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Can infrastructure improvements mitigate unsafe traffic safety culture: a driving simulator study exploring cross cultural differences

Abstract

This paper presents the results of a cross-cultural study to investigate the influence of traffic safety culture and infrastructure improvements on driver behaviour. To achieve this, the driving style of UK drivers was compared with that of Nigerians with and without experience of driving in the UK. A driving simulator experiment compared the actual driving style of these three groups of drivers in different safety critical scenarios. The simulated road environment varied depending on how much infrastructure was provided (low or high infrastructure). In addition, the Driver Behaviour Questionnaire was used to collect self-reported data on violations, errors and lapses. It was hypothesised that Nigerian drivers with no experience of driving in a UK road system would report and engage in more unsafe driving behaviour compared to the other two groups, and that increasing infrastructure would have little positive benefit. Overall, the results supported these hypotheses, indicating that the behaviours of drivers are interpretable in relation to their traffic safety culture, compared to changes in their driving environment.

Keywords: driver behaviour, driving simulator, Nigeria, traffic safety culture, road environment, infrastructure improvement

1 Introduction

National differences in traffic safety exist, with High Income Countries (HICs) outperforming the Low and Middle Income Countries (LMICs). Countries such as Norway, Sweden and the UK have decreased their road traffic fatality rates in the past decades, but they continue to rise in most LMICs. In its Global Status Report on Road Safety (2018), the World Health Organisation (WHO) reports that the highest road traffic fatality rates are in the African and South-East Asian regions. Although Africa is the least motorised (2%) region of the world, it accounts for 16% of all recorded crash deaths. Nigeria and South Africa have the highest fatality rates (33.7 and 31.9 deaths per 100,000 population, respectively) being above the African average of 24 deaths per 100,000 population (WHO, 2013). Reducing road traffic injuries has a positive effect on national income growth (World Bank, 2017) and thus for LMICs, in particular, efforts to understand and improve traffic safety are imperative.

1.1 Traffic safety culture

Factor et al. (2007), in their “social accident” model, stated that drivers belonging to different social groups interpret a given situation differently and this varied interpretation could result in crashes. In most LMICs, there is a paucity of formal traffic rules, resulting in drivers developing ways of communicating and interacting with each other informally (e.g. Gregory, 1985; Edensor, 2004). This has given rise to the term “traffic culture”.

The term “culture” is common in the social sciences and humanities. Hoebel (1966) described culture as an integrated system of learned behaviour patterns. According to Bealer et al. (1965), culture is the belief structure, shared ideas and directives for action that are embodied by a community. North (1990) citing the work of Boyd & Richerson (1985) defined culture as "transmission from one generation to the next, through teaching and imitation of knowledge, values, and other factors that influence behaviour." Given that it strongly affects the way people live and behave, culture could influence the way people behave in traffic. Warner et al. (2009) suggest that an explanation for diversity in violations and crash involvement could be due to cultural differences. Thus the road safety values associated with a society or country would be expected to have a significant influence on driving behaviour. Leviäkangas (1998) described traffic culture as the sum of all factors (skills, attitude and behaviour of drivers as well as vehicles and infrastructure) which either directly or indirectly influence a country's level of traffic safety. According to Iversen & Rundmo (2004), societal norms and pressure contribute to shaping attitudes towards rule-breaking and risk-taking behaviour.

A country's traffic safety culture is defined by its social norms, values and beliefs formed and nurtured by formal and informal rules. Formal rules which are mostly enforced by authorities may change overnight, but informal rules are developed as a result of constant interaction with other road users and the road environment. According to Özkan (2006), these informal rules are usually embodied in the customs and traditions of the road users and are not easy to change. He redefined traffic culture of a country as "the sum of all external factors (eco-cultural-socio-political, national, group, organisational, and individual factors) and practices (e.g. education, enforcement, engineering, emergency services) for the goals of mobility and safety to cope with internal factors (road users, roads, and vehicles) of traffic".

According to WHO (2018), road fatalities rates in LMICs are more than double that in the HICs. Drivers in LMICs have been reported to exhibit more risky behaviour than drivers from HICs (Lund & Rundmo, 2009; Bener et al., 2008). The World Bank (2012) states that it is possible that cultural factors are more relevant in LMICs in accounting for high rates of traffic fatalities due to scant regulations which are not enforced due to limited resources and a lack of training for the police to manage traffic regulations. The high incidence of road traffic crashes in these countries can also be attributed to aberrant behaviour on the part of road users, unsafe vehicles, substandard road design and maintenance, little or no driver education and lack of enforcement of traffic safety laws (Peden et al., 2004). Atchley et al. (2014) confirmed these national differences from a comparison of traffic safety culture between China, Japan and the United States. Although they do not explicitly discuss driving styles, they conclude that the different crash risk records of the three countries are related to different cultural values attached to risk perception and obedience to traffic rules and regulations. Self-report studies by Nordfjærn et al. (2011; 2014) examined country cluster differences based on different cultural frameworks in road traffic risk perception, attitude towards road safety and driver behaviour in samples from Norway, Russia, India, Ghana, Tanzania, Uganda, Turkey and Iran. The results showed that Norwegians reported overall stronger traffic safety attitudes and behaviour (drink driving, seatbelt use, speeding) but drivers from Africa (Ghana and Uganda) reported the highest risk perception. They further claim that contrary to the cultural theory, prediction models revealed that cultural factors were stronger predictors of driver behaviour than risk perception.

Özkan et al. (2006) used the Driver Behaviour Questionnaire (DBQ) to collect self-reported data from drivers across six countries (Finland, Great Britain, Greece, Iran, The Netherlands and Turkey). Two hundred and forty-two drivers were chosen from each of the six countries, matched for age and gender. The results revealed differences between drivers from "safe" Western/Northern European and Southern European/Middle Eastern countries on DBQ items and scales. The authors conclude that driving style mediates the relationship between traffic culture (i.e. country) and the number of crashes. Their analyses also demonstrated the importance of driver characteristics and behaviours in predicting the number of traffic crashes and this varies from country to country. Thus, measures that succeed in a particular culture might not succeed in other cultures, considering the differences in traffic safety culture.

1.2 The road environment

Apart from traffic culture, driving behaviour and safety is also influenced by the road environment (Dixit et al., 2012; Hao et al., 2016), comprising of the vehicle, road infrastructure and traffic regulations. In this paper, the environment specifically refers to the external conditions to the vehicle (the road infrastructure).

The road environment, including its traffic layout and safety features have a critical impact on road user safety (Jamroz, 2011). According to ROSPA (2010), environmental factors, including the road environment are the prime cause in 2-3% of crashes and contribute to about 18% of road crashes in total. However, altering and redesigning the road environment for example, by improving infrastructure can play an important role in road safety (Pérez, 2006). Good road infrastructure improves traffic safety by contributing to forming behaviours which can be performed automatically. Improvements in the road infrastructure (such as road signs, traffic lights and road markings) can reduce crashes, by reducing opportunities for road users to make errors; and if errors do occur, making the environment more forgiving (Almqvist & Hyden, 1994). High quality road infrastructure improves traffic safety by automatically triggering safe behaviours (Theeuwes & Godthelp, 1995; Martens, 2007). According to Elvik & Vaa (2004), the application, for instance, of traffic control signals at four arm junctions may lead to a 30% reduction in personal injury accidents.

The road infrastructure conveys a wealth of information that guides drivers' activity and their interactions with other road users. For example, a speed limit sign instructs drivers that they must drive no faster than the limit shown. However drivers' perception of safe speed often differ depending on the road environment as some will often underestimate the actual level of risk. Some drivers may not know the speed limits on certain roads if they are not posted. This may encourage higher speeds, thereby increasing the likelihood of collisions and their severity. This can be further exacerbated by insufficient, poorly maintained or misleading road markings and signs, poor road surfaces and street furniture (Stanton et al., 2009). Unfortunately and especially in LMICs, roads are currently being built and reconstructed without any consideration for safety (Uzondu, 2018). These may lead to driving behaviours that are not appropriate, could mislead drivers and directly trigger crashes. It is crucial, therefore, that the road environment provides appropriate information to those using it as this may be one of the ways to improve behaviour and reduce crash rate.

Infrastructure improvements have become a priority in road safety programmes and strategies (WHO, 2011) and are mostly derived from experience in HICs. However, if drivers in LMICs have come to rely on and react to cultural cues, rather than infrastructural ones, perhaps investment in infrastructure is misdirected and may not achieve the desired traffic safety results.

