Applied Ergonomics 58 (2017) 461–470

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

An approach to vehicle design: In-depth audit to understand the needs of older drivers

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ARTICLE INFO

Article history:
Received 15 December 2015
Received in revised form
2 June 2016
Accepted 29 July 2016
Available online 17 August 2016

Keywords:
Vehicle design
Driving
Automotive ergonomics
Older drivers
Ageing
Human factors
Posture
Seat design
Control design

ABSTRACT

The population of older people continues to increase around the world, and this trend is expected to continue; the population of older drivers is increasing accordingly. January 2012 figures from the DVLA in the UK stated that there were more than 15 million drivers aged over 60; more than 1 million drivers were aged over 80. There is a need for specific research tools to understand and capture how all users interact with features in the vehicle cabin e.g. controls and tasks, including the specific needs of the increasingly older driving population. This paper describes an in-depth audit that was conducted to understand how design of the vehicle cabin impacts on comfort, posture, usability, health and wellbeing in older drivers. The sample involved 47 drivers (38% female, 62% male). The age distribution was: 50–64 (n = 12), 65–79 (n = 20), and those 80 and over (n = 15). The methodology included tools to capture user experience in the vehicle cabin and functional performance tests relevant to specific driving tasks. It is shown that drivers' physical capabilities reduce with age and that there are associated difficulties in setting up an optimal driving position such that some controls cannot be operated as intended, and many adapt their driving cabins. The cabin set-up process consistently began with setting up the seat and finished with operation of the seat belt.

1. Introduction

There is a growing older population globally: in Europe the percentage of people aged over 65 is expected to rise from 16% in 2010 to 29% in 2060 (Creighton, 2014). The European population aged over 80 is set to rise significantly; in 1960 it was just 1–2%, but in 2010 this figure reached 4%, and it is estimated that in Europe the population aged over 80 will increase to 12% by 2060. In parallel to this, the number of older drivers is increasing across the world. According to January 2012 figures of the DVLA in the UK, there are more than 15 million drivers aged over 60; more than 1 million are aged over 80 (Institute of Advanced Motorists, 2012; Dvla, 2010). Drivers aged 65 and older are predicted to represent over 16% of the driving population in the USA by 2020 (Tamiya et al., 2011). It has been estimated that 11% of over 65s buy a new car every two years (Statista, 2016). The automotive industry is therefore facing new challenges as the market demographic evolves (Bhise, 2012). One challenge is determining and meeting the needs of older drivers, which represents and increasingly important target population. Driving is an assumed activity for many older people whilst carrying out their daily activities and vital for maintaining independence in tasks such as shopping, keeping medical appointments, performing voluntary duties, sustaining a contributory role in the family, and maintaining a social life (e.g. Musselwhite and Haddad, 2008). In a questionnaire study of over 900 respondents, Karali et al. (2016) found that older drivers (65+) reported more discomfort in the lower limb when driving than younger drivers, although back discomfort reduced. A higher prevalence of older drivers than younger drivers reported driving in challenging conditions such as foggy days or busy traffic 'difficult'; similarly more older than younger drivers found it difficult to move their body when reversing (28% vs 22%). It was noted that about 10% drivers of all ages found adjusting the seat controls difficult.

The literature indicates that many of the issues for older drivers identified in the 1990s relating to visual, cognitive, environmental and particularly physical factors are still commonly encountered (Middleton et al., 2005; Bradley et al., 2008; Musselwhite and Haddad, 2008; Smith et al., 1993). According to Gyi (2013) more

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http://dx.doi.org/10.1016/j.apergo.2016.07.017

data is needed to focus on dynamic and functional anthropometric measurements in vehicle design to accommodate the specific needs of older drivers. Examples include postures for reversing, postures for operation of seat adjustment controls, opening car boots, reach to the seat belts and reach to adjust mirrors. A study conducted by Williams et al. (2011) explored user-centred design and evaluation of electrically operated seat adjustment controls in luxury vehicles (SUVs). This study was based on analysis of the positive and negative comments on ease of use, accessibility and feel. Negative comments were mainly related to obstruction and space restrictions when accessing the controls on the side of the seat, i.e. the arm rest was causing obstruction. Interestingly, this study did not focus on age and gender. Furthermore, the minority of vehicles are equipped with electrically operated seat controls and manual adjusters have additional design challenges.

