ORIGINAL ARTICLE

ACCEPTANCE AND USE OF LANE CHANGE ASSISTANCE SYSTEM AMONG EARLY ADOPTERS IN MALAYSIA

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ABSTRACT

Lane Change Assistance (LCA) system in cars can potentially mitigate blind spot related crashes; but its effectiveness largely depends on driver acceptance and proper use. Although still in early stages, the volume of cars equipped with LCA system is expected torise in the near future as the technology has been considered in the New Car Assessment Program for Southeast Asian Countries (ASEAN NCAP) 2017 Rating Scheme. Therefore, this study is initiated to assess user acceptance of and experience with LCA-equipped cars. Self-administered questionnaires were distributed to owners of LCA-equipped cars at selected service centres in the Klang Valley from November 2016 to February 2017. From a total of 276 valid responses, results revealed that most owners greatly considered LCA system when purchasing their cars and agreed that the systems had positively altered their driving behaviours i.e. regularly using the turn signal and checking the side mirrors. Nevertheless, about 20% of the respondents stated theirannoyance and distraction by the LCA systems due to unnecessary warnings from various sources, aside from getting too many warnings during traffic congestion. The study findings provide some practical implications that can aid the industry and relevant stakeholders in gauging the issue and actual situations concerning the use of LCA system in Malaysia.

Keywords: *Driver acceptance, driver assistance system, early adopter, lane change assistance system*

INTRODUCTION

The emergence and advancement of various Driver Assistance Systems (DASs) have significantly contributed toward improved vehicle safety worldwide. Generally, DAS intends to assist drivers by preventing errors while driving, warningthem of any impending miscalculation,aside from providing partial driving assistance[1].

In Malaysia, with the recent revision to the New Car Assessment Program for Southeast Asian Countries (ASEAN NCAP)rating scheme[2], it is predicted that the volume of vehicle models equipped with advanced DASs particularly Lane Change Assistance (LCA) system will imminently increase despite being only fitted in high-end luxury models at present[3]. Such an outcome is part of ASEAN NCAP's strategic approaches to reduce the escalating number of motorcycle fatalities in the region[4].

LCA system, which has the capability to detect road users in blind spot zones and provide warnings to drivers, has great potential to help prevent lane-change related crashes and injuries. Based on data from both the National Automotive Sampling System General Estimates System (NASS GES) and Fatality Analysis Reporting System (FARS), it was estimated that if all US vehicles were equipped with LCA system, the cases of moderate-to-severeinjuries and fatal crashes per year could be reduced by about 20,000 and 393 cases respectively[5]. In addition, the benefits of LCA system, if combinedwith the Lane Departure Warning (LDW) system, are about double as high as their costs[6].

LCA system has three functions; namely blind spot warning function, approaching vehicle warning function or both functions[7]. The warning functions—which are generally designed based on coverage zone, approaching vehicle speed and roadway radius of curvature—vary among manufacturers. Typically, radars or cameras are used to monitor the stipulated zones and provide visual or audio-visual warnings to drivers if there is an attempt to perform lane-change manoeuvring[5,8].

The Human Machine Interface (HMI) is a critical part of any DAS, including LCA system. Such an innovation is likely to be useful if the driver understands the information displayed and acknowledges its reliability[6]. A driver needs to know the operational status of the system, whether there are faults or malfunctions and more importantly, the driver needs to recognisewarnings as well as their meaning.

For instance, the location of visual alert varies between manufacturers and models. In certain Volvo models, as shown in Figure 1, the visual indicator is placed at the A-pillar of the car on both driver and front passenger sides.On the other hand, the Toyota Camry Hybridhas the indicator on its side mirrors as illustrated inFigure 2. The different location of visual alert may affect how drivers respond to the systems.

Due tothe various warning mechanisms, some drivers tend to regard the system as an annoyance and disable it. This definitely defeats the purpose of introducing such an advanced system into the market. In other words, the intended benefits of LCA system cannot be optimally achieved if it is not well accepted and widely utilised by the potential users. In addition, previous studies have also indicated that many technologies failed to reach the main targets due to low user acceptance[9,10].

