Article:

Lee, YM orcid.org/0000-0003-3601-4191, Miller, K, Crundall, D et al. (1 more author) (2020) Cross-cultural effects on detecting multiple sources of driving hazard: Evidence from the deceleration detection flicker test. Transportation Research Part F: Traffic Psychology and Behaviour, 69. pp. 222-234. ISSN 1369-8478

https://doi.org/10.1016/j.trf.2020.01.013

Cross-cultural effects on detecting multiple sources of driving hazard: Evidence from the Deceleration Detection Flicker Test

Yee Mun LEE[1], Karl MILLER[2], David CRUNDALL[3], Elizabeth SHEPPARD[2]

[1]University of Leeds

[2]University of Nottingham

[3]Nottingham Trent University

Please address correspondence concerning this manuscript to:

Yee Mun LEE

Research Fellow - Human Factors of Vehicle Automation

Institute for Transport Studies

University of Leeds

LS1 9JT

Leeds

United Kingdom

E-mail: y.m.lee@leeds.ac.uk

Karl MILLER

School of Psychology

The University of Nottingham

University Park

Nottingham

NG7 2RD

UK

E-mail: lpxkm9@nottingham.ac.uk

David CRUNDALL
Professor
School of Social Sciences
Nottingham Trent University
50 Shakespeare St
Nottingham
NG1 4FQ
UK
E-mail: david.crundall@ntu.ac.uk

Elizabeth SHEPPARD
Assistant Professor
School of Psychology
University of Nottingham
University Park
Nottingham
NG7 2RD
UK
E-mail: elizabeth.sheppard@nottingham.ac.uk

Abstract

Collision rates in Malaysia are much higher than the UK; do these reflect poorer hazard perception skill or does exposure to hazardous events improve hazard detection ability? The deceleration detection flicker test (DDFT) was used to investigate the effect of experience and cross-cultural differences between Malaysian and UK drivers in their ability to detect the deceleration of a lead vehicle while simultaneously identifying any secondary hazards in side roads. Matched groups of participants with lower or higher levels of experience were recruited from the University of Nottingham in the UK and Malaysia. Malaysian drivers were significantly less accurate than UK drivers in detecting the deceleration of lead vehicles on urban roads, and significantly less accurate in detecting the presence of secondary hazards across all road types. Experienced drivers were significantly faster than novices in detecting decelerations of the lead vehicle, and were significantly more accurate in detecting the presence of secondary hazards. The study concludes that high exposure to hazardous events on the road in Malaysia does not yield expertise in this hazard perception task, although the DDFT does differentiate experience cross-culturally.

Keywords: attention allocation, cross-cultural, deceleration detection flicker test, driving hazard perception, Malaysia, UK.

1. Introduction

The vast majority of the research conducted on driver behaviour has been carried out in developed countries, where driving is relatively safe, and collision and fatality rates are relatively low. This research has led to advances in our understanding of drivers' behaviour, perception, and decision-making processes, as well as informing interventions to improve road safety. However, most of the world's road-related fatalities occur on the roads of developing countries, where research is rather limited by comparison (Nantulya & Reich, 2002; Peden et al., 2004; Toroyan, 2009). This raises the question whether conclusions drawn from research carried out in developed countries with relatively safe driving environments also apply in countries where the driving environment is more hazardous with higher fatality rates.

It seems highly plausible that the environment to which a road user is exposed on a daily basis would influence various psychological processes involved in driving. In particular, whether it is a safe environment where drivers make few violations, or a less safe environment where frequent hazardous behaviour occurs, repeated exposure to such contexts has the potential to impact various aspects of driver cognition. For instance, what a driver perceives, what he/she attends to, as well as the judgments or decisions that he/she makes are all likely to be subject to top-down influences of a drivers' prior experiences, in addition to bottom-up factors such as the saliency, colour of the vehicles, motion, and spatial frequencies.

One aspect of driving that encompasses many of these cognitive processes is hazard perception (HP), or the ability to detect potentially dangerous events on the roads. Driving hazard perception has been investigated extensively in developed countries, as it is the only higher-order aspect of driving that has been found to be associated with crash liability across several studies (Boufous et al., 2011; Horswill et al., 2010; Quimby et al., 1986). Consequently, a hazard perception test is included in driver licensing in several countries including the UK, the Netherlands, and parts of Australia – with some evidence that this has resulted in reduced crash liability in newly qualified drivers (Wells et al., 2008).

Lim et al. (2013) questioned whether such tests could be easily transferred to developing countries where driving culture might be very different. In 2016, there were 1792 road deaths in the UK (population: 65,788,574) and 7152 road deaths in Malaysia (estimated population: 31,660,000). Respectively, this represents 3 and 23 deaths per 100,000 inhabitants (DfT, 2017, MIROS, 2017). The Malaysian road environment is therefore far more hazardous than the UK driving environment. The authors questioned whether Malaysian drivers would have greater hazard perception expertise than UK drivers due to greater exposure to hazards on the roads. Alternatively, if the correlation between HP ability correlates and crash liability that has been observed within populations (e.g. Horswill et al., 2015) extends between populations, HP ability might be poorer for Malaysian drivers, in line with the higher crash risk in Malaysia. They carried out a cross-cultural investigation comparing hazard perception in drivers from the UK and Malaysia who were matched for experience. The frequently-used hazard perception reaction time paradigm was used, where participants were presented with video clips containing driving hazards filmed in both countries, and were asked to press a button when they detected that a hazard was developing. It was found that Malaysian drivers (N = 55) identified significantly fewer hazards than UK drivers (N = 45) and were also significantly slower in overall response times. The study concluded that the poorer performance in Malaysian drivers might partly be due to an increased criterion for reporting hazards as a result of them becoming desensitised to such events on their native roads. Similar differences have since been observed between UK (N = 52), Spanish (N = 51), and Chinese drivers (N = 50), with Chinese drivers (who drive in a more hazardous environment than either group of European drivers) spotting significantly fewer hazards and responding later significantly (Ventsislavova et al., 2019). However, another possible explanation for the difference is that UK drivers are familiar with the hazard-perception test format (as they must pass a hazard perception test to obtain a licence), and this may have conferred a benefit. Malaysian drivers on the other hand, were not tested with the HP test but were required to take part in the theoretical test, complete a minimum of 16 hours of on-road driving lessons, and complete and pass the on-road driving test (slope test, 3-point turn, reverse parking, parallel parking, and driving on the road).

Lim et al. (2014) went on to conduct a second cross-cultural study comparing UK (N = 40) and Malaysian drivers (N = 37) using a 'What Happens Next?' (WHN) test, or a hazard prediction test (see also Jackson et al., 2009; Crundall 2016). This involved presenting edited versions of the same videos of driving hazards (i.e. from the UK and Malaysia) in which the clips terminated immediately just as the hazard onsets. The participant was then required to predict what event would happen next from four multiple-choice options (Lim et al., 2014). As this measure does not ask participants to make a judgment about whether a hazard has taken place, it should be unaffected by hazard criterion. It was found that Malaysian drivers were significantly poorer in predicting what would happen next on the road than UK drivers when matched for experience. These findings might point to the conclusion that driving in a hazardous environment not only affects hazard criterion but also impairs hazard prediction ability. However, as the authors pointed out, although the WHN paradigm is not identical in nature to the reaction-time method trained in the UK driving test, it remains possible that experience with the reaction-time test offers some transfer to the WHN test given the overall similarities. Therefore, it may be that the apparent hazard perception advantage for UK drivers even on the WHN test is still due to familiarity with hazard perception testing, and that this masks true (or at least comparable) hazard perception competence in Malaysian drivers.

