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VALIDITY OF THE MULTIDIMENSIONAL DRIVING STYLE INVENTORY IN MALAYSIAN DRIVERS

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VALIDITY OF THE MULTIDIMENSIONAL DRIVING STYLE INVENTORY IN MALAYSIAN DRIVERS

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DECLARATION

I declare that this dissertation entitles "Validity of the Multidimensional Driving Style Inventory in Malaysian Drivers" is the result of my research except as cited in the references. The dissertation has not been accepted for any degree and is not concurrently submitted in the candidature of any other degree.

Signature : ....

Name : Sarah Atikah Binti Muhamad Ridzuan Nasaruddin

Date : 23/10/20

APPROVAL

I hereby declare that I have read this dissertation, and in my opinion, this dissertation is sufficient in terms of scope and quality as partial fulfilment of Master of Mechanical Engineering.

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Date : 23/10/20

ABSTRACT

This study aims to classify the driving styles (DS) in Malaysia by using the Multidimensional Driving Styles Inventory (MDSI) for drivers in Malaysia. Users of the future automated vehicles (AV) will usually prefer their vehicles to drive like themselves. The driving style of the AV need to be humanised to prevent the technology from being ignored and to avoid causing any health-related problems. This research also intends to find the correlation between the personality traits (trust to the automated system and desire for control) with the Malaysian's driving styles. Besides, the differences between the sociodemographic variables with the style has also been studied. Previously, this MDSI study has been performed in Malaysia but was carried out in English while in this study, it was carried out in the Malay language. A total of 430 respondents took part in this study. The MDSI was analysed using exploratory factor analysis (EFA), Pearson correlation analysis, Mann-Whitney and Kruskal-Wallis test. The results revealed five Malaysian driving styles factors: careful, risky, angry-impatient, dissociative, and anxious. The Pearson correlation results show that careful drivers have a significant effect on trust and desire for control while the angry-impatient drivers show a significant effect with the desire for control. The results of the sociodemographic variables show significant effects with careful, risky, angry-impatient and anxious driving styles. The dissociative driving style shows no significant effect on the sociodemographic variables.

PENGESAHAN INVENTORI GAYA PEMANDUAN PELBAGAI DIMENSI TERHADAP PEMANDU MALAYSIA

ABSTRAK

Kajian ini bertujuan untuk mengklasifikasi gaya memandu (DS) di Malaysia dengan menggunakan inventori gaya memandu pelbagai dimensi (MDSI) untuk pemandu di Malaysia. Pengguna kenderaan automatik (AV) masa depan biasanya akan lebih memilih kenderaan mereka untuk memandu seperti diri mereka sendiri. Gaya memandu kenderaan automatik perlu dibuat sesuai pilihan manusia bagi mengelakkan teknologi daripada diabaikan dan tidak menyebabkan masalah yang berkaitan dengan kesihatan. Kajian ini juga bertujuan untuk mencari korelasi antara ciri personaliti (kepercayaan kepada sistem automatik dan keinginan untuk mengawal) dengan gaya pemanduan di Malaysia. Selain itu, korelasi antara pembolehubah sosiodemografi dengan gaya pemanduan juga telah dikaji. Sebelum ini, kajian MDSI telah dilaksanakan di Malaysia, tetapi ia telah dijalankan dalam Bahasa Inggeris manakala dalam kajian ini ia dijalankan dalam Bahasa Melayu. Seramai 430 responden telah mengambil bahagian dalam kajian ini. MDSI telah dianalisis dengan menggunakan analisis faktor eksploratori (EFA), analisis korelasi Pearson, ujian Mann-Whitney dan Kruskal-Wallis. Keputusan kajian menunjukkan lima faktor gaya memandu di Malaysia: berhati-hati, berisiko, pemarah-tidak sabar, disosiatif, dan cemas. Keputusan korelasi menunjukkan bahawa pemandu yang berhati-hati mempunyai kesan yang ketara ke atas kepercayaan dan keinginan untuk mengawal. Pemandu yang pemarah-tidak sabar menunjukkan korelasi yang signifikan dengan keinginan untuk mengawal. Hasil pemboleh ubah sosiodemografi menunjukkan kesan yang signifikan dengan gaya pemanduan yang berhati-hati, berisiko, tidak sabar, dan cemas. Gaya pemanduan disosiatif tidak menunjukkan kesan yang signifikan terhadap pemboleh ubah sosiodemografi.

