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REVIEW

Does the diagnosis of Alzheimer's Disease imply immediate revocation of a driving license?

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Abstract

Driving competence is strongly related to the autonomy and the feelings of self-worth of advanced agers. At present, older drivers appear to retain their driving license for longer periods of time as well as to drive more commonly and to cover longer distances as compared to the past. Nonetheless according to epidemiological data, older individuals appear to be a vulnerable driving group that manifests increased rates of road fatalities. Along this vein, several lines of previous research have focused on exploring the driving behavior of individuals with two common cognitive disorders, namely Alzheimer-dementia (AD) and Mild Cognitive Impairment (MCI). Based on previous findings, patients with AD commonly present increased driving difficulties at a level that clearly supports the discontinuation of driving. Nonetheless, some patients with AD, especially in the mild stages, retain adequate driving skills that are similar to those of cognitively intact individuals of similar age. As concern the group of drivers with MCI, it seems that there is an accentuated risk to develop driving difficulties, but their performance is not consistently worse than that of healthy control drivers. Nonetheless, additional studies are warranted for detecting useful predictors of driving behavior in the specific clinical group. Under this perspective and by integrating the previous findings, we suggest the need for implementing a personalized approach when taking decisions about the driving competence of drivers with AD and MCI that is based on the effective synthesis of multimodal driving-related indexes by the specialties of neurology, neuropsychology and transportation engineering.

Keywords: Driving, Dementia, Alzheimer disease, Mild Cognitive Impairment, Driving behavior.

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Introduction

Retaining a high and well preserved functional status is strongly interwoven with the self-esteem, self-worth, psychological health and the overall quality of life of older individuals. Under this perspective the continuation of driving for advanced agers is commonly an issue of high importance that is strongly related to their autonomy and their feelings of self-value and usefulness. Notably, loss of driving privileges can lead to an increase in the levels of depressive symptoms, thus compromising the psychological health of this group of individuals [1-4]. Even when such a decision is made voluntarily due to the acknowledgment of decreased driving ability and increased perceived difficulties, the psychological influence can still affect the quality of life of the former drivers.

At present, older drivers tend to drive more frequently, to cover longer distances, and to retain their driving privileges for longer periods of time, as compared to the past [5]. Moreover, the total percentage of older drivers in the society is increasing [6], thus underlying the importance of exploring the effect of normal and pathological aging on driving ability. Under this framework, recent epidemiological data state that older drivers have increased risk to be engaged in motor accidents and that life loss in the elderly represents the 26% of all life losses from car accidents in the EU [5, 7].

The effect of normal aging on driving ability has been investigated at a considerable extent [8-10]. Several findings indicate that a decline in driving ability can be associated with various age-related impairments which may affect general health [11], vision [12, 13], and cognitive functioning [7, 14].

Driving is a multimodal task that engages various cognitive resources that are commonly affected by the aging process, and, therefore, the attenuation of the cognitive system is a critical factor that may explain the increased rate of road fatalities in the group of older drivers [15, 16]. Indicatively, driving requires well preserved executive functions in order to process simultaneously multiple environmental cues, to predict the development of traffic situations, as well as to make rapid, accurate and safe decisions [17]. In addition, visuospatial skills, attention, and memory are cognitive functions that appear to also subserve the demanding task of on-road driving [17].

As previously mentioned the specific cognitive functions appear to be generally affected by the aging process [18-20], but this is especially the case for cognitive disorders that have a considerable prevalence in older individuals, such as Mild Cognitive Impairment (MCI), and dementia of the Alzheimer type (AD) [21-23].

The objective of this paper is to present and discuss the current knowledge about the driving behavior and fitness of patients with AD and MCI. In addition, by integrating the various sources of evidence we develop a rationale that supports the implementation of a personalized approach when taking decisions about the driving fitness of patients belonging in the specific clinical groups.

Cognitive disorders and driving: general comments

Alzheimer's disease (AD) is the most common type of dementia [24, 25], with increasing age considered as the most important risk factor [26, 27]. In the early stages of the disease, a variety of symptoms can be observed, with gradually progressive memory decline being the most prominent symptom. As the disease progresses, cognitive deterioration may become more widespread and severe and include, apart from memory deficits, visuospatial and attentional disturbances, executive dysfunction, language-related impairments and apraxia [28]. Notably, the aforementioned symptoms are commonly interwoven with driving fitness that requires various physical and mental abilities, such as the capacity to judge distances, to simultaneously manage multiple incoming stimuli, to maintain attention for long periods of time, to perform sequencing skills, to demonstrate immediate reaction in case of adverse events, and succeed proper interpretation of traffic signs and signals. Moreover, an accurate judgment of someone's own ability to drive and the resultant compensatory behavior are prerequisites of safe driving, an ability that is often impaired in dementia [29-33].

