Mild Cognitive Impairment and driving: Does in-vehicle distraction affect driving performance?

Ion N. Beratis[a†],
Dimosthenis Pavlou[b†],
Eleonora Papadimitriou[b],
Nikolaos Andronas[a],
Dionysia Kontaxopoulou[a],
Stella Fragkiadaki[a],
George Yannis[b],
Sokratis G. Papageorgiou[a]

[a] Cognitive Disorders/Dementia Unit, 2nd Department of Neurology, University of Athens, "Attikon" University Hospital, 1 Rimini Str, 12462 Haidari, Athens, Greece, Tel: +302105832466

[b] National Technical University of Athens, Department of Transportation Planning and Engineering, 5 Heroon Polytechniou str. GR-15773 Athens, Tel: +302107721380, Fax: +302107721454

[†] These two authors have contributed equaly and are joint first authors.

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Corresponding author: Sokratis G. Papageorgiou, MD, PhD
Head of Cognitive Disorders/Dementia Unit
2nd Department of Neurology, National and Kapodistrian University of Athens,
University General Hospital 'ATTIKON',
1 Rimini Str, 12462 Haidari, Athens, Greece,
Phone: 0030-210-5832466, Email: sokpapa@med.uoa.gr

Abstract

Objectives: In-vehicle distraction is considered to be an important cause of road accidents. Drivers with Mild Cognitive Impairment (MCI), because of their attenuated cognitive resources, may be vulnerable to the effects of distraction; however, previous relevant research is lacking. The main objective of the current study was to explore the effect of in-vehicle distraction on the driving performance of MCI patients, by assessing their reaction time at unexpected incidents and accident probability.

Methods: Thirteen patients with MCI (Age: 64.5±7.2) and 12 cognitively intact individuals (Age: 60.0±7.7), all active drivers were introduced in the study. The driving simulator experiment included three distraction conditions: a) undistracted driving, b) conversing with passenger and c) conversing through a hand-held mobile phone.

Results: The mixed ANOVA models revealed a greater effect of distraction on MCI patients. Specifically, the use of mobile phone induced a more pronounced impact on reaction time and accident probability in the group of patients, as compared to healthy controls. On the other hand, in the driving condition "conversing with passenger" the interaction effects regarding reaction time and accident probability were not significant. Notably, the aforementioned findings concerning the MCI patients in the case of the mobile phone were observed despite the effort of the drivers to apply a compensatory strategy by reducing significantly their speed in this driving condition.

Conclusion: Overall, the current findings indicate, for the first time, that a common driving practice, such as the use of mobile phone, may have a detrimental impact on the driving performance of individuals with MCI.

Keywords: Mild Cognitive Impairment; driving simulator; driving performance; reaction time, accident probability

Introduction

Mild Cognitive Impairment and driving

The concept of Mild Cognitive Impairment (MCI) has been considered and described as a cognitive state that lies between normal aging and dementia (Petersen et al., 1995). Patients with MCI exhibit cognitive decline beyond what is expected to be normal, according to neuropsychological norms, but their functionality is well-preserved and do not meet the required criteria for dementia. The most common type of MCI, defined as amnestic MCI, refers to a case in which episodic memory impairments predominate but general cognitive functioning remains intact (Petersen et al., 2001; Petersen, 2004).

MCI has been associated with various underlying etiologies (Reisberg et al., 2008). In particular, MCI may evolve as a result of a neurodegenerative process, such as Alzheimer's disease (AD); most of the subjects with memory loss (amnestic MCI) will progress to AD at a rate of 10% to 15% per year (Petersen, 2004). Also, another possible cause for the appearance of MCI is the presence of cerebrovascular pathology due to small vessel disease (executive or multi-domain) (Petersen, 2004).

Along with other common cerebral disorders affecting cognition, the association between MCI and driving behavior has been explored by several lines of previous research because of the strong link that exists between driving and cognitive functioning. As Reger et al., (2004) have suggested, the main cognitive functions critical for safe driving according to their meta-analysis that focused on patients with dementia are the following: attention (quick perception of the environment), executive functions (make rapid and accurate decisions), visuospatial skills (i.e. judging distances, maneuvering the vehicle correctly) and memory (journey planning, adapting behavior, sign recognition). Regarding the patients with MCI, a very recent meta-analysis concluded that measures engaging executive and attentional resources as well as measures of visuospatial ability and global cognition appear to be interwoven with the driving performance of drivers belonging to the specific clinical group (Hird et al, 2016).