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LIST OF ABBREVIATION

AV	Automated vehicle
MIROS	Malaysian Institute of Road Safety Research
DBQ	Driving Behaviour Questionnaires
MDSI	Multidimensional Driving Style Inventory
ARDES	Attention-Related Driving Error Scale
EFA	Exploratory Factor Analysis
ANOVA	Analysis of Variance
AI	Artificial Intelligence
DDT	Dynamic Driving Task
SAE	Society of Automotive Engineer
BASt	Germany's Federal Highway Research Institute
OEDR	Object and Event Detection and Response
NDRT	Non-Driving Related Task
DS	Driving Style
SPSS	Statistical Package for the Social Sciences
KMO	Kaiser-Meyer-Olkin
SD	Standard Deviation
CFA	Confirmatory Factor Analysis

CHAPTER 1

INTRODUCTION

1.1 Background

Automated vehicle (AV) will soon be deployed, and automakers are yet to define how the automated vehicle should be driving. Ideally, human drivers prefer an automated vehicle to operate according to their driving behaviour which based on specific traits such as personality (e.g., trust and desire for control) and skill (e.g., acceleration, deceleration and braking). Since the automated vehicle is formed from various logic sensors and has higher technical capabilities than human drivers, an automated vehicle is projected to have only one type of driving behaviour, which is to maximise safety and efficiency. Hence, an automated vehicle might operate differently than the human driver's expectation and would lead to physical and mental discomfort.

This research aims to investigate and formulate the driving behaviour (a driver who drives in Malaysia) of the future automated vehicle. The inconsistent of driving behaviour preference will lead to the abandonment of the automated vehicle technology because the users feel uncomfortable or distrust the system. Worse, the unexpected driving behaviour of automated vehicle will lead to motion sickness since the driving profile is unpredictable to the occupants. The research begins by exploring and classifying the type of driving behaviour and human driver by the data collected from the multidimensional driving style inventory questionnaires. Furthermore, this study also will investigate the respondents' "desirability for control" as well as "trust" in the future automated vehicle. The correlation of Malaysian driving style and the demographic factors will also be contemplated. This study will contribute to the development of a taxonomy for future automated vehicle's driving behaviour that aims to improve the users' comfort and mitigate any health issue.

1.2 Problem Statement

It was predicted that by the year 2030, an automated vehicle, also known as a self-driving car or a fully automated vehicle, would be fully ready to be driven on the road. At the national level, Malaysian Institute of Road Safety Research (MIROS) in their effort to reduce the number of road fatalities has pushed the employment of automated vehicle in Malaysia by the year 2030. One of the significant advantages of automated driving is in terms of road safety (Dokic et al., 2015). Road accidents were found to occur primarily because of human errors. Therefore, in fully automated driving, human drivers will no longer control the vehicle at the "operational level" (physical driving) but instead only at the "strategic level" (giving instruction). Taking over driving from human drivers could reduce road accidents by as high as 90% (Arbib & Seba, 2017).

However, autonomous driving behaviours that are associated with acceleration forces need to be specified first to produce the best experience and accelerate the adoption rate of automated vehicle technology for future users (drivers). In general, automated vehicle users would prefer their vehicle to drive the way they operate. Therefore, the study on how automated vehicle operates should be done with regards to human preferences. Automated vehicle's driving behaviour need to be humanised to avoid the dismissal of the technology and no inducing any health-related issues to the user. Up until now, how automated vehicles should operate or drive on the road is still not clear (Meder et al., 2018; Oliveira et al., 2019).

Focus on how an automated vehicle will be operated or behaved has only been shifted recently such as the works of Basu, Yang, Hungerman, Singhal, and Dragan (2017) and Oliveira, Proctor, Burns, and Birrell (2019). They did the study on driving behaviour of future automated vehicle on a driving simulator. Nonetheless, studies on a real-road with human users especially on driving behaviour of automated vehicle are relatively new, and many aspects need to be concretised before the automated vehicle is ready to be used by the user on the road.

Moreover, there are few methods or measurements to find out human driving behaviour other than the experimental study as mentioned above. As such by collecting the data using a survey or questionnaires through a paper copy or online platform that was done by many researchers (De Winter & Dodou, 2010; Guého et al., 2014; Long & Ruosong, 2019; Padilla et al., 2020; Peña-Suárez et al., 2016; Taubman-Ben-Ari et al., 2004; van Huysduynen et al., 2015). There are several established questionnaires to determine the types of driving styles for a human driver, such as the Driver Behaviour Questionnaire (DBQ) that was developed by Reason et al. (1990). As stated by De Winter and Dodou (2010), DBQ is a reliable method and appropriate for analysing multiple kinds of driver behaviours abnormalities. Other than that, by referring to the DBQ and the Multidimensional Driving Style Inventory (MDSI), Ledesma et al. (2010) designed the Attention-Related Driving Error Scale (ARDES) items questionnaires. The MDSI has been commonly used to evaluate the relationships in various cultural environments between driving types and traffic offences and injuries. There are several studies done validating on the MDSI on their respective countries such as in Netherlands and Belgium (van Huysduynen et al., 2015), China (Long & Ruosong, 2019), Malaysia (Karjanto et al., 2017) and Argentina (Padilla et al., 2020).