MCI is a clinical condition that commonly represents the predementia stage of a variety of diseases leading to dementia, most frequently AD being the most prevalent outcome [22]. In the present work, it is presented as a distinct entity because despite its high prevalence—it is observed in about 16% of individuals over 64 years in the general population [34]— it has been relatively neglected in the driving literature. The neuropsychological characteristics of MCI overlap significantly with those of aging, and because of the progressive nature of MCI, the specific clinical condition requires longitudinal follow-up.

Driving Profile of patients with AD

The first study to report motor vehicle accidents for cognitively impaired individuals was by Walter in 1967 [35]. Since then, a number of researchers have demonstrated that individuals with moderate or severe dementia are incapable of driving [17, 31, 36, 37, 38, 39, 40]. Some of the main concerns regarding the continuation of driving from patients with dementia involves the increased risk of at-fault car accidents [41-43] and the possibility of getting lost [44, 45], posing a significant risk to individual and public road safety.

Some studies underline the finding that patients with dementia of the Alzheimer's type are 2.5 to 4.7 times more likely to get involved in a car accident than other elderly drivers of similar age but without dementia [39, 46, 47, 48, 49].

However, sufficient evidence suggested that 50% of AD patients do not cease driving for at least three years after

their initial diagnosis [33, 39, 40, 48, 50, 51, 52, 53]. Very recently, a study of a memory clinic conducted in northern Italy reported that 87% of patients with dementia were still active drivers [54] while Vaughan et al. [55] reported that in the women Health Initiative program (mean age 82.3±3.6), 60% of patients with MCI and 40% of patients with dementia were still driving. Those findings pose significant concerns as regards the evaluation and monitoring of driving fitness in patients with neurodegenerative disorders.

Patients with AD are more likely to commit errors while driving [45, 56, 57]. More specifically, a study assessed AD patients with an on-road driving experiment and reported that patients with mild AD made significantly more incorrect turns, got lost more often and were at greater risk to commit at-fault safety errors. However, their basic control abilities of the vehicle appeared to be normal [45]. A more recent study [57], revealed that patients with AD were less likely to use a safety belt and they got lost more often. The last study assessed driving ability through an experiment using in-vehicle technology through continuous registration of driving parameters [57]. Another recent study demonstrated that patients with dementia were at higher risk to make driving errors especially while driving at straight condition which has not yet been considered as a difficult or "high challenge" condition [56].

Nonetheless, not all patients with AD are incapable of driving, especially in the milder stages of the disease [46, 48, 49, 53, 58, 59, 60, 61]. Indicative is the study of Brown et al. (2005) which observed that 76% of a group of mild AD patients were able to pass an on-road driving test. Along the same vein, the study by Ott et al. [53] revealed that patients with mild dementia of the Alzheimer's type may be able to continue driving for a long time, under regular follow-up assessments and monitoring. Another study by Barco et al. [56] revealed that 44% of patients with dementia passed an on road assessment. Also, in a study investigating the characteristics of crashes in patients with very mild and mild AD who continued to drive in comparison to healthy individuals, no significant differences were found at the crash rates among any of the aforementioned groups indicating similar possibilities of in-vehicle crashes despite their clinical diagnosis [61]. However, the specific study reported that group-differences were found at the causes and consequences of the accident, where AD patients were more likely to get involved in at-fault crashes with injuries. Another study by Ernst et al. [48] investigating the driving profile of patients with AD and frontotemporal dementia, found that a considerable percentage of AD patients retained adequate driving skills by maintaining a steady driving style with sufficient monitoring of the road environment.

By summarizing and integrating the above findings, it becomes evident that the clinicians should follow a personalized approach when making recommendations about driving continuation/discontinuation. This decision should be based on the unique profile of each patient, the stage of the disease, the severity of cognitive results, the behavioral symptoms and the need for regular follow-up evaluations as explained later in the text. Finally, supporting the autonomy and the self-esteem of patients with AD should always be taken into account.

Driving Profile of patients with MCI

According to accumulating evidence, in addition to memory deficits, patients with MCI may present impairments on executive functions [62] and also on complex abilities of daily living [21]. In the case of driving fitness, research findings indicate that the MCI population is at risk for presenting increased difficulties, although their performance on on-road or on simulator testing is not consistently worse than that of their healthy counterparts [63-65].