1.3 The current study

In this study, Nigeria and the UK were used as sample countries due to the distinct differences in terms of traffic safety performance. Nigeria has one of the worst traffic safety performances in the world while the UK is one of the countries with the best, as evidenced by their traffic fatality rate (21.4 and 3.1 per 100,000 vehicles respectively).

Based on the literature reviewed, we define traffic safety culture as a general understanding of drivers' behaviour and attitudes within the traffic environment, encompassing the road infrastructure, vehicles, road user behaviour and general traffic safety management. The study focussed on the extent to which a road environment with either low or high amounts of infrastructure can mediate the effect of a traffic safety culture facilitative of unsafe driving behaviour. Although Nigeria has one of the highest road fatality rates in the world, to the knowledge of the authors, there are no empirical studies which attempt to examine and observe the driving behaviour of Nigerians in detail. It is expected that this present study would fill this gap and provide some useful insights needed to develop evidence-based strategies for improving the road safety profile in Nigeria and may help to understand the role road safety culture plays as a contributory factor to road safety performance in LMICs. Therefore this study aimed to investigate the influence of traffic safety culture and infrastructure improvements on driver behaviour.

2 Method

2.1 Study design

A two-way (2x3) mixed design was employed. The between-subject factor was Culture of the participants with 3 levels (NG, NG/UK and UK drivers). The NG drivers had gained their licence and driving experience in Nigeria only whilst the UK group were licenced and exposed to UK traffic only. Finally, the NG/UK group had driven and gained exposure to the traffic culture in both countries. The within-subjects factor was Infrastructure with 2 levels (low and high). In the low infrastructure condition, traffic signs, road markings and traffic signals were minimal, whilst in the high infrastructure condition, these were present and conformed to UK standards. All participants drove on roads with low and high infrastructure, counterbalanced to account for order effects.

2.2 Participants

Participants were recruited using printed adverts placed at different locations in the University of Leeds and the city centre. The eligibility criteria for all participants was stated clearly on the recruitment email and adverts. As an additional measure, an email was sent to those who indicated interest to take part in the study, where they were asked to confirm where they had experience of driving. Subsequently, potential participants completed a set of questions on google form which included questions about their driving experience (e.g. "do you have experience of driving in any developing or developed country"), where they obtained their driving licenses and had experience of driving (UK, Nigeria, Nigeria/UK). Sixteen participants were recruited to each group (NG: 12 males, 4 females; NG/UK: 12 males, 4 females; UK: 11 males, 5 females) aged 19 to 55 years old. No significant age differences were found between the three groups (NG: M=31.75, SD=8.43; NG/UK: M=32.56, SD=7.20; UK: M=30.25, SD=5.56). Every participant held either a Nigerian and/or a full UK/EU license and had at least 2 years of driving experience (range 2-20 years). As a gesture of appreciation, all participants were given £20 for taking part in the study.

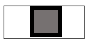
2.3 Driving scenarios

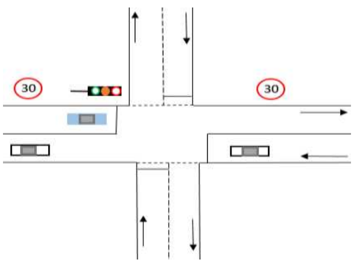
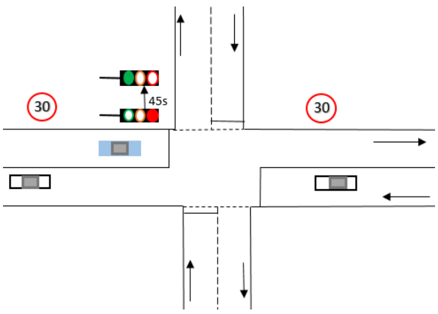
A high-fidelity driving simulator (University of Leeds Driving Simulator UoLDS; https://uolds.leeds.ac.uk/) was used to create a realistic setting where behaviours relevant to safe driving could be examined. UoLDS uses a 2005 Jaguar S-type vehicle model housed in a 4m spherical projection dome with a 300° field of view projection system. It has fully operational controls, including a steering wheel with force feedback and pedals, as well as rear and side view mirrors. A spherical screen projection area displays the road environment at a resolution of 3x1920x1200 to the front and 1024x768 in the peripheral and rear views. The side mirrors provide a field of view of 42°, displayed on CRT screens. While driving, the participant perceives longitudinal and lateral movement via a “hexapod” motion base and X-Y table that together provide a realistic perception of motion.

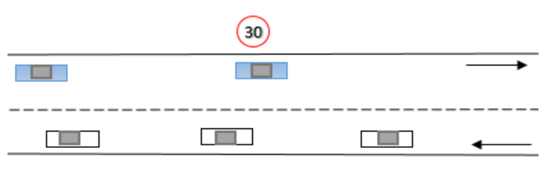
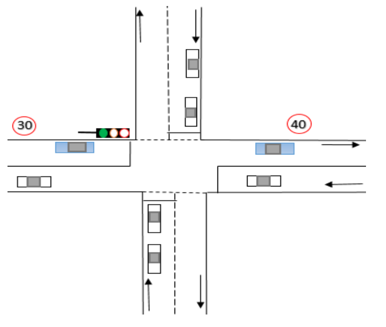
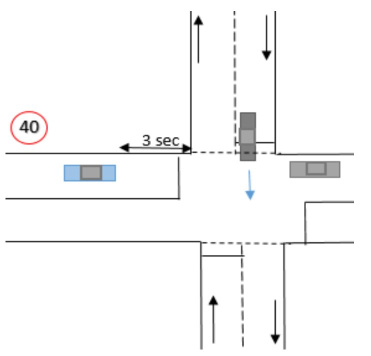
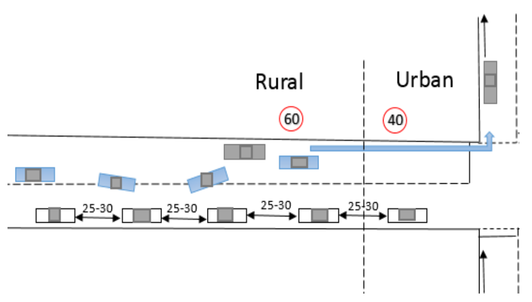
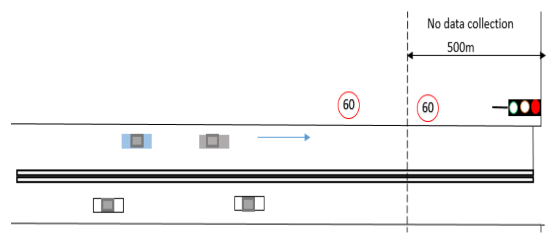
A 20km road was developed consisting of urban and rural segments forming an approximate 26-minute drive. The road was comprised of one lane in each direction with choreographed traffic in the participants’ lane and in the opposite lane. The speed limit varied between 30mph (48km/h), 40mph (64 km/h) and 60 mph (97 km/h). Seven traffic scenarios were developed, of which four were modified by the level of infrastructure. Table 1 provides details of all seven scenarios, as well as details regarding how the infrastructure was modified.

Table 1: Traffic scenarios

The participant, leader and other road users in the sketch are represented by:

 Participant  Leader/crossing car  other road users

Road layout	Scenario description
	**Amber dilemma** The participant approached a green traffic light which changed to amber 2.5 seconds before they reached the junction. They had to decide whether to cross the junction or brake to a stop. If they crossed the junction when the light was showing red, a violation was recorded.
	**Junction approach and departure** The participant approached a red traffic light and were required to wait for 45 seconds. When the light turned to green, they could accelerate through the junction. Mean and standard deviation of deceleration rate on the 100m approach to the junction, impatient waiting behaviour, acceleration rate away from the junction and time to reach the speed limit were recorded.

