Driving errors, accidents and their predictors in patients with cognitive disorders

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Athens, 26 June 2015
To drive or not to drive

PREDICTIVE FACTORS

- Age = 85
- Gender = male
- MCI or mild dementia
- Previous accidents (2, last 1 year)
- Alcohol test +
Introduction

- Life loss in elderly represent the **26% of all life losses from car accidents in the EU** (Eurostat, 2014)

- Cognitive functions contribute to a successful driving

- **Cognitive functions are compromised in ~25% of the elderly population.** Diverse etiologies:
  - Degenerative: AD (AD dementia – or prodromal AD -amnestic MCI), PD, DLB,…
  - Vascular (VaD or Vascular MCI),
  - Drug induced,….

- Taking into account that the % of the **elderly** in society is increasing while at the same time the **level of motorization also increases** (Yannis et al, 2010), **the need to investigate the impact of the above conditions on driver performance becomes critical.**
There is role for the neurologist

- ADVICE about the issue: “to drive or not to drive”
- ADVICE about the issue: “how and when to drive”
  (defining restrictions for safe driving in a patient)

- ADVICE for adaptations of national regulations
- ADVICE for adaptations of vehicles (e.g. reminders), adaptations of roads (e.g. frequency of road signals)

- In close collaboration with other scientists (multi disciplinary approach)
Cognitive functions critical for safe driving

- **Attention**
  - quick perception of the environment

- **Visuospatial skills**
  - positioning of the car on the road
  - manoeuvring the car in lane changes
  - judging distances, speed

- **Executive functions**
  - process multiple simultaneous environmental cues
  - predicting the development of traffic situations
  - make rapid, accurate and safe decisions

- **Memory**
  - journey planning
  - adapting behaviour
  - sign recognition, memorization

(adapted from Reger et al. 2004)
Age-related cognitive decline

**FIGURE 15.4**
LONGITUDINAL CHANGES IN SIX INTELLECTUAL ABILITIES FROM AGE 25 TO AGE 95

Source: Adapted from Schaie, K.W. (2012). Developmental Influences on Adult Intelligence: The Seattle Longitudinal Study (2nd ed.), Fig. 5.8. New York: Oxford University Press.
On-road studies

- **fitness to drive control**
  (by an instructor)

- **naturalistic driving**
  (instrumented vehicles in real traffic conditions)

- **field test** (instrumented vehicles in test site)
Driving simulator experiments

Their Advantages

• Collection of data which would be very difficult to collect under real traffic conditions

• Exploration of any possible driving scenario

• Driving conditions are identical for all drivers

Their Disadvantages

• Non totally realistic simulated road environment

• Simulator sickness (~25% drop-out)
Surveys and Questionnaires on Stated behaviour

- A reference questionnaire is built, based on the list of selected topics
- A representative sample of general or specific population is interviewed
- Information is asked from the drivers AND from their close relatives.

Comparison with the “objective” measures is interesting (Economou et al, EAN, Berlin, 2015)
Alzheimer's Disease and Driving
Alzheimer's disease and driving

- Patients with dementia at a moderate or severe stage (CDR >1) are incapable of driving

- AD patients are 2.5 to 4.7 times more likely to be involved in a car crash than age-matched controls

  (Brown and Ott 2004; Dobbs et al. 2002; Ernst et al. 2010; Withaar et al. 2000, Brorsson, 1989; Massie & Campbell, 1993; Tuokko et al., 1995)

- But 50% of patients with AD continue driving for at least three years after their initial diagnosis

  (Adler and Kuskowski 2003; Seiler et al. 2012)

  (Johansson and Lundberg, 1997; Dubinsky et al., 1992; Rizzo et al., 2001; Charlton et al., 2004; Uc et al., 2005; Uc et al., 2006; Ott 2008; Ernst et al. 2010)
However, not all patients are incapable of driving, especially in the earlier stages of the disease.

- Up to a **76% of patients with mild AD** are still able to pass an on-road driving test.

