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## Driving a better driving experience: a questionnaire survey of older compared with younger drivers

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### ABSTRACT

A questionnaire survey of drivers ( $n = 903$ ) was conducted covering musculoskeletal symptoms, the vehicle seat, access to specific vehicle features, ingress/egress, driving performance and driving behaviours. Significantly, more discomfort was reported by older drivers (aged 65+) in the hips/thighs/buttocks and knees. Older drivers reported more difficulty parallel parking ( $p \leq 0.01$ ), driving on a foggy day ( $p \leq 0.01$ ), and turning their head and body to reverse ( $p \leq 0.001$ ). They also reported that their reactions were slower than they used to be ( $p \leq 0.01$ ). Dissatisfaction was found by all drivers with adjusting the headrest (height and distance), seat belt height and opening/closing the boot. There is a growing population of older people globally, and the number of older drivers is showing a parallel increase. Clearly, efforts are needed to ensure car design of the future is more inclusive of older drivers.

**Practitioner Summary:** This paper describes a questionnaire survey of drivers on their driving experience – the vehicle seat, access to specific vehicle features, ingress/egress, driving performance and driving behaviours. Comparisons are made by age and gender. Issues with driving and vehicle design particularly for older drivers in the UK are identified.

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### KEYWORDS

Vehicle ergonomics; ageing; ergonomics methods and tools; driving

### 1. Introduction

Consistent with changes in life expectancy and birth rates globally, the UK has a growing population of older people; over the last 25 years, the number of adults over 65 grew to 10.3 million people and the number of people aged over 85 has increased more than 50% to 1.4 million (UK National Statistics 2013). Indeed, western Europe has one of the oldest populations and the number of people aged over 65 is predicted to rise from 16% in 2010 to 30% in 2060: the number of over 80s will be also predicted to rise to 11.5% (Creighton 2014). As part of this global trend, Japan has become a super-aged society with one in four persons over the age of 65 (Kawahara and Narikawa 2015). The number of older drivers is also increasing, and in 2012, there were over 15 million drivers over the age of 60 and more than 1 million of these were over 80 (IAM 2012). Figures from the USA indicate that there will be 33 million drivers aged over 65 years by 2020 (Marottoli and Richardson 1998). In addition, Tamiya et al. (2011) have predicted that by 2020, drivers aged 65 and older will represent 16.2% of the driving population in the USA. The fastest growing driving population is the older-old (drivers age

75 and over) meaning that automotive engineers need to consider these older buyers (Bhise 2011).

The effects of the ageing process on the body are well known and well documented. In terms of anthropometry, stature (and associated measures) decreases with age particularly in women, due to muscle atrophy, and compression and thinning of the inter-vertebral discs; body size and girths decrease in later years at about 50 years in men and 60 years in women (Pheasant and Haslegrave 2006); range of joint motion and flexibility of tendons declines with increasing age (Herlihy 2007; Steenbekkers 1998); muscle strength shows a rapid decline after the age of 50 (Metter et al. 1999); and the tolerance and recovery of spinal tissues reduces (McGill 2007). In addition, there are sensory impairments such as reduced contrast sensitivity, discrimination and visual acuity (Ortiz et al. 2013), and a reduction in the detection of high-frequency sounds (Panno 2005; Whitbourne 2002); Giacomini 2014 estimates that the majority of the over 50s experience some level of hearing loss.

It is important to remember that people will age at different rates dependent on both intrinsic (eg genes, gender) and extrinsic (eg diet, environment, lifestyle)

**Table 1.** Structure of the survey and summary of questions.

Sections	Questions
Background	Age? Gender? Work (F/T, P/T), /retired/student (job title, hours, time with employer)? Drive as part of job (hours)?
Main vehicle	Make? Model? Automatic? Annual mileage? Hours/week?
Musculoskeletal symptoms	Nordic Musculoskeletal Questionnaire (NMQ)
In-vehicle controls	Headlights, indicators, horn, wipers, temperature, radio, pedals, hand brake, mirrors Operation of controls (5-point scale: very difficult – very easy)
Vehicle seat controls	Fore-aft adjustment, backrest angle, seat height, lumbar (in/out, up/down), head restraint (height, distance), seat belt (reach, pulling across body, fastening/unfastening, setting up) Satisfaction with adjustments (5-point scale: very dissatisfied – very satisfied)
Accessing vehicle	Opening the car door, ingress/egress, the boot, car bonnet, fuel cap, trips/falls Comfort (5-point scale: very comfortable – very uncomfortable)
Driving performance	Parking (parallel, car park), driving in the daylight/dark, reversing, weather conditions (sun, rain, fog), making a right turn onto a main road, keeping a constant speed, safe distance, busy traffic, changing lanes Carrying out driving tasks (5-point scale: very difficult – very easy)
Driving behaviours	Speed, reaction time, night vision, reading signs, reaching and operating controls, using technology, accidents Extent of agreement with 15 statements (5-point scale: strongly disagree – strongly agree)