According to previous studies, individuals with MCI as compared to cognitively intact individuals show more commonly driving difficulties in a variety of driving indexes that are associated with the optimal operation of the vehicle. For example, patients with MCI may present difficulties maintaining lane control and proper speed, taking left-hand turns, stopping at traffic signs and performing successfully a car-following task (Wadley at al., 2009; Devlin et al., 2012; Griffith et al., 2013; Kawano et al., 2012). Furthermore, they may also present shorter mean time to collision and worse overall driving performance in comparison to healthy elderly drivers (Wadley et al., 2009; Griffith et al., 2013; Hird et al., 2016) Nonetheless, on the average their driving performance is not consistently worse than that of their healthy counterparts (Devlin et al., 2012; Frittelli et al., 2009; Griffith et al., 2013; Olsen et al., 2014; Wadley et al., 2009). Also, drivers with MCI show behaviors of situational avoidance that are similar, though of a milder form, to those of people with a diagnosis of dementia (O'Connor et al., 2014; Olsen et al., 2010).

Driver distraction

Driver distraction constitutes a particular human factor of road accident causation. Driver distraction is generally defined as “a diversion of attention from driving, because the driver is temporarily focusing on an object, person, task or event not related to driving, which reduces the driver’s awareness, decision making ability and/or performance, leading to an increased risk of corrective actions, near-crashes, or crashes” (Regan et al., 2011). More specifically, driver distraction involves a secondary task, distracting driver attention from the primary driving task (Donmez et al., 2006; Sheridan, 2004) and may include four different types: physical distraction, visual distraction, auditory distraction and cognitive distraction (Breen 2009; SWOV, 2016).

Driver distraction factors can be subdivided into those that occur outside the vehicle (external) and those that occur inside the vehicle (in-vehicle). Driver distraction factors that occur inside the vehicle seem to have greater effect on driver behaviour and safety. Horberry et al., (2006) confirm that in-vehicle distraction sources have a more important effect on driver performance, compared to the increased complexity of the stimuli received from the road and traffic environment. Moreover, certain studies report that external distraction factors are less than 30% of the total distraction factors (Kircher, 2007; Stutts et al., 2005). Other studies specify that external distraction factors account for less than 10% of all distraction factors (Sagberg, 2001).

According to accumulating evidence, one of the most important in-vehicle distractors appears to be the use of mobile phone (Burns et al., 2002; Dragutinovits and Twisk, 2005; McEvoy et al., 2005; Sagberg, 2001). Patel et al., (2008) by assessing 14 common types of driver distraction, concluded that the highest perceived risk appeared in the case of mobile phone use, whereas "conversing to passengers" was considered as one of the distractors with the lowest perceived risk. Also, the greater distraction load of the mobile phone use, as compared to the conversation with passengers, was documented by NHTSA (2008). In particular, the use of mobile phone was associated with more than 3 times increased accident risk compared to "conversing with a passenger".

The aforementioned pattern of findings may be explained by previous research indicating that the mobile phone use is a high-demand distraction task that can engage all four types of distraction (Breen, 2009; SWOV, 2016). In particular, physical distraction appears when using one or both hands to manipulate the phone, visual distraction is present in cases where the gaze of the driver alternates between the road and the mobile phone's screen, auditory distraction may emerge by the initial ringing of the phone or by the actual conversation, and finally cognitive distraction occurs because the driver allocates concurrently cognitive resources in the tasks of driving and of conversation (Young et al., 2003; Dragutinovits and Twisk, 2005; SWOV, 2016).

Previous research has examined the influence of driver demographics like age and gender on driving performance under driving conditions with distraction. A greater negative impact on the reaction time of older drivers compared to young drivers that used a mobile phone was reported by Caird et al. (2008). Along the same vein, a driving simulator experiment conducted by Nilsson and Alm (1991) showed that elderly drivers' reaction time to an unexpected event was significantly larger than that of young drivers when distracted by a mobile phone conversation. Within the group of older drivers, measures of cognitive functioning that engage attentional resources appear to moderate the link between distraction and driving performance (Cuenen et al., 2015). Also, a study that focused on patients with AD, detected that the presence of difficulties on performing accurate judgments under conditions of distraction could effectively predict the deterioration of the on-road driving skills of the specific group of drivers (Ott & Daiello, 2010).

