

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

Yee Mun LEE¹, Karl MILLER², David CRUNDALL³, Elizabeth SHEPPARD²

¹University of Leeds

²University of Nottingham

³Nottingham 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.

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1. Introduction

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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.

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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.

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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

47 several studies (Boufous et al., 2011; Horswill et al., 2010; Quimby et al., 1986).
48 Consequently, a hazard perception test is included in driver licensing in several countries
49 including the UK, the Netherlands, and parts of Australia – with some evidence that this has
50 resulted in reduced crash liability in newly qualified drivers (Wells et al., 2008).

51 Lim et al. (2013) questioned whether such tests could be easily transferred to
52 developing countries where driving culture might be very different. In 2016, there were 1792
53 road deaths in the UK (population: 65,788,574) and 7152 road deaths in Malaysia (estimated
54 population: 31,660,000). Respectively, this represents 3 and 23 deaths per 100,000
55 inhabitants (DfT, 2017, MIROS, 2017). The Malaysian road environment is therefore far
56 more hazardous than the UK driving environment. The authors questioned whether
57 Malaysian drivers would have greater hazard perception expertise than UK drivers due to
58 greater exposure to hazards on the roads. Alternatively, if the correlation between HP ability
59 correlates and crash liability that has been observed within populations (e.g. Horswill et al.,
60 2015) extends between populations, HP ability might be poorer for Malaysian drivers, in line
61 with the higher crash risk in Malaysia. They carried out a cross-cultural investigation
62 comparing hazard perception in drivers from the UK and Malaysia who were matched for
63 experience. The frequently-used hazard perception reaction time paradigm was used, where
64 participants were presented with video clips containing driving hazards filmed in both
65 countries, and were asked to press a button when they detected that a hazard was developing.
66 It was found that Malaysian drivers (N = 55) identified significantly fewer hazards than UK
67 drivers (N = 45) and were also significantly slower in overall response times. The study
68 concluded that the poorer performance in Malaysian drivers might partly be due to an
69 increased criterion for reporting hazards as a result of them becoming desensitised to such
70 events on their native roads. Similar differences have since been observed between UK (N =
71 52), Spanish (N = 51), and Chinese drivers (N = 50), with Chinese drivers (who drive in a

72 more hazardous environment than either group of European drivers) spotting significantly
73 fewer hazards and responding later significantly (Ventsislavova et al., 2019). However,
74 another possible explanation for the difference is that UK drivers are familiar with the
75 hazard-perception test format (as they must pass a hazard perception test to obtain a licence),
76 and this may have conferred a benefit. Malaysian drivers on the other hand, were not tested
77 with the HP test but were required to take part in the theoretical test, complete a minimum of
78 16 hours of on-road driving lessons, and complete and pass the on-road driving test (slope
79 test, 3-point turn, reverse parking, parallel parking, and driving on the road).

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

96 that this masks true (or at least comparable) hazard perception competence in Malaysian
97 drivers.

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

119 As the methodology discriminates between experienced and novice drivers, it can be
120 seen as validly measuring a facet of driving skill – experience here acting as a proxy for crash

121 liability due to collisions being over-represented in newly qualified drivers (Mayhew et al,
122 2003). This accords with other studies which imply that less experienced drivers tend to have
123 a narrower spread of visual search while driving (Chapman & Underwood, 1998; Underwood
124 et al., 2001). The benefit of this task is that the structural differences between this and the
125 hazard perception test used as part of driver licensing in the UK make it far less likely that
126 any advantage would be conferred by prior experience with the typical hazard perception
127 testing procedure. Therefore the DDFT may offer a fairer indication of the relative abilities of
128 drivers in the two countries to attend to multiple sources of potential hazard. A further
129 motivation for using the task in Malaysia in particular is that rear-end collisions constitute the
130 second most common crash type making up 28.4% of the road fatalities (MIROS, 2017).
131 Hence, determining whether and how well Malaysian drivers are able to detect deceleration
132 of lead vehicles could contribute to our understanding of this kind of crash.

133 The current study aimed to investigate cross-cultural performance of UK and
134 Malaysian drivers in hazard perception using the Deceleration Detection Flicker Task
135 (Crundall, 2009) with tests designed using stimuli relevant to each country. The two tests
136 differed in terms of roadways and vehicles depicted, though, as both countries have left-hand
137 driving, there were no concerns about asymmetrical attention differences between the groups
138 (Thompson & Sabik, 2018). The methodology of Crundall (2009) was adapted to determine
139 how the driver's country of origin and driving experience affects performance in detecting
140 the deceleration of the car ahead (primary task) while simultaneously having to detect
141 threatening and non-threatening peripheral hazards (secondary task). If repeated exposure to a
142 hazardous real-life driving environment detrimentally impacts hazard perception skill
143 (perhaps through an increase in criterion bias) then Malaysian drivers may be slower or less
144 accurate on the DDFT. Alternatively, if exposure to a hazardous driving environment serves
145 to further hone hazard perception skills, Malaysian drivers should perform better than UK

