



How does automated driving affect attention and distraction?

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EASY (Effects of Automated Systems on Safety)



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Objectives

- To understand the human factors and safety implications of Advanced Driver Assistance Systems that supplant the driver in control of the vehicle
- To investigate the effects of various type of ADAS — taking over longitudinal control, lateral control, and a combination of the two
- To develop means for mitigating any negative safety implications of such systems

The tool



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Experiment 1: What do drivers do when driving is automated?

Research questions



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- Do drivers continue to monitor the road?
- How much are they willing to engage in secondary tasks?

Voluntary tasks



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- Play
- Read
- Groom (makeup, etc.)
- Eat
- Watch DVD
- Puzzle (Sudoku)
- Listen to radio
- Other (inc comedy moments etc)



1. Manual baseline
2. Semi-automated
 - a. Half of participants have longitudinal support (\approx ACC)
 - b. Half have lateral support (\approx LKS)
3. Highly automated (long. + lat.)

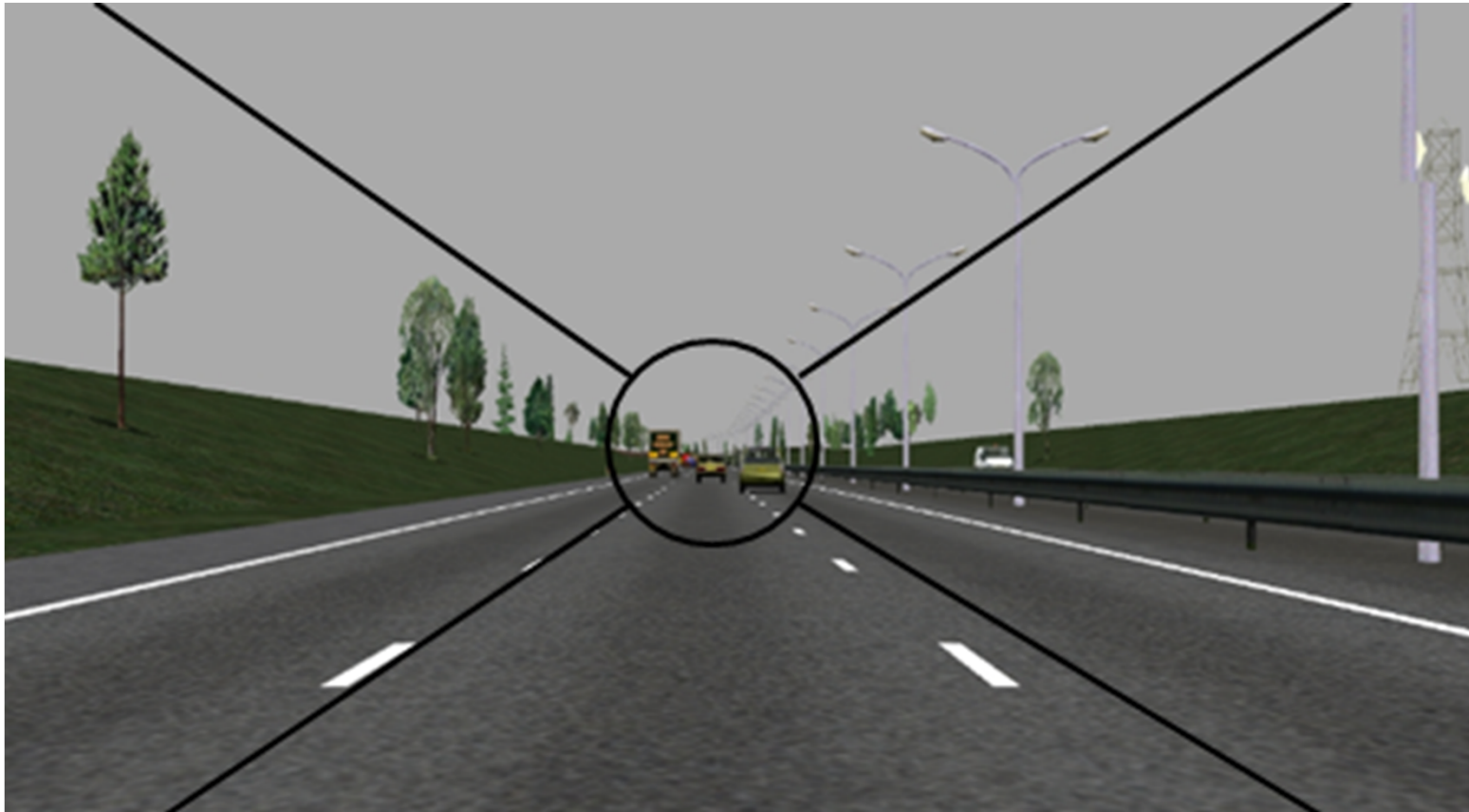
In that order!