In order to circumvent the test-familiarity criticism, we have turned to an alternative measure of a very specific type of hazard perception. Crundall (2009) developed and validated an alternative methodology which allows researchers to investigate drivers' ability to detect multiple potential hazards, named the "Deceleration Detection Flicker Paradigm" (DDFT). Drivers, who were from the UK (N = 60), were presented with a series of photographs taken from the point of view of a driver on a road with a lead car. The photos were presented sequentially such that it appeared as though the driver is moving along the road, with each photograph being separated from the next by a brief blank blue screen, which registers as a flicker. The drivers' primary task was to detect when the car ahead appeared to decelerate, indicated by an increase in the size of the car in front over successive images (as it apparently moves closer). Occasionally an additional car was inserted into a side road in the scene, which was either facing towards (threatening) or facing away (non-threatening) from the main carriageway. Participants were required to detect these threatening and non-threatening vehicle hazards as they appeared in the periphery. The photographs were also taken on three different road types (rural, suburban and urban) to investigate the effect of complexity of road information on drivers' attention allocation to multiple hazards. It was found that experienced drivers were significantly better than novice drivers in both the primary (detecting the deceleration of the car ahead) and secondary tasks (better at detecting the peripheral hazards). Drivers also generally performed significantly better on the road types that were less visually cluttered i.e. they performed best on rural roads and least well on urban roads.

As the methodology discriminates between experienced and novice drivers, it can be seen as validly measuring a facet of driving skill – experience here acting as a proxy for crash liability due to collisions being over-represented in newly qualified drivers (Mayhew et al, 2003). This accords with other studies which imply that less experienced drivers tend to have a narrower spread of visual search while driving (Chapman & Underwood, 1998; Underwood et al., 2001). The benefit of this task is that the structural differences between this and the hazard perception test used as part of driver licensing in the UK make it far less likely that any advantage would be conferred by prior experience with the typical hazard perception testing procedure. Therefore the DDFT may offer a fairer indication of the relative abilities of drivers in the two countries to attend to multiple sources of potential hazard. A further motivation for using the task in Malaysia in particular is that rear-end collisions constitute the second most common crash type making up 28.4% of the road fatalities (MIROS, 2017). Hence, determining whether and how well Malaysian drivers are able to detect deceleration of lead vehicles could contribute to our understanding of this kind of crash.

The current study aimed to investigate cross-cultural performance of UK and Malaysian drivers in hazard perception using the Deceleration Detection Flicker Task (Crundall, 2009) with tests designed using stimuli relevant to each country. The two tests differed in terms of roadways and vehicles depicted, though, as both countries have left-hand driving, there were no concerns about asymmetrical attention differences between the groups (Thompson & Sabik, 2018). The methodology of Crundall (2009) was adapted to determine how the driver's country of origin and driving experience affects performance in detecting the deceleration of the car ahead (primary task) while simultaneously having to detect threatening and non-threatening peripheral hazards (secondary task). If repeated exposure to a hazardous real-life driving environment detrimentally impacts hazard perception skill (perhaps through an increase in criterion bias) then Malaysian drivers may be slower or less accurate on the DDFT. Alternatively, if exposure to a hazardous driving environment serves to further hone hazard perception skills, Malaysian drivers should perform better than UK drivers. In line with Crundall (2009), we also predicted that experienced drivers (3-10 years of active driving experience) will perform better than novices (less than a year of active driving experience) – which would provide cross-cultural validation of the test. Finally, as in Crundall (2009), we expected drivers to perform better on the less cluttered road types i.e. to perform best for rural roads and least well for urban roads. This design of the study also allowed investigation of whether there is a familiarity effect i.e. whether drivers perform better on the task when viewing stimuli from their own country than the other, less familiar country. Given that unfamiliar scenes should challenge visual skills more than familiar scenes, it might be expected that performance would be degraded for the unfamiliar scenes compared with familiar ones.

2. Methods

2.1. Participants

Ninety drivers were recruited for this study. All participants were university students: 41 of them were from the University of Nottingham Malaysia campus and 49 were from the University of Nottingham UK campus. The groups were therefore closely matched in terms of educational background. For the UK drivers, 23 were classified as low-experience drivers (11 female) with a mean age of 20.43 (*S.D.* = 2.02), and all reported less than a year of driving experience since getting their driving license in the UK. The remaining 26 UK drivers, were classified as higher-experience (13 female) with a mean age of 23.77 (*S.D.* = 2.44), and they had a range of active driving experience from 3 to 10 years (*M* = 5.15, *S.D.* = 2.04) since obtaining their UK driving license.

For the Malaysian drivers, 20 were classified as low-experience drivers (10 female) with a mean age of 18.85 (*S.D.* = 1.57), and all reported less than a year of driving experience since getting their driving license in Malaysia. The other 21 Malaysian drivers were classified as higher-experience (11 female) with a mean age of 22.52 (*S.D.* = 2.99), and a range of active driving experience from 3 to 9.5 years (*M* = 4.86, *S.D.* = 2.09) since getting their driving license in Malaysia. An independent samples t-test showed no significant difference of experience between the higher-experience UK and higher-experience Malaysian drivers, $t(45) = .19$, $p = .63$. All drivers had normal or corrected-to-normal vision.

2.2. Design

A 2 x 2 x 2 x 3 mixed design was used. The two between-subject independent variables were driving experience (experienced drivers or novices) and country of origin of drivers (UK drivers or Malaysian drivers). The two within-subject independent variables were country of the roads used as stimuli (UK or Malaysia) and road type (rural, suburban, or urban roads). Accuracy (%) and reaction time (ms) were analysed in both the primary and secondary tasks.

There were two experimental blocks (UK roads and Malaysian roads) which consisted of 30 trials each (with ten trials each of rural, suburban and urban roads), and the order was counterbalanced.

2.3.Stimuli

The UK stimuli were taken from Crundall (2009), which consisted of photographs of rural, suburban and urban roads in Nottinghamshire. The photographs depicted the viewpoint of a driver who is looking forward and following a lead vehicle. To create a Malaysian version of the task, following Crundall (2009) another 120 pictures of 3 road types were taken in Klang Valley in Malaysia. In line with Crundall (2009), the rural roads in Malaysia were all single carriageway roads in the countryside without pedestrians or parked cars. Suburban roads were roads with a single carriageway with terraced houses at the side, with occasional parked vehicles. Urban roads had shops at the side, a single carriageway with almost constant parked cars, with pedestrians and speed bumps.

A photograph of the rear view of a white Perodua Myvi (a small sedan) was also taken. It was then edited using Photoshop to create versions that were the same size as the rear of each of the sizes of vehicle used in the UK stimuli. The smallest of these versions was pasted into each photograph to create a simulated distance of 17m. Crash sequences were created to constitute the primary task (deceleration detection). These simulated crashing with the lead vehicle, whereby the lead vehicle would appear to jump closer to the viewer in discrete steps of 1 m. The crash sequence (primary task) was created by pasting the larger sizes of the car (without brake lights) to create the distances for 16, 15, 14, and 13m. For the secondary task, which involved the occasional additional insertion of a car into a side road (from the left or right), either waiting to enter the main carriageway/facing towards (threatening), or having just turned off the main carriageway into the side road/facing away (non-threatening). To create the pictures, side-on photographs of a dark blue Perodua Viva and a dark red Proton Exora were taken and pasted into the Malaysian roads (same number, size, location as the UK versions). The UK versions consist of a silver Renault Clio as the lead vehicle, a black Ford Fiesta and a dark red Renault Scenic were used as the secondary vehicles (see examples in Figure 1).

