Fitness to drive of older drivers with cognitive impairments
Piersma, Dafne

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Document Version
Publisher's PDF, also known as Version of record

Publication date:
2018

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

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Download date: 22-02-2024
7. General discussion

7.1. Background

The goal of this PhD thesis was to systematically study how different factors contribute to variations in fitness to drive between patients with cognitive impairment, which resulted in a procedure to assess fitness-to-drive in older patients with cognitive impairments in a clinical setting. In this project, patients with cognitive impairments of different aetiologies were invited to participate, together with a close relative. The first type of assessment was clinical interviews conducted with the patients and their relatives. The second type of assessment was a neuropsychological assessment and the third was a driving simulation test. At a later time, patients also participated in the ‘gold standard’ on-road driving evaluation at the Dutch driving licence authority. After completion of the fitness-to-drive assessment, a driving recommendation was provided by the researchers. Approximately seven months later, patients were asked about their adherence to the driving recommendation and changes in their mobility during a follow-up interview. First, a fitness-to-drive assessment strategy was developed using the three types of assessments for the evaluation of fitness to drive in patients with Alzheimer’s disease (AD) in a clinical setting. Second, the proposed strategy was validated and it was investigated whether this strategy could also be used for patients with other types of dementia. Finally, patients were followed-up to investigate whether driving recommendations given after the fitness-to-drive assessment were effective and what the consequences were for the mobility of patients with cognitive impairments.

7.2. The developed strategy for the assessment of fitness to drive in patients with Alzheimer’s disease

Patients with AD who failed the on-road assessment displayed significantly worse scores than patients who passed the on-road assessment on all three types of assessments, i.e. clinical interviews, neuropsychological assessment, and driving simulator rides (see Chapter 3). For each separate type of assessment, four variables were identified that predicted the outcome of the “gold standard” on-road assessment with an accuracy above 80%. When comparing the three types of assessments, the best predictive accuracy (94.6%) was based on the neuropsychological assessment. Moreover, when the three
types of assessments were combined an even more accurate prediction (97.4%) of on-road driving performance was reached. Therefore, cut-off scores were provided using a combination of all three types of assessments.

Each type of assessment has advantages and disadvantages. Clinical interviews are in principle easy to conduct in clinical practice and already frequently used in the diagnostic process. However, self-reports as well as proxy-reports provide only subjective results, which can be biased. For a better interpretation of self-evaluation of driving safety, the importance of driving for the patient and their relatives should also be evaluated. Besides deliberately answering questions more positively (or negatively) than the actual experience, this can also happen unintentionally. Patients with cognitive impairments are well-known for having difficulties recognizing their own symptoms and impairments (Mullen et al., 1996), but also for informants gradual and mild cognitive decline may be difficult to perceive. Therefore, information derived from clinical interviews should be interpreted with caution. The most reliable measure from clinical interviews in the context of driving appears to be the Clinical Dementia Rating (CDR) (Iverson et al., 2010). Although the total score of the CDR has been shown useful for many clinical purposes, in this thesis we found that two subscales were of particular value for the prediction of fitness to drive in AD, namely Orientation and Judgement & Problem solving. It is possible that shorter interviews could provide enough information, which is highly relevant since there is often not sufficient time to conduct the entire CDR in clinical practice. Another option might be to promote referral from general practitioners, neurologists, and geriatricians to neuropsychologists and occupational therapists for a comprehensive assessment of fitness to drive.

Neuropsychological assessments are common practice in clinical settings and provide objective measurements of cognitive functions. Nevertheless, using only global cognitive measures such as the MMSE is insufficient for a fitness-to-drive evaluation (Bennett, Chekaluk, & Batchelor, 2016; Fitten et al., 1995; Lincoln et al., 2006). When composite test batteries are used and multiple cognitive domains relevant for driving are assessed, a better prediction of on-road driving can be derived (Bennett et al., 2016). In addition, tests specifically designed for driving evaluations such as a hazard perception test and a traffic theory test are closely linked to on-road driving performance (Chapter 3) and have higher face validity than traditional neuropsychological tests. This implies that a standard neuropsychological examination used in diagnostics
does not provide enough information about fitness to drive, and specific fitness-to-drive testing is necessary.