48 participants, within-subject, driving on a three-lane motorway

Regions for visual attention allocation



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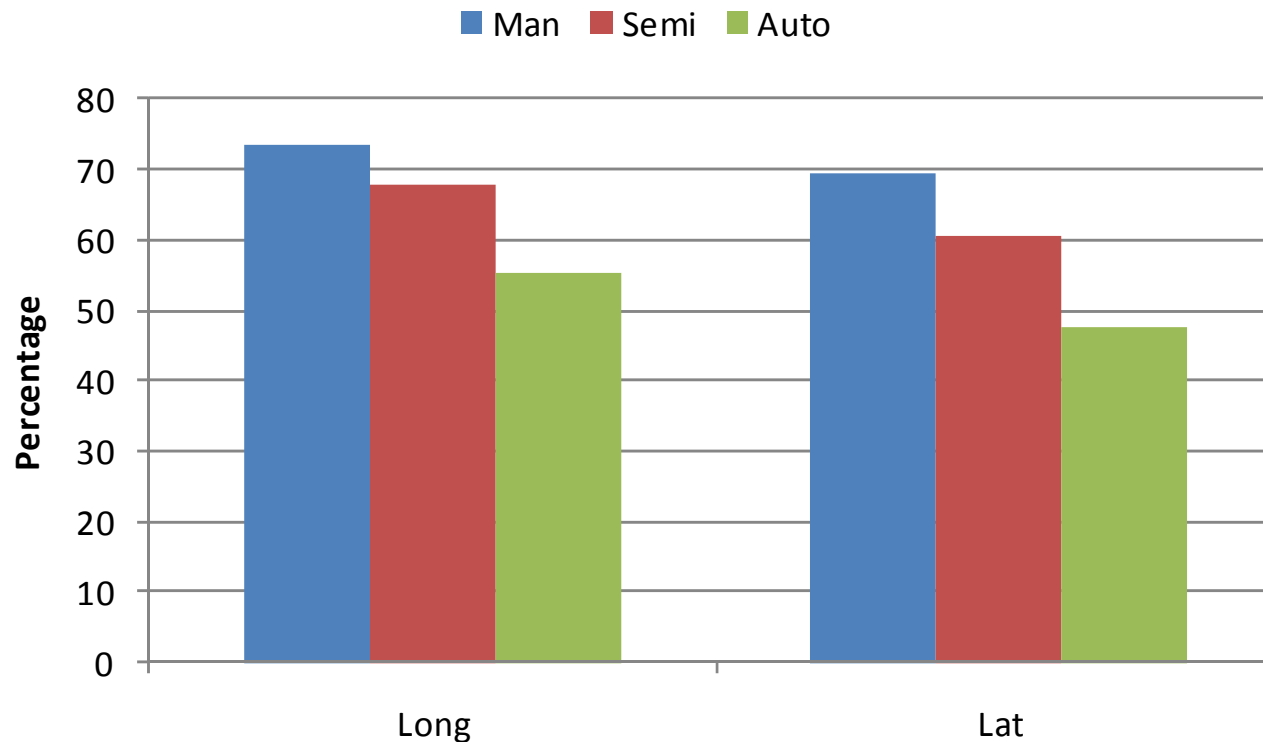


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Visual attention allocation to the central region



