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

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5. Assessing fitness to drive in patients with different types of dementia

ABSTRACT
Dementia is a risk factor for unsafe driving. Therefore, an assessment strategy has recently been developed for the prediction of fitness to drive in patients with Alzheimer’s disease (AD). The aim of this study is to investigate whether this strategy is also predictive of fitness to drive in patients with non-AD dementia, i.e. vascular dementia, frontotemporal dementia, and dementia with Lewy bodies. Predictors were derived from three types of assessment: clinical interviews, neuropsychological tests, and driving simulator rides. The criterion was the pass–fail outcome of an official on–road driving assessment. About half of the patients with non-AD dementia (n = 34) failed the on-road driving assessment. Neuropsychological assessment (AUC = .786) was significantly predictive of fitness to drive in patients with non-AD dementia, however, clinical interviews (AUC = .559) and driving simulator rides (AUC = .404) were not. The fitness-to-drive assessment strategy with the three types of assessment combined (AUC = .635) was not found to significantly predict fitness to drive in non-AD dementia. Different types of dementia require different measures and assessment strategies.

5.1. Introduction
The most common types of dementia are Alzheimer’s disease (AD), vascular dementia (VaD), frontotemporal dementia (FTD), and dementia with Lewy bodies (DLB) (Goodman et al., 2016). In early stages, different patterns of cognitive dysfunctions may be present in patients with different types of dementia. Initial impairments of AD usually lie in the cognitive domain of memory, whereas VaD often starts with cognitive slowing, FTD with behavioural or language impairments and DLB with visuospatial impairments. These different impairments may have different effects on activities of daily living such as driving (Piersma, de Waard, et al., 2016; Snyder, 2005).

4 This chapter was based on Piersma, D., Fuermaier, A. B. M., de Waard, D., Davidse, R. J., de Groot, J., Doumen, M. J. A., ... Tucha, O. (in press). Assessing Fitness to Drive in Patients with Different Types of Dementia. *Alzheimer Disease & Associated Disorders*. http://doi.org/10.1097/WAD.0000000000000221
Many patients with different types of dementia continue driving (Seiler et al., 2012), but dementia is a risk factor for traffic safety. There is consensus that patients with moderate to severe dementia should not drive anymore (Lundberg et al., 1997). However, in the early stages of dementia, some patients still drive safely while others do not (Lundberg et al., 1997). In order to advise patients with mild dementia about driving, patients should be assessed on fitness to drive (Fitten et al., 1995; Piersma, Fuermaier, et al., 2016; Piersma, de Waard, et al., 2016). On-road driving assessments are the ‘gold standard’ because of a high face validity, but it is infeasible to assess all drivers with dementia on the road. A reliable and validated fitness-to-drive assessment strategy for clinical application would therefore be useful (Omer, Dolan, Dimitrov, Langan, & McCarthy, 2014). However, it seems crucial to validate fitness-to-drive assessment strategies for patients with different types of dementia separately, because they may vary in symptoms and in the effects of symptoms on driving behaviour (Fujito et al., 2016; Martin, Marottoli, & O’Neill, 2013; Piersma, de Waard, Davidse, Tucha, & Brouwer, 2016).

Studies on driving with non-AD dementia are scarce. There is only one study on driving with VaD (Fitten et al., 1995), which showed that patients with VaD made more driving errors on the road than healthy participants (Fitten et al., 1995). Patients with VaD might not operate a car quickly enough and may not perceive other road users or signs in time as a consequence of cognitive slowing (Piersma, de Waard, et al., 2016). Nonetheless, some patients with VaD have mild symptoms for a long time and these patients may be safe drivers for several years after diagnosis.