	**Speed choice** Over a distance of 2.5km, participants drove on a 30 mph (48 km/h) speed limit road, with straights and curves and oncoming traffic. Mean speed, speed variation and speed limit exceedence were measured. In the high infrastructure version of this scenario, speed limit signs were positioned repeatedly along the road.
	**Hazard anticipation** Participants approached a green traffic light, with other stationary vehicles on the minor arms of the junction, visible to the participant. Speed and deceleration rates were recorded over a distance of 350m.
	**Conflict handling** This scenario required participants to interact with a vehicle whose behaviour posed a potential conflict. As the participant approached an unsignalised junction where they had priority, at 3 seconds Time To Junction (TTJ), a car approached from the left arm and crossed the road in front of the participant. Time To Collision (TTC) to the emerging car, Brake Reaction Time (BRT) and spot speed were measured. In the high infrastructure version of this scenario, speed limit signs were positioned prior to the junction.
 	**Overtaking** Two potential overtaking scenarios were presented to participants on a road with a 60mph speed limit. In the first, a low flow of oncoming traffic with a range of time headways approximately 25-30 seconds and travelling at 40mph, provided a permitted, overtaking opportunity. The number of overtaking attempts, time headway to the lead and oncoming vehicles, maximum speed, distance tailway and indicator use were recorded. In the high infrastructure version of this scenario, speed limit signs were positioned repeatedly along the road. In the second overtaking scenario, the high infrastructure version included solid double white lines to indicate that overtaking was prohibited. The propensity for participants to violate the road markings was recorded.

2.4 Driver Behaviour Questionnaire

To examine the differences in self-reported driving behaviour between the three driver groups, the original 50-item DBQ (Reason et al., 1990) was modified (see Appendix 1) and piloted on a sample of Nigerian drivers. Thirty-three original items were retained and 17 were modified to ensure clarity and relevance for the Nigerian driving context. For example, the item "Park on a double-yellow line and risk a fine" was modified to "Park on a double-yellow line/diagonally striped area and risk a fine", due to the scarcity of double yellow lines on Nigerian roads. This measure was taken because the pilot study showed that there was difficulty among Nigerian respondents in interpreting some terms in the original version of the DBQ as some descriptions of the road environment involved designs which are not obtainable in Nigeria. It provided ideas and the opportunity to modify the questionnaire and include terms that are common to Nigerians. The original wordings were retained together with the modifications so that it could be used by all groups of drivers. After the modifications, a second pilot study was conducted to ascertain that the DBQ could be used especially in the Nigerian sample without the difficulties encountered in the first pilot study. As standard with the DBQ, respondents were asked to indicate how often they performed each behaviour in the last two years using the scale of 0 (= never) to 5 (= nearly all the time). The aim was to identify key items which were rated differently by drivers from the three different traffic cultures.

2.5 Hypotheses

It was hypothesised that the effect of Culture would be observed as a main effect whereby NG drivers would exhibit (and report via the DBQ [errors, lapses and violations]) more unsafe behaviour than the other two groups. Such unsafe behaviour would include traffic light, speed and overtaking violations, later braking on approach to junctions as well as poorer hazard and conflict handling skills. A main effect of Infrastructure was expected, with high infrastructure encouraging safer driving. An Infrastructure x Culture interaction was also hypothesised such that in the low infrastructure condition, the NG/UK and UK group would maintain their safer driving behaviour, whereas the NG drivers would revert to more unsafe driving behaviour

2.6 Procedure

During recruitment, to prevent the participants from preparing for the study, they were told that the study was about 'how different people drive', without giving details. At the beginning of the session, participants were briefed, reminded that the experiment was voluntary, asked to read the information sheet, prompted to ask questions and signed the consent form. They were briefed on how to operate the simulator and that they were expected to drive as they would normally do. Together with the experimenter, participants performed a 10-minute practice drive to become familiar with the driving simulator. The scenarios involving junctions and other vehicles in the participant trajectory were not included in the practice drive to prevent learning. Then, they were given a short break during which they were monitored for any signs of motion sickness. After this, they were asked to start the main experiment. All participants completed two drives (low and high infrastructure), each approximately 26-minute duration, separated by a short break and then completed the DBQ. Subsequently, a debriefing took place and they had the opportunity to ask questions about the study.

2.7 Data analysis

The raw simulator data was processed in R to extract the dependent variables, separately for each scenario. A mixed methods ANOVA was performed with a between-subjects factor Culture (3 levels:

NG; NG/UK; UK) and a within-subjects factor Infrastructure (2 levels: low and high). Where the assumption of sphericity was violated, the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. Main and interaction effects are reported, along with post hoc tests where appropriate (Bonferroni correction was used). Statistical significance was accepted at $p < 0.05$. For the three scenarios where a traffic light was present, analysis was conducted on data from the high infrastructure only (as traffic lights were absent in the low infrastructure condition) using a one way ANOVA. Where the normality, homogeneity of variances, or outlier assumptions were not met, the non-parametric Kruskal-Wallis test was used. Where results were based on counts, Chi-square was used to determine whether there were any associations between the variables. Post hoc tests using residual analysis were conducted on statistically significant variables to test the direction of association in each cell and to determine which cell differences contributed to the Chi-square result. The size of the standardized residuals was compared to the critical values that correspond to an alpha of 0.05 (+/- 1.96).

The DBQ data were analysed using the Statistical Package for the Social Sciences (SPSS Version 24). Before analysis, data were screened for invalid or unusual cases and incorrectly entered data. One-way analysis of variance (ANOVA) with pairwise post hoc Bonferroni correction was used to identify differences in the tendency to commit aberrant driving behaviours across the three groups of drivers.

3 Results

3.1 Driving simulator data

The mean values (SD in brackets) for the dependent variables are presented in tables for each scenario.

3.1.1 Amber dilemma

This scenario involved participants approaching a green traffic light at a junction which changed to amber 2.5 seconds before they reached it. No statistically significant main effects of Culture were found with regards the frequency of red light violations.

3.1.2 Junction approach and departure

In this scenario, the participant approached a red traffic light, waited for 45 seconds and accelerated through the junction when the traffic light turned green. On approach to the junction, a main effect of Culture on variation in deceleration was found [$F(2, 45) = 6.804$, $p = .003$] with post-hoc testing showing that UK drivers decelerated more smoothly than NG drivers by $0.33 m/s^2$ (Table 2). No significant differences were found between the other groups for this measure.

Whilst waiting at the red traffic light for 45 seconds, a measure of impatience was implied by observing if drivers tended to creep forwards in anticipation of the light turning green. Results showed that 63% of NG, 38% of NG/UK and 31% of UK drivers crept forwards and a Kruskal-Wallis test demonstrated a significant difference in the mean ranks of the distance covered by the three groups [$\chi^2(2) = 6.693$, $p = .035$]. Dunn's pairwise tests revealed significant differences between the NG and UK and NG and NG/UK groups. The median distance covered was higher for the NG drivers by 2.07m compared to the UK and 1.59m compared to NG/UK drivers. There was no difference between the UK and NG/UK groups.

When the traffic light turned green, a main effect of Culture on acceleration was found, [F (2, 45) =8.067, *p* = .001], with post hoc comparisons revealing that NG drivers accelerated more harshly than NG/UK (*p* = .002) by 0.19m/s^2 and UK (*p* = 0.006) drivers by 0.17m/s^2. This resulted in them reaching the speed limit quicker [F (2, 45) = 12.335 *p* = .000]; they reached the speed limit in almost half the time of NG/UK (*p*= .002) and UK drivers (*p* = .000).

Table 2: Mean (SD) values for junction approach and departure

Scenario	Variable	Culture		
		NG	NG/UK	UK
Deceleration to red light	Mean deceleration (m/s^2)	-0.10 (0.06)	-0.01 (0.05)	-0.09 (0.04)
	SD. deceleration (m/s^2)	**0.96 (0.26)[d]**	0.75 (0.27)	0.63 (0.22)
Impatient behaviour	*Distance covered (m)	**14.11[a]**	6.67	4.17
Acceleration from green light	Acceleration (m/s^2)	**0.35 (0.19)[a]**	0.16 (0.15)	0.18 (0.06)
	Time to reach speed limit (secs)	**12.41 (10.65)[a]**	22.97 (8.55)	26.13 (3.79)

[a] sig. different from the other two cultures; [b]sig. different from NG; [c]sig. different from NG/UK; [d]sig. different from UK
*mean ranks

3.1.3 Speed choice (Low and High Infrastructure)

Over a distance of 2.5km, participants were required to drive on a 30 mph (48.3 km/h) road in both high and low infrastructure conditions. In the high infrastructure condition, there were speed signs present and none in the low infrastructure condition. Figure 1 shows the speed profiles across all experimental conditions.