factors. Smith, Meshkati, and Robertson (1993) conclude from an overview of the literature that older people show the greatest individual variability of any age cohort, and therefore, chronological age is a poor predictor of physical and behavioural aspects of driving. For example, in an anthropometry study of 750 participants, it was found that although force exertion decreases with age, the differences between males and females were much larger than those between age groupings (Voorbij and Steenbekkers 1998).

General ageing combined with the effects of injury or disease over the life course will have an effect on physical and mental capabilities including those influencing and required of the driving task. Despite this, there is surprisingly little empirical research in this area but difficulties include the following:

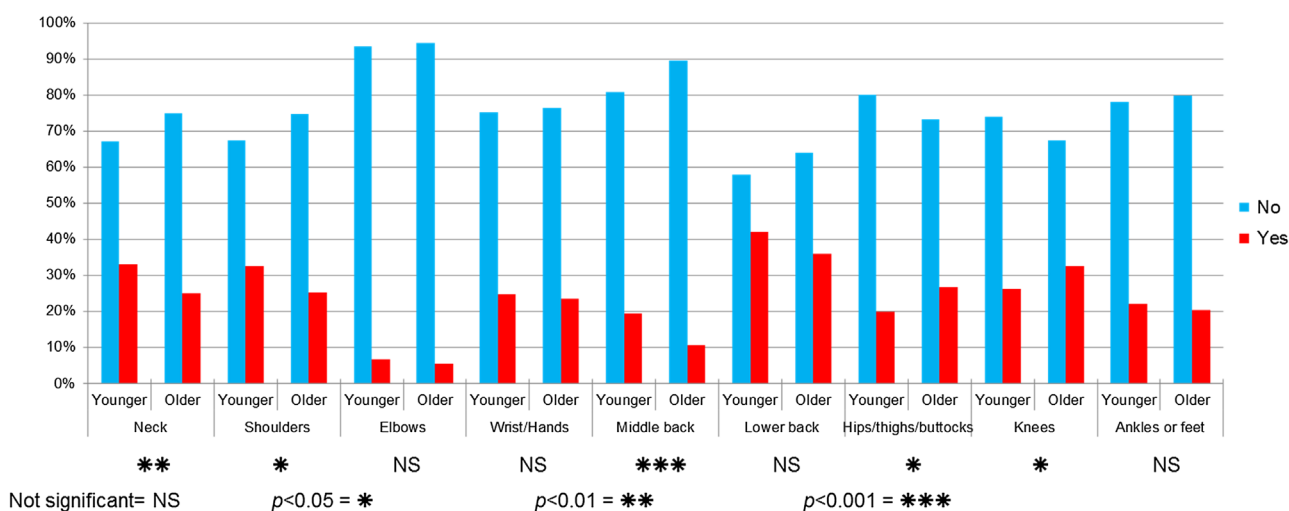
- Maintaining a constant speed following a vehicle and on the motorway, keeping within lane (Bunce et al. 2012).
- Turning the head and body to park, reduced field of view, unintentional speeding, difficulties reading engine feedback with quieter modern engines (Bradley et al. 2008).
- Identifying road signs, maintaining a constant speed, parking and reversing, glare from the sun, driving at night and longer reaction times (Musselwhite and Haddad 2008).
- Reduced reaction times with complexity, longer decision times, making right turns (Middleton et al. 2005).
- Difficulty with ingress/egress (Herriotts 2005)