Driving with FTD was investigated using interviews and driving simulators, but no on-road driving assessments were reported yet (De Simone, Kaplan, Patronas, Wassermann, & Grafman, 2007; Ernst et al., 2010; Fujito et al., 2016; Turk & Dugan, 2014). Antisocial behaviour, agitation, impulsivity, and distraction due to FTD may lead to speeding, ignoring road signs, running red lights, and not recognizing pedestrians at intersections, all having the clear potential to cause accidents (De Simone et al., 2007; Ernst et al., 2010; Fujito et al., 2016; Turk & Dugan, 2014). Moreover, impairment of judgement may cause difficulty estimating distances between vehicles (Fujito et al., 2016), and result in a lack of understanding that particular driving behaviour is inappropriate and risky (Ernst et al., 2010). Based on the moderately progressive course and early behavioural symptoms, it has been suggested
that patients with FTD should cease driving soon after diagnosis (Ernst et al., 2010; Fujito et al., 2016; Wilson & Pinner, 2013).

There is only one study on driving with DLB (Yamin, Stinchcombe, & Gagnon, 2015). In this driving simulator study, patients with DLB were regularly speeding, swerving, running red lights and causing accidents (Yamin et al., 2015). DLB has a slowly progressive course, but the initial symptoms, i.e. visual hallucinations, visuospatial impairments, fluctuations in attention, and parkinsonism, may already impede safe driving at the time of diagnosis (Wilson & Pinner, 2013).

To address the need for validated fitness-to-drive assessment strategies, an assessment strategy was developed recently for patients with AD (Piersma, Fuermaier, et al., 2016). The assessment strategy consisted of clinical interviews, a neuropsychological assessment, and driving simulator rides, because these three types of assessments were shown to provide non-redundant information for the prediction of fitness to drive in patients with AD. The aim of the present study is to investigate whether the suggested assessment strategy is also predictive for fitness to drive in patients with VaD, FTD, and DLB. We hypothesize that the proposed strategy will aid the prediction of fitness to drive, because cognitive and functional aspects important for driving are assessed. However, the differences in clinical syndromes of VaD, FTD, and DLB may result in a considerable drop in predictive accuracy compared to the original study on patients with AD. The measures of the three types of assessments may differ in how disease-specific they are in predicting fitness to drive, therefore the different types of assessments will also be evaluated separately.

5.2. Methods

5.2.1. Participants

Participants were recruited and assessed according to the study protocol described by Piersma and colleagues (Piersma, Fuermaier, et al., 2016). The study was approved by the Medical Ethical Committee at the University Medical Center Groningen, the Netherlands. Inclusion criteria for patients were an age above 30, a valid driving licence, a wish to continue driving, and a diagnosis of dementia in very mild to mild stages (Clinical Dementia Rating (CDR) < 2). Exclusion criteria were the diagnosis of neurological or psychiatric conditions unrelated to dementia that may influence driving
performance and usage of medications legally incompatible with driving (ICADTS category III drugs). Additionally, patients were screened on visual functions according to legal limits for driving, i.e. a minimum visual acuity of 0.5 and a minimum horizontal field of view of 120 degrees.