146 drivers. In line with Crundall (2009), we also predicted that experienced drivers (3-10 years
147 of active driving experience) will perform better than novices (less than a year of active
148 driving experience) – which would provide cross-cultural validation of the test. Finally, as in
149 Crundall (2009), we expected drivers to perform better on the less cluttered road types i.e. to
150 perform best for rural roads and least well for urban roads. This design of the study also
151 allowed investigation of whether there is a familiarity effect i.e. whether drivers perform
152 better on the task when viewing stimuli from their own country than the other, less familiar
153 country. Given that unfamiliar scenes should challenge visual skills more than familiar
154 scenes, it might be expected that performance would be degraded for the unfamiliar scenes
155 compared with familiar ones.

156

157 2. Methods

158 2.1. Participants

159 Ninety drivers were recruited for this study. All participants were university students:
160 41 of them were from the University of Nottingham Malaysia campus and 49 were from
161 the University of Nottingham UK campus. The groups were therefore closely matched in
162 terms of educational background. For the UK drivers, 23 were classified as low-
163 experience drivers (11 female) with a mean age of 20.43 (*S.D.* = 2.02), and all reported
164 less than a year of driving experience since getting their driving license in the UK. The
165 remaining 26 UK drivers, were classified as higher-experience (13 female) with a mean
166 age of 23.77 (*S.D.* = 2.44), and they had a range of active driving experience from 3 to 10
167 years (*M* = 5.15, *S.D.* = 2.04) since obtaining their UK driving license.

168 For the Malaysian drivers, 20 were classified as low-experience drivers (10 female)
169 with a mean age of 18.85 (*S.D.* = 1.57), and all reported less than a year of driving
170 experience since getting their driving license in Malaysia. The other 21 Malaysian drivers

171 were classified as higher-experience (11 female) with a mean age of 22.52 (*S.D.* = 2.99),
172 and a range of active driving experience from 3 to 9.5 years ($M = 4.86$, *S.D.* = 2.09) since
173 getting their driving license in Malaysia. An independent samples t-test showed no
174 significant difference of experience between the higher-experience UK and higher-
175 experience Malaysian drivers, $t(45) = .19$, $p = .63$. All drivers had normal or corrected-to-
176 normal vision.

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178 2.2. Design

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

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

188

189 2.3. Stimuli

190 The UK stimuli were taken from Crundall (2009), which consisted of photographs of
191 rural, suburban and urban roads in Nottinghamshire. The photographs depicted the
192 viewpoint of a driver who is looking forward and following a lead vehicle. To create a
193 Malaysian version of the task, following Crundall (2009) another 120 pictures of 3 road
194 types were taken in Klang Valley in Malaysia. In line with Crundall (2009), the rural
195 roads in Malaysia were all single carriageway roads in the countryside without

196 pedestrians or parked cars. Suburban roads were roads with a single carriageway with
197 terraced houses at the side, with occasional parked vehicles. Urban roads had shops at the
198 side, a single carriageway with almost constant parked cars, with pedestrians and speed
199 bumps.

200 A photograph of the rear view of a white Perodua Myvi (a small sedan) was also
201 taken. It was then edited using Photoshop to create versions that were the same size as the
202 rear of each of the sizes of vehicle used in the UK stimuli. The smallest of these versions
203 was pasted into each photograph to create a simulated distance of 17m. Crash sequences
204 were created to constitute the primary task (deceleration detection). These simulated
205 crashing with the lead vehicle, whereby the lead vehicle would appear to jump closer to
206 the viewer in discrete steps of 1 m. The crash sequence (primary task) was created by
207 pasting the larger sizes of the car (without brake lights) to create the distances for 16, 15,
208 14, and 13m. For the secondary task, which involved the occasional additional insertion
209 of a car into a side road (from the left or right), either waiting to enter the main
210 carriageway/facing towards (threatening), or having just turned off the main carriageway
211 into the side road/facing away (non-threatening). To create the pictures, side-on
212 photographs of a dark blue Perodua Viva and a dark red Proton Exora were taken and
213 pasted into the Malaysian roads (same number, size, location as the UK versions). The
214 UK versions consist of a silver Renault Clio as the lead vehicle, a black Ford Fiesta and a
215 dark red Renault Scenic were used as the secondary vehicles (see examples in Figure 1).

