The Effect of Airport Road Access Design on Senior Drivers' Wayfinding

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***Abstract*— The purpose of this study was to evaluate the impact of airport road access wayfinding and signage preferences on senior driver. Wayfinding complexity varied due to differing levels of airport road-side furniture such as traffic signs and bollards. Experienced car drivers were asked to drive self-designed simulated routes. Forty drivers in the age ranges: 50 to over 60 were selected to perform the study. Questionnaire then were distributed after driving simulation test was performed. The driver performance was analysed by Mean and Standard Deviation (SD), and discussed with reference to the use of the driving simulator and drivers' general experience. The results confirmed that there is a correlation between airport road access wayfinding design and senior driving performance**

Keywords*—Airport; Road Access; Wayfinding; Simulator; Senior Drivers*

1. Introduction

An effective airport road access with a systematic traffic signing system is essential for the efficient use of the road network. Wayfinding are important elements to airport road access design. Airport users are dependent on wayfinding in order to provide them with hazard warnings, road traffic and direction. In order to make the best and safest of airport road networks, clarity of signs and road markings play an important role to wayfinding design [1]. A consistent airport traffic sign system is instantly recognisable and becomes familiar to airport users. This consistency has been delivered through legislation and guidance which ensures that airport traffic signs can be seen and readily understood under all common road conditions.

In this paper, airport road access wayfinding is defined as a process in which drivers navigate an airport landside environment using information support systems (e.g. signage, architectural clues, streetlights and road markings). It includes the process of finding a way in the geographical space and identifies present location, knowing how to get to and from the airport. The wayfinding process involves decision making in response to continuing a journey, information received from the environment and which route is the best alternative to continue to navigate [2]. A straightforward concept has been adopted in the structure of airport road access wayfinding design. Simplifying wayfinding provision will eliminate the effort in delivering an aesthetic value of signage as the aim is to reduce investment cost.

2. Airport Road Access Wayfinding Design

With the rapid development of the air transport industry, the ability of passengers to travel worldwide is significantly increased. Airport management faces different challenges in improving passenger services such as to find common ground to satisfy road access design from professional viewpoints. Airport road access wayfinding development should indicate the preferences of passenger and airport staff itself. For example, airport road access development aims to reduce the traveling time and delay of passenger and airport staffs to the airport. The following are the viewpoints of airport management regarding road access wayfinding [1]: (1) airport signs are an identity or branding of the airport (i.e. use of similar colour and style of signs), providing a sense of arrival and the beginning of the airport user's experience; and (2) airport signs should look different to motorway signs. In contrast, the viewpoints of road sign design professionals are as follows: (1) airport signs should comply with all traffic signs' regulations and design criteria; and (2) the more an airport road can be made to look and function like a regular road, the more it will conform to driver expectations which will lead to a safe behaviour and less frustrating driving experience.

Airport road access wayfinding is a complex system to urban environment. Signage information systems are very important in providing various services and functions to the drivers. According to

Transport Scotland [3], a complete street must provide a structure within a road corridor whether the road is a motorway or a country lane. It includes road signs of all descriptions such as variable message and directions signs to tourist destinations (i.e. lighting, safety fences, barriers and bollards). A good airport road access wayfinding increases safety concern to the drivers. Airport road access wayfinding information is important to making a quick decision to go to an intermediate destination [2], such as departure or arrival terminals or intersection and interchange points. The following points should be applied to wayfinding design in airport area.

1. The wayfinding is positioned to ensure consistency of information. Visual clutter is reduced and drivers are presented with key information at critical decision making points;
2. The content of the wayfinding to support drivers' goals is appropriate in the area it is located;
3. The text information is legible and easy to read at realistic viewing distances;
4. Any symbols used are clear and easy to understand;
5. The information is clear, sufficient, unambiguous and easy to read; and
6. The colour should enhance the readability of the signs.

