Driving behavior and Parkinson disease

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Driving is a complex skill that requires adequate information processing, sustained **attention** or **vigilance**, concentration and good memory. Drivers must have **control over impulse** and risk-taking and their judgment should be mature and unimpaired with the ability to anticipate the action of other road users.

Cuevas 2008

Parkinson's Disease is a neurodegenerative disorder characterized by Motor and NON-Motor symptoms

- Motor symptoms
  - Bradykinesia
  - At least one of the following
    - Muscular rigidity
    - 4-6 Hz rest tremor
    - postural instability not caused by primary visual, vestibular, cerebellar, or proprioceptive

- Non-motor Symptoms
  - Constipation
  - Orthostatic Hypotension
  - Olfaction Disorder (Hyposmia)
  - REM Sleep Behavior Disorder (RBD)
  - Cognitive Impairment (from PD-MCI to PDD)
  - Neuropsychiatric Symptoms (Anxiety, Depression, Impulse control)

Cognitive Impairment (from PD-MCI to PDD) and Driving

The most frequently cognitive impairments occur in the domains of attention/executive functions, visuospatial ability , psychomotor speed and memory

(Bradley 1989, Muslinovic 2005)

These deficits may appear even in the early stages of the disease

(Dubois 1997, Suzuki 2008)

Non-motor symptoms of PD (visual & cognitive dysfunction, increased daytime sleepiness) may have negative impact on driving performance.

(Schlesinger 2003, Uc 2006, Amick 2007)

PD drivers continue driving during the 1st decade of their illness

(Singh 2007, Uc 2006)

Inclusion Criteria

- Valid Driving License (> 3 YEARS)
- Regular and NO Occasional Car Driving (>2.500 Km/year, , > 10km/week , >1 drive/week)
- Non Dementia
- Mild Dementia (CDR ≤ 1)
- Not Severe PD (H & Y ≤ 3)

Exclusion Criteria

- Use of Alcohol / Illicit Substance
- Psychiatric Disease
- Vertigo or Nausea during driving (driver or passenger)
- Pregnancy
- Visual Acuity <10/20 (B.O)
- Neurological Disease other than PD and Mild Dementia

Neuropsychological Assessment

Global Cognitive Status

- Mini Mental State Examination Test & Montreal Cognitive Assessment test

Cognitive Domain	Tests
• *Verbal Memory and Learning*	The Hopkins Verbal Learning Test-Revised
• *Verbal Working Memory*	Letter Number Sequencing task -Wechsler Adult Intelligence Scale-IV
• *Visual Scanning/Memory and Learning*	
Spatial Memory and Learning	The Brief Visuospatial Memory Test-Revised
	Driving Scenes Test-Neuropsychological Assessment Battery
• *Visuospatial Perception*	Line Orientation Test –Repeatable Battery of Neuropsychological Screening
	Clock Drawing Test
• *Visuospatial Working Memory*	Spatial Span Task- Wechsler Memory Scale
	Driving Scenes Test-Neuropsychological Assessment Battery
• *Constructional ability*	Clock Drawing Test
• *Attention/Information Processing Speed/Perception*	Trail Making Test –part A, Comprehensive Trail Making Test, Symbol Digit Modalities Test , Witkin's- Embedded Figures Test , Useful Field of View
• *Selective and Divided Attention*	Useful Field of View
	Driving Scenes Test-Neuropsychological Assessment Battery
• *Executive Functions*	Frontal Assessment Battery , Trail Making Test-part B
	Spatial Addition Task -Wechsler Memory Scale , Clock Drawing Test
•	
• *Psychomotor vigilance*	Psychomotor Vigilance Test
• Apraxia Screening	The Upper Limb Apraxia Screening Test

Neurological Assessment

Neurological Examination

- **UPDRS-motor scale**
- **Hohen & Yahr scale**
- Hachinski Ischemic scale
- Clinical Dementia Rating (CDR)

Motor Ability Tests

- **Rapid Paced Walk**
- **Tandem Walking**
- **Tandem Walking reverse counting**
- **Head rotation Task**
- **Foot Taping Test**

