

A Study of Cultural Influence in Automotive HMI: Measuring Correlation between Culture and HMI Usability

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ABSTRACT

This paper describes a comparative study aimed at identifying cultural differences in automotive-HMI usability. This was part of a larger research to investigate in depth the problems users experience with vehicle-HMI in emerging-regions and help in the development of HMI design guidelines to include cultural consideration. Culture is recognised as a significant influence on user behaviour, as it correlates with certain preferences and abilities. A system may be fully usable for one group of users and environmental conditions but totally unsuitable for another. Even if a conscientious engineer designs a proper human-machine-interface for use in a given environment, the designer is often unable to foresee effects of a different culture on vehicle's HMI usability. Culture has different patterns of social behaviour and interaction which have led many researchers to develop cultural-models to describe these differences. With these in mind, current focus of this study seeks to address three interrelated questions, 1) Are there elements within automotive-HMI that can be identified as culturally specific? 2) Does culture influences user usability performances and how or if cultural-model can be applied to explain the findings? 3) How cultural-model can assist in understanding cross-cultural differences in automotive-HMI usability. This study is based on Hofstede cultural-model. The research assessed their application in cross-cultural differences and applicability in automotive-HMI. To identify cultural sensitive design elements for usability and universal access, systematic usability experimentation was performed in a vehicle-HMI-system. The result showed different cultural groups have different behavioural tendencies and performances while using HMI in a vehicle.

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INTRODUCTION

While there is a natural assumption that all human beings accomplish interpretation of visually perceive information and sense-making in very similar ways, this ignores behavioural and neurological findings showing how each human perceive information is strongly influenced by their cultural background [1, 2, 3, 24]. In the field of Human-Computer Interaction (HCI), researchers have often pointed out that, interface designs differ between countries [4, 5]. For example, websites designed by members of Eastern cultures are often thought to be much more visually complex and colourful than those in Western cultures [9]. The information density even varies between websites of different European countries [4, 5]. Research suggests that such differences in designs result from variances in people's visual perception abilities, which are shaped by their culture [24]. As such cultural influence affects how users interact with interfaces,

and that there is a need to integrate such "cultural abilities" into design approaches of the systems in order to adapt their intended users [18].

With respect to automotive HMI, design and development has largely focused on the needs and preferences of drivers from western markets [7]. It is unclear how drivers from these regions, whose culture, language and driving environment differs from western societies, will respond to the imported HMI method in terms of their comprehension and acceptance of the system features and user interaction [6]. Therefore to use these systems successfully in different regions it is important to meet the needs and preferences of drivers in target region. The importance of cross-regional or cultural issues in the design of in-vehicle HMI systems has been acknowledged by many authors [6, 7, 23, 26].

The risk of not taking these into account during HMI design phases includes the risk of ending up with a product that is not only unusable [7] but also, potentially dangerous [8].

Culture

Cultural influences are often the reason why consumers place more weight on some product attributes than on others. Culture is recognised as a significant influence on human behaviour as it provides people with a sense of identity and an understanding of acceptable attitudes and behaviour within society. In many ways, culture affects our context of use and perception of a product, thus impacts everyday lives. For example, psychologists have found that culture influences memory, judgment, perception and decision making [10, 12, 21]. Hence, culture is the logical starting point for examination of user behaviour [27]. Culture can be defined in many terms. Some defines culture as expressed through symbols, heroes, rituals and values. For others, culture can influence learning style, attitudes to change, memory, aesthetic tastes, information encoding and overall acceptance of technology [30]. Another definition sees culture as a set of learned and shared knowledge that makes one society different from another [31]. These various definitions reflect some of the many attempts that have been made to understand how cultures differ between group & societies and to organise these differences into concrete measurable elements for understanding. Culture has even been defined as the entire way of life of people. As such, it includes their technology and material artefacts-anything one would need to know to become a functioning member of the society [11].