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

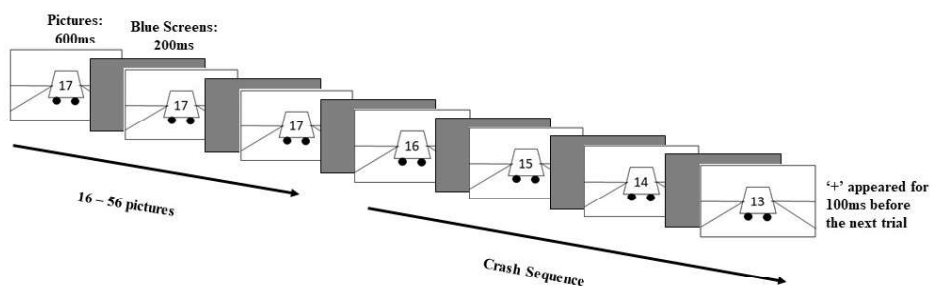
221

222 2.4. Procedure

223 The procedure was a replication of Crundall (2009). Participants were seated 70cm
 224 from the screen on which stimuli were presented with an approximate visual angle of 28 x
 225 22 degrees, as they were free to move their heads. Participants were informed about the
 226 flickering of this task: even though the flickering rate was not high, they were asked to be
 227 aware of this regarding family incidences of epilepsy.

228 The experiment was conducted in two blocks (UK roads and Malaysian roads) with
 229 30 trials each, and counterbalancing was used. Participants were given three practice trials
 230 (one for each road type) at the beginning of each block. Pictures were presented for
 231 600ms with a flash (blue screen for 200ms) between each picture. A fixation cross of
 232 100ms was presented before each trial. Each trial (lasting between 13s and 45s, and 35s
 233 on average) consisted of between 16 and 56 varied pictures of road scenes with the car
 234 ahead at a distance of 17m before the crash sequence happened at a pseudo-random point.

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



249
 250 Figure 2. The figure shows the timeline of one trial. During the first part of the trial (before
 251 the crash sequence was initiated), there were 16-56 pictures, and a secondary vehicle
 252 appeared on one out of 20 pictures on average. At a random point, the crash sequence would
 253 then be initiated, with each successive image showing a larger lead car (the numbers on the
 254 cars in the image reflect the apparent distance of the lead car. Numbers were not present in
 255 the actual images). All road pictures were presented for 600ms and alternated with blue

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

258

259 **3. Results**

260 **3.1. Primary Task**

261 The primary task required drivers to respond as quickly as possible when the car in front
 262 appeared to become nearer. Percentage accuracy, and response times to the primary task were
 263 compared across conditions via a 2 (Malaysian or UK drivers) x 2 (Malaysian or UK roads) x
 264 2 (experienced drivers or novices) x 3 (rural, suburban or urban) mixed Analysis of Variance
 265 (ANOVA).

266 **3.1.1. Accuracy (%)**

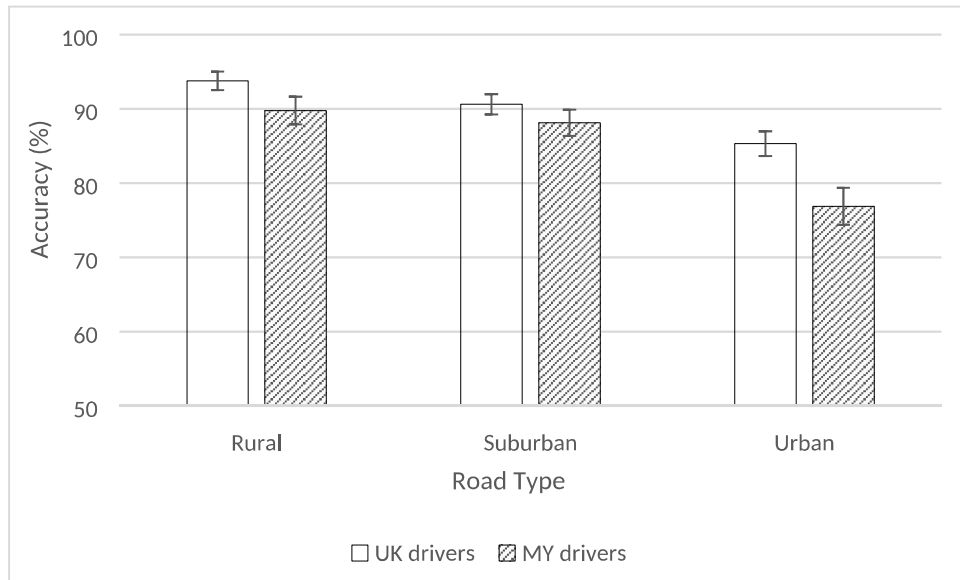
267 Table 1. The accuracy in the primary task of UK and Malaysian drivers with different levels
 268 of experience for different road countries and road types

