

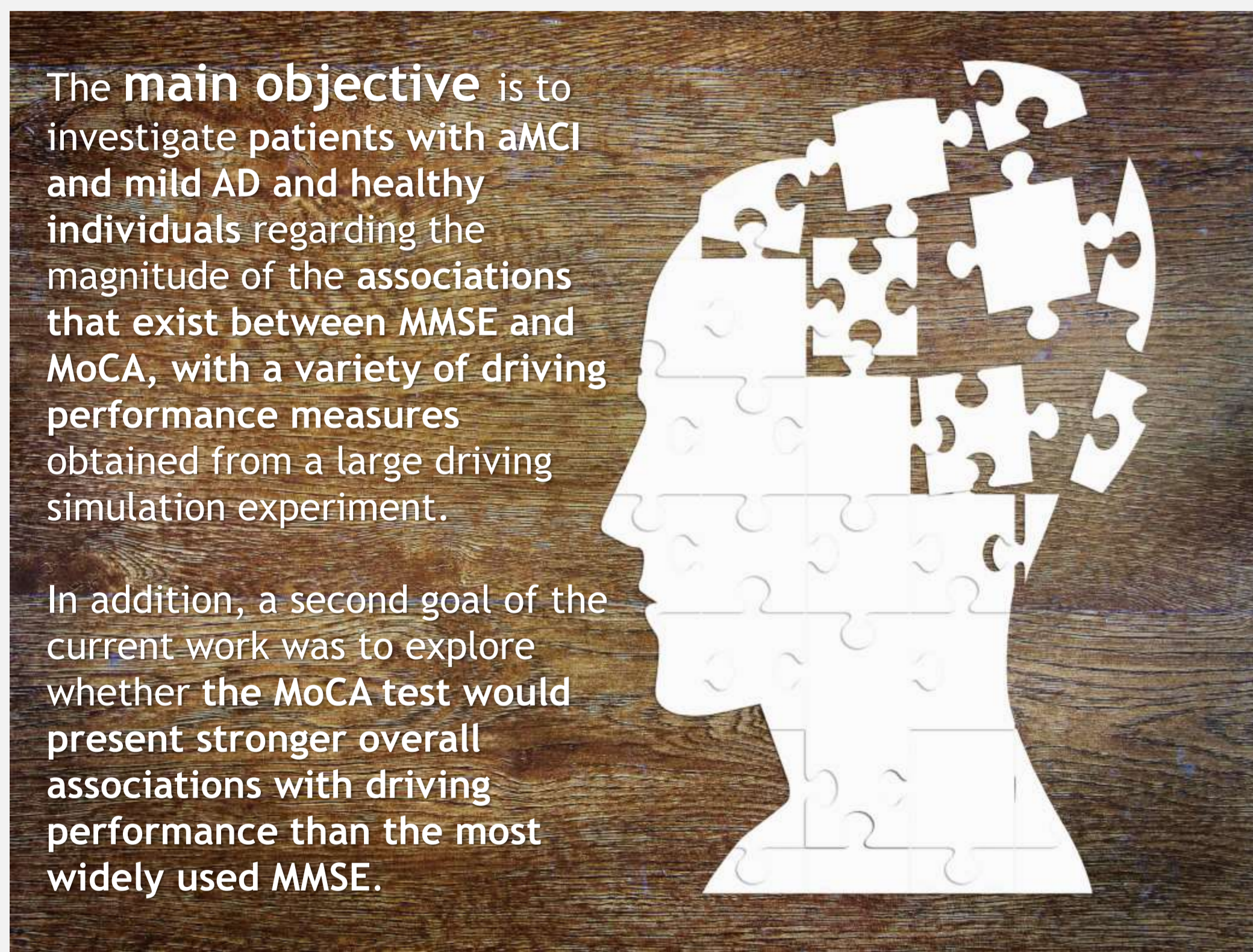
The value of Mini Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) in the prediction of fitness to drive in patients with amnesic Mild Cognitive Impairment (aMCI) and mild Alzheimer's disease (AD)

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Introduction - Background

- Mini Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) are commonly used screening tests for the evaluation of general cognitive ability.
- Previous studies, investigating the relation between MMSE and driving ability, have revealed contradictory results.
- Hollis et al. (2015), is the only study so far, that has examined the MoCA comparatively to MMSE performance in order to predict driving fitness, indicating stronger associations of MoCA with driving performance in cognitively impaired individuals.



The main objective is to investigate patients with aMCI and mild AD and healthy individuals regarding the magnitude of the associations that exist between MMSE and MoCA, with a variety of driving performance measures obtained from a large driving simulation experiment.

In addition, a second goal of the current work was to explore whether the MoCA test would present stronger overall associations with driving performance than the most widely used MMSE.