There are many models operationalise the culture and systematically divide it into measurable & comparable parts. Each of these models proposes a different way of understanding or qualifying the differences in culture. These cultural theories include the Pyramid Model [39], the Iceberg Model [40], and the Onion Model [38]. All of them consider culture to be comprised of at least an outer surface layer (the directly observable aspects of culture) and a deeper, hidden layer (the intrinsic aspects of culture, outside immediate awareness) [6]. Amongst all available cultural models, Hofstede's cultural dimension theory is one of the most widely used pieces of research among scholars and practitioners. Hofstede [32, 33, 34, 35] defines culture as a broad, collective pattern of cognitions, affects and actions that have important consequences for the functioning of societies, of groups within those societies and of individual members of such groups. Based on elaborated research Hofstede developed five cultural dimensions that capture culture through scores on four values. These dimensions are: Power-distance, Individualism vs. Collectivism, Masculinity vs. Femininity, Uncertainty Avoidance, and Long vs. Short-term Time Orientation. The five dimensions of culture influencing a wide range of behaviours are summarised in Table 1. Previous researches provided general justification for the use of Hofstede's dimensions to make comparisons among cultural groups. Therefore the current study focused on the cultural dimensions developed by Hofstede [39].

Table 1. Five Hofstede's dimensions of culture

Dimensions	Characteristics	Example countries
Power distance	<i>High Power Distance:</i> Centralised decision making, management and superiors are highly respected and have the last say in decisions. <i>Low Power Distance:</i> Everyone expects to share in decision making, management hierarchies are flatter and more open to questioning	Germany and Scandinavian countries score low on this dimension
Individualism / Collectivism	<i>High Individualism:</i> Social ties are loose, Individuals expected to look after themselves. <i>High Collectivism:</i> Individuals are strongly incorporated into groups of family, school, government policies often favour the group over individual rights	Individualistic countries are: Australia, Canada, US, UK, and Holland. Latin America countries are extremely Collectivistic countries
Masculinity/ Femininity	<i>High Masculinity:</i> Favours assertiveness, Emphasis on competition. <i>High Femininity:</i> Focused on quality of life, Importance placed on the wellbeing of relationships	The countries that score high is Japan; countries that score low are Sweden and Norway
Uncertainty avoidance	<i>High Uncertainty Avoidance:</i> Strictly defined rules of behaviour and formality, Things that are different or unexplained can be viewed as dangerous. <i>Low Uncertainty Avoidance:</i> Willingness to take risks, more experimentation and / or innovative behaviour	Countries that score high on this dimension are Latin countries; Countries that score low are Denmark, the UK, Hong Kong and Singapore
Long/short-term orientation	<i>Long-term time orientation:</i> Promotes virtue and persistence, Focus towards future rewards. <i>Short-term time orientation:</i> Emphasise the past and present, Fosters a respect for tradition	Philippines, Nigeria, & Pakistan display low in LTO index

Influence of Culture on User Abilities

Results from behavioural studies suggest that a person's cultural background can be correlated with certain preferences and abilities [1, 24]. Culture is also the reason why user differs in their ability to cope with situations of uncertainty [18]. For an example, previous studies suggest that with complex websites (many hyperlinks), users of certain national cultures (e.g. many Eastern countries) are more likely to develop 'lost in hyperspace' feeling than others [4]. In these cases, if designer understand the effects of cultural abilities on the design space then a clear definition of interfaces beyond a one-size-fits-many-Westerners approach can be developed [18]. Behavioural studies based on cultural theories continued to show two major areas of user interface impact in user performance. These are user usability and performance towards use of any system.

Usability: Research on usability has identified the relationship between culture and usability, sometime refers as culturability [41]. For an example, web sites in IT world which varies across cultures are based on cultural specific characteristics or cultural markers [25] defined by Hofstede [39]. User's preference for a web site is also affected by culturally specific features [43]. Furthermore, use of language translation (when implemented intelligently) affects user satisfaction [44], so does, the use of culturally familiar or unfamiliar icons [45]. In summary culture has impact on many important aspects of usability. Usability is defined as a construct comprising a user's perceptions of

product/system effectiveness, efficiency, and user satisfaction, combined with the actual effectiveness and efficiency of the product as a whole [17]. The original term usability has evolved over the last few decades. Earlier definition of usability usually focused on performance-related criteria such as ease of use and effectiveness [22], but more recently the concept of usability has been expanded to include subjective aspect, user satisfaction [36]. To measure and compare the usability of a product or system across two cultures, it is these factors that must be measured and compared [17, 20, 37].