Figure 1 – Placement of visual indicator for certain Volvo models[11]

Figure 2 – Placement of visual indicator for Toyota Camry Hybrid[12]

To date, only a handful of studies have assessed drivers' acceptance of and experience with LCA system. For example, a survey involving 294 Volvo owners via telephone interview revealed about 18% of them occasionally turned off their blind spot information system, mainly as a consequence ofgetting inappropriate or false warnings during bad weather[13]. In a recent mail-in surveyamong Dodge and Jeep owners,it was found that 5% of them had disabled the blind spot monitoring system due to system detection failure[14].

In Malaysia, there is a lack of knowledge pertaining to acceptance and usage of LCA system among early adopters. In order to gain a better understanding of early adopters' experience in the country, a survey was conducted among owners of selected car models equipped with LCA system. It is important to compare experiences of LCA system between owners of different vehicle types as the technology has started to proliferate local automobile market.

METHODS

The findings presented in this paper are derived from a wider study on acceptance of LCA system among relevant car owners in Malaysia. The questions were adopted and adapted from previous studies[13,14]. The questionnaire consists of three main parts, namely (i) user profiling (age, gender, education etc.); (ii) user ownership and experience (awareness, usage and behavioural response towards the system); and (iii) established items based on Technology Acceptance Model (TAM). This paper will only discuss the results pertaining to user ownership and experience.

This cross-sectional study involvedMalaysian owners of Volvo, Mazda and Toyota car models. Sampling was conducted in two stages. The first stage was to choose six service centres in the Klang Valley to represent each make which were randomly selected. In the second stage, owners who were present at the selected service centres for scheduled maintenance were approachedbased on convenience.

Permission to conduct the survey at the premises were obtained from the service centres involved at least two weeks before the actual data collection. In order to ensure the survey went smoothly, on-duty service advisors were briefed regarding the purpose of study and requested to provide explanation to customers upon checking their documents and discussing the related maintenance matters. Potential customers who consented to participate, as identified by the service advisors, were then approached and given further explanation on the questionnaire and their rights to anonymity.

Representatives including personal assistants, chauffeurs and next of kin who were requested by the owner to bring the car to the service centres were not selected as respondents. In total, 300 questionnaires were distributed (100 for each make); but only 276 valid responses were analysed. The questionnaires at Mazda service centres recorded the most number of incomplete or invalid responses as opposed to those collected at Volvo and Toyota service centres. All the descriptive analyses, presented in the form of number (n) and percentage (%) or mean (SD), were performed usingIBM SPSS Statistics Version 21.

RESULTS

Table 1 describes the demographic profiles ofrespondents who were categorised into three groups,which largely comprised older adults as suggested in previous studies[13,14]. The majority ofowners are aged 40 years and below (46.4%) mainly because ownership of high-end luxury vehicle isdominated by people earning higher

income. Most of the respondents were male (74.6%) and hadobtained tertiary education (80.1%). In terms of income, the majority of respondents earned less than RM10,000 per month (44.7%). The distribution of ownership period was evenly distributed between one (12 months), two (24 months) and three years (36 months).

Approximately 59% of the car owners had actually considered LCA system as part of their decision making when purchasing their present car - Volvo owners accounted for the highest percentage (73.5%), followed by owners of Mazda (59.3%) and Toyota (42.4%). In addition, most of them (77.2%) understood howLCA system worked. Based on Table 2, both Volvo and Toyota owners saw the dealership's demonstration as the main reference to understand the benefit of LCA system while the majority of Mazda owners explored the functionality of the system on their own, while on the road.