- Participants:** 44 patients with aMCI (mean age=69.1, SD=8.9), 23 patients with mild AD (mean age= 73.7, SD=6.8) and 30 cognitively intact individuals (age=65.9, SD=5.7).
- Clinical Evaluation:** All the participants underwent a complete neurological, neuropsychological and ophthalmological assessment. General cognitive ability was measured by the administration of MMSE & MoCA. The diagnosis of aMCI was made according to the Petersen and Morris (2005) clinical criteria, while the diagnosis of mild AD was made according to the McKhann et al. (2011) criteria.

"Driving at the simulator" assessment

- quarter-cab driving FOERST simulator (validated against a real world environment)
- 3 LCD wide screens 42" (full HD: 1920x1080pixels) with total field of view 170 degrees.
- At first, one practice drive (usually 10-15 minutes)
- Then, the participant drives two sessions (~10 minutes each)
- Each session corresponds to a different road environment:
 - a rural route (2.1 km long), single carriageway, zero gradient, mild horizontal curves and
 - an urban route (1.7km long), at its bigger part dual carriageway, separated by guardrails. Two traffic controlled junctions, one stop-controlled junction and one roundabout are placed along the route.
- During each session, 2 unexpected incidents occur:
 - sudden appearance of an animal on the roadway, and
 - sudden appearance of a child chasing a ball on the roadway or of a car suddenly getting out of a parking space.



Analysis data and methods

- Pearson r correlations were carried out in order to assess the association between the MMSE and MoCA performance with driving performance measures for each group: Average speed, Lateral position, Headway distance, Reaction time, Accident probability, and Speed limit violations.

TABLE 1 Correlations between MMSE, MoCA and Driving Indexes in Control group

Driving Indexes	Rural Area				Urban Area			
	MMSE		MoCA		MMSE		MoCA	
	r	p-value	r	p-value	r	p-value	r	p-value
Average speed	.03	.86	-.11	.61	-.11	.63	-.17	.48
Lateral position	-.06	.77	-.20	.33	.02	.94	-.32	.18
Headway distance	-.02	.93	-.05	.79	.18	.45	.38	.10
Reaction time	-.04	.83	.09	.66	-.05	.86	.01	.97
Accident probability	-.29	.14	-.32	.12	.18	.45	-.15	.59
Speed limit violations	-.30	.13	-.20	.33	-	-	-	-

Results - Pearson r correlations - Control Group:

- No significant correlations were found between the MMSE, MoCA and the driving indexes in the group of cognitively intact individuals.

TABLE 2 Correlations between MMSE, MoCA and Driving Indexes in aMCI patients

Driving Indexes	Rural Area				Urban Area			
	MMSE		MoCA		MMSE		MoCA	
	r	p-value	r	p-value	r	p-value	r	p-value
Average speed	.01	.94	-.05	.77	-.01	.96	.09	.61
Lateral position	-.10	.55	-.33	.055	.22	.22	.18	.32
Headway distance	.02	.91	.04	.83	-.16	.38	.01	.94
Reaction time	-.33	.045*	-.42	.01*	-.78	.000**	-.47	.02*
Accident probability	-.34	.041*	-.046	.006*	-.56	.003*	-.47	.02*
Speed limit violations	-.23	.18	-.39	.02*	.20	.27	.34	.059

Results - Pearson r correlations - aMCI patients:

- In aMCI patients, MMSE and MoCA scores were significantly correlated with reaction time and the accident probability in both rural and urban environments, while non-significant correlations were observed in the remaining driving indices in neither rural nor urban areas.
- MoCA was significantly correlated with speed limit violations in the rural environment.
- No other significant correlations were observed between the MoCA performance and the rest of the driving indexes.

TABLE 3 Correlations between MMSE, MoCA and Driving Indexes in mild AD patients

Driving Indexes	Rural Area				Urban Area			
	MMSE		MoCA		MMSE		MoCA	
	r	p-value	r	p-value	r	p-value	r	p-value
Average speed	.41	.09	.48	.044*	.29	.26	.34	.21
Lateral position	.22	.37	.06	.79	.21	.43	-.04	.88
Headway distance	-.53	.024*	-.57	.014*	-.28	.29	-.26	.32
Reaction time	.07	.77	-.09	.69	-.16	.59	-.13	.68
Accident probability	.21	.39	.13	.61	-.54	.03*	-.53	.037*
Speed limit violations ^a	-	-	-	-	-	-	-	-

