

Hands on the wheel, head in the clouds? Mind wandering signatures in simulated manual driving

Séverine Brelaud, PhD Candidate

Numa Babilio (Renault Group), Thomas Andrillon (ICM), Tal Seidel Malkinson (IMoPA)



Mind Wandering: background

Defining Mind Wandering (MW)

A shift from the ongoing task towards self-generated thoughts and feelings

Smallwood & Schooler (2015)

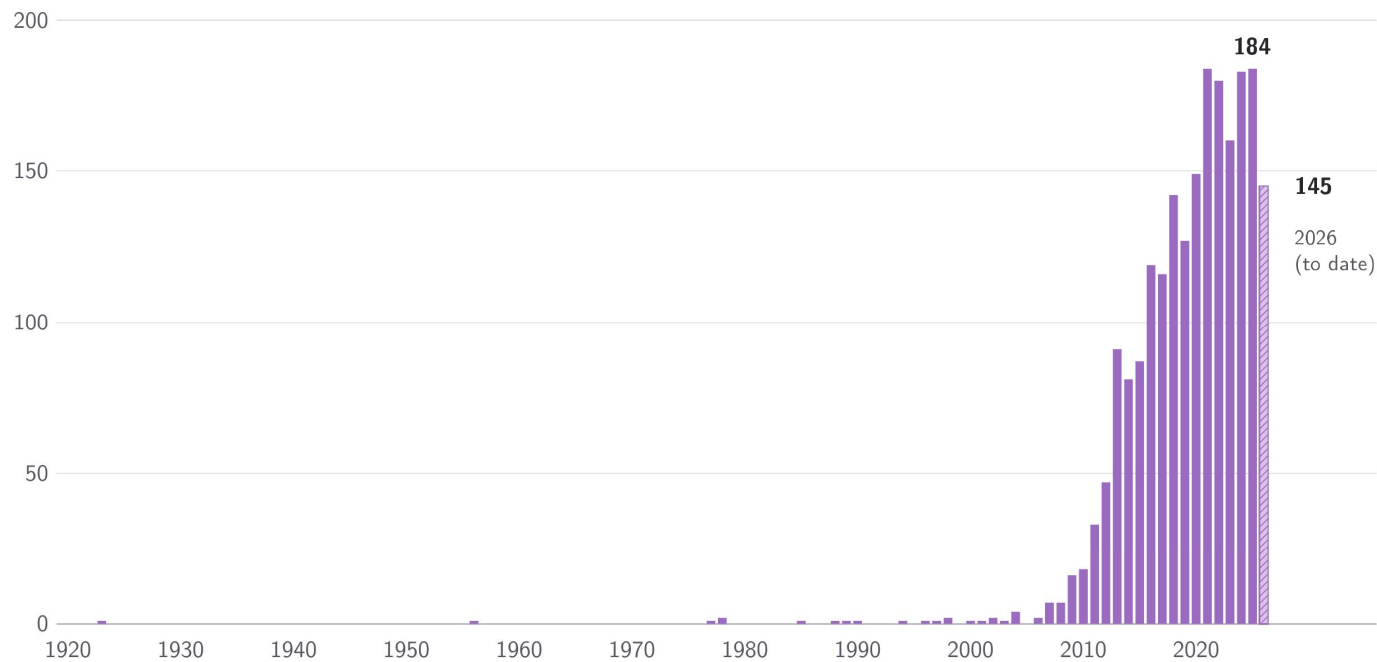
→ A form of inattention



MW publications

Mind wandering publications indexed in PubMed, per year

Search query: "mind wandering" · 2,101 records, 1923–2026



Source: PubMed, National Library of Medicine; search "mind wandering", results by year; accessed 9 October 2026.
Hatched bar: 2026 is incomplete.

Mind wandering has attracted growing research interest over the past 15 years.