Driving simulation has even higher face validity than laboratory traffic tests. Other important advantages of driving simulation are having control over the encountered traffic situations as well as the behaviour of other traffic participants and the possibility to implement critical traffic situations in a safe environment. However, not every simulated traffic situation can be directly related to a comparable traffic situation on the road (Aksan et al., 2016; Veldstra et al., 2015). Currently, there is no agreement on an established and ready-to-use simulator ride with determined output variables to evaluate fitness to drive. Furthermore, driving simulators are not available in all clinical settings. Moreover, participants’ evaluations of the driving simulation varied markedly from ‘fantastic’ and ‘very realistic’ to ‘this is not comparable with my own car’ and ‘I feel sick’. In that regard, simulator sickness is a serious issue in the older population (Classen et al., 2011; Withaar, 2000). Although we tried to use simulator scenarios that would not evoke simulator sickness by not using any sharp turns and limiting the number of objects in the periphery, about one third of all participants could not finish the driving simulation due to nausea and/or dizziness. Simulator sickness should be avoided, because it causes distress to the participants and simulated driving performance cannot be evaluated reliably when participants have symptoms of simulator sickness. Nonetheless, completed driving simulator rides can have added value for the prediction of fitness to drive (Chapter 3 and 4).

7.3. Validation of the developed strategy

In Chapter 4, the strategy developed using patients with AD was applied on a sample of patients with mild cognitive impairment (MCI). The complete approach combining all three types of assessments achieved a high predictive accuracy of detecting patients who were unfit to drive (94.4%) (according to the outcome of the on-road driving assessment), which was close to the predictive accuracy of the original study on patients with AD (97.4%). Although the final result is comparable with the original study, the three types of assessments did not contribute equally to the prediction of fitness to drive in MCI. Clinical interviews did not aid the prediction here, while neuropsychological assessment and driving simulator rides were both valid predictors of fitness to drive in MCI. It could be that self-reports are less reliable in the MCI group than in the AD group, because very mild impairments are difficult to perceive. However, an interesting finding of
another study was that self-reported decline in driving ability did predict a diagnosis of MCI (Vardaki, Dickerson, Beratis, Yannis, & Papageorgiou, 2016) suggesting that self-report can be informative in this context. In general, the proposed strategy combining three types of assessments revealed adequate accuracy in predicting fitness to drive in patients with MCI.

7.4. Variability between patients with cognitive impairments

Patients with cognitive impairments comprise a very heterogeneous group as aetiologies, symptoms, impairments, and course differ to a large extent. Bearing this in mind, it may not be surprising that an assessment strategy predicting fitness to drive of patients with AD does not necessarily predict fitness to drive of patients with other types of dementia (see Chapter 5). This corresponds with previous studies showing that an assessment strategy for stroke could not predict on-road driving performance in patients with traumatic brain injury or dementia (Radford, Lincoln, & Murray-Leslie, 2004; Selander, Johansson, Lundberg, & Falkmer, 2010). Although one approach for the assessment of fitness to drive for all patients with cognitive impairments would be practical, it currently appears impossible to achieve sufficient predictive accuracy using a single assessment strategy for such a large heterogeneous group. Patients with different types of dementia may become unfit to drive by different trajectories with different patterns of errors and compensatory behaviours, and capturing all of those elements in one approach is very hard and would probably require an even more comprehensive approach than used in this thesis. Consequently, different types of dementia require different fitness-to-drive assessment strategies.

Nonetheless, the neuropsychological assessment that was used for patients with AD was also predictive of fitness to drive in non-AD dementia (Chapter 5), therefore (some of) the proposed neuropsychological measures could be useful for fitness-to-drive assessment strategies for patients with non-AD dementia as well. Importantly, the neuropsychological assessment contained both classical neuropsychological tests as well as newly developed specific traffic tests. In particular specific traffic tests may aid the prediction of fitness to drive in multiple types of dementia, because these tests are not designed to detect particular deficits in cognitive functions (which differ between types of dementia) that influence driving, but rather provide indications of cognitive abilities and skills needed to perform tasks that are important for driving.
Hazard perception, for example, appears crucial for all drivers, irrespectively of the presence or type of dementia.

