



Department of Transportation  
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# Cognition, Behaviour and Driving

26 June 2015, Athens  
Amphitheater NIMTS



# Driving behaviour and mild Dementia



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- Differences on Driving Indexes between patients with AD and healthy participants
- Differences between AD drivers who exhibited similar driving performance to the control group and AD drivers who had impaired driving performance
- Self-assessment of driving performance

## Participants

- 23 patients with **Alzheimer Disease (AD)**
- 23 **healthy** individuals

## Criteria

- have a **valid driving license**
- **Regular drivers**
- have **CDR: 0 - 1**
- **not have important psychiatric history** for psychosis
- **not have any important motor disorder** that prevent them from basic driving moves
- not have dizziness, nausea while driving, either as a driver or as a passenger
- not be an alcoholic or have any other drug addiction
- not have any important eye disorder that prevent him from driving safely
- not have any disease of the Central Nervous System

Table 1. Demographics of AD and control groups

|  | AD group<br>(24 males) |           | Control group<br>(12 males &<br>12 females) |           | T-test |        |
|--|------------------------|-----------|---|-----------|--------|--------|
|  | Mean                   | Std. Dev. | Mean  | Std. Dev. | T      | p      |
| <b>Age</b>                                   | 73.5                   | 6.7       | 67.2  | 6.2       | -3.80  | .000** |
| <b>Education</b>                             | 10.7                   | 4.2       | 15.1  | 3.8       | 3.46   | .001** |
| <b>Driving Experience</b>                    | 42.5                   | 9.4       | 40.4  | 5.4       | -.74   | .464   |
| <b>Days per week</b>                         | 4.1                    | 1.7       | 5.3   | 1.9       | 1.93   | .064   |
| <b>Number of Accidents</b><br>(last 2 years) | 1.2                    | 2.1       | .8  | 1.4       | -.62   | .538   |
| <b>Traffic Violations</b> (last 2 years)     | .8                     | 1.3       | 2.0   | 2.6       | 1.47   | .152   |
| <b>Fines</b> (last 2 years)                  | .3                     | .8        | .1  | .5        | -.65   | .518   |

# Results

## Control vs. AD Group on Driving Indexes

### Rural Area - Condition Without Distraction

|                           | AD group |       | Control group |       | t-test |        |
|---------------------------|----------|-------|---------------|-------|--------|--------|
|                           | Mean     | SD    | Mean          | SD    | T      | p      |
| Average Speed             | 32.8     | 7.8   | 40.3          | 7.6   | 3.11   | .004** |
| Average Speed Variation   | 9.7      | 3.8   | 10.7          | 2.8   | .94    | .352   |
| Lateral Position          | 1.5      | .17   | 1.5           | .09   | -.632  | .531   |
| Lateral Positon Variation | .29      | .05   | .27           | .06   | -1.42  | .164   |
| Headway Average           | 610.8    | 181.2 | 503.5         | 111.5 | -2.28  | .028*  |
| Headway Average Variation | 273.8    | 100.8 | 222.1         | 54.9  | -2.04  | .048*  |
| Wheel Average             | -1.3     | 1.5   | -1.7          | 0.5   | -1.31  | .196   |
| Wheel Average Variation   | 16.9     | 2.5   | 16.7          | 2.2   | -.26   | .796   |
| Reaction Time             | 2457.6   | 967.8 | 1511.9        | 442.6 | -4.04  | .000** |
| Number of Crashes         | .53      | .77   | .09           | .31   | -2.37  | .023*  |
| Speed Limit Violation     | .05      | .23   | .09           | .31   | .50    | .620   |