AD is a progressive disease and the Neurologist has to decide: **which is the proper time for dissuading a patient from driving?**

*Duchek JM et al. J Gerontol Psychol Sci 1998*
*Ott BR et al. Neurology 2008, Brown and Ott 2004; Ernst et al., 2010; Withaar et al. 2000*

*Iverson DJ et al. Neurology 2010 (update of the AAN 2000 practice parameter on driving and dementia*
Alzheimer's disease and driving

The Neurologist has to take also into account that:

Ability to drive is of primary importance for:

a) maintaining autonomy and functional activity
b) promoting independence
c) preserving self-esteem

- Loss of driving licensure can lead to an increase in depression symptoms

(Gardezi et al., 2006; Marottoli et al., 1997; Ragland et al., 2005)
On-road assessment (Uc et al., 2004)

Drivers with mild AD made significantly:
- more incorrect turns
- got lost more often
- more at-fault safety errors

Although, basic control abilities of the vehicle were normal.

In-vehicle technology (Eby et al., 2012) continuous registration of driving parameters

Drivers with mild AD had an avoidance behavior

- Drove smaller and fewer distances, at lower traffic roads
- stayed closer at home and had a preference for daylight driving
- lower driving speed
- less likely to use a safety belt and got lost more often
Predictors of driving ability in patients with AD

Performance on neuropsychological tests:
1. visuospatial
2. attentional,
3. executive
4. memory

is associated with driving competence in patients with AD

(Brown et al., 2005; De Raedt et al., 2001; Paccalin et al., 2005; Uc et al., 2004; Whelihan et al, 2005, Brown et Ott, 2004; Elkin-Frankston et al., 2003; Ott et al., 2003; Ott et al., 2008; Reger et al., 2004; Szlyk et al., 2002; Uc et al., 2005; Grace et al., 2005; Asimakopoulos et al., 2012; Etienne et al., 2013)
Studies have suggested that:

- **Neuropsychological tests in combination with neurological variables**
  
  could be used to make driving recommendations in patients with AD

*(Dawson J et al. Neurology 2009, Fritelli et al., 2009; Ott et al., 2008; Ott et al., 2003; Rizzo et al., 1997)*
Practice Parameter update: Evaluation and management of driving risk in dementia

Report of the Quality Standards Subcommittee of the American Academy of Neurology

<table>
<thead>
<tr>
<th>CDR 0.5-1.0</th>
<th>CDR 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate for risk factors</td>
<td></td>
</tr>
</tbody>
</table>

### Risk factors:

**Level B evidence**
- Caregiver report of marginal or unsafe skills
- History of citations
- History of crashes
- Driving < 60 miles / week
- Situational avoidance
- Aggression, impulsivity
- MMSE ≤ 24

**Level C evidence**
- Alcohol, medications, sleep disorders, visual impairment, motor impairment

**Other**

### Risk factors:

- **None**
  - CDR 0.5
- **Few**
  - CDR 0.5
  - CDR 1.0
- **Several**
  - CDR 0.5
  - CDR 1.0
  - CDR 0.5
- **Multiple**
  - CDR 0.5

### Risk Management

- Encourage family support for alternate transportation.
- Strongly consider voluntary surrender of driving privileges.
- Consider DMV referral or professional driving evaluation, based on state guidelines.

### Intervention

Pursuant to state guidelines

Cognition behaviour and driving, 26 June 2015, Athens
(Iverson et al., Neurology, 2010)

• However, although useful, these guidelines are rather general

• The proposed algorithm for evaluating driving competence includes only general cognitive measures (MMSE) which are not closely related to driving competence.

• The results are not reported in terms of a precise relative risk based on the presence of a risk factor or a cutoff score
Mild Cognitive Impairment and Driving
Driving performance in MCI - controversial

- Wadley et al., 2009 on-road
- Jeong et al., 2012 questionnaire
- Devlin et al., 2012 simulator

- Wadley et al., 2009 on-road
- Jeong et al., 2012 questionnaire
- Devlin et al., 2012 simulator
Driving errors in MCI

- Left-head turns
- Lane control
  (Wadley et al., 2009)
- Increased Mean time to collision
  (Fritteli et al., 2009)
- Qualitative judgments
- Slower Reaction time
- Reduced ability to control speed
  (Duchek et al., 2003, Devlin et al., 2012)
- “Pedal confusion” (inappropriate motor response such as pressing the accelerator instead of the brake pedal)
  (Snellgrove, 2005)
Predictors of driving ability in the MCI

