Is distracted driving performance affected by age? First findings from a driving simulator study

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Abstract

The objective of this research is the investigation of the effect of age on distracted driving performance. For this purpose, a driving simulator experiment was carried out at the simulator of the National Technical University of Athens, in which 72 participants from three different age groups were asked to drive under different types of distraction (no distraction, conversation with passenger, mobile phone use) in rural road environment. The data collected from the driving simulator experiment include longitudinal control measures (mean speed, headways), lateral control measures (lateral position) and the reaction time of the driver at unexpected incidents and their analysis showed that distracted driving performance is indeed affected by age. More specifically, participants either talking on the mobile phone or conversing with a passenger were found to drive at lower speeds, with increased headways and with higher reaction times compared to undistracted driving. Furthermore, regarding different age groups, the effect of distracted driving on older drivers is higher than the respective effect in middle aged drivers, while driving distraction has the lowest impact on young drivers.

Keywords: Road safety, driving simulator, driver distraction, driving behaviour.

1. Introduction

Over the next decades, there will be a substantial increase in both the number and proportion of older people in industrialized countries (OECD, 2001). With the aging of the population it is also anticipated that there will be an increase in older drivers licensing rates (Hakamies-Blomqvist, 1993) and in passenger car use. Demographic growth, increased licensing rates and increased car use will combine to produce an increase in the number of older drivers on the road and will lead to a commensurate increase in future accident levels (Trick and Caird, 2001).

Although older drivers are involved in a few accidents in terms of absolute numbers, they represent one of the highest risk categories for accidents involving fatalities and serious injuries per number of drivers and per distance travelled, probably because of their great fragility and reduced tolerance to injury (OECD, 2001). Li et al. (2003) have estimated that at least 60% of the increase in fatality rate per distance travelled for those aged 60 and over can be accounted by increases in fragility.

Moreover, driver distraction is estimated to be an important cause of vehicle accidents. Although driver distraction can be considered as part of everyday driving, the penetration of various new technologies inside the vehicle, and the expected increase of use of such appliances in the next years, makes the investigation of their influence on the behaviour of drivers and on road safety very essential.

Furthermore, although older drivers represent the fastest growing segment of the driving population, limited research has been conducted to evaluate the impact of distraction on driving performance and accident risk among older drivers.

Lam (2002) examined the association between distraction, both inside and outside the vehicle, and the risk of being in an accident for drivers of different ages. Fatal and casualty crash data collected by New South Wales police during 1996-2000 were examined, and crashes were categorized as resulting from no distraction, from distraction inside the vehicle, from distraction outside the vehicle, and from using a handheld phone. Lam reported that there was no significant increase in the risk of being killed or injured in a crash for drivers using a handheld phone in most age groups, when compared with those crashed drivers without any distraction, except for 25-29 years old drivers.

Similarly, the National Highway Traffic Safety Administration 100-Car Study (Dingus et.al., 2006) demonstrated that the rate of inattention-related crashes and near-crashes (where inattention activities included drivers eating, writing, conversing with a passenger, or looking away from the forward roadway at rear-view mirrors, or at objects inside or outside the vehicle) decreased dramatically with age. Inattention rates were found to be as much as four times higher for younger drivers (18-20 years) relative to older drivers (35 years and older).

Vollrath et.al. (2002) reported 28% reduction in the risk of a driver being responsible for an accident in the presence of passengers. A possible explanation for this finding is that older drivers use passengers as co-pilot to help them navigate to unfamiliar destinations or to alert them to potential hazards. However, although Vollrath et. al. (2002) showed that this benefit was strongest in some situations (e.g., keeping a safe distance from other cars), it was weaker in other situations (e.g., at crossroads, in situations involving right of way, while overtaking, while turning).

Most recently, McEvoy et al. (2007) examined the prevalence and type of distracting activities involved in serious injury crashes. Interviews were conducted with hospitalized drivers within hours of their crash. Types of distracting activities before the crash included passengers (11.3%) lack of concentration (10.8%) an outside object/person/event (8.9%) adjusting in vehicle equipment (2.3%), mobile phone (2%), other object/animal/insect in vehicle (1.9%), smoking (1.2%), eating or drinking (1.1%), or other (0.8%). Crashes involving a distracting activity were more likely to be reported by young drivers (17-29 years) compared with drivers aged 50 years and older (39.1% vs. 21.9%). Driving experience was also a strong predictor of distraction-related crashes (38% for drivers with less than 10 years' experience vs. 21% for drivers with more than 30 years'). As expected, age was highly correlated with driving experience. For each additional year of driving experience, a driver was 2% less likely to have a crash involving a distracting activity.