Usability Performance (Cognitive): Human cognitive process works in two sequential phases while interacting with visual display information system [42]. The first stage is listening phase. In this initial phase the user receives perceptual information, becomes aware of what is happening on the screen, and then associates the perceived information with semantic meanings and finally reasons about the presented information (information analysis). In the second stage, speaking phase, users provide information back to the software application. The initial listening phase is known as affordance perceptions. Once users have understood the information being presented they enter the phases of: applicability check, enactment with expectations and confirmation. Culture affects all phases of cognitive process (listening and speaking phase) [42]. To understand cultural impact in cognitive process particularly information analysis stages, a study of Korean and British mobile phone users found that the two groups have distinct preferences for the mobile phone designs, different frustrations and different favourite features which may account for different patterns of use and acceptance [28]. Previous studies provided a comprehensive view about why people from the East and the West think, analyse information differently [21]. The study observed a number of differences between Asians and North Americans: focus on saliency versus context, taxonomic categorisation versus relational categorisation; future stability versus future change, emphasis on logic versus emphasis on intuition, ultimate correctness versus need for the middle way, etc. Human cognition is therefore culturally dependent and can be summarised as pre-determining factor on how user thinks, perceive and use information.

RESEARCH QUESTIONS & HYPOTHESES

Technology tools are artefacts of the cultures and context in which they are created, and their suitability to a given group is a key component in their acceptance and successful use [16, 29]. It is the engineer's and designer's job to create an optimum usability between the basic components of the human & technology system. A system may be fully usable for one combination of user, task and environmental conditions but totally unsuitable for another. Even if a conscientious engineer designs a proper human-machine interface for use in a given environment, the designer is often unable to foresee the effects of a different culture on the vehicle's usability. It is difficult to prevent possible negative cultural effects when a system is used in an environment different from that for which it was designed. And since there are no quantitative data exists

regarding cultural constraints, the only way the engineer can make the design compatible with regard to cultural factors is to actively integrate the user population in the design process. To appreciate how cultural differences influence the acceptability and usability of an interface, key differences between regions both in terms of their driving and legislative environments, and their language and cultural values, must be identified and considered [6].

The advances in vehicle Human Machine Interfaces are driven by customer demand, the desire of automotive manufacturers to add value and by technology which offers increasingly sophisticated and cost effective options. These requirements are applied to all markets wherever vehicles are targeted. The reason for such common application is that consumer preferences in vehicle HMI design do not neatly fall into market segments. Therefore many automotive engineers and designers start the design process seeking to address the majority preferences such as visual aesthetic, ease of use, integration and customisation. However different markets have different rules and operate with different customer expectation. With such differences, comes a major challenge. As more information is brought into the car, with more diversity of style, priority and urgency, interfacing to these features within the constraints of the vehicle will require new and innovative methods of interaction, and a new set of paradigms for the design of in-vehicle HMI. The challenge here has multiple facets. Firstly, much of the information that is being presented to the driver must be relevant to his/her needs in order to safely operating the vehicle. Secondly, the safety constraint varied between regions. Thirdly, any design approach has to support cultural localisation to appeal region's driver and their usability. However given that there has been little systematic analysis of how cultural theories can help the field of human machine interfaces particularly in automotive industry, it is important to consider its effect and influence on automotive HMI particularly in the area of use and usability. In this regard, there are key questions needs to be addressed 1) Are there elements within automotive HMI that can be identified as culturally specific? 2) Does culture influence user usability performances and how or if cultural-model can be applied to explain the findings? 3) How cultural-models can assist in understanding cross-cultural differences in automotive HMI usability. In this study, commonly considered factors such as perceptions of efficiency, effectiveness (usefulness, ease of use, ease of learning) and satisfaction which were derived by Hornbaek [46] are considered as an effect of culture.

Based on the previous preceding research questions, the following null hypotheses were examined to assess the role of culture and its relation in automotive HMI system use and usability.

H0: There are no significant cultural differences in values and orientation between two cultural groups who use automotive HMI.