The role of memory on patients with mild cognitive impairment

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Objective-Presentation Structure

Objective

To explore the association between working memory and MCI in a driving simulator

Presentation Structure

1. MCI and driving performance; driving simulators research
2. working memory
3. general information
4. driving simulator experiment
5. data analysis
6. results
7. conclusions
8. limitations and future research

MCI and driving performance

- With the aging of the driving population there is a greater prevalence of medical conditions and an associated loss of functional abilities needed to safely control a motor vehicle.
- There is considerable evidence that declines in cognition increase crash risk among older drivers, with a particular focus on neurological diseases such as dementia that can lead to driving impairments.
- Individuals with MCI as well as those in the earliest stages of a progressive, dementing illness may be able to continue to drive safely for some time.

MCI and driving performance

- Researchers have underlined the “need for increased vigilance among clinicians, family members and individuals with MCI for initially benign changes in driving that may become increasingly problematic over time”.
- The importance of identifying drivers with early dementia or mild cognitive impairment (MCI) is underscored by their reduced capacity to self-regulate.

Driving simulators research

- Driving simulators have the capacity to distinguish between controls and drivers with Alzheimer's disease, Parkinson's disease or stroke, and have enabled a better understanding of driving impairments and driver error.
- Another advantage of driving simulators is that the complex activity of driving can be deconstructed into isolated cognitive skills necessary for safe driving. One of the key cognitive functions for safe driving is working memory.

Working memory

- ✓Working memory allows a driver to remember and apply when needed, navigational directions and rules for traffic operations, even as the driver is processing and responding to the real-time demands of steering, anticipating and avoiding conflicts, and performing other moment-to-moment vehicle control tasks.
- ✓The ability to recall directions and information from signs and other traffic control devices is an important element in avoiding the confusion that can lead to accidents.
- ✓Those drivers with working memory problems are more likely to become lost and/or confused, and to respond inappropriately to unusual or unexpected traffic situations,
- ✓Research has shown that (age-related) impairments in working memory are a significant predictor of at-fault crashes

Working memory

✓Executive functions strongly interact with working memory, and with attention, which operates on the contents of working memory

- decision-making
- impulse control
- judgment
- task switching
- planning

Study Objective

To determine how varying levels of operational and tactical simulated driving task demands might differentially affect message recall for older drivers with MCI, versus a group of age-matched, healthy controls.

Distract/ “DriverBrain

DriverBrain

Performance of drivers with cerebral diseases at unexpected incidents

ARISTEIA research programme

DISTRACT

Causes and impacts of driver distraction: a driving simulator study

THALES research programme

General Information

✓Participants in the larger investigation provided the pool of subjects for this study.

✓These individuals included current drivers with a cerebral pathological condition (neurological disease) and drivers with no known pathological condition. They:

- had to have driven for more than 3 years; more than 2500km during the last year; at least once a week and at least 10km/week during the last year;
- had a Clinical Dementia Rating scale (CDR) score <1;
- had no significant psychiatric history of psychosis or significant kinetic disorder;
- could not suffer dizziness or nausea; be pregnant; be alcoholic or have any other drug addiction; have any significant eye disorder or any disease of the central nervous system.

General Information

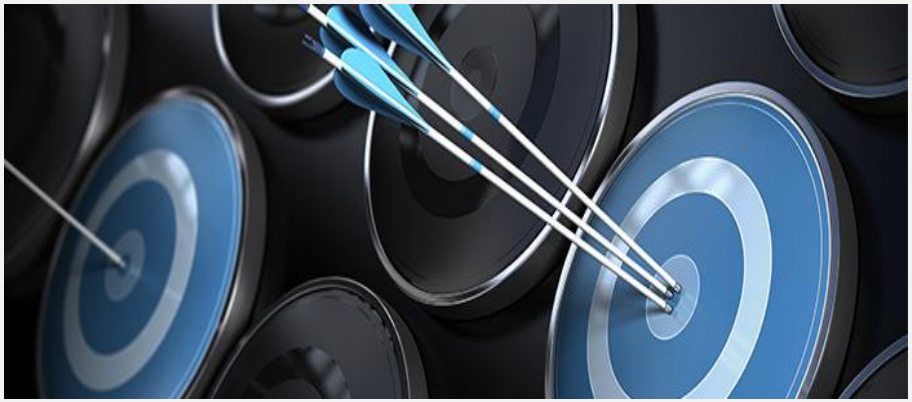
- FOERST Driving Simulator FPF (¼ cab)
  - ❑ 3 LCD screens (40”, 1920x1080pixels)
  - ❑ Total field of view = 170degrees
- Participants
- Two driver groups: A MCI group and a control group.
- The MCI group: 12 subjects; mean age = 64.8 years (s.d. = 8.9, range 51-76); 8 males and 4 females.
- The control group: 12 subjects; 6 men and 6 women; with no pathological condition; mean age = 59.5 years (s.d.=7.2; range 51-78).
- The two groups were not statistically different (a=0.05) in terms of age, driving experience, driving exposure (number of days driven per week, number of trips per day and kilometers per week), number of years of education, total accidents, and accidents in the past two years.

