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The traffic behavior of pedestrians with mild Alzheimer's Disease or Mild Cognitive Impairment in urban areas, and its neuropsychological predictors

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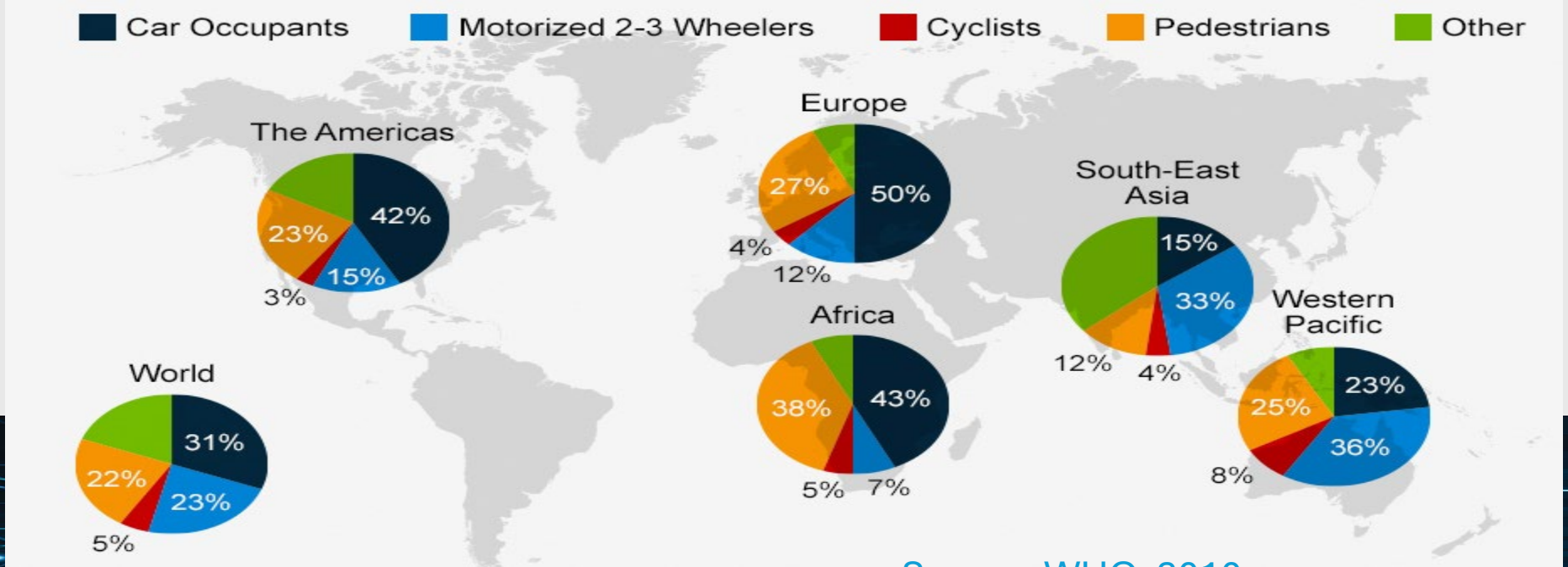
Background

- Pedestrian accidents constitute a major road safety problem worldwide
- A significant share of older people (>65 years) are fatally injured as pedestrians in road accidents (44% in Greece, 35-40% in the EU, 23% in the US)
- Mild Cognitive impairment is a pre-dementia condition with considerable prevalence in the population (13% in Greece, 7-33% in the EU, 22% in the US)



Functions critical for safe walking

- Street walking is both a sensorimotor and cognitive task
  - Balance, posture and coordination
  - Walking speed
  - Vision & visuospatial perception
  - Attention (selective, divided)
  - Memory (destination, names of roads)
  - Executive functions (e.g. decision making)

Pedestrians with cognitive impairments are often forgotten (in data, in planning…)

Current knowledge

In contrast to the abundance of research on the driving ability of people with cognitive disability / dementia, research and data on pedestrian movement ability are scarce

- Neurofibrillary Tangles (NFT), which constitute a neuropathologic hallmark of AD, were associated with specific road accident conditions *(crash victim autopsies)*
- Cognitive deficits increase the risk for elderly pedestrians to be involved in crashes or in unsafe road – crossing decisions
- Wayfinding abilities are worse in elderly with cognitive decline, compared to the heathy elderly

Findings from virtual environments

- Pedestrians with mild dementia were more likely to:
  - make crossing decisions that would lead to potential collisions
  - initiate crossing considering only the safety of the near lane and ignoring traffic in the far lane
  - Processing speed and visual attention (UFOV) abilities significantly explain virtual collisions.