Referring physicians established the diagnosis of VaD with the NINDS-AIREN criteria (Román et al., 1993), the diagnosis of FTD and its variants by the criteria of the International bvFTD Criteria Consortium (Rascovsky et al., 2011) and the International PPA Consortium (Gorno-Tempini et al., 2011), and the diagnosis of DLB using the criteria of the DLB consortium (McKeith et al., 2005). Two patients with VaD had to be excluded because they did not fulfil the visual requirement of a minimum horizontal visual field of 120 degrees, resulting in fourteen patients with VaD who completed the study. Moreover, two patients with FTD had to be excluded because their visual acuity was below the requirement of 0.5. Two additional patients with FTD were excluded because they did not perform the on-road assessment. Hence, twelve patients with FTD completed the study. The behavioural variant of FTD was diagnosed in seven cases, the semantic variant in two cases and primary progressive aphasia in one case. One case was diagnosed with both the behavioural and semantic variant of FTD. In one case, the diagnosis of FTD was not specified as a particular variant. Finally, eight patients with DLB participated in this study. Table 5.1 shows characteristics of the three patient groups.
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Table 5.1. Characteristics of patients with vascular dementia, frontotemporal dementia, and dementia with Lewy bodies.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>VaD (n = 14)</th>
<th>FTD (n = 12)</th>
<th>DLB (n = 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>75.0 (5.3)</td>
<td>67.3 (10.3)</td>
<td>71.7 (10.3)</td>
</tr>
<tr>
<td>Male sex, No. (%)</td>
<td>12 (85.7%)</td>
<td>9 (75.0%)</td>
<td>7 (87.5%)</td>
</tr>
<tr>
<td>Education, mean of 7 stages (SD)</td>
<td>4.6 (1.1)</td>
<td>5.2 (0.8)</td>
<td>5.3 (1.8)</td>
</tr>
<tr>
<td>CDR-score, No. (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0 (0.0%)</td>
<td>1 (8.3%)</td>
<td>3 (37.5%)</td>
</tr>
<tr>
<td>0.5</td>
<td>11 (78.6%)</td>
<td>9 (75.0%)</td>
<td>4 (50.0%)</td>
</tr>
<tr>
<td>1</td>
<td>3 (21.4%)</td>
<td>2 (16.7%)</td>
<td>1 (12.5%)</td>
</tr>
<tr>
<td>MMSE-score, mean (SD)</td>
<td>22.3 (2.1)</td>
<td>25.2 (3.1)</td>
<td>26.3 (2.8)</td>
</tr>
<tr>
<td>Medication affecting the CNS, No. (%)</td>
<td>5 (35.7%)</td>
<td>2 (16.7%)</td>
<td>2 (25.0%)</td>
</tr>
<tr>
<td>Driving experience, mean (SD), y</td>
<td>54.2 (7.0)</td>
<td>46.2 a (7.2)</td>
<td>48.8 (9.2)</td>
</tr>
<tr>
<td>Driving experience, mean (SD), km</td>
<td>2,454,000</td>
<td>1,500,000 b</td>
<td>1,208,000</td>
</tr>
<tr>
<td>Car accident in past year, No. (%)</td>
<td>2 (14.3%)</td>
<td>1 (8.3%)</td>
<td>1 (12.5%)</td>
</tr>
<tr>
<td>Traffic ticket in past year, No. (%)</td>
<td>1 (7.1%)</td>
<td>4 (33.0%)</td>
<td>2 (25.0%)</td>
</tr>
</tbody>
</table>

a For 11 patients out of 12 patients, because 1 patient did not report the information.
b For 10 patients out of 12 patients, because 2 patients did not report the information.

Abbreviations: VaD, vascular dementia; FTD, frontotemporal dementia; DLB, dementia with Lewy bodies; Education, Verhage scale for the Dutch educational level ranging from 1 (primary school not finished) to 7 (university level); CDR-score, Clinical Dementia Rating Total Score; MMSE-score, Mini Mental State Examination Sum Score (range 0-30); CNS, central nervous system; Medications include antidepressants, cholinergic medications, dopaminergic medication, GABAergic medication and a natural sedative.

5.2.2. Measures

The following description of methods entails only the measures used in the prediction equations as derived from the original study (Piersma, Fuermaier, et al., 2016). Measures of clinical interviews included two subscores of the CDR, i.e. Orientation and Judgement & Problem Solving (Morris, 1993), the patients’ judgements of their own driving safety, and recent driving experience. The neuropsychological assessment comprised the Mini-Mental State Examination (MMSE; Folstein et al., 1975; Kok & Verhey, 2002), the Reaction Time S2 (Prieler, 2008), the Hazard Perception Test (Vlakveld, 2011), and a Traffic Theory Test (see Piersma, Fuermaier, et al., 2016 for details). Fixed-based Jentig50 driving simulators of ST Software were used. Driving
simulator measures included the minimum speed when approaching an intersection with traffic lights, the number of collisions in a ride with intersections and two measures concerning a merging manoeuvre, i.e. the deceleration of the rear car after merging and the time headway directly after merging (see Piersma, Fuermaier, et al., 2016 for details).