## Control vs. AD Group on Driving Indexes

### Urban Area - Condition Without Distraction

|                                | AD group      |              | Control group |              | t-test       |               |
|--------------------------------|---------------|--------------|---------------|--------------|--------------|---------------|
|                                | Mean          | SD           | Mean          | SD           | T            | p             |
| Average Speed                  | 24.7          | 6.7          | 27.9          | 5.3          | 1.45         | .158          |
| <b>Average Speed Variation</b> | <b>9.2</b>    | <b>2.4</b>   | <b>11.5</b>   | <b>2.9</b>   | <b>2.31</b>  | <b>.028*</b>  |
| Lateral Position               | 3.2           | .63          | 2.9           | .74          | -1.32        | .165          |
| Lateral Positon Variation      | 1.7           | .54          | 1.5           | .65          | -1.07        | ,292          |
| Headway Average                | 125.3         | 26.1         | 129.2         | 36.1         | .35          | ,732          |
| Headway Average Variation      | 56.9          | 8.4          | 54.2          | 11.6         | -.770        | .448          |
| <b>Wheel Average</b>           | <b>7.6</b>    | <b>1.4</b>   | <b>6.3</b>    | <b>1.6</b>   | <b>-2.28</b> | <b>.030*</b>  |
| Wheel Average Variation        | 24.6          | 11.1         | 27.3          | 11.4         | .67          | .508          |
| <b>Reaction Time</b>           | <b>1683.6</b> | <b>460.5</b> | <b>1196.8</b> | <b>427.9</b> | <b>-2.85</b> | <b>.008**</b> |
| <b>Number of Crashes</b>       | <b>.62</b>    | <b>.81</b>   | <b>.00</b>    | <b>.00</b>   | <b>-2.67</b> | <b>.013*</b>  |

## Control vs. AD Group on Driving Indexes

### Rural Area - Condition With Distraction

|                                  | AD group     |              | Control group |              | t-test       |              |
|----------------------------------|--------------|--------------|---------------|--------------|--------------|--------------|
|                                  | Mean         | SD           | Mean          | SD           | T            | p            |
| <b>Average Speed</b>             | <b>33.9</b>  | <b>8.7</b>   | <b>42.3</b>   | <b>9.6</b>   | <b>2.69</b>  | <b>.011*</b> |
| Average Speed Variation          | 9.9          | 3.2          | 11.8          | 4.1          | 1.50         | .143         |
| Lateral Position                 | 1.5          | .18          | 1.4           | .12          | -.72         | .477         |
| Lateral Positon Variation        | .31          | .05          | .28           | .06          | -1.31        | .199         |
| <b>Headway Average</b>           | <b>644.9</b> | <b>167.6</b> | <b>492.5</b>  | <b>168.5</b> | <b>-2.65</b> | <b>.012*</b> |
| <b>Headway Average Variation</b> | <b>288.2</b> | <b>107.6</b> | <b>197.9</b>  | <b>73.8</b>  | <b>-2.75</b> | <b>.010*</b> |
| Wheel Average                    | -2.4         | .98          | -2.2          | 0.5          | .87          | .388         |
| Wheel Average Variation          | 17.1         | 2.2          | 18.1          | 2.1          | 1.41         | .168         |
| Reaction Time                    | 2407.2       | 700.4        | 1961.5        | 1077.4       | -1.39        | .174         |
| Number of Crashes                | .43          | .59          | .28           | .61          | -.68         | .497         |
| Speed Limit Violation            | .04          | .21          | .21           | .42          | 1.58         | .123         |

## Control vs. AD Group on Driving Indexes

### Urban Area - Condition With Distraction

|                           | AD group |       | Control group |       | t-test |        |
|---------------------------|----------|-------|---------------|-------|--------|--------|
|                           | Mean     | SD    | Mean          | SD    | T      | p      |
| Average Speed             | 23.1     | 4.9   | 28.9          | 3.6   | 3.16   | .005** |
| Average Speed Variation   | 8.7      | 2.8   | 11.6          | 2.8   | 2.31   | .032*  |
| Lateral Position          | 3.4      | .67   | 3.3           | .61   | -.38   | .703   |
| Lateral Positon Variation | 1.8      | .57   | 1.7           | .63   | -.26   | .800   |
| Headway Average           | 129.6    | 14.6  | 113.5         | 22.8  | -1.89  | .073   |
| Headway Average Variation | 56.3     | 6.6   | 56.1          | 6.9   | -.09   | .929   |
| Wheel Average             | 7.9      | 1.3   | 8.1           | 0.8   | .33    | .743   |
| Wheel Average Variation   | 20.7     | 2.7   | 24.2          | 4.9   | 1.96   | .064   |
| Reaction Time             | 1592.1   | 473.2 | 1530.3        | 450.6 | -1.2   | .267   |
| Number of Crashes         | .13      | .38   | .11           | .31   | -.25   | .803   |