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)

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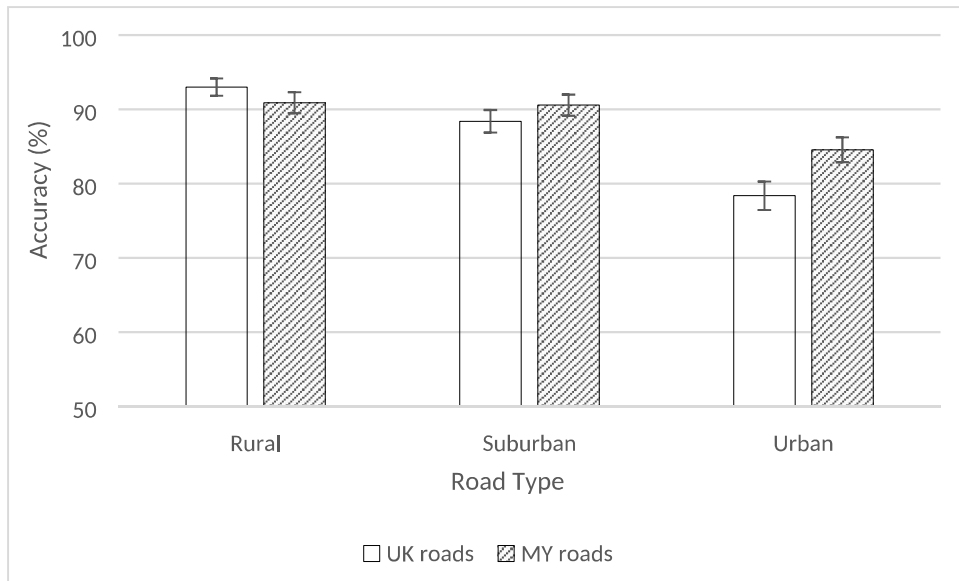
270 Table 1 shows accuracy in the primary task (percentage of crashes detected) for the
 271 various driver groups across different road types. There was a significant main effect of
 272 nationality, $F(1, 86) = 5.00, p = .03, \eta_p^2 = .06$, whereby UK drivers were more accurate ($M =$
 273 $89.77, SD = 11.37$) than Malaysian drivers ($M = 84.91, SD = 15.75$) in detecting crash
 274 sequences. A main effect of road type was also found, $F(2, 172) = 62.79, p < .001, \eta_p^2 = .42$.
 275 Pairwise comparisons (with Bonferroni correction) showed that drivers were more accurate

276 on rural ($M = 91.73$, $SD = 12.00$) than suburban roads ($M = 89.29$, $SD = 13.78$), $p < .05$ and
 277 rural than urban ($M = 81.00$, $SD = 16.37$), $p < .001$. Drivers were also more accurate on
 278 suburban than urban roads, $p < .001$. There was no main effect of experience, $F(1, 86) = 1.31$,
 279 $p = .25$, $\eta_p^2 = .02$ and road country, $F(1, 86) = 2.66$, $p = .11$, $\eta_p^2 = .03$.



280
 281 Figure 3. UK and Malaysian drivers' accuracy (%) on different road types (error bars depict
 282 standard error of the mean)

283 There was a significant interaction between road type and nationality, $F(2, 172) = 4.61$, p
 284 $= .01$, $\eta_p^2 = .05$ (see Figure 3). Independent samples t -tests revealed that UK drivers (85.31%)
 285 were better at detecting crash sequences than Malaysian drivers (76.86%) only on urban
 286 roads, $t(88) = 2.82$, $p < .01$. One-way ANOVAs showed that UK drivers ($F(2, 96) = 25.94$, p
 287 $< .001$, $\eta_p^2 = .35$) were more accurate on rural (93.78%) than suburban (90.61%), $p < .05$ and
 288 rural than urban roads (85.31%), $p < .001$; but Malaysian drivers ($F(2, 80) = 35.76$, $p < .001$,
 289 $\eta_p^2 = .42$) were no different in accuracy on rural (89.76%) and suburban roads (88.12%), and
 290 were only significantly less accurate in urban roads (76.86%) as compared to rural, $p < .001$
 291 and suburban roads, $p < .001$.



292

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

295 There was also a significant interaction between road country and road type, $F(2, 172) =$
 296 $7.76, p = .001, \eta_p^2 = .08$ (see Figure 4). Paired samples t-tests revealed that drivers were
 297 significantly better on Malaysian urban roads (84.56%) than UK urban roads (78.36%), $t(89)$
 298 $= 3.23, p < .005$ but there was no difference between the two countries for the other road
 299 types.