However, to the best of our knowledge previous research has not focused on the role of distraction on the driving behavior of patients with MCI, a common clinical condition with a high prevalence in the group of older drivers (Zanetti et al., 2006).

Objectives

The goal of the present study was to explore the role of in-vehicle distraction on critical road safety measures, namely reaction time at unexpected incidents and accident probability, in drivers with MCI, by applying a driving simulator experiment. The in-vehicle distractors that were applied included a low-demand distraction task, namely conversation with a passenger, as well as a high-demand distraction task, namely the use of hand-held mobile phone while driving. Our underlying rationale was that the decreased cognitive resources of individuals with MCI could possibly accelerate the negative impact of distraction on their driving performance. Notably, patients with MCI appear to be commonly affected in divided attention procedures (Okonkwo et al., 2008) and, therefore, a driving condition including in-vehicle distraction could prove to be a really hard task for drivers with MCI.

In particular, we hypothesized that the high-demanding distractor would have an augmented negative effect on the reaction time and the accident risk of patients with MCI as compared to cognitive intact individuals of similar age, education and driving experience. For the driving condition with the low-demanding distraction task we expected a heightened effect of distraction on the driving performance of MCI patients but of a lesser extent than the one observed under the high-demanding distraction task. For the driving condition without distraction we expected differences of a smaller extent between the two examined groups on reaction time and accident probability according to previous research that indicates that the driving performance of patients with MCI is not consistently worse than that of cognitively intact individuals under ordinary driving conditions.

Methodology

Participants

Initially, 39 individuals with similar demographics (20 "MCI patients" and 19 "Healthy Controls") were introduced in the study. However, due to simulator sickness 14 participants (7 "MCI patients" and 7 "Healthy Controls") did not manage to complete the entire "driving at the simulator" experiment. Hence, 25 participants of similar demographic characteristics completed the whole procedure. The MCI group included 13 subjects with a mean age of 64.5 years (s.d.=7.2), 60% males. The control group consisted of 12 subjects, 60% males too, who were medically evaluated and found to have no pathological condition, with a mean age of 60.0 years (s.d.=7.7). In Table 1, the between-group comparisons in age, driving experience, driving exposure (number of days driven per week and kilometers per week), in the number of years of education, the total accidents and accidents in the past two years, the self-reported levels of simulator sickness (caused by the driving simulator) and the Clinical Dementia Rating (CDR) score are presented. A CDR score of 0.5 (Morris, 1993) was required together with the confirmation of cognitive impairments according to the results of a comprehensive neuropsychological assessment. The criteria applied for the diagnosis of MCI were those developed by Petersen & Morris (2005), which include complaints for memory impairment by the patients or a family member, verified impairment on at least one cognitive domain, but with preserved functional abilities of daily living and absence of dementia.

The following inclusion criteria were required for participation in the current study: a) valid driving license, b) more than 3 years of driving experience, c) driving more than 2500km during the last year, d) driving at least 10km/week during the last year, e) no history of psychosis, f) absence of any significant motor disorder that prevents them from basic driving movements, g) absence of dizziness or nausea while driving, either as a driver or as a passenger, h) absence of alcohol or any other drug addiction, i) absence of any significant eye disorder that prevents them from driving safely. Also, because one of the driving conditions included the use of hand-held mobile phone, an essential requirement for all participants was that this specific driving practice is part of their everyday driving routine.

The difference in age between the two groups was not statistically significant at the 0.05 level (p=0.126); the groups were not statistically different in terms of gender, driving experience, frequency of driving (number of days and kilometers they drive per week), years of education, (reported) number of recent accidents (none for both groups, within the last two years) and in terms of simulator sickness (Table 1).

(Table 1 to be inserted here)

Procedure

The clinical group of the study included consecutive visitors of the Outpatient Memory Clinic of our Department that met specific inclusion criteria, as previously described. The control group included individuals that were family members or informants of various patients that visited the Memory Clinic during the period of the study and were specially selected in order the two groups to be similar regarding their age, gender, driving experience, and driving frequency. None of the participants of the control group was family member of patients included in the clinical group of the current study. The data collection included two phases. During the first phase all participants went through a two-day medical/ neurological, neuropsychological and ophthalmological assessment in order to well document the presence of a disorder and its characteristics. The neuropsychological evaluation that was carried out aimed at assessing various cognitive domains, such as general cognitive functioning, episodic memory, information processing speed, psychomotor speed, visual attention, divided attention, selective attention and aspects of executive functioning. The second phase had as goal to evaluate the driving behavior of the participants by applying a driving simulator experiment that included different driving scenarios.