Functional status of study sample

- All MCI subjects were classified with amnestic MCI; 9 were single domain amnestic MCI and 3 multiple domain amnestic MCI.
- The diagnosis of MCI was based on the criteria of Petersen et al. (2005)
- The analysis revealed significant differences between the control and the MCI group in verbal episodic memory (Hopkins Verbal Learning Test-Revised) and information processing speed (SDMT).
- Measures of general cognitive functioning (MMSE), working memory (LNS), visuospatial memory (BVMT), psychomotor speed (TMTA), mental flexibility (TMTB) and visuospatial perception (JLO) did not differ significantly between the two groups.

Experiment

- The experiment measured the effect of different levels of intervening driving task demand (i.e., between message presentation and recall) on the recall of the sign information.

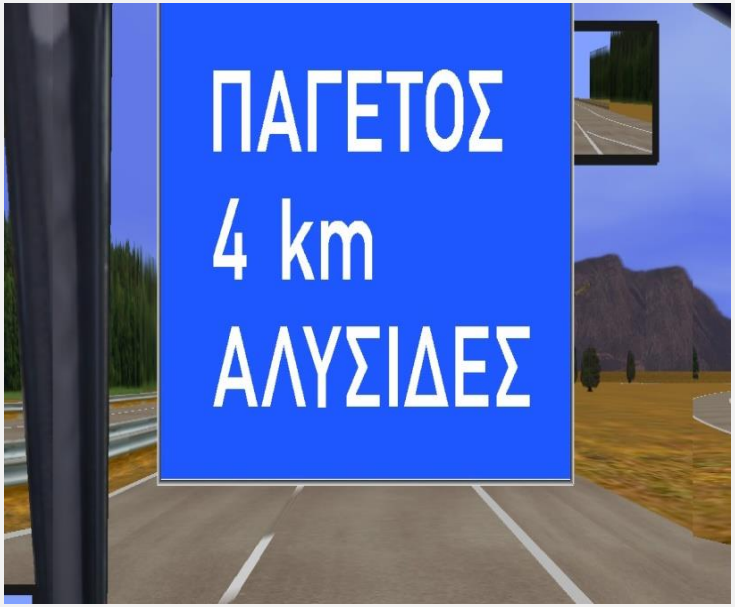


Experiment

- A repeated measures design included three conditions of increasing task demand: TC1,TC2, and TC3; these were simulator drives of approximately 100 sec duration each.
- A sign message was presented for a fixed interval (8 sec) that was constant across study participants before the beginning of each drive.
- Drivers were asked to read aloud and rehearse the message and then the drive began.
- The order of presentation of conditions TC1, TC2, and TC3 was randomized.

Experiment

- ✓Three equivalent messages were constructed for presentation at the beginning of each of the three test conditions, using a common format including three information units:
  - *a type of situation ahead*
  - *a distance*
  - *a driver action that is required*



- ✓Immediately after the end of each drive, the experimenter assigned a score 0-3.

Experiment

Subjects were instructed to:

- ✓ to respond to traffic control information and always maintain safe gaps with other vehicles just as they would when actually driving.
- ✓ to maintain a constant speed at the posted speed limit unless they are forced to slow down due to road conditions (specifically, a road section where barriers were present). "*In this situation, drive at what you feel is the maximum safe speed for conditions*."
- ✓ to execute a lane change in response to a discriminative stimulus (activation of the brake lights on a lead vehicle).
- ✓ on the recall task*: "Please look at and remember this highway sign message. I will ask you to recall this message at the end of the drive."*

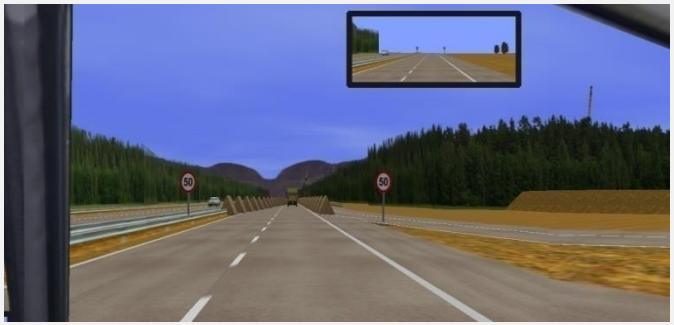
Experiment

TC1-Demand Level 1.

Drivers experienced the lowest level of demand, required to respond only to operational-level driving tasks.

TC2-Demand Level 2.

Drivers made a double lane change that involved driving through a road work section (intermediate level of demand).



TC3-Demand Level 3.

Drivers were presented with the same road work section and associated steering requirements but after these forced lane changes they were required to execute an additional lane change *if* a discriminative stimulus (activation of the brake lights on a lead vehicle) was presented (the highest level of demand).