In a super-aged society, where the majority of the population are older and many have reduced physical and mental capabilities, there is a need to ensure that products and services are well designed so that people can engage with them. Goddard and Nicolle (2012) reported that from the older users' perspective,

a good design is easy to use, functions in the way that is expected and is simple to understand. Waller et al. (2015) make the case that understanding diversity and responding to this diversity with good design decisions is paramount for inclusive design. The automotive industry is therefore facing new challenges and one such challenge is determining the needs of older drivers, a new target population (Bhise 2011). Driving is an important activity for many people and helps keep independence in tasks such as shopping, attending the doctors' surgery and visiting friends (Musselwhite and Haddad 2008). An important part of this is to understand some of the issues with current car design; studies in this area are important with the changing demographics leading to design which includes older drivers of the future. The research presented in this paper is adapted from a PhD thesis concerned with improving the driving experience of older drivers (Karali 2015).

## 2. Methodology

A questionnaire survey was conducted to explore key issues with the driving experiences of older compared with younger drivers and identify key challenges for the automotive sector. Baseline data were collected such as age, vehicle type and annual mileage together with musculoskeletal symptoms experienced. Questions then focussed on potential issues for older drivers identified from the literature (Table 1). For example, physical limitations may affect the operations of in-vehicle controls, adjusting the vehicle seat and accessing the vehicle. Self-ratings of driving performance were obtained based on the Driving Habits Questionnaire (Ortiz et al. 2013; Owsley et al. 1999). Perceptions of driving behaviours were captured based on levels of agreement with some of the issues identified in the extant literature. Finally, participants were asked to write any other comments in each section of the questionnaire as appropriate.



**Figure 1.** The 12-month prevalence of musculoskeletal symptoms, older compared with younger drivers ( $n = 903$ ).

A stratified sampling technique was employed, whereby the driving population was divided into subgroups by gender and age (20–34, 35–49, 50–64, 65–79, 80+). Motoring organisations (eg ROSPA, IAM), older peoples' networks (eg Age UK, University of the Third Age) and public places (eg supermarkets, service stations) were used to randomly target drivers. Snowball techniques were also used to broaden the sample. Participation was voluntary, and approval was received from the Loughborough University Ethical Committee. Supplementary interviews ( $n = 15$ ) were also conducted with a different sample of older drivers (65 and over), using the questionnaire as the basis for the interview. These interviews were aimed at specifically obtaining qualitative data and to gain further understanding of some of the issues involved in the driving experiences of older drivers.

Data from the questionnaire were analysed using SPSS and Excel, to gain an understanding of the whole sample and differences between age and gender. Statistical methods such as chi-squared, Mann–Whitney  $U$ -test and log linear analysis were used. Analysis of the interview data was based on a thematic qualitative data analysis which was conducted manually by selecting the main themes of the questionnaire.

### 3. Results

Over 900 drivers took part in the questionnaire survey which took place between July and September 2012; 46.5% ( $n = 420$ ) were older drivers (65 and over) and 53.5% ( $n = 483$ ) were younger (under 65). Drivers aged over 80 represented 7.1% ( $n = 64$ ) of the sample. About 59% of drivers in the sample were male and 41% were female. With regard to exposure to driving (in terms of annual mileage), only 14% of older drivers drove above 10,000

miles/year compared with 31% of younger drivers. Only 5% of drivers over 80 years old did this kind of mileage. The interviewees ( $n = 15$ ) were males and females aged 65–79 and 80+.

#### 3.1 Musculoskeletal symptoms

High levels of musculoskeletal symptoms were reported in the lower back (39.2%), knees (29.2%), neck (29.2%) and shoulders (29.1%) for the whole sample. Significantly, more symptoms of discomfort were reported by older drivers in the hips/thighs/buttocks ( $p \leq 0.05$ ) and knees ( $p \leq 0.05$ ) in the last 12 months compared to younger drivers (Figure 1). However, younger drivers reported higher levels of symptoms in the middle back ( $p \leq 0.001$ ), neck ( $p \leq 0.01$ ) and shoulders ( $p \leq 0.05$ ). Not surprisingly, younger drivers reported more of their symptoms were directly related to their work: the neck ( $p \leq 0.001$ ), shoulders ( $p \leq 0.001$ ), wrist/hands ( $p \leq 0.001$ ), middle back ( $p \leq 0.001$ ), lower back ( $p \leq 0.001$ ), hips/thighs/buttocks ( $p \leq 0.01$ ) and ankles or feet ( $p \leq 0.01$ ). This indicates that the level of activity of the younger respondents may be greater than the older ones.

