Journal of Technology and Operations Management Volume 12, Issue 2, 2017, pp.53-61
http://stmlportal.net/jtom/wp-content/uploads/2018/05/p853-61.pdf

THE IMPACT OF AIRPORT ROAD WAYFINDING ON SENIOR DRIVER BEHAVIOUR

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ABSTRACT

The purpose of this study was to measure the impacts of airport road access design and wayfinding systems on senior driver performances. A car driving simulator was used to model scenarios of differing wayfinding complexity and road design. Three scenario types were designed consisting of 3.8 miles of airport road (i.e. approximately 4 minutes driving to complete each scenario). Experienced car drivers were asked to drive simulated routes. Forty drivers in the age ranges: 50 to 54, 55 to 59 and those aged over 60 were selected to perform the study. Participants drove for approximately 20 minutes to complete the simulated driving. The driver performance was compared between age groups. Results were analysed by Mean, Standard Deviation and ANOVA Test, and discussed with reference to the use of the driving simulator. The ANOVA results showed that in comparison of senior drivers' age group, there is a low impact between driving behaviour and road safety on airport road access wayfinding design.

Keywords: Safe driving behaviour, road safety, wayfinding, signage, simulator, senior driver

INTRODUCTION

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. For example, airport road access development aims to reduce the traveling time and delay to the airport. The following are the viewpoints of airport management regarding road access wayfinding (Harding et al., 2011): (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. Given the capacity of an airport landside transportation system, the growth of aviation industry produces road congestion which, in turn, worsens the quality of the landside environment and has the consequence of limiting the convenience of travellers arriving at and departing from the airport. The provision of a rapid and convenient access transportation system delivers significant benefits to the operation of an airport and its potential users. As a result, the development of efficient airport road access wayfinding is required to thereby provide better access to the airport terminal building.

AIRPORT ROAD ACCESS ACCIDENT STATISTICS

Figures 1 shows the number of road accidents at UK airport landsides from 2010 to 2014. Ten airports with the highest road access accidents and incidents have been highlighted. Traffic accidents at an airport road access are a disruption of the balance among three components, which are human, vehicle and environment (Mamais, 2009). Six airports show more than 100 reported casualties at the airport road access. London Heathrow Airport (LHR) has the highest reported casualties in five years (542 casualties), followed by Gatwick Airport (199 casualties), Edinburgh Airport (190 casualties), Glasgow Airport (160 casualties), Manchester Airport (137 casualties) and London Luton Airport (100 casualties).

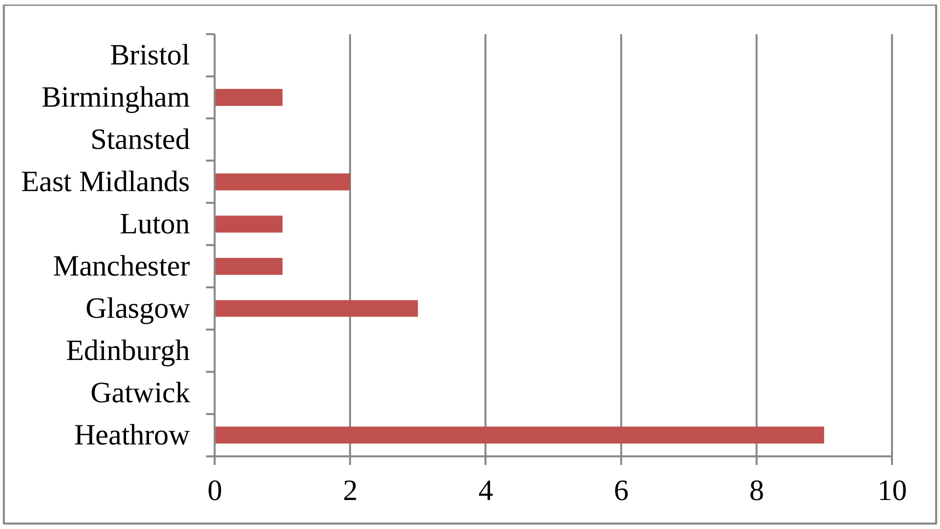

Figure 1: Total fatal casualties at UK Airports from 2010-2014 (Source: CrashMap, 2015)

In 2014, London Heathrow Airport experienced 129 reported accidents at the road access which was higher than other airports in the UK. There were 542 reported accidents in five years (484 of slight casualties, 49 of serious casualties and 9 of fatal casualties). As a comparison, total casualties increased by 38 per cent in 2013. The higher casualties reported at Heathrow road access in 2014. Heathrow is the biggest and busiest airport in the UK and Europe by passenger traffic, and the third busiest airport in the world by total passenger traffic (London Heathrow Airport, 2016). Heathrow was also the most visited airport by all modes of transport (e.g. private car, taxi and bus) in 2014 (Department for Transport, 2015c). Travelling by private car (i.e. 29 per cent) is the second largest mode of transport preferred by travellers to reach Heathrow Airport after taxi (30 per cent). As the busiest airport in the UK with 7.5 million visitors as at March 2016, Heathrow Airport is exposed to the risk of road access accidents. The contributory factors to road accidents at Heathrow could be of failure to look properly and failure to judge other person's path or speed (Department for Transport, 2015a, 2015c). Gatwick Airport notified as having 199 reported casualties in five years (zero fatal casualties and 2 serious casualties) in 2014. Edinburgh Airport, in contrast, shows zero fatal casualties in five years and zero serious casualties in 2014.