Focus on the MDSI as this would be the heart of this study to find out the Malaysian driver's type, other countries researcher already translated the questionnaires into their native language. However, this has not been done in Malaysia. Although, previously, this MDSI study has been performed in Malaysia by Karjanto et al., (2017), it was carried out in English but not in the native mother tongue. Therefore, these research questionnaires will be executed in Malay, which is the Malaysian national language for the respondent to have a better understanding of the question concern.

1.3 Research Objectives

The main objectives of this study are:

1. To classify the Malaysian drivers driving styles using the multidimensional driving style inventory (MDSI) and analyse using the Exploratory Factor Analysis (EFA).
2. To identify the relationship between Malaysian personality traits (trust and desire for control) with the driving styles using Pearson correlation analysis.
3. To identify the differences among the sociodemographic profile and driving styles using Mann-Whitney and Kruskal-Wallis test.

1.4 Research Questions

1. How to define the multidimensional driving style of human drivers into one-dimensional classification?
2. What is the relationship between Malaysian personality traits ("trust" and "desire for control") and human driving style in Malaysia?
3. Are there any differences of driving styles of human driver in Malaysia based on sociodemographic profile?

1.5 Scope of Work

The scope of this study are:

i. The multidimensional driving style inventory (MDSI) (Taubman-Ben-Ari et al., 2004), desirability for control (Burger & Cooper, 1979) and trust (Merritt et al., 2013) questionnaires that have been validated were used for this study.

ii. The drivers who only drive on the Malaysian road and possess a valid driving license were considered for the inference statistical analysis.

iii. The data collected from the questionnaire were analysed using Exploratory Factor Analysis (EFA), Pearson correlation analysis, Mann-Whitney and Kruskal-Wallis test.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, state-of-the-art research studies related to automation, driving style, and their influence on the automated vehicle will be reviewed. The automation will be discussed in Section 2.2, including the Sub-section from 2.2.1 to 2.2.4 on the topics of the level of automation, fully automated vehicle, non-driving related task, and automated vehicle driving style, respectively. Next, the driving style will be reviewed in Section 2.3, followed by the Sub-section of 2.3.1 and 2.3.2 that discussed the human driving styles and type of measurement of driving styles, respectively. The MDSI that is used to measure human's driving style will be explained in Section 2.4. In that section, the comparison between the MDSI research that has been done previously in other countries is explained. Lastly, the MDSI in Malaysia is reviewed in Section 2.5, and the Sub-section 2.5.1 discussed on the MDSI done in Malaysia using English as the medium for the questionnaire.

2.2 Automation

In this technological era, automation can be considered as an essential element as it is providing a more significant impact on human factors engineering development. A good match between the work environment and human skill is one of the definitive objective in human factors engineering (Van Vuuren, 1987). The purpose of having automation is in point of fact to decrease the human dependant factors and to upgrade the ability or productivity as well as to permit accuracy to grant the human needs. Nearly all sectors, automation incorporates several main components, systems, processes, and work functions. Based on the previous researches, automation encompasses a lot of applications in numerous fields. Some examples, are digital forensic, drug testing production and information, electrical automation control, robotic, automotive and automation in process industries (Asquith & Horsman, 2019; Giubilato et al., 2019; Sun et al., 2017; Tu et al., 2019; Vdovin & Chichekin, 2016; Yang, 2020).

In today's competitive world, the advancement of technology in automation can also be seen through the artificial intelligence (AI). AI have been studied and developed by human to automate various jobs to ease human. The AI application can be learned throughout the process and improved eventually (Coombs et al., 2020). Automation has been described as an equipment agent that can perform task usually done by humans (Parasuraman and Riley, 1997). There are fewer things for people to do as robots take on more significant roles. Automation can thus reduce workload. Automation may also provide operators with better influence over increasingly dynamic processes (Woods, 2018), or minimize individual output uncertainty and thereby minimize errors.

