Capturing Cultural Differences between UK and Malaysian Drivers to Inform the Design of In-Vehicle Navigation Systems

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ABSTRACT: Attending to cultural diversity is important for products and technology intended for global placement, such as automobiles, yet many products (and associated interfaces) lack genuine cultural differentiation. For example, in-vehicle navigation systems are typically identical in form and function across world markets, differing only in the local language and map database. To capture and explore culturally-salient design factors, we utilised a scenario-based design methodology, involving 6 experienced drivers from the UK and Malaysia. Participants were asked to portray their ideal navigation system interface designs – by drawing pictograms and devising accompanying spoken messages – to direct drivers along 3 prescribed routes in the UK, Malaysia and Japan. Routes were presented using video and paper maps, with the order of presentation counterbalanced between groups; participants were not told in advance from which country each route was derived. Proposed designs highlight differences at a country level, which are consequently interpreted from a cultural perspective. For example, Malaysian drivers included a higher density of navigational elements in their designs, particularly in their home environment, compared to UK drivers. Malaysian drivers also created more incremental designs, particularly on the approach to a manoeuvre, suggesting a desire for greater navigational support at this point in the journey. Landmarks were consistently incorporated in designs, but differences were noted in cultural salience. Additionally, the phrasing of instructions (e.g. "go straight on"), nomenclature for road elements (e.g. 'roundabout') and distance declaration conventions (e.g. units) differed at a country level. The findings can be used to inform the design of culturally-attuned in-vehicle navigation systems.

KEY WORDS: human engineering, human machine interfaces, difference among individuals / Culture, Design, Navigation, UK, Malaysia [C2]

1. Introduction

Modern vehicles have become suffused with computers and technology, aiming to enrich the driving experience by informing and entertaining drivers and enhancing safety, comfort and vehicle control. This has led to a proliferation of in-vehicle devices and human-machine-interfaces (HMIs), all vying for driver attention. Associated research has therefore naturally tended to focus on issues of usability and the effects on driving performance and driver distraction, with original equipment manufacturers (OEMs) often applying the same recommendations and HMI design solutions across their entire fleet of vehicles. However, given the global nature of the automotive market, OEMs may deploy the same vehicle models, containing the same HMIs, across a number of different countries, with only cursory attention given to local adaptation, such as translating text/menus and selecting the appropriate geographical region for map/navigation databases. While this may have obvious benefits for manufacturers, it is also important to recognise that drivers' attitudes and acceptance may also be influenced by a local cultural perspective.

There are many classic, theoretical metamodels that attempt to describe the concept of culture and organise cultural data. These typically consider culture at a national level, and ascribe cultural dimensions [1, 2]. This allows different cultural groups (typically countries) to be compared based upon their relative position within each dimension and/or by determining a cultural 'score'. There is evidence that cultural dimensions, such as *power-distance* [1] and *high-context* [2], have been applied as a tool in human computer interaction (HCI) research – for example, to predict user interaction behaviour with web pages [3, 4] and to inform the design of driver information systems [5]. There is a further body of evidence (and numerous anecdotal accounts), which demonstrates that *failure* to attend to cultural diversity in the design of products and technology intended for global market placement or worldwide distribution can lead to difficulty comprehending and using the technology; in a driving context this may elevate visual/cognitive demand, distract drivers or result in them ignoring or de-activating the technology – clearly, any benefits will not be realised if the technology is switched off or ignored. A commonly cited example is the rather lacklustre reception to the introduction of the 'Nova' car in Latin America by General Motors. Low interest and poor sales were

ultimately attributed to its name – 'no va' – which, in Spanish, literally means 'not go' [6].