- The Useful Field of View (UFOV®) neuropsychological test has been associated with driving and walking performance in the elderly

Source: Dommes A. et al. (2013) , Functional declines as predictors of risky street-crossing decisions in older pedestrians, Accident Analysis & Prevention, 59, 135–143

Objectives

- To measure and analyse **the walking and crossing behaviour of elderly with mild AD or MCI**, compared to that of healthy controls
- To identify the **cognitive functions** that are associated with decreased pedestrian performance
- To investigate the potential of medical **neuropsychological assessment tools as predictors** of poor pedestrian performance

The present research aims to offer greater ecological validity and the ability to observe the actual behavior of cognitively impaired elderly people on the road in real traffic conditions.

Methodology: observational study

Inclusion Criteria

- ✓ Patients diagnosed with mild AD or MCI
- ✓ Age over 55 years old
- ✓ Both patients and healthy elderly had to be able to walk autonomously, without the assistance of a caregiver or a device

Exclusion Criteria

- × Patients diagnosed with AD in late stage (severe)
- × Elderly participants with difficulty in movement
- × Deficits of visual acuity or hearing ability.
- × Other neurologic or psychiatric disorders

Participants

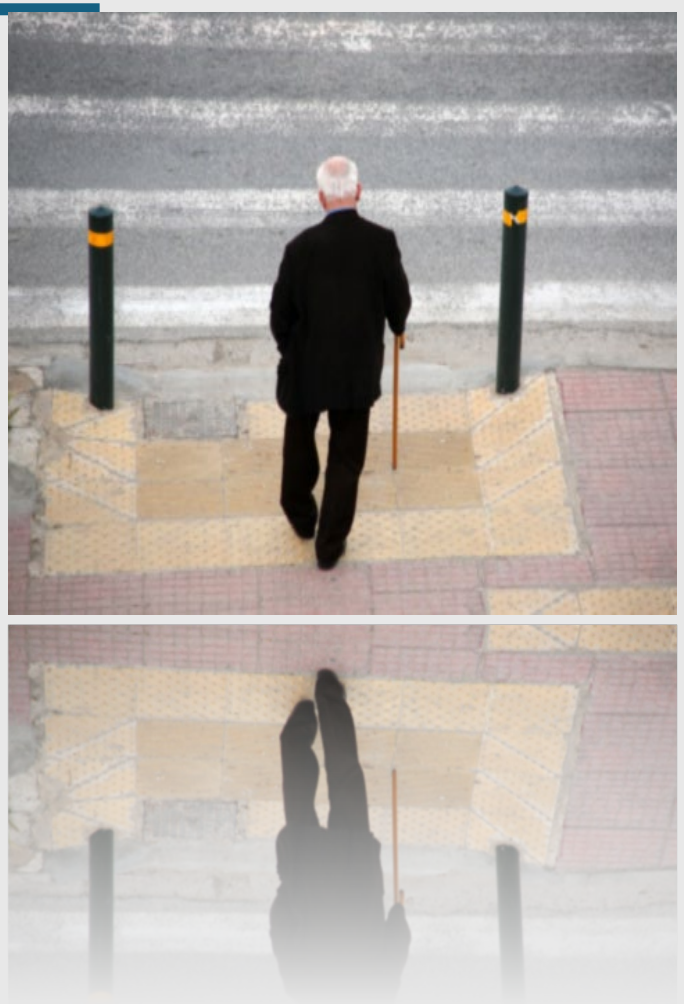
	AD Patients (N=15)		MCI Patients (N=15)		Controls (N=15)		ANOVA	
	Mean	SD	Mean	SD	Mean	SD	F	P
Gender(m/f)	13/2	-	8/7	-	7/8	-	-	0.053
Age	77.27	5.09	73.27	5.31	74.93	4.46	2.45	0.098
Education	11.53	3.85	10.73	4.65	11.60	4.08	.197	0.822