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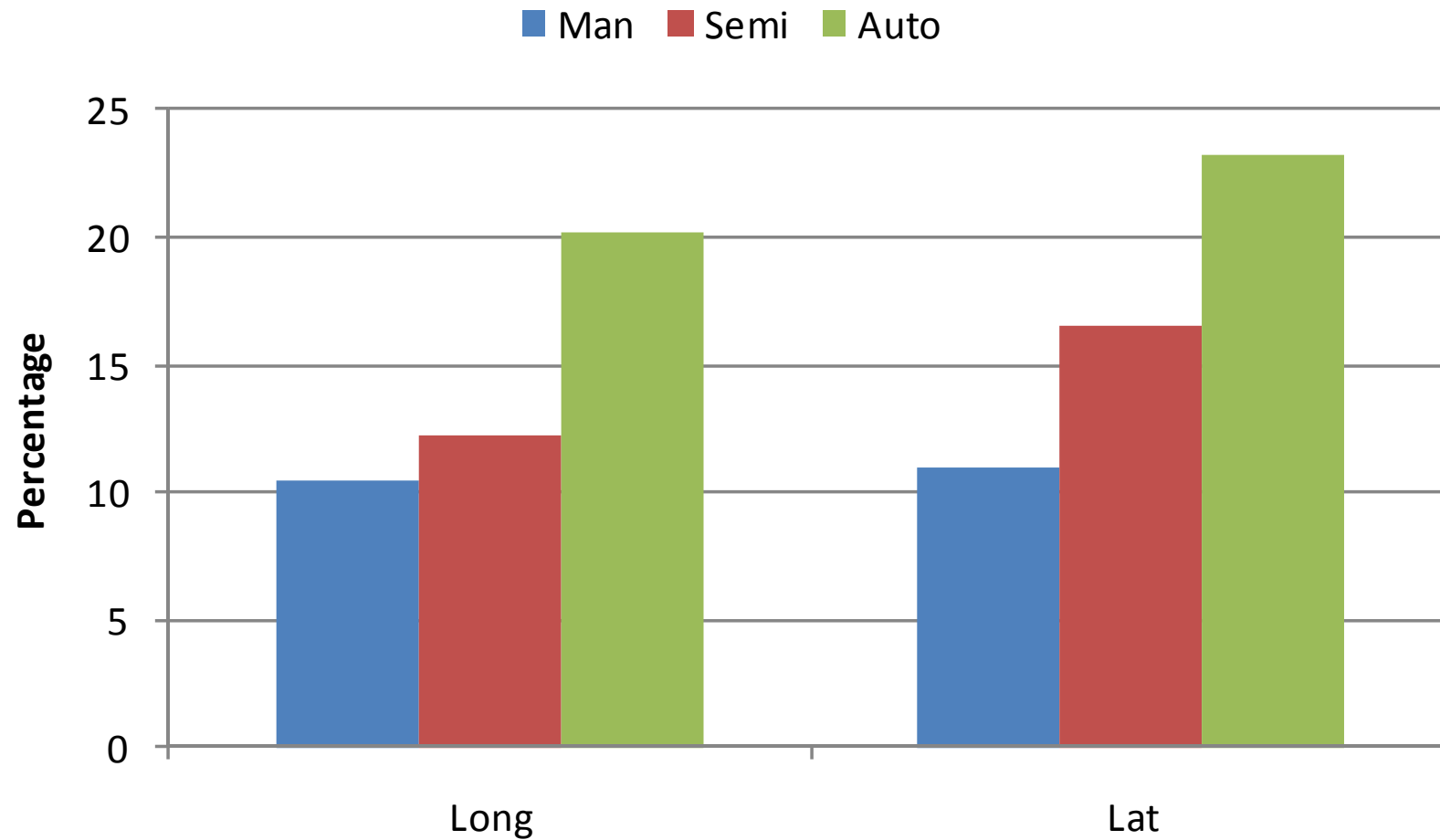


Exp Group	Repeated-Measures ANOVA			Post-hoc t-tests		
	<i>F</i>	<i>p</i>	η_p^2	Pair	<i>p</i>	<i>D</i>
Long	$F(2,38) = 20.05$	< 0.01	0.51	Man – Semi	< 0.01	0.65
				Semi – Auto	< 0.01	0.85
				Man - Auto	< 0.01	1.33
Lat	$F(2,36) = 21.81$	< 0.01	0.55	Man – Semi	< 0.01	0.50
				Semi – Auto	< 0.01	0.71
				Man - Auto	< 0.01	1.21