7.5. Predictive accuracy measures

A relevant question is how many unsafe drivers can we allow to remain undetected (i.e. “misses”) and how many safe drivers can we accept to be advised to cease driving prematurely after a fitness-to-drive assessment (i.e. “false alarms”)? Kay and colleagues (Kay, Bundy, Clemson, Cheal, & Glendinning, 2012) proposed a minimum of 90% for both sensitivity and specificity if the purpose of an assessment strategy is to replace on-road driving assessments. This means that up to one in ten unsafe drivers is allowed to continue driving and up to one in ten safe drivers must cease driving prematurely, assuming around 50% of patients are fit to drive. The proposed values are difficult to reach or even approach, in particular in validation studies (this PhD thesis is no exception). To my knowledge, the only fitness-to-drive assessment for patients with cognitive impairments that yielded sensitivity and specificity above 90% was the combination of DriveSafe with DriveAware (Kay et al., 2012). These statistics were calculated on one randomly selected sample (n = 52) and verified on a second sample (n = 44) (Kay et al., 2009), and were also validated in an additional study (Hines & Bundy, 2014) on patients with cognitive impairments related to a variety of diagnoses. However, this assessment strategy was not a full replacement of the on-road driving assessment. Two cut-off points were used, meaning that very safe and very unsafe drivers could be identified. These patients do not have to perform an on-road driving assessment anymore, but everyone with a score in-between the two cut-offs is still referred for an on-road assessment. This applied to almost half of all patients assessed with DriveSafe/DriveAware raising the question whether it is acceptable to implement a procedure to classify only about half of all assessed patients as safe or unsafe drivers. Nonetheless, trichotomization of fitness-to-drive assessment results could facilitate replacement of on-road driving assessments with very unsafe drivers by a clinical approach that would be very safe. Furthermore, in an ageing society, waiting times for on-road driving assessments may lengthen due to the increasing demand; therefore options for timely replacement of on-road assessments for a proportion of drivers will be welcome. In addition, fitness-to-drive assessments could be applied in the clinical setting in countries where on-road driving assessments are hardly available or performed very inconsistently. There are also various circumstances in which an addition to the on-road driving assessment could be beneficial. As a first example, patients
may be offered a rehabilitation-oriented fitness-to-drive assessment in a clinical setting to prepare themselves for the official on-road driving assessment, and this rehabilitation-oriented information could aid patients in their decision to report their disease to the driving licence authority and might reveal options on how to improve their driving performance before they are formally assessed on the road. A second example is to use clinical fitness-to-drive assessments for patients who failed the on-road driving assessment but wish to know whether they could improve their driving performance, including patients who objected to the procedure and decision of the Dutch driving licence authority. To improve the accuracy of decisions on fitness to drive, an extra on-road driving assessment could be offered to patients who failed the first on-road driving assessment while they passed the clinical fitness-to-drive assessment.

7.6. The on-road driving assessment

In most studies, including this PhD thesis, an on-road driving assessment is the ‘gold standard’ to assess fitness to drive. On-road driving has the highest face validity (i.e. representativeness) of all mentioned types of assessments, and there are trained experts to judge the on-road driving assessments in the Netherlands. However, there are some methodological issues. The official outcome of an on-road assessment is based on the subjective judgement of an expert on practical fitness to drive. The Test-Ride Investigating Practical fitness to drive (TRIP) form (Withaar, 2000) as used for standardization of on-road driving assessments in this thesis is not in use in official relicensing procedures while participants drive different routes depending on their own residential area in their own car. The advantage of this approach is that people drive in a familiar environment, which is where they probably drive most of the time, and therefore it is most relevant to observe driving performance there. This also requires a lower cognitive load compared to a fixed route in an unfamiliar area in a standard car. Nevertheless, on-road driving assessments are one-time evaluations that vary in encountered traffic situations and weather circumstances. A problem is that the validity and reliability of on-road driving assessments, even those including the TRIP form, have not been thoroughly researched. Both the interrater and test-retest reliability of on-road driving assessments have been questioned (Hunt et al., 1997; Ott et al., 2012), global ratings of on-road driving assessments correlate with naturalistic driving performance only moderately, and differences in driving performance remain poorly understood (Davis et al., 2012). In the end, not only clinical fitness-to-
drive evaluations, but also on-road driving assessments could lead to incorrect classifications of safe and unsafe drivers.