❖ Control group

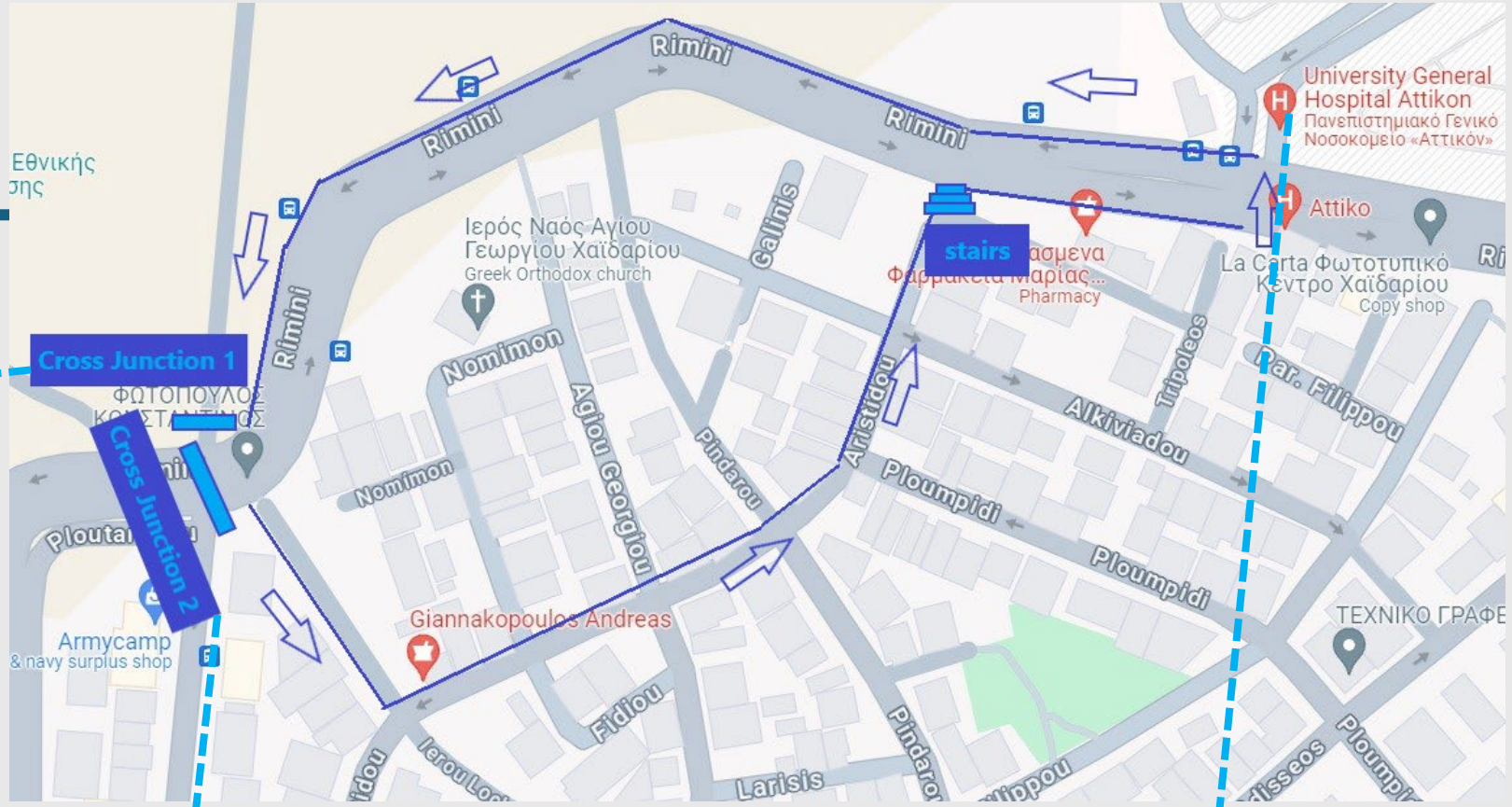
- matched for age and education.
- individuals who did not report any history of neurological or psychiatric disorders or cognitive complaints and had a Mini-Mental State Examination score over 27.

