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

I. N. Beratis[1], N. Andronas[1], A. Economou[2], D. Pavlou[3], A. Liozidou[1], R. Antonellou[1], G. Yannis[3], L. Stefanis[1], S. G. Papageorgiou[1]

[1]2nd University Department of Neurology, "Attikon" University General Hospital, [2]Department of Psychology, University of Athens, [3]Department of Transportation Planning & Engineering, National Technical University of Athens

EFNS EUROPEAN FEDERATION OF NEUROLOGICAL SOCIETIES

ENS

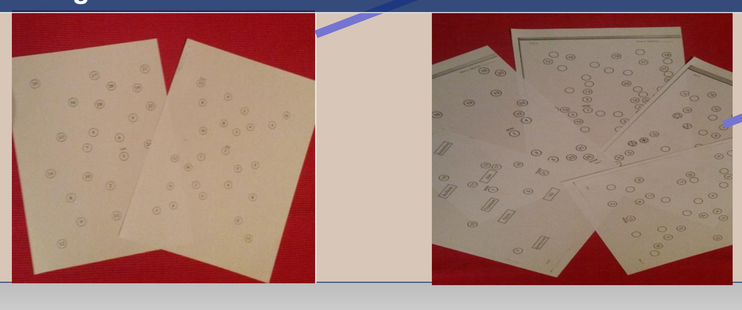
OPERATIONAL PROGRAMME EDUCATION AND LIFELONG LEARNING investing in knowledge society
MINISTRY OF EDUCATION & RELIGIOUS AFFAIRS, CULTURE & SPORTS MANAGING AUTHORITY
NSRF 2007-2013
European Union European Social Fund
Co-financed by Greece and the European Union

INTRODUCTION

- The multimodal clinical picture of Parkinson's disease (PD) influences negatively various aspects of cognition, behavior and motor control that are closely linked to the capacity of an individual to maintain adequate driving skills.
- Epidemiological data indicate increased risk of car accidents in patients with PD (Dubinsky et al., 1991; Meindorfner et al, 2005)
- Considerable effort has been directed toward the identification of neuropsychological measures that can serve as predictors of fitness to drive in individuals with PD.
- An indicative neuropsychological test that has been identified in several studies as predictor of driving skills in patients with PD is the Trail Making Test (TMT), especially part B of the specific test (Amick et al., 2007, Classen et al., 2009; Grace et al., 2005)

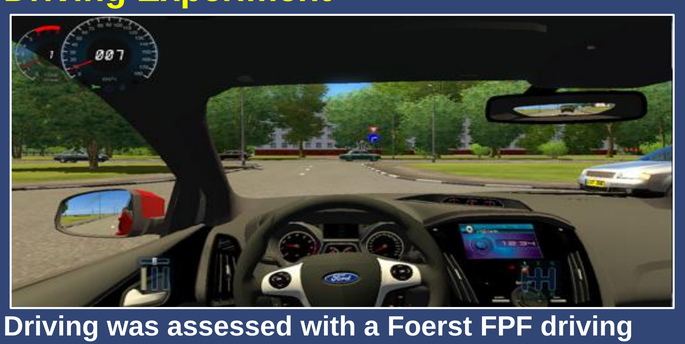
OBJECTIVE

Objective of the present work was to assess the capacity of an alternative version of the TMT, namely of the Comprehensive Trail Making test (CTMT; Reynolds, 2002) to serve as predictor of driving fitness in patients with PD as well as to compare the CTMT with the original TMT. To the best of our knowledge this is the first study in the field utilizing the CTMT



PATIENTS & METHODS

- Inclusion criteria were the presence of a valid driver's license, regular car driving, a score equal to or less than 0.5 on the CDR, and a score between 1 and 3 in the scale of Hoehn & Yahr.
- A total of 11 patients with PD were introduced in the study. The collection of the data included: (a) a clinical medical and neurological assessment , (b) extensive neuropsychological assessment that included the administration of the TMT and the CTMT in two different sessions taking place in different days(≈2 month interval), and (c) a driving simulation experiment
- **Driving Experiment**



- Driving was assessed with a Foerst FPF driving simulator, in different conditions
- **Data Collection**
- **Phase 1**: Practice session (5-10 min.)
- **Phase 2**: Two driving sessions (about 20 min. each) on urban streets with multiple lanes, and on a two-lane rural road. An unexpected incident occurs in each of the two sessions (sudden appearance of pedestrian or child on the road, sudden appearance of an animal on the rural road).