• Measures associated with driving performance in patients with MCI
  • mental flexibility (TMT-B)
  • inhibitory control (modified Stroop test)
  • visual attention (TMT-A)

* When controlling for memory impairment, TMT-B seemed to be the best predictor

(Kawano et al., 2012)
Driving and Parkinson’s Disease
Risk of accidents in PD

• Increased risk for accidents:
  Which is related to **Motor** symptoms but mostly to **Cognitive** alterations

• **15% of PD** patients with an active driving license were engaged in a car accident during a period that covered the past five years (Meindorfner et al., 2005)
Predictors-PD

Tests predicting driving competence in patients with PD:

- **executive,**
- **attentional,** and
- **Visuospatial**

(Amick et al., 2007; Classen et al., 2009; Classen et al., 2011; Uc et al., 2006; Uc et al., 2009)

Fitness to drive in patients with PD is associated also with

- **manual dexterity,**
- **contrast sensitivity,**
- **duration of the disease,** and
- **severity of the disease according to the H&Y scale** (Devos et al., 2007; Worringham et al., 2006)
Our data in patients with Cognitive Disorders

The
Large
Driving Simulator
Experiment
A large driving simulator experiment

- on driving behaviour including driver distraction (fall 2013 – fall 2015)

- An interdisciplinary research team: Neurologists, Neuropsychologists, Transportation Engineers

- Phases of the Experiment
  - Part 1. Medical, Ophthalmological & Neurological evaluation (~2 hours)
  - Part 2. Neuropsychological Assessment (~2.5 hours) and Questionnaire on driving habits (~20 minutes)
  - Part 3. Driving simulation experiment (~1.5 hour)

- Sample size: 225 persons examined > 55 years old

  (MCI = 59, AD= 25, PD= 25, Normal Controls= 45)

co-funded by the Greek Research Secretariat and the European Commission
Methodology

Inclusion Criteria

- Valid driving license
- Regular driver without accidents
- Clinical Dementia Rating (CDR): 0 to 1
- No history of psychosis or other Psychiatric or Neurological disease
- No dizziness, nausea while driving, either as a driver or as a passenger
- No alcoholism or drug addiction
- No visual disturbance preventing them from driving safely
In-vehicle distraction and brain pathologies: Effects on reaction time and accident probability

Dimosthenis Pavlou, Eleonora Papadimitriou, Sophia Vardaki, George Yannis, John Golias, Sokratis G. Papageorgiou

Sample of the study:
- 140 participants of more than 55 years of age
- 31 controls (aver. 64.5 y.o., 20 males)
- 25 AD patients (aver. 75.4 y.o.)
- 59 MCI patients (aver. 70.1 y.o.)
- 25 PD patients (aver. 66.1 y.o.)
Assessment of Distraction

- Undistracted condition
- Conversation with a passenger
- Conversation on the Mobile phone

True?
Driving Simulator - Quantitative Measures

1. average driving speed (km/h)
2. speed variation (variation of average speed)
3. Average wheel position
4. wheel position variation (variation of wheel steering angle in degrees)
5. lateral position (average vehicle distance from the central road axis in meters)
6. lateral position variation (the standard deviation of lateral position)
7. average headway (average time to cover the distance from other vehicles in meters)
8. headway variation (the standard deviation of headway)
9. Sudden brakes
10. Engine Stops
11. Speed limit violations
12. Hits of side bars
13. number of crashes
14. reaction time in unexpected incidents (in milliseconds)

• Urban Driving: i) parked car enters suddenly the road, a ball and a child cross suddenly the road
• Rural Driving: sudden appearance of animal

With and Without DISTRACTION
Driving Simulator Experiment Results
Driving performance profiles of drivers with brain pathologies

Dimosthenis Pavlou, Ion Beratis, Eleonora Papadimitriou, George Yannis, John Golas, Sokratis G. Papageorgiou

Sample of the study:
114 participants of more than 55 years of age
- 34 controls (aver. 66.0 y.o.)
- 17 AD patients (aver. 75.4 y.o.)
- 35 MCI patients (aver. 70.1 y.o.)
- 16 PD patients (aver. 66.1 y.o.)