Kyung and Nussbaum (2010) compared the postures of older drivers (n = 20) with younger (n = 38) in two different vehicle classes: sedan and SUV. They identified that older drivers had a smaller angle of the right elbow and the left hip in the sedan. The results for SUVs identified six joint angles that were smaller; indicating older drivers adopted postures close to the steering wheel. Differences between males and females were not explored in this study. Similarly, a study conducted by Porter and Gyi (1998) identified that females had lower arm flexion and elbow angles compared to males; this also indicates that females adopt their driving postures closer to steering wheel compared to males, but this study did not compare ages. Interestingly, the results of a questionnaire survey study conducted by Herriotts (2005) revealed that 95.2% of drivers were able to adopt a comfortable driving position. Whilst 31% of older drivers reported using additional items on their seat such as a bead mat and seat cushion, only 2.1% of younger drivers did. The study was based on a postal survey, to explore difficulties experienced by older drivers with an aim to identify specific focus areas for further research. The sample was formed of a large group of older drivers (n = 1013, age 60–79) and a small group of younger drivers (n = 97, age 20–59).

While not a focus for this study, cognitive and physiological decrements would be expected to affect driving performance for older drivers. Musselwhite (2016) summarised the issues facing older drivers in 7 categories: attention, cognitive overload, cognitive processing speed, perceptual speed, working memory, task switching and eyesight. These were mapped on to common driving errors and it was noted that many of the categories of decrement would be expected to directly affect all of the errors in the list. The cognitive and physiological capabilities of older drivers should not be assumed to be identical to those of younger drivers, and will become more important to manufacturers as the number of older drivers increases. However the cognitive performance of all ages has a wide range, and many older drivers can perform very well in tests. For example, Key et al. (2016) showed that situation awareness scores for older individuals often matched and exceeded those for younger ones, although on average younger drivers showed superior hazard perception.

Designing vehicles to accommodate the needs of older drivers has social and economic implications for users and the manufacturers. Identifying these needs will enable drivers of all ages to be better accommodated in the design process; older users can maintain their independence, drive for longer periods and remain socially connected for longer. In return this would have a positive impact on their health and reduce the workload of daily activities e.g. shopping, visiting doctors and relatives etc. In parallel to this, manufacturers would potentially increase their sales to this market with constant improvements to their vehicles and technologies. Whilst manufacturers do aim to be inclusive in their designs, it is recognised that there is an increasing population of older drivers and future improvements need to ensure that the entire market is considered. The aim of the research presented in this paper is to understand how design of the vehicle cabin impacts on older drivers. To this end, a methodology is also described which may be of interest to other researchers in the automotive field.

1.1. Purpose/objectives of the study

The purpose of this study was to explore how users (older drivers) interact with controls in automotive cabins. It was designed to capture the user experience in relation to design of the vehicle cabin (e.g. seat set-up process, the seat design, ease of adjustments, posture analysis), to measure physical functional performance of older drivers and understand how these can affect driving related tasks; cognitive function was out of scope for this study. The focus of the study was directed by the outcomes of a previous questionnaire of over 900 drivers with 420 aged 65 or over (Karali et al., 2016).

2. Methodology

Two vehicles were audited in the same session: the participant's own vehicle and a test vehicle (2010 Nissan Qashqai sports utility vehicle, 2010–2013 model variant (SUV)) which was the same for each person. A repeated measures design was used to understand the problems experienced, preferences, and likes/dislikes about the vehicle cabin area such as the seat and seat controls. The detailed procedure is summarised in Table 1. The audit was conducted for convenience either at the participant's home, Loughborough University or other suitable venue and was designed to last between 1.5 and 2 h. Assessment tools were selected from Eby et al., (2006) in order to understand how declines in functional performance could affect carrying out specific driving related tasks (shown in Table 2). These tests were included in order to determine whether specific physical performance limitations affected the overall driver abilities. The Hamilton Veale test was used for the assessment of contrast sensitivity.

At the start of the audit background information was obtained about participants (e.g. gender, age). The audit was carried out first in the participant's own vehicle (a familiar vehicle) and then the test vehicle (an unfamiliar vehicle). The participant's vehicle was used first in order to help build rapport between experimenter and the volunteers, and to allow them to learn the test protocol in a familiar environment. The seat set-up process was evaluated to capture user decisions on seat and driving positions and their experiences of conducting specific tasks to achieve these decisions. Both qualitative and quantitative data were obtained from video recordings using a rearward-facing wide-angle camera mounted on the windscreen. Assistance was given (by the researcher) to participants who struggled or needed help during the seat set-up process (e.g. locating and operating the controls) and this was noted. A 5-point scale was used for the usability evaluation of the controls reach (too far, slightly too far, ok, slightly too close, too close), ease of operation and accessibility (very easy, easy, ok, difficult, very difficult). Posture was measured following Porter and Gyi (1998) to capture the driving position of participants. Posture measurements were taken with an extendable goniometer (Fig. 1) to measure the joint angles (based on anatomical landmarks) and seat positions measured using a specially designed tool (Fig. 2). Finally, the functional assessments (Table 2) were taken of participants, together with anthropometric measurements using methods described in Pheasant and Haslegrave (2006).

A stratified purposive sampling strategy was adopted focusing on age. Males and females were sought to participate in the study. The sample was divided into three age sub groups (50–64, 65–79