CONTACT INFORMATION

Corresponding author: Sokratis G. Papageorgiou, MD, PhD
2nd Department of Neurology, National University of Athens, University General Hospital 'ATTIKON', 1 Rimini Str, 12462 Haidari, Athens, Greece,
Phone: 0030-210-5832466, Email: sokpapa@med.uoa.gr

ABSTRACT

INTRODUCTION: The Trail Making test (TMT) has been identified in several studies as predictor of driving skills in patients with Parkinson's disease (PD). Objective of the present work was to assess the capacity of an alternative version of the TMT, namely of the Comprehensive Trail Making test (CTMT; Reynolds, 2002) to serve as predictor of driving fitness in patients with PD. **METHODS**: Inclusion criteria were the presence of a valid driver's license, regular car driving, a score equal to or less than 0.5 on the CDR, and a score between 1 and 3 in the scale of Hoehn & Yahr. A total of 11 patients with PD were introduced in the study. The collection of the data included: (a) a clinical medical and neurological assessment, (b) extensive neuropsychological assessment, and (c) a driving simulation experiment. **RESULTS**: Very high correlations of certain subtests of the CTMT were observed with the average speed and speed variation that surpassed the correlations obtained with the classical TMT. Indicatively, CTMT-4 explained 82.3 % of the variance in average speed [R^2 =.823, $F(1,9)=37.29$, $p<.001$] and 82.8 % of the variance in speed variation [R^2 =.828, $F(1,9)=38.38$, $p<.001$]. Additionally, two subtests of the CTMT were significantly correlated with reaction time of the driver in unexpected incidents, while the classical TMT subtests did not. Also, CTMT subtests were significantly associated with the headway distance (distance from the vehicle ahead). **CONCLUSION**: Preliminary findings underline the role of executive abilities in various measures of driving performance and support the usefulness of CTMT in the investigation of driving capacity in drivers with PD.

RESULTS

ASSOCIATIONS OF TMT AND CTMT SCORES WITH INDEXES OF DRIVING PERFORMANCE

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

Table.1 Demographics and TMT/CTMT scores

	Mean	SD	Range
Age	64.09	10.62	44-81
Education	13.18	3.84	6-18
TMTA (sec)	71.36	44.13	24-165
TMTB (sec)	173.36	98.83	38-300
CTMT1 (sec)	81.40	35.00	30-133
CTMT2 (sec)	93.80	50.16	22-196
CTMT3 (sec)	103.60	67.40	42-279
CTMT4 (sec)	104.90	60.61	38-199
CTMT5 (sec)	183.00	106.20	48-300

Table.2 PD vs Normal Group on Driving Indexes

	PD		Normal Group	
	Mean	SD	Mean	SD
Average Speed	37.33	11.78	43.62	7.33
Speed Variation	11.39	4.18	12.87	11.39
Reaction Time (sec)	2.23	0.83	1.78	0.28
Headway Distance*	481.08	214.87	309.61	122.52

* $p<.05$

DISCUSSION / CONCLUSION

- In agreement with previous studies the integrity of the executive system appear to play a major role on the driving performance of patients with PD
- The present findings support the application of the CTMT by future driving studies as an alternative option to the classical TMT
- The different types of task switching-abilities assessed by the CTMT appear to increase the capacity of the instrument to predict various indexes of driving performance, namely average speed, speed variation, reaction time, and headway distance
- The more simple nature of the CTMT4 as compared to TMTB could reduce the possibility for floor effects and, thus, provide complementary information about the mental-flexibility resources of specific clinical populations
- Future studies are warranted for exploring the capacity of the CTMT to serve as predictor of driving competence during on road, ecologically valid, driving conditions with the use of larger sample sizes

SUMMARY

- Various subtests of the CTMT appear to have the capacity to serve as predictors of driving performance in patients with PD
- This is especially the case for CTMT4 that requires from the participants to connect numbers in ascending order that appear either as Arabic numerals or in the form of written words
- The overall pattern of findings indicate an advantage of the CTMT as compared to the original TMT

REFERENCES/ACKNOWLEDGEMENTS

Dubinsky RM, Gray C, Husted D, Busenbark K, Vetere-Overfield B, Wiltfong D, et al. Driving in Parkinson's disease. Neurology. 1991;41:517-20.

Meindorfner C, Korner Y, Moller JC, Stiasny-Kolster K, Oertel WH, Kruger HP. Driving in Parkinson's disease: mobility, accidents, and sudden onset of sleep at the wheel. Movement disorders : official journal of the Movement Disorder Society. 2005;20:832-42

Amick MM, Grace J, Ott BR. Visual and cognitive predictors of driving safety in Parkinson's disease patients. Archives of clinical neuropsychology : the official journal of the National Academy of Neuropsychologists. 2007;22:957-67.

Classen S, McCarthy DP, Shechtman O, Awadzi KD, Lanford DN, Okun MS, et al. Useful field of view as a reliable screening measure of driving performance in people with Parkinson's disease: results of a pilot study. Traffic injury prevention. 2009;10:593-8.

Grace J, Amick MM, D'Abreu A, Festa EK, Heindel WC, Ott BR. Neuropsychological deficits associated with driving performance in Parkinson's and Alzheimer's disease. Journal of the International Neuropsychological Society : JINS. 2005;11:766-75.

Reynolds CR. Comprehensive Trail Making Test: Examiner's manual. 2002. Austin, Texas: PRO-E.

This paper is based on two research projects implemented within the framework of the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF), namely the Research Funding Program: THALES. Investing in knowledge society through the European Social Fund, and the Action: ARISTEIA (Action's Beneficiary: General Secretariat for Research and Technology), co-financed by by the European Union (European Social Fund – ESF) and Greek national funds.