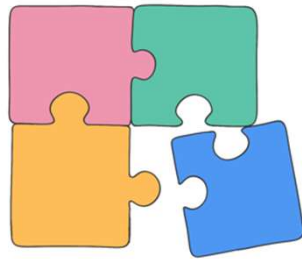
Frequency and benefits of MW

MW occurs 46,9% of the time, regardless of the activity

→ Drivers reported MW during 42% to 64% of their driving time



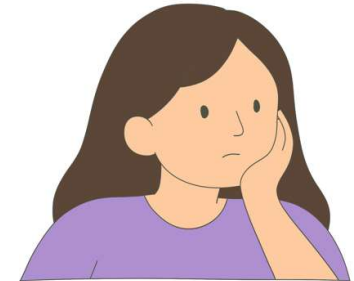
Creativity



Problem solving



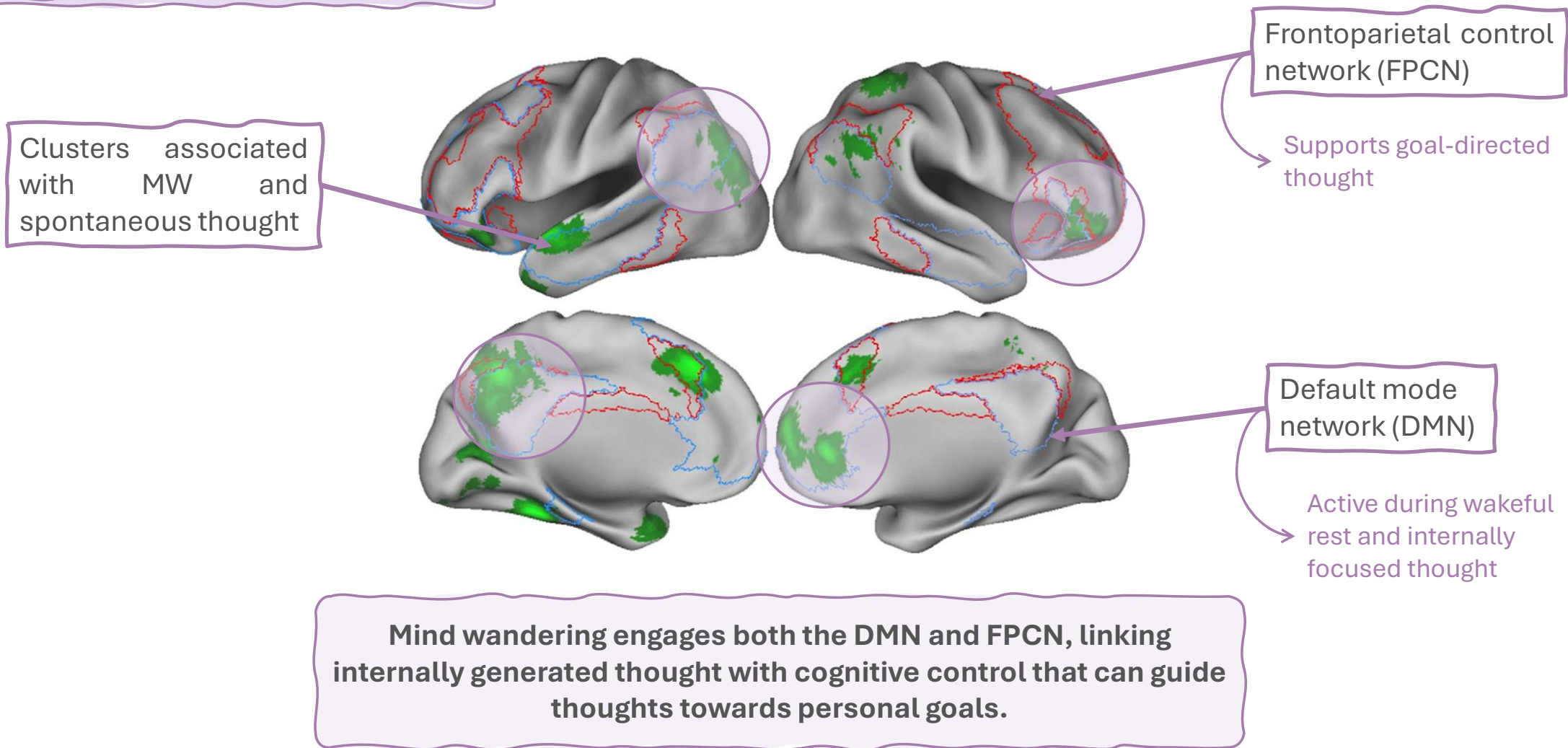
Planning



Relieving boredom

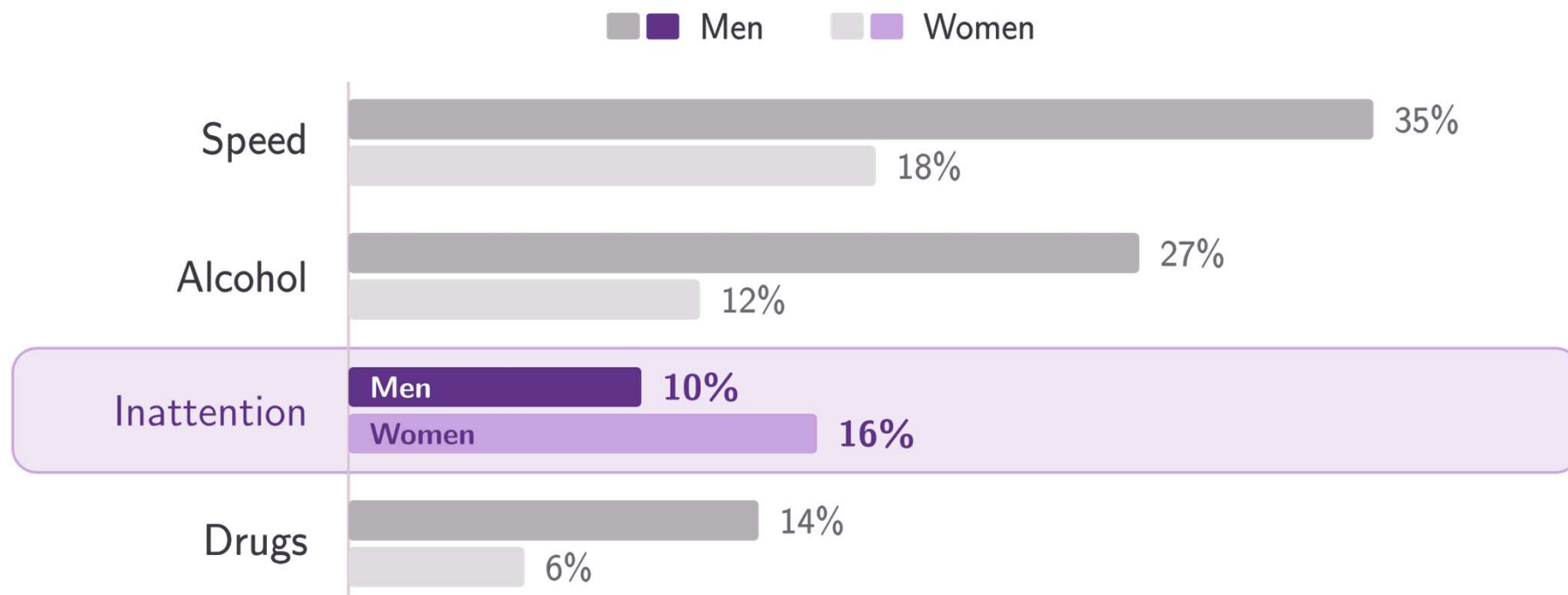
Burattello et al. (2018), Sjöström et al. (2018), Sjöström et al. (2019), Sjöström et al. (2020)

MW in the brain



Fox et al. (2015); Christoff et al. (2016)

Inattention and road safety



The chart refers to inattention overall. It does not isolate MW from it.

Highly distracting thoughts can contribute to driver inattention.
Third presumed factor responsible for car crashes
Drivers reporting these thoughts were more likely to be responsible for a crash.

Observatoire National Interministériel de la Sécurité Routière (ONISR) (2012) and (2015)

Experimental protocol

Research questions and hypothesis

Does MW have a distinct behavioural and physiological signature compared to task-focused state?

→ We expected differences in driving performance, eyetracking measures and heart rate.

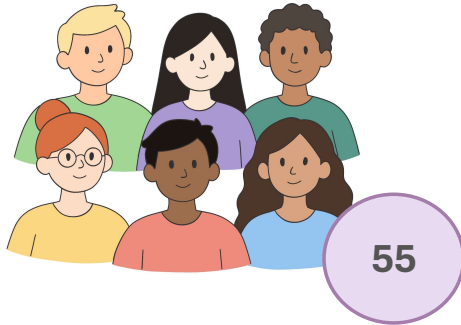
Do driving context and a short break influence the behavioural and physiological differences between MW and task-focused state?

→ We expected MW-related differences to be less pronounced after the break and more pronounced on rural roads.