A number of researchers support the view that the clinical symptomatology of MCI may indeed affect in a negative way driving ability, through the detection of more driving errors in comparison to cognitively intact elderly drivers such as difficulties in maintain proper speed and car positioning, errors in right and left turns, pedal confusion as well as difficulties in identifying information from on-road signs [63, 64, 66]. However, some studies reported that the differences between MCI and controls, although present, did not reach statistical significance [65, 67].

Predictors of driving performance

Previous research indicates that performance on tests measuring visuospatial and attentional abilities, executive functioning and possibly memory is associated with the ability to drive safely in patients with dementia [17, 33, 45, 53, 68, 69]. These findings appear to make sense intuitively. As Brown and Ott [46] suggest, the ability to properly process visual information as well as to organize and monitor multiple stimuli at once are critical components of driving.

However, other studies have found no association of cognitive testing with driving competence in patients with dementia. For example, Barco et al. [56] examined driving performance in patients with dementia and classified them in two groups, depending on their success on the on-road driving assessment (pass/fail). According to their results, the severity of cognitive decline as evaluated by their informants (Assessing Dementia 8 Screening Interview [AD8]) was the only factor that significantly distinguished the two groups while no significant differences were found in cognitive measures between the two groups.

Due to the moderate relationships of the neuropsychological tests with driving measures and individual variability, relying only on these tests for making recommendations regarding future restrictions in driving in patients with dementia may not be adequate. Although individual neuropsychological tests have shown a certain degree of relationship with driving measures, no single neuropsy-

chological battery can consistently and reliably predict driving behavior. Rather, different neuropsychological measures may be related to different aspects of driving behavior. Ideally, neuropsychological tests should be used in combination with other measures, such as findings from neurological assessment and administration of actual or simulated road tests, to make driving recommendations [53, 63, 70, 71, 72, 73].

Brown et al. [68], compared the evaluation of driving ability as rated by four distinct raters (the participants themselves, an informant, an experienced neurologist as well as a professional driving instructor) to the actual driving performance. According to their results, the only measure of driving ability which was significantly correlated with actual driving performance was the one performed by the neurologist along with the score on the Mini-Mental State Examination (MMSE) which was at borderline correlated to the neurologist's ratings.

Another study conducted by Herrmann et al. [74] examined the factors associated with voluntary driving cessation in a sample of patients with mild to moderate dementia. The measures that appeared to significantly contribute to the decision about deserting driving were the scores from the Geriatric Depression Scale (GDS), the MMSE as well as specific subscales from the Neuropsychiatric Inventory (NPI), namely apathy, agitation and hallucinations. The American Academy of Neurology (AAN) has published Practice Parameters about prediction of driving performance according to a Clinical Dementia Rating scale score (CDR) [75], the MMSE [76], reports from the informants as well as other characteristics of driving behavior [59]. However, those guidelines are rather general and further research is warranted for developing valid cut-off scores on various neurological and neuropsychological measures as regards the accurate prediction of driving performance.

The role of distraction has been neglected. Our findings have shown that distractive conditions affect severely driving ability in patients with AD [77].

As regards measures that can predict driving ability in the clinical group of MCI, current research is sparse. In reference to the detection of neuropsychological predictors, measures of mental flexibility, inhibitory control and visual attention appear to be associated with driving performance in patients with MCI, but this issue needs further investigation [64].

Recently, significant associations were reported between measures of insomnia (Athens Insomnia Scale) and sleepiness (Epworth Sleepiness Scale) with longitudinal parameters of driving behavior, such as variation of lateral position, average speed and headway distance in patients with MCI [78]. Moreover, driving distraction with the use of mobile phone has been shown to have detrimental effects on driving in patients with MCI compared to healthy elderly [77].

Overall, it appears than certain cognitive and functional measures could be helpful in detecting individuals with MCI that might have less optimal or problematic driving skills. Nonetheless, neurological and neuropsychological testing, as in the case of AD, should be viewed as one part of the screening process that is accompanied when necessary by on-road driving evaluation.