3. Senior Drivers and Driving Behaviour

There are challenges in defining when an individual becomes an elderly or senior citizen. Most developed countries set the age of senior citizen at 65 years old, but in other regions such as Africa, the "senior" threshold is much lower at 50 years [4]. Orimo et al. [5] stated that with recent technology in the medical and health science industry, the average lifespan has increased rapidly, thus, such a definition of elderly to simply include all persons over 65 years might be no longer appropriate for this era with a life expectancy of 80 years. WHO [4] agreed that a definition of senior is arbitrary and introduces additional problems of data comparability across nations. For example, the MDS (Minimum Data Set)[1] Project collaborators agreed at the 200 Harare MDS Workshop to use the chronological age of 60 years as a guide for the working definition of "old"; however, this definition was revisited (i.e. "older" was set at the age of 50 years) due to it not taking into account the real situation of older persons in developing countries.

Therefore, the airport road access wayfinding research set the minimum age of 50 years as a "senior" and selected forty senior drivers aged 50 years and above as a sample of the population. The definition of "senior" being aged 50 years and above was set to allow an accepted minimum "older" age (i.e. based on the MDS Workshop case) globally [6]. This research, hopefully, could be extended to be applied to other countries for airport road access wayfinding improvements.

In terms of driving behaviour, choices or decisions are important elements when drivers have to decide among two or more different roads to the airport. Difficulties in making a quick choice cause a big complexity to the driver, such as time wasting, motivation decrease, no short turns and road accidents. Drivers use two immediate elements of wayfinding; choices and clues to navigate to the airport. Choices are related to instance decision points in wayfinding [7]. Decision points (also refer as choice points) are the points where drivers need to make a quick decision using available information (i.e. exit from highway and split between roads leading to terminal and parking). The choices give opportunity to decide two or more alternative ways of road access. Drivers prefer to use a clue to make estimation on road architecture. Clues include any signs and physical architecture along the road. Mitchell [8] agreed signage should be specific, designed and placed in accordance to national standards which have advantages to drivers in terms of being able to locate, read and understand them within a timeframe.

Senior drivers are likely to drive to the airport due to carrying extra luggage and preferring more time spent in the vehicle [9], [10]. DfT [11] reported that private car is the preferred transportation mode to reach the airport; i.e. Manchester Airport (57 per cent), London Luton Airport (54 per cent), Gatwick Airport (43 per cent), Stansted Airport (39 per cent), and London Heathrow Airport (29 per cent). With a current ageing population throughout much of the developed world, there is an imminent need to understand the current transportation requirements [12], [13] of senior drivers, and to ensure sustained safe mobility and comfort on airport road access [10], [12], [14]. The results confirmed that the wayfinding has importance for the promotion of road safety.

CrashMap [15] reported the high road accidents rate on airport road access; i.e. London Heathrow Airport (LHR) had the highest reported casualties (129 casualties), followed by Gatwick Airport (43

[1] The workshop was convened on behalf of the World Health Organization's Minimum Data Set (MDS) Project on Ageing and Older Adults in sub-Saharan Africa, by South African MDS Project collaborators Monica Ferreira (Institute of Ageing in Africa, University of Cape Town) and Craig Schwabe (Geographic Information Systems Centre (GIS), Human Sciences Research Council).

casualties), Edinburgh Airport (39 casualties), Glasgow Airport (26 casualties), Manchester Airport (19 casualties) and London Luton Airport (15 casualties) in 2014.

Hence, an improvement on airport road access wayfinding, road safety and comfort for senior drivers and airport users should be considered by airport management, road sign design professionals and road authorities.

4. Research Methodology

Three scenario types were designed to provide a variety of driving scenarios and complexity of the road designs to the airport. The complexity of wayfinding varied to assess the safe driving behaviour on alternative airport road access design. Drivers' decisions and judgement are extremely important while driving especially when they have to make a rapid decision or whilst making decisions under pressure at decision points [16], [17]. Drivers need to demonstrate visual scanning of the driving environment. They also must be able to make a quick scan of the signage information. Drivers often will face degrees of pressure and anxiety on journeys to airports in order to ensure that flights are not missed.