#### 3.2 In-vehicle controls

In general, drivers found it easy to operate most in-vehicle controls. Difficulties in pressing the horn were the most frequently reported problem: 7.5% of participants found it difficult or very difficult, followed by difficulties with temperature controls (5.7%), side-view mirror (4.3%) and radio (4.0%). Age and gender were also compared, and no significant differences were found with age but more difficulties were found by females in pressing the horn ( $p \leq 0.01$ , 10.1% of females compared to 5.7% of males). The supplementary interviews revealed that in

**Table 2.** Reported driving performance, whole sample, older and younger drivers ( $n = 902^*$ ).

Driving behaviours	All drivers ( $n = 903$ )	Older ( $n = 420$ )	Younger ( $n = 482^*$ )	Chi-squared ( $p$ ) ( $p \leq 0.05$ )
Difficult = difficult and very difficult, * = 1 missing case	Difficult (%)	Difficult (%)	Difficult (%)	
Driving on a foggy day	20.7	25.2	17.0	$p = 0.002$
Parallel parking between two cars at the side of a road	14.4	16.4	12.7	
Driving in the dark	9.3	10.5	8.7	
Reversing the vehicle	7.2	8.1	6.4	
Driving in the rain	6.2	4.8	7.5	
Driving on a sunny day	5.0	5.7	4.6	
Driving in busy traffic	3.7	1.9	5.2	$p = 0.009$
Parking in a marked space in a car park	3.4	3.1	3.7	
Changing into another lane when driving on a dual carriageway	3.4	3.3	3.5	
Making a right turn onto a main road	2.3	2.9	1.9	
Keeping a constant speed	1.8	2.1	1.5	
Keeping a safe distance from the car in front	1.3	1.2	1.5	
Driving in daylight	0.7	0.5	0.8	

emergency situations, older drivers cannot always press the horn instantly. The small size, locating the controls and the angle of the steering wheel were reported to cause delay in operation, particularly if the driver was focusing on the road

### 3.3 Vehicle seat controls

Drivers were more frequently dissatisfied with setting the seat belt height (10.5%), adjusting the headrest (10.5%) and adjusting the lumbar support (8%). No significant differences were found with age, but females reported significantly more difficulty than males with adjusting the headrest height ( $p \leq 0.001$ ). Reasons given for this difficulty included reaching, accessing and operating the controls while seated.

### 3.4 Accessing the vehicle

The survey found that 9.7% of participants reported being uncomfortable with egress and 6.9% with ingress but no age and gender differences were found. Regarding the question based on fall/trip incidents, the majority (94.1%) reported never experiencing a fall/trip incident. However, this does equate to 1 in 17 of the sample having an accident. Surprisingly, 8.1% of younger drivers reported fall incidents compared to 3.3% of older drivers ( $p \leq 0.01$ ). With gender, 7.9% of females reported experiencing a fall incident compared to 4.5% of males ( $p \leq 0.05$ ).

Participants were asked to indicate ease of access to specific features of their vehicle. The greatest number of difficulties was reported with the release button on the bonnet (18.5%), the release button in-vehicle (13.1%), reaching and pulling the boot door down to close it (8.2%) and lifting the bonnet (8.2%). Age and gender were compared: females reported more difficulties than males operating the release button in-vehicle ( $p \leq 0.001$ ) and with the release button on the bonnet ( $p \leq 0.001$ ). No

significant differences were found with age. With reaching and pulling the boot door down to close, 11.8% of older drivers compared to 5.2% of younger drivers reported difficulties ( $p \leq 0.001$ ). In addition, more females (13.6%) than males (4.5%) reported difficulty ( $p \leq 0.001$ ). Binary logistic regression was used to explore any interaction between age and gender but this was not significant indicating that this finding was not specifically older females. However, in the supplementary interviews, older females reported reasons as being shorter in stature and having less mobility and reduced reach.