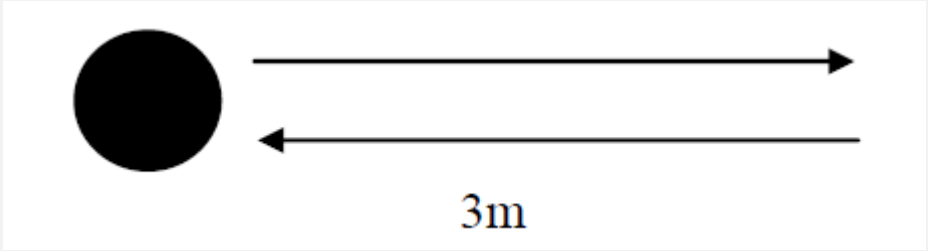
Neuropsychiatric-Behavioral Evaluation

- Geriatric Depression Scale (GDS-short)
- **NPI**
- **Frontal Behavioral Inventory (FBI)**
- Frontal Behavioral Inventory (FAQ)
- Instrumental Activities of Daily Living (IADL)
- Informant Questionnaire of Cognitive Decline in Elderly (IQCODE)
- **PDSS (…..RBD?)**
- Athens Insomnia Scale
- Epworth Sleepiness Scale
- Beck Anxiety Index (BAI)
- PHQ-9
- ASRS V1.1
- Pelli-Robson Contrast Sensitivity Test (PRCST)

Motor Ability Tests

Rapid Paced Walk

The measuring tape is laid on the floor, pulled out to its full 3 meter length, and locked open at this length. The patient walks next to the measuring tape, turns at the end, and walks back to the start position. The total walking distance is 6 meter.



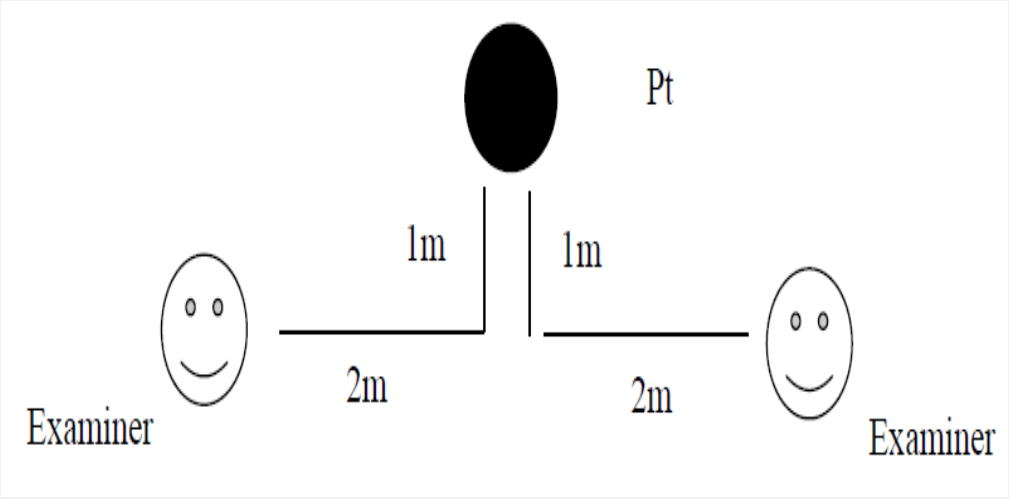
Time >7.5sec: 2.5x , Time >9sec: 3x possibility to get involved in car accident or to commit traffic violation. (Staplin et al.2003)

Motor Ability Tests

Head Rotation Task

The examiner stands at a pre-marked location behind Pt, and holds up a random number of fingers while the client is facing straight forward. The examiner delivers the instruction, "Just as you would turn your head and upper body to look over your right shoulder to back your car or change lanes, please turn and tell me as quick as possible, how many fingers I have raised and return to the straight forward position" . This task will be repeated three times towards to Right and afterwards, three times to the Left. The examiner records whether the client can accurately identify the number of fingers raised. The examiner records the correct and the false answers to both sides. (S.Papageorgiou et al.).