- 16% lower average speed in impaired drivers in both low and high traffic volumes and higher variability of speed
- higher time-headway (more than 50%) in impaired drivers
- large variability in impaired drivers’ headways along the driving route. This means that they cannot adjust their speed and have difficulties in keeping constant and safe headways.
Lateral position:

- Lateral position results appear to be the same between the two groups.

- However, large variability in impaired drivers’ lateral position,

That means difficulties

- in positioning the vehicle properly in the lane.

Fig. 3. Average Lateral Position Profiles of examined groups
REACTION TIME

**AD** group had the worst reaction times compared to all other groups (no distraction)

- No Significant effect of "conversation with passenger", in rural and urban roads for all participants.
- **Significant effect** of the mobile phone on all impaired groups in rural road, especially for the AD and PD groups (increase of reaction time > 1 sec)
Driving performance profiles of drivers with brain pathologies in rural roads

Dimosthenis Pavlou, Ion Beratis, Eleonora Papadimitriou, George Yannis, John Golias, Sokratis G. Papageorgiou

Accident Probability

- **Increased accident probability** for the MCI, AD and PD groups in rural and urban area
- No Significant effect of “conversation with passenger”, in rural and urban roads for all participants.
- The use of the mobile phone in the MCI and especially the AD and PD groups (in rural driving environment) sharply increased the accident probability
Driving Errors (composite score including: speed limit violations, driving on outside road lines, hit of side bars, traffic sign violations)

- No significant difference in the “undistracted” and the “conversation” condition.
- In the rural area the use of mobile phone mostly affected the drivers with AD.
- In the urban area the use of mobile phone affected the drivers with MCI.
Alzheimer’s Disease

Alzheimer's Disease
Average Speed

47% of AD patients were on the range (±1SD) of normal performance

<table>
<thead>
<tr>
<th></th>
<th>AD (normal performance)</th>
<th>AD (impaired performance)</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>MMSE</td>
<td>24.6</td>
<td>3.2</td>
<td>21.6</td>
</tr>
<tr>
<td>CTMT1-5</td>
<td>103.8</td>
<td>29.6</td>
<td>176.9</td>
</tr>
</tbody>
</table>
Percentage of AD drivers that exhibited similar driving performance to the Control group (±1SD)

**Reaction Time**

55% of AD patients were on the range (±1SD) of normal performance

<table>
<thead>
<tr>
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<th>AD (normal performance)</th>
<th>AD (impaired performance)</th>
<th>t-test</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>MMSE</td>
<td>23.5</td>
<td>3.7</td>
<td>23.1</td>
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<tr>
<td>NPI</td>
<td>7.3</td>
<td>8.8</td>
<td>28.1</td>
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<tr>
<td>FBI</td>
<td>7.5</td>
<td>5.9</td>
<td>17.4</td>
</tr>
<tr>
<td>CDT</td>
<td>6.00</td>
<td>1.2</td>
<td>4.00</td>
</tr>
<tr>
<td>PHQ-9</td>
<td>1.9</td>
<td>1.1</td>
<td>7.4</td>
</tr>
</tbody>
</table>
Mild Cognitive Impairement
Predictors of driving performance in individuals with MCI: preliminary results

Sokratis Papageorgiou¹, Ion Beratis¹, Nikolaos Andronas¹, Alexandra Economou², Dimosthenis Pavlou³, Anastasios Bonakis¹, George Tsivgoulis¹, Leonidas Stefanis¹, George Yannis³

¹2nd University Department of Neurology, “Attikon” University General Hospital, ²Department of Psychology, University of Athens, ³Department of Transportation Planning & Engineering, National Technical University of Athens
Number of Crashes in the MCI

**Predictors:**

- (1\text{st} level) general cognitive functioning (MMSE)
- (2\text{nd} level) visuospatial memory (BVMT\_Recognition, $\beta=-.40$, $p=.056$) and speed of attention (UFV\_1, $\beta=.48$, $p=.027$)

The model explained **77.3%** of the variance in number of crashes

- $R^2=.773$, $F(3,10)=11.35$, $p=.001$

In the cognitively intact group the same regression model did not contribute to the prediction of number of crashes