Visual attention allocation to the left region



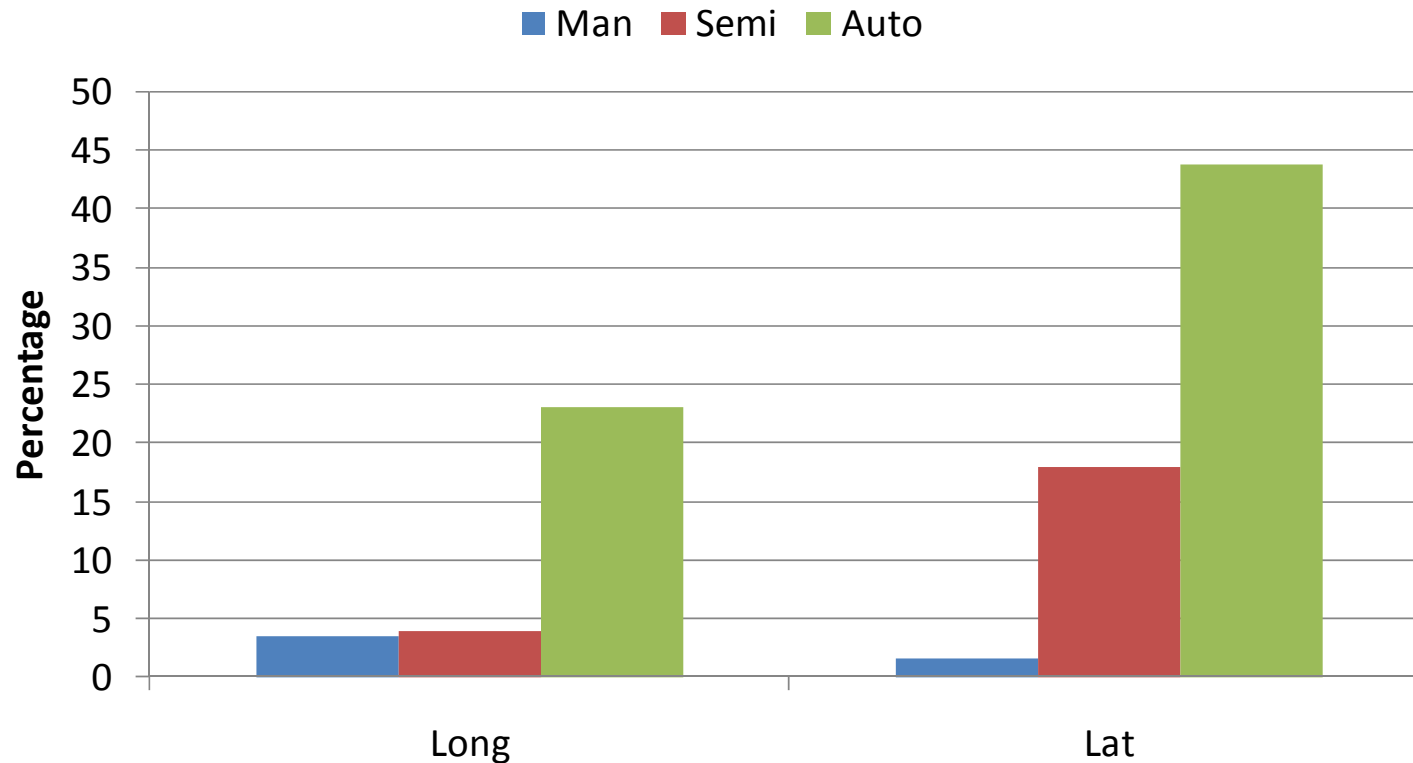
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Uptake of DVD task: proportion of journey time



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Exp Group	Mean			Repeated-Measures ANOVA			Post-hoc t-tests		
	Man	Semi	Auto	<i>F</i>	<i>p</i>	η_p^2	Pair	<i>p</i>	<i>d</i>
Long	3.5%	4.0%	23.1%	<i>F</i> (2,48) = 4.78	< 0.05	0.17	Man – Semi	0.34	0.03
							Semi – Auto	< 0.05	0.63
							Man - Auto	< 0.05	0.67
Lat	1.6%	18.0%	43.7%	<i>F</i> (2,46) = 13.90	< 0.01	0.36	Man – Semi	< 0.05	0.63
							Semi – Auto	< 0.01	0.65
							Man - Auto	< 0.01	1.37

- Longitudinal and lateral control are substantially different
- In the absence of a lead vehicle, drivers are willing to take their eyes off the road for substantial time slices. Where the lead vehicle is remote or absent, there is no need for continuous checking.
- With lateral control, drivers are aware that a small change in heading angle can soon result in a lane or roadway excursion. So drivers feel a need to check their heading error continuously