7.7. Implementation of fitness-to-drive assessments

It is a controversial issue whether fitness-to-drive assessments (regardless of the setting) should be performed in older and cognitively impaired individuals (Martin, Marottoli, & O’Neill, 2013). Although there is agreement on the rationale to remove unsafe drivers from the road in order to improve traffic safety, this turns out to be less straightforward in practice. The primary goal is to prevent traffic accidents. However, traffic accidents are not easy to investigate. First, accidents cannot be studied prospectively in patients who failed the on-road driving assessment, because patients who ceased driving cannot be involved in future car accidents (as a driver). For this reason, it remains unknown whether these patients would have caused accidents if they would have continued to drive. Second, although retrospective studies could be informative since previous accidents may predict future accidents, self-report of previous accidents may not be reliable, especially not when asking individuals with cognitive impairment. Third, traffic accidents represent an unpractical outcome measure in cross-sectional research, because accidents do not occur very often on a per person basis and also because the severity of accidents differs. That many persons do not experience accidents is fortunate, nevertheless, older drivers, especially those with medical conditions, are at high risk of accidents when considering the distance driven and consequences of accidents are often more serious for older persons (Dobbs, Heller, & Schopflocher, 1998; Ryan, Legge, & Rosman, 1998). All this implicates that it is important, but difficult to investigate whether fitness-to-drive assessments lead to a reduction in accidents. There are also reasons why not all unsafe drivers are removed from the road by fitness-to-drive assessments, namely not all of them will sign up for a fitness-to-drive assessment, incorrect classifications of unsafe (and safe) drivers appear inevitable, and not everybody adheres to driving cessation advice (see Chapter 6). In the end, the number of prevented car accidents may be limited and another worry is that older people who are no longer driving might be at high risk to be injured as a cyclist or pedestrian (Brouwer & Ponds, 1994; Hakamies-Blomqvist, Johansson, & Lundberg, 1996; Martin et al., 2013). These findings may suggest that age-related screening for fitness to drive is not justifiable (Hakamies-Blomqvist et al., 1996). Age itself is also not a good predictor of accidents (Ball & Owsley, 2003; Transportation Research Board, 1988). However, ageing is related to the occurrence of functional impairments and diseases. Cognitive impairment, for
example, does contribute to a higher accident risk (Lundberg, Hakamies-Blomqvist, Almkvist, & Johansson, 1998); therefore fitness-to-drive assessments for medical at-risk groups would have greater potential to reduce the number of traffic accidents.

A secondary goal of fitness-to-drive assessments might be to improve car mobility of patients with cognitive impairment. This effect is not demonstrated in the current literature (Martin et al., 2013). Nonetheless, a positive outcome of a fitness-to-drive assessment may promote sustained car mobility preventing premature driving cessation. Anecdotal evidence (from participants in this PhD research) suggests that it is valuable to assure that driving is still safe after receiving a diagnosis of dementia. The high adherence to a positive driving advice as described in Chapter 6 supports this, but it is not known whether these patients would also have continued to drive if they did not participate in the fitness-to-drive assessment. It is important to note that fitness-to-drive assessments should not only be used for the identification of unsafe drivers, but mostly for rehabilitation purposes. Not only at the societal level, but especially at the family and personal levels questions about fitness to drive often arise and consequently clinicians are called upon in everyday practice. Frequently, the question may not only be whether the patient with cognitive impairment is currently still driving safely, but mostly what can be done to accomplish safe driving despite cognitive impairments. A fitness-to-drive assessment could identify strengths and weaknesses of the patient that could be used to improve driving performance. For example, when traffic theory knowledge is not maintained, refreshing this knowledge could make a difference. As another example, driving errors in driving simulation could indicate which manoeuvres a patient should practice during additional on-road driving lessons. Patients who doubt their fitness to drive whilst still driving safely and patients with trainable gaps in knowledge and skills needed for driving could benefit from prolonged car mobility with help from a fitness-to-drive assessment.