Driving at the simulator

All participants (healthy controls and MCI patients) went through the same experimental procedure. The driving simulator experiment started with a practice drive (usually 10-15 minutes), until the participant fully familiarized with the simulation environment. It is noted that none of the participants had previous exposure to driving simulator environments. Afterwards, the participants were invited to drive on a rural environment that had the following characteristics: 2.1km long rural route for each distraction condition, single carriageway with 3m lane width, zero gradient and mild horizontal curves (Figure 1). The traffic volume conditions in the session were medium, corresponding to an average traffic volume Q=300vehicles/hour.

(Figure 1 to be inserted here)

The three distraction conditions concerned: a) undistracted driving, b) driving while conversing with a passenger and c) driving while conversing through a hand-held mobile phone. The following topics were discussed during the distraction conditions by following a counterbalanced approach among the participants: family, interests, news and origin, and the conversation tasks were all performed by the same Research Associate at the NTUA. After completing the driving task, participants were asked whether the specific distracting tasks in the driving simulator environment were equally demanding as in the case of their everyday driving routine. All participants applied positively as they considered that the demands of the tasks did not change in the simulator environment.

In total, the whole session included 3 trials of the simulated route. During each trial, 2 unexpected incidents were scheduled to occur at fixed points along the drive. More specifically, incidents concern the sudden appearance of an animal (deer or donkey) on the roadway. The hazard appeared at the same location for the same trial but not at the same location among trials, in order to avoid learning effects. Regarding the time-point that the hazard appeared, it depended on the speed of each driver in order the participants to have identical time to react, either they drove fast or slowly. The experiment was fully counterbalanced concerning the order of the trials.

The NTUA driving simulator is a motion base quarter-cab manufactured by the FOERST Company. The simulator consists of 3 LCD wide screens 40’’ (full HD: 1920x1080pixels), driving position and support base. The dimensions at a full development are 230x180cm, while the base width is 78cm and the total field of view is 170 degrees. Research evidence from on-road testing supports the validity properties of the driving simulator that was applied in the current study (Yannis et al., 2015).

Ethics

The study was approved by the Ethics Committee of the University General Hospital "ATTIKON". Informed consent was obtained from all individuals studied; it was explained to them that participation was on a voluntary basis and that they had the right to withdraw any time they wished to. Participants were informed on the nature of the study, the duration of their engagement and the type of information that they would be asked to give during the data collection process. Also, participants were ensured of the anonymity and confidentiality of the procedure. Finally, participation was voluntary and no compensation was offered.

Results

Firstly, according to the Mann-Whitney U test analysis that was applied the cognitively intact individuals outperformed the MCI patients on the following cognitive domains: a) verbal episodic memory (Hopkins Verbal Learning Test), b) information processing speed (Symbol Digit Modalities Test), c) visual search and psychomotor speed (Trail Making Test-Part A), d) mental flexibility (Trail Making Test-Part B), e) working memory (Letter Number Sequencing), f) overall visual attention (Driving Scenes Test), and (g) Useful Field of View-Part 3 (Selective Attention) (Table 2).

(Table 2 to be inserted here)

For the purpose of this research, 4 driving performance measures were examined: a) mean speed of the driver’s vehicle along the route (excluding from the calculation 50 meters before and 50 meters after each of the two incidents), b) speed variability (excluding from the calculation 50 meters before and 50 meters after each of the two incidents), c) reaction time at unexpected incident, calculated as the time between the first appearance of the incident on the road and the moment the driver starts to brake in milliseconds and d) accident probability, calculated as the proportion of unexpected incidents resulting in accidents, to total incidents. Table 3 illustrates the mean values and SD of the various driving indexes for the control and the MCI group under the following driving conditions: a) no distraction, b) conversing with a passenger, c) hand-held mobile phone use.