Attending to cultural diversity is therefore clearly important, and particularly so in situations where the needs of different cultural audiences are being addressed simultaneously (e.g. websites), or where culturally diverse expectations must be met, such as in-vehicle HMI design [7], [8]. However, identifying the key cultural factors associated with interaction design is complex – factors are likely to be multi-faceted and intertwined, and not limited to the choice of HMI elements such as colours, fonts, symbols, naming, abbreviations etc. Consequently, determining culturally relevant user requirements and preferences can be problematic – notwithstanding the inherent difficulties in undertaking cross-cultural research (especially where this is conducted outside the researcher's own cultural background and experience) [9] – the driving context presents unique challenges: the road environment is likely to differ significantly between countries and local driving behaviour will be bound by rules and regulations at both a formal and informal level. Indeed, there is clear evidence that a national identity exists with respect to vehicles and drivers [10].

There is some evidence that questionnaires and surveys have been employed to investigate the technological needs and concerns of different cultural groups [11], [12], [13], [14], [15]. For example, questionnaires have identified that Chinese drivers were more concerned with the *usefulness* of in-vehicle devices, whereas Indonesians considered *simplicity of use* paramount, and attitudes and opinions of Australian drivers were strongly motivated by the *aesthetics* of the design [12]. Elsewhere, Chinese drivers have expressed a preference towards *flat information hierarchies* and *clearer information layouts*, and were less concerned with the ability to customise an interface than Australian drivers [15].

While questionnaires are easy to administer, and can attract the attention of a high number of respondents, it can often be difficult to generalise findings and develop any practical design guidance from responses. Thus, results are often novel and interesting but of limited practical application. In contrast, engaging potential users during empirical investigations and evaluations can reveal genuine usability problems and may expose cultural inconsistencies in design, but require a fully-operational prototype (at least in so far as the functionality under investigation). Moreover, such investigations may only serve to highlight problems, and not offer solutions, and are likely to occur too late in the design cycle to adequately incorporate significant changes within subsequent designs.

An alternative approach, employed here, is to use a scenario-based design methodology. This offers greater flexibility in system design by adopting a storybook style approach [16] – here utilising low-end tools of pen and paper – thereby encouraging participants to consider and express their ideal technological solution at the start of the design cycle, typically unencumbered by what is technically feasible. In so doing, design activities are more accessible to a wider range of stakeholders – most significantly the people who will actually use the technology – and allows different concepts to be expressed, visualised, explored and reflected upon, before committing to a final design. Thus, results are more likely to be amenable to interpretation as practical design guidance (compared to using questionnaires or prototyping), and culturally-attuned.

1.1. In-Vehicle Navigation Systems

A key driving-related task that has benefitted significantly from technological advancements over recent years is navigation and route-finding. Evidence suggests that many people experience fundamental problems in determining and following routes while driving and are less confident when travelling in unfamiliar areas [17]. In-vehicle navigation systems (IVNS) aim to support these drivers in their route-finding and route-following performance by presenting the 'correct' sequence of goals that correspond to their chosen route [18]; typically, this comprises turn-by-turn direction presented visually and/or audibly. Research has demonstrated that IVNSs enhance navigational performance and reduce mental workload when compared to more traditional methods of route finding, such as reading maps and road signs [17], [19]. This is largely due to the simplicity and reduced timescales of navigational decision making.

IVNSs are therefore popular and widely used in automobiles today, existing as factory-fitted units, mobile (nomadic) devices and smartphone applications. However, devices typically lack cultural differentiation – models are often identical in form and function across the world, differing only in the local language and map database. However, attitudes towards interface layouts, menu structure and the representation of navigational information, are likely to differ between cultures and these are expected to have an impact on driver satisfaction and product usability [20], [21], [22], [23]. Indeed, a previous study [13] revealed discrepancies in the opinion of drivers from different cultural backgrounds regarding the road environment and types of navigational information deemed to be of value when creating personalised route-following instructions.