The on-road driving assessments were carried out by approved experts on practical fitness to drive of the Dutch driving test organisation (CBR). Experts were blind to the participants’ diagnoses and test results. They rated driving behaviour of patients on the Test Ride Investigating Practical fitness to drive forms (Tant et al., 2002; Withaar et al., 2000). Finally, a pass, doubtful or fail outcome was given by the expert. This outcome was recoded into a dichotomous item which indicates whether or not a participant is fit to drive, i.e. pass outcomes indicated that participants could retain their driving licence while doubtful or fail outcomes indicated that participants would have lost their driving licence if this was an official relicensing assessment.

5.2.3. Statistical analyses

Missing data
The traffic theory test measure of one patient with VaD was missing. Because of simulator sickness, 7 (50.0%) patients with VaD, 3 (25.0%) patients with FTD, and 2 (25.0%) patients with DLB were excluded entirely from analyses that involved driving simulator rides. Because of technical problems, driving simulator measures of one patient with VaD and of one patient with FTD were missing. In addition, one driving simulator measure, i.e. the deceleration of the rear car after merging, was missing of one patient with VaD and one patient with DLB, because these participants merged onto the motorway after all cars had passed. Since these two patients did complete the driving simulator rides, it was decided to impute the two missing values using an imputation model (including all complete variables of the specific patient group) that was estimated by maximum likelihood (ML), providing a singly imputed dataset.

Evaluation of the prediction model for fitness to drive
The goal of the analysis was to evaluate whether fitness to drive of patients with non-AD dementia can be predicted with a prediction model that has been developed using data of patients with AD (Piersma, Fuermaier, et al., 2016). The previously proposed prediction equations were applied using data of 34 patients with non-AD dementia: 14 VaD, 12 FTD, and 8 DLB. Receiver Operating Characteristic (ROC) analyses were used to evaluate the
predictive accuracy of the model. The area under the curve (AUC) was used as a classification measure with larger areas indicating better predictive accuracy. The three groups of predictor variables, i.e. clinical interviews, neuropsychological assessment and driving simulator rides, and the complete approach (i.e. variables from all groups of predictors) were evaluated in separate ROC analyses in order to explore the accuracy of each set of variables in predicting fitness to drive for non-AD dementia.

5.3. Results

Four of fourteen patients with VaD, five of twelve patients with FTD, and five of eight patients with DLB passed the on-road driving assessment. Overall, 14 (41.2%) patients passed and 20 (58.8%) patients failed the on-road driving assessment. Results of patients who passed and failed the on-road assessment are presented in Table 5.2.
Table 5.2. Comparison of patients with non-AD dementia who passed and who failed the on-road driving assessment on predictor variables*.

| Clinical interviews                        | Pass (n = 14) | Fail (n = 20) | ES  
|-------------------------------------------|---------------|---------------|---
| CDR Orientation                           | 0.3 (0.3)     | 0.6 (0.5)     | 0.77  
| CDR Judgement & Problem solving           | 0.6 (0.4)     | 0.7 (0.4)     | 0.22  
| Judgement driving safety b                | 1.2 (0.4)     | 1.2 (0.4)     | 0.03  
| Recent driving experience c               | 2.6 (0.8)     | 2.8 (1.6)     | 0.14  

| Neuropsychological assessment             | Pass (n = 14) | Fail (n = 19) | ES  
|-------------------------------------------|---------------|---------------|---
| MMSE-score                                | 24.9 (2.7)    | 23.6 (3.3)    | 0.46  
| RT S2 RT (msec)                           | 281.3 (47.5)  | 426.9 (258.5) | 0.75  
| Hazard perception (Correct trials)        | 15.8 (2.7)    | 12.5 (4.2)    | 0.93  
| Traffic theory (Response time in sec)     | 7.4 (0.7)     | 8.0 (1.3)     | 0.52  