Figure 1. Sample photographs containing the lead car at a distance of 17m. Top row shows examples from Malaysian roads, and bottom row shows examples from UK roads (from left: rural, suburban, urban) with threatening and non-threatening hazards

2.4. Procedure

The procedure was a replication of Crundall (2009). Participants were seated 70cm from the screen on which stimuli were presented with an approximate visual angle of 28 x 22 degrees, as they were free to move their heads. Participants were informed about the flickering of this task: even though the flickering rate was not high, they were asked to be aware of this regarding family incidences of epilepsy.

The experiment was conducted in two blocks (UK roads and Malaysian roads) with 30 trials each, and counterbalancing was used. Participants were given three practice trials (one for each road type) at the beginning of each block. Pictures were presented for 600ms with a flash (blue screen for 200ms) between each picture. A fixation cross of 100ms was presented before each trial. Each trial (lasting between 13s and 45s, and 35s on average) consisted of between 16 and 56 varied pictures of road scenes with the car ahead at a distance of 17m before the crash sequence happened at a pseudo-random point.

Once the crash sequence had triggered, subsequent road scenes would show the lead car getting sequentially closer: 16m, 15m, 14m and finally 13m (see Figure 2 for illustration). Participants were required to press the ‘space bar’ when they detected that the car in front appeared to become nearer. A successful response was recorded if participants pressed the space bar between the onset of the images with the lead car at 16 m and the offset of the image with the car at 13 m. Participants were then presented with a message on screen congratulating them for avoiding a collision. Alternatively, participants were informed that they had crashed if they did not manage to press the space bar before the last scene of the crash sequence (13m). Simultaneous to this task, a secondary target (for the secondary task) appeared on one picture out of 20, on average, with an equal chance of being a threatening and non-threatening car appearing in a side road. Participants were required to press ‘0’ when they detected a non-threatening hazard and ‘1’ when a threatening hazard was spotted. The experiment took approximately one hour. Ethical approval was obtained at The University of Nottingham Malaysia and University of Nottingham UK (S1036).

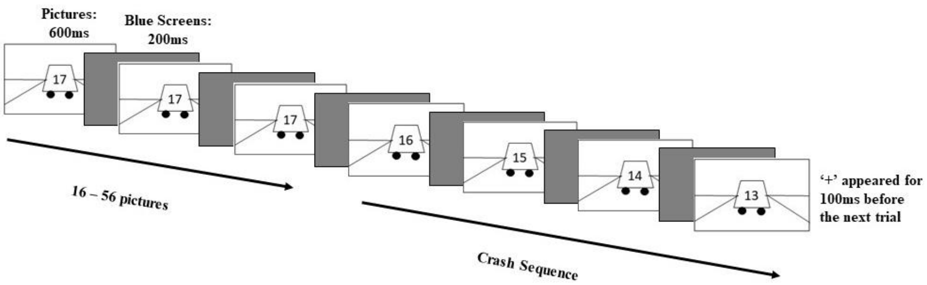

Figure 2. The figure shows the timeline of one trial. During the first part of the trial (before the crash sequence was initiated), there were 16-56 pictures, and a secondary vehicle appeared on one out of 20 pictures on average. At a random point, the crash sequence would then be initiated, with each successive image showing a larger lead car (the numbers on the cars in the image reflect the apparent distance of the lead car. Numbers were not present in the actual images). All road pictures were presented for 600ms and alternated with blue

screens (200ms). A fixation point (100ms) was then presented before the beginning of the next trial.

3. Results

3.1. Primary Task

The primary task required drivers to respond as quickly as possible when the car in front appeared to become nearer. Percentage accuracy, and response times to the primary task were compared across conditions via a 2 (Malaysian or UK drivers) x 2 (Malaysian or UK roads) x 2 (experienced drivers or novices) x 3 (rural, suburban or urban) mixed Analysis of Variance (ANOVA).

3.1.1. Accuracy (%)

Table 1. The accuracy in the primary task of UK and Malaysian drivers with different levels of experience for different road countries and road types

Accuracy (%)		UK Drivers		MY Drivers	
		Novices	Experienced	Novices	Experienced
UK Road	Rural	92.61 (11.37)	95.77 (6.43)	94.00 (13.92)	89.05 (11.36)
	Suburban	89.13 (11.25)	90.77 (14.12)	84.79 (17.09)	88.10 (15.04)
	Urban	80.87 (12.76)	84.23 (14.19)	72.63 (24.84)	73.81 (18.30)
	Average	87.54 (11.79)	90.26 (11.58)	83.81 (18.62)	83.65 (14.90)
MY Road	Rural	92.17 (13.47)	94.23 (9.87)	86.00 (16.98)	90.00 (12.65)
	Suburban	87.39 (16.85)	94.62 (8.59)	89.00 (14.83)	90.48 (12.44)
	Urban	83.48 (17.99)	91.92 (11.32)	81.00 (14.83)	80.00 (16.73)
	Average	87.68 (16.10)	93.59 (9.93)	85.33 (15.55)	86.83 (13.94)

Table 1 shows accuracy in the primary task (percentage of crashes detected) for the various driver groups across different road types. There was a significant main effect of nationality, $F(1, 86) = 5.00$, $p = .03$, $\eta_p^2 = .06$, whereby UK drivers were more accurate (M = 89.77, SD = 11.37) than Malaysian drivers (M = 84.91, SD = 15.75) in detecting crash sequences. A main effect of road type was also found, $F(2, 172) = 62.79$, $p < .001$, $\eta_p^2 = .42$). Pairwise comparisons (with Bonferroni correction) showed that drivers were more accurate on rural (M = 91.73, SD = 12.00) than suburban roads (M = 89.29, SD = 13.78), $p < .05$ and rural than urban (M = 81.00, SD = 16.37), $p < .001$. Drivers were also more accurate on suburban than urban roads, $p < .001$. There was no main effect of experience, $F(1, 86) = 1.31$, $p = .25$, $\eta_p^2 = .02$ and road country, $F(1, 86) = 2.66$, $p = .11$, $\eta_p^2 = .03$.

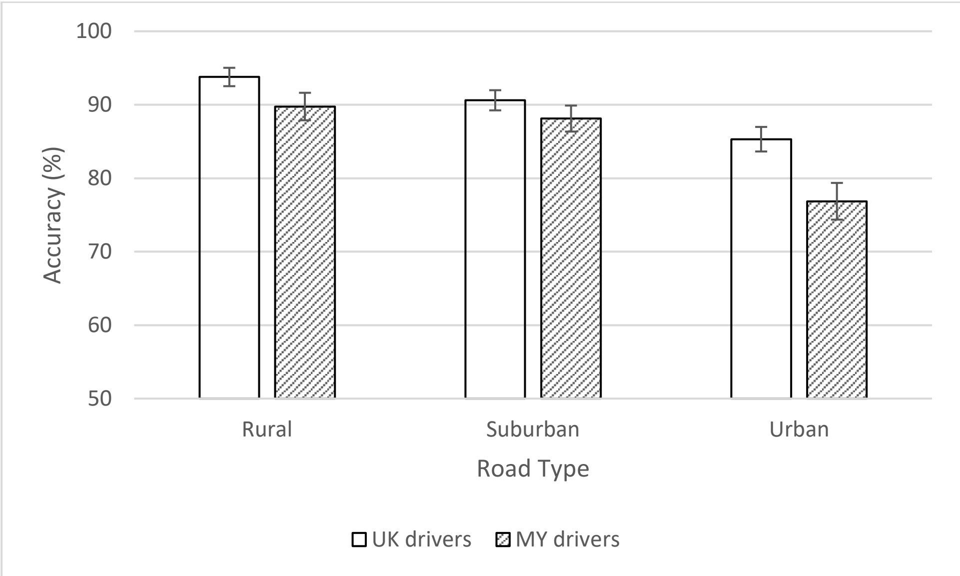

Figure 3. UK and Malaysian drivers' accuracy (%) on different road types (error bars depict standard error of the mean)