Two distinct situations stood out when discussingLCA system usage, namely the frequency of use and the activation status. As shown in Table 3, most owners of all three makes, admitted to always use LCA system with Mazda owners having the lower percentage. Furthermore, several owners stated to purposely havingthe system deactivated and this was mainly due to the high degree ofperceived annoyance and distraction, as shown in Table 4. A notable example of owners' displeasure stemmed from the unnecessary warnings in situations such as during inclement weather (heavy downpour) and encountering roadside objects or road furniture. Users also felt highly distracted by the deluge of warnings during traffic congestion. Other reasons mentioned included distraction during high speed travels, side mirror dominance and ensuring the sideway hazard.

The majority of respondents agreed that their driving behaviourhad changed positively due to the use of LCA system. As explained in Table 5, owners indicated an increase in safe driving acts including using turn signal and checking side mirror more often with LCA system fitted. The system also minimizeddriver's head movementin checking thesurrounding and yet very few believed that LCA system was able to make them more alert of the associated hazards.

Table 1 - Descriptive information of the samples (n=276)

Item	Category	Frequency	Percentage (%)
Age *Mean (SD): 42.08 (11.04)*	40 years old and below 41 to 50 years old 51 years old and above	128 77 71	46.4 27.9 25.7
Gender	Male Female	206 70	74.6 25.4
Highest level of education	Secondary and lower Tertiary (*certificate, diploma, degree*)	52 196	19.9 80.1
Monthly income	Below MYR10,000 MYR10,001 to MYR15,000 MYR15,001 to MYR20,000 Above MYR20,000	117 70 35 40	44.7 26.7 13.4 15.3
Car make	Volvo Toyota Mazda	98 92 86	35.5 33.3 31.2
Duration of ownership *Mean (SD): 24.54 (21.37)*	Less than 12 months 13 to 24 months 25 months and above	87 97 92	31.5 35.1 33.3

Table 2 – Source of reference contributing to owners' awareness of LCA system functionality

	Volvo (*n*=86)	Toyota (*n*=56)	Mazda (*n*=72)
Car manual	19 (22.1%)	24 (40.7%)	21 (29.2%)
Demonstration by dealership	48 (55.8%)	33 (55.9%)	18 (25.0%)
Trying out on the roadway	37 (43.0%)	19 (32.2%)	44 (61.1%)

Table 3 – Frequency of use and activation status

	Volvo (*n*=98)	Toyota (*n*=92)	Mazda (*n*=86)
How often do you use this system while driving?			
Always used	82 (83.7%)	77 (83.7%)	56 (65.1%)
Sometimes used	15 (15.3%)	13 (14.1%)	27 (31.4%)
Rarely used	1 (1.0%)	2 (2.2%)	3 (3.5%)
Have you ever deactivated (turned off) this system while driving?			
Always turned off	1 (1.0%)	0 (0.0%)	1 (1.2%)
Sometimes turned off	13 (13.3%)	3 (3.3%)	13 (15.1%)
Rarely turned off	17 (17.3%)	2 (2.2%)	18 (20.9%)
Never turned off	67 (68.4%)	87 (94.5%)	54 (62.8%)

Table 4 – Reasons for deactivating LCA system

	Volvo (*n*=30)	Toyota (*n*=5)	Mazda (*n*=24)
Annoying/ distracting due to unnecessary warning	22 (73.3%)	0 (0.0%)	3 (12.5%)
Annoying/ distracting due to bombarded warnings during traffic congestion	8 (26.7%)	3 (60.0%)	12 (50.0%)
Annoying/ distracting due to audio warnings	0 (0.0%)	0 (0.0%)	7 (29.1%)
Distraction during high speed travelling	0 (0.0%)	0 (0.0%)	1 (4.2%)
More confident on checking side mirrors manually	0 (0.0%)	1 (20.0%)	1 (4.2%)
Worrisome feeling that LCA light may mislead other motorists	0 (0.0%)	1 (20.0%)	0 (0.0%)