| Driving simulator rides                   | Pass (n = 8)  | Fail (n = 12) | ES  
|-------------------------------------------|---------------|---------------|---
| Minimum speed at intersection (km/h) d    | 4.1 (10.8)    | 10.2 (20.8)   | 0.37  
| Number of collisions                      | 0.9 (1.0)     | 0.5 (0.8)     | 0.48  
| Deceleration rear car after merging (km/h)| -0.6 (1.1)    | -1.3 (2.1)    | 0.42  
| Time headway after merging (sec)          | 1.4 (0.6)     | 1.0 (0.5)     | 0.78  

* Effect size (ES) is indicated by Cohen’s d.

b Judgement about driving safety whether participant is (1) still driving as safely as when the participant was middle-aged, (2) is driving less safely compared to when the participant was middle-aged, or (3) drives unsafely.

c Kilometres driven in the previous twelve months: (1) less than 1.000 km, (2) 1.000–5.000 km, (3) 5.000–10.000 km, (4) 10.000–20.000 km, (5) 20.000–30.000 km, (6) 30.000–50.000, (7) more than 50.000 km.

d Intersection with need to give right of way, the traffic lights at this intersection turn yellow and subsequently red.

* Prediction equations:
- Clinical interviews = CDR Orientation*0.675 + CDR Judgement & Problem Solving*1.036 + Judgement driving safety*1.250 + Recent driving experience*-0.576.
- Neuropsychological assessment = MMSE*0.129 + RT S2 RT*-0.003 + Correct trials of Hazard Perception*0.206 + Response time of traffic theory*-0.310.
- Driving simulator rides = Minimum speed interaction 2*0.021 + Number of collisions*0.738 + Deceleration rear car*-0.367 + Time headway*0.732.
- Complete approach = Clinical interviews*0.328 + Neuropsychological assessment*-0.620 + Driving simulator rides*0.483.

Abbreviations: CDR, Clinical Dementia Rating (range 0-3); MMSE-score, Mini Mental State Examination Sum score (range 0-30); RT S2 RT, Reaction time test S2 Reaction time; Hazard perception, Hazard Perception Test (range 0-25).

Prediction equations derived from the previous study on patients with AD were applied (Piersma, Fuermaier, et al., 2016). ROC analysis showed that the clinical interviews (n = 34) were not predictive of fitness to drive in patients with non-AD dementia with a non-significant AUC close to chance.
level, AUC = .559, SE = 0.104, p = .564. In contrast, ROC analysis revealed that neuropsychological assessment (n = 33) was predictive of fitness to drive in this patient group with a significant AUC of .786, SE = 0.081, p = .006. Similar to clinical interviews, driving simulator rides (n = 20) were not found to aid the prediction of fitness to drive in patients with non-AD dementia, AUC = .417, SE = 0.130, p = .537. The complete approach with the three types of assessments combined (n = 20) was not useful for the prediction of fitness to drive in this sample of patients with non-AD dementia, AUC = .635, SE = 0.129, p = .316.