1.2. Overview of Study

With this in mind, we conducted an investigation to capture drivers' expectations of a navigational interface while navigating in culturally different road environments. The aim was to reveal cultural makers that could be used during the formative design of in-vehicle navigation systems to satisfy culturally-diverse markets. To enable this, experienced and active drivers from the UK and Malaysia were provided with a blank canvas and asked to consider how they would present navigational instructions when travelling through road environments (presented using video footage) from the UK, Malaysia and Japan.

2. Method

2.1. Participants

Six participants were recruited to take part – three from the UK and three from Malaysia. Participants were recruited through paper advertisements placed at the University of Nottingham, and comprised either students or staff. Collectively, participants drove more than 10,000 miles annually and had a mean age of 31 years old. Each cultural group had two female and one male participant. All participants had experience using vehicle navigation systems – four within their respective home country (UK or Malaysia), and the remaining two participants (from the Malaysia group) had only used vehicle navigation systems while driving on UK roads.

Fig. 1 Screenshots from the videos, showing road scenes from UK (top), Japan and Malaysia (bottom).

2.2. Apparatus, Design and Procedure

The scenarios for this study were created using video footage captured by the authors from the driver's perspective when travelling through routinely navigable road networks in the UK, Malaysia and Japan (see Figure 1). The videos were recorded using a camcorder during daytime, with ambient lighting, weather condition etc. matched as closely as practicable between locations; additionally, road markings, road signage, road furniture, landmarks and other road users were clearly visible to participants in each video. Routes were selected with a similar number of navigational decision points in each setting.

Participants were seated at a desk in front of a 17-inch monitor and asked to watch each video. Videos were shown to participants in a balanced sequence and no association with the country of origin or town names was provided. Participants were able to pause and replay each video at any time during the task.

After watching each video, participants were asked to draw their ideal route instruction/ pictogram, using coloured pen markers and a blank interface template, for each navigational decision point they identified during the journey. Participants were also asked to construct a descriptive message that could be delivered as a voice instruction to accompany each presentation.

Fig. 2 Example paper map, showing highlighted route in the UK.

To assist participants, they were provided with corresponding paper maps, on which the selected route was highlighted (see example in Figure 2), and the following written description of the task:

> *You are travelling in an unfamiliar environment with vehicle navigation systems in three road environments. One of the road environments is from your home country while the other two road environments are from foreign countries. In each environment, you are given the task to design YOUR own navigational interface for vehicle navigation system. You may use information from the environment and map to design interfaces that you perceive as useful for the three road environments. You are also required to WRITE any useful navigational instructions you would like to hear for the interfaces that you have created.*

Each design was captured digitally and labelled as appropriate. The resulting designs were grouped according to road environments. At the end of the video task, participants were interviewed about their personal driving experience and their views about the road environments shown in the video. The study took between 30 minutes and 1½ hours to complete. All testing was conducted in English and took place at the University of Nottingham campus in the UK.

2.2. Analysis and Measures

Proposed designs were analysed to determine different types of route descriptors and information elements used by drivers/navigators, based on a taxonomy originally presented by Lynch [24], later developed by Down and Stea [25] and more recently by Burnett [26]. This categorisation scheme – also successfully employed in other navigation-related research [27], [28] – distinguishes navigational information elements based on their association with direction (ego, local or world), distance (absolute, relative or cost-based), path (road: class, geometry, lanes, road-rules, prior turns), node (junction: angle, type), landmarks (name, descriptor, locator, reference) and road signs (place name, road number, road name) (see [26], for further information). Results are presented and discussed under the following themes, informed by the Burnett taxonomy [26], which emerged during analysis:

- Density of navigational information
- Structure and content of written instructions
- Depiction of landmarks
- Depiction of roundabouts

3. Results and Analysis

3.1. Density of Navigational Information

The amount of interface designs offered by participants for each journey varied within and between each cultural group, suggesting that drivers determined the type and number of navigational decision points differently. Drivers from Malaysia produced more interface designs than UK drivers, with the most designs associated with their home environment (between 6 and 9), and the approach to manoeuvres, compared to the other two environments: UK drivers consistently produced fewer designs ($N_{max} = 4$).