## Control vs. AD Group on Driving Indexes

- In **Rural Area** AD patients found to drive slower, keep longer distances from the ahead driving car, have a greater headway variation, have slower reaction time and greater accident probability than the control group
- In **Urban Area** similar results were found with the exception of headway distance and headway variation
- Under the **distraction condition** with conversation, fewer significant differences were found between the two groups

## Control vs. AD Group on Driving Indexes

### 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

### On-road assessment *(Ott et al., 2008)*

Drivers with mild AD:

- had lower performance than the control group, had more accidents and presented a more significant decline of their driving skills over time.
- the level of impairment depends on severity of dementia, age and educational level and some individuals with very mild dementia may **retain their ability to drive for long periods of time**
- Thus, it is recommended to provide regular follow-up evaluations to determine fitness to drive over time

Percentage of AD drivers that exhibited similar driving performance to the Control group

## Average Speed

- 47% of AD patients were on the range ( $\pm 1$ SD) of normal performance

|                   | AD (normal performance) N=8 |      | AD (impaired performance) N=10 |      | t-test |        |
|-------------------|-----------------------------|------|--------------------------------|------|--------|--------|
|                   | Mean                        | SD   | Mean                           | SD   | T      | p      |
| MMSE              | 24.6                        | 3.2  | 21.6                           | 3.7  | 1.80   | .090   |
| CTMT1             | 103.8                       | 29.6 | 176.9                          | 77.8 | -2.46  | .029*  |
| CTMT2             | 106.5                       | 43.2 | 214.3                          | 55.2 | -4.24  | .001** |
| CTMT3             | 122.1                       | 41.4 | 229.5                          | 72.4 | -3.59  | .003** |
| CTMT4             | 134.7                       | 61.7 | 246.4                          | 48.9 | -3.84  | .002** |
| CTMT5             | 246.6                       | 52.1 | 315.7                          | 38.9 | -2.87  | .013*  |
| Incidental memory | 4.7                         | 1.1  | 6.0                            | 1.1  | -2.09  | .060   |

Percentage of AD drivers that exhibited similar driving performance to the Control group

## Lateral Position

- **100%** of AD patients were on the range ( $\pm 1$ SD) of normal performance

Percentage of AD drivers that exhibited similar driving performance to the Control group

## Head Way Distance

- **35%** of AD patients were on the range ( $\pm 1$ SD) of normal performance

|                            | AD (normal performance) N=6 |            | AD (impaired performance) N=12 |            | t-test      |               |
|----------------------------|-----------------------------|------------|--------------------------------|------------|-------------|---------------|
|                            | Mean                        | SD         | Mean                           | SD         | T           | p             |
| MMSE                       | 25,0                        | 3.5        | 21.9                           | 3.5        | 1.73        | .103          |
| <b>BVMT Delayed Recall</b> | <b>3.2</b>                  | <b>2.4</b> | <b>.92</b>                     | <b>1.4</b> | <b>2.34</b> | <b>.033*</b>  |
| CTMT2                      | 113.6                       | 48.7       | 185.5                          | 74.4       | -2.07       | .058          |
| CTMT3                      | 124.8                       | 47.5       | 203.7                          | 81.4       | -2.13       | .053          |
| CTMT4                      | 141.0                       | 70.9       | 217.4                          | 71.8       | -2.03       | .064          |
| CTMT5                      | 248.6                       | 48.2       | 299,0                          | 56.1       | -1.79       | .096          |
| <b>Driving Scenes Test</b> | <b>33.2</b>                 | <b>9.5</b> | <b>21.1</b>                    | <b>5.2</b> | <b>3.22</b> | <b>.007**</b> |