Experimental conditions

- A real – life environment (configured route)
- Origin and Destination the entrance of University General Hospital “Attikon”
- Duration: 17 minutes
- Participants held a destination map, indicating the junctions to be crossed and the roads to be walked along
- Participants were followed by an observer, video-recording the walking task; data processing measured:
  - Orientation
  - Dangerous Crossing Location
  - Traffic Signal Violation
  - Velocity



Study area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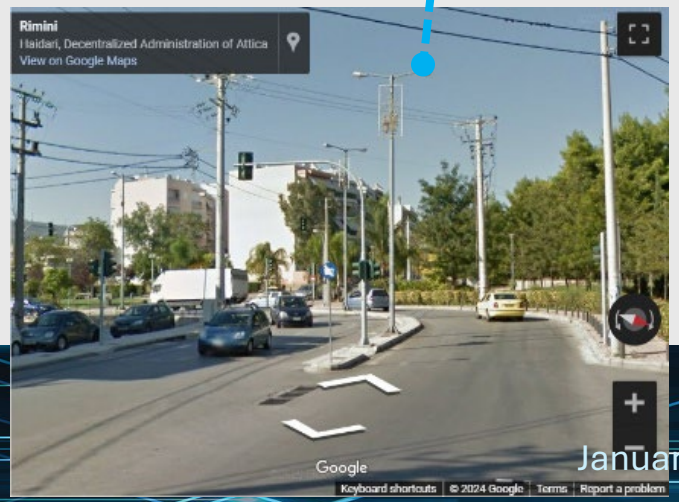
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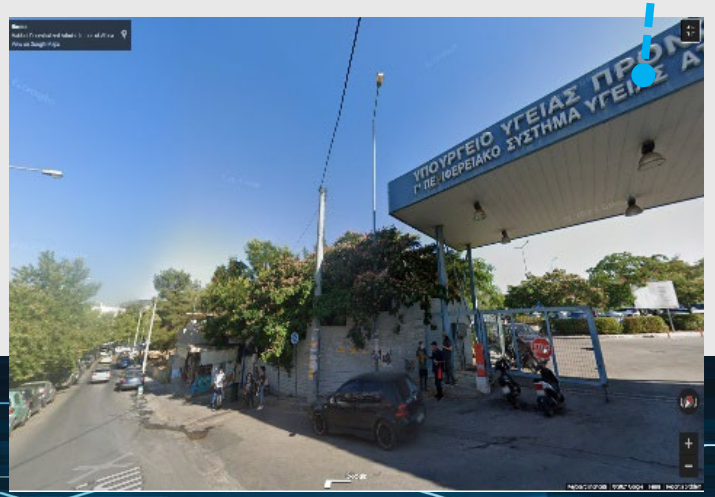
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Neuropsychological evaluation

- Mini Mental State Examination (MMSE): general assessment of cognitive functions
- 5 object test: recall of the locations of five everyday objects, immediately after placement and after a brief period of time – visuospatial memory
- Clock Drawing Test (CDT) – executive function and visual-spatial function
- Trail Making Test A & B (TMTA, TMTB) – visual search speed, scanning, speed of processing, mental flexibility, and executive functioning
- Frontal Assessment Battery (FAB): general assessment of executive functions
- Hopkins Verbal Learning Test (HVLT): verbal learning and memory
- Digit Span: attention
- Judgement of Line Orientation (JLO): visuospatial function

Results – group differences in walking behaviour

- One-way ANOVA

	AD Patients (N=15)		MCI Patients (N=15)		Controls (N=15)		ANOVA		Post hoc comparisons
	Mean	SD	Mean	SD	Mean	SD	F	P	
Orientation	1.13	0.31	-1.13	0.31	1.73	0.31	15.91	**0.000**	**AD<MCI**** **AD<CT****
Dangerous crossing location	0.73	0.53	-0.73	0.53	-0.13	0.53	1.07	0.353	
Traffic Signal Violation	0.33	0.54	-0.33	0.54	0.66	0.54	0.75	0.479	
Velocity	0.04	0.27	-0.43	0.27	0.84	0.27	6.71	**0.003**	**AD<CT**** **MCI<CT****