The higher number of designs offered by Malaysian drivers for their home environment may indicate the need for greater navigational support amongst these drivers, but may also reflect better cultural attachment and familiarity with this location.

The density of navigational information presented in each design (based on the Burnett taxonomy [26]) also differed between groups – Malaysian drivers generally used more elements in each design than UK drivers (see Table 1). Even so, both groups used a similar *range* of elements – Malaysian drivers used 11 navigational elements within their designs overall, while the UK group used 10, out of 22 possible navigational elements from the categorisation scheme [26]. The most frequently used element (in both groups) was *direction (ego)* with participants either sketching arrows or writing directions from the driver's perspective.

The participants in the Malaysia group also used more navigational elements in their home environment when compared with the other two road environments – 63 in total, compared to 44 and 36 for the UK and Japan, respectively. Again, this could reflect greater cultural affinity with their home environment amongst Malaysian drivers. As before, UK drivers were more consistent in their appraisal of the different road environments with the number of elements, in total, ranging from 15 to 19.

However, it is noteworthy that UK drivers selected different navigational elements when appraising unfamiliar (Malaysia and Japan) environments. For example, *absolute distance* and *geometry* elements were only utilised by UK drivers in Malaysian and Japanese road networks (see Table 1).

3.2. Structure of Written Instructions

Participants were asked to include written navigational instructions, which they would expect to hear as voice prompts in the real system, for all navigational decision points. Interestingly, not all participants believed that spoken instructions were required to support every manoeuvre. Overall, Malaysian drivers included more navigational instructions than their UK counterparts – 36 by Malaysian drivers, compared to 20 by British drivers.

Common messages were observed within both groups, particularly on the approach to junctions or where there was a change in the geometry or course of the road ahead, although there was no clear pattern evident in either cultural group regarding a common structure of instructions (see Table 2).

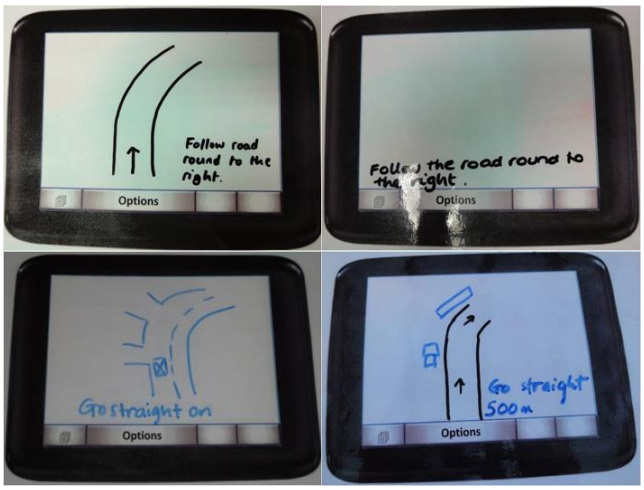

Fig. 3 Examples of phrases proposed by UK drivers (top) and Malaysian drivers (bottom).

It is noteworthy that, when describing a straight-on manoeuvre, UK drivers provided additional information by describing the course of the road ahead ("Follow the road *round to the right*"), whereas Malaysian drivers were content with a more straightforward instruction (e.g. "Go straight on"). Even so, graphical representations offered by both groups clearly depicted the road geometry. Examples to illustrate this point (in this case the road bears to the right) are shown in Figure 3.

3.3. Depiction of Landmarks

Landmarks are frequently cited during the ad hoc provision of directions [29]. Combined with directional instructions such as 'turn right', landmarks can ease route-following by indicating when and where these actions should be taken. During the study, landmarks were typically highlighted with a *locator* (e.g. post-box *on the corner*, church *on left*), and were most commonly presented as pictograms, although several landmarks were also evident as locators in written instructions, intended for verbal delivery.