Data analysis

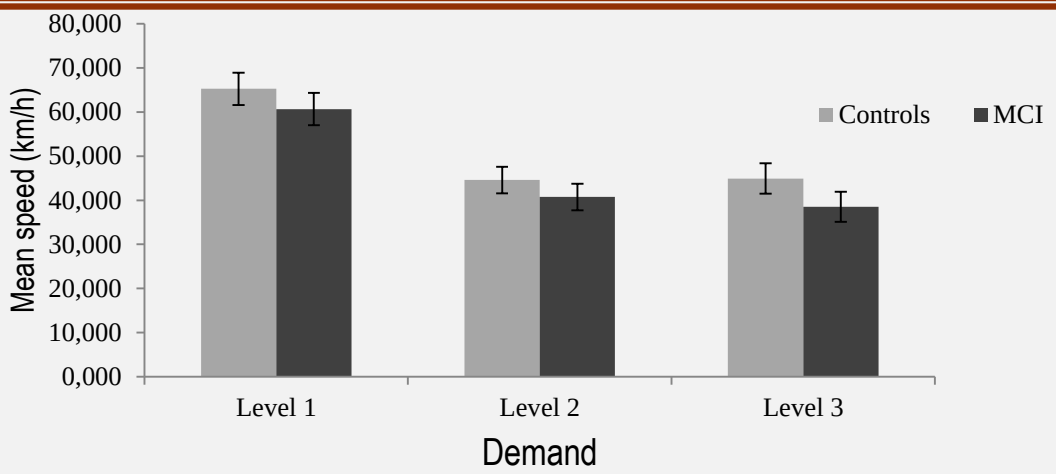
Differences in speed

- Data analyses examined differences in drivers' speed choice under each test condition, to check that the hypothesized differences in task demand had operational consequences.

Differences in sign recall scores

- Data analyses examined differences in sign recall evaluate the hypothesized deficit for MCI drivers versus controls, and a potential interaction of sign message recall with task demand level.

Mean Speed (two-way mixed ANOVA)



- On average, at Demand Level 1 the mean speed was higher than in Levels 2 and 3
- The mean speed of the MCI group was lower than the mean speed of the control group across all levels of task demand (non-significant trend)
- The differences in speed associated with the level of driving task demand were significant ($F(1.53, 35.57)=32.09$, $p<0.001$).

the level of demand was indeed varied by imposing different types of operational and tactical driving tasks on subjects

Generalized Estimating Equations-recall scores

	Parameter	B	Std. Error	Exp(B)	95% CI for Exp(B) Lower	95% CI for Exp(B) Upper	Hypothesis Test Wald Chi-Square	Hypothesis Test df	Hypothesis Test Sig.
Threshold	Recall score =0	-0.65	0.41	0.52	0.23	1.16	2.55	1.00	0.11
	Recall score ≤1	0.57	0.41	1.77	0.79	3.94	1.93	1.00	0.165
	Recall score ≤2	2.91	0.70	18.36	4.71	72.24	17.47	1.00	0
	Controls	2.46	0.74	11.76	2.72	50.40	10.94	1.00	0.001
	MCI	0		1.00	1.00	1.00			
	TC1-Level1	0.9	0.46	2.46	0.99	6.11	3.77	1.00	0.052
	TC2-Level 2	1.58	0.43	4.85	2.08	11.36	13.33	1.00	0
	TC3-Level3	0							

- MCI group performed more poorly in message recall, demonstrating higher percentages of low recall scores (0 and 1) than the control group.
- Controls were more likely to perform better than MCI drivers in the sign recall task; this trend was statistically significant:
- Disregarding group membership, subjects performed better in the recall of sign information in TC1 versus TC3, although this difference was not significant.
- Performance in the sign recall task was more likely to be higher in TC2 (lower level of driving task demand) than TC3, and this difference was statistically significant.

Conclusions

- Drivers with mild cognitive impairment (MCI) performed significantly more poorly on a sign recall task across varying levels of driving task demand than a age-matched cognitively-intact comparison group.
- The results suggest that (older) drivers with mild cognitive impairment will be at a disadvantage when new information is presented, for example, on a variable message sign or in-car visual display, that must be retained in working memory and applied after some additional period of driving.
- Differences shown in this study suggest that this effect will be exaggerated as driving task demand increases.

Study limitations

- Results were not analyzed in relation to individual characteristics associated with driving competence such as driving experience, etc., nor functional status..
- Older drivers are more likely to experience simulator sickness, so an effect of sampling bias on study results cannot be ruled out.
- This must be characterized as an exploratory study due to its small sample size

Future Work

- The trend for poorer performance for the MCI group needs to be explored further.
- Use of larger samples to better account for the influence on driving behaviors and performance of confounding variables (e.g., age, driving experience, exposure) that are associated with driving competence.
- Simulators will remain an essential tool to better understand the interaction between individual differences and varying situational demands on safe and effective vehicle control.
- There is a need to analyze the extent to which performance differences may be attributed to actual differences in visual and cognitive functional abilities.

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