Percentage of AD drivers that exhibited similar driving performance to the Control group

## Wheel Average Variation

- **73%** of AD patients were on the range ( $\pm 1$ SD) of normal performance

|                              | AD (normal performance) N=13 |             | AD (impaired performance) N=5 |              | t-test       |               |
|------------------------------|------------------------------|-------------|-------------------------------|--------------|--------------|---------------|
|                              | Mean                         | SD          | Mean                          | SD           | T            | p             |
| MMSE                         | 23.5                         | 3.3         | 21.4                          | 4.7          | 1.08         | .294          |
| FAB                          | 10.1                         | 1.9         | 8.1                           | 4.1          | 1.47         | .160          |
| HVLT total recall            | 13.5                         | 5.1         | 8.6                           | 2.2          | 2.05         | .057          |
| <b>NPI</b>                   | <b>11.3</b>                  | <b>13.6</b> | <b>31.5</b>                   | <b>16.8</b>  | <b>-2.46</b> | <b>.029*</b>  |
| <b>PHQ-9</b>                 | <b>1.9</b>                   | <b>2.3</b>  | <b>9.2</b>                    | <b>6.5</b>   | <b>-3.47</b> | <b>.004**</b> |
| <b>IADL</b>                  | <b>6.6</b>                   | <b>1.5</b>  | <b>10.0</b>                   | <b>4.7</b>   | <b>-2.33</b> | <b>.034*</b>  |
| <b>CTMT3</b>                 | <b>147.7</b>                 | <b>66.9</b> | <b>239.5</b>                  | <b>75.6</b>  | <b>-2.27</b> | <b>.040*</b>  |
| <b>CTMT4</b>                 | <b>154.1</b>                 | <b>64.6</b> | <b>277.0</b>                  | <b>22.7</b>  | <b>-3.65</b> | <b>.003**</b> |
| <b>Psychomotor Vigilance</b> | <b>454.0</b>                 | <b>80.1</b> | <b>947.6</b>                  | <b>393.5</b> | <b>-4.10</b> | <b>.002**</b> |

Percentage of AD drivers that exhibited similar driving performance to the Control group

## Speed Limit Violations

- **95%** of AD patients were on the range ( $\pm 1$ SD) of normal performance

Percentage of AD drivers that exhibited similar driving performance to the Control group

## Reaction Time

- **55%** of AD patients were on the range ( $\pm 1$ SD) of normal performance

|                       | AD (normal performance) N=10 |       | AD (impaired performance) N=7 |       | t-test |        |
|-----------------------|------------------------------|-------|-------------------------------|-------|--------|--------|
|                       | Mean                         | SD    | Mean                          | SD    | T      | p      |
| MMSE                  | 23.5                         | 3.7   | 23.1                          | 2.1   | .41    | .691   |
| NPI                   | 7.3                          | 8.8   | 28.1                          | 16.1  | -3.29  | .005** |
| FBI                   | 7.5                          | 5.9   | 17.4                          | 11.2  | -2.18  | .048*  |
| CDT                   | 6.00                         | 1.2   | 4.00                          | 2.2   | 2.42   | .028*  |
| PHQ-9                 | 1.9                          | 1.1   | 7.4                           | 5.3   | -3.49  | .004** |
| Psychomotor Vigilance | 408.8                        | 184.9 | 745.2                         | 393.7 | -2.10  | .059   |



Percentage of AD drivers that exhibited similar driving performance to the Control group

## Accident Probability

- **63%** of AD patients were on the range ( $\pm 1$ SD) of normal performance

## Percentage of AD drivers that exhibited similar driving performance to the Control group

- One part of AD patients had the ability to drive as well as the control group
- Differences in neuropsychological tests were found between AD with normal driving performance and AD with impaired driving performance
- Neuropsychiatric symptoms could also differentiate between these two groups