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Experiment 2: Mitigation strategies



2 mitigation strategies tested



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1. **Fixed system:** the automated system was turned off 6 minutes after it had been turned on. After the automated system was turned off the third time, it remained off until the end of the drive.
2. **Variable system:** the automated system was turned off when the participant failed to pay attention to the central region of the forward view. The central region was defined as 10 degree yaw and 6 degree pitch based on the mode of glances over the previous 60 seconds. There were two criteria for determining lack of attention:
 - The participant's glances did not fall in the centre region for a consecutive 10-second period.
 - The participant's glances did not fall in the centre region for an cumulative 30-second period within the previous 60 seconds.

System operation



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- Automaton would be turned off, when either criterion was met.
- Automation would attempt to resume after 1 minute of manual driving
- The switch between highly automated and manual driving was controlled by the vehicle. It was not driver selectable.
- 3 drives by each participant on a 3-lane motorway:
 - manual
 - fixed-time automation
 - variable time automation
- Counterbalanced
- Participants were to refrain from engaging in secondary tasks

Recall task



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There were 9 VMS signs along the route. The 1st, 4th and 7th showed a message, while the rest were blank. At the end of each drive, participants were asked to recall the contents of the VMS.

**DON'T DRINK
AND DRIVE**

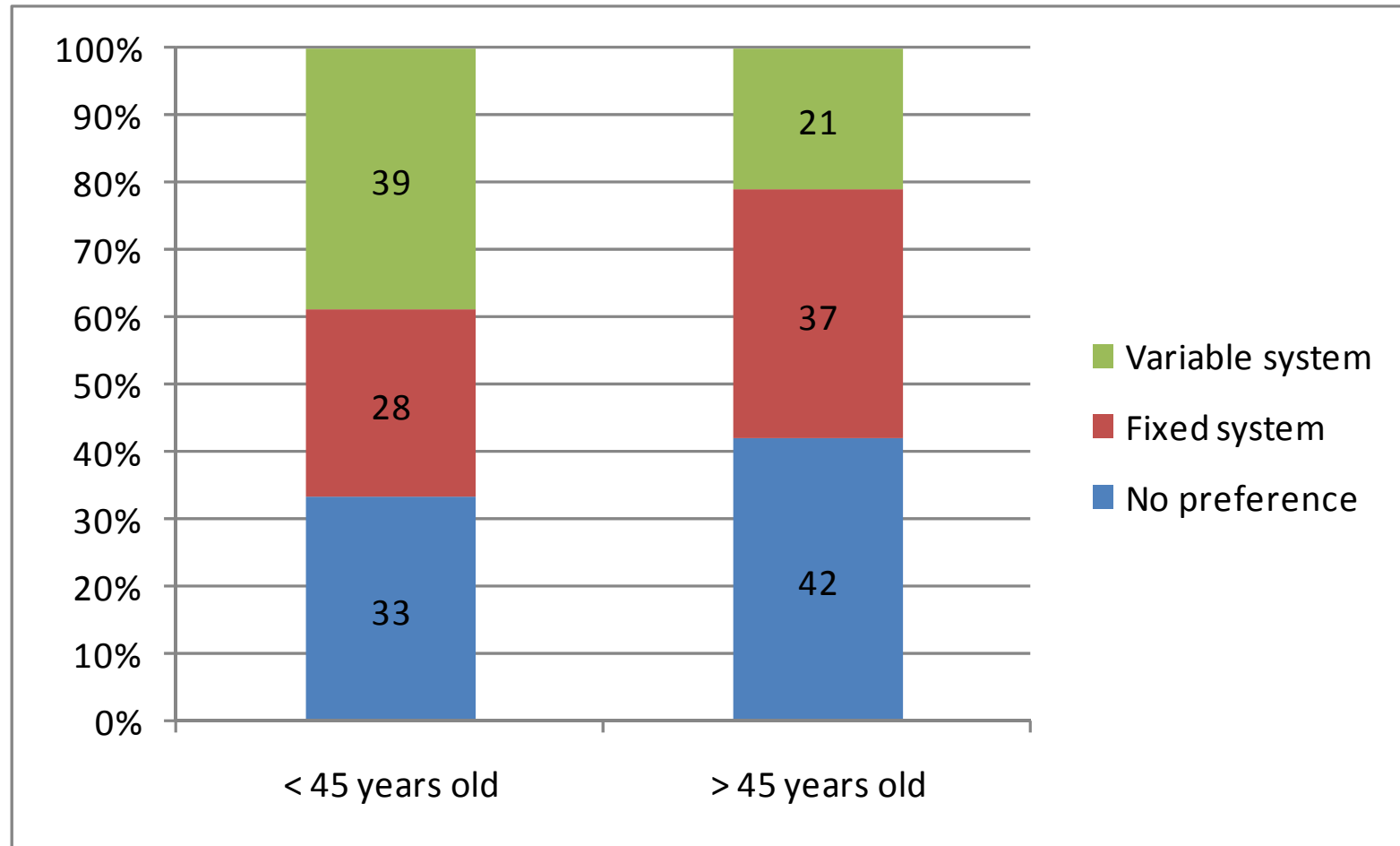
**BARNSELY BRIDGE
CLOSED**

**TO J39
28MILES 25 MINS**

System preference 1



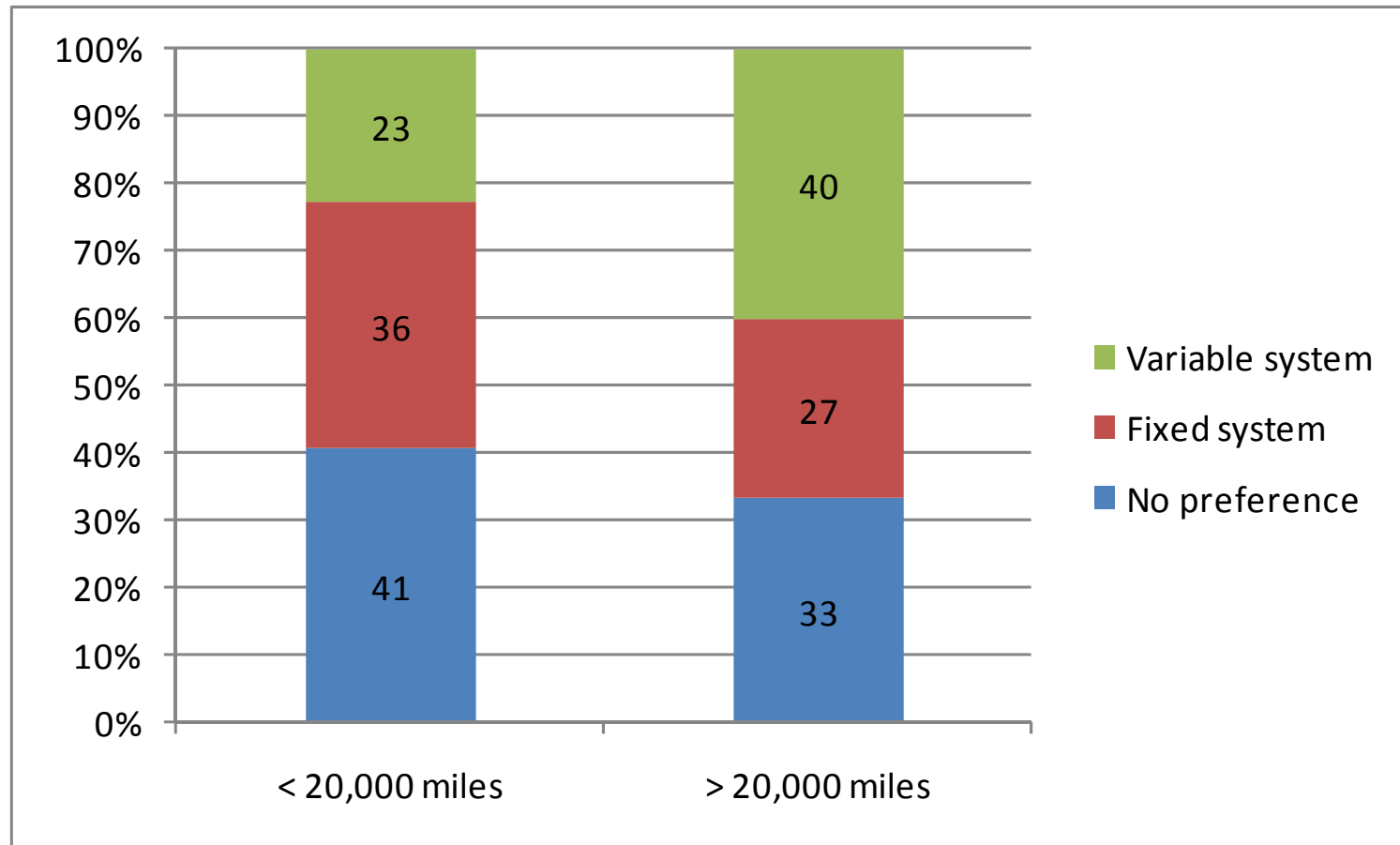
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System preference 2