Similarly, Bedard and Meyers (2004) reported that, although the presence of passengers exerted an overall protective effect for older drivers (65 years and older), the beneficial effect was not present for all types of actions. For drivers aged 65 to 79 years, the presence of passengers was associated with a reduced risk for some unsafe actions (e.g., driving the wrong way), but a higher risk of other actions (e.g., ignoring signs, warnings, or right of way).

The objective of this research is the investigation of the effect of the age on distracted driving performance. The paper is structured as follows: In the beginning, older driver behaviour characteristics critical for safe driving are presented. Then, a large driving simulator experiment is presented, in which participants from three different age groups were asked to drive under different types of distraction (no distraction, conversation with passenger, mobile phone use) in rural road environment. Finally, the results are presented and discussed and some concluding remarks are provided.

2. Older driver behaviour and safety characteristics

The road safety of older road users is to a large extent determined by two factors: functional limitations and physical vulnerability. Both factors contribute to the relatively high fatality rate for older road users as a result of accidents. Functional limitations can increase accident risk, whereas a higher physical vulnerability increases injury severity.

A third reason for the high fatality rate of older adults seems to be their low annual mileage. In general, drivers travelling fewer kilometers have increased accident rates per kilometer compared to those driving more kilometers (Safetynet, 2009). These three explanations for the high fatality rate for older drivers are most probably connected, with the physical and mental condition of the driver having the biggest influence on the other two factors. Drivers who have a medical condition are also likely to be more fragile than other older drivers and will also drive less frequently or at least drive shorter distances.

Regarding the cognitive functions related to older driving, several researchers (Parasuraman and Nestor, 1991; Duchek et al., 1998) have argued that selective attention is most specific to driving deficits in older drivers, or in drivers with some pathological condition (e.g. dementia). Identifying important information in the environment while ignoring irrelevant information may be especially important driving skills. Drivers may compensate for declines in selective attention by driving more slowly, thereby allowing more time for information processing (Hakamies-Blomqvist, 1993). Furthermore, visuospatial deficits are commonly observed in older drivers, especially with early dementia, represented by a disturbance in formative activities such as assembling, building, and drawing, so that the individual is unable to assemble parts in order to form a whole (Benton, 1994).

Regarding basic accident characteristics, many older-driver collisions occur at intersections. Additionally, older drivers face difficulties with increasingly complex road design and traffic conditions, particularly when driving at higher speeds (Holland, 2001) and on freeways (Knoblauch et al., 1997; Lerner and Ratte, 1991; Vardaki, 2008). Driving-performance problems include a reduced capacity for comprehending instructions and judging gaps, decreased visual search and problems in maintaining speed (McKnight and McKnight, 1999). Relevant studies on pre-crash manoeuvres and contributing factors to freeway crashes indicate that older drivers are much more likely than younger drivers to be merging or changing lanes, or passing/overtaking prior to a crash (Staplin et al., 2001).

3. Methodology

3.1. Overview of the experiment

Driver distraction research often makes use of driving simulators, as they allow for the examination of a range of driving performance measures in a controlled, relatively realistic and safe driving environment. Driving simulators, however, vary substantially in their characteristics, and this can affect their realism and the validity of the results obtained. Despite these limitations, driving simulators are an increasingly popular tool for measuring and analyzing driver distraction, and numerous studies have been conducted, particularly in the last decade.

Within this research, a large driving simulator experiment was designed by an interdisciplinary research team of transportation engineers, neurologists and psychologists. The experiment includes three types of assessments:

- Medical / neurological assessment:
  The first assessment concerns the administration of a full clinical medical, ophthalmological and neurological evaluation, in order to well document the presence of a disorder and its characteristics.
- Neuropsychological assessment:
  The second assessment concerns the administration of a series of neuropsychological tests and psychological-behavioural questionnaires to the participants.
- Driving at the simulator:
  The third assessment concerns the driving behaviour by means of programming of a set of driving tasks into a driving simulator for different driving scenarios.

