthén&Muthén.

National Road Safety Commission. *Road Traffic Crashes in Ghana: Statistics 2015.*Accra, Ghana: Ministry of Transport; 2016.

National Road Safety Commission. *Road Traffic Crashes in Ghana: Statistics 2016.*Accra, Ghana: Ministry of Transport; 2017.

Özkan, T., Lajunen, T., Chliaoutakis, J. E., Parker, D., &Summala, H. (2006). Cross-cultural differences in driving behaviours: A comparison of six countries. *Transportation Research Part F: Traffic Psychology and Behaviour, 9*(3), 227-242. doi:https://doi.org/10.1016/j.trf.2006.01.002

Petridou, E., &Moustaki, M. (2000). Human factors in the causation of road traffic crashes. *European journal of epidemiology*, *16*(9), 819-826.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*, 879–903.

Qu, W., Zhang, Q., Zhao, W., Zhang, K., & Ge, Y. (2016). Validation of the Driver Stress Inventory in China: Relationship with dangerous driving behaviours. *Accident Analysis and Prevention 87,* 50–58.

Reason, J., Manstead, A., Stradling, S., Baxter, J., & Campbell, K. (1990). Errors and violations on the roads: a real distinction? *Ergonomics*, *33*(10-11), 1315-1332.

Road Traffic Act. (2004). Act 683, Republic of Ghana.

SPSS, I. (2011). *IBM SPSS statistics for Windows, version 20.0.*New York: IBM Corp.

Stanojević, P., Lajunen, T., Jovanović, D., Sârbescu, P., &Kostadinov, S. (2018). The driver behaviour questionnaire in South-East Europe countries: Bulgaria, Romania and Serbia. *Transportation Research Part F: Traffic Psychology and Behaviour*, *53*, 24-33.

StataCorp. (2013). *Stata Statistical Software: Release 13.* College Station, TX: StataCorp LP.

Stephens, A.N., &Fitzharris, M. (2016). Validation of the Driver Behaviour Questionnaire in a representative sample of drivers in Australia. *Accident Analysis and Prevention 86,* 186–198.

Sullman, M. J., Meadows, M., &Pajo, K. B. (2002). Aberrant driving behaviours amongst New Zealand truck drivers. *Transportation Research Part F 15,* 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.

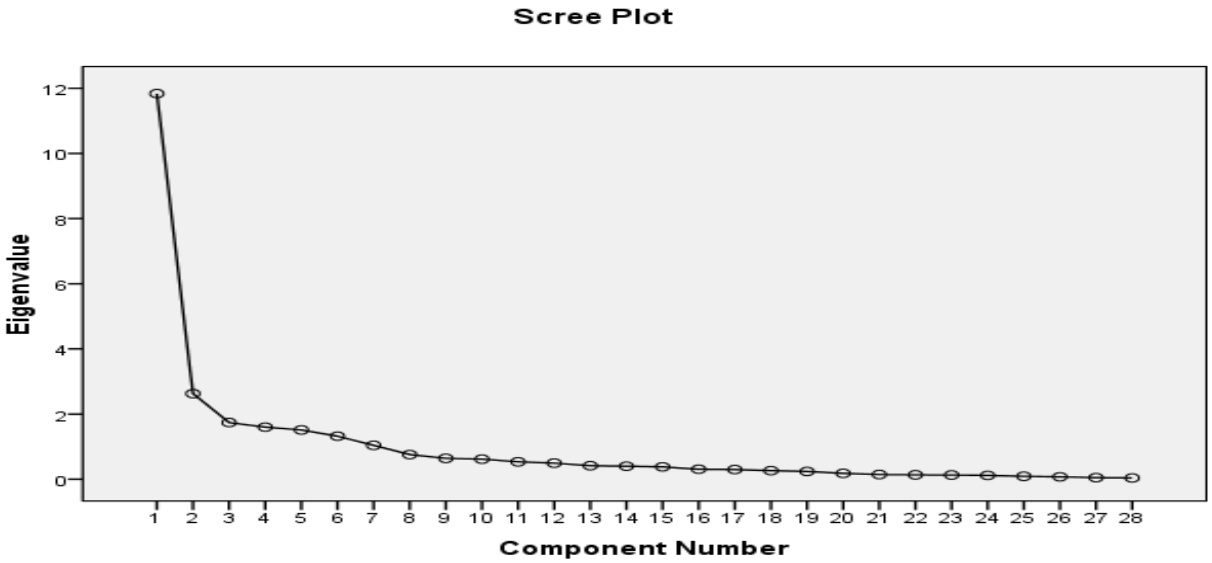
Ulleberg, P., &Rundmo, T. (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety Science 41 (5),* 427–443.