The patient groups were too small to evaluate the prediction model for the three types of dementia separately, however, to get an idea whether the results from the three different types of non-AD dementia diverge, their mean scores on the predictor variables were explored (Table 5.3). Patients with VaD had poorer mean scores on the predictor variables of clinical interviews and neuropsychological assessment than patients with FTD and patients with DLB, which was particularly evident for the scores on the MMSE and the Hazard Perception Test. In general, patients with DLB had ‘safer’ mean scores on the predictor variables than the other two patient groups, for example an adequate Reaction Time S2 score. Notably, patients with FTD judged their own driving safety as safe, but approached an intersection with traffic lights with a high speed compared with the other two patient groups. Nonparametric comparisons using Kruskal-Wallis tests showed statistically significant differences between the patient groups in MMSE-score, \( \chi^2(2) = 10.228, p = 0.006 \), Hazard perception (Correct trials), \( \chi^2(2) = 10.198, p = 0.006 \), Traffic theory (Response time), \( \chi^2(2) = 7.852, p = 0.020 \), and the number of collisions in the driving simulator, \( \chi^2(2) = 6.358, p = 0.042 \). Mann-Whitney post-hoc tests indicated worse performance of patients with VaD compared to the other two groups of patients in the majority of comparisons (Table 5.3). In conclusion, the three patient groups appeared to differ in their scores on the predictor variables.
Table 5.3. Predictor variables of patients with vascular dementia, frontotemporal dementia, and dementia with Lewy bodies.

<table>
<thead>
<tr>
<th>Predictor variable</th>
<th>Group mean (SD)</th>
<th>KW test</th>
<th>Mann Whitney U tests</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VaD (n = 14)</td>
<td>FTD (n = 12)</td>
<td>DLB (n = 8)</td>
</tr>
<tr>
<td>Clinical interviews</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDR Orientation</td>
<td>0.6 (0.5)</td>
<td>0.4 (0.4)</td>
<td>0.3 (0.3)</td>
</tr>
<tr>
<td>CDR Judgement &amp; Problem solving</td>
<td>0.7 (0.3)</td>
<td>0.6 (0.4)</td>
<td>0.5 (0.4)</td>
</tr>
<tr>
<td>Judgement driving safety(^a)</td>
<td>1.2 (0.4)</td>
<td>1.1 (0.3)</td>
<td>1.4 (0.5)</td>
</tr>
<tr>
<td>Recent driving experience(^b)</td>
<td>2.3 (1.1)</td>
<td>2.8 (1.6)</td>
<td>3.1 (1.0)</td>
</tr>
<tr>
<td>Neuropsychological assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE-score</td>
<td>21.9 (1.7)</td>
<td>25.2 (3.1)</td>
<td>26.3 (2.8)</td>
</tr>
<tr>
<td>Reaction Time S2 (msec)</td>
<td>406 (313)</td>
<td>366 (116)</td>
<td>297 (52)</td>
</tr>
<tr>
<td>Hazard perception (Correct trials)</td>
<td>11.1 (3.6)</td>
<td>15.3 (3.4)</td>
<td>16.5 (2.1)</td>
</tr>
<tr>
<td>Traffic theory (Response time in sec)</td>
<td>8.3 (1.0)</td>
<td>7.3 (0.9)</td>
<td>7.4 (1.1)</td>
</tr>
<tr>
<td>Driving simulator rides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum speed at intersection (km/h)(^c)</td>
<td>2.8 (6.6)</td>
<td>13.4 (24.8)</td>
<td>5.1 (12.6)</td>
</tr>
<tr>
<td>Number of collisions</td>
<td>1.3 (0.8)</td>
<td>0.4 (0.7)</td>
<td>0.3 (0.8)</td>
</tr>
<tr>
<td>Deceleration rear car after merging (km/h)</td>
<td>-1.2 (1.4)</td>
<td>-1.5 (2.4)</td>
<td>0.0 (0.0)</td>
</tr>
<tr>
<td>Time headway after merging (sec)</td>
<td>1.1 (0.6)</td>
<td>1.4 (0.6)</td>
<td>0.8 (0.4)</td>
</tr>
</tbody>
</table>

\(^a\) Judgement about driving safety whether patient is (1) still driving as safely as when the patient was middle-aged, (2) is driving less safely compared to when the patient was middle-aged, or (3) drives unsafely.

\(^b\) Kilometres driven in the previous twelve months: (1) less than 1.000 km, (2) 1.000–5.000 km, (3) 5.000–10.000 km, (4) 10.000–20.000 km, (5) 20.000–30.000 km, (6) 30.000–50.000, (7) more than 50.000 km.