Serious casualties have gradually declined since 2012 at Edinburgh Airport. Reported serious casualties at Glasgow, Manchester and London Luton Airport have been gradually declining since 2010. In addition, the serious casualties dropped by 80 per cent at Glasgow Airport and 63 per cent at Manchester Airport in 2014. However, the fatal accidents rose 100 per cent at Glasgow Airport in 2014. London Luton Airport reported one serious and fatal casualty, respectively, in five years. Accidents at the airport road access are mainly due to increased traffic near an airport area (AEF, 2008). AEF (2008) suggested that using public ground transportation such as bus and train would help to reduce road accidents at the airport road access.

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 (Casutt et al., 2014; Hassan et al., 2015). 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 (including signage) provided. Scenario 2 or 'Complex' scenario was designed as a busy road and more complex in terms of road access design and wayfinding (including signage). 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 (including signage).

Procedure

The simulation participants 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. It is most often used during experiment-based research and is the best way of obtaining basic information in the most efficient way (Sekaran, 2003). Thus, convenient sampling is the most appropriate sampling design for this paper because the collection of information is collated from the population of participants who are conveniently available to provide it.

40 experienced car drivers holding a valid driving license volunteered to take part in the study. The age of drivers ranged from 50 to over 60 with a sample mean age of 58.60 years. Complete instructions were given before the simulation started. Drivers were instructed to drive to the airport with the aid of wayfinding and signage in the driving scenario.

The simulation test was 3.8 miles long for each scenario and took approximately 20 - 30 minutes to complete all three simulations. Participants decided which route to use based on the provided signage and wayfinding systems. The scenario was tested randomly. Participants were not tested by order or number of simulation (i.e. for example, participant A was tested with scenario 1 followed with scenario 3 then scenario 2, participant B was tested with scenario 2 followed with scenario 3 then scenario 1, and participant C was tested with scenario 3 followed with scenario 1 then scenario 2).

Data Analysis

The mean and standard deviation were used in this research as they are the most common descriptive statistics, and a very useful tool of statistical rules, in normal distribution (Beins & McCarthy, 2012; Robson & McCartan, 2016; Sekaran, 2003). Beins and McCarthy (2012) stated that ANOVA compares group means to assess the reliability of different means. In this research, ANOVA was used to measure the most prevalent importance of driving behaviour, road safety and the complexity of road design. The ANOVA test measures the differences of the independent variable (e.g. drivers' age group) and the dependent variables (e.g. risk of collision and centreline crossings). The level of significance ($p < 0.05$) was set in this study while 95% confidence level was selected as a conventionally accepted level (Sekaran, 2003).
Table 2 shows the recommended parameters that were measured (Dorn & Stannard, 2006) on airport road access wayfinding design.

RESULTS

Drivers' Age and Gender

There were a total of 40 respondents who volunteered to participate in this research as a convenience sampling design was applied. Table 3 shows the age group of senior drivers who volunteered as participants in this research.

Table 1

The range of drivers' ages

	Minimum	Maximum	Mean	Standard Deviation
Age	50	71	58.60	5.31

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 percent) and 16 female drivers (40 percent) completed the driving simulation test. The selection of senior drivers' gender was based on convenience sampling and volunteered feedback during invitation timeframe (e.g. six months).

ANOVA Test Results for Simulated Driving Performance

The research hypothesis is as follows:

Null Hypothesis (H_0): There is no significant effect of airport road access complexity design on driving behaviour.

Alternative Hypothesis (H_1): There is a significant effect of airport road access complexity design on driving behaviour.

Tables 2 and 3 show the results of the simulated driving performance by senior drivers; 'Less Complex' (Simulation 1), 'Complex' (Simulation 2) and 'More Complex' (Simulation 3) relation to airport road access wayfinding design. Results of lane position, steering, acceleration and speed were identified in mean and Standard Deviation (SD).

Table 2
Driving performance in mean and standard deviation

Measure	Simulation 1		Simulation 2		Simulation 3	
	Mean	SD	Mean	SD	Mean	SD
Lane position (feet)	-11.55	3.36	-11.67	2.97	-12.01	2.08
Steering (degree/secs)	9.02	4.31	10.75	3.15	11.20	3.28
Acceleration (g's)[1]	0.02	0.01	0.02	0.02	0.02	0.03
Speed (miles/hour)	41.65	6.21	41.47	4.85	41.45	4.37

Table 3
ANOVA results for drivers' driving performance

Driver's Mistake	Simulation 1		Simulation 2		Simulation 3	
	F	p-value	F	p-value	F	p-value
Lane position (feet)	0.62	0.55	0.41	0.67	1.56	0.22
Steering (degree/secs)	0.08	0.92	0.81	0.45	0.64	0.53
Acceleration (g's)	3.26	**0.05***	2.36	0.11	0.17	0.85
Speed (miles/hour)	2.08	0.14	0.65	0.53	0.94	0.40

*Indicates significant results < 0.05.