Visual representations of landmarks varied in fidelity, but were nevertheless differentiated (e.g. based on type and size). For example, rows of shops can be seen as small squares and large buildings as 'houses' with a pitched roof (see Figure 4).

Table 1 Summary of navigational elements presented in designs.

Navigation Element	UK		Malaysia (My)		Japan	
	UK	My	UK	My	UK	My
Direction	7	12	11	17	7	9
Distance		7	3	9	1	3
Path	5	12	5	11	3	11
Node	3	6		12	2	4
Landmark	1	6		12	2	9
Road Signs		1		2		
Total	16	44	19	63	15	36

One of the participants from the Malaysia group reported a greater 'conformity' and 'satisfaction' if recognisable, 'global' landmarks were included in designs, such as a sign showing the Ford logo that was evident alongside a road in the Japanese example.

Landmarks with local, cultural relevance were also utilised, but only by those for whom the landmark held cultural significance, and typically only in pictorial form. For example, a mosque (masjid) was present in the video of the Malaysia roads: this was highlighted and labelled on the designs offered by two Malaysian drivers (see Figure 4), but was notably absent from UK drivers' offerings.

3.3. Depiction of Roundabouts

There were also differences evident in the depiction and nomenclature associated with roundabouts, which were only present in the UK road scenario. For example, one of the British participants referred to a roundabout using a local term – 'island'. British participants also identified the required exit based on *prior turns*, describing the relative position of the road, for example, "Take the 3rd exit".

Amongst Malaysian drivers, there were several different interpretations associated with roundabouts. For example, the roundabout was perceived as an analogue clock face, thus the required exit was described as being at "9 o'clock". Malaysian drivers also used *ego-centred direction*s such as *"turn left at the roundabout"* and identified the correct *lane* to successfully exit the roundabout. The *ego-centred direction* elements for the roundabout were represented pictorially using an arrow or expressed in the written navigational instruction. Examples of the diversity of instructions associated with the roundabout are shown in Figure 5.

Distance declaration conventions also differed between groups, with Malaysian drivers using the metric system, indicating distance in metres; in contrast, UK drivers used imperial units (i.e. yards). Both groups estimated approach distances in multiples of 100.

4. Discussion

The study revealed a broad range of navigational information formats and designs, which were scrutinised according to the Burnett taxonomy [26]. Ego-centred directions, absolute distance, road geometry, landmark name and locator elements were all evident in both pictorial interface designs and proposed accompanying spoken instructions.

Malaysian drivers generally presented more information when given the freedom to construct navigational interfaces and instructions, particular in their home environments; this also included culturally-relevant landmarks, such as the Malaysian mosque. A possible conclusion is that Malaysian drivers favour higher information content while navigating, compared to UK drivers. Nevertheless, there were notably fewer elements proposed by Malaysian drivers when describing routes in non-native driving environments, such as the UK and Japan. An alternative explanation therefore is that the Malaysian drivers were more attuned with culturally-relevant navigational markers in their own driving environment – and were therefore able to successfully

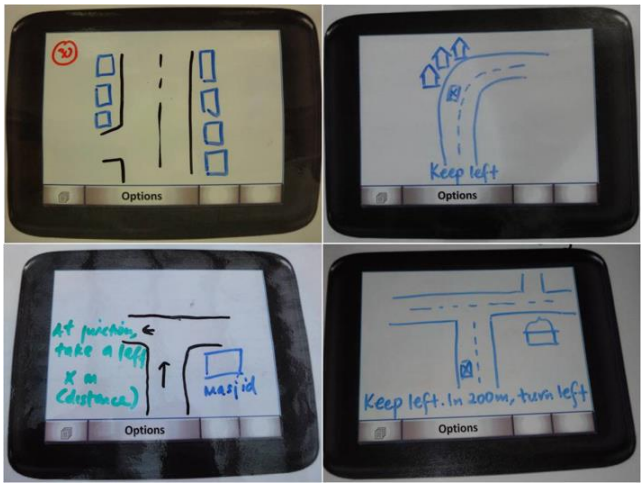

Fig. 4 Examples of landmark locator elements, showing buildings (top) and mosque (bottom)