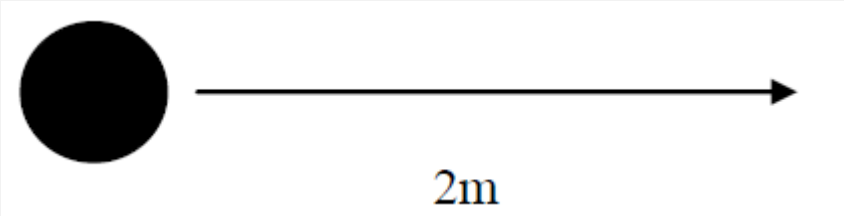
Errors: 2.56x (Staplin, 2003), 6x (Marottoli, 1998) to get involved or commit Accident



Motor Ability Tests

Tandem Walking (2m)

The Pt is invited to walk through a straight line 2m long in heel-toe mode



Tandem Walking (2m) Reverse Counting

The Pt is invited to walk through a straight line 2m long in heel-toe mode with simultaneous reverse counting

Foot Tapping Test

The test administrator places on the floor a piece of paper (A4 format page) in front of the participant, at a distance of 40-50cm from the front edge of the chair. The patient will have to touch his /her right foot to the floor 5 times alternately on each side of the A4 paper moving from one side to the other on every tap. The total number of taps will be 10.

DRIVING PERFORMANCE PROFILES OF DRIVERS WITH PARKINSON'S DISEASE

D.Pavlou[1], E.Papadimitriou[1], S.Vardaki[1], P.Papantoniou[1], N.Andronas[2], G.Yannis[1], J.Golias[1] and S.G. Papageorgiou[2]

21 PD & 41 Controls (Age>55)

Simulator Study

Driving Scenarios: Urban, Rural & Motorway in High and Low traffic volume

Driving Performance Measures

- Mean Speed
- Time Headway
- Reaction Time
- Lateral Position
- Lateral Position Variability
- Mean Wheel Steering Angle
- Steering Angle Variability
- Accident Probability

Results

Mean Speed

- PD drive at Lower Speed (- 20%)
- Traffic volume have the same effect on ALL drivers

Time Head Way

- PD Keep Very Large Headways
- Traffic volume affects MORE the PD group

Lateral Position

- PD drivers tend to drive “to the left” compared with the control ones at Low traffic volume. High traffic volume leads to more conservative driving

Lateral Position Variability

- PD drivers have difficulty in positioning the vehicle inside the lane especially in low traffic volume.

Steering Angle

- PD participants in low traffic volume tend to turn the wheel “to the left” compared with the other groups.
- No other significant differences were detected.

Steering Angle Variability

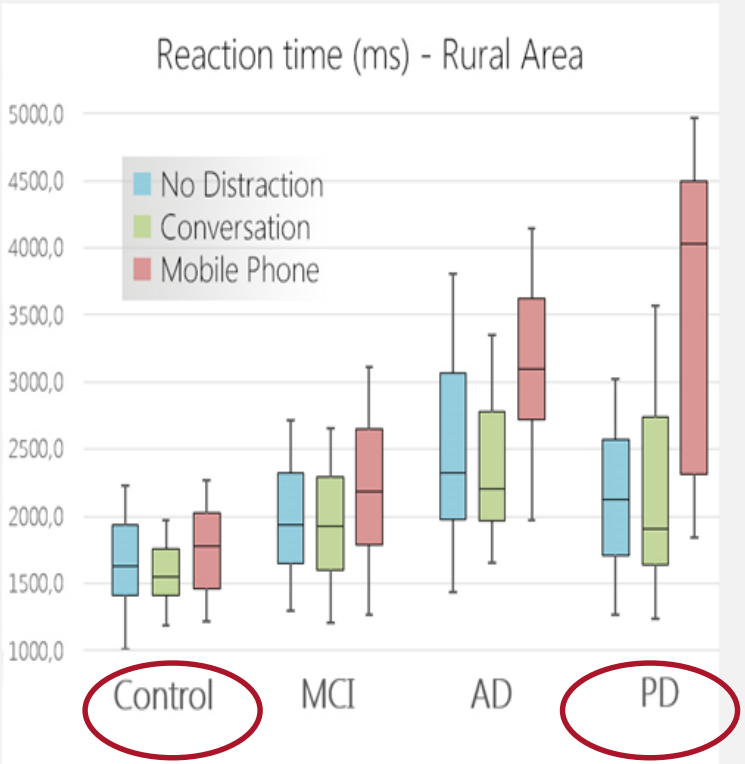
- PD participants have higher variability in wheeling angle compared with the control group in both traffic volumes.