Table 3 shows the ANOVA results for Simulations 1, 2 and 3. The alternative hypothesis has been rejected, and at the same time, the null hypothesis was accepted at a significant alpha of 0.05. The hypothesis states that there is a low impact on driving behaviour and road safety on airport road access wayfinding design. However, the ANOVA test shows that the senior drivers were accelerating assertively in Simulation 1 (F=3.26, p=0.05). It means that the alternative hypothesis has been accepted and at the same time the null hypothesis was rejected at a significant alpha of 0.05. The significant result indicates that senior drivers are likely to be slowing at some point in the 'Less Complex' scenario (e.g. at junctions and roundabouts) to read and view traffic signs.

Slowing the vehicle also means that senior drivers were gaining speed in a slow rate area (i.e. likely to brake immediately at decision points) to the airport.

Senior drivers were likely to drove closer to the kerb in Simulation 3 (F=1.56, p=0.22) compared to Simulation 1 (F=0.62, p=0.55) and Simulation 2 (F=0.41, p=0.67). They were more likely to steer less sharply in Simulation 2 (F=0.81, p=0.45) compared to Simulation 1 (F=0.08, p=0.92) and Simulation 3 (F=0.64, p=0.53). Senior drivers accelerated more assertively in Simulation 1 (F=3.26, p=0.05) compared to Simulation 2 (F=2.36, p=0.11) and

[1] SD results: Simulation 1 (0.0136), Simulation 2 (0.01526) and Simulation 3 (0.02531).

Simulation 3 (F=0.17, p=0.85). They also were likely to drive faster in Simulation 1 (F=2.08, p=0.14) compared to Simulation 2 (F=0.62, p=0.53) and Simulation 3 (F=0.94, p=0.40). Overall results show that the senior drivers' performance during navigation to the airport has low impacts on airport road access wayfinding design.

Mean and SD results of simulated driving performances by senior drivers are analysed in the next sections. The analyses are focused on the impact of driving performances (i.e. on safe driving behaviour) by age group of senior drivers while performing navigation to the airport.

DISCUSSION AND CONCLUSION

The paper suggests that driving simulation is useful for testing drivers' wayfinding ability in a virtual environment. The study investigated the impacts of senior drivers' performance on simulated airport road access wayfinding design. ANOVA results showed that drivers' particular age group had a low impact on senior driving performances and airport road access wayfinding design. The study suggested that driving simulation is useful to test drivers' wayfinding process in virtual environments and validated selected research variables (i.e. wayfinding obstacles and contributing factors to wayfinding difficulties).

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 (Mårdh, 2016). When drivers' acceptable incoming information load is exceeded, they tend to neglect other information based on the level of importance (i.e. if the 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, the error is possible during this process (Casutt et al., 2014). 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.

In conclusion, the study revealed that senior drivers' attention and ability to process signage and wayfinding information is limited. These limitations can create difficulties because driving requires the division of attention between control tasks, guidance tasks and navigational tasks. 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, drivers can only determine acceptable information loads that they can manage (Mårdh, 2016). When drivers' acceptable incoming information load is exceeded, they tend to neglect other information based on the level of importance (i.e. if the 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, the error is possible during this process (Casutt et al., 2014). Drivers were less focused on information that turns out to be important, while less important information was retained. In addition to information processing limitations, 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 (Chevalier et al., 2016) and failure to detect a vehicle on a conflicting path at an intersection (Dukic & Broberg, 2012; Mårdh, 2016; Oxley, Fildes, Corben, & Langford, 2006) that exposed drivers to the risk of collisions and reduced road safety.

FUTURE RESEARCH

This research addressed the gaps in the literature on the airport road access wayfinding and the relationship between senior driving behaviour and road safety on airport road access wayfinding design. A driving simulator has been used as a tool to measure the relationship between these variables. In this section, further directions for future research are suggested. Firstly, Satellite Navigation (Sat Nav) was suggested as one of the objectives to assess its impact on senior driving behaviour towards airport road access wayfinding. However, the Sat Nav was not built-in in the STISIM driving simulator Version 2. The idea of the insertion of Sat Nav as a tool to aid senior drivers to perform airport wayfinding hopefully would extend the current research, with additional variables on the impact of airport road access design using a simulated driving scenario. Secondly, senior drivers aged 50 years and over were chosen to participate in this research. Results from the simulated driving test were analysed, and findings were measured only focusing on senior drivers' attributes. It is suggested that this research could be extended to the younger drivers and with a consideration of gender to assess any effects on driving behaviour and road safety on the complexity of road design. Thirdly, this research using a driving simulator was mainly focused on airport road access wayfinding. The research could be extended to other areas such as the hospital and school environments. The impact of road access complexity to senior drivers in these areas is perhaps an interesting topic for future research.

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