7.8. Adherence to driving recommendations

A significant proportion of patients (46%) received a recommendation to continue driving in the present study (Chapter 6). Adherence to this recommendation was above 90% in a sample of patients with cognitive impairment who wish to continue driving. Even with the positive outcome of a fitness-to-drive assessment, patients should be made aware that the progression of dementia will lead to driving cessation eventually. A very small
A group of patients received a recommendation to follow driving lessons and sign up for an official on-road driving assessment. Around 40% of these patients ceased driving at follow-up, and the majority did not adhere to the driving recommendation before deciding to cease driving. There may be different reasons for this decision, but it could be that some patients ceased driving prematurely because they experienced too much stress related to the recommended procedure. Some patients also mentioned that an investment in driving lessons may not be worthwhile if it results in only a very short period (i.e. a maximum of one year) of prolonged car mobility. Most patients who continued to drive adhered to at least part of the driving recommendation, but almost 30% did not. This does not necessarily mean that the driving recommendation was ignored, because some patients had adapted their driving and a few still had plans to sign up for the official on-road driving assessment. Driving restriction, however, may not be enough to prevent accidents. These patients may need to be reminded and motivated by people around them to adhere to the driving recommendation.

Even though it was opposite to their wish, driving cessation recommendations were followed by the vast majority of patients (79%). Moreover, a few patients who did not cease driving yet, were probably going to in the near future. Three intrapersonal factors, i.e. female gender, progression of dementia, and perceived health decline, facilitated driving cessation. However, about one in six patients did not consider driving cessation at all despite the serious concerns raised regarding their fitness to drive. Some of them were convinced that driving was still safe. A few felt it was safe to drive together with a co-pilot, but there is no evidence that this is truly safe (Bédard, Molloy, & Lever, 1998; Shua-Haim, Shua-Haim, & Ross, 1999). Non-compliant patients may have a decreased awareness of their cognitive impairments, but it is noteworthy that their co-pilots apparently agree with driving continuation. This implies that not only be the patient needs to be convinced of driving cessation advice, but also close relatives who may have an interest in the patient continuing to drive. Correspondingly, it was found that interpersonal factors play a large role in driving cessation. A social network that supports driving cessation and stimulates the transition to alternative transportation may promote adherence to driving cessation advice.
7.9. Mobility transition counselling

Research has largely focused on driving, which is the preferred mode of transport of many people, but not the only way to retain mobility. Mobility transition counselling is about driving, but also about planning for alternative transportation (Berg-Weger, Meuser, & Stowe, 2013). If driving is still safe now, it may not be safe anymore next year, and many older drivers outlive their fitness to drive (Foley, Heimovitz, Guralnik, & Brock, 2002). Remarkably, research about the safety of using alternative transportation when having cognitive impairments is lacking so far. Cycling is reported as an important mode of transport for many patients with cognitive impairment (see Chapter 6), but the vulnerability of cyclists and older people in general is of concern for the personal safety of patients (Brouwer & Ponds, 1994). In Chapter 6, it is described that a proportion of patients with cognitive impairment were able to sustain their mobility after driving cessation through the use of alternative transportation (i.e. cycling, public transport), but mobility is reduced for the majority of patients. Alternative transportation should become more visible and accustomed to patients with cognitive impairments, with potential for dementia friendly taxi services which guide patients at least from door-to-door. Patients with cognitive impairments may be in need of mobility transition counselling, taking the individual’s preferences and impairments into account. Therefore mobility transition counselling should be provided to patients who need to cease driving but also to those who are still fit to drive when receiving a diagnosis of cognitive impairment. It may be easier to adopt alternative modes of transport when cognitive impairments are still mild, and patients can already start with this transition when they are still driving.

Despite the potential of mobility transition counselling, it is not clear where and by whom mobility counselling is provided in many countries, including the Netherlands. A country that has implemented mobility counselling is the United Kingdom, where a network of centres offers information, advice and assessment about mobility, though largely focused on driving. In the Netherlands, the driving licence authority only advises about driving and driving cessation, not about alternative transport. Physicians may be asked to support their patients in the transition from driving to alternative transportation, but they are limited in time and resources to advise patients about mobility. In addition to a talk about different modes of transportation, practical assistance in arranging other transport may be necessary; examples are renting a mobility scooter or subscribing for specialized taxi services. In the Netherlands, so-called case-managers might be able to provide this assistance.
for patients with cognitive impairment and help can also be sought from the municipality according to the law called ‘Wmo-vervoer’. The law ‘Wmo-vervoer’ intends to enable independent participation in society for all Dutch citizens through support in transport mobility, such as reduced rates for a shared taxi for people with restrictions in mobility. Consortium ‘Blijf Veilig Mobiel’ and organisation ‘Veilig Verkeer Nederland’ are also concerned with mobility of older persons in the Netherlands, they provide online information about many modes of transportation. These sources, however, may not be well-known and not easy to access for older patients with cognitive impairment. Family members probably play a large role in arranging (help for) alternative transportation. More social services will be needed to increase the accessibility of alternative transportation for patients with cognitive impairment in order to promote mobility, independence, social participation and well-being.