*p<.05, **p<.001

Results – correlations of behaviour with neuropsychological tests - AD group

Neuropsychological Tests	Traffic Signal Violation		Dangerous Crossing Location		Velocity		Orientation	
	r	p-value	r	p-value	r	p-value	r	p-value
MMSE	-0.46	0 .087	-0.65	**0.008****	-0.02	0.943	-0.35	0.193
DS(back)	-0.69	**0.004****	-0.75	**0.001****	-0.09	0.747	-0.16	0.566
5 Object (DR)	-0.71	**0.003****	-0.64	**0.010****	-0.14	0.629	0.34	0.211
JLO	-0.34	0.213	-0.66	**0.007****	0.21	0.446	-0.49	0.061
FAB	-0.02	0.933	0.28	0.303	0.59	**0.023***	-0.17	0.537

*p<.05, **p<.001

Results – correlations of behaviour with neuropsychological tests - MCI group

Neuropsychological Tests	Traffic Signal Violation		Dangerous Crossing Location		Velocity		Orientation	
	r	p-value	r	p-value	r	p-value	r	p-value
MMSE	0.56	0.844	-0.20	0.336	0.34	0.207	-0.26	0.356
DS(back)	0.34	0.213	0.00	0.980	0.46	0.084	-0.44	0.095
5 Object (DR)	-0.47	**0.046***	-0.51	**0.048***	-0.19	0.492	0.20	0.284
JLO	0.33	0.230	-0.22	0.440	0.10	0.716	-0.12	0.648
FAB	0.40	0.132	0.52	**0.046***	0.13	0.641	-0.13	0.636

*p<.05, **p<.001

Multiple regression – AD group

Neuropsychological Tests	Dangerous Crossing Location				Traffic Signal Violation			
	B	SE B	B	P	B	SE B	B	P
MMSE	-0.10	0.16	-0.160	0.543	-0.11	0.17	-0.188	0.520
DS(back)	-1.74	0.37	-0.790	**0.000****	-1.40	0.45	-0.661	**0.010***
JLO	-0.05	0.08	-0.180	0.493	0.09	0.09	0.296	0.318
5Object(DR)	0.04	0.21	0.041	0.857	-0.18	0.22	-0.205	0.429
R^2	.62				.53			

*p<.05, **p<.001

- The Digital Span test is a significant predictor of observed unsafe crossing behaviour and traffic signal violation

Regression – MCI group

Neuropsychological Tests	Dangerous Crossing Location				Traffic Signal Violation			
	R^2	B	F	P	R^2	B	F	P
5Object(DR)	0.44	-0.38	10.23	**0.007****	0.44	-1.64	10.18	**0.007****