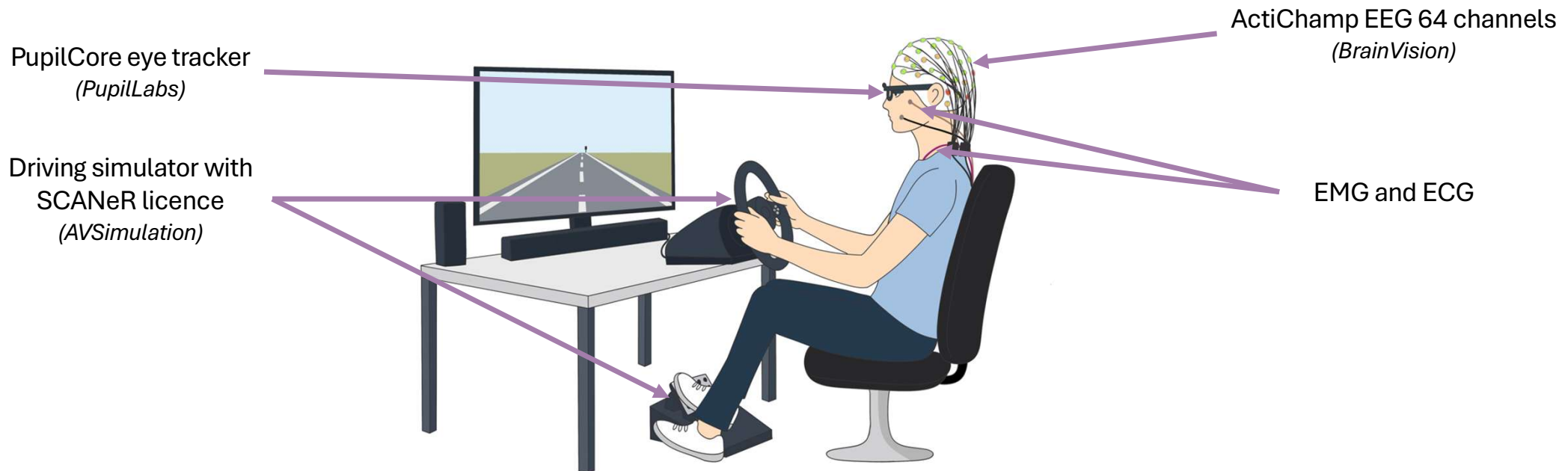
Does driver drowsiness differ between MW and task-focused state?

→ We expected greater drowsiness during MW.

Participants and equipment



18-35 years old (mean 24.5 ± 4.3 ; 23 M/32F)
With driving license
Without sleep disorders, vigilance impairment or glasses



Driving scenario

Legend



Speed limit
(rural and urban)



Traffic lights
(red and green)



Pedestrian crossing without
pedestrian



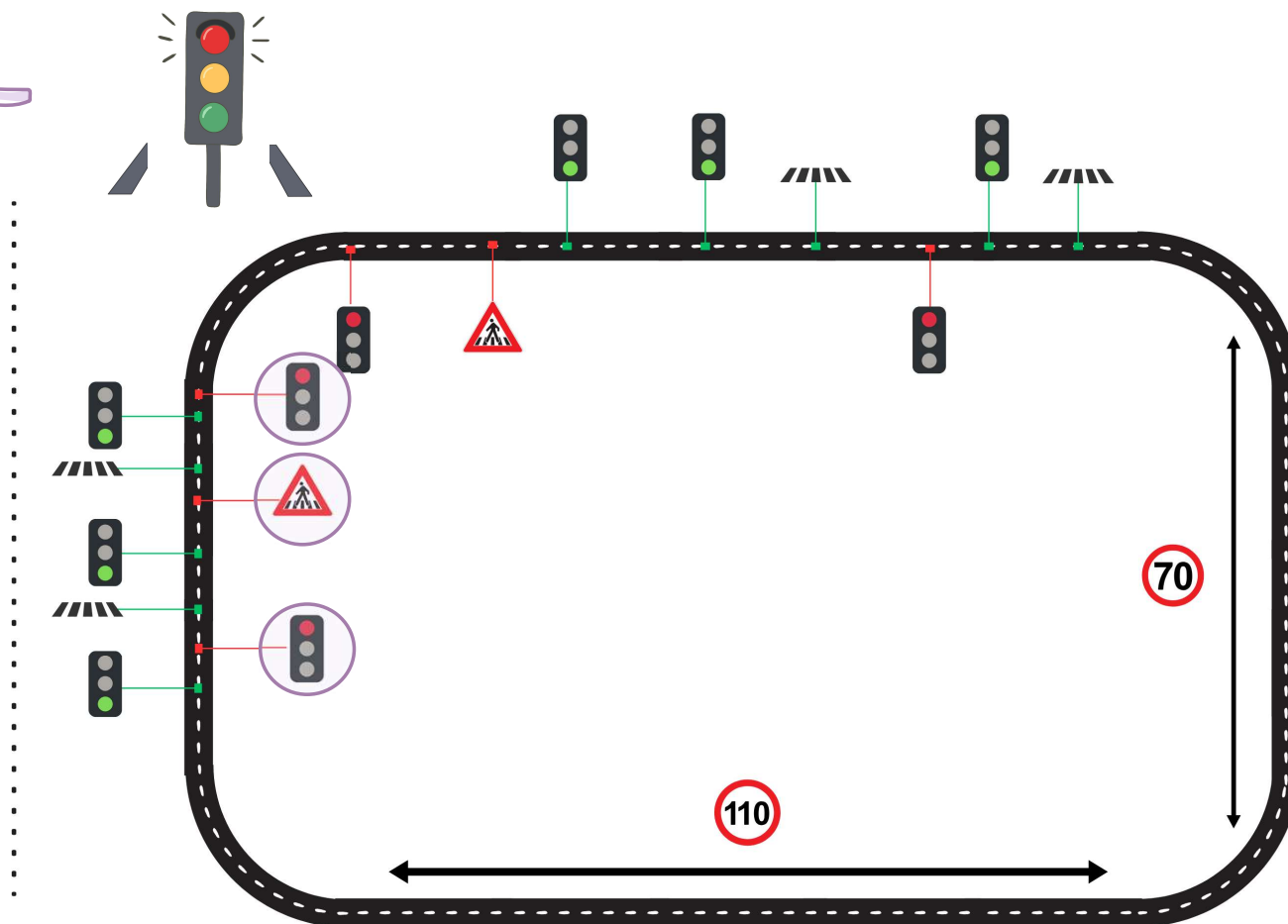
Pedestrian crossing with
pedestrian



"Go" events



"No Go" events



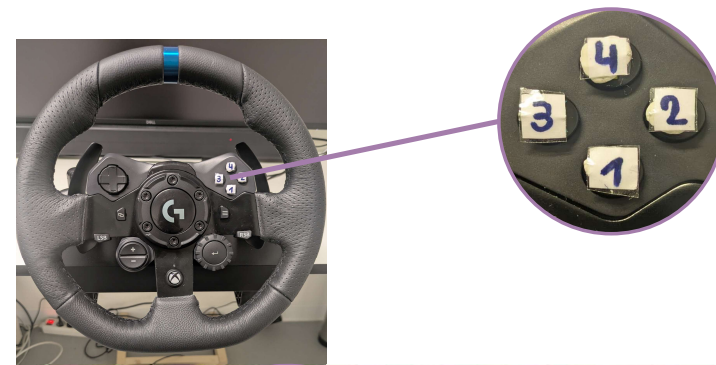
50 minutes of
driving

20 minutes of
break

50 minutes of
driving

Thoughts sampling method: Probe caught

An auditory probe every **60 to 90 seconds**, answering via the steering wheel



What are you thinking about?