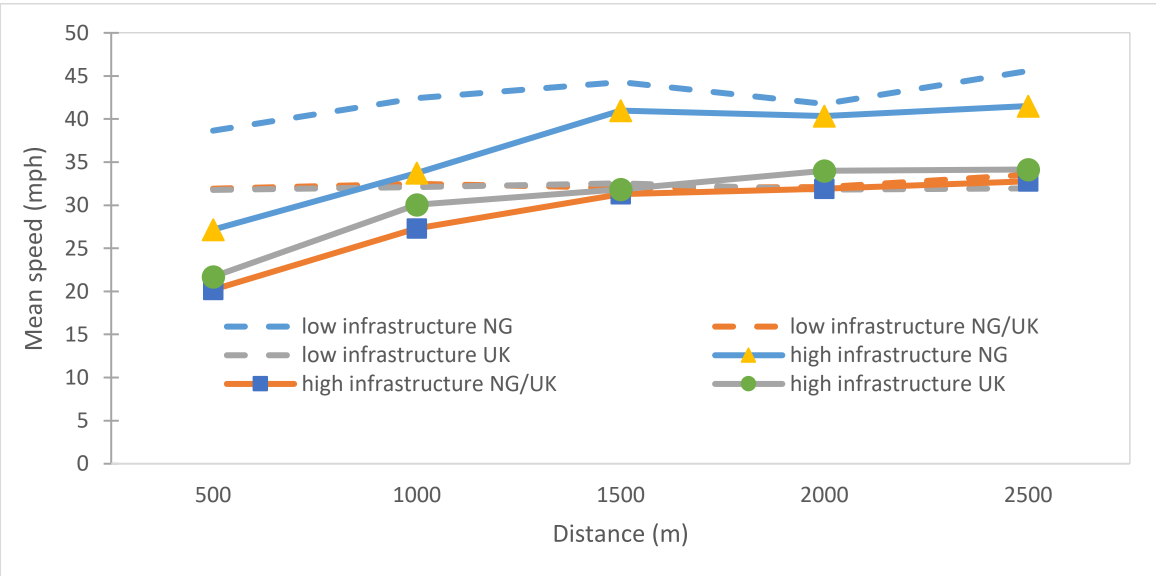


Figure 1: Speed profile in the speed choice scenario, by Culture and Infrastructure

Several main effects of Culture were found, Table 3. First, there was a significant main effect of Culture [F (2, 90) = 9.420, *p* = .000] on mean speed. Post hoc comparisons showed that NG drivers drove at a mean speed 7.44mph higher than NG/UK drivers (*p* = .000) and 4.31mph higher than UK drivers (*p* = .043). There were no significant differences between NG/UK and UK drivers. Culture was also influential on the proportion of time drivers spent exceeding the speed limit [F (2, 90) = 3.781, *p* = .026]: NG drivers exceeded the speed limit more (by 15.43%) compared to the NG/UK drivers (*p* = .032). There were no significant differences between either NG and UK drivers or NG/UK and UK drivers. There were no significant main effects of Infrastructure or any interactions between Culture and Infrastructure for all the variables measured.

Table 3: Mean (SD) values for the speed choice scenario

Variable	Infrastructure	Culture		
		NG	NG/UK	UK
Mean speed (mph)	Low	**44.51 (8.84)[a]**	34.65 (4.76)	35.50 (6.17)
	High	**43.62 (10.9)[a]**	32.51 (5.51)	32.78 (3.68)
SD. Speed (m/s)	Low	8.90 (3.72)	7.15 (2.88)	6.02 (3.86)
	High	4.19 (1.43)	3.18 (1.52)	2.49 (0.86)
Speed limit exceedance (% of time)	Low	**91.40 (9.47) [c]**	79.64 (16.63)	84.35 (16.65)
	High	**88.56 (28.31)[c]**	60.45 (29.90)	75.92 (20.90)

[a] sig. different from the other two cultures; [b]sig. different from NG; [c]sig. different from NG/UK; [d]sig. different from UK

3.1.4 Hazard anticipation

This scenario involved participants approaching a green traffic light, with other stationary vehicles on the minor arms of the junction. There was a significant main effect of Culture [F (2, 45) = 6.393, *p* = .004] on mean speed, Table 4. Post-hoc analysis indicated that NG drivers drove at a higher mean speed (higher by 8.31mph) compared to the NG/UK drivers (*p* = 0.004) and (higher by 6.55mph) the UK drivers (*p* = .031). There was no significant difference between NG/UK and UK drivers. There was also a main effect of Culture on variation in deceleration [F (2, 45) = 4.619, *p* = .015]. Post-hoc comparisons revealed that NG drivers decelerated more harshly than the UK drivers by 0.22m/s^2. There were no significant differences between NG and NG/UK or NG/UK and UK.

Table 4: Mean (SD) values for the hazard anticipation scenario

Variable	Culture		
	NG	NG/UK	UK
Mean speed (mph)	**39.88 (10.12)[a]**	31.58 (3.48)	33.34 (5.41)
Mean deceleration (m/s^2)	0.06 (0.80)	0.05 (0.07)	0.04 (0.04)
SD. deceleration (m/s^2)	**0.50 (0.35)[d]**	0.31 (0.10)	0.28 (0.11)

[a] sig. different from the other two cultures; [b]sig. different from NG; [c]sig. different from NG/UK; [d]sig. different from UK

3.1.5 Conflict handling (Low and High Infrastructure)

The conflict handling scenario involved a vehicle emerging from a side road and crossing in front of the participant. They were required to avoid the conflict by applying the brakes (even if they were travelling below the speed limit). Several main effects occurred for Culture but none for Infrastructure, Table 5. There was a significant main effect of Culture on TTC with the merging vehicle [F (2, 45) = 4.723, *p* = .014], with further analysis showing that the TTC of NG drivers to the merging vehicle was significantly lower by 0.77secs compared to that of the NG/UK drivers (*p* =

.013). There were no significant differences between either the UK and NG/UK drivers or NG and UK drivers.

Table 5: Mean (SD) values for the conflict handling scenario

Variable	Infrastructure	Culture		
		NG	NG/UK	UK
TTC (secs)	Low	**1.41 (1.17)**[c]	2.23 (1.70)	1.56 (0.708)
	High	**1.38 (1.08)**[c]	2.10 (2.04)	1.72 (0.43)
Spot speed at TTJ = 3secs (mph)	Low	**52.00 (7.37)**[a]	37.42 (8.92)	40.16 (11.79)
	High	**47.25 (11.27)**[a]	41.44 (5.38)	37.71 (4.21)
BRT (secs)	Low	**3.01 (0.78)**[a]	2.56 (0.22)	2.53 (0.37)
	High	**2.93 (0.28)**[a]	2.62 (0.32)	2.58 (0.31)

[a] sig. different from the other two cultures; [b]sig. different from NG; [c]sig. different from NG/UK; [d]sig. different from UK

At a TTJ of 3 secs, a significant main effect of Culture on spot speed [$F(2, 18) = 6.598$, $p = .007$] and BRT [$F(2, 18) = 6.317$, $p = .008$] was found, shown in Figure 2:. Post hoc comparisons showed that the spot speed of NG drivers was 10.2mph higher than that of the NG/UK ($p = .020$) and 10.7mph higher than UK drivers ($p = .014$). Additionally, it took NG drivers a significantly longer time, 0.38secs more, to react to the hazard compared with NG/UK ($p = .026$) and 0.42secs more, compared with the UK ($p = .015$) drivers. There was no significant difference between UK and NG/UK drivers. There was no main effect of Infrastructure or interactions between Infrastructure and Culture.