(Table 3 to be inserted here)

A mixed between-within subjects analysis of variance was conducted to assess the impact of distraction (no distraction, conversation, mobile phone) on the average speed, the speed variability, the reaction time and the accident probability of the two groups of the study, namely of cognitively intact individuals and of patients with a diagnosis of MCI. Figure 2 includes all these results that are subsequently described in a separate manner.

(Figure 2 to be inserted here)

Mean speed

There was a significant main effect of distraction on average speed, $F(2,46)=7.21$, $p=0.002$, partial $\eta^2=0.24$. In particular, the application of post-hoc comparisons with Bonferroni correction showed that average speed was significantly lower in the driving condition with the use of mobile phone as compared to the driving condition without the presence of distraction ($p=.002$). On the other hand the difference on average speed between the driving condition with mobile phone and the driving condition with conversation did not reach the level of statistical significance ($p=.086$). Finally, the average speed was similar under the driving condition without the presence of distraction and the driving condition with conversation ($p=.826$). The interaction effect between distraction and clinical group (cognitively intact/MCI patients) on average speed was not significant, $F(2,46)=2.47$, $p=.096$, partial $\eta^2=0.097$. Finally, the analysis revealed a significant main effect of clinical group (cognitively intact/MCI patients) on average speed, $F(1,23)=9.45$, $p=.005$, partial $\eta^2=0.291$, indicating that in general the patients with MCI had a significantly lower average speed than the cognitively intact drivers.

Speed variability

There was a non-significant main effect of distraction on speed variability, $F(2,46)=2.46$, $p=0.097$, partial $\eta^2=0.97$. The interaction effect between distraction and clinical group (cognitively intact/MCI patients) on speed variability was not significant, $F(2,46)=.10$, $p=0.990$, partial $\eta^2=0.000$. Finally, the analysis revealed a significant main effect of clinical group (cognitively intact/MCI patients) on speed variability, $F(1,23)=4.71$, $p=.041$, partial $\eta^2=0.170$, indicating that in general the patients with MCI had a significantly smaller amount of speed variability than the cognitively intact drivers.

Reaction time

There was a significant main effect of distraction on reaction time, $F(2,44)=12.57$, $p<0.001$, partial $\eta^2=0.364$. In particular, the application of post-hoc comparisons with Bonferroni correction showed that reaction time was significantly larger in the driving condition with the use of mobile phone as compared to the driving condition without the presence of distraction ($p=.001$). Also, reaction time was significantly larger in the driving condition with mobile phone than the driving condition with conversation ($p=.007$). Finally, reaction time was similar under the driving condition without the presence of distraction and the driving condition with conversation ($p=1.00$). The interaction effect between distraction and clinical group (cognitively intact/MCI patients) on reaction time was significant, $F(2,44)=3.74$, $p=.032$, partial $\eta^2=0.145$. To break down this interaction, contrasts were performed comparing the two different types of distraction to the driving condition without distraction across drivers with MCI and cognitively intact drivers. The aforementioned analysis revealed a significant interaction effect when comparing the reaction time of drivers with MCI and of cognitively intact drivers in the driving condition with the use of mobile phone compared to the driving condition without distraction $F(1,22)=7.12$, $p=.014$ partial $\eta^2=0.244$. In particular, this interaction effect indicates a significantly larger increase of reaction time in the MCI group under the driving condition with the use of mobile phone as compared to the group of cognitively healthy drivers. On the other hand, the interaction effect regarding the driving condition with conversation compared to the driving condition without distraction was not significant $F(1,22)=2.33$, $p=.141$ partial

η^2=0.096. Finally, the analysis revealed a significant main effect of clinical group (cognitively intact/MCI patients) on reaction time, $F(1,22)$=10.81, p=.003, partial η^2=0.329, indicating that in general the patients with MCI had a significantly larger reaction time than the cognitively intact drivers.