incorporate these within navigation designs and instructions – but were less able to identify equivalent culturally-relevant markers in other, less familiar, settings. The general reliance on landmark *locator* elements (rather than *names* or *descriptors*) by Malaysian drivers in UK and Japan road environments, further suggests cultural detachment in less familiar environments.

In contrast, there was little difference between the type, quantity and presentation of information proposed by UK drivers for *all* environments, and instructions were less attuned to culturally-specific elements. Instead, UK participants relied on *ego-centred* directions and *locator* landmarks. This is consistent with previous findings by the authors [13] and may suggest that UK drivers prefer lower information content compared to Malaysian drivers, or may be less discriminating in their choice of navigational cues in culturally-diverse environments. Similar findings are reported by Heimgärtner [5], [30], who found differences in the density of information revealed through the number of point-of-interests (POIs) selected by three cultural groups: China, the UK and Germany.

There was also a notable difference observed in the number of designs offered by different cultural groups, with Malaysian drivers generally proposing a higher number of navigational interface designs on the approach to a manoeuvre. The navigation task can be considered a continuous task, with support required across a number of different stages. For example, information may be required before the driver begins the journey, on the approach to a manoeuvre, immediately prior to or directly following the

Table 2 Examples of proposed voice instructions.

Environment	UK participants	Malaysia participants
UK	*Continue through pedestrian crossing to roundabout*	*Go straight on* *Turn left* *Keep right*
Malaysia	*Take the first left* *Turn left*	*Go straight on* *Keep left* *Turn left*
Japan	*Follow road along* *Turn left* *Follow road to right*	*Go straight on* *Keep left*

Fig. 5 Depictions of UK roundabout, showing (clockwise from top-left) 'island' descriptor, 'clock face' instruction, ego-centred pictogram and ego-centred instruction.

completion of a manoeuvre, or across the whole time frame of the navigation task [26]. The results of the current study suggest that Malaysian drivers required more information on the approach to a manoeuvre. Again, similar cultural differences were reported by Heimgärtner [5], [30], who found Chinese participants required 30% more advice messages prior to a turning than British and German drivers.

It is noteworthy that the navigation interface designs offered by both groups for the routes in Japan were less densely populated with navigational information (some suggested interactions solely relied on verbal messages). This may be due to difficulties interpreting elements shown on the maps and in the video (some of which were presented in Japanese); it may also reflect the culturally different road environments – Green [31] attributes much of the early commercial success of navigation systems (at least in part) to the lack of navigation cues in the natural driving environment in Japan, where streets are often not named, buildings are numbered chronologically, and the road network is often not gridlike.

A common feature of many of the proposed designs was landmarks. The utility of landmarks as navigational cues has frequently been cited in the literature [17], [29], [32], [33], [34], [35]. However, there are significant obstacles associated with utilising landmarks as cues within navigation systems. Issues include: identifying the most appropriate landmark to use at navigational decision points, and the laborious nature of collecting, describing and maintaining a database of these. In a cultural context, selecting a good landmark also requires knowledge of its attributes and cultural or social significance [17]. This was clearly evident in the current study – for example, Malaysian drivers, for whom the mosque held significant meaning, used this in their instructions; in contrast, the mosque was absent from all UK drivers' designs. This finding is supported in other research [13].