\(^c\) Intersection with need to give right of way, the traffic lights at this intersection turn yellow and subsequently red.

Statistical significance (p < .05) is indicated by *. Abbreviations: VaD, vascular dementia; FTD, frontotemporal dementia; DLB, dementia with Lewy bodies; CDR, Clinical Dementia Rating (range 0-3); MMSE-score, Mini Mental State Examination Sum score (range 0-30); Hazard perception, Hazard Perception Test (range 0-25); KW test, Kruskal-Wallis test.
5.4.  Discussion

About half of the patients failed the on-road driving assessment suggesting that VaD, FTD, and DLB are risk factors for unsafe driving. This is in line with previous studies showing that patients with VaD make more driving errors on the road and that patients with FTD and DLB make more driving errors in driving simulation, in comparison to healthy drivers (De Simone et al., 2007; Fitten et al., 1995; Yamin et al., 2015). Nevertheless, a considerable proportion of patients of each type of dementia passed the on-road driving assessment. Likewise, Fitten and colleagues showed a large variation in on-road driving performance among patients with VaD indicating that some patients with VaD are fit to drive while others are unfit to drive (Fitten et al., 1995). Although research including on-road driving of patients with FTD and DLB was lacking, it has been argued that patients with FTD and DLB should cease driving very soon after the diagnosis is established (Ernst et al., 2010; Fujito et al., 2016; Wilson & Pinner, 2013). In a study by Seiler and colleagues, only 9 out of 16 patients with FTD had ceased driving (a rate comparable with patients with AD and VaD), while as many as 10 out of 11 patients with DLB had ceased driving (Seiler et al., 2012). The current study suggests that not all patients with FTD and DLB are unfit to drive. Consequently, all patients with dementia who wish to continue driving should be assessed on fitness to drive.

In this study, it was found that the prediction model for fitness to drive in patients with AD was not predictive for fitness to drive in patients with non-AD dementia (AUC = .635). Although the applied neuropsychological assessment battery was of significant value for the prediction of fitness to drive in patients with non-AD dementia (AUC = .786), the selections of predictor variables from clinical interviews (AUC = .559) and driving simulator rides (AUC = .417) were not. Clinical interviews may be of limited utility for the prediction of fitness to drive in patients with dementia, because it requires insight of patients into their own abilities, and careful attention of informants to the patients’ behaviour. In this study, patients with FTD estimated their driving safety as not being declined which is in accordance with a previous study stating that patients with FTD may not realize that their driving behaviour is risky (Ernst et al., 2010). It can be concluded that the primary use of clinical interviews is to discuss the impact of dementia on driving and to score the severity of dementia.
Furthermore, the selected measures from the driving simulator rides may not serve the prediction of fitness to drive in patients with non-AD dementia, because these measures do not represent all critical traffic situations, and patients with different types of dementia may have difficulties in different traffic situations. This would suggest that other driving simulator measures might be better predictors in patients with non-AD dementia. To start with, different measures from the current driving simulator rides could be investigated, e.g. measures reflecting lane control. Another issue with driving simulation is that some measures are difficult to interpret in terms of “safe” or “unsafe” driving, as both a high and a low value may indicate poor driving performance. For example, one patient group might be too slow while another patient group might be too fast in similar situations of simulated driving. A solution might be using measures differently for different patient groups, e.g. driving slowly might predict unsafe driving in patients with VaD, whereas speeding could be a predictor for unsafe driving in patients with FTD and DLB. Currently, driving simulator rides provide a safe environment for subjective clinical evaluations of fitness to drive, but objective evidence-based measures with cut-offs still have to be defined for the prediction of fitness to drive in non-AD dementia.