We established three scenarios representing different degrees of airport road design complexity. Scenario 1 or 'Less Complex' scenario was designed to be as less busy as possible to test the effect of road design on drivers' wayfinding to the airport. Drivers' behaviour and safety during navigation were also tested. The signage placement and road furniture were included to assess drivers' adaption to the actual airport road design with accurate wayfinding provided. Scenario 2 or 'Complex' scenario was designed as a busy road and more complex in terms of road access design and wayfinding. Curved roads and warning signage were included in order to measure the impact of airport road design on drivers' safety and driving behaviour. Multiple signage types (e.g. diamond and rectangle signs) in the simulation design were considered. Scenario 3 or 'More Complex' scenario was designed as a busiest airport road with different types of direction and warning signs (e.g. diamond and rectangle signs), advertisement signs and complexity of airport road design provided with accurate wayfinding systems.

In order to increase the validity of the research on airport road access wayfinding research, the quantitative approach was applied. Items and concepts were be operationalised through a self-designed questionnaire. Bryman [18], [19] stated quantitative study is maintained by the distance between observers and experiential along with the possibility of external checks upon one's questionnaire. The respondents were selected based on convenient sampling and participation in this study was completely voluntary. Convenience sampling is a non-random (nonprobability) sampling technique that involves using whatever participants can conveniently be studied [20]. Forty experienced car drivers holding a valid driving license volunteered to take part in the study. The self-designed questionnaire was distributed after each simulation assessment and procedure.

The questionnaire was divided into three sections. The first section indicates respondent demographic profiles. General information is useful in obtaining data on the background of the respondents which might have a direct correlation with the responses to the questionnaire statement [20], [21], [23]. Section two evaluates the impact of simulated airport road access wayfinding on senior drivers' driving performance. The Likert scale is a method designed to measure attitudes [21]. The Likert scale was used in this research to examine how strong senior drivers' agreed or disagreed with the statements [20] on a 5-point scales; *1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agreed, and 5 (strongly agreed).* These values expressed the relative weights and direction of the research objective and questions, which were determined by the favourableness or unfavourableness of the questions.

The responses were analysed and presented in frequency analysis and graphs. Section three examines the impact of wayfinding information and drivers' navigation to the airport. The dichotomous scale was used to elicit a *Yes* or *No* answer. Dichotomous scale allows respondents to choose one of two values or an answer to two different aspects of a concept [22]. Simple questions were asked based on the drivers' general and past experience of driving to the airport. The responses were analysed and presented in frequency analysis and graph. All questions in Section 1, 2 and 3 were analysed based on senior drivers' experience on three simulated scenarios ('Less Complex', 'Complex' and 'More Complex' scenario) and general experiences of driving. The results were compared and presented in frequency analyses and graphs.

5. Results

5.1 Drivers' Age and Gender

There was a total of forty respondents who volunteered to participate in this research as a convenience sampling design was applied. The minimum and maximum age of the senior drivers are 50 and 71 years old, respectively. Mean and

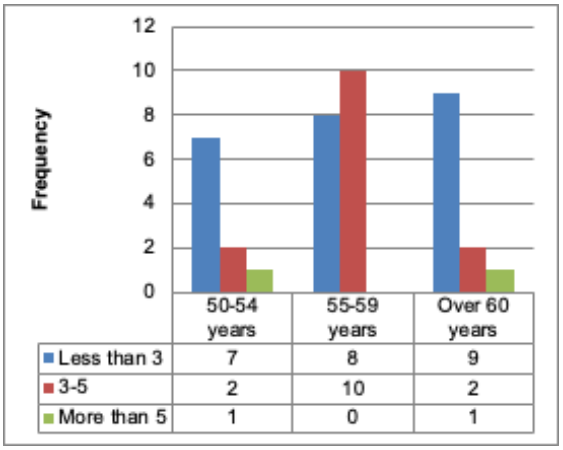
standard deviation of age range was computed as 58.60 and 5.31, respectively. The mean and SD results revealed that most of the participants were aged in the range of 53 to 63 years. In total, 24 male drivers (60 per cent) and 16 female drivers (40 per cent) successfully completed the questionnaires after the driving simulation test. The selection of senior drivers' gender was based on convenience sampling and volunteered feedback during invitation timeframe (e.g. 6 months).