7.10. Limitations and directions for future research

In this PhD thesis, an assessment strategy was developed to investigate fitness to drive of patients with AD and it was validated on patients with MCI. However, the sample size of the validation study is small, and a new validation study on a large independent sample of patients with AD and MCI is warranted before clinical application can be advised. Moreover, with an adapted cut-off more patients with MCI could be correctly classified as fit or unfit to drive, therefore different cut-offs require validation in studies with new samples of patients with AD and MCI.

About a third of the participants were hampered by simulator sickness during the driving simulator rides. It is not easy to circumvent this problem as it is not possible to screen for simulator sickness in advance (and if even possible, this might result in a selection bias). There are suggestions to change the simulator scenarios or driving simulator surroundings to reduce simulator sickness (Bridgeman et al., 2014; Domeyer et al., 2013; Keshavarz, Novak, Hettinger, Stoffregen, & Campos, 2017), but these are not yet validated and cannot fully eliminate simulator sickness. More research should be dedicated to the attenuation of simulator sickness, because the number of patients that experience simulator sickness is high which limits the usefulness of driving simulator rides in clinical practice.

The proposed assessment strategy in its present form is not advised to be applied for the assessment of fitness to drive in patients with non-AD
dementia, therefore also new approaches must be developed for patients with other common types of dementia such as vascular dementia, frontotemporal dementia, and Lewy body dementia. Developing assessment strategies based on the required abilities for safe driving is desirable, but there is no generally accepted model of driver behaviour that could serve as a basis. If a model is devised that captures all aspects of driver behaviour, a fitness-to-drive assessment that follows this model would be too elaborate by the inclusion of many measures that are required to represent all aspects of driving. Therefore, selections of measures must be made depending on the type of dementia. For patients with rare or unclear diagnoses of cognitive impairment, it will be difficult to develop a standardized fitness-to-drive assessment that is accurately predicting on-road driving performance. In these cases, on-road driving assessments might remain necessary to evaluate fitness to drive. It is important to stress that this PhD thesis demonstrates that fitness-to-drive assessment could be compared with accident risks of patients with cognitive impairments who passed the on-road driving assessment could be compared with accident risks of other patient groups and whether fitness-to-drive assessments targeted at medical at-risk groups are as safe drivers as other groups that are allowed to drive, but it would not be possible in countries with mandatory reporting of drivers with dementia, a prospective study is required. Another interesting method to investigate this further, research should be conducted across borders. Accident results of patients with AD should not be generalized to the entire population of patients with cognitive impairment in future research.

At this stage, information about which driving difficulties occur in patients with different types of dementia is very limited while this knowledge may be very valuable for the selection of measures that might predict on-road driving performance in specific patient groups. The only study investigating on-road driving in two different types of dementia, AD and VaD, showed a comparable mean drive score between both groups, but more eye movements in patients with VaD compared with AD in an on-road driving assessment (Fitten et al., 1995). Differences in driving difficulties could be investigated further using the TRIP forms of this study and also in a naturalistic driving study in which the driving performance of patients with different types of dementia is monitored in their own cars for longer periods of time. In addition, a longitudinal study in which patients with different types of dementia perform half-yearly on-road driving assessments would be very helpful to determine for how long driving licences of patients with different forms of dementia should be extended and when re-assessment of fitness to drive is necessary. When combining these two studies, the validity and reliability of on-road driving assessments could also be studied more thoroughly.