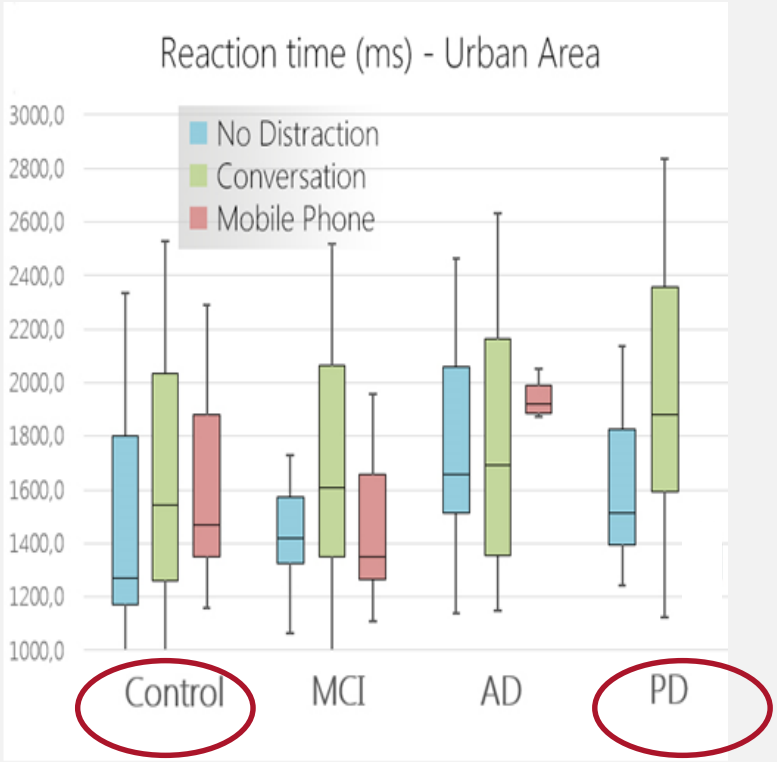
Driving performance profiles of drivers with brain pathologies

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

REACTION TIME

- 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)**





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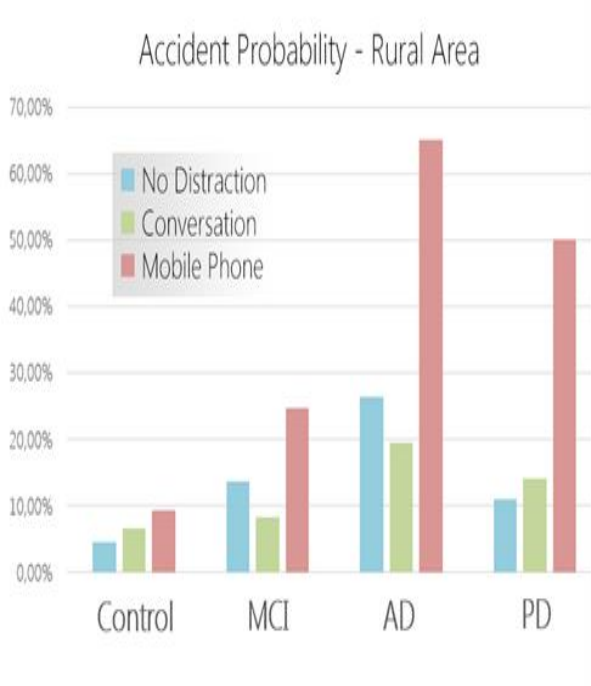
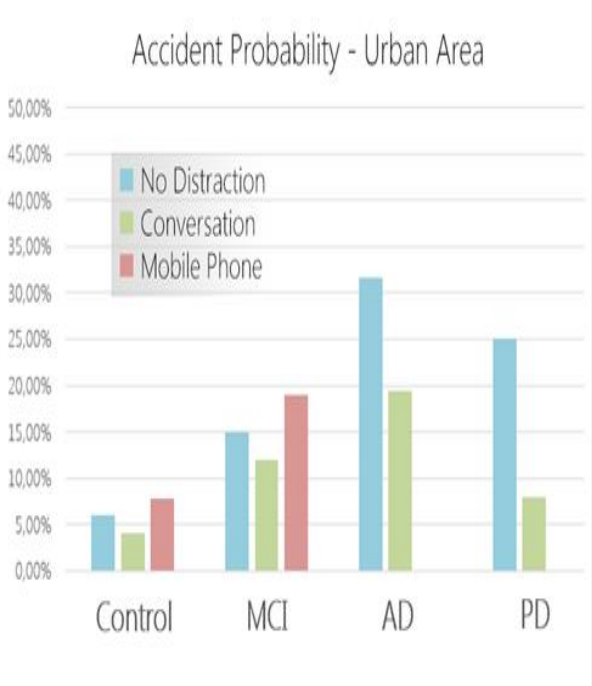
Accident Probability