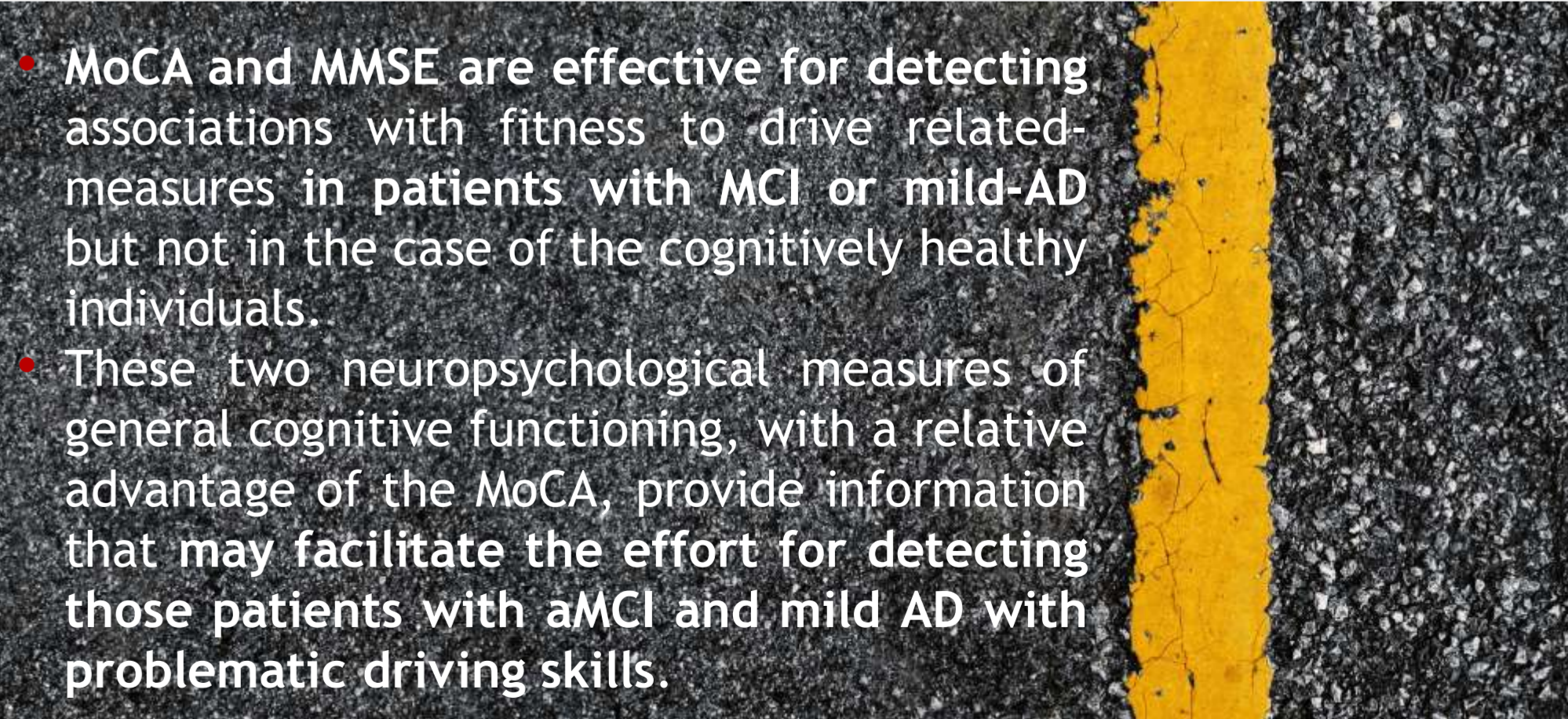
^a In the AD group, no speed limit violations were recorded

Results - Pearson r correlations - AD Patients:

- In AD patients, MMSE performance significantly correlated with headway distance in the rural environment and with accident probability in the urban environment.
- MoCA performance was significantly correlated with headway distance and average speed in the rural environment as well as with accident probability in the urban environment.

Conclusions -Discussion

- Both MMSE and MoCA were associated with crucial driving indexes that have an integral link with overall driving fitness.
- In patients with aMCI, both neuropsychological instruments were associated with the critical measures of reaction time to unexpected incidents and accident probability.
- In addition, the MoCA scores were significantly associated with speed limit violations in the rural area.
- In patients with aMCI, MoCA has a slight advantage as compared to MMSE regarding the number of significant associations that were observed with fitness to drive related-measures.
- In the mild AD group, headway distance in the rural area and accident probability in the urban area presented significant associations with both cognitive screening tests.
- MoCA was also associated with average speed in the rural area.
- MoCA appears to have a slight advantage as compared to MMSE also in the case of patients with mild-AD.
- Importantly, our findings indicate absence of significant associations between the driving variables and both MMSE and MoCA performance in the healthy elderly group.



- MoCA and MMSE are effective for detecting associations with fitness to drive related-measures in patients with MCI or mild-AD but not in the case of the cognitively healthy individuals.
- These two neuropsychological measures of general cognitive functioning, with a relative advantage of the MoCA, provide information that may facilitate the effort for detecting those patients with aMCI and mild AD with problematic driving skills.

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