There was a significant interaction between road type and nationality, $F(2, 172) = 4.61$, $p = .01$, $\eta_p^2 = .05$ (see Figure 3). Independent samples t-tests revealed that UK drivers (85.31%) were better at detecting crash sequences than Malaysian drivers (76.86%) only on urban roads, $t(88) = 2.82$, $p < .01$. One-way ANOVAs showed that UK drivers ($F(2, 96) = 25.94$, $p < .001$, $\eta_p^2 = .35$) were more accurate on rural (93.78%) than suburban (90.61%), $p < .05$ and rural than urban roads (85.31%), $p < .001$; but Malaysian drivers ($F(2, 80) = 35.76$, $p < .001$, $\eta_p^2 = .42$) were no different in accuracy on rural (89.76%) and suburban roads (88.12%), and were only significantly less accurate in urban roads (76.86%) as compared to rural, $p < .001$ and suburban roads, $p < .001$.

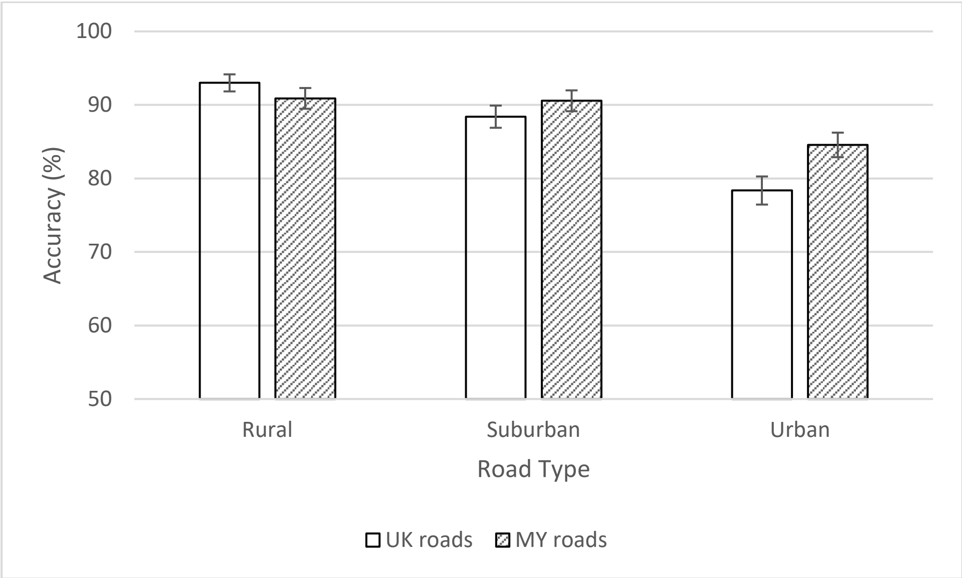

Figure 4. Drivers' accuracy (%) on different road types and road countries (error bars depict standard error of the mean)

There was also a significant interaction between road country and road type, $F(2, 172) = 7.76$, $p = .001$, $\eta_p^2 = .08$ (see Figure 4). Paired samples t-tests revealed that drivers were significantly better on Malaysian urban roads (84.56%) than UK urban roads (78.36%), $t(89) = 3.23$, $p < .005$ but there was no difference between the two countries for the other road types.

3.1.2. Reaction Time (ms)

Table 2. The reaction times (ms) in the primary task of UK and Malaysian drivers with different levels of experience for different road countries and road types.

Reaction Time (RT)		UK Drivers		MY Drivers	
		Novices	Experienced	Novices	Experienced
UK Road	Rural	2306 (424)	2232 (321)	2273 (477)	2119 (524)
	Suburban	2293 (294)	2216 (431)	2397 (553)	2144 (569)
	Urban	2595 (308)	2424 (477)	2567 (552)	2400 (651)
	Average	2398 (342)	2291 (410)	2412 (528)	2221 (581)
MY Road	Rural	2408 (311)	2265 (341)	2471 (420)	2227 (699)
	Suburban	2410 (235)	2330 (278)	2393 (534)	2118 (622)
	Urban	2526 (443)	2345 (461)	2593 (523)	2383 (568)
	Average	2448 (330)	2313 (361)	2486 (492)	2243 (630)

Where drivers made a correct response, reaction times were calculated. Table 2 shows the mean reaction time for the various driver groups completing the primary task across different road types. Experienced drivers (*M* = 2267 ms, *SD* = 495) were significantly faster at detecting crash sequences than novice drivers (*M* = 2436 ms, *SD* = 423), $F(1, 86) = 4.36$, $p = .04$, $\eta_p^2 = .05$. There was also a significant main effect of road type, $F(2, 127) = 26.15$, $p < .001$, $\eta_p^2 = .23$. Pairwise comparisons with Bonferroni correction revealed that drivers were faster on rural (*M* = 2288, *SD* = 440) than urban roads (*M* = 2479, *SD* = 498), $p < .001$; and were faster on suburban (*M* = 2288, *SD* = 440) than urban roads, $p < .001$; with no difference between rural and suburban roads. There was no main effect of nationality, $F(1, 86) = .07$, $p =.79$, $\eta_p^2 = .001$ and road country $F(1, 86) = 1.67$, $p = .20$, $\eta_p^2 = .02$.

There was a significant interaction between road country and road type, $F(2, 172) = 3.60$, $p =.03$, $\eta_p^2 = .04$. Paired samples *t*-tests showed that this interaction is caused by participants responding significantly faster for UK (2234ms) than Malaysian (2338ms) rural roads, $t(89) = 2.65$, $p = .01$, while there was no such difference for suburban or urban roads. No other effects or interactions were found.

3.2. Secondary Task

The secondary task required drivers to identify the threatening (pressing ‘1’) and non-threatening (pressing ‘0’) peripheral vehicles as quickly as possible, while simultaneously performing the primary task. 2 (Malaysian or UK drivers) x 2 (Malaysian or UK roads) x 2 (experienced drivers or novices) x 3 (rural, suburban or urban) mixed ANOVAs were conducted for both accuracy (correctly identified the threat level) and reaction time.

3.2.1. Accuracy in identification (%)

Table 3. The accuracy in the secondary task of UK and Malaysian drivers with different levels of experience for different road countries and road types

Accuracy (%)		UK Drivers		MY Drivers	
		Novices	Experienced	Novices	Experienced
UK Road	Rural	63.22 (28.29)	75.88 (16.66)	58.23 (27.47)	63.90 (26.73)
	Suburban	63.11 (29.34)	73.25 (21.27)	54.51 (28.14)	59.68 (27.44)
	Urban	59.78 (33.01)	75.34 (18.02)	58.14 (25.44)	55.43 (26.72)
	Average	62.04 (30.21)	74.82 (18.65)	56.96 (27.02)	59.67 (26.96)
MY Road	Rural	66.08 (24.42)	77.11 (15.97)	59.04 (26.86)	66.48 (28.49)
	Suburban	64.63 (22.47)	77.48 (18.71)	61.53 (25.97)	70.16 (25.15)
	Urban	59.53 (28.33)	75.58 (20.34)	56.76 (25.47)	54.80 (25.64)
	Average	63.41 (25.07)	76.72 (18.34)	59.11 (26.1)	63.81 (26.43)

Table 3 shows accuracy in detecting threatening and non-threatening hazards for the various driver groups across differing road types. UK drivers (M = 69.25, SD = 23.07) were more accurate than Malaysian drivers, (M = 59.89, SD = 26.63), $F(1, 86) = 4.10$, $p < .05$, $\eta_p^2 = .046$. A main effect of road type was found, $F(2, 172) = 9.64$, $p < .001$, $\eta_p^2 = .037$. Pairwise comparisons revealed that drivers were more accurate on rural roads (M = 66.24, SD = 24.36) than urban roads (M = 61.92, SD = 25.37), $p < .001$ and also more accurate on suburban (M = 65.54, SD = 24.81) than urban roads, $p < .005$.