- **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





distrACT driverBRAIN

DRIVING PERFORMANCE PROFILES OF DRIVERS WITH PARKINSON'S DISEASE

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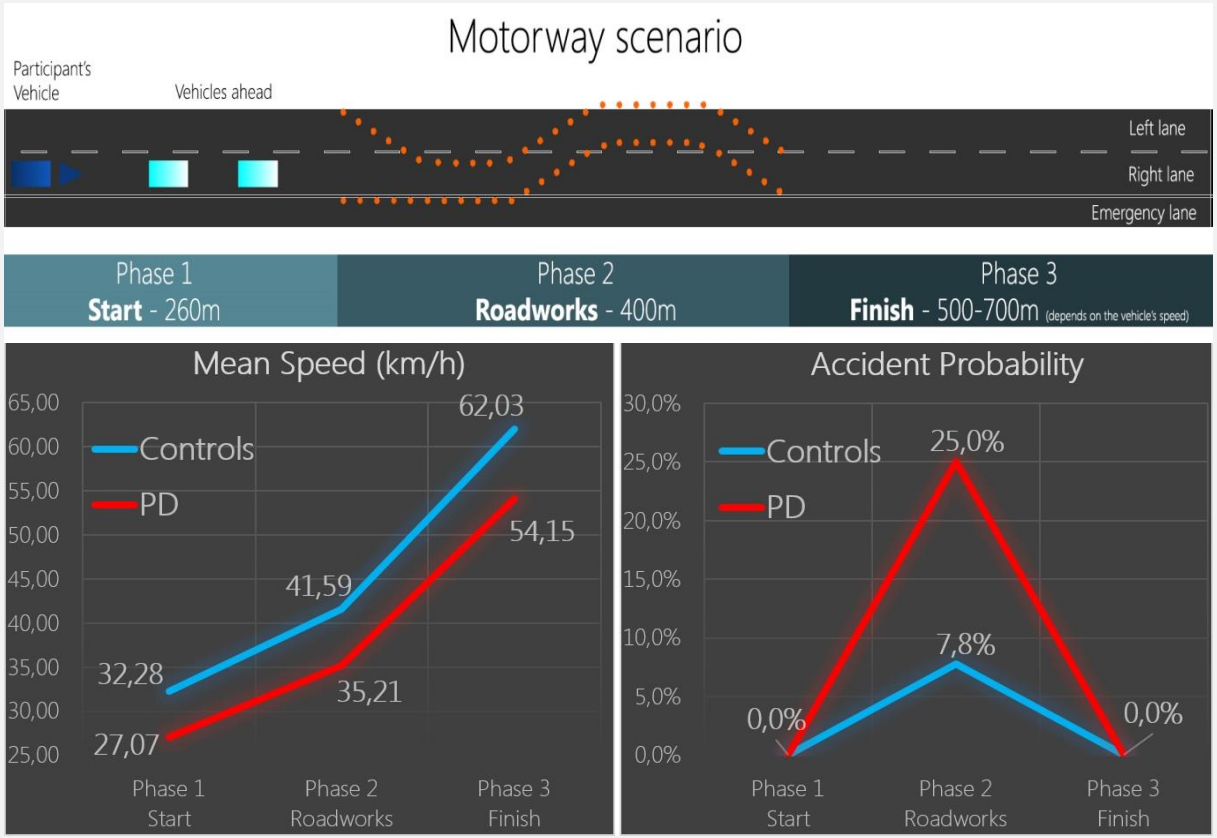


It is easily detectable the lower speed for the PD group along the driving route (approximately 15% lower speed overall) and at the same time the accident probability inside the roadworks segment is 3 times higher. PD participants drive at 35 km/h inside the work-zone segment and have 25% accident probability. They seem to have difficulty in making the maneuver even with low speed.