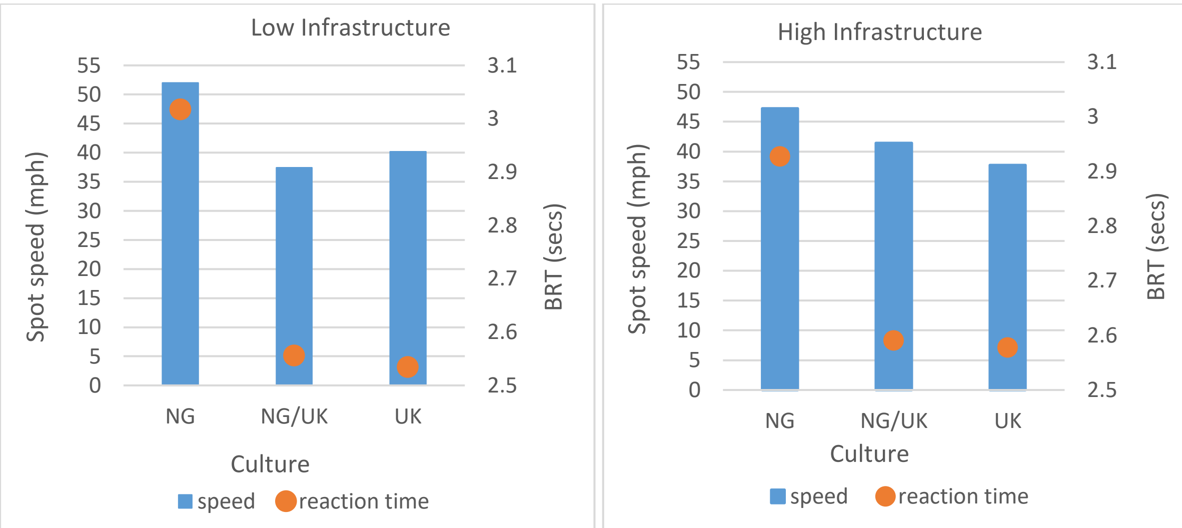


Figure 2: Spot speed and BRT by Culture and Infrastructure

3.1.6 Permitted overtaking (Low and High Infrastructure)

The permitted overtaking scenario provided opportunities for participants to overtake the lead vehicle when they felt safe to do so. Several main effects of Culture were found, Table 6. The total number of attempts at overtaking for the different groups revealed a non-significant trend for a greater tendency among the NG drivers to performing overtaking compared to NG/UK and UK drivers.

The overtaking manoeuvre was studied in more detail by measuring the proximity of the participant's vehicle to both the lead and oncoming vehicle during the overtaking manoeuvre, as well as the time spent in the overtaking lane. The way in which participants merged back into the lane was also recorded by using a measure of tailway, with a lower value indicating a sharper cutting in manoeuvre. There was a significant main effect of Culture on time headway at the start of overtaking [F (2, 30) = 4.45, *p* = .020]. Post hoc comparisons revealed a significant difference between the time headway of NG drivers and UK drivers (*p* = .018), lower for NG drivers by 0.31secs. There were no statistically significant differences between the NG and NG/UK or NG/UK and UK drivers. There was no main effect of Infrastructure and no interaction between Culture and Infrastructure on time headway.

Maximum speed reached during the overtaking manoeuvre was also measured. There was a significant main effect of Culture on maximum speed reached during overtaking [F (2, 31) = 4.733, *p* = .016]. Post hoc comparisons showed that speed was higher for UK, compared to NG drivers by 5.96mph (*p* = .013). There were no statistically significant differences between the other groups. There were no significant main effects of Infrastructure on maximum speed and no significant interaction between Infrastructure and Culture.

Distance tailway with the lead vehicle provided a measure of how sharply a driver pulled back in front of it. There was a significant main effect of Culture on distance tailway [F (2, 30) = 7.380, *p* = .002]. Post hoc comparison showed that there was a significant difference between the tailway of UK and NG drivers (*p* = .002), higher for UK drivers by 10.95mph. There were no significant differences between the other groups. There were no main effects of Infrastructure on tailway and no interaction between Infrastructure and Culture.

For time headway with the oncoming vehicle at the end of overtaking and indicator use, no significant main effects of Culture and Infrastructure, and no interactions between the conditions were found.

Table 6: Mean (SD) values for the overtaking (permitted) measures

Variable	Infrastructure	Culture		
		NG	NG/UK	UK
*Attempts (count)	Low	16	12	14
	High	19	11	14
*Successful overtaking (%)	Low	93.75	62.50	81.25
	High	87.5	68.75	87.5
Time Headway to lead car (sec)	Low	**0.47 (0.31)[d]**	0.51(0.21)	0.71 (0.23)
	High	**0.39 (0.36)[d]**	0.69 (0.38)	0.74 (0.24)
Max speed (mph)	Low	**47.94 (5.92)[d]**	52.14 (6.86)	52.58 (5.14)
	High	**49.13 (5.20)[d]**	49.94 (6.31)	56.40 (4.60)
Time Headway to on-coming vehicle (sec)	Low	11.25 (3.5)	11.59 (3.1)	8.37 (3.61)
	High	8.68 (2.91)	8.89 (3.81)	7.10 (2.65)
Distance tailway (m)	Low	**15.13 (9.94)[d]**	20.14 (6.20)	27.44 (10.62)
	High	**13.94 (9.81)[d]**	17.83 (7.36)	23.53 (7.04)

***Indicator use (%)**	Low	68.8	68.8	75.0
	High	81.3	87.5	87.5

[a] sig. different from the other two cultures; [b]sig. different from NG; [c]sig. different from NG/UK; [d]sig. different from UK
*represent total numbers and percentage frequency

3.1.7 Prohibited overtaking (Low and High Infrastructure)

In the high infrastructure scenario, an "overtaking prohibited" sign was placed at about 110km before the double solid white line marking; this was absent in the low infrastructure condition. A statistically significant association between Culture and the number of violators for the low infrastructure ($\chi^2 = 7.807$, $p = .020$) and high infrastructure ($\chi^2 = 13.844$, $p = .001$) conditions was found, Table 7. Post hoc testing showed that among drivers who violated the no overtaking rule, there were more NG drivers than would be expected for both the low infrastructure and high infrastructure conditions.

Table 7: Measures in the overtaking (prohibited) scenario

Variable	Infrastructure	Culture		
		NG	NG/UK	UK
Violation (count)	Low	**8** [a]	4	1
	High	**11** [a]	5	1

[a] sig. different from the other two cultures; [b]sig. different from NG; [c]sig. different from NG/UK; [d]sig. different from UK

3.2 Driver Behaviour Questionnaire

Appendix 2 shows the mean scores (SD) for each of the individual items relating to violations, errors and slips/lapses in the DBQ for the three groups of drivers.

There were significant differences between the three cultures for 15 of the 50 items (nine violations and six slips/lapses), see Table 8. For the violations (five ordinary and four aggressive), NG drivers reporting a higher frequency than NG/UK and UK drivers for 8/9 of them. With regards slips/lapses, NG/UK drivers reported slips/lapses more frequently than did the other two cultures, for 4/6 of them. No differences in errors were found. The NG drivers reported a significantly higher annual crash involvement compared to NG/UK and UK drivers.

Table 8: Mean (SD) significant DBQ measures and self-reported yearly crash involvement

Variables	NG	NG/UK	UK	F (2,45)	Eta^2
Yearly crash involvement	1.50 (1.37) [a]	.50 (1.27)	.56 (.73)	.38	.14
Violations					
V2 Drive without papers (OV)	1.38 (1.31) [d]	1 (1.15)	.13 (.34)	6.24	.22
V4 Impatient, overtake on the inside (AV)	2.31 (1.44) [c]	1.31 (.79)	1.44 (1.26)	3.30	.13
V5 Drive close to or 'flash' the car in front (AV)	2.38 (1.41)	1.63 (1.45)	.44 (1.03) [a]	8.87	.28
V6 Risky overtaking (AV)	1.56 (1.36) [d]	1.38 (1.14)	.56 (.63)	3.80	.14
V8 Angry, give chase (AV)	.13 (1.29) [a]	1.06 (1.39)	1.06 (1.38)	6.07	.21
V14 Cut corner on a left/right-hand turn (OV)	.94 (1.12)[d]	.88 (.72)	.25 (.44)	3.51	.13

V16 Ignore give-way signs (OV)	1.00 (1.32) [d]	.75 (.78)	.06 (.25)	4.72	.17
V17 Drive wrong way down one-way street (OV)	1.00 (.82) [a]	.38 (.62)	.19 (.54)	6.46	.22
V19 Get involved in unofficial races (OV)	.81 (.98) [d]	.63 (.81)	.06 (.25)	4.37	.16
Slips/lapses					
S2 Locked out of car with keys inside	.75 (1.18) [d]	.69 (.95)	.12 (.71)	3.62	.14
S11 overtake without checking mirror	.94 (1.06)	1 (.89)	.13 (.34) [a]	5.59	.20
S13 Turning right/left, nearly hit cyclist/tricycle	1.00 (1.09)	1.13 (1.03)	.19 (.40) [a]	5.16	.19
S15 Misjudge speed of oncoming vehicle	1.31 (1.01) [d]	1.19 (.91)	.56 (.51)	3.65	.14
S16 Fail to see pedestrian stepping out	.56 (.81)	.94 (.85) [d]	.25 (.45)	3.57	.14
S19 Try to overtake vehicle turning left/right	1 (.967)	1.25 (1.13) [d]	.44 (.63)	3.20	.13

[a] sig. different from the other two cultures; [b]sig. different from NG; [c]sig. different from NG/UK; [d]sig. different from UK

4 Discussion

This study sought to discover if three groups of drivers, trained and experienced in different traffic safety cultures, displayed and reported different road safety behaviour. In addition, the efficacy of implementing infrastructure measures known to improve road safety in HICs was evaluated across all three groups of drivers. It was hypothesised that traffic safety culture would mediate the positive effects of infrastructure.