5.2 Frequency of Travelling to the Airport

Figure 1 shows the proportion of frequency of travelling by age group. Drivers aged 55 to 59 years make up the majority airport road access users (45 per cent), followed by drivers aged over 60 years (30 per cent) and drivers aged 50 to 54 years (25 per cent). The survey shows that 10 respondents aged 55 to 59 years travelled 3 to 5 times a year to the airport, followed by 8 respondents drove less than 3 times a year. The result also shows that 9 drivers aged over 60 years travelled less than 3 times a year. 7 drivers aged 50 to 54 years travelled less than 3 times a year, followed by 2 respondents travelled 3 to 5 times a year and 1 respondent, drive more than 5 times a year to the airport.

In total, 60 per cent of senior drivers travelled to the airport less than 3 times a year, followed by 35 per cent of senior drivers who travelled between 3 to 5 times, and only 5 per cent of senior drivers who travelled more than 5 times a year to the airport. Chang [10] found that senior drivers preferred a safe and comfortable journey to the airport. Improving the quality of road access and services of access mode could attract more senior travellers to access the airport.

From the survey results, it can be concluded that senior drivers prefer to drive to the airport. The contributing factors, such as an increase of frequent travellers to the airport, better airport road access to ease driving option to senior drivers, an increase in the well-being of senior drivers and the growing reluctance of individuals to change their modal behaviour once they enter retirement [13], [24] are highly considered.

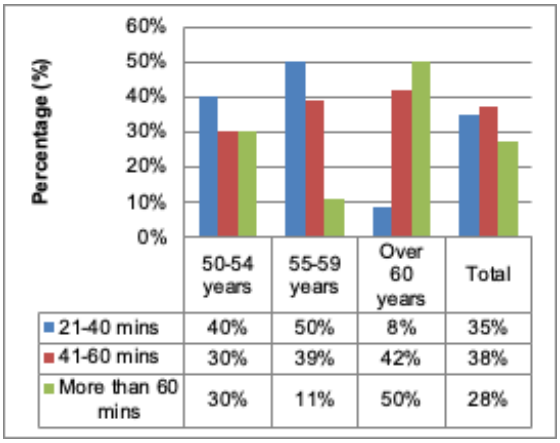


	50-54 years	55-59 years	Over 60 years
Less than 3	7	8	9
3-5	2	10	2
More than 5	1	0	1

Figure 1. Proportion of drivers by age and frequency of travelling

5.3 Time Spent from the Road to the Airport

Figure 2 shows the proportion of time spent from departure point (e.g. residential area) to the airport. The following are the results of time spent by senior drivers: 38 per cent (15 respondents) spent 41 to 60 minutes on the road before arriving at the airport, followed by 35 per cent (14 respondents); 21 to 40 minutes, and 28 per cent (11 respondents); more than 60 minutes. Based on the proportion of the drivers' age group, 50 per cent and 39 per cent of respondents aged 55 to 59 years spent 21 to 40 minutes and 41 to 60 minutes to the airport, respectively. Figure 2 also shows that 50 per cent and 42 per cent of respondents aged 60 years and overspent more than 60 minutes and 41 to 60 minutes to arrive at the airport, respectively.



	50-54 years	55-59 years	Over 60 years	Total
21-40 mins	40%	50%	8%	35%
41-60 mins	30%	39%	42%	38%
More than 60 mins	30%	11%	50%	28%

Figure 2. Proportion of drivers by time spent from departure point to the airport

Based on the driving simulation test, senior drivers took an early turn at the roundabout and interchange. They were also not able to judge the exact distance in meters and occasionally took a wrong turn [25], [26]. Senior drivers also required a longer period of time to read and process the

wayfinding and traffic signs information. Senior drivers read the information displayed on traffic signs, potentially glance frequently in their rear view mirror, detect the image of traffic signs information and understand the meaning and recalling of its content to relate it with the current environment [27]–[29]. This process influenced decision making and increased the travelling time of senior drivers when driving to the airport.