About **ON** driving

About the **ED** environment

About internal **MW** thoughts

About nothing / **MB** do not remember



How absorbed were you in this thought?

ON

ED

MW

MB

1 – Not at all immersed

2

3

4 – Very immersed



What is your level of alertness?

1 – Fully alert

2

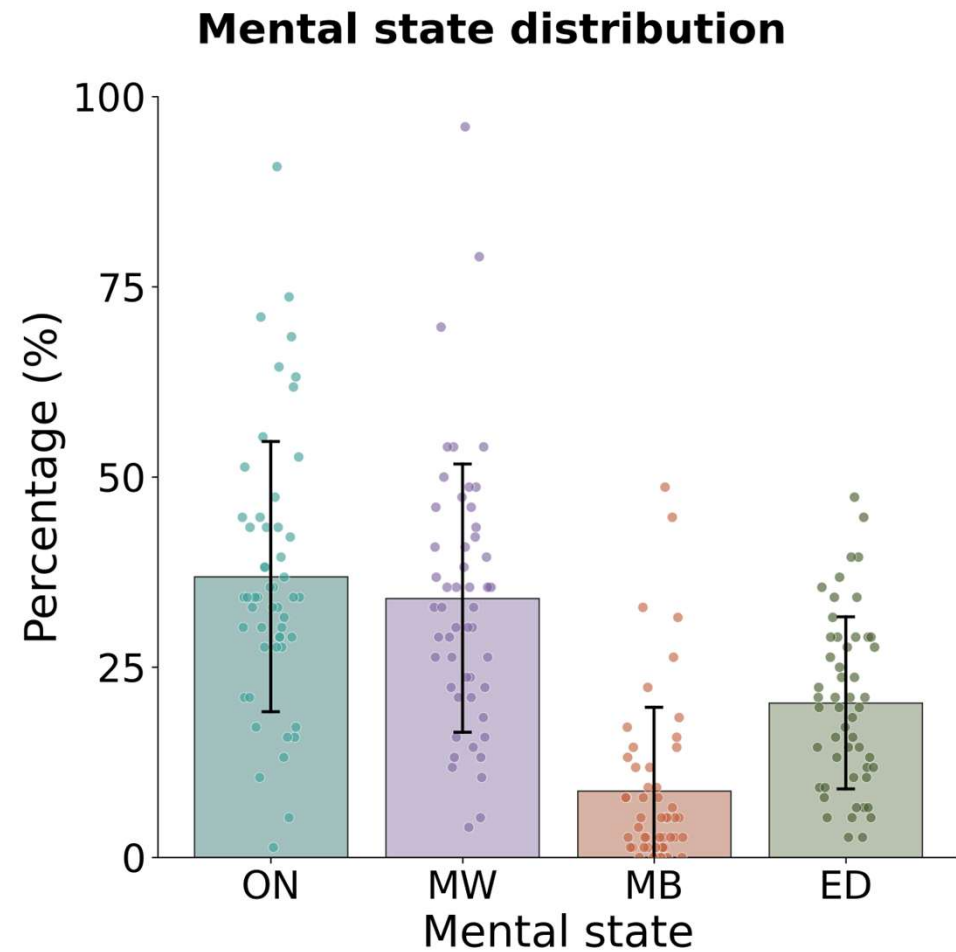
3

4 – Very drowsy

Experimental results

Mental state distribution

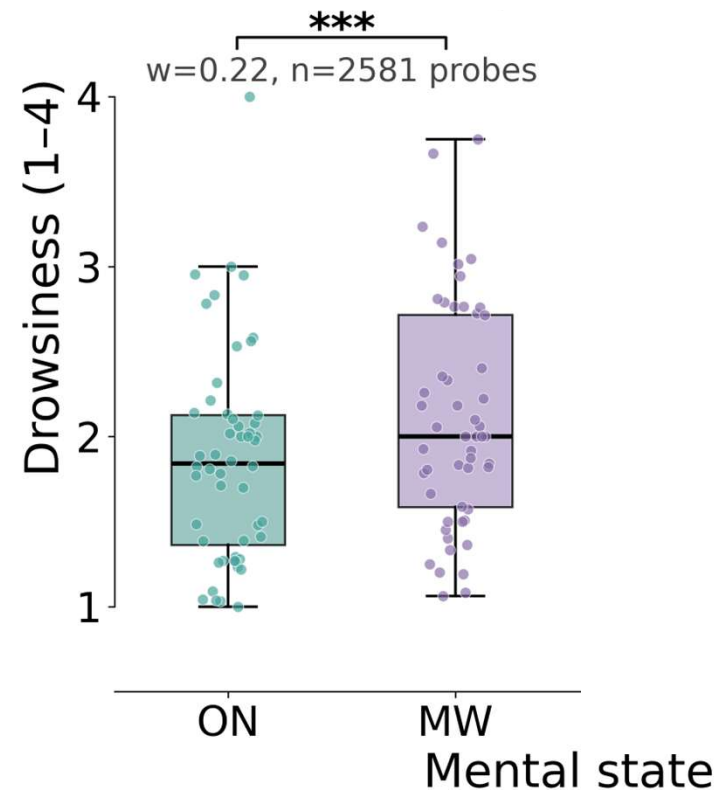
Across all participants, **ON (36,9%)** and **MW (34,1%)** were the most frequent states, followed by ED (20,3%) and MB (8,7%).