The study also revealed 'roundabouts' as a potential factor in cultural differentiation. Though not strictly a landmark, many of the salient features of roundabouts are shared with those of a landmark, which can be considered as, "an object in the landscape, which, by its conspicuousness, serves as a guide in the direction of one's course" [36]. In contrast to other landmarks, however, drivers may be required to negotiate a roundabout as part of their journey, as they did during the current study. It is therefore perhaps unsurprising that both cultural groups incorporated roundabouts within their instructions. Of particular interest, however, was the unique ways that different cultural groups referred to roundabouts and described how to negotiate them. For example, UK drivers indicated the required turning based on its relative or consecutive position ("Take the 3rd exit"). In contrast, one of the Malaysian drivers referred to the roundabout as a clock-face and used this analogy to indicate the required turning ("at 9 o'clock").

There were also differences in the wording of proposed accompanying verbal messages, particularly regarding the geometry of the road ahead. Differences in the phrasing of directional instructions can lead to incorrect goal formation [18]. For example, an instruction to *"Go straight on..."* may be misinterpreted if the geometry of the road ahead is not 'straight'. Equally, an instruction to *"turn right"* may be ambiguous if the road itself bears to the right. On a cultural level, such ambiguities may exist due to the mental models – in the Curzon et al. study [18], it is thought that the system was designed based on a Japanese mental model of navigation, while the participants in the study were familiar with navigating UK roads. In another example, Chinese drivers responded unfavourably when presented with the mental model of a navigation system designed for German users, and vice versa [17]. The different distance measurement preferences (metric versus imperial units) is another important cultural difference highlighted by the study, and is consistent with human factors design issues for in-vehicle navigation and route guidance systems [37].

Overall, the study has highlighted important and novel differences at a cultural level between UK and Malaysian drivers that can be used to inform design, confirming the necessity of attending to cultural factors during the design of in vehicle navigation systems. Collectively, the findings suggest that, 'information density' and the natural road environment are important cultural differences between UK and Malaysian drivers and should be reflected in designs. It is also suggested that culturally-specific landmarks (such as mosques) and nation-specific features of the road (such as roundabouts) could be used in navigation systems. Nevertheless, it is recognised that participant numbers were limited during the study, and only drivers from the UK and Malaysia were represented. Therefore, the findings should not be considered as prescriptive, and the authors advise against drawing conclusions too soon.

It is also recognised that, in the assertions made, it is assumed that the participants were entirely representative of their respective nations. Not only may this be presumptive, it is also acknowledged that not all people in a country are expected to conform to every aspect of their national culture – there may be attitudes and behaviour at an individual level that differ to opinions at a country level. Finally, it is noted that the attitudes and opinions expressed by participants may have been influenced by their prior experience with navigation systems. Nevertheless, the aim of the paper is to explore the ideas and preferences for the presentation of navigational information amongst cultural diverse drivers and to reveal cultural makers that could be used during the formative

design of in-vehicle navigation systems intended for deployment in different markets around the world.

5. Conclusion

A study to explore cultural differences in the presentation and interpretation of navigational information has revealed differences in the number and type of navigational elements proposed by UK and Malaysian drivers, when asked to design route support interfaces applicable to UK, Malaysian and Japanese road networks. Landmarks were consistently incorporated in designs and therefore appear to offer a useful addition to culturally-attuned navigation systems, particularly in familiar 'home' settings, but care should be taken to ensure culturally-relevant examples are selected. In addition, the phrasing of instructions (e.g. "go straight on") and nomenclature for road elements (e.g. 'roundabout') appeared to differ between nations suggesting that these factors should receive further consideration before being applied across culturally diverse situations. The findings can be used to inform the design of culturally-immersed in-vehicle navigation systems, although it is recognised that the results were based on a limited number of particpants, and therefore caution should be applied generalising the findings to a wider population. Nevertheless, the study demonstrates clear utility and value in utilising scenario-based design methodology to elicit user requirements and inform the design of culturally-relevant technology. Further work should consider larger cohorts of test participants, originating from a wider range of nations. Proposed designs elements could also be incorporated in low-fidelity mock-ups or prototypes to allow designs to be evaluated in situ.

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