*p<.05, **p<.001

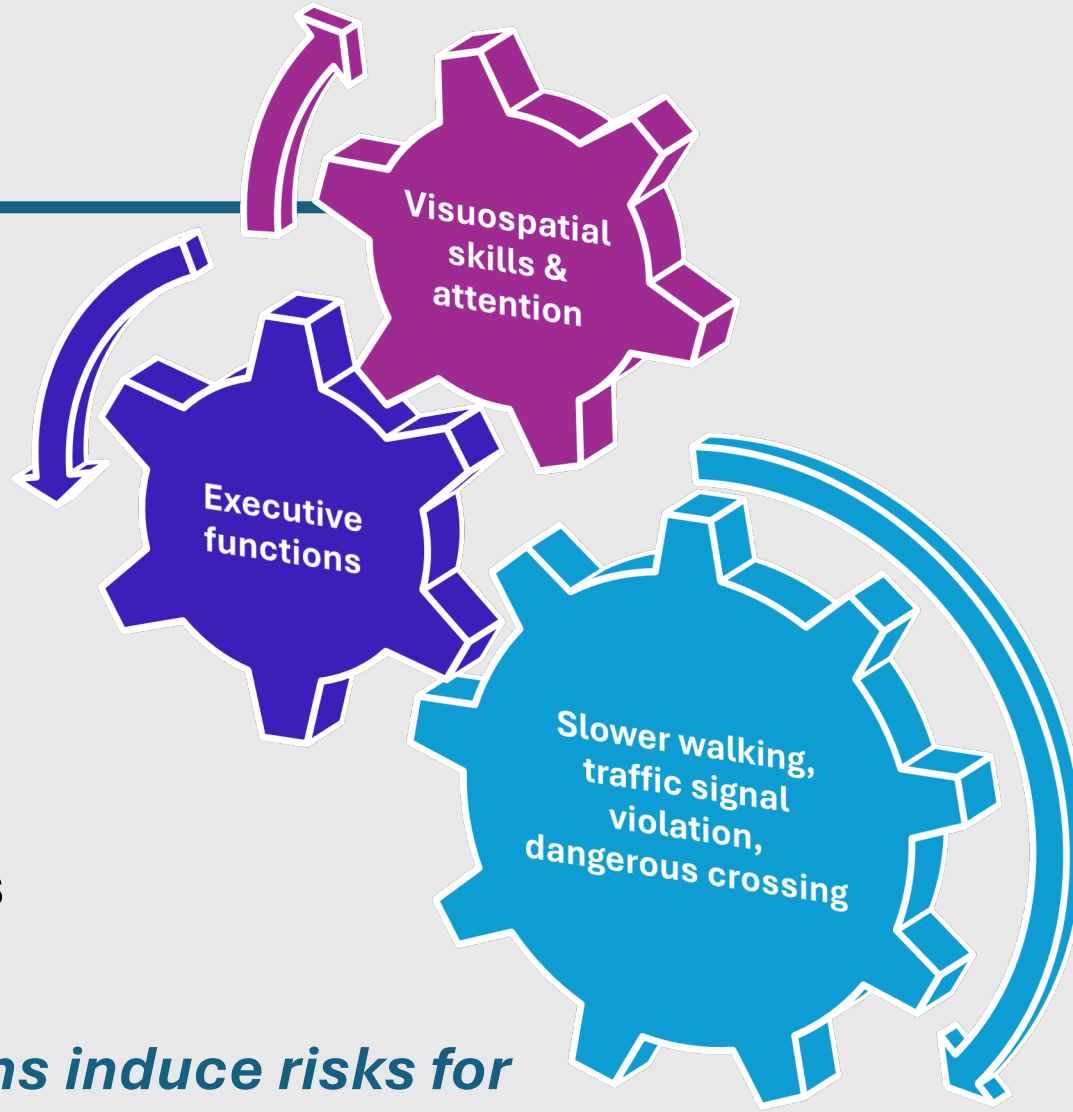
- The 5-Object test is a significant predictor of observed unsafe crossing behaviour and traffic signal violation

Summary of findings

- Differences between healthy elderly and patients with mild AD or MCI in parameters of pedestrian behavior such as **speed and orientation**
- AD and MCI patients have lower speed crossing than healthy old pedestrians
- No differences between AD and MCI patients in road – crossing decisions and signal display compliance
- Cognitive tests engaging visuospatial and executive functions have a significant **correlation with unsafe crossing behavior**
- Neuropsychological tests may be a predictive factor of pedestrians' behavior and therefore potentially prevent possible fatal accidents.

Discussion

- Dementia causes significant impairment of functions critical for pedestrian movement.
- Dementia often results in the cessation of driving, leaving walking as the only option for mobility and social participation for older individuals.
- However, avoiding the risk of a road accident is not guaranteed by stopping driving.



Cognitive impairments of elderly pedestrians induce risks for themselves, rather than for other road users

Recommendations for urban transport planning

Inclusive urban areas for cognitively impaired people

- Median islands on two-way streets may help older pedestrians cross the road in two stages
- Signalization improvements (e.g. audible signals, “countdown”).
- Traffic signs (frequency and readability) for wayfinding
- **Speed management**: lowering speed limits , traffic calming, protection of areas with high activity of older pedestrians (e.g. ‘hospital zones’).

The Anonymous Pedestrians
Wroclaw, Poland

Recommendations for transport & health authorities

Interdisciplinary collaboration

- Use of neuropsychological tests to identify potential traffic risk
- Joint research programmes for engineers, urban planners & medical experts for the urban safety of older people

Educational programs

- Mixed physical-cognitive training to enhance the motor skills of older pedestrians, along with control procedures in complex perceptual situations.
- Raise self-awareness among elderly (and their caregivers) of their declining abilities.

Thank you!

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