300 3.1.2. Reaction Time (ms)

301 Table 2. The reaction times (ms) in the primary task of UK and Malaysian drivers with
 302 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)

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304 Where drivers made a correct response, reaction times were calculated. Table 2 shows the
305 mean reaction time for the various driver groups completing the primary task across different
306 road types. Experienced drivers ($M = 2267$ ms, $SD = 495$) were significantly faster at
307 detecting crash sequences than novice drivers ($M = 2436$ ms, $SD = 423$), $F(1, 86) = 4.36$, $p =$
308 $.04$, $\eta_p^2 = .05$. There was also a significant main effect of road type, $F(2, 127) = 26.15$, $p <$
309 $.001$, $\eta_p^2 = .23$. Pairwise comparisons with Bonferroni correction revealed that drivers were
310 faster on rural ($M = 2288$, $SD = 440$) than urban roads ($M = 2479$, $SD = 498$), $p < .001$; and
311 were faster on suburban ($M = 2288$, $SD = 440$) than urban roads, $p < .001$; with no difference
312 between rural and suburban roads. There was no main effect of nationality, $F(1, 86) = .07$, p
313 $= .79$, $\eta_p^2 = .001$ and road country $F(1, 86) = 1.67$, $p = .20$, $\eta_p^2 = .02$.

314 There was a significant interaction between road country and road type, $F(2, 172) = 3.60$,
315 $p = .03$, $\eta_p^2 = .04$. Paired samples t -tests showed that this interaction is caused by participants
316 responding significantly faster for UK (2234ms) than Malaysian (2338ms) rural roads, $t(89)$
317 $= 2.65$, $p = .01$, while there was no such difference for suburban or urban roads. No other
318 effects or interactions were found.

319

320 3.2. Secondary Task

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

326 3.2.1. Accuracy in identification (%)

327 Table 3. The accuracy in the secondary task of UK and Malaysian drivers with different
328 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)

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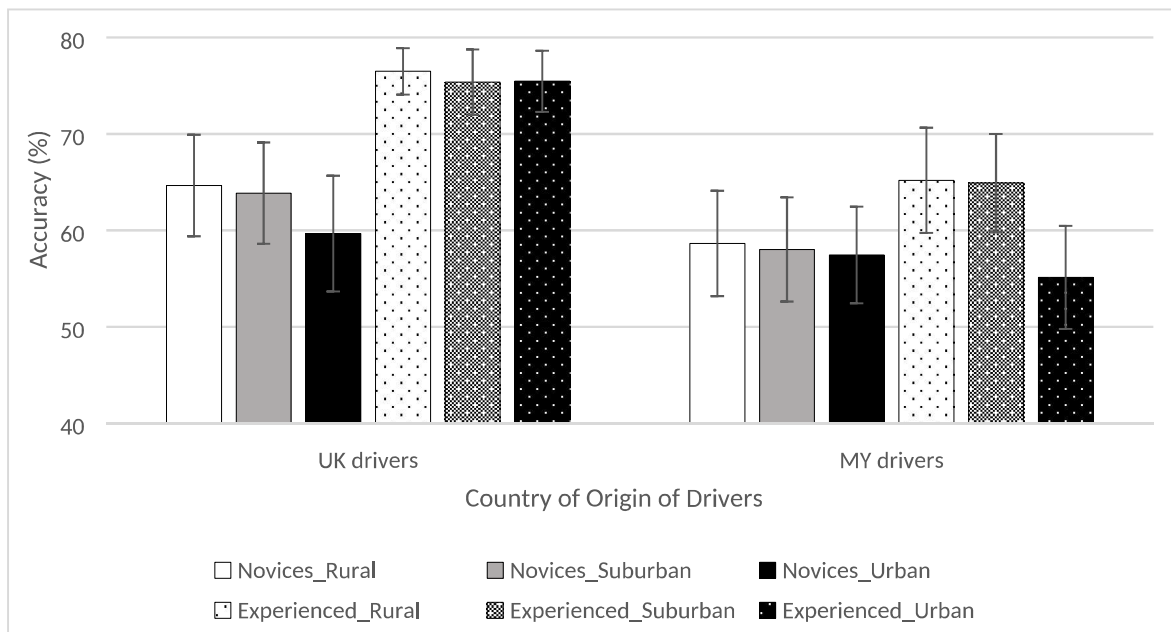
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Table 3 shows accuracy in detecting threatening and non-threatening hazards for the various driver groups across differing road types. UK drivers ($M = 69.25, SD = 23.07$) were more accurate than Malaysian drivers, ($M = 59.89, SD = 26.63$), $F(1, 86) = 4.10, p < .05, \eta_p^2 = .046$. 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, $p < .005$.



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339

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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)

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

344 For UK drivers, there was a main effect of experience, $F(1, 47) = 4.91, p = .032, \eta_p^2 =$
345 $.095$, whereby experienced drivers (62.73%) were more accurate than novices (75.77%). No
346 other main effect or interaction was found.