Parasuraman and Riley (1997) mentioned that as the automation improves over the times and if the adjustment of the function from a person to a device or machine is comprehensive and permanent, then that fully function is no longer considered as automation, but it is called a machine operation. The automated vehicle is one of the examples. It is transforming how we drive or move. The expectation is to reduce road traffic, reduce commuting rates, and no more roundabouts for parking spaces would allow our everyday commutes quicker, less crowded, and convenient. It will also reduce harmful vehicle emissions, thus enhancing the air quality that we breathe (Stern et al., 2019). The full automated vehicles may not yet be the standard in our routine life. However, the truth of the matter is not as distant as we may assume. Soon, a fully automated vehicle will be on the road. However, to achieve full automation, technology will be slowly introduced to the consumer. Therefore, different levels of automation will offer various advantages and options to the human driver.

2.2.1 Level of Automation

In a complete general task of driving, the operational and tactical behaviour related to the dynamic parts of driving is gathered into what is associate with the dynamic driving task (DDT) (SAE International, 2014). The driving automation levels are specified by comparing the particular position of each of the three primary agents (human, the vehicles automated system, and other vehicle component or system) plays in the DDT and/or DDT fall-back results (SAE International, 2019). Figure 2.1 shows the DDT on conventional vehicles operated by humans without the driving automation system. The control of the system and the commands provided to the system are a function performed solely by the driver based on their understanding, experience, knowledge, and desired results. The introduction of modern driving automation technology that requires additional portions of the driving role to be reassigned from the driver to the vehicle may theoretically alter the conventional driver-vehicle connection. Figure 2.2 indicates both the human driver and the automation are capable of driving the car. For examples, the cruise control system which is a programmed that set by the drivers to move at a constant speed as well as an anti-lock braking system that enable drivers with more stability and shorter stopping distance on slippery roads or through panic braking (Alonso et al., 2011).

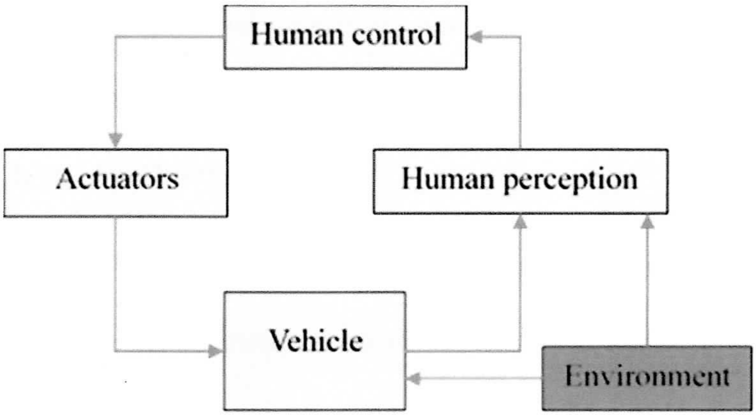

Figure 2.1: Human operation of a conventional automobile (dynamic driving task) (Christensen et al., 2015)

