Predictors of accidents in patients with mild cognitive impairment, mild Alzheimer's disease and healthy controls in simulated driving

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BACKGROUND & AIMS

Older drivers, especially those with mild cognitive impairment (MCI) or mild Alzheimer's disease (AD), make more safety errors than middle-aged drivers and are at higher risk of being involved in accidents. It is therefore important to investigate the variables that predict accident risk. The driving simulator offers a valid way of assessing driving performance and is especially valuable for studying accident risk in different driving scenarios.

The present study investigates the driving variables that are predictors of accidents in middle-aged and older drivers, drivers with MCI, and drivers with mild AD in simulated driving.

METHODS

Participants

- 21 healthy controls over 52 years of age (age of youngest patient)
- 37 Mild Cognitive Impairment (MCI) patients
- 16 mild Alzheimer's disease (AD) patients

All participants were regular drivers, who completed all four driving conditions

Driving simulator experiment

- Data from **Distract and DriverBrain** research projects
- All participants underwent neurological, neuropsychological and ophthalmological assessment
- **Driving simulator assessment**: all drivers drove a quarter-cab FOERST driving simulator (3 LCD wide screens 42'', full HD: 1920x1080pixels - total field of view 170 degrees, validated against a real world environment) in **4 rural conditions**, counterbalanced across participants. **Two unexpected incidents** occurred per driving condition.

moderate traffic (R1, R3)
with & without distraction

high traffic (R2, R4)
with & without distraction

- A practice drive (10-15 minutes) preceded the driving assessment
- The test drive took place in a single carriageway route, zero gradient, with mild horizontal curves

Distraction condition: conversation with passenger (R3, R4)

Measures

- **Average speed** (in km)
- **Headway average** (distance from the vehicle ahead in m)
- **Lateral position** (distance from the right road border in m)
- **Average speed variability** (*SD* of average speed)
- **Headway variability** (*SD* of headway average)
- **Lateral position variability** (*SD* of lateral position)
- **Reaction time** (RT) average breaking RT at unexpected incidents
- **Accidents** at unexpected incidents

- The measures were z-transformed based on the performance of all 90 control participants in each of the four driving conditions (mean age 46±16.04)

RESULTS

R1 (mod. traffic)			Model 1					Model 2					Model 3		
Variable	*B*	*SE B*	*β*	*t*	*p*-value	*B*	*SE B*	*β*	*t*	*p*-value	*B*	*SE B*	*β*	*t*	*p*-value
(constant)	0.34	0.06		5.62	<0.001	0.22	0.07		3.15	0.002	0.30	0.07		4.08	<0.001
Average RT	0.32			3.13	0.003	**0.10**	**0.03**	**0.32**	**3.13**	**0.003**	**0.15**	**0.04**	**0.46**	**4.10**	**<0.001**
Average speed z	-0.15			-1.31	0.19	0.06			0.46	0.65	-0.21			-1.33	0.19
Headway avg z	0.15			0.30	0.20	-0.02			-0.13	0.89	0.27			1.84	0.07
Lateral position z	0.04			0.32	0.75	0.00			-0.00	1.00	-0.07			-0.69	0.49
SD Avg speed z	0.08			0.72	0.48	0.31			2.62	0.011	**0.22**	**0.08**	**0.31**	**2.66**	**0.011**
SD Headway avg z	0.14			1.24	0.22	-0.06			-0.45	0.66	0.22			1.45	0.15
SD Lateral pos z	**0.30**	**0.08**	**0.39**	**3.54**	**0.001**	**0.30**	**0.08**	**0.39**	**3.76**	**<0.001**	**0.21**	**0.08**	**0.27**	**2.53**	**0.014**
MCI	-0.07			-0.63	0.53	-0.02			-0.21	0.84	-0.06			-0.56	0.58
AD	0.16			1.42	0.16	-0.02			-0.16	0.86	0.05			0.45	0.66
R^2			**0.15**					**0.25**					**0.32**		
F for change in R^2			12.53		0.001			9.77		0.003			6.88		0.011