347 For Malaysian drivers, there was no main effect of experience but there was a main
348 effect of road type, $F(2, 78) = 7.44, p = .001, \eta_p^2 = .16$. Pairwise comparisons with
349 Bonferroni correction showed that drivers were significantly more accurate for rural
350 (61.92%) than urban (56.29%), $p = .001$; and suburban (61.47%) than urban, $p = .013$, but
351 there was no difference for rural and suburban. There was an interaction between road type
352 and experience, $F(2, 78) = 5.20, p < .01, \eta_p^2 = .12$. Post hoc ANOVAs showed that there was
353 no effect of road type for novices but there was for experienced drivers, $F(2, 40) = 13.98, p <$
354 $.001, \eta_p^2 = .41$. Pairwise comparisons with Bonferroni correction revealed that Malaysian
355 experienced drivers were significantly better for rural (71.44%) than urban (66.37%), $p =$
356 $.001$; and suburban (70.70%) than urban roads, $p < .001$. Experienced drivers were also
357 significantly more accurate than novices for rural roads ($t(88) = 2.04, p = .046$; experienced
358 71.44% and novices 61.85%), and suburban roads ($t(88) = 2.04, p = .050$; experienced
359 70.70% and novices 61.15%) but not on urban roads ($t(88) = 1.51, p = .134$).

360

361 In addition, there was a two-way interaction between road country and road type, $F(2,$
362 $172) = 3.43, p = .035, \eta_p^2 = .038$. Paired samples t-tests showed that drivers are more accurate
363 on Malaysian suburban (68.94%) than UK suburban roads (63.33%), $t(89) = 2.55, p = .013$.
364 No differences were found on the other road types.

365

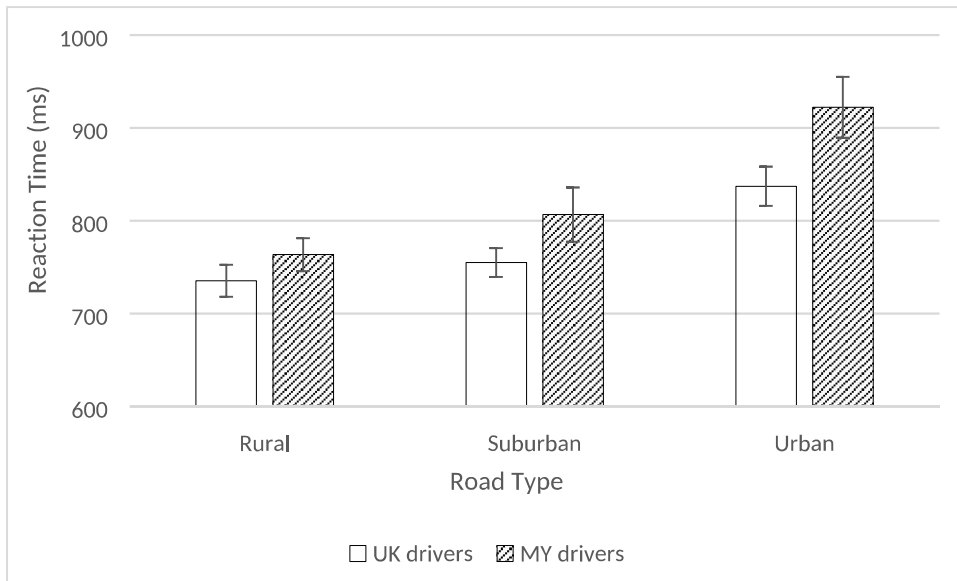
366 3.2.2. Reaction Time (ms)

367 Table 4. The reaction times (ms) in the secondary task of UK and Malaysian drivers with
 368 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)

369

370 Where correct responses were made (pressing ‘1’ when a threatening hazard was spotted
 371 and ‘0’ when a non-threatening hazard was spotted), reaction times were calculated. Table 4
 372 shows the reaction time for correctly identifying the secondary vehicles, for the various driver
 373 groups when completing the secondary task across different road types. There was a
 374 significant main effect of road type, $F(2, 132) = 78.47, p < .001, \eta_p^2 = .54$. Pairwise
 375 comparisons revealed that drivers were significantly faster on rural roads ($M = 750, SD =$
 376 117) than suburban roads ($M = 785, SD = 152$), $p < .001$, rural roads than urban roads ($M =$
 377 $881, SD = 182$), $p < .001$ and suburban roads than urban roads, $p < .001$.