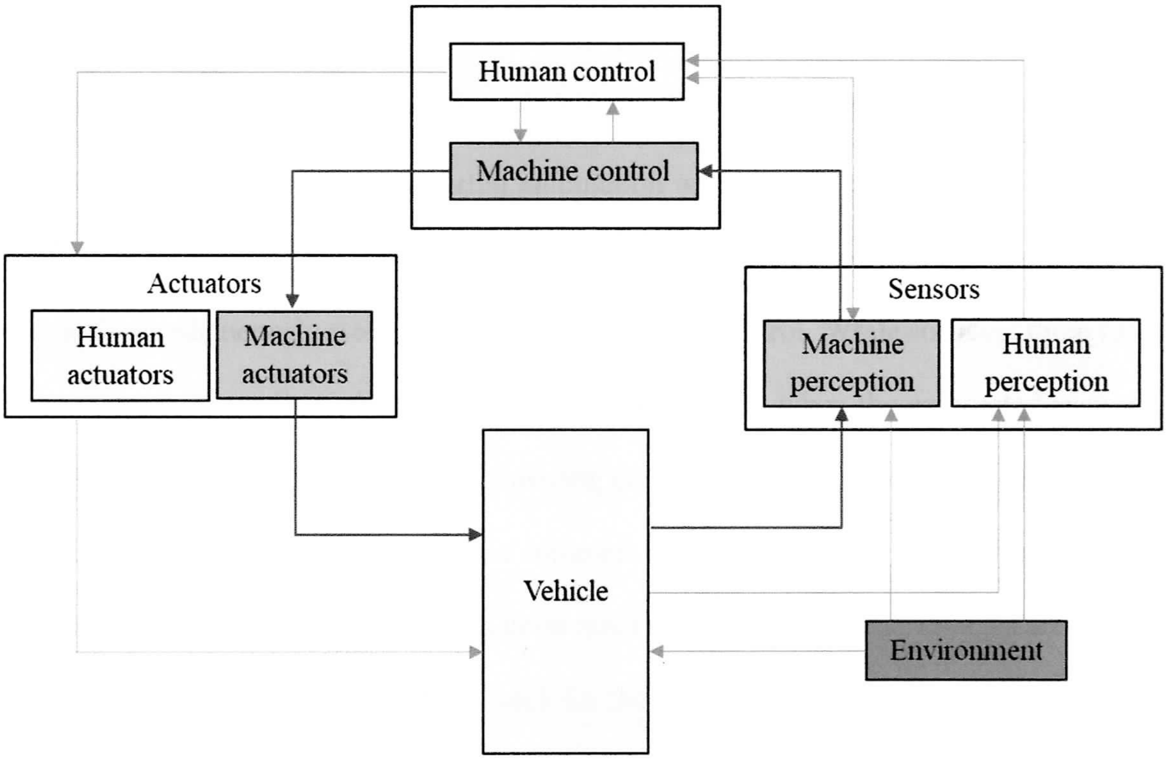

Figure 2.2: The dynamic driving task with machine automation (Christensen et al., 2015)

Automation levels are therefore differentiated by the following functional characteristics, which are further defined in the Society of Automotive Engineer, SAE J3016 as well as Germany's Federal Highway Research Institute (BASt). BASt is the German Government Practical, Technical-Scientific Research Institute in the field of road engineering documents (Christensen et al., 2015), state that the function or task of DDT consists of lateral and longitudinal control as well as to object and event detection and response (OEDR). The functional features of DDT include the driving approach, condition, place competence, and the ability to fall back.

Table 2.1 shows the function distribution of the driving automation level by SAE/BASt. According to this archive visual, there are six (6) levels of automation classifications which assignation by the driver or the automation system. For the lowest level in the automation, which is level zero (0), the automobile's technology at this level does not apply the DDT. Thus, it is no automation as the drivers are in full control and must have an appropriate response to all driving situations. For level one (1), the automation system is in a sustained mode, which includes as such the adaptive cruise control and the lane-keeping system. Other than that, for level two (2), it is partial automation whereby the automation is automated, and the lateral and longitudinal control function simultaneously. As such, the lane-keeping system is simultaneously working with adaptive cruise control. While for level three (3) of automation, it is conditional automation, which means that when the automated system is appointed, the driver will not subject to driving unless if required to do so by the features to reassume. Starting from this level, it is a complete DDT as it includes all the three functions of it. Besides, for level four (4), it is a large automation system as the vehicles are capable of working or operate on their own as such for the braking, steering and accelerating (SAE International, 2018; SAE International Standards & ISO, 2019). The distinction between level 3 and level 4 in the driving automation system is that for level 3, it would reach a minimum danger without driver assistance. In contrast, level 4 does not do so consistently (Christensen et al., 2015). Level five (5) or the full automation system (also known as fully automated vehicle and self-driving vehicle) can perform the DDT thoroughly in all traffic conditions with no driver responsibilities to take charge of the driving.

Table 2.1: The function distribution by SAE/BASt driving automation (Christensen et al., 2015)

Automation Level Name	Dynamic Driving Sub-Tasks (DDT)		Functional Capability	
	Sustained Execution of Lateral and/or Longitudinal Control	**Object & Event Detection and Response (ORDER)**	**Fall-back Performance of Dynamic Driving Task**	**Driving Mode Circumstances, Location Capabilities**
0 No Automation	Driver	Driver	Driver	None of the DDT is automated
1 Driver Assistance	Driver and system	Driver	Driver	Some driving modes
2 Partial Automation	System	Driver	Driver	Some driving modes
3 Conditional Automation	System	System	Driver	Some driving modes
4 High Automation	System	System	System	Some driving modes
5 Full Automation	System	System	System	All driving modes

2.2.2 Fully Automated Vehicle

Fully automated vehicles or a hundred percent automation system in automotive may not be the norm yet in our road or daily lives. Previously, Bose and Ioannou (1999) studied on the effect of the traffic flow characteristics with mix manual and semi-automated vehicles, and the result shows that the semi-automated cars provide a better acceleration movement, improve air quality, and fuel efficiency. Bazilinskyy et al. (2019) studied the expectation and perceptions of the public on the introduction of fully automated vehicles concerning whether they believe most vehicles in their country of residence should be able to operate entirely automatically. The result shows the announced median year was 2030. Nonetheless, it is expected to be earlier than the mentioned year for people who aware and noticed about the technology as such from the Tesla Autopilot or Google Driverless Car.