The current literature does not reveal whether the implementation of fitness-to-drive assessments reduces the number of prospective traffic accidents and/or improves car mobility (Martin et al., 2013). Despite the methodological difficulties, it is important to design and conduct studies to investigate
whether fitness-to-drive assessments targeted at medical at-risk groups accomplish these goals. There are multiple methods to consider. The accident risk of patients with cognitive impairments who passed the on-road driving assessment could be compared with accident risks of other patient groups and healthy older drivers. This would indicate whether the patients who passed were as safe drivers as other groups that are allowed to drive, but it would not demonstrate whether the patients who failed were unsafe drivers. In order to investigate this further, research should be conducted across borders. Accident risks of patients with cognitive impairments in countries without a fitness-to-drive assessment are likely to be higher than in countries where fitness-to-drive assessments are established, because less unsafe drivers should be on the road in the latter countries. In some countries, state records of accidents are available to study accidents retrospectively (Ball, Owsley, Sloane, Roenker, & Bruni, 1993). A limitation is that countries differ also in many other aspects than having established fitness-to-drive assessments and it may therefore be difficult to draw valid conclusions from these comparisons. In a country without mandatory reporting of drivers with dementia, a prospective study may be possible in which patients who undergo fitness-to-drive assessments are compared with patients who do not with regard to the number of accidents and mobility (Martin et al., 2013). Another interesting method to consider, which is safe and also possible to conduct in countries with mandatory reporting of drivers with dementia, is to study both patients who passed and who failed the on-road driving assessment half a year and a year thereafter in a driving simulator to compare accident rates and driving errors between both groups.

Another matter that deserves further attention is the reluctance to cease driving of a proportion of patients who are deemed unfit to drive. Interventions to promote driving cessation should be investigated, and involvement of family members is crucial. However, it must be emphasized that many patients would not need an additional intervention to cease driving after a fitness-to-drive assessment. Moreover, for some patients who are aware of the impairments of old age, the driving cessation process might even occur naturally without any intervention or fitness-to-drive assessment. It must be emphasized that driving cessation is usually not an immediate decision, but a long-lasting personal process (Liddle et al., 2013) that should be respected. A related area for research is how mobility and well-being can be maintained after driving cessation. Without alternative transportation many patients can become isolated at home. In line with this, accessibility and safety of
alternative transportation for patients with cognitive impairment should be studied, e.g. of taxi services and cycling.

Additionally, there should be more research on rehabilitation-oriented assessments of fitness to drive to reveal options to compensate for cognitive impairments. Fitness-to-drive assessments provide information about individuals’ weaknesses for which they may require in-car support, education or training as well as strengths that could be used in rehabilitation. As an example, for some patients with wayfinding difficulties, driving with a navigation system might facilitate a prolonged duration of driving continuation. In this context, the development of technological innovations, in particular (partially) automated vehicles is very promising. Current highly automated vehicles, however, may not be suitable for patients who are unfit to drive as the driver needs to intervene when unexpected situations occur or in case of road works (Aeberhard et al., 2015), i.e. in traffic situations in which patients with cognitive impairment need support, they would have to drive themselves. Nonetheless, if cars become fully automated, there is no need of a driver anymore, therefore, patients with cognitive impairment who are no longer fit to drive may be allowed to travel in fully automated cars in the future. Although this idea is very attractive, there are many hurdles to take before all traffic will become fully automated (Aeberhard et al., 2015; Kyriakidis, Happee, & de Winter, 2015).

7.11. Conclusions

This thesis addresses how fitness to drive should be assessed in patients with different aetiologies of cognitive impairment. This topic is very relevant as patients with cognitive impairment are at risk for unsafe driving, but a large proportion of them are fit to drive in early stages of their disease warranting individual evaluations. A fitness-to-drive assessment including clinical interviews, neuropsychological tests, and driving simulator rides is a promising approach for patients with AD. Additionally, for patients with different types of dementia (e.g. vascular dementia, frontotemporal dementia, Lewy body dementia) different assessment strategies must be developed to evaluate their fitness to drive. Driving recommendations given after fitness-to-drive assessments were effectively promoting driving continuation of patients who were fit to drive and driving cessation of patients who were no longer fit to drive. In the process of driving cessation, patients with cognitive impairment may need support to stimulate the transition to alternative transportation, in order to retain mobility and social participation.