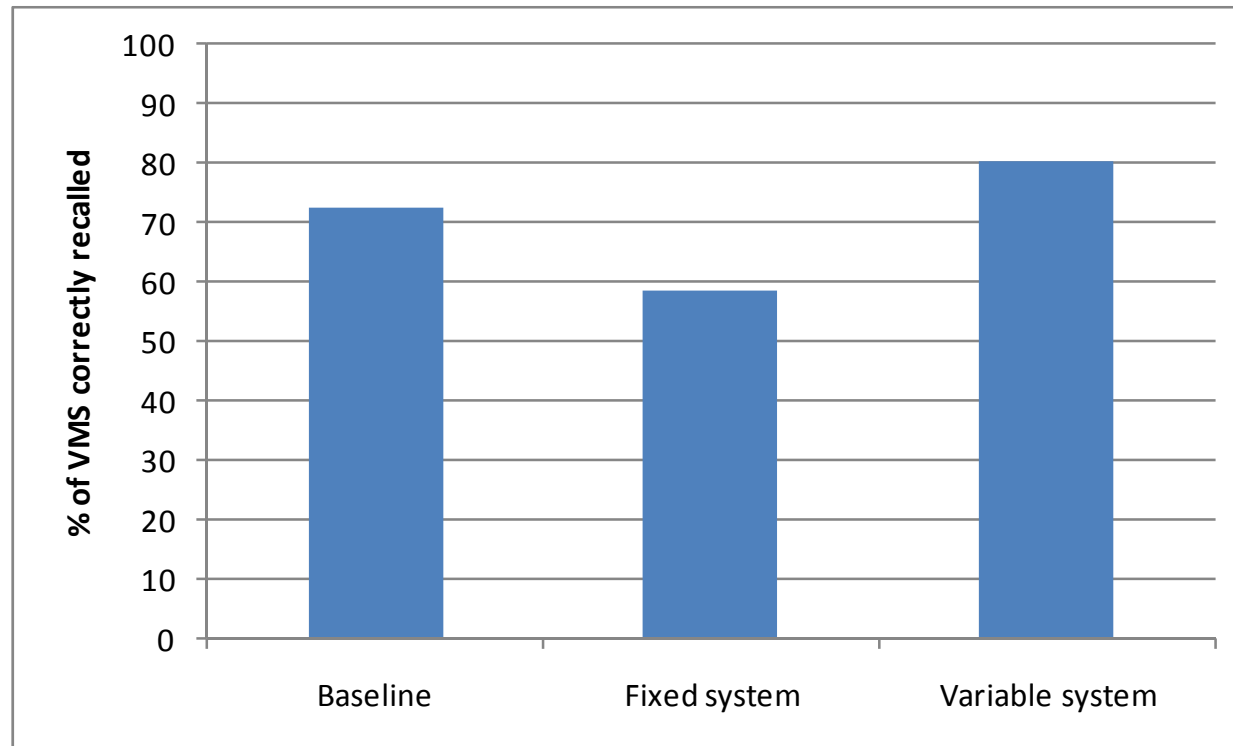
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VMS recall



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RM ANOVA		Post hoc pairwise comparison	
<i>F</i> statistic	<i>p</i> value	pair	<i>p</i> value
F (2,72) = 6.051	0.004	Baseline – Fixed	0.075
		Fixed – Variable	0.001
		Variable – Baseline	NS

Conclusions



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- The path to automation may matter
- With high automation, there is a very strong temptation to engage in non-driving-related tasks
- Mitigation strategies to maintain attention can be effective

A Turin taxi driver at night, in the fog, on the motorway



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Thank you for your attention!
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