Drowsiness distribution

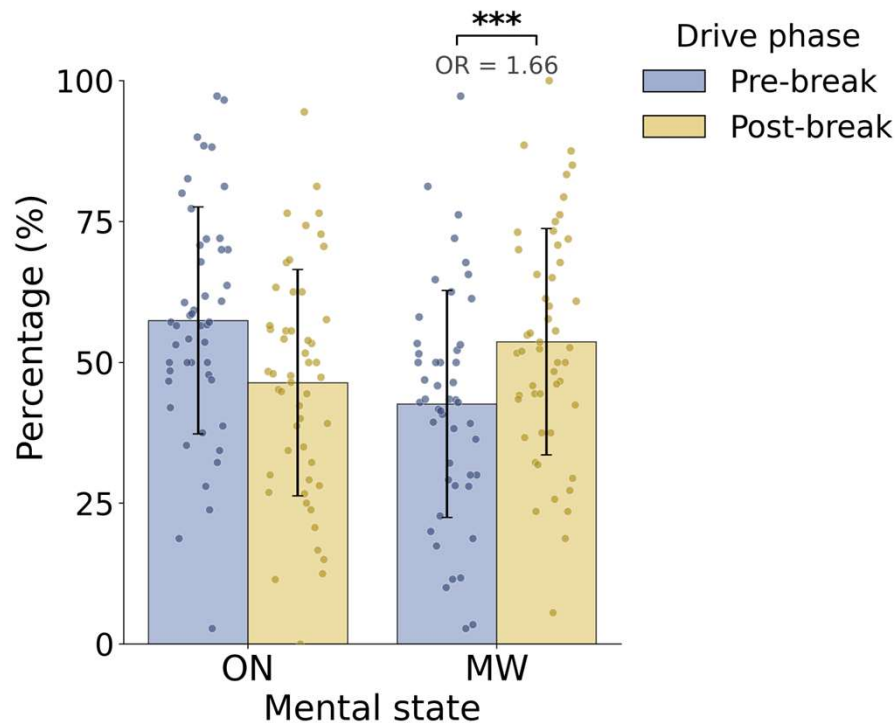
Drowsiness distributions differed significantly between MW and the other states, with generally **higher ratings during MW** than ON or ED, and **lower ratings than MB**.

Drowsiness — MW vs other states

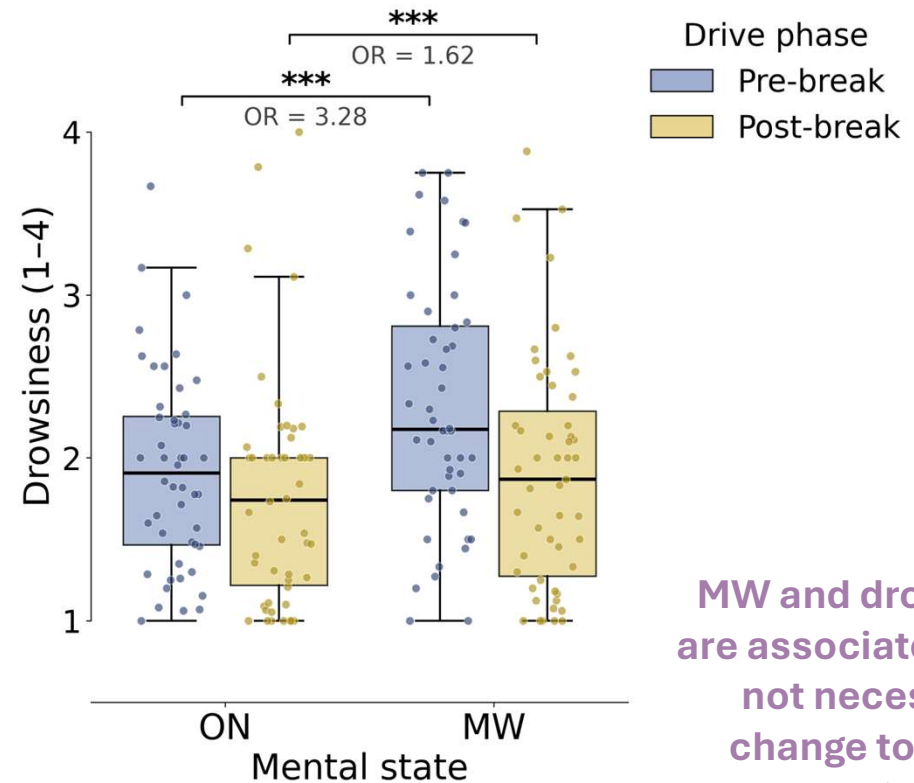


Mental states and drowsiness within drive phase

Mental state distribution — MW vs ON by drive phase



Drowsiness — MW vs ON by drive phase



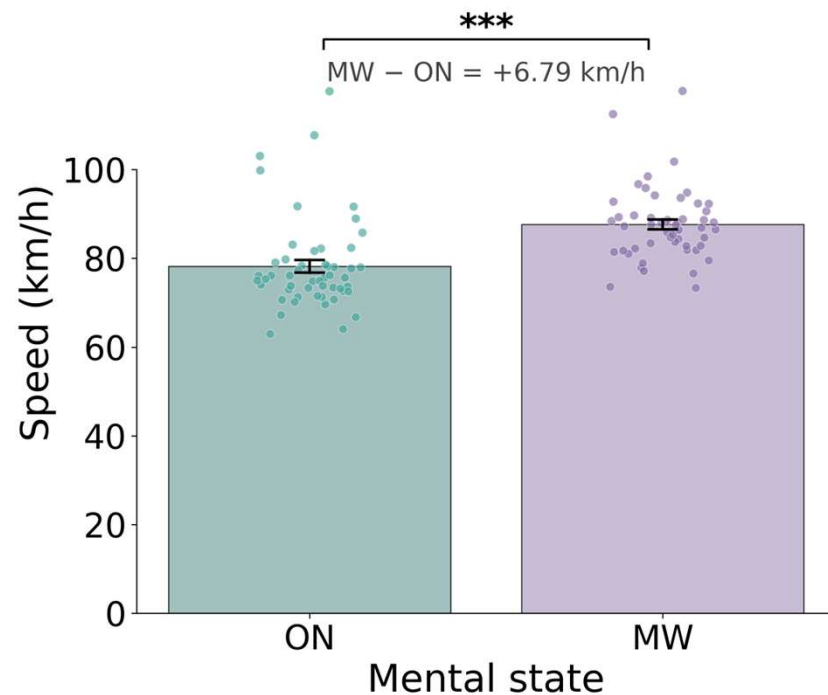
MW and drowsiness are associated, but do not necessarily change together.

MW was associated with **greater drowsiness than ON** in both phases, yet the observed post-break pattern showed **more MW alongside lower drowsiness ratings**.