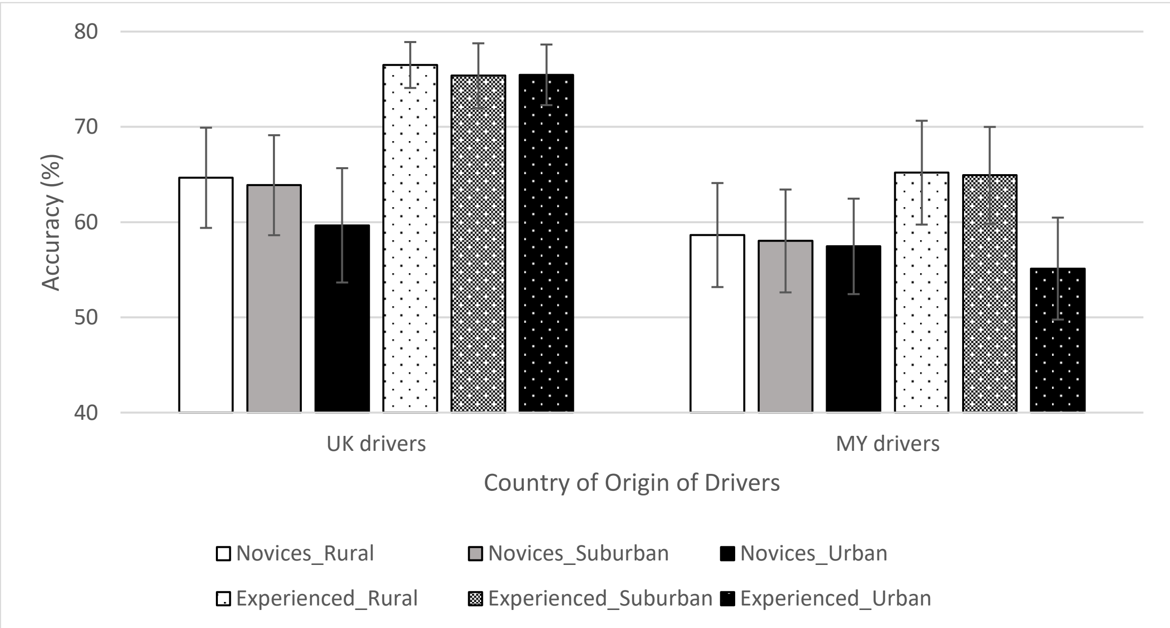

Figure 5. The accuracy (%) of UK and Malaysian drivers with different experience levels on different road types (error bars depict standard error of the mean)

A three-way interaction was found between road type, nationality and experience (see Figure 5), $F(2, 172) = 6.50$, $p < .005$, $\eta_p^2 = .07$. To further investigate this interaction, two 2 (experience) x 3 (road type) mixed ANOVAs were conducted.

For UK drivers, there was a main effect of experience, $F(1, 47) = 4.91$, $p = .032$, $\eta_p^2 = .095$, whereby experienced drivers (62.73%) were more accurate than novices (75.77%). No other main effect or interaction was found.

For Malaysian drivers, there was no main effect of experience but there was a main effect of road type, $F(2, 78) = 7.44$, $p = .001$, $\eta_p^2 = .16$. Pairwise comparisons with Bonferroni correction showed that drivers were significantly more accurate for rural (61.92%) than urban (56.29%), $p = .001$; and suburban (61.47%) than urban, $p = .013$, but there was no difference for rural and suburban. There was an interaction between road type and experience, $F(2, 78) = 5.20$, $p < .01$, $\eta_p^2 = .12$. Post hoc ANOVAs showed that there was no effect of road type for novices but there was for experienced drivers, $F(2, 40) = 13.98$, $p < .001$, $\eta_p^2 = .41$. Pairwise comparisons with Bonferroni correction revealed that Malaysian experienced drivers were significantly better for rural (71.44%) than urban (66.37%), $p = .001$; and suburban (70.70%) than urban roads, $p < .001$. Experienced drivers were also significantly more accurate than novices for rural roads ($t(88) = 2.04$, $p = .046$; experienced 71.44% and novices 61.85%), and suburban roads ($t(88) = 2.04$, $p = .050$; experienced 70.70% and novices 61.15%) but not on urban roads ($t(88) = 1.51$, $p = .134$).

In addition, there was a two-way interaction between road country and road type, $F(2, 172) = 3.43$, $p = .035$, $\eta_p^2 = .038$. Paired samples t-tests showed that drivers are more accurate on Malaysian suburban (68.94%) than UK suburban roads (63.33%), $t(89) = 2.55$, $p = .013$. No differences were found on the other road types.

3.2.2. Reaction Time (ms)

Table 4. The reaction times (ms) in the secondary task of UK and Malaysian drivers with different levels of experience for different road countries and road types.

Reaction Time (RT)		UK Drivers		MY Drivers	
		Novices	Experienced	Novices	Experienced
UK Road	Rural	751 (129)	720 (114)	767 (120)	775 (68)
	Suburban	811 (152)	766 (118)	857 (293)	800 (78)
	Urban	861 (211)	790 (135)	917 (218)	937 (215)
	Average	808 (164)	759 (122)	847 (210)	837 (120)
MY Road	Rural	727 (93)	746 (144)	770 (159)	744 (111)
	Suburban	761 (80)	704 (81)	802 (263)	776 (151)
	Urban	846 (129)	863 (138)	921 (238)	912 (169)
	Average	778 (101)	771 (121)	831 (220)	811 (144)

Where correct responses were made (pressing '1' when a threatening hazard was spotted and '0' when a non-threatening hazard was spotted), reaction times were calculated. Table 4 shows the reaction time for correctly identifying the secondary vehicles, for the various driver groups when completing the secondary task across different road types. There was a significant main effect of road type, $F(2, 132) = 78.47$, $p < .001$, $\eta_p^2 = .54$. Pairwise comparisons revealed that drivers were significantly faster on rural roads ($M = 750$, $SD = 117$) than suburban roads ($M = 785$, $SD = 152$), $p < .001$, rural roads than urban roads ($M = 881$, $SD = 182$), $p < .001$ and suburban roads than urban roads, $p < .001$.