378

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

381 There was an interaction between road type and nationality (see Figure 6), $F(2, 132) =$
 382 $3.16, p = .046, \eta_p^2 = .046$. Independent samples t-tests revealed that UK drivers (835ms) were
 383 faster (approaching significant) than Malaysian drivers (901ms) only on urban roads, $t(76) =$
 384 $1.85, p = .068$. Differences were not found for any other road type. One-way ANOVAs
 385 revealed a significant main effect of road type for UK drivers, $F(2, 80) = 44.29, p < .001, \eta_p^2 =$
 386 $.53$ (pairwise comparisons with Bonferroni correction showed no difference between rural
 387 and suburban roads but differences between the other road types, $p < .001$) and also
 388 Malaysian drivers, $F(2, 56) = 34.74, p < .001, \eta_p^2 = .55$ (pairwise comparisons with
 389 Bonferroni correction showed differences between all 3 road types, drivers were faster on
 390 rural than suburban roads, $p = .042$; rural than urban, $p < .001$; and suburban than urban, $p <$
 391 $.001$).

392 Finally, there was also an interaction between road country and road type, $F(2, 132) =$
 393 $4.52, p = .019, \eta_p^2 = .064$. Paired samples t-tests revealed that drivers were significantly faster

394 on Malaysian suburban (752ms) than UK suburban roads (808ms), $t(76) = 2.66, p < .01$ while
 395 differences was not found on other road types.

396 3.2.3. Accuracy in detection (%)

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

412

413 Table 5. The accuracy in detecting secondary vehicles of UK and Malaysian drivers with
 414 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)

415

416 A 2 x 2 x 2 x 3 mixed ANOVA (see Table 5) found similar main effects as the analyses in
417 Section 3.2.1. UK drivers ($M = 88.32$, $SD = 16.36$) were more accurate than Malaysian
418 drivers, ($M = 76.30$, $SD = 25.2$), $F(1, 86) = 9.19$, $p < .005$, $\eta_p^2 = .097$. A main effect of road
419 type was found, $F(2, 172) = 46.07$, $p < .001$, $\eta_p^2 = .35$. Pairwise comparisons with Bonferroni
420 correction revealed significant differences between all 3 pairs of road type, $ps < .001$ (Rural
421 roads: $M = 86.67$, $SD = 18.84$; suburban: $M = 82.59$, $SD = 20.64$; and urban $M = 77.66$, $SD =$
422 22.86). In addition, the effect of road country was significant, $F(1, 86) = 5.75$, $p = .019$, $\eta_p^2 =$
423 $.063$, whereby drivers performed more accurately on Malaysian roads ($M = 84.08$, $SD =$
424 20.42) than UK roads ($M = 80.53$, $SD = 21.14$).

425 There was also a two-way interaction between road country and road type, $F(2, 172) =$
426 11.44 , $p < .001$, $\eta_p^2 = .117$. Paired samples t-tests showed that drivers were more accurate on
427 Malaysian suburban (87.94%) than UK suburban roads (78.70%), $t(89) = 4.80$, $p < .001$. No
428 differences were found on the other road types.

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

432 4. Discussion

433 4.1. The effects of driver origin and driving experience

434 UK drivers were more accurate than Malaysian drivers in detecting the deceleration of the
435 lead vehicles although this effect was confined to urban roads (primary task), with a medium
436 effect size. Similarly, in the secondary task, which involved the identifying of peripheral
437 vehicles facing towards or away from the roadway, UK drivers also outperformed Malaysian
438 drivers by detecting and identifying more of the vehicles correctly, although the effect size

439 here was small. The two nationalities did not differ in reaction time in either task (aside from
440 UK drivers being faster than Malaysian drivers in detecting peripheral hazards on suburban
441 roads) suggesting no signs of a trade-off between speed and accuracy, as well as there being
442 no apparent trade-off in performance on the two tasks.

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

449 The question remains as to why the Malaysian drivers performed the task less effectively.
450 It has been argued elsewhere that exposure to hazardous environments might result in
451 desensitisation to hazards in general (Lim et al., 2013). A similar argument could perhaps be
452 advanced in that a criterion bias could occur in relation to detecting acceleration.

453 Theoretically, Malaysian drivers could require a greater increase in size of the lead car before
454 they consider it to be decelerating than UK drivers. However, if this was the case, one might
455 expect that the reaction time for detecting deceleration would be greater for Malaysian than
456 UK drivers whereas in fact there was no difference for the two groups. Instead, it seems more
457 likely that Malaysian drivers were using suboptimal attentional strategies, resulting in their
458 sometimes missing the relevant events altogether. Further research that includes more general
459 measures of attention is needed to determine whether these differences in performance are
460 limited to the driving domain or reflect more general cross-cultural differences in dividing
461 attention.