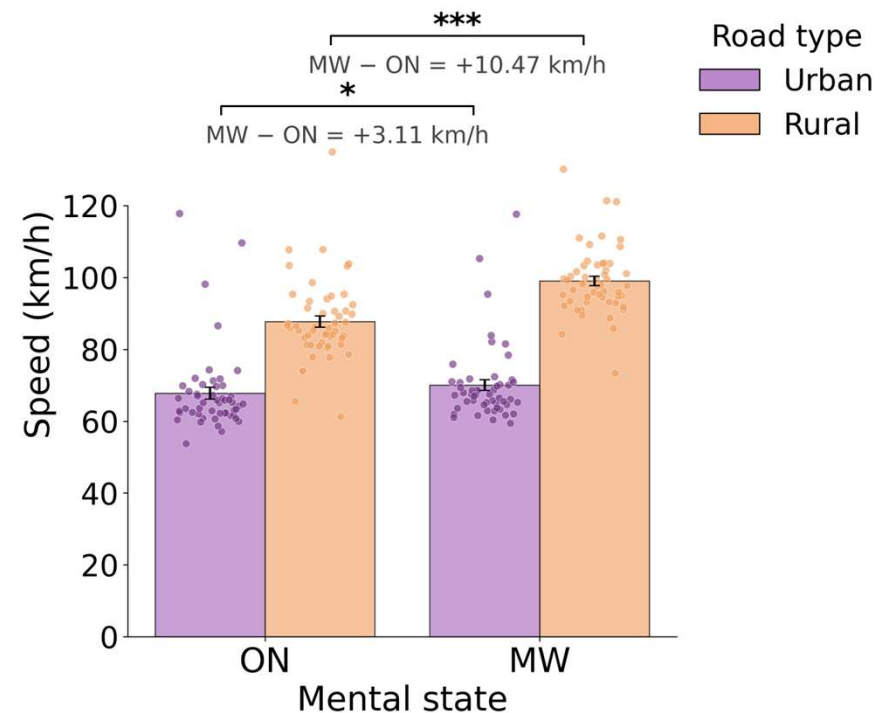
Driving measures

Speed (km/h)

Vehicle speed (10 s before the probe) — MW vs ON



Vehicle speed (10 s before the probe) — MW vs ON by road type

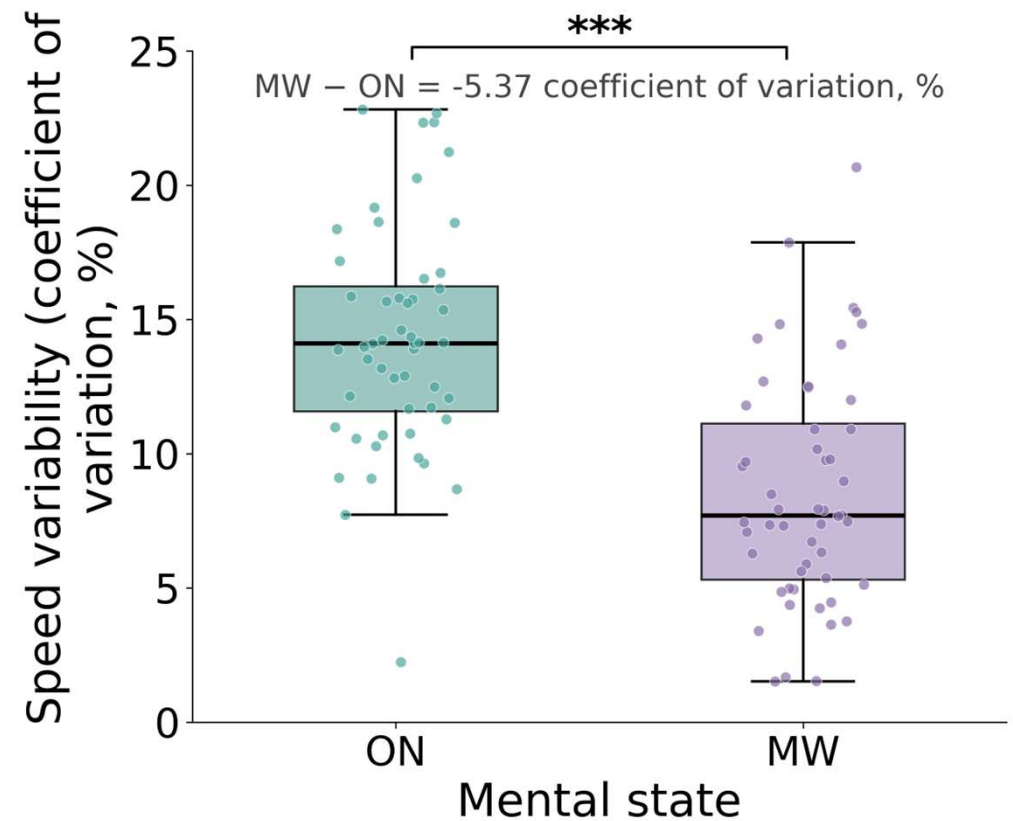


Vehicle speed was **higher during MW than ON**, with a larger difference on rural roads.

Speed variability (CV)

Speed variability was **lower during MW than ON**, with no significant interactions with driving phase or road type

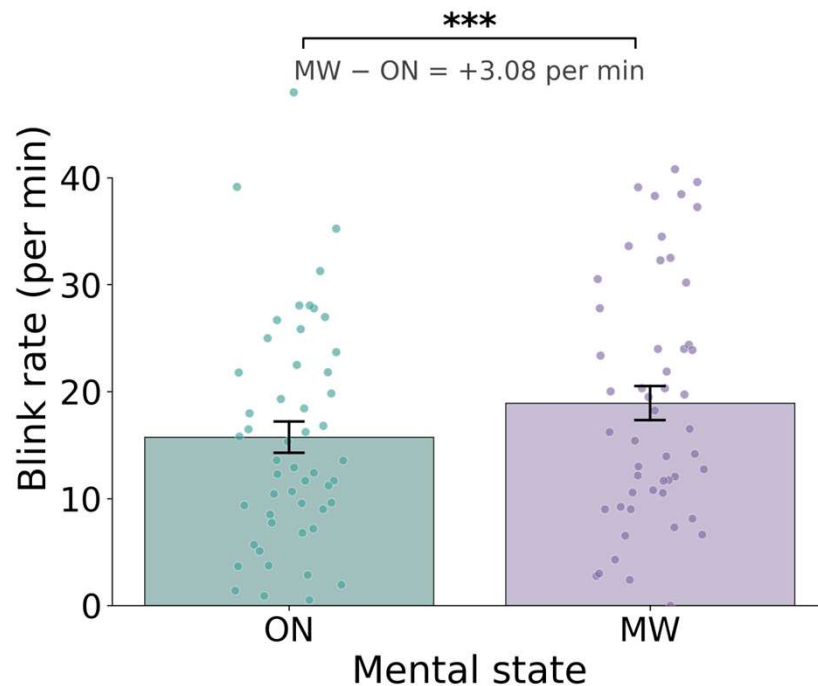
Speed variability (CV) (10 s before the probe) – MW vs ON