5.4 Impact of Airport Road Access Wayfinding on Senior Driver Performance

Table 1 shows the respondent feedback based on driving in Simulation 1 (Less Complex), 2 (Complex) and 3 (More Complex) scenarios. All selected respondents successfully completed the driving simulation 1, 2 and 3.

Table 1. Respondent feedback in mean and standard deviation (SD)

Parameter	Simulation 1		Simulation 2		Simulation 3	
	Mean	SD	Mean	SD	Mean	SD
It was easy to drive on the road	4.40	0.90	4.20	0.85	3.45	1.18
I noticed that the trees were blocking some of the road signs	1.75	0.90	1.78	0.89	1.83	0.96
There were too many traffic lights	1.68	0.94	1.78	1.05	1.85	0.95
Poor visibility along road because of terrain	2.50	1.18	2.38	1.05	2.83	1.32
At the junction on the road to the airport, I was able to make a fast decision	4.33	0.89	4.10	0.90	3.53	1.06
The bend on the road did not affect my feeling of safety	3.48	1.11	3.10	1.26	2.90	1.41
The level of traffic did not make any difference to my driving	3.13	1.34	2.95	1.40	2.70	1.49
I felt safe to perform the simulated driving exercise	4.43	0.93	4.53	0.72	4.58	0.71
The signs were easily noticeable	4.28	0.85	4.25	0.87	4.00	0.82
I could not read the text on the signs	1.55	0.75	1.78	0.80	2.05	1.06
I was looking for the word of "airport" on the sign	3.95	1.06	4.10	0.93	4.38	0.98
Type of warning signs were adequate	4.45	0.71	4.38	0.90	4.20	0.94
The font of the road signs were clear and readable	4.53	0.68	4.33	0.73	4.23	0.83
The signage helped me navigate easily	4.75	0.54	4.68	0.66	4.48	0.78
There were too many road-side adverts	2.65	1.25	2.73	1.34	2.80	1.30
I could not read the adverts	1.65	0.80	1.80	0.91	2.03	1.17
I was distracted by the adverts	1.93	1.05	2.20	1.16	2.43	1.32
The frequency of warning signs were adequate	4.20	0.82	4.03	1.00	3.80	0.85
The variable speed limit signs were noticeable	4.38	0.84	4.28	0.72	3.95	0.90

5.4.1 Simulation 1 (Less Complex Scenario)

All respondents agreed that the driving simulation test was safe and convenient to complete (mean=4.43, SD=0.93). In term of road access wayfinding design, respondents found it easy and "less complex" to drive on the road (mean=4.40, SD=0.90). Table 1 shows that the respondents were able to make a fast decision at the decision point (mean=4.33, SD=0.89) on their journey to the airport. Car movement and the opposite lane were also considered in simulated driving. Adding more to that, the results shows that respondents were not distracted by road traffic movement (mean=3.13, SD=1.34). The road traffic is created in the driving simulation due to measuring the driving manoeuvre and behaviour of senior drivers whilst in the traffic situation. Although, the airport road access design indicates a simple and convenient wayfinding in a 'Less Complex' scenario, a road bend and terrain has been developed in a simulated road. It allowed the researcher to assess respondents' visibility and the cognitive process in decision making. At the same time, it will increase road safety while steering on the bend. Respondents believed that this terrain (mean=2.50, SD=1.18) reduced their driving control and visibility towards the upcoming road. Bends on the road did not affect the driving safety of the senior drivers (mean=3.48, SD=1.11). Senior drivers did not pay attention to trees blocking traffic signs (mean=1.75, SD=0.90). The frequency of traffic lights (mean=1.68, SD=0.94) was acceptable in Scenario 1.