In six of the seven driving simulator scenarios, the NG/UK and UK drivers tended to show safer patterns of behaviour compared to the NG drivers. The NG drivers travelled at higher speeds and spent more time exceeding the speed limit, on links and at junctions. This desire to make progress, was also captured in their propensity to overshoot junction markings whilst awaiting a green light and subsequent faster acceleration. Such impatience has also been termed as aggressive driving Laagland (2005) and Tasca (2000). It is well known that high and inappropriate speed is one of many factors contributing to the number and severity of road traffic crashes in Nigeria (FRSC, 2018). The speed of traffic on many Nigerian roads is much higher than the speed limit (Uzondu et al., 2018) and according to FRSC (2018), 44% of road traffic crashes in Nigeria in 2017 were caused by speeding. It would be reasonable to believe that international differences in the number of road traffic crashes would partly be affected by driver’s speed choice. According to Warner et al. (2009), drivers who live in a country with fewer road traffic fatalities (i.e. Sweden), report a more positive attitude towards complying with the speed limit, a higher intention and a larger proportion of the time spent complying compared with drivers who live in a country with more road traffic fatalities (i.e. Turkey).

As the NG drivers were travelling faster on approach to junctions, compared to the other two groups, they were subsequently required to brake more sharply as they reached it. Coupled with longer reaction times, the NG drivers had shorter TTCs to the emerging vehicle in the conflict scenario, thus compromising safety (Minderhoud & Bovy, 2001). Even though the TTC of the UK drivers was also short, travelling at a lower speed enabled them to react faster to the hazard compared to the NG drivers. The faster reaction times displayed by the NG/UK and UK drivers could be as a result of hazard perception training, as all NG/UK and UK participants would have practised for and passed the traditional hazard perception test in order to obtain their license (Lim et al., 2014). This finding is consistent with Bates et al. (2013) and McDonald et al. (2015) who showed that drivers who participated in hazard perception training could identify more hazards, scan their driving environment more effectively, anticipate hazards more quickly and slow down more when approaching hazards, than those who did not participate in such training.

As well as these differences in control level skills (Michon, 1985), NG drivers exhibited different higher-order decision making skills, compared to the other groups. They engaged in more overtaking and in doing so accepted smaller safety margins to the vehicle they overtook. Research has shown that increases in the number of overtaking manoeuvres correlates with increases in crash probability (Hauer, 1971). Drivers seeking to overtake can be more at risk of a rear-end crash due to the tendency of drivers to maintain shorter headways prior to overtaking (Hegeman, 2008; Ghods et al., 2012), a tendency of the NG drivers observed in this study. In contrast, the maximum speed reached during the overtaking manoeuvre was higher for UK drivers in the two overtaking scenarios compared to the NG/UK and NG drivers. This is efficient on the one hand because time spent completing overtaking will be reduced (Chandra & Shukla, 2012) but may compromise safety. NG drivers showed greater propensity to violate the no-overtaking rule. This could be due to lack of knowledge of what the markings represent.

Moving onto the effect of adding infrastructure, there was no change in behaviour in any of the four scenarios where this was implemented. For example, in both overtaking scenarios, the behaviour of the three groups of drivers was similar irrespective of the infrastructure conditions. This is likely due to the fact that there was a floor effect in the propensity to overtake in the UK and NG/UK driver groups such that being exposed to more infrastructure could not improve their behaviour further. Similarly, in the speed choice scenario, NG/UK and UK drivers travelled at appropriate speed even in the low infrastructure condition, whereas NG drivers travelled at high speeds in both. In the conflict handling scenario, the three groups of driver exhibited similar behaviour in both infrastructure conditions.

Moving onto the self-report measures of the DBQ, consistent with past studies (Özkan et al., 2006; Warner et al., 2011; Bener et al., 2013), there were no statistically significant differences in the frequency of reported errors between the three driver groups. However, NG drivers reported a higher number of violations compared to the other two groups, and that, rather unexpectedly, the NG/UK drivers reported a higher number of slips/lapses compared to NG and UK drivers. Rule violation is one of the important predictors of road traffic crashes and conflicts in Nigeria (FRSC, 2018; Uzondu et al., 2019). Although aggressive and ordinary violations were grouped together in this study, the results showed that they were more common in the NG group. Aggressive behaviours involve being hostile especially towards other road users and aggressive drivers act on their anger by showing this hostility. This finding may partly explain why Nigeria has poorer traffic safety records than the UK (WHO, 2018).

The results are in line with Özkan et al. (2006) who revealed that drivers from safe countries exhibited safer behaviours especially in the scenarios where speed, acceleration, hazard reaction, overtaking, traffic light compliance were measured compared to drivers from ‘‘dangerous’’ countries. In addition, research has also shown that drivers from countries with high crash rates are less motivated than those with low crash rate to comply with traffic laws and are more likely to drive aggressively (Shinar & Compton, 2004).

In summary, the results provide preliminary evidence that poor traffic safety culture could be resistant to change, despite improvements in infrastructure. It supports Novaco (2001) and WHO (2009), that improvements in the road environment alone may not bring about significant changes in drivers' behaviour especially for the NG drivers who have a history of unsafe driving behaviour which has been further confirmed from the results of this study. Additionally, in six out of seven scenarios, the behaviour of the NG/UK group was similar to that of the UK group which could be due to exposure to the new traffic safety culture (which includes other drivers), rather than only repeated exposure to the higher level of infrastructure. According to Delicado (2012), if drivers do not drive safely, it is not a simple lack of knowledge and skills or their unwillingness. The problem appears to be connected to routine behaviour (safety culture), which is inherently very difficult to change. Musselwhite et al. (2010) argue that regardless of whether a person intends to drive safely or not, habitual processes (developed out of frequent experience with the environment) tend to supersede cognitive processing. Driving tasks such as braking and accelerating tend to be automated and can be carried out without conscious attention (Boer & Hoedemaeker, 1998); thus bringing safety into the consciousness of NG drivers would require more than just improvements in the road environment alone. It is not enough to only focus on infrastructural developments when developing measures to improve traffic safety in LMICs. One way of influencing road safety outcomes could be by changing a society's attitude and behaviour towards risk taking (i.e. its safety culture). This could be achieved by taking into consideration any unique characteristics of the society such as socio-economic status, demography, culture, traffic environment, and the law of the countries (Bener et al., 2003; Özkan et al., 2006). Another way of dealing with the problems of unsafe driving could be through driver education and training which may address the unawareness of basic rules and regulations. This is very important, because unsafe behaviours were recorded even though improvements in infrastructure was made. Therefore, drivers need to be made aware of what driving behaviour is expected of them. This can incorporate strategies that target specific behaviours and highlight the consequences of unsafe behaviour, for example, driving at the appropriate speed, increasing safety margins, compelling drivers to their indicator etc. The goal is to enable drivers to make correct decisions and be safe in traffic. This must be conducted by competent instructors and examiners who possess the right knowledge and skills.