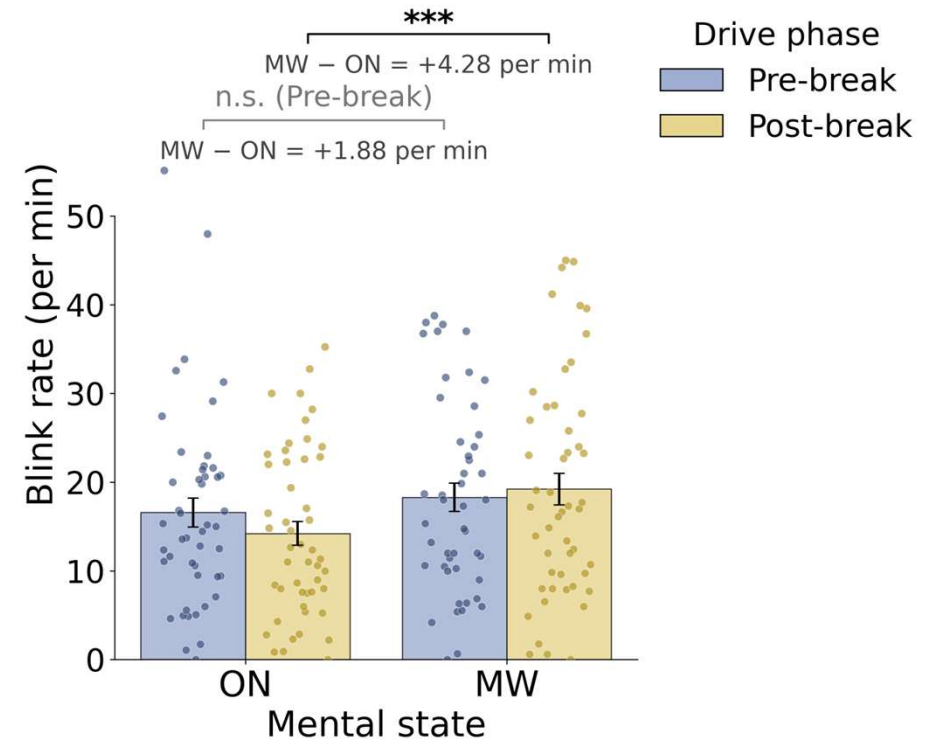
Oculometric measures

Blink rate

**Blink rate (10 s before the probe)
— MW vs ON**



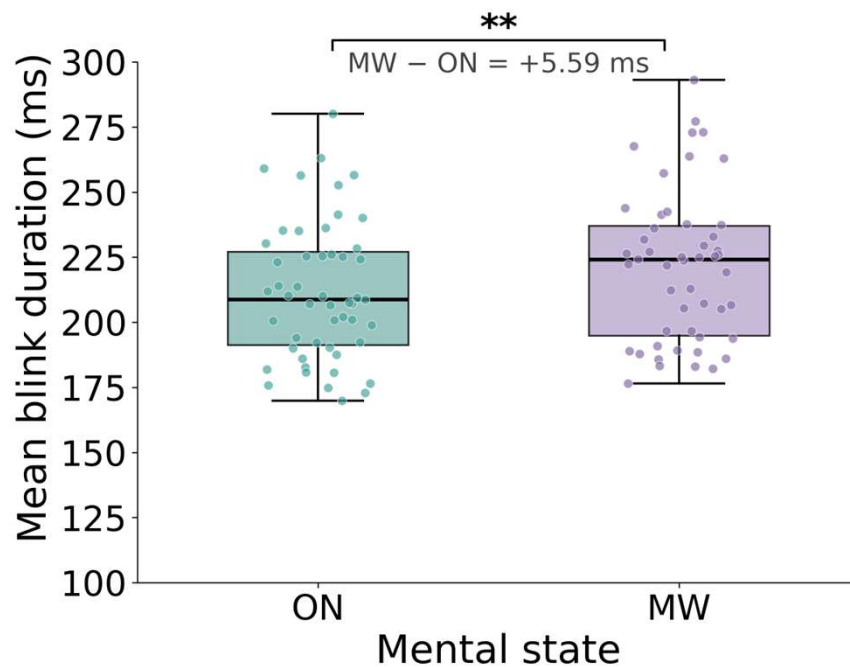
**Blink rate (10 s before the probe) — MW
vs ON by drive phase**



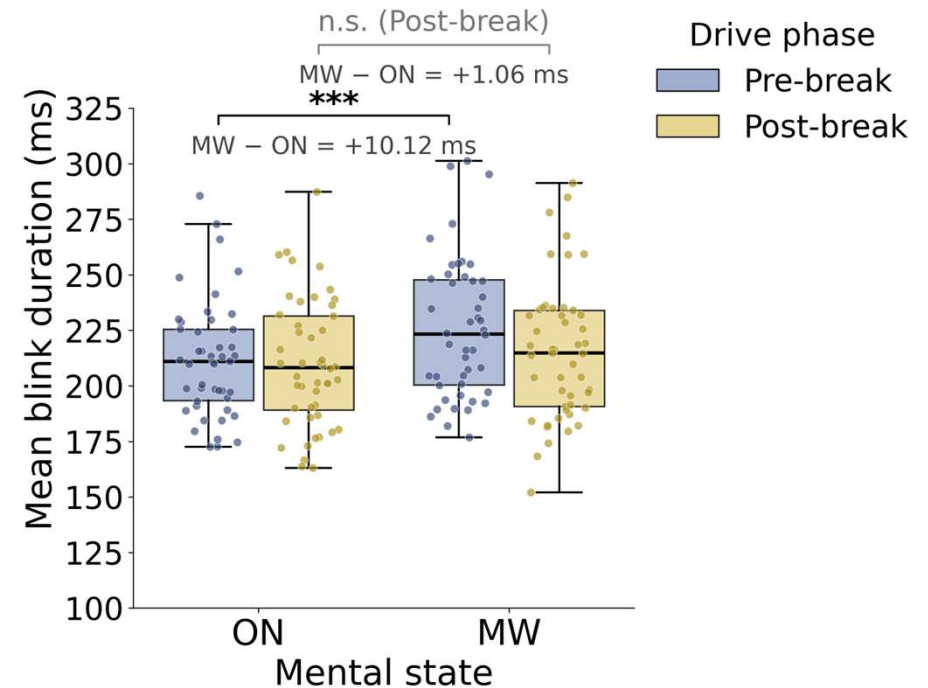
Blink rate was **higher during MW than ON**, with a larger difference after the break