Table 1 also shows the respondents agreed that road signs were important in drivers' wayfinding. The signs font were clear and readable (mean=4.53, SD=0.68) and were clearly important on airport road access wayfinding design. The results show that (1) the signs were easily noticeable (mean=4.28, SD=0.85), (2) the type of warning signs were adequate (mean=4.45, SD=0.71), (3) the frequency of warning signs were adequate (mean=4.20, SD=0.82) and (4) the variable speed limit signs were acknowledge (mean=4.38, SD=0.84), respectively.

Participants were also looking for the word 'airport' on the signs (mean=3.95, SD=1.06) to continue their journey to the airport. However, the senior drivers found that the road advertising signs were not distracted; (1) could not be read (mean=1.65, SD=0.80) and (2) distracted by the advert signs (mean=1.93, SD=1.05). 14 of respondents agreed that there were too many advertising signs on the roadside (mean=2.65, SD=1.25) which could distract their driving performance when driving to the airport. However, airport road advertising (including advert sign) is important to generate extra airport income. Therefore, airport planners should find the balance between the safety and commercial provision in order to develop an ideal road access wayfinding design.

5.4.2 Simulation 2 (Complex Scenario)

All respondents felt safe (mean=4.53, SD=0.72) while driving in the simulated scenario. The 'Complex' road design was easy to drive along as respondents were able to make a fast decision at the junction of the road (mean=4.20, SD=0.85). Senior drivers believed that the road bend affected drivers' safety on road (mean=3.10, SD=1.26). The results showed that from 40 respondents, the road traffic movement (mean=2.95, SD=1.40) are distracted while they are driving to the airport. Poor visibility on the road due to the terrain, and frequency of traffic lights on the road (mean=2.38, SD=1.05 and mean=1.78, SD=0.89), respectively, were not affecting driving focus towards the airport.

The traffic signs clearly assisted road navigation to the airport (mean=4.68, SD=0.66). A traffic sign is important to direct, inform and control senior drivers' behaviour in order to make the roads as safe as possible. The necessity of signs is not just for new drivers that have passed their driving test, but for all road users, including experienced professional drivers. The complexity of road scenario and various speed limits led to senior drivers not being able to read the text on the signs when necessary (mean=1.78, SD=0.80). Bazire and Tijus [30] suggested that road signs should not be ambiguous as they were designed to assist drivers in complying with the law prescriptions whilst driving. However, the ambiguity of traffic signs led to misunderstandings or to the simple omission of the signs' information. Similar to 'Less Complex' scenario, respondents were looking for the word 'airport' on signs to continue their journey to the airport (mean=4.10, SD=0.93).

5.4.3 Simulation 3 (More Complex Scenario)

The more complex of airport road design access wayfinding design led to difficulties in navigating to the airport. The complexity of the airport road access design affected respondents driving performance in Simulation 3. Based on the results, (1) the respondents navigate easily (mean=4.48, SD=0.78), (2) the signs were easily noticeable (mean=4.00, SD=0.82), (3) type of warning signs is adequate (mean=4.20, SD=0.94), (4) the font on signs were clear and readable (4.23, SD=0.83), (5) the frequency of warning signs were adequate (mean=3.80, SD=0.85), and (6) the variable speed limit signs were noticeable (mean=3.95, SD=0.90), respectively. These results confirmed that respondents pay more attention on wayfinding tools to navigate to the airport. As for road advertising signs, respondents found that (1) the road advertising (mean=2.80, SD=1.30) were adequate, (2) the adverts could not be read (mean=2.03, SD=1.17) by 5 respondents, and (3) 11 respondents became distracted while driving to the airport (mean=2.43, SD=1.32), respectively. Due to the complexity of road scenario and various speed limits, respondents were not able to read the text on the signs when necessary (mean=2.05, SD=1.06). However, respondents agreed that they looked for the word 'airport' on signs to continue their journey to the airport (mean=3.95, SD=0.90). Psychologically, drivers are more aware of different types of signs and what the signs look like, so that they can respond automatically.