# Results

## Self-assessment of driving performance

### Self- assessment Questionnaire

| Difficulties in:   | AD   |    | Controls |    | t-test |        |
|--|------|----|----------|----|--------|--------|
|  | Mean | SD | Mean     | SD | T      | p      |
| Dividing your attention to several actions simultaneously  | 2.3  | .9 | 1.6      | .7 | -2.01  | .053   |
| Estimating the distance and speed of other vehicles  | 1.9  | .6 | 1.5      | .7 | -1.73  | .090   |
| Observing vehicles and pedestrians in front of you who suddenly approach from lateral direction  | 2.2  | .9 | 1.5      | .5 | -2.50  | .019** |
| Paying attention to traffic signals in an environment where there are other signs                | 2.3  | .8 | 1.9      | .9 | -1.08  | .289   |
| Concentrating and preserving attention   | 1.7  | .9 | 1.4      | .7 | -1.17  | .251   |
| Immediate reacting when forced braking   | 2.0  | .9 | 1.5      | .5 | -1.94  | .064   |
| Hand flexibility, leg and neck   | 1.8  | .9 | 1.0      | .0 | -3.33  | .003** |
| Having sufficient knowledge of traffic rules and new traffic signs                               | 1.8  | .9 | 1.6      | .7 | -.71   | .484   |
| Adjusting in situations when sudden changes in traffic arrangements appear on a your usual route | 2.3  | .9 | 1.6      | .9 | -2.01  | .055   |



## Professional Drivers

### Diagnosis: **Alzheimer's Disease**

- A 78 year old right handed man
- 10 years of education
- bus driver (retired)

### Neuropsychological findings:

- MMSE: 22/30
- MoCA: 15/30
- CDT Free: 6/7
- FAB: 11/18
- Verbal Fluency: 5/1 min
- TMT A: 71 sec
- TMT B: >5 min

# ΣΥΓΚΕΝΤΡΩΤΙΚΑ ΣΤΟΙΧΕΙΑ ΟΔΗΓΗΣΗΣ ΣΤΟΝ ΠΡΟΣΟΜΟΙΩΤΗ ΟΔΗΓΗΣΗΣ

| ΑΣΤΙΚΗ ΟΔΟΣ (τυπικές συνθήκες)  |   | Δεδομένα Προσομοιωτή |               |                                |               | Αποτίμηση |   |
|---------------------------------|---|----------------------|---------------|--------------------------------|---------------|-----------|---|
|                                 |   | Οδηγός               | Ομάδα Ελέγχου | Τυπ. Απόκλιση Εύρος καν. Τιμών |               |           |   |
| Δείκτες κατά μήκος της οδήγησης |   | D154                 | MT            |                                |               |           |   |
| A1                              | M.T. ταχύτητας                              | 22,86                | 33,04         | 4,88                           | 28,16 - 37,92 |           | μη τυπικός - αργός                      |
| A2                              | Διακύμανση ταχύτητας                        | 7,63                 | 13,37         | 3,01                           | 10,36 - 16,38 |           | μη τυπικός - μικρή διακύμανση ταχύτητας |
| A3                              | M.T. χρονοαπόστασης από προπορευόμενο όχημα | 70,65                | 36,14         | -                              | - - -         |           |   |
| Δείκτες θέσης του οχήματος      |   |                      |               |                                |               |           |   |
| A5                              | M.T. Απόστασης από το άκρο της οδού         | 1,81                 | 2,44          | 0,60                           | 1,84 - 3,04   |           | τυπικός                                 |
| A6                              | Διακύμανση απόστασης από το άκρο της οδού   | 1,19                 | 1,68          | 0,37                           | 1,31 - 2,05   |           | τυπικός                                 |
| A7                              | M.T. θέσης τιμονιού                         | 7,19                 | 7,34          | 1,79                           | 5,55 - 9,13   |           | τυπικός                                 |
| A8                              | Διακύμανση θέσης τιμονιού                   | 19,75                | 22,97         | 3,93                           | 19,04 - 26,90 |           | τυπικός                                 |
| Δείκτες αντίδρασης σε συμβάν    |   |                      |               |                                |               |           |   |
| A9                              | Χρόνος αντίδρασης                           | 1,33                 | 1,35          | 0,67                           | 0,68 - 2,02   |           | τυπικός                                 |
| A10                             | Πιθανότητα ατυχήματος σε συμβάν             | 12,50%               | 4,28%         | -                              | - - -         |           |   |
| Γενικοί δείκτες                 |   |                      |               |                                |               |           |   |
| A11                             | Παραβάσεις ορίου ταχύτητας                  | 0                    |               |                                |               |           |   |
| A13                             | Συνολικά ατυχήματα                          | 1                    |               |                                |               |           |   |