Table 5 – Behavioural change due to LCA system use

	Volvo (*n*=98)	Toyota (*n*=92)	Mazda (*n*=86)
No difference	14 (14.3%)	57 (62.0%)	21 (24.4%)
Used turn signal more often	38 (38.8%)	23 (25.0%)	36 (41.9%)
Turned their heads less often	37 (37.8%)	15 (16.3%)	31 (36.0%)
Checked side mirrors more often	43 (43.9%)	34 (40.0%)	39 (45.3%)
Became more alert	8 (8.2%)	1 (1.1%)	1 (1.2%)

DISCUSSION

LCA system clearly has the potential to reduce a substantial proportion of lane-change related crashes. Nevertheless, its success largely depends on how drivers use and respond to such a system. The majority of car owners in this study claimedto having the technologyconstantly

activated. Yet, there were owners who purposely deactivate the system, mainly because of the perceived high level of annoyance and distraction.

In the study, Volvo owners were found to have been presented with two distinct detection methods, namely the camera-based and radar-based systems. Car ownersequipped with camera-based system reported to have experienced more instances of false or unnecessary warnings. This was perhaps due to the high sensitivity of camera-based sensors as compared to radar-based sensors with better detection capability in adverse weather such as rain or fog[6,15].Previous studies have also indicated similar situations[13,14].

Furthermore, several owners reported to have been overwhelmed by warnings particularly during traffic congestion. Such an accountwas prevalent among Mazda owners, where LCA system came with both visual and audio alerts. Perhaps the audio alerts made the situation intolerable for Mazda owners compared to Volvo and Toyota owners, where the LCA system only had visual alerts. This suggests the effects of different types of alert should be monitored further as drivers gain more exposure and experience using them in due time.

This study also echoed the belief thatLCA system could positively improve driving behaviour. The system urgescar owners to assess surrounding hazards and give cues by means of signalling. This is consistent with survey findings[13,14]with regards to Volvo, Dodge and Jeep owners as well as a road evaluation test[16]. Such a finding is very important for ASEAN NCAP in ensuring that introduction of LCA system in its rating can further increase vehicle safety level in Malaysia and throughout the region. It can also be used as a basis for more stringent requirementsto be considered in the upcoming ASEAN NCAP Roadmap 2021-2030.

Nonetheless, the lack of driver head movement to assess the surrounding is associated with the so called “overreliance” on the LCA system, and is perhaps debatable depending on whether the reduction of head movement can be considered as positive or negative[17]. Here, less movement could also mean that the task to assess the hazards would be less troublesome, thus reducing physical and mental workload. More studies aredefinitely needed in order to understand the issue of overreliance especially if it will lead to less safe driving behaviours.

The limitations of this study should also be noted infuture studies. The survey sample may not be representative of the exact population of Malaysian owners of LCA-equipped vehicles as the studywas only conducted in Klang Valley. A study done in less congested areas may reveal different findings. In addition, application of the system may have different outcome in rural areas due to dissimilar road profile and traffic flow. It should also be noted that this study only covered high-end luxury car owners, whereby the results including activation rate and motivation of doing so could vary had the system been available in more affordable cars.

CONCLUSION

In conclusion, the study revealed that owneracceptance and experience with LCA system among Malaysian early adopters was high with most of them claiming LCA system had positively altered their driving behaviour. Despite that, there were a substantial proportion of owners who felt being annoyed and distracted with LCA system due to unwarranted warnings from various sources and receiving too many warnings during traffic congestion. Thus, manufacturers have to consider the problems raised by owners to ensure that future LCA system can cater to various HMIs in order to optimize its benefit in reducing lane-change related crashes. It is also important to extend this study to different vehicle makes as LCA system is expected to be available in more cars and become more affordable to drivers with different demographic profiles as the population of ASEAN road users continue to expand.

ABBREVIATIONS

Driver Assistance System – DAS, Lane Change Assistance – LCA, New Car Assessment Program for Southeast Asian Countries – ASEAN NCAP, Technology Acceptance Model – TAM.

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COMPETING INTERESTS

There is no conflict of interest.

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