One limitation of the present study is the sample size; thus it is important to note that the sample group used in this study does not necessarily represent the drivers in each society, especially regarding the use of the DBQ (as this version was adapted for the first time for NG drivers). Therefore, a direction for future research would be the replication of these same items including some items from the Nigerian Highway Code in a larger sample of NG drivers. This would help to establish the reliability and generalizability of the results. However, even if the present sample is not a perfect representation of the Nigerian population, the reported DBQ scores serves as a strong foundation for establishing a Nigerian version of the instrument. Another important aspect for furthering the current study would be the recruitment of more homogeneous sample groups (including gender) for all cultures and to examine the possible approaches for improving the behaviour of Nigerian drivers. In addition, to investigate if the number of years the individual drivers in the NG/UK group has spent driving in the UK has an effect on adapting to the UK road environment. This could not be done in this research because the comparisons carried out were between groups of drivers and not individual drivers. It would also be important to consider and investigate other variables (such as age, driving experience, gender) that may influence the safe and unsafe driving behaviours observed in this study. The extent to which the results of this study can be generalised is very important because it was a self-reported and driving simulator study, and it is possible for results to diverge from what would be obtained in the real world. Therefore, it is suggested that the results could provide a basis for future studies in this area.

Notwithstanding these limitations, this study has provided a contribution to the understanding of cross-cultural differences in driving behaviour and from these results, four policy recommendations are suggested:

First, this research acknowledges that a society's traffic safety culture influences driving behaviour, and therefore, implies that behaviour-changing interventions developed on a good understanding of drivers' cultural environment could be successful.

Second, the findings suggest that more country-specific research should be undertaken. The differences observed between the driving behaviour of Nigerian and UK drivers, could mean that road safety solutions, which are usually adopted by Nigeria from HICs, may not be effective unless they are adapted to take into account local behaviours.

Third, the results of this study can be used to improve safety education programs by increasing drivers' awareness of the behaviours that can increase crash risk.

Fourth, the study empirically provides the basis to develop countermeasures specific to the most frequently committed unsafe behaviours on Nigerian roads.

The differences between groups of drivers require the development of cultural-differentiated policies relevant to each culture. Strict laws and severe sanctions, along with the teachings of cultural values, particularly concerning safety, should be implemented to address unsafe behaviour. Therefore, this study can be used to inform future research directions to promote cultural change. The promotion of safety culture especially in LMICs is pertinent considering the findings of this study and the need to develop tailored approaches to culture change. Having an appropriate strategy and action plan is different from implementation. As there are several excellent road safety management systems around the world, these cannot be implemented effectively without a political and communal willingness to develop a safe traffic system. Change in road safety culture would require political will and a strong commitment from all levels of government. A paradigm shift based on a change in road user's thinking is needed; behaviour modification and the establishment of the principle of socially and religiously unacceptable violations of traffic laws could be a good starting point. It is hoped that a consistent and collective effort from individuals, communities and the government can help to achieve sustainable road safety practices in Nigeria. Considering the "limited" resources available for road safety interventions in Nigeria, and most LMICs, it will be appropriate to focus more on evidence-based solutions, which have proved to be effective and easy to implement.

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Appendices

Appendix 1: Driver Behaviour Questionnaire (DBQ)

Participant id: _________

Dear Participant,

Thank you for volunteering to participate in this survey, which is a part of the driving simulator experiment and being undertaken as part of PhD research in the Institute for Transport Studies, University of Leeds, UK. The purpose of the survey is to investigate drivers' behaviours. The questionnaire is simple and you are not required to give precise answers. If after giving a response, you change your mind, please cross it neatly and circle another one. Your responses will be anonymous and treated in strictest confidence. Your participation is completely voluntary, but should you feel concerned you have the right to stop participating at any time.

PART A: QUESTIONS ABOUT YOU

This section is designed to help us know about your general characteristics.

1. Gender: male ___ female ___
2. Age: prefer not to answer ___ under 19 ___ 19-34 ___ 35-55 ___ 55+ ___
3. How many road crashes you have been involved in the last three years? crashes_______
4. How long have you been driving? Less than 2 years ___ 3-6 years ___ 6-15 years ___ more than 15 years ___.
5. Where do you have experience of driving? Nigeria_______ UK_______ both _______

PART B: QUESTIONS ABOUT YOUR DRIVING BEHAVIOUR

For each question, you are required to indicate the frequency with which you have performed each type of behaviour by circling the appropriate number.

How often do you:	Never	Hardly ever	Occasionally	Quite often	frequently	Nearly all the time
1. Attempt to drive away from traffic lights in wrong gear?	0	1	2	3	4	5
2. Check your speedometer and discover that you are unknowingly travelling faster than the speed limit?	0	1	2	3	4	5
3. Lock yourself out of your car with the keys still inside?	0	1	2	3	4	5
4. Become impatient with a slow driver in the outer lane and overtake on the inside?	0	1	2	3	4	5
5. Drive as fast along country/village roads at night on low beam as you would on high beam?	**0**	**1**	**2**	**3**	**4**	**5**
6. Attempt to drive away without first having switched on the ignition?	0	1	2	3	4	5

7. Drive especially close to or 'flash' the car in front of you as a signal for that driver to go faster or get out of your way?	0	1	2	3	4	5
8. Forget where you left or parked your car?	0	1	2	3	4	5
9. Distracted or preoccupied, failed to realise on time that the vehicle ahead has slowed and have to slam on the brakes to avoid a collision?	0	1	2	3	4	5
10. Intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa?	0	1	2	3	4	5
11. Turn left/right on to a main road into the path of an oncoming vehicle that you hadn't seen, or whose speed you had misjudged?	0	1	2	3	4	5
12. Misjudge the available space where you parked your car and nearly (or actually) hit another vehicle?	0	1	2	3	4	5
13. Realize you have no clear recollection of the road along which you have just been traveling?	0	1	2	3	4	5
14. **Miss your exit on a motorway/highway and have to make a lengthy detour?**	0	1	2	3	4	5
15. Forget which gear you are currently in and have to check with your hand?	0	1	2	3	4	5
16. Stuck behind a slow-moving vehicle on a two-lane highway, you are driven by frustration and try to overtake in risky circumstances?	0	1	2	3	4	5
17. Intending to drive to destination A, you suddenly realize that you are en route to B, because that is your more usual destination?	0	1	2	3	4	5
18. Take a chance and run the red light?	0	1	2	3	4	5
19. Angered by another driver's behaviour, you give chase with the intention of giving him/her a piece of your mind?	0	1	2	3	4	5
20. Try to overtake without first checking your mirror, and then get hooted/horned at by the car behind which has already begun its overtaking manoeuvre?	0	1	2	3	4	5
21. Deliberately disregard the speed limits at any time (morning, afternoon, evening, night)?	0	1	2	3	4	5
22. Forget when your road tax/insurance/vehicle papers expires and discover that you are driving illegally?	0	1	2	3	4	5
23. Forget that your lights are on full beam until 'flashed' by other motorists?	0	1	2	3	4	5
24. On turning left/right, nearly hit a cyclist/tricycle who has come up beside you?	0	1	2	3	4	5
25. In a queue of vehicles turning left/right on to a main road, pay such close attention to the	0	1	2	3	4	5

traffic approaching from the right/left that you nearly hit the car in front?						
26. Drive even though you realize that you may be over the legal blood-alcohol limit?	0	1	2	3	4	5
27. Have an aversion to a particular class of road user, and indicate your hostility by whatever means you can?	0	1	2	3	4	5
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?	0	1	2	3	4	5
29. **Park on a double-yellow line/diagonally striped area and risk a fine?**	0	1	2	3	4	5
30. **Underestimate/Misjudge speed of an oncoming vehicle when overtaking?**	0	1	2	3	4	5
31. Hit something when reversing that you had not previously seen?	0	1	2	3	4	5
32. Fail to notice someone stepping out from behind a bus or parked vehicle until it is nearly too late?	0	1	2	3	4	5
33. Plan your route badly, so that you meet traffic congestion you could have avoided?	0	1	2	3	4	5
34. Overtake a single line of stationary or slow-moving vehicles, only to discover that they were queueing to get through a one lane gap or roadwork lights?	0	1	2	3	4	5
35. Overtake a slow-moving vehicle on the inside lane or hard shoulder of a motorway?	0	1	2	3	4	5
36. Cut the corner on a left/right-hand turn and have to swerve violently to avoid an oncoming vehicle?	0	1	2	3	4	5
37. Get into the wrong lane when approaching an intersection or roundabout?	0	1	2	3	4	5
38. Fail to read the signs correctly, and exit from a roundabout on the wrong road?	0	1	2	3	4	5
39. Fail to give way when a bus is signalling its intention to pull out?	0	1	2	3	4	5
40. Ignore 'give way' signs, and narrowly avoid colliding with traffic having right of way?	0	1	2	3	4	5
41. Fail to check your mirrors before pulling out, changing lanes, turning etc.?	0	1	2	3	4	5
42. Attempt to overtake a vehicle that you hadn't noticed was signalling its intention to turn right/left?	0	1	2	3	4	5
43. Deliberately drive the wrong way down a deserted one-way street?	0	1	2	3	4	5
44. Disregard red lights when driving late at night along empty roads?	0	1	2	3	4	5