### 3.5 Driving performance

Participants were asked to indicate how they find carrying out specific driving tasks (Table 2). The most frequently reported problems were driving on a foggy day (20.7%), parallel parking (14.4%) and driving in the dark (9.3%). Older drivers more frequently reported difficulty driving on a foggy day than younger drivers (25.3% compared with 16.8%,  $p \leq 0.01$ ), and females reported more difficulty than males (29.3% compared with 14.8%  $p \leq 0.001$ ). In order to investigate whether there was an interaction with the variables age and gender, a log linear analysis was carried out to examine 3-way interactions (ie foggy day/parallel parking  $\times$  age  $\times$  gender). However, the third-order effect was not significant for any of these variables, so there is no evidence that the effect of age is different for males and females. This can be interpreted that older drivers are experiencing more difficulty compared to younger drivers; it is not specifically older females that have difficulty.

Similarly, with parallel parking, 16.9% of older drivers compared with 12.3% of younger drivers reported difficulty ( $p \leq 0.01$ ) and 20.1% of females compared with 10.5% of males ( $p \leq 0.001$ ). There were no age and gender differences with driving in the dark, but the supplementary interviews indicate that older drivers are less likely to drive at night anyway.

**Table 3.** Reported driving behaviours, whole sample, older and younger drivers ( $n = 902^*$ ).

Driving behaviours	All drivers ( $n = 903$ )	Older ( $n = 420$ )	Younger ( $n = 482^*$ )	Mann-Whitney <i>U</i> -test ( $p$ )
Agree = agree and strongly agree, $*=1$ missing case	Agree (%)	Agree (%)	Agree (%)	
Other drivers' lights restrict my vision when driving at night	46.7	45.2	48.1	
I have difficulty turning my head and body around when reversing	24.5	27.9	21.6	$p = 0.000$
Operating entertainment systems distract me from driving (eg playing radio)	23.7	21.4	23.7	
Operating navigation systems distract me from driving	22.9	19.0	26.3	$p = 0.051$
I feel more safe driving below the speed limit	22.8	24.3	23.2	
I worry about having an accident	17.8	15.2	20.1	
My reactions are slower that they used to be (eg braking in an emergency)	15.6	19.3	12.9	$p = 0.000$
I sometimes cannot judge my speed	10.4	7.6	12.0	$p = 0.01$
I have difficulty judging the speed of oncoming vehicles	10.0	9.3	11.6	$p = 0.06$
I sometimes have difficulty with identifying and reading road signs	9.9	9.0	10.6	
I sometimes cannot hear the horns of other vehicles/sirens from emergency vehicles	8.6	7.9	9.5	$p = 0.07$
I sometimes have trouble judging the distance from the vehicle in front	5.2	4.5	5.8	
My speedometer is hard to read during the day time	4.9	4.8	5.4	
My speedometer is hard to read driving at night time	3.1	3.1	2.9	$p = 0.98$
I sometimes push the wrong pedal	2.4	1.7	3.1	

### 3.6. Driving behaviours

Self-reported driving behaviours are shown in Table 3. Half of all respondents (46.7%) reported that other drivers' lights restricted their vision when driving at night; more females (53.3%) than males (42.5%) reported this ( $p \leq 0.001$ ). No age difference was found, which may be because older drivers are less likely to drive at night. Older drivers (31.7%) reported more difficulties than younger drivers (18.4%) with turning their head and body around during reversing ( $p \leq 0.001$ ). Similarly, older drivers reported their reactions were slower than they used to be (eg braking in an emergency situations) compared to younger drivers ( $p \leq 0.01$ ). Older drivers also reported being less distracted by operating navigation systems (19.5% compared with 25.5%) but no significance was found. Reasons for this may include that older drivers are more experienced, they know the routes and they tend to travel shorter distances; therefore, they may be less likely to use these technologies compared to younger drivers. No other significant differences due to age and gender were found.

## 4. Discussion

The survey has provided a large data set to identify the key issues with driving experiences of older compared to younger drivers and compare and evaluate the findings with the literature. Interestingly, it has been identified that most of the issues found in the literature over the last 20 years still exist today and many are common for both older and younger drivers. For example, in the literature review conducted by Smith, Meshkati, and Robertson (1993) on older drivers, issues were found to be driving at

night, turning the head and body around when reversing, reaching the seat belt and getting in/out of the vehicle.