Discussion and conclusions

This review had as goal to present the current knowledge about the driving behavior of individuals with two common cognitive disorders, namely AD and MCI. In the case of AD, accumulating evidence indicates that the driving fitness is generally compromised, but some patients with mild AD retain adequate driving skills. Hence, a diagnosis of AD should not be considered by itself as an adequate criterion for loss of driving privileges. What appears to be the best option is the implementation of a personalized approach that is based on the unique profile of each driver with AD. In this direction, neurological and neuropsychological indexes could be useful sources of information regarding the driving fitness of any individual belonging to the specific clinical group. However, this does not imply that various predictors should be used in isolation replacing the on-road driving evaluation, when a decision about continuation/discontinuation of driving is to be made. Instead, their role is to provide complementary information in order to enhance the validity of the overall decision as well as to guide choices about the proper time for taking the decision to cease driving. Under this perspective, it is very important for the patient with AD to participate in the decision and the overall planning about the cessation of driving, along with the involvement and support of mental-health professionals when required. In addition, for the renewal of their driving license and for keeping a balance between personal/public safety and self-determination, patients with AD should be required to undergo a detailed driving evaluation that covers various components, namely a practice road rule test, assessment of physical, visual, sensory and cognitive abilities, as well as an on-road assessment. Also, for supporting the effectiveness of the relevant driving recommendations it is critical to include periodic re-evaluations that follow the temporal course of the progression of the disease. Nonetheless, when serious concerns arise regarding personal or public road safety, specific legislation measures should exist for the removal of the driving license of patients with AD. Indicative of such an effort is the decision pathway about fitness to drive that was developed from health services and experts in order to establish a set of easily adaptable guidelines for the best possible regulation of driving continuation or discontinuation in the elderly [79].

Regarding the driving competence of drivers with MCI, in the majority of cases they are not considered incapable of driving. Nonetheless, they have the tendency of making more driving errors than their healthy counterparts and it seems that a portion of drivers with MCI has considerably increased driving difficulties. Therefore, more consistent

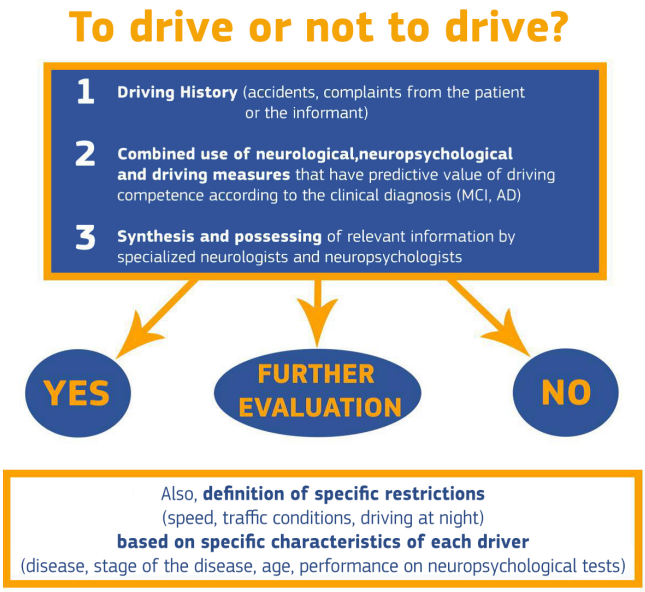

Figure 1. Proposed evaluation of drivers with AD or MCI.
AD = Alzheimer's disease; MCI = Mild Cognitive Impairment

and regular monitoring of driving ability on this clinical group is suggested to be formally implemented, in order to detect small changes in driving behavior and make proper regulations on time. Latest literature on the clinical features of MCI indicates that neuropsychiatric symptoms may be present in up to 50% of the patients such as irritability, aggressiveness or depressive symptomatology. Those features may influence in a negative way driving ability. Thus, special care for the early identification and treatment of probable neuropsychiatric symptomatology is suggested in order to elongate the continuation of their driving privileges. Also, neurological and neuropsychological indexes could provide useful information about the cognitive profile of patients with MCI, thus facilitating the implementation of a personalized approach for any driving-related decisions and recommendations that might need to take place.

Based on the outcomes of the current work, the role of the Neurologist, the Neuropsychologist and the Transportation engineer is of critical importance for investigating and evaluating driving ability in the elderly, especially in the case of drivers with cognitive disorders, such as MCI and AD. According to our view, the restriction or total loss of driving privileges is a complicated and serious decision that should not be taken without the active participation of a well-trained Neurologist and Neuropsychologist with deep understanding of the information provided by neurological and neuropsychological measures that are linked to driving fitness according to accumulating findings of previous research. In conclusion, decisions related to the critical question "continue to drive or not?" and concerns about the group of drivers with cerebral diseases should be based on an interdisciplinary approach that integrates the specialties of neurology, neuropsychology and transportation engineering. The schematic representation of the proposed approach is illustrated in **Figure 1**.

Abbreviations

American Academy of Neurology (AAN) Ad = Alzheimer's disease; CDR = Clinical Dementia Rating; GDS = Geriatric Depression Scale; MCI = Mild Cognitive Impairment; MMSE = Mini-Mental State Examination; NPI = Neuropsychiatric Inventory

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Competing interests

The authors declare no conflict of interest

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