- $R^2=.279$, $F(3,10)=1.29$, $p=.330$

Normal Group ($Mean=.43$, $SD=.65$) vs MCI Group ($Mean=.56$, $SD=.81$)

- $t(28)=.49$, $p=.25$
Predictors of driving performance in MCI

- **Depressive** symptoms questionnaire
  - Patient Health Questionnaire (PHQ-9)

- **Sleeping** abnormalities questionnaires
  - Epworth *sleepiness* scale
  - Athens *insomnia* scale

<table>
<thead>
<tr>
<th></th>
<th>MCI</th>
<th>Controls</th>
<th>NS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>PHQ-9</td>
<td>4,58</td>
<td>4,02</td>
<td>3,31</td>
</tr>
<tr>
<td>Epworth</td>
<td>5,97</td>
<td>2,98</td>
<td>5,23</td>
</tr>
<tr>
<td>Athens</td>
<td>4,21</td>
<td>3,72</td>
<td>3,19</td>
</tr>
</tbody>
</table>

Beratis et al, 1st EAN Congress, Berlin, 2015
There was a unique contribution of DEPRESSIVE SYMPTOMS (PHQ-9) on predicting various indexes of driving performance only in the MCI group even after controlling for the role of neuropsychological measures and sleep disturbances.

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>PHQ-9 contribution</th>
<th>$\beta$</th>
<th>$t$</th>
<th>$p$</th>
<th>$R^2$ Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral Position Variation</td>
<td>.60</td>
<td>.60</td>
<td>2.89</td>
<td>.011*</td>
<td>.635</td>
</tr>
<tr>
<td>Average Speed</td>
<td>.62</td>
<td>.62</td>
<td>2.52</td>
<td>.023*</td>
<td>.490</td>
</tr>
<tr>
<td>Average Headway</td>
<td>-.61</td>
<td>-.61</td>
<td>2.43</td>
<td>.028*</td>
<td>.468</td>
</tr>
<tr>
<td>Headway Variation</td>
<td>-.59</td>
<td>-.59</td>
<td>2.34</td>
<td>.034*</td>
<td>.463</td>
</tr>
<tr>
<td><strong>No. of Crashes</strong></td>
<td>.70</td>
<td>.70</td>
<td>2.84</td>
<td>.012*</td>
<td>.485</td>
</tr>
<tr>
<td>Hits of Side Bars</td>
<td>.39</td>
<td>.39</td>
<td>2.11</td>
<td>.052</td>
<td>.705</td>
</tr>
<tr>
<td><strong>Speed Limit Violation</strong></td>
<td>.61</td>
<td>.61</td>
<td>2.84</td>
<td>.012*</td>
<td>.613</td>
</tr>
<tr>
<td>Average Wheel Position</td>
<td>-.59</td>
<td>-.59</td>
<td>2.50</td>
<td>.025*</td>
<td>.524</td>
</tr>
</tbody>
</table>

Beratis et al, submitted, 2015
Sleep Disturbances

Sleep disturbances (sleepiness - insomnia) were correlated with Driving variables, only in MCI patients.

**MCI Group**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EpworthScale</th>
<th>AthensInsomniaScale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Lateral Position</td>
<td>0.163</td>
<td>-0.034</td>
</tr>
<tr>
<td>Lateral Position Variation</td>
<td>0.355</td>
<td>0.502</td>
</tr>
<tr>
<td>Average Speed</td>
<td>0.345</td>
<td>0.224</td>
</tr>
<tr>
<td>Headway Average</td>
<td>-0.373</td>
<td>-0.167</td>
</tr>
<tr>
<td>Wheel Average</td>
<td>0.141</td>
<td>-0.374</td>
</tr>
<tr>
<td>Reaction Time</td>
<td>-0.308</td>
<td>-0.223</td>
</tr>
</tbody>
</table>

**Control Group**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>EpworthScale</th>
<th>AthensInsomniaScale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Lateral Position</td>
<td>-0.137</td>
<td>-0.24</td>
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<tr>
<td>Lateral Position Variation</td>
<td>-0.368</td>
<td>0.111</td>
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<tr>
<td>Average Speed</td>
<td>0.001</td>
<td>0.224</td>
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<tr>
<td>Headway Average</td>
<td>0.071</td>
<td>-0.059</td>
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<tr>
<td>Wheel Average</td>
<td>0.118</td>
<td>-0.011</td>
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<tr>
<td>Reaction Time</td>
<td>-0.062</td>
<td>0.113</td>
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</table>

Beratis et al, 1st EAN Congress, Berlin, 2015
Parkinson’s Disease

Parkinson’s Disease
The present findings support the application of the CTMT by future driving studies as an alternative option to the classical TMT.