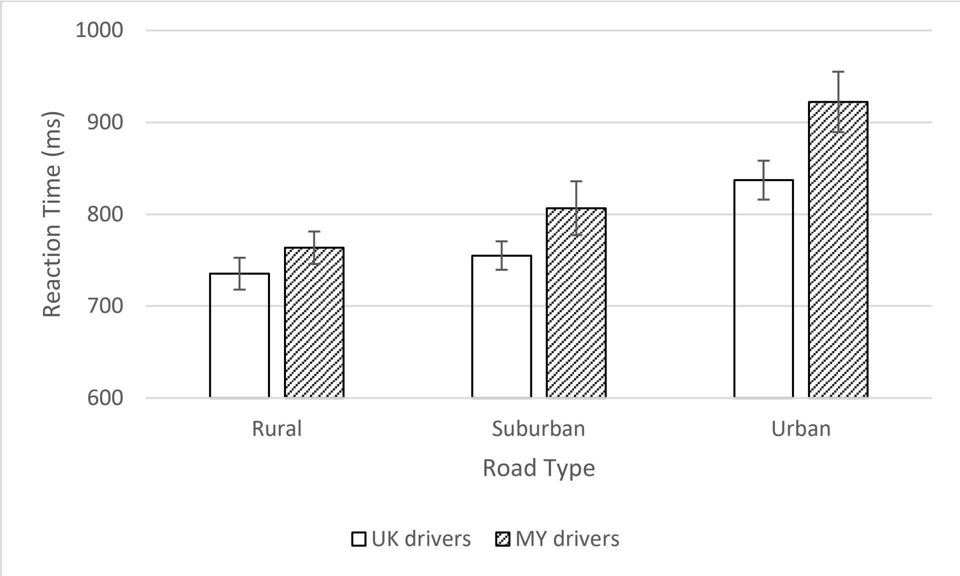

Figure 6. UK and Malaysian drivers' reaction time (ms) in the secondary task on different road types (error bars depict standard error of the mean)

There was an interaction between road type and nationality (see Figure 6), $F(2, 132) = 3.16$, $p = .046$, $\eta_p^2 = .046$. Independent samples t-tests revealed that UK drivers (835ms) were faster (approaching significant) than Malaysian drivers (901ms) only on urban roads, $t(76) = 1.85$, $p = .068$. Differences were not found for any other road type. One-way ANOVAs revealed a significant main effect of road type for UK drivers, $F(2, 80) = 44.29$, $p < .001$, $\eta_p^2 = .53$ (pairwise comparisons with Bonferroni correction showed no difference between rural and suburban roads but differences between the other road types, $p < .001$) and also Malaysian drivers, $F(2, 56) = 34.74$, $p < .001$, $\eta_p^2 = .55$ (pairwise comparisons with Bonferroni correction showed differences between all 3 road types, drivers were faster on rural than suburban roads, $p = .042$; rural than urban, $p < .001$; and suburban than urban, $p < .001$).

Finally, there was also an interaction between road country and road type, $F(2, 132) = 4.52$, $p = .019$, $\eta_p^2 = .064$. Paired samples t-tests revealed that drivers were significantly faster on Malaysian suburban (752ms) than UK suburban roads (808ms), $t(76) = 2.66$, $p < .01$ while differences was not found on other road types.

3.2.3. Accuracy in detection (%)

A further analysis was conducted to investigate drivers' accuracy in detecting the secondary vehicles regardless of the accuracy in identification of whether it was a 'threatening' or 'non-threatening' hazard. For example, drivers were asked to press '0' for non-threatening hazard, but if the driver had pressed '1' instead, in this detection analysis the responses were still considered as correct. This analysis was conducted to determine whether the previously observed difference in accuracy for UK and Malaysian drivers was due to failures in detection or categorisation errors (where the driver detects a peripheral hazard but fails to correctly identify its threat level). This is particularly relevant because parking bays at an angle to the road are very common in Malaysia, so Malaysian drivers might be more likely than UK drivers to encounter a reversing vehicle from the roadside onto the main carriageway (Section 3.2.1.). Consequently, Malaysian drivers might not consider a peripheral vehicle pointing away from the carriageway to offer less threat than one that faces towards the roadway, and in fact might even consider a reversing vehicle to be more threatening given the greater difficulty for the driver to see behind the vehicle. This then would potentially cause a disadvantage for Malaysian drivers in making the categorisation.

Table 5. The accuracy in detecting secondary vehicles of UK and Malaysian drivers with different levels of experience for different road countries and road types

Accuracy (%)		UK Drivers		MY Drivers	
		Novices	Experienced	Novices	Experienced
UK Road	Rural	84.02 (22.87)	97.17 (5.64)	79.03 (21.76)	82.46 (25.25)
	Suburban	78.90 (24.48)	91.27 (9.80)	67.19 (27.34)	73.85 (27.34)
	Urban	76.97 (28.74)	93.54 (9.68)	71.97 (23.73)	70.01 (27.04)
	Average	79.96 (25.36)	93.99 (8.37)	72.73 (24.28)	75.44 (26.54)
MY Road	Rural	88.30 (18.64)	98.00 (5.12)	80.42 (27.72)	83.99 (23.71)

Suburban	86.65 (19.89)	96.63 (8.57)	81.13 (22.81)	85.07 (24.85)
Urban	80.30 (27.31)	88.07 (15.53)	70.64 (24.84)	69.78 (26.01)
Average	85.08 (21.95)	94.23 (9.74)	77.40 (25.12)	79.61 (24.86)

A 2 x 2 x 2 x 3 mixed ANOVA (see Table 5) found similar main effects as the analyses in Section 3.2.1. UK drivers (M = 88.32, SD = 16.36) were more accurate than Malaysian drivers, (M = 76.30, SD = 25.2), $F(1, 86) = 9.19$, $p < .005$, $\eta_p^2 = .097$. A main effect of road type was found, $F(2, 172) = 46.07$, $p < .001$, $\eta_p^2 = .35$. Pairwise comparisons with Bonferroni correction revealed significant differences between all 3 pairs of road type, ps < .001 (Rural roads: M = 86.67, SD = 18.84; suburban: M = 82.59, SD = 20.64; and urban M = 77.66, SD = 22.86). In addition, the effect of road country was significant, $F(1, 86) = 5.75$, $p = .019$, $\eta_p^2 = .063$, whereby drivers performed more accurately on Malaysian roads (M = 84.08, SD = 20.42) than UK roads (M = 80.53, SD = 21.14).

There was also a two-way interaction between road country and road type, $F(2, 172) = 11.44$, $p < .001$, $\eta_p^2 = .117$. Paired samples t-tests showed that drivers were more accurate on Malaysian suburban (87.94%) than UK suburban roads (78.70%), $t(89) = 4.80$, $p < .001$. No differences were found on the other road types.

The previous three-way interaction between road country, nationality and experience found in Section 3.2.1 was not significant in this analysis. No other interaction or main effect was found.

4. Discussion

4.1. The effects of driver origin and driving experience

UK drivers were more accurate than Malaysian drivers in detecting the deceleration of the lead vehicles although this effect was confined to urban roads (primary task), with a medium effect size. Similarly, in the secondary task, which involved the identifying of peripheral vehicles facing towards or away from the roadway, UK drivers also outperformed Malaysian drivers by detecting and identifying more of the vehicles correctly, although the effect size here was small. The two nationalities did not differ in reaction time in either task (aside from UK drivers being faster than Malaysian drivers in detecting peripheral hazards on suburban roads) suggesting no signs of a trade-off between speed and accuracy, as well as there being no apparent trade-off in performance on the two tasks.

This pattern of performance is in line with the previous studies which have found poorer hazard perception task performance in Malaysian than UK drivers matched for experience (Lim et al., 2013; Lim et al., 2014), and suggests that the findings in those previous studies may not be entirely explained by prior experience with hazard perception testing. Instead, the results suggest that Malaysian drivers may be less adept at dividing their attention between different sources of hazard than their UK counterparts.