Accident probability

There was a significant main effect of distraction on accident risk, $F(2,44)$=4.14, p=0.023, partial η^2=0.158. Nonetheless, the application of post-hoc comparisons with Bonferroni correction showed that accident risk did not differ significantly between the driving condition with the use of mobile phone and the driving condition without the presence of distraction (p=.139). Also, the difference on accident risk between the driving condition with mobile phone and the driving condition with conversation marginally failed to achieve the level of statistical significance (p=.066). Finally, accident risk was similar under the driving condition without the presence of distraction and the driving condition with conversation (p=1.00). The interaction effect between distraction and clinical group (cognitively intact/MCI patients) on accident risk was significant, $F(2,44)$=5.16, p=.010, partial η^2=0.190. To break down this interaction, contrasts were performed comparing the two different types of distraction to the driving condition without distraction across drivers with MCI and cognitively intact drivers. The aforementioned analysis revealed a significant interaction effect when comparing the accident risk of drivers with MCI and of cognitively intact drivers in the driving condition with the use of mobile phone compared to the driving condition without distraction $F(1,22)$=6.96, p=.015 partial η^2=0.240. In particular, this interaction effect indicates a significantly greater increase of accident risk in the MCI group under the driving condition with the use of mobile phone as compared to the group of cognitively healthy drivers. On the other hand, the interaction effect regarding the driving condition with conversation compared to the driving condition without distraction was not significant $F(1,22)$=0.13, p=.719 partial η^2=0.006. Finally, the analysis revealed a non-significant main effect of clinical group (cognitively intact/MCI patients) on accident risk, $F(1,22)$=1.77, p=.196, partial η^2=0.075.

Conclusions and discussion

The present study focused on the effect of distraction on the driving behaviour of patients with MCI, by exploring three distraction conditions, namely driving without distraction, driving while conversing with a co-passenger and driving while conversing through a handheld mobile phone. Overall, according to the main effects of the clinical condition (Control vs. MCI) on the outcome variables that integrate the information from the three distraction conditions, the patients with MCI were driving with lower average speed, showed less speed variability, and presented larger reaction times in the case of unexpected incidents, but did not possess an increased accident risk . In addition, the interaction effects that were observed indicate a greater impact of distraction on the MCI patients in the case of reaction time and accident risk. Specifically, the distraction condition that was responsible for this interaction effect was the driving scenario that required the use of a handheld mobile phone, whereas in the case of the conversation the analysis did not reveal a significantly larger increase of reaction time and accident risk in the group of drivers with MCI. Finally, according to the main effects of distraction on the outcomes variables, in the driving condition that required the use of the mobile phone the drivers independently of their diagnosis reduced their average speed and showed a larger reaction time in the case of unexpected incidents.

In summary, the overall pattern of findings regarding the main effects of clinical condition and the interaction effects that were observed indicates that drivers with MCI differ in a significantly way from cognitively healthy drivers in various important driving indexes, especially under demanding driving conditions that include the presence of distraction. Possibly, the presence of more demanding driving tasks accentuates the differences in the driving behavior of the two groups and this is the reason why previous research that has assessed driving behavior under ordinary driving conditions is reporting differences of a smaller extent between drivers with MCI and cognitively intact individuals (Frittelli et al., 2009; Kawano et al., 2012; Olsen et al., 2014; Wadley et al., 2009).

In line with the hypothesis of the study the use of mobile phone had the most pronounced negative effect on the driving behavior of individuals with MCI as compared to a group of cognitively intact individuals of similar age, gender, education, and driving experience. In particular, the reaction time in unexpected incidents of drivers with MCI increased on average roughly 40% under the driving condition with the use of mobile phone whereas in the group of cognitively intact drivers the equivalent increase was only 13%. Moreover, the group of drivers with MCI had a striking increase of the risk of being engaged in a car accident when using a mobile phone that was not present in the non-clinical group of the study. Notably, the aforementioned pattern of findings was observed despite the fact that the drivers with MCI tried to adjust their driving behavior by reducing at an important extent their driving speed when using a mobile phone, as indicated by the main effect of distraction on average speed that was observed. On the other hand, the presence of a conversation with a co-passenger did not change in a significant way the reaction time and the accident risk of the patients with MCI as compared to the driving condition without distraction. Hence, low-demand distraction tasks, such as conversing with a co-passenger, do not appear to alter important driving indexes of patients with MCI, probably because their cognitive system is able to function in a sufficient way under conditions of dual-tasking when the performed tasks do not allocate high amounts of cognitive resources. On the other hand, this is not the case for high-demand distraction tasks, such as the use of the mobile phone (Patel et al., 2008; NHTSA 2008; Breen, 2009; SWOV, 2016), because probably this kind of conditions surpass the limits of their cognitive resources.