The applied neuropsychological assessment was useful for fitness-to-drive evaluations in patients with non-AD dementia, especially specific traffic tests may have the potential to predict fitness to drive in multiple types of dementia. This fits with the promising results with DriveSafe/DriveAware in groups of patients with cognitive impairments related to a variety of diagnoses (Hines & Bundy, 2014; Kay, Bundy, & Clemson, 2009). When developing new assessment strategies, it should also be considered which symptoms and impairments are likely to result in unsafe driving per aetiology and how these can be assessed. For example, cognitive slowing in VaD and visuospatial functions in DLB could be evaluated in a neuropsychological assessment (Levy & Chelune, 2007). Patients with FTD show impairments of behaviour (‘do’) rather than of maximal performance (‘can do’), which is difficult to measure with neuropsychological tests. Since it is common for patients with FTD not to realize that their driving behaviour is risky, inquiries with informants could be included when investigating fitness to drive in FTD. In brief, different algorithms using different measures may be needed to predict fitness to drive in patients with different types of dementia.
In future studies on fitness to drive in patients with non-AD dementia, dichotomized outcome scores might not always be feasible, therefore trichotomization may need to be considered (Molnar, Patel, Marshall, Manson-Hing, & Wilson, 2006a). This means that outcome scores will be divided into three groups: safe, unsafe and indeterminate. The latter group should be referred to additional fitness-to-drive assessments. Such an approach could improve the classification of driving safety.

This is the first study in which the prediction of fitness to drive in patients with three different types of non-AD dementia was investigated. Strengths of the study are that all patients were assessed according to the same protocol and that on-road driving evaluations were performed. In many studies on fitness to drive, patients with AD and other types of dementia were pooled into one group. In this study, it was found that the prediction equation with measures from clinical interviews, neuropsychological assessment and driving simulator rides that predicted fitness to drive in patients with AD did not apply to patients with non-AD dementia. These findings may imply that it is not possible to predict fitness to drive for all patients with dementia with one assessment strategy. Moreover, patients with different types of non-AD dementia also seem to differ in fitness-to-drive assessment results based on the exploration of their mean scores, which indicates that fitness-to-drive assessment strategies require validation for each type of dementia separately. It is important to note that the differences in mean scores between the patient groups are likely to be affected by the severity of cognitive impairment (i.e. the severity of cognitive impairment may have been worse in patients with VaD than in patients with FTD and DLB in this sample), in addition to the different types of dementia. The heterogeneity of the samples of patients with dementia may partially explain why predictive accuracies of fitness-to-drive assessment strategies were often low in previous studies (Dickerson, 2014).

In the current study, three types of dementia were pooled into one non-AD dementia group, because of small sample sizes. As a consequence, the results do not reveal whether the proposed assessment strategy was, for example, predictive for one of the three types of dementia included. To investigate this, the number of correct classifications for each type of dementia was counted after application of cut-off -0.6 as suggested in the original study (Piersma, Fuermaier, et al., 2016). For patients with VaD, the cut-off was too strict, because all six patients with VaD were classified as fail while two of them passed the on-road assessment. For patients with DLB, the cut-off was
too lenient since all six patients with DLB were classified as pass while three of them failed the on-road assessment. In the FTD group, the classification accuracy was better, nonetheless, two out of eight patients were incorrectly classified as pass. These results confirm that the proposed strategy cannot predict fitness to drive in each group of patients with non-AD dementia.

In conclusion, the results of this study show that a valid assessment strategy for the prediction of fitness to drive in patients with AD (Fuermaier et al., 2017; Piersma, Fuermaier, et al., 2016) is not useful for the prediction of fitness to drive in patients with non-AD dementia. This is in line with previously stated notions that each type of dementia has its own typical symptoms, resulting in different impairments and variations in driving behaviour (Fujito et al., 2016; Piersma, de Waard, et al., 2016). The implication of the findings is that assessment strategies for the prediction of fitness to drive should be developed specifically tailored to VaD, FTD, and DLB.