45. Drive with only 'half-an-eye' on the road while looking at a map, changing a CD player or radio channel etc.?	0	1	2	3	4	5
46. Fail to notice pedestrians crossing when turning into a side street from a main road?	0	1	2	3	4	5
47. Get involved in unofficial 'races' with other drivers?	0	1	2	3	4	5
48. 'Race' oncoming vehicles for a one-car gap on a bad, narrow or obstructed road?	0	1	2	3	4	5
49. Brake too hard or quickly on a slippery road and/or steer the wrong way in a skid?	0	1	2	3	4	5
50. Misjudge your crossing interval when turning right/left and narrowly miss colliding?	0	1	2	3	4	5

In bold: modified items

Appendix 2: Differences in different cultures' self-reported yearly crash involvement and tendency to commit different unsafe driving behaviours

Variables	NG	NG/UK	UK	F(2,45)	Eta^2
Yearly crash involvement	**1.50(1.37)** [c]	**.50(1.27)**	**.56 (.73)**	**.38***	**.14**
Violations					
V1 Unknowingly speeding (OV)	2.88(.95)	2.75(1.52)	2.31(1.14)	.92	.04
V2 Drive without papers (OV)	**1.38(1.31)** [d]	**1(1.15)**	**.13(.34)**	**6.24***	**.22**
V3 Fail to see pedestrian waiting (OV)	.88(1.03)	.94(.68)	.56(.73)	.95	.04
V4 Impatient, overtake on the inside (AV)	**2.31(1.44)** [c]	**1.31(.79)**	**1.44(1.26)**	**3.30***	**.13**
V5 Drive close to or 'flash' the car in front (AV)	**2.38 (1.41)**	**1.63(1.45)**	**.44(1.03)** [a]	**8.87***	**.28**
V6 Risky overtaking (AV)	**1.56(1.36)** [d]	**1.38(1.14)**	**.56(.63)**	**3.80***	**.14**
V7 Take a chance and run the red light (OV)	.63(.72)	.81(1.17)	.19(.40)	2.42	.09
V8 Angry, give chase (AV)	**.13(1.29)** [a]	**1.06(1.39)**	**1.06(1.38)**	**6.07***	**.21**
V9 Disregard speed at night (OV)	1.25(1.34)	1.38(1.14)	1.56(1.42)	.23	.01
V10 Drink and drive (OV)	.19(.544)	.13(.34)	.25(.57)	.25	.01
V11 Have an aversion (AV)	.50(.73)	.75(.77)	.25(.77)	1.73)	.07
V12 Illegal parking (OV)	.44(.62)	.88(.88)	.56(.89)	1.23	.05
V13 Overtake on right/left on motorway (OV)	.94(1.12)	.94(.85)	.94(1.12)	.00	.00
V14 Cut corner on a left/right-hand turn (OV)	**.94(1.12)** [d]	**.88(.72)**	**.25(.44)**	**3.51***	**.13**
V15 Fail to give way to bus (OV)	.81(1.17)	1.25(1.34)	1.19(.83)	.70	.03
V16 Ignore give-way signs (OV)	**1.00(1.32)** [d]	**.75(.78)**	**.06(.25)**	**4.72***	**.17**
V17 Drive wrong way down one-way street (OV)	**1.00(.82)** [a]	**.38(.62)**	**.19(.54)**	**6.46***	**.22**
V18 Disregard red lights when driving (OV)	.81(.98)	.81(1.38)	.25(.58)	1.59	.07
V19 Get involved in unofficial races (OV)	**.81(.98)** [d]	**.63(.81)**	**.06(.25)**	**4.37***	**.16**

V20 Race vehicles for a one-car gap (AV)	.63(.96)	.69(.79)	.13(.34)	2.74	.11
Errors					
E1 Drive as fast on low beam as on high beam	1.50(1.2)	.88(.72)	1.13(1.09)	1.50	.06
E2 Turn left/right on to vehicle's path	1.44(1.03)	.88(.89)	.88(.72)	2.14	.09
E3 Misjudge available space/gap in car park	.75(.86)	1.25(1.12)	1(.82)	1.13	.05
E4 Hit something when reversing	.94(.85)	.88(.72)	.38(.50)	3.05	.12
E5 Plan route badly	1.44(.96)	1.69(1.07)	1.25(1.24)	.64	.03
E6 Overtake queue	1.51(1.03)	1.44(1.03)	.75(.86)	2.90	.11
E7 Get into wrong lane at roundabout	1.25(1.18)	1.13(1.09)	1.69(.87)	1.25	.05
E8 Brake to quickly	.63(1.15)	.75(.78)	.38(.62)	.76	.03
E9 Misjudge crossing interval when turning right/left	.56(.73)	.88(.81)	.25(.58)	3.10	.12
Slips/lapses					
S1 Attempt to drive away in wrong gear	1.13 (1.03)	1.12 (1.24)	.88(.62)	.59	.03
S2 Locked out of car with keys inside	**.75 (1.18)** [d]	**.69(.95)**	**.12(.71)**	**3.62***	**.14**
S3 Attempt to drive off without switching on the ignition	.44(.81)	.31(.48)	.38(.70)	.12	.01
S4 Forget where car is	1.19(1.33)	.81(.91)	.75(.68)	.88	.04
S5 Distracted, have to brake hard	1.38(.81)	1.13(.89)	1.13(.50)	.59	.03
S6 Intend to switch on wipers, but switch on lights	1.56(1.15)	1.44(1.09)	.69(.95)	3.14	.12
S7 No recollection of recent road	1.19(1.17)	1.44(1.37)	1.31(.80)	.20	.01
S8 Miss exit on a motorway/highway	1.81(1.38)	2.06(.99)	1.69(.87)	.48	.02
S9 Forget which gear	1.00(1.10)	1.31(1.10)	1.50(.82)	1.01	.04
S10 On usual route by mistake	1.19(1.10)	1.75(1.07)	1.63(1.09)	1.18	.05
S11 overtake without checking mirror	**.94(1.06)**	**1(.89)**	**.13(.34)** [a]	**5.59***	**.20**
S12 Forget light on main beam	1.38(1.20)	1.44(1.31)	1.06(.68)	.53	.02
S13 Turning right/left, nearly hit cyclist/tricycle	**1.00(1.09)**	**1.13(1.03)**	**.19(.40)** [a]	**5.16***	**.19**
S14 Queuing, nearly hit car in front	1.19(1.17)	1.25(.86)	.69(.79)	1.67	.07
S15 Misjudge speed of oncoming vehicle	**1.31(1.01)** [d]	**1.19(.91)**	**.56(.51)**	**3.65***	**.14**
S16 Fail to see pedestrian stepping out	**.56(.81)**	**.94(.85)** [d]	**.25(.45)**	**3.57***	**.14**
S17 exit roundabout on the wrong lane	1.19(1.28)	1.44(1.09)	1.38(.96)	.22	.01
S18 Manoeuvre without checking mirror	1.06(1.06)	1(.73)	1(.73)	.03	.00
S19 Try to overtake vehicle turning left/right	**1(.967)**	**1.25(1.13)** [d]	**.44(.63)9**	**3.20***	**.13**
S20 Only half-an-eye on the road	1.44(1.41)	1.50(1.59)	1.94(1.39)	.55	.02
S21 Fail to see pedestrians crossing	.56(.73)	.88(.89)	.81(.66)	.75	.03

Results are based on one way ANOVA, with Bonferroni correction. All the numbers are presented as Mean (SD); **(In bold)** * statistically significantly different at 0.05%. [a] statistically significantly different from other two cultures (p<0.05); [b] statistically significantly different from NG (p<0.05); [C] statistically significantly different from NG/UK (p<0.05) [d] statistically significantly different from UK (p<0.05). V=Violations (OV-ordinary violation; AV-aggressive violation); E=Errors and S= Slips/lapses