Significantly, more discomfort was reported by older participants in the hips/thighs/buttocks and knees compared to younger. In a study conducted by Porter and Gyi (2002), the 12-month prevalence of musculoskeletal symptoms in the large joints such as hips, ankles and elbows was found to be higher in older ages. In the current study, no significant differences were found for ankles and elbows between younger and older age groups. Also, although not significant, there was a trend for older participants to report less lower back discomfort compared to younger. This was also reported by Porter et al. (1992) and was due to the specification of the car, particularly the fact that the older participants drove more luxury cars with more adjustable features: there was a positive correlation with the price of the car and the drivers' age. For the current study, younger participants reported higher levels of musculoskeletal symptoms in the neck, shoulders and middle back than older. This may be related to the driving exposure lower as annual mileage and weekly driving hours were reported by the older drivers. In addition, the level of activity of younger participants was greater than for older ones (eg work). High levels of musculoskeletal symptoms were reported in the lower back, knees, neck, shoulders and elbows by the whole sample. Some similarities were found with the pattern of musculoskeletal symptoms in other studies of drivers, for example pharmaceutical sales representatives (Sang, Gyi, and Haslam 2009), whereby the lower back, neck and shoulders were most frequently reported areas.

Based on the seat features and their adjustability, the features that caused the most dissatisfaction were headrest

(distance from the head), headrest (height), setting the seat belt height and lumbar support adjustments. There were significant differences by gender but not with age: generally, females reported more difficulty. It is important to acknowledge that all these seat features require a certain amount of reach, turning the body while seated and fine adjustment to set them to the desired position. Therefore, the location and the reach distance of these adjustments could have an impact on this response. An interesting finding from the survey was associated with accessing specific vehicle features, such as the release button on the bonnet and the bonnet release button in-vehicle. No significant differences were found with age, but there were significant differences between males and females. This may be related to the experience of the users with these controls and how often they use them. The supplementary interviews found that the majority of these interviewees (particularly females) reported that they never used these features and that they were only accessed when they take their vehicle for servicing.

Reaching and pulling the boot door down to close was also reported as a difficult task, and age and gender differences were found. This is likely to be as a result of females being shorter than males making these reach tasks more difficult and to some extent ageing on the body as there is a reduction in the stature and flexibility (Perissinotto et al. 2001; Pheasant and Haslegrave 2006; Sorkin, Muller, and Andres 1999). Bhise (2011) also describes the potential effect of ageing on interaction with vehicle features such as lifting the boot and unlatching seat belts but this was not found with the current study. These are clearly design-related issues that need more focus on the needs of older drivers and females.

The responses from the survey showed that the most uncomfortable task related to ingress/egress was getting out of the vehicle (9.5% of whole sample): in general, getting into a vehicle was considered an easier task. This finding was similar to a questionnaire survey conducted by Herriotts (2005) of 1000 drivers; comparing older (age 60–79) with younger drivers (aged 20–59) difficulty with egress was reported by 32.2% of the older drivers and ingress by 25.5%. The main car features identified as causing difficulties with entering and exiting a vehicle were the sill height, seat cushion, door aperture and the steering wheel.

It is worrying that in the current study, 6% of the sample had experienced a fall incident during ingress/egress, but this was mainly with egress. In addition, fall incidents were more common with younger drivers ( $p \leq 0.01$ ), and the main explanation is that younger drivers reported rushing to get out of the car. Dellinger, Boyd, and Haileyus (2008) conducted a study analysing the injuries admitted to emergency departments in USA (2001–2003), whereby

43% of these injuries were falls related to ingress/egress from vehicles, but in this case, they were mainly associated with older drivers. As older people can be frail, they may need to attend hospitals to get treated after any fall incident, leading to hospital admissions being higher.

Data based on the driving performance showed similarities with the literature, such as difficulty with driving in bad weather, eg foggy days, driving at night and parking/reversing; this was observed for the whole sample but particularly older drivers. Smith, Meshkati, and Robertson (1993) reported a decline in miles driven with increasing age and that older drivers avoid driving in bad weather and at night. Also, the supplementary interviews from the current study found that older drivers were less likely to drive at night. In studies conducted by Bradley et al. (2008) and Musselwhite and Haddad (2008), as with the current study, parking and reversing the vehicle were reported as the most difficult tasks to perform by older drivers compared to younger. Some of the reasons for this were due to decline in physical capabilities such as difficulty turning body around and variation of visibility/field of view in contemporary vehicles. These authors also indicate that older drivers also experience difficulty keeping a constant speed, but the findings of the current study showed that only 1.8% of the whole sample reported this and there was no relationship with age.