The driving profile of individuals with MCI according to our results changed radically under the more demanding driving condition that included the use of a hand-held mobile phone. The detection of this strong adverse effect of the mobile phone on the driving performance of individuals with MCI could be explained by their reduced cognitive resources (Aggarwal et al., 2005; Bennett et al., 2002), especially during the performance of divided attention procedures that engage increased levels of cognitive resources (Okonkwo et al., 2008). Following this perspective, it is suggested that the parallel execution of two tasks, namely of driving and using a hand-held mobile phone, placed the group of drivers with MCI in a particularly vulnerable position due to the need to effectively divide their attention under demanding conditions. Notably, in the challenging driving task that required the use of the mobile phone, the drivers independently of their clinical status applied a compensatory strategy by reducing their speed, but the outcome was not successful for the patients with MCI, as indicated by the marked increase of reaction time and accident risk that was observed.

A factor that may explain the adoption of this compensatory approach, apart from the increased difficulty per se of this driving task, is the accentuation of the perceived risk that previous research has documented regarding the mobile phone use while driving (Patel et al., 2008). However, independently of the underlying reasons, this strategy was only effective in cognitively intact drivers but not in drivers with MCI.

To the best of our knowledge this was the first study that examined the role of distraction on the driving performance of individuals with MCI. Hence, this work adds to previous studies that have explored the link between distraction and driving performance in the general population (Caird et al., 2008; Cuenen et al., 2015; McEvoy et al., 2005; Patel et al., 2008;) or other clinical groups (Uc et al., 2006b; Uc et al., 2008) and indicates that especially the use of mobile phone has the capacity to alter the driving skills of MCI patients in ways that could be truly dangerous as reflected by the striking increase of accident risk and the clearly larger reaction time in unexpected incidents. Thus, the current research by exploring the impact of distraction on the driving performance of individuals with a common clinical condition that has a high prevalence among older drivers, supports further the need for the suspension of a common driving practice that is extremely popular for an important portion of the population.

In the present study, the drivers with MCI were relatively young according to epidemiological data focusing on the specific clinical condition (Roberts & Knopman, 2013). Factors that may explain the specific trend could be related to the inclusion criteria of the study regarding the driving profile of the participants that required a valid driving license and regular car driving as well as the use of hand-held mobile phone during their everyday driving routine. Hence, prospective studies could expand the findings of the current work by focusing on older patients with MCI in order to cover the typical age range of the specific clinical condition. In addition, a parameter that needs to be recognized is that the driving measures were obtained from a simulation environment and not from on-road driving. Hence, future research could increase our insight and strengthen the current findings by investigating in individuals with MCI the impact of mobile phone use as well as of conversation on on-road driving conditions. Also, another constraint that should be mentioned is the relatively small sample size of the present study that made possible the detection only of rather large effect sizes. Nonetheless, despite this restriction, the impact of mobile phone use on the driving performance of patients with MCI was large enough in order to make feasible the exploration of the main goals of the present study. In addition, it should be noted that the two groups were similar in terms of age, gender, education, and driving experience, thus sufficient control was imposed on critical confounding factors that could potentially influence in various unwanted ways the observed pattern of findings. Finally, due to its nature the variable assessing the accident risk of the drivers regarding unexpected incidents had a small number of degrees of freedom, and, therefore, for gaining a more thorough insight, future research is encouraged to complement the information regarding accident risk with additional surrogate measures related to driving safety apart from reaction time, such as time to collision or hits of side bars.

In conclusion, the take-home message of the current work is not suggesting that the use of mobile is a safe practice for cognitively intact drivers. Instead, the present study by focusing on MCI patients provides complementary information regarding the reasons that drivers should avoid using a hand-held mobile phone. In addition, it indicates the importance of developing and implementing campaigns specially designed for advanced agers regarding the adverse role of the mobile phone and of other potential electronic distractors on driving safety, especially when taking into account the high frequency of older drivers that are keen on using this type of devices while driving (Vernon et al., 2015). Moreover, the pattern of findings that was observed paves the way for exploring the role of other types of distractors on the driving behavior of patients with MCI as well as of the impact of the mobile phone use on drivers belonging to other clinical groups. Overall, these observations may have considerable practical importance because they provide useful information for the formulation of efficient driving recommendations that have the capacity to reduce the risk for road fatalities in a sensitive group of car drivers.

Conflict of Interest

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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