<table>
<thead>
<tr>
<th>AVERAGE SPEED</th>
<th>SPEED VARIATION</th>
<th>REACTION TIME</th>
<th>HEADWAY DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMB: $R^2=55.7$, $F(1,9)=11.34$, $p=.008$</td>
<td>TMB: $R^2=48.6$, $F(1,9)=8.52$, $p=.017$</td>
<td>TMB: $R^2=9.4$, $F(1,9)=0.93$, $p=.360$</td>
<td>TMB: $R^2=40.6$, $F(1,9)=6.15$, $p=.035$</td>
</tr>
<tr>
<td>CTMT1: $R^2=80.3$, $F(1,9)=32.67$, $p&lt;.001$</td>
<td>CTMT1: $R^2=70.2$, $F(1,9)=19.80$, $p=.002$</td>
<td>CTMT1: $R^2=54.2$, $F(1,9)=4.46$, $p=.015$</td>
<td>CTMT1: $R^2=64.1$, $F(1,9)=14.31$, $p=.005$</td>
</tr>
<tr>
<td>CTMT2: $R^2=73.4$, $F(1,9)=22.09$, $p=.002$</td>
<td>CTMT2: $R^2=49.4$, $F(1,9)=7.82$, $p=.023$</td>
<td>CTMT2: $R^2=27.4$, $F(1,9)=3.02$, $p=.120$</td>
<td>CTMT2: $R^2=58.2$, $F(1,9)=11.15$, $p=.010$</td>
</tr>
<tr>
<td>CTMT3: $R^2=62.3$, $F(1,9)=13.20$, $p=.007$</td>
<td>CTMT3: $R^2=32.7$, $F(1,9)=3.89$, $p=.047$</td>
<td>CTMT3: $R^2=20.3$, $F(1,9)=2.04$, $p=.191$</td>
<td>CTMT3: $R^2=59.5$, $F(1,9)=11.73$, $p=.009$</td>
</tr>
<tr>
<td>CTMT4: $R^2=82.3$, $F(1,9)=37.29$, $p&lt;.001$</td>
<td>CTMT4: $R^2=82.8$, $F(1,9)=38.38$, $p&lt;.001$</td>
<td>CTMT4: $R^2=47.4$, $F(1,9)=7.22$, $p=.028$</td>
<td>CTMT4: $R^2=65.7$, $F(1,9)=15.31$, $p=.004$</td>
</tr>
<tr>
<td>CTMT5: $R^2=66.9$, $F(1,9)=16.15$, $p=.004$</td>
<td>CTMT5: $R^2=9.05$, $F(1,9)=0.915$, $p=.367$</td>
<td>CTMT5: $R^2=10.3$, $F(1,9)=0.915$, $p=.367$</td>
<td>CTMT5: $R^2=45.9$, $F(1,9)=6.79$, $p=.031$</td>
</tr>
</tbody>
</table>
Frontotemporal Dementia
Clinical Case, E.V.

Diagnosis: FTD

- A 49 year old right handed woman
- 9 years of education
- Housewife
- Speech disorders (verbal apraxia, logopenia)
- Apathy, Loss of Insight
- Frontal atrophy, Mild hippocampal atrophy (L)

Neuropsychological findings
- MMSE: 25/30 (-4 calculation, -1 language)
- MoCA: 22/30
- CDT Free: 6/7
- FAB: 12/18
- Verbal Fluency: 11/1 min
- TMT A: 33 sec
- TMT B: >5 min
### Summary Individual Data of Driving at the Simulator