An important safety-related finding of this study was related to driving behaviour, where half of the whole sample reported other drivers' lights restrict their vision when driving at night – 47% of drivers reporting problems. In addition, 25% of the whole sample (in particular older drivers) reported difficulty turning their head and body around when reversing. This was also observed by Isler, Parsonson, and Hansson (1997) in a study focused on the age-related effects of restricted head movements on the useful field of view of older drivers. This indicates that as advocated by Gyi (2013) that more data are needed to focus on dynamic and functional anthropometric measurements in vehicle design to accommodate specific needs of older drivers, such as postures for reversing. Similarly, 21% of older drivers reported their reactions were slower than they used to be, compared to 11% of younger drivers. This finding was also identified by Middleton et al. (2005) where drivers aged 65 and over had significantly longer decision times when carrying out specific driving tasks based on a simulation study. In addition, in the interview study conducted by Musselwhite and Haddad (2008), participants also reported this. Regarding the navigation and entertainment systems, older drivers reported having less distraction when using these systems. Reasons for this may include that older drivers are more experienced and they know the routes, they also travel short distances and are less likely to use these technologies.

Questions based on operation of in-vehicle controls indicate that in general, most participants found it easy to operate most in-vehicle controls. The greatest difficulty reported was with pressing the horn (7.5% of the whole sample). No significant differences were found with age but there were, however, differences in gender: 10.1% of females compared to 5.7% of males found it difficult pressing the horn ( $p < 0.01$ ). This issue related to the horn has not been identified in the literature. Depending on the vehicle make/model, it is possible that the horn controls are different sizes, forms and are located in different positions on or near the steering wheel. This needs further exploration in order to determine the requirement for ideal location, size and visibility of these controls in order to prevent the difficulties reported and which may be experienced in future. With regard to older drivers' use of the horn, supplementary interviews indicate that in emergency situations, older drivers cannot always press the horn instantly; this was mainly due to the small size of the horn. The angle of the steering wheel and the location of the controls also seem to have an effect, for example if the horn button is located on both sides of the steering wheel, the driver cannot locate it as they are focusing on the road; this causes delay with finding the horn button. Research conducted by Ryu et al. (2009) focusing on older drivers' interaction with in-vehicle controls reported that compared to younger, older people took longer (slower reaction time) and with higher error rates in general during actual driving conditions. This study was looking at interaction of older drivers with the LCD display, cluster gauge and temperature controls/air conditioning in order to establish design guidelines for this age group by focusing on visibility and accessibility to these controls.

## 5. Limitations

Since these data were collected in the UK, some of the findings may not be applicable globally, due to different cultural, environmental and physical characteristics. Another limitation is that during the interviews with older drivers (particularly the over 70s), it was observed that they were limiting themselves with regard to expressing the difficulties they experienced. Although it was clearly explained to them the information they provide will be kept confidential, they had concerns that their licence might be taken away.

It is also important to consider the population available for study; the 'healthy worker effect' can mean that studies investigating a sample of drivers provide only a sample of the drivers who are fit and able to drive. Those who are unable to drive will inevitably not be present in the sample population, therefore risking a biased set of results.

## 6. Conclusions

This study has provided data to understand the key issues reported by drivers of all ages. Difficulties with the seat controls were common for all ages such as adjusting the headrest (height and distance), seat belt height and lumbar support. Access to the bonnet, the boot of the vehicle and pressing the horn were particular problems for female drivers. Driving at night (other drivers' lights) was reported as a problem by nearly half the sample and was as much of a problem for younger drivers. Some issues were, however, age related, such as older drivers reporting difficulties turning their body to reverse the vehicle and parking, and performance measures, such as driving on a foggy day and emergency braking.

It is interesting that many of the problems identified in this study are similar to those identified in the literature from more than 10 years ago with the implication that cars still do not fully meet customer needs. The automotive industry is facing the challenge of including the needs of older drivers, and although technology is improving, cost effective solutions are hard to achieve in the competitive environment of the industry.

The findings of this research will be used to focus in more detail on understanding how design of the vehicle cab impacts on posture, comfort, health and well-being in older drivers.

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