6. Discussion

The paper suggests that driving simulation is useful for testing drivers' wayfinding ability in a virtual environment. There are three major of driving simulation that affects the ease of driving orientation and wayfinding designs to the airport. Firstly, the sign design of driving scenario's should be distinctive and different [1]. Airport 'directional arrow' sign should be bigger, bold text, different colour and symbol than other signs. The airport landside signs should be identical in term of size, colour and style to be compared with current motorway signs. The senior drivers could differentiate and signifies the airport signs while they are performing wayfinding. Therefore, it is very important that airport signs adhere to copy, styles and sizes, consistent terminology and symbols and uniform colours of basic guiding principles standard functions [1], [31], [32]. Message content should be easily understood by airport travellers. For instance, first time travellers require different information rather than frequent flyers. Secondly, some attributes in driving simulation can be seen from various viewpoints. For example, the 'Less Complex' scenario was developed with 'comfort' driving environment which allows drivers to view the routes and landmarks more easily and distinctively compared than other scenarios. Adding more to that, in some attributes of simulated driving such as 'More Complex' scenario, senior drivers require sign direction to be displayed as far as possible to the airport [32]. Thirdly, as age increases, it is certain that general health and fitness will begin to deteriorate which leads to road accident risks. The senior drivers felt that their driving experience skills and driving abilities may not be as good as they once were [33]. As a result, senior driver controls their driving experience and develop a more defensive and cautious driving behaviour as they grow older. The senior drivers are commonly involved in collisions often because they misjudge the speed or distance of other vehicles or fail to see a hazard [34]–[36]. From the driving simulation results, it shows that the 'more complex' of road design makes wayfinding more difficult. For

instance, the senior drivers made more errors in the ’more complex’ scenario which led to risk of collisions, exceeding the speed limit, centreline crossings, and road edge excursions. Senior drivers are more likely to have more driving errors which leads to road accidents.

7. Conclusion

The study revealed that senior drivers’ attention and ability to process signage and wayfinding information is limited. These limitations create difficulties because driving requires the division of attention between control tasks, guidance tasks and navigational tasks. Senior drivers’ attention can be switched rapidly from one wayfinding information source to another. This means that drivers only attend well to one source at a time. For instance, while driving to the airport, drivers can only extract a small proportion of the available information from the road scene (i.e. airport directional signs). Thus, to interpret a limited information processing capacity while driving, senior drivers can only determine acceptable information loads that they can manage [37]. When drivers’ acceptable incoming information load is exceeded, they tend to neglect other information based on level of importance (i.e. if driver was looking for the word ‘airport’ on the sign, they tend to neglect the speed limit signs). As with decision making of any sort, error is possible during this process [17]. Senior drivers were less focused on information that turns out to be important, while less important information was retained. In addition to information processing limitations, senior drivers’ attention is not fully within their conscious control. For drivers with some degree of experience, driving is a highly automated task. Driving can be performed while the driver is engaged in thinking about other matters. Most drivers, especially a frequent traveller to the airport or one familiar with the airport route, have experienced the phenomenon of becoming aware that they have not been paying attention during the last few miles of driving (e.g. airport staff). The less demanding the driving task, the more likely it is that the drivers’ attention to the airport wayfinding and signage will wander, either through internal preoccupation or through engaging in non-driving tasks. Factors such as complexity of road design and environment or increased traffic congestion could also contribute to distracted driver’s ability to keep track of wayfinding. Inattention may result in unintentional movements out of the lane, exceeding the speed limit [38] and failure to detect a vehicle on a conflicting path at an intersection [37], [39], [40] that exposed drivers to the risk of collisions and reduced road safety.

7.1 Limitations

Driving simulators have a few disadvantages. For instance, simulator sickness (a type of motion sickness) is experienced by senior drivers whilst “driving” in the simulator room; it may include dizziness, headache, nausea and vomiting [41]. Apparently, a senior driver would be compromised when experiencing these symptoms and it may not be appropriate for all drivers to be involved in a simulated driving experience. Gruening et al. [42] claimed that the information gained through driving simulations may be misleading if the simulator does not provide an appropriate analogue to the simulated scenario, and that high reliability driving simulations are sometimes far more expensive than vehicle testing.

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