World Bank Group. (2015). *World development indicators 2015*. World Bank Publications.

World Health Organization. (2018). *WHO country cooperation strategy at a glance: Ghana* (No. WHO/CCU/18.02/Ghana). World Health Organization.

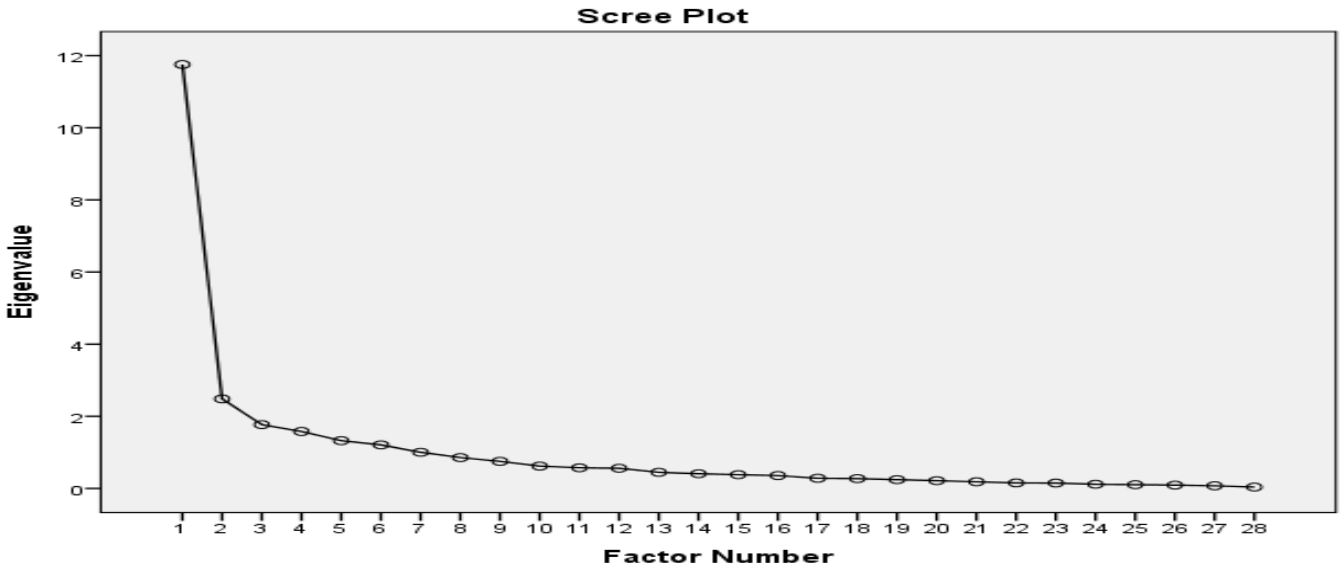
Appendices

Appendix A: Screeplot from the Exploratory Factor Analysis of the Driver Behaviour Questionnaire in Ghana (N= 453)



Appendix B: Screeplot from the Exploratory Factor Analysis of the Driver Behaviour Questionnaire for commercial and private car drivers in Ghana

B1: Commercial drivers (N=339)



B2: Private drivers (N = 114)