The question remains as to why the Malaysian drivers performed the task less effectively. It has been argued elsewhere that exposure to hazardous environments might result in desensitisation to hazards in general (Lim et al., 2013). A similar argument could perhaps be advanced in that a criterion bias could occur in relation to detecting acceleration. Theoretically, Malaysian drivers could require a greater increase in size of the lead car before they consider it to be decelerating than UK drivers. However, if this was the case, one might expect that the reaction time for detecting deceleration would be greater for Malaysian than UK drivers whereas in fact there was no difference for the two groups. Instead, it seems more likely that Malaysian drivers were using suboptimal attentional strategies, resulting in their sometimes missing the relevant events altogether. Further research that includes more general measures of attention is needed to determine whether these differences in performance are limited to the driving domain or reflect more general cross-cultural differences in dividing attention.

In the primary task, effects of experience level were not found in accuracy, but were observed in reaction time, whereby experienced drivers were significantly faster in detecting the deceleration of lead vehicles as compared to novices, with a small effect size. In the secondary task, experienced drivers were more accurate than novices in identifying the secondary vehicles across all conditions, apart from when Malaysian drivers were viewing urban roads, on which Malaysian experienced drivers performed particularly poorly. It is not clear why the advantage of experience disappeared for Malaysian drivers specifically on the urban roads, although it is worth noting that the urban road condition was generally the most challenging for participants, as discussed in more detail below. One possibility might be that the drivers from the two countries had differing levels of experience with different road types. If the Malaysian drivers were less familiar with urban roads in general this might explain their poorer performance on urban roads in comparison to UK drivers. As we did not include any measure of what kind of roads the drivers had frequently used we cannot rule this out as an explanation. However, the study was conducted at a University close to Kuala Lumpur, Malaysia’s largest city, at which the majority of Malaysian students are from the city and surrounding areas. Future research could examine directly the impact of experience of different road types on task performance, although it is not necessarily easy to quantify such experience effectively.

Experienced drivers were faster than novices for the primary task but not the secondary task. The study thus did not replicate all of the results of Crundall (2009)’s experiment, which found experience effects for both tasks in both accuracy and reaction time. One possible explanation for this is that the experienced drivers in this study (average of 5.15 years for UK drivers and 4.86 years for Malaysian drivers) did not have quite as high experience as those in Crundall (2009)’s experiment (average of more than 7 years). Nevertheless, the current research still found some advantage of experience in both tasks, supporting the validity of the DDFT as an index of driver skill, cross-culturally.

4.2.Road Type and Road Country

As predicted, there was an effect of road type in all analyses, mostly with large effect sizes, whereby drivers were most accurate and fastest in detecting hazards on rural roads and least accurate and slowest on urban roads. This finding was in line with Crundall (2009) and many other studies, which have explained the effect of road type as being a result of visual clutter affecting mental workload and hazard detection (e.g. Cox et al., 2017; Crundall & Underwood, 1998; Miura, 1990). The lower speed limits that are typically set in urban environments may help offset higher risks associated with human information processing limitations in cluttered environments. There was also an interaction between road type and road country in all analyses, although the nature of this interaction differed. Drivers were less accurate in detecting deceleration of lead vehicles on UK urban roads than Malaysian urban roads, and were also faster in detecting deceleration on UK rural than Malaysian rural roads. In the secondary task, drivers were more accurate and faster in identifying secondary vehicles on Malaysian suburban than UK suburban roads. Drivers were also more accurate in detecting the presence of a secondary vehicle (regardless of identifying it correctly) on Malaysian suburban roads than UK suburban roads.

It is likely that these differences arose from visual differences between the stimuli, such as differences in contrast or subtle variability in visual clutter, and it is not possible to conclude that they reflect true differences in how easy or difficult hazards are to detect in general in the two driving environments. Although care was taken to ensure that the two stimuli sets were as well matched as possible, these slight differences are inevitable given the complexity of the stimuli, and the fact that the photographs were taken on genuine roads in the two locations (Lee et al., 2015).

4.3.Familiarity Effect

As in previous studies (Lee at al., 2015; Lim et al., 2014), there was no interaction between driver origin and road country in any analysis, implying that environmental familiarity did not lead to an advantage for drivers in detecting the deceleration of lead vehicles or dividing their attention to identify and detect secondary hazards (Lee et al., 2015). This implies the skills of detecting deceleration of lead vehicles and peripheral hazard detection are transferrable between different driving environments, at least within the groups tested here. However, it is worth noting that although the appearance of the driving environment differed for the UK and Malaysian stimuli, the dynamics of the task and locations of the hazards to be detected were the same for both stimuli sets. Context familiarity effects are more likely to arise when making comparisons between countries with left and right-hand drive systems, where the spatial layout of the road and events on it and consequently visual attentional habits can be strikingly different (e.g. Thompson & Sabik, 2018).

4.4 Limitations

Before discussing the potential implications of the findings in this study, it is important to highlight some limitations of the research. It should be noted that the samples recruited in this study were fairly homogenous in nature. Participants were students, mostly undergraduates, at two campuses of the University of Nottingham. The advantage of this was that the samples should have been fairly well matched on demographic variables. However, clearly neither sample is entirely representative of the wider population of the country. Given that cross-cultural differences were observed even within these fairly homogenous and matched samples of participants, it could be the case that even greater differences would be found if we were able to gain larger more representative samples from each location. Nevertheless, as it stands, we do not currently know how generalisable the findings are to the two nations as a whole. Further research should aim to recruit cross-cultural samples with a broader range of age and experience as well as more diversity on other demographic variables, such as socioeconomic status, level of education, and geographic location (urban vs rural), and consider the effects of sex on task performance.

Also, we used length of active driving experience since obtaining the license as the measure of driving experience, as opposed to some other measure such as distance per annum. This was the same measure used by Crundall (2009) allowing some comparability between studies. However, it should be noted that findings might have differed had we operationalised experience in a different way.

4.5 Implications

Rear-end collisions were the second highest crash configuration in Malaysia making up 28.4% of the road fatalities (MIROS, 2017). The results of our study here indeed suggest that Malaysian drivers may be less capable in detecting deceleration of the vehicle in front which is one factor that could make rear end collisions more likely. One can argue that this task might have underestimated Malaysian drivers' abilities in real driving conditions as the lead vehicle would typically have their brake lights on while braking which this study did not include. Consistent with this, Crundall previously incorporated brake lights in the task and found that everyone spotted the lights and responded accordingly. Having said that, drivers often initially slow down by simply removing their foot from the accelerator, without pressing the brake pedal, so relying only on brake lights is not sufficient to detect deceleration in every situation. If a driver can detect early indicators of deceleration prior to the application of the brake, this should also allow the him/her to more effectively predict what will happen next and to respond more safely. Moreover, if Malaysian drivers failed to detect deceleration of a lead vehicle in a relatively simple computer-based task, their ability might be even poorer in real-life driving situations, which are more flexible and unpredictable with greater other demands.

Various measures and strategies have been proposed to improve road safety in Malaysia, with the target to reduce the predicted road deaths in 2020 by 50%. One of the safety measures that has been applied in Malaysia is that all new car models are to be equipped with ABS brakes (IRTAD, 2013) which was implemented in part to reduce the occurrence of rear-end collisions. However, the findings of this study suggest that this might not be enough if Malaysian drivers are generally weaker in detecting the deceleration of lead vehicles. More advanced technologies such as Advanced Driver Assistance Systems (ADAS) and Forward Collision Warning Systems (FCW) which may help drivers with detecting these occurrences could be the next safety measures to implement. However, Malaysia is still a developing country and it is unlikely that these will be as commonly used as in the UK. These advanced technologies are not always available everywhere in the world especially not in low- and middle-income countries (IRTAD, 2015).