Prediction of driving performance in patients with Parkinson's disease : Motor Ability Tests

RAPID PACED WALK, HEAD ROTATION TASK, FOOT TAPPING TEST

- **Control group/PD group:**
  No correlation found

TANDEM WALKING

- **Control group**
  No correlation found

- **PD group:**
  - Mean Speed* (r=-.72, p=.008),
  - Speed Variability* (r=-.72, p=.008),
  - Headway Space Variability * (r=.59, p=.045),
  - Steering Angle Variability* (r=-.60, p=.041),
  - Sudden Brake* (r=-.61, p=.037),
  - Speed Limit Violation* (r=-.64, p=.025).

TANDEM WALKING WITH RNC

- **Control group:**
  No correlation found

- **PD group**:
  - Speed Variability (r=-.60, p=.039)
  - Sudden Brake (r=-.57, p=.050)

UPDRS-III (motor)

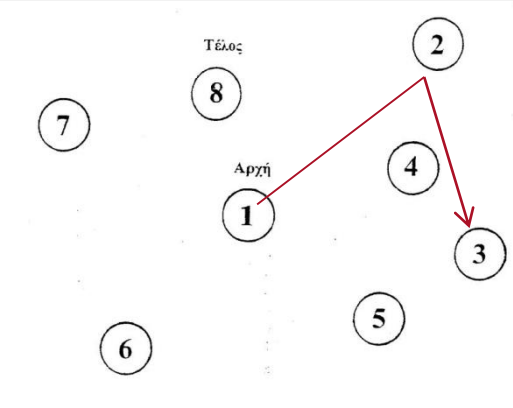
- **PD group:**
  - Speed Variability (r=-.65, p=.023)
  - Steering Angle Variability (r=-.73, p=.008)

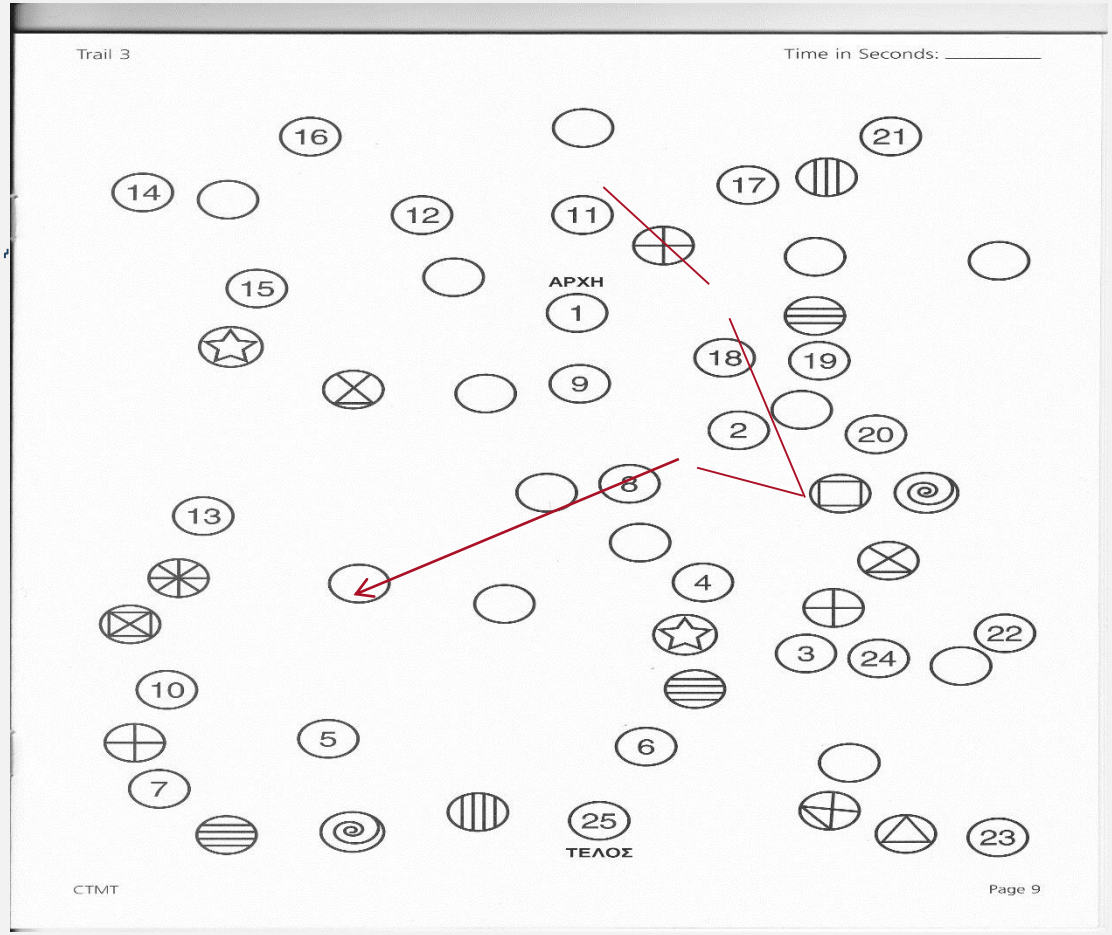
N.Andronas et al. 27th National Neurology Conference of the Hellenic Neurological Society, 2015