R2 (high traffic)			Model 1					Model 2		
Variable	*B*	*SE B*	*β*	*t*	*p*-value	*B*	*SE B*	*β*	*t*	*p*-value
(constant)	0.05	0.06		0.80	0.43	0.10	0.05		1.75	0.09
Average RT	**0.23**	**0.04**	**0.55**	**5.56**	**<0.001**	**0.30**	**0.04**	**0.74**	**7.56**	**<0.001**
Average speed z	0.34			3.06	0.003	0.03			0.17	0.87
Headway avg z	-0.33			-3.08	0.003	-0.12			-0.96	0.34
Lateral position z	0.09			0.92	0.36	0.08			0.88	0.38
SD Avg speed z	0.44			4.44	<0.001	**0.21**	**0.05**	**0.44**	**4.44**	**<0.001**
SD Headway avg z	-0.33			-2.90	0.005	-0.05			-0.35	0.73
SD Lateral pos z	0.22			2.23	0.03	0.06			0.57	0.57
MCI	0.17			0.17	0.87	-0.03			-0.28	0.78
AD	0.14			0.13	0.89	0.11			1.11	0.27
R^2			**0.30**					**0.45**		
F for change in R^2			30.91		<0.001			19.71		<0.001

Predictor of RT (R1 & R2): Average speed

R3 (mod. distraction)			Model 1		
Variable	*B*	*SE B*	*β*	*t*	*p*-value
(constant)	0.22	0.06		3.75	<0.001
Average RT	0.09			0.81	0.42
Average speed z	0.17			1.41	0.16
Headway avg z	-0.18			-1.58	0.12
Lateral position z	0.09			0.74	0.47
SD Avg speed z	0.23			1.96	0.053
SD Headway avg z	-0.12			-1.06	0.29
SD Lateral pos z	**0.16**	**0.05**	**0.34**	**3.04**	**0.003**
MCI	-0.17			-1.57	0.12
AD	0.08			0.70	0.48
R^2			**0.12**		
F for change in R^2			9.26		0.003

Predictor of RT (R3): Headway variation Lateral position variation

R4 (high distraction)			Model 1					Model 2			
Variable	*B*	*SE B*	*β*	*t*	*p*-value	*B*	*SE B*	*β*	*t*	*p*-value
(constant)	-0.01	0.07		0.14	0.89	0.02	0.07		0.35	0.73
Average RT	**0.15**	**0.03**	**0.55**	**5.37**	**<0.001**	**0.17**	**0.03**	**0.63**	**5.91**	**<0.001**
Average speed z	0.16			1.37	0.18	-0.00			-0.01	0.99
Headway avg z	-0.20			-1.75	0.09	-0.10			-0.71	0.46
Lateral position z	0.02			0.22	0.82	0.01			0.11	0.91
SD Avg speed z	0.23			2.14	0.036	**0.11**	**0.05**	**0.23**	**2.14**	**0.036**
SD Headway avg z	-0.16			-1.39	0.17	-0.05			-0.33	0.74
SD Lateral posz	-0.03			-0.26	0.80	-0.03			-0.26	0.80
MCI	-0.14			-1.35	0.18	-0.14			-1.43	0.16
AD	0.06			0.56	0.58	0.10			0.91	0.37
R^2			**0.30**					**0.34**		
F for change in R^2			28.84		<0.001			4.59		0.036

Predictor of RT (R4): Average speed Patient status

CONCLUSION

- Longer RT, larger speed variation (in a negative direction), larger lateral position variation predicted accidents at unexpected incidents but patient status did not.
- Lower speed was associated with longer RT at unexpected incidents; patient status contributed marginally to RT (in R4) over and above average speed.
- Patient status was hardly associated with either accident rate or RT over and above the driving measures, and is by itself an insufficient indicator for the decision to stop driving at a given point in time. An individualized approach is needed than includes assessing performance in the critical driving variables.