There are a large number of other measures and strategies that have been introduced to improve road safety in Malaysia. Firstly, measures have been introduced that aim to increase enforcement of traffic rules e.g. Community-Based Programmes, Automated Enforcement System, and Concentrated enforcement activity during festival periods. Secondly, some measures aim to improve vehicle equipment and quality e.g. Day-Running-Lights, New Car Assessment Programme for new cars, Safety Star Grading for Bus Operators, and Performance indicators for periodic technical inspection (PUSPAKOM). Finally, some measures adapt the driving infrastructure e.g. Authorised Left Turn, and Policy to Enhance Guardrail Standard. However, one potentially important strategy which has not been taken into account is simple cognition-based driving training.

Although drivers were more accurate and quicker in responding to hazards on rural roads as compared to urban roads in this experiment, it is worth pointing out that road fatalities are higher in rural areas (66%) than urban areas (34%) in Malaysia (Darma, Karim & Abdullah, 2017). The general speed limit on urban roads in Malaysia is 50km/h (31mph), whereas it is 90km/h (56mph) on rural roads (IRTAD, 2013) and the compliance rate with the speed limit on rural roads was reported as only about 74% among Malaysian drivers (Jamila et al., 2012). Similarly, in the UK, it was reported that the majority of road fatalities occurred on rural roads (almost 60%) followed by inside urban areas and motorway. The general speed limit on urban roads in UK is 30mph (48km/h), whereas it is 60mph (97km/h) and 70mph (113km/h) for rural roads and motorways respectively. Exceeding the speed limit was identified as a factor in all crashes (4%), in 12% of which road fatalities occur (IRTAD, 2014). This suggests that we should not underestimate the risk associated with driving in rural areas, especially within Malaysia.

4.6 Conclusion

This study provides further evidence, in line with previous studies (Lim et al., 2013; Lim et al., 2014), that exposure to a hazardous driving environment may not yield an expertise effect in hazard perception for Malaysian drivers, even in those who have considerable driving experience. The Malaysian drivers tested in this study performed less accurately than UK drivers in detecting the deceleration of lead vehicles especially on urban roads, despite having the same amount of years of active driving experience. Malaysian drivers were also less accurate in detecting and identifying peripheral hazards across all conditions. Various measures and strategies have been proposed to improve road safety in Malaysia, with the target to reduce the predicted road deaths in 2020 by 50%. However, one potentially important strategy which has not been taken into account is simple cognition-based driving training.

Reference

Boufous, S., Ivers, R., Senserrick, T., & Stevenson, M. (2011). Attempts at the practical on-road driving test and the hazard perception test and the risk of traffic crashes in young drivers. *Traffic Injury Prevention, 12 (5),* 475–482.

Chapman, P., & Underwood, G. (1998). Visual search of driving situations: Danger and experience. Perception, 27(8), 951–964.

Cox, J. A., Beanland, V., & Filtness, A. J. (2017). Risk and safety perception on urban and rural roads: Effects of environmental features, driver age and risk sensitivity. *Traffic Injury Prevention*, *18(7),* 703–710. https://doi.org/10.1080/15389588.2017.1296956

Crundall, D., Crundall, E., Clarke, D., & Shahar, A. (2012). Why do car drivers fail to give way to motorcycles at t-junctions? *Accident; Analysis and Prevention, 44(1)*, 88–96. https://doi.org/10.1016/j.aap.2010.10.017

Crundall, D (2016). Hazard prediction discriminates between novice and experienced drivers. *Accident Analysis and Prevention, 86*, 47-58.

Crundall, D. (2009). The Deceleration Detection Flicker Test: a measure of experience? Ergonomics, *52(6),* 674–684.

Darma, Y., Karim M. R., & Abdullah, S. (2017). An analysis of Malaysian road traffic death distribution by road environment. *Sadhana, 42(9),* 1605-1615.

DfT (2017). Reported road casualties in Great Britain: 2016 annual report.

Horswill, M. S. Hill, A. & Wetton, M. (2015) Can a video-based hazard perception test used for driver licensing predict crash involvement? *Accident Analysis and Prevention,* 82 (23), 213-219

Horswill, M.S., Kemala, C.N., Wetton, M., Scialfa, C.T., & Pachana, N.A. (2010). Improving older drivers' hazard perception ability. *Psychology and Aging, 25 (2),* 464–469

Jackson, L., Chapman, P., & Crundall, D. (2009). What happens next? Predicting other road users' behaviour as a function of driving experience and processing time. *Ergonomics, 52(2),* 154–164.

IRTAD (2013). International transport forum road safety annual report. OECD ITF, Paris

IRTAD (2014). International transport forum road safety annual report. OECD ITF, Paris

IRTAD (2015). International transport forum road safety annual report. OECD ITF, Paris

Jamilah M.M. et al, MRR03/2012: Evaluation of the Effectiveness of Ops Bersepadu Hari Raya, 2011

Lee, Y. M., Sheppard, E., & Crundall, D. (2015). Cross-cultural effects on the perception and appraisal of approaching motorcycles at junctions. *Transportation Research Part F: Traffic Psychology and Behaviour, 31*, 77-86.

Lim, P. C., Sheppard, E., & Crundall, D. (2013). Cross-cultural effects on drivers' hazard perception. *Transportation Research Part F: Traffic Psychology and Behaviour, 21,* 194–206.

Lim, P. C., Sheppard, E., & Crundall, D. (2014). A predictive hazard perception paradigm differentiates driving experience cross-culturally. *Transportation Research Part F: Traffic Psychology and Behaviour, 26,* 210–217.

Mayhew D. R., Simpson H. M., & Pak A. (2003). Changes in collision rates among novice drivers during the first months of driving. *Accid. Anal. Prev, 35,* 683–691.

MIROS (2017) Available at: https://www.miros.gov.my/1/publications.php?id_event=131&idxs_page=4&searchPage=84. (Accessed 04.09.2018)

Miura, T. (1990). Active function of eye-movement and useful field of view in a realistic setting. In: Groner, R., d'Ydewalle, G., Parham, R. (Eds.), From Eye to Mind. Information Acquisition in Perception, Search, and Reading. North-Holland, Amsterdam, pp. 119–127

Nantulya, V. M., & Reich, M. R. (2002). The neglected epidemic: Road traffic injuries in developing countries. BMJ: British Medical Journal, 324(7346), 1139–1141.

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A. A., Jarawan, E., et al (2004). World report on road traffic injury prevention. Geneva: World Health Organization.

Quimby, A.R., Maycock, G., Carter, I.D., Dixon, R., & Wall, J.G. (1986). Perceptual Abilities of Accident Involved Drivers. *Transport and Road Research Laboratory.*

Thompson, C. & Sabik, M (2018). Allocation of attention in familiar and unfamiliar traffic scenarios. *Transportation Research Part F: Traffic Psychology and Behaviour, 55,* 188-198.

Toroyan, T. (2009). Global status report on road safety: Time for action. Geneva: World Health Organization

Underwood, G., Crundall, D., & Chapman, P. (2011). Driving simulator validation with hazard perception. *Transportation Research Part F: Traffic Psychology and Behaviour, 14,* 435–446.

Ventsislavova, P., Crundall, D., Baguley, T., Castro, C., Gugliotta, A., Garcia-Fernandez, P., Zhang, W., Ba, Y., & Li, Q. (2019). A comparison of hazard perception and hazard prediction tests across China, Spain and the UK. *Accident Analysis & Prevention*, *122*, 268-286.

Wells, P., Tong, S., Sexton, B., Grayson, G., & Jones, E. (Eds.), 2008. *Cohort II: A Study of Learner and New Drivers.* Department of Transport, London.