462 In the primary task, effects of experience level were not found in accuracy, but were
463 observed in reaction time, whereby experienced drivers were significantly faster in detecting

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

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

488 4.2. Road Type and Road Country

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

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

511 4.3. Familiarity Effect

512 As in previous studies (Lee et al., 2015; Lim et al., 2014), there was no interaction
513 between driver origin and road country in any analysis, implying that environmental
514 familiarity did not lead to an advantage for drivers in detecting the deceleration of lead
515 vehicles or dividing their attention to identify and detect secondary hazards (Lee et al., 2015).
516 This implies the skills of detecting deceleration of lead vehicles and peripheral hazard
517 detection are transferrable between different driving environments, at least within the groups
518 tested here. However, it is worth noting that although the appearance of the driving
519 environment differed for the UK and Malaysian stimuli, the dynamics of the task and
520 locations of the hazards to be detected were the same for both stimuli sets. Context familiarity
521 effects are more likely to arise when making comparisons between countries with left and
522 right-hand drive systems, where the spatial layout of the road and events on it and
523 consequently visual attentional habits can be strikingly different (e.g. Thompson & Sabik,
524 2018).

525 4.4 Limitations

526 Before discussing the potential implications of the findings in this study, it is important to
527 highlight some limitations of the research. It should be noted that the samples recruited in this
528 study were fairly homogenous in nature. Participants were students, mostly undergraduates,
529 at two campuses of the University of Nottingham. The advantage of this was that the samples
530 should have been fairly well matched on demographic variables. However, clearly neither
531 sample is entirely representative of the wider population of the country. Given that cross-
532 cultural differences were observed even within these fairly homogenous and matched
533 samples of participants, it could be the case that even greater differences would be found if
534 we were able to gain larger more representative samples from each location. Nevertheless, as
535 it stands, we do not currently know how generalisable the findings are to the two nations as a

536 whole. Further research should aim to recruit cross-cultural samples with a broader range of
537 age and experience as well as more diversity on other demographic variables, such as
538 socioeconomic status, level of education, and geographic location (urban vs rural), and
539 consider the effects of sex on task performance.

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

545 4.5 Implications

546 Rear-end collisions were the second highest crash configuration in Malaysia making up
547 28.4% of the road fatalities (MIROS, 2017). The results of our study here indeed suggest that
548 Malaysian drivers may be less capable in detecting deceleration of the vehicle in front which
549 is one factor that could make rear end collisions more likely. One can argue that this task
550 might have underestimated Malaysian drivers' abilities in real driving conditions as the lead
551 vehicle would typically have their brake lights on while braking which this study did not
552 include. Consistent with this, Crundall previously incorporated brake lights in the task and
553 found that everyone spotted the lights and responded accordingly. Having said that, drivers
554 often initially slow down by simply removing their foot from the accelerator, without
555 pressing the brake pedal, so relying only on brake lights is not sufficient to detect
556 deceleration in every situation. If a driver can detect early indicators of deceleration prior to
557 the application of the brake, this should also allow the him/her to more effectively predict
558 what will happen next and to respond more safely. Moreover, if Malaysian drivers failed to
559 detect deceleration of a lead vehicle in a relatively simple computer-based task, their ability

560 might be even poorer in real-life driving situations, which are more flexible and unpredictable
561 with greater other demands.

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

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

584 Although drivers were more accurate and quicker in responding to hazards on rural roads
585 as compared to urban roads in this experiment, it is worth pointing out that road fatalities are
586 higher in rural areas (66%) than urban areas (34%) in Malaysia (Darma, Karim & Abdullah,
587 2017). The general speed limit on urban roads in Malaysia is 50km/h (31mph), whereas it is
588 90km/h (56mph) on rural roads (IRTAD, 2013) and the compliance rate with the speed limit
589 on rural roads was reported as only about 74% among Malaysian drivers (Jamila et al., 2012).
590 Similarly, in the UK, it was reported that the majority of road fatalities occurred on rural
591 roads (almost 60%) followed by inside urban areas and motorway. The general speed limit on
592 urban roads in UK is 30mph (48km/h), whereas it is 60mph (97km/h) and 70mph (113km/h)
593 for rural roads and motorways respectively. Exceeding the speed limit was identified as a
594 factor in all crashes (4%), in 12% of which road fatalities occur (IRTAD, 2014). This
595 suggests that we should not underestimate the risk associated with driving in rural areas,
596 especially within Malaysia.

597 4.6 Conclusion

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

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Yee Mun LEE: Conceptualization, Methodology, Software, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Visualization, Project administration. Karl MILLER: Formal analysis, Investigation, Data Curation, Writing - Review & Editing. David CRUNDALL: Software, Resources, Writing - Review & Editing. Elizabeth SHEPPARD: Conceptualization, Writing - Review & Editing, Supervision, Project administration.