Blink duration

Mean blink duration (50-500 ms blinks) (10 s before the probe) — MW vs ON

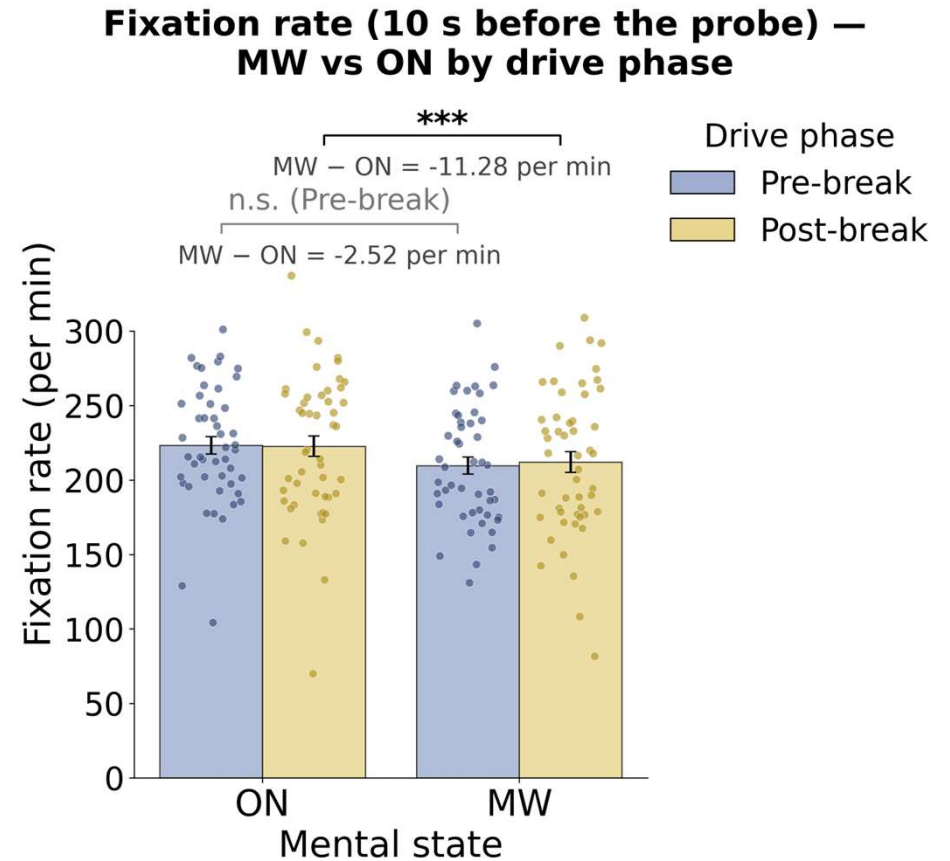
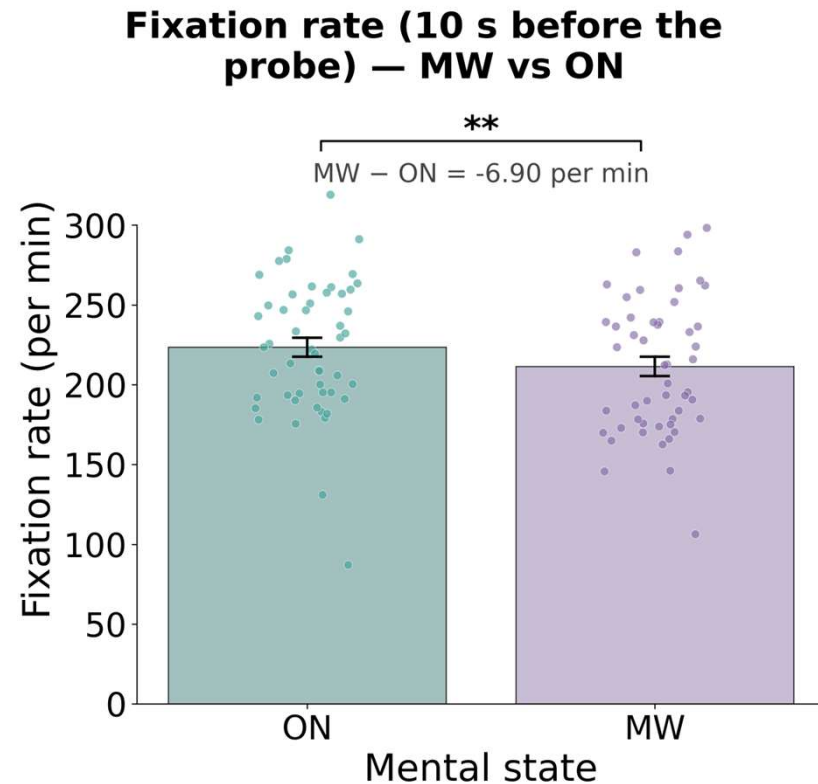


Mean blink duration (50-500 ms blinks) (10 s before the probe) — MW vs ON by drive phase



Blinks were **longer during MW than ON**, with a larger difference before the break.

Fixation rate



Fixation rate was **lower during MW than ON**, with a larger difference after the break.

Cardiac measures

Cardiac measures

Mind wandering (MW) vs on-task (ON): cardiac measures

	MW – ON	MW × road type	MW × drive phase	Drowsiness (linear trend, per step)
<i>Heart (10 s before the probe)</i>				
Heart rate	n.s.	n.s.	n.s.	n.s.
Beat-to-beat heart rate variability (RMSSD)	n.s.	n.s.	n.s.	n.s.
Overall heart rate variability (SDNN)	n.s.	n.s.	n.s.	+2.33 ms ***

Models with drowsiness: LMM, MW – ON with Satterthwaite tests.

MW × factor: the interaction test of the model.

* $p < .05$ ** $p < .01$ *** $p < .001$ n.s. = not significant - = not in the model

Conclusion

Main findings

Mind wandering accounted for around 1/3 of probes on average across participants and was associated with greater drowsiness than on-task.

Drivers drove faster with more stable speed during MW than on-task.

Eye-tracking differences varied across driving phases

Cardiac measures showed no significant overall MW-ON differences

Take Home Message

Mind Wandering is common during driving and is associated with changes in driving behaviour and eyetracking measures

Driving context, driving phase and driver drowsiness matter when interpreting MW-related differences

Combining more measures and comparing a wider range of mental states may help identify a signature specific to MW

Thank you for your attention!

Acknowledgements

Numa Basilio, PhD

Thomas Andrillon, PhD

Tal Seidel Malkinson, PhD



severine.