| ΥΠΕΡΑΣΤΙΚΗ ΟΔΟΣ (τυπικές συνθήκες) |  | Οδηγός        |                                |      |               | Αποτίμηση |   |
|------------------------------------|--|---------------|--------------------------------|------|---------------|-----------|---|
|                                    |  | Ομάδα Ελέγχου | Τυπ. Απόκλιση Εύρος καν. Τιμών |      |               |           |   |
| Δείκτες κατά μήκος της οδήγησης    |  | D154          | MT                             |      |               |           |   |
| Y1                                 | M.T. ταχύτητας                                   | 38,44         | 48,66                          | 7,65 | 41,01 - 56,31 |           | μη τυπικός - αργός                      |
| Y2                                 | Διακύμανση ταχύτητας                             | 8,47          | 14,03                          | 3,91 | 10,12 - 17,94 |           | μη τυπικός - μικρή διακύμανση ταχύτητας |
| Y3                                 | M.T. χρονοαπόστασης από προπορευόμενο όχημα      | 44,85         | 28,90                          | -    | - - -         |           |   |
| Δείκτες θέσης του οχήματος         |  |               |                                |      |               |           |   |
| Y5                                 | M.T. Απόστασης από το άκρο της οδού (διακύμανση) | 0,60          | 0,80                           | 0,13 | 0,67 - 0,93   |           | τυπικός                                 |
| Y6                                 | Διακύμανση απόστασης από το άκρο της οδού        | 0,25          | 0,27                           | 0,06 | 0,21 - 0,33   |           | τυπικός                                 |
| Y7                                 | M.T. θέσης τιμονιού                              | -1,71         | -2,01                          | 0,46 | -2,47 - -1,55 |           | τυπικός                                 |
| Y8                                 | Διακύμανση θέσης τιμονιού                        | 15,46         | 17,91                          | 1,67 | 16,24 - 19,58 |           | τυπικός                                 |
| Δείκτες αντίδρασης σε συμβάν       |  |               |                                |      |               |           |   |
| Y9                                 | Χρόνος αντίδρασης                                | 2,21          | 1,47                           | 0,52 | 0,95 - 1,99   |           | μη τυπικός - αργές αντιδράσεις          |
| Y10                                | Πιθανότητα ατυχήματος σε συμβάν                  | 0,00%         | 12,20%                         | -    | - - -         |           |   |
| Γενικοί δείκτες                    |  |               |                                |      |               |           |   |
| Y11                                | Παραβάσεις ορίου ταχύτητας                       | 0             |                                |      |               |           |   |
| Y13                                | Συνολικά ατυχήματα                               | 0             |                                |      |               |           |   |



- Patients with AD faced difficulties in driving performance, however, not all patients are incapable of driving
- AD with normal driving performance in comparison with AD with impaired performance had differences in neuropsychological test and neuropsychiatric symptoms
- In comparison with the control group, patients with AD seem to report some difficulties concerning cognitive ability during driving





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# Cognition, Behaviour and Driving

26 June 2015, Athens  
Amphitheater NIMTS

distrACT  
driverBRAIN

OPERATIONAL PROGRAMME  
EDUCATION AND LIFELONG LEARNING  
MINISTRY OF EDUCATION & RELIGIOUS AFFAIRS  
H. H. TRIKUPHOS, A. S. PAPADAKIS  
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# Driving behaviour and mild Dementia



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Athens, 26 June 2015