#### Urban Road

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Driver Control Group</th>
<th>MT</th>
<th>St. Dev.</th>
<th>Range of Values</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Longitudinal Parameters</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Average Speed</td>
<td>30.53</td>
<td>31.84</td>
<td>5.46</td>
<td>26.38 - 37.30</td>
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</tr>
<tr>
<td>Standard Deviation of Mean Speed</td>
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<td>12.66</td>
<td>3.09</td>
<td>9.57 - 15.55</td>
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<tr>
<td>Average Headway</td>
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<td>36.21</td>
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<tr>
<td><strong>Lateral Parameters</strong></td>
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<tr>
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<tr>
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<td>0.39</td>
<td>1.30 - 2.08</td>
<td>No typical</td>
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<tr>
<td>Average Steering Angle</td>
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<td>7.11</td>
<td>1.77</td>
<td>5.34 - 8.88</td>
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<tr>
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<tr>
<td>Reaction Time</td>
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<tr>
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<td>0.63</td>
<td>0.74 - 2.00</td>
<td>Not typical</td>
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<td><strong>General Parameters</strong></td>
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<td>Total Accidents</td>
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#### Rural Road

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<tr>
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<td><strong>Longitudinal Parameters</strong></td>
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<td>7.41</td>
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<td>0.07</td>
<td>0.20 - 0.34</td>
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<td>0.71</td>
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<td>17.56</td>
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<td>Reaction Time</td>
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<td>0.56</td>
<td>1.00 - 2.12</td>
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<td><strong>50.00%</strong></td>
<td><strong>8.78%</strong></td>
<td>0.56</td>
<td>1.00 - 2.12</td>
<td>Not typical</td>
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<td><strong>General Parameters</strong></td>
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</table>
Clinical Case, E.F.

Diagnosis: tv-FTD

- A 63 year old right handed man
- 7 years of education
- pastry chef (retired)

- Memory complaints
- mild disinhibition (overfamiliarity +)
- Temporal atrophy asymmetric (L> R). Mild hippocampal atrophy
- No impulsivity

Neuropsychological findings

MMSE: 22/30 (-2 orientation in space, -1 orient in time, -1 calculation, -3 recall, -1 3-step command)
- MoCA: 14/30
- CDT Free: 5/7
- FAB: 12/18
- Verbal Fluency: 2/1 min
- TMT A: 77 sec
- TMT B: >5 min
## Summary Individual Data of Driving at the Simulator

### Urban Road

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Driver</th>
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<th>Assessment</th>
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<tbody>
<tr>
<td><strong>Longitudinal Parameters</strong></td>
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<tr>
<td>A1 Average Mean Speed</td>
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<td>A5 Average Lateral Position (from right border)</td>
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<td>2.46</td>
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<td>A9 Reaction Time</td>
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<td>A10 Accident probability</td>
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<td>A11 Speed limit violations</td>
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<td>A13 Total accidents</td>
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<td>Y5 Average Lateral Position (from right border)</td>
<td>0.73</td>
<td>0.80</td>
<td>0.15</td>
<td>0.65 - 0.95</td>
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<tr>
<td>Y6 Standard Deviation of Lateral Position</td>
<td>0.29</td>
<td>0.27</td>
<td>0.07</td>
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<td>Y11 Speed limit violations</td>
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<tr>
<td>Y13 Total accidents</td>
<td>0</td>
<td></td>
<td>0</td>
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</tbody>
</table>
There is role for the Neurologist

- ADVICE about the issue: “to drive or not to drive”
- ADVICE about the issue: “how and when to drive” (defining restrictions for safe driving in a patient)

- ADVICE for adaptations of national regulations
- ADVICE for adaptations of vehicles (e.g. reminders), adaptations of roads (e.g. frequency of road signals)

- In close collaboration with other scientists (multi disciplinary approach)
Department of Transportation Planning and Engineering, National Technical University of Athens, 2nd Department of Neurology, “Attikon” University General Hospital, Department of Psychology, University of Athens
Driving errors, accidents and their predictors in patients with cognitive disorders

George Yannis
Professor
Department of Transportation, Planning and Engineering
National Technical University of Athens

Sokratis G. Papageorgiou, MD, PhD
Associate Professor
Cognitive Disorders/Dementia Unit
2nd Department of Neurology, University General Hospital “ATTIKON“
Medical School, University of Athens

Athens, 26 June 2015