Prediction of driving performance in patients with Parkinson's disease: preliminary findings on the role of the Comprehensive Trail Making test

I. N. Beratis, N. Andronas, A. Economou, D. Pavlou, A. Liosidou, R. Antonellou, G. Yannis, L. Stefanis, S. G. Papageorgiou

EFNS-ENS Joint Congress of European Neurology,2014





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AVERAGE SPEED	SPEED VARIATION	REACTION TIME	HEADWAY DISTANCE
TMA: R^2=58.3, F(1,9)=12.59, p=.006	TMA: R^2=48.3, F(1,9)=8.40, p=.018	TMA: R^2=28.9, F(1,9)=3.67, p=.088	TMA: R^2=53.4, F(1,9)=10.32, p=.011
TMB:R^2=55.7, F(1,9)=11.34, p=.008	TMB:R^2=48.6, F(1,9)=8.52, p=.017	TMB:R^2=9.4, F(1,9)=0.93, p=.360	TMB:R^2=40.6, F(1,9)=6.15, p=.035
CTMT1:R^2=80.3, F(1,9)=32.67, p<.001	CTMT1:R^2=70.2, F(1,9)=19.80, p=.002	CTMT1:R^2=54.2, F(1,9)=9.46, p=.015	CTMT1:R^2=64.1, F(1,9)=14.31, p=.005
CTMT2:R^2=73.4, F(1,9)=22.09, p=.002	CTMT2:R^2=49.4, F(1,9)=7.82, p=.023	CTMT2:R^2=27.4, F(1,9)=3.02, p=.120	CTMT2:R^2=58.2., F(1,9)=11.15, p=.010
CTMT3:R^2=62.3, F(1,9)=13.20, p=.007	CTMT3:R^2=32.7, F(1,9)=3.89, p=.084	CTMT3:R^2=20.3 F(1,9)=2.04, p=.191	CTMT3:R^2=59.5, F(1,9)=11.73, p=.009
CTMT4:R^2=82.3, F(1,9)=37.29, p<.001	CTMT4:R^2=82.8, F(1,9)=38.38, p<.001	CTMT4:R^2=47.4, F(1,9)=7.22, p=.028	CTMT4:R^2=65.7, F(1,9)=15.31, p=.004
CTMT5:R^2=66.9, F(1,9)=16.15, p=.004	CTMT5:R^2=53.1, F(1,9)=9.05, p=.017	CTMT5:R^2=10.3, F(1,9)=0.915, p=.367	CTMT5:R^2=45.9, F(1,9)=6.79, p=.031

Results

- Very high correlations of CTMT with the Average Speed and Speed Variability
- CTMT surpassed the correlations obtained with the classical TMT

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