3.2. Sampling scheme

The sample of participants comprises two distinct groups:

- One "impaired" group of participants with some pathological condition (e.g. neurological disease), explicitly selected by the neurology / neuropsychology research teams.
- One "control" group of participants with no known pathological condition.

A sample of 300 participants is to be examined in approximately 2 years time. Currently the experiment is at an early stage and 72 healthy participants aged 25-75 years old have completed the driving trials. Impaired participants are not considered in this research. It is therefore noted that the preliminary findings of this work are based on a relatively small sample of drivers, and therefore need to be considered with some caution.

3.3. Driving at the simulator

The design of the distracted driving scenarios is a central component of the experiment and includes driving in different road and traffic conditions, such as in a rural, urban area with high and low traffic volume. More specifically, this assessment includes an urban driving session with up to six trials and a rural driving session with up to six trials. These trials aim to assess driving performance under typical conditions, with or without external distraction sources. The driving simulator experiment takes place at the Department of Transportation Planning and Engineering of the National Technical University of Athens, where the Foerst Driving Simulator FPF is located. It is a quarter-cab simulator with a motion base.

The driving simulator experiment begins with a practice drive (usually 5-10 minutes), until the participant fully familiarizes with the simulation environment. Afterwards, the participant drives the two sessions (~20 minutes each). Each session corresponds to a different road environment:

- A rural route that is 2.1 km long, single carriageway and the lane width is 3m, with zero gradient and mild horizontal curves.
- An urban route that is 1.7km long, at its bigger part dual carriageway, separated by guardrails, and the lane width is 3.5m. Moreover, narrow sidewalks, commercial uses and parking are available at the roadsides.

Within each road / area type, two traffic scenarios and three distraction conditions are examined in a full factorial within-subject design. The distraction conditions examined concern undistracted driving, driving while conversing with a passenger and driving while conversing on a mobile phone.

The traffic scenarios are:

- QL: Moderate traffic conditions – with ambient vehicles' arrivals drawn from a Gamma distribution with mean m=12 sec, and variance σ^2=6 sec, corresponding to an average traffic volume Q=300 vehicles/hour.
- QH: High traffic conditions – with ambient vehicles' arrivals drawn from a Gamma distribution with mean m=6 sec, and variance σ^2=3 sec, corresponding to an average traffic volume of Q=600 vehicles/hour.

Consequently, in total, each session (urban or rural) includes six trials, i.e. six drives of the simulated route. During each trial of the experiment, 2 unexpected incidents are scheduled to occur at regular intervals along the drive (but not at the exact same point in all trials, in order to minimize learning effects). More specifically, incidents in the rural area concern the sudden appearance of an animal (deer or donkey) on the roadway. The experiment is counterbalanced concerning the number and the order of the trials, on the basis of several combinations of the parameters of interest.

4. Results

Because it is unlikely that all potential determinants will be of equal importance to the study, and because this research is currently at an early stage and the sample is still relatively small a selection of the critical measures is necessary. As a result of the literature review and of pilot-testing different options, the following key measures were analysed in this stage:

- Mean speed - refers to the mean speed of the driver along the route, excluding the small sections in which incidents occurred, and excluding junction areas.
- Mean headway - refers to the time distance between the front of the simulator vehicle and the front of the vehicle ahead
- Standard deviation of lateral position - refers to the variability of the distance between the simulator vehicle and the right border of the road.
- Reaction time - refers to the time between the first appearance of the event - "obstacle" on the road and the moment the driver starts to brake.

In order to analyse these key measures a descriptive analysis took place through box plots. A box plot (also known as a box-and-whisker chart) is a convenient way to show groups of numerical data, such as minimum and maximum values, upper and lower quartiles, median values, outlying and extreme values.

The spacing between the different parts of the box plot indicates the degree of dispersion (spread) and skewness in the data and identify outliers. More specifically, regarding box plots:

- The line in the middle of the boxes is the median
- The bottom of the box indicates the 25th percentile. Twenty-five percent of cases have values below the 25th percentile. The top of the box represents the 75th percentile. Twenty-five percent of cases have values above the 75th percentile. This means that 50% of the cases lie within the box.

4.1. Mean speed

In Figure 1, the mean speed of drivers is presented per distraction factor (no distraction, conversation, mobile phone use) and per age group (young, middle aged, older). It is observed that older drivers drive in lower speeds regarding young and middle aged drivers, while drivers of all age groups reduce their speed, especially while talking on the mobile phone. Furthermore, while conversing with the passenger drivers do not change the mean speed in the different distraction situations.

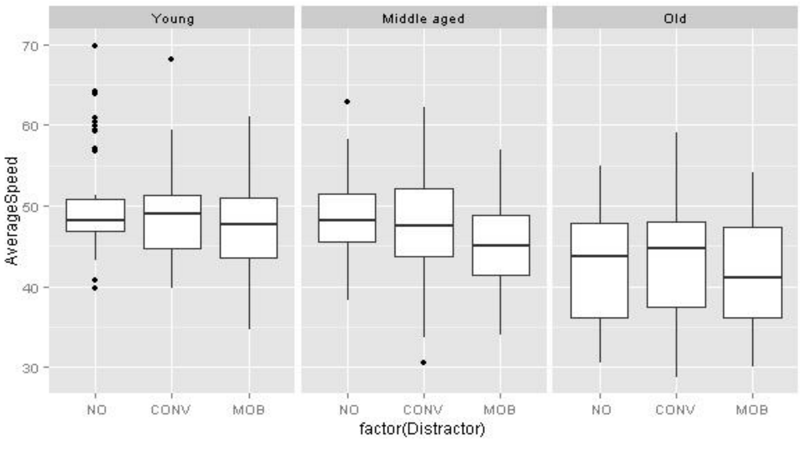

Figure 1. Average speed per distraction factor and age group

4.2. Standard deviation of lateral position

In figure 2, the variability of lateral position (standard deviation of lateral position) of drivers is presented per distraction factor and per age group and shows that it clearly differs per age group. More specifically, young drivers drive more conservatively and are better able to maintain their lateral position than middle aged and older drivers. On the other hand, there are no big differences in the standard deviation of the lateral position with or without distraction, probably because the participants drive on a single narrow lane (lane width equal to 3 meters) and there are no opportunities for e.g. lane changing, overtaking etc.

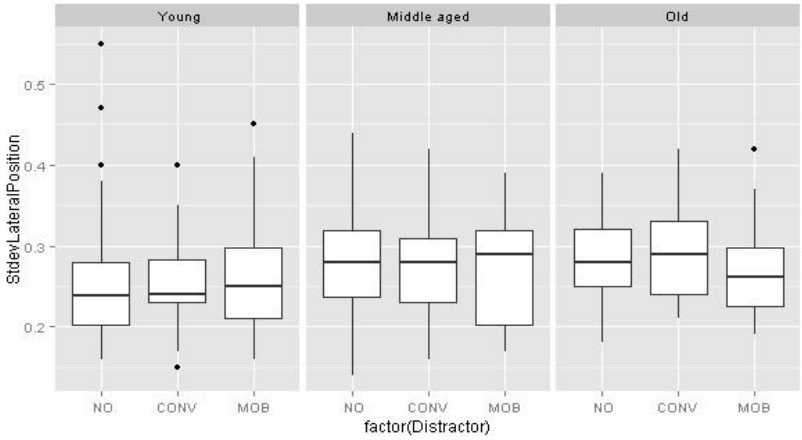

Figure 2. Standard Deviation of lateral position per distraction factor and age group

4.3. Headway

Figure 3 shows the mean headway of drivers. It is clearly observed that, while talking on the mobile phone, drivers of all age groups keep much larger headways from the vehicle ahead compared to all other trials. This is obviously happening because of their lower speed and their conservative driving. Furthermore, no pattern can be identified between conversing with passenger and driving without any distraction regarding young and older drivers.

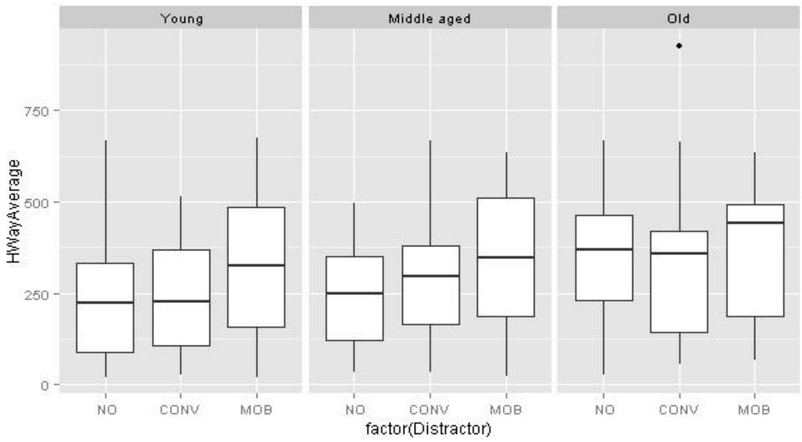

Figure 3 Headway per distraction factor and age group

4.4. Reaction time

As mentioned previously, during each trial of the experiment, 2 unexpected incidents are scheduled to occur at fixed points along the drive. In figure 4, the reaction time of drivers in these events is presented. It is observed that distracted drivers of all age groups have higher reaction times, as expected. Furthermore, the worst reaction time while talking on the mobile phone occurs in older drivers, while without any distraction young and middle aged drivers achieved the best reaction time. Finally, the reaction time of young and middle aged drivers, while conversing with the passenger, is similar with undistracted driving.

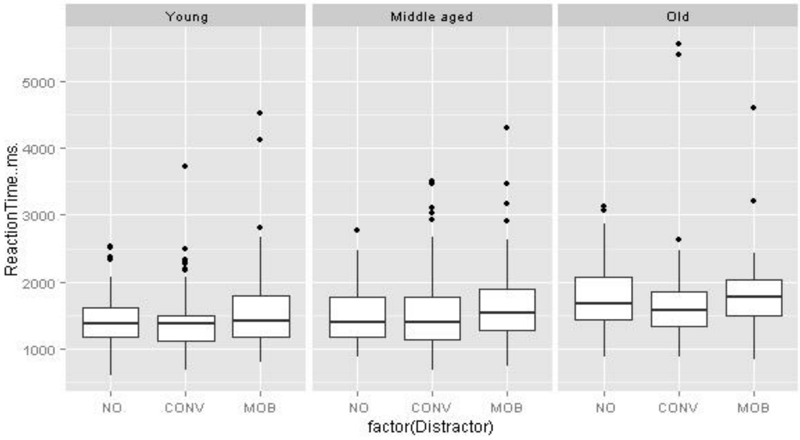

Figure 4. Reaction time per distraction factor and age group

5. Conclusions and discussion

This paper analysed the driving performance of drivers of different age groups in order to investigate the effect of age and distraction on driving parameters. For this purpose, 72 participants from three different age groups were asked to drive under different types of distraction (no distraction, conversation with passenger, mobile phone use) in rural road environment with low and high traffic volume. The preliminary results suggest that the specific methodology and design confirm the initial hypotheses and may reveal differences between driving without any distraction source, conversing with the passenger or talking on the mobile phone for different age groups.

More specifically, older drivers drive in lower speeds compared to young and middle aged drivers. Furthermore, drivers of all age groups reduce their speed, especially while talking on the mobile phone. On the other hand, while conversing with the passenger, drivers do not change the mean speed in the different distraction situations. As would be expected, this reduced speed, in general, results under given ambient traffic conditions in increased headways. The increased headways regarding driving, while talking on the mobile phone, were observed in all age groups in low and high traffic, while no pattern can be identified between conversing with passenger and driving without any distraction regarding young and older drivers.

Moreover, drivers of all age groups talking on the mobile phone were found to have difficulty in maintaining the vehicle position on the lane, while driving in rural areas. This increased variability in lateral positioning is probably due to the additional cognitive workload of the distracted driver, who drives less carefully. On the other hand, there are no big differences in the standard deviation of the lateral position, without distraction or conversing with the passenger, of young and older drivers, probably because the participants drive on a single narrow lane (lane width equal to 3 meters) and there are no opportunities for e.g. lane changing, overtaking.

The reaction time of the drivers at unexpected incidents exhibited differences between talking on the mobile phone, conversing with the passenger and driving without any distraction. Middle aged and older drivers, while talking on the mobile phone, were found to have worse reaction times, compared to driving without any distraction or conversing with the passenger, suggesting that the use of mobile phone, while driving, has a potential negative impact on road safety and may lead to increased accident risk.

It is noted that the above results concern preliminary findings from the first steps of data processing; especially on older drivers talking on the mobile phone and therefore need to be considered with some caution. For this reason, all potential effects of distracted driving on driving performance should be identified and taking into account. The representativeness of the sample could also be improved especially regarding the gender. However, the above results are quite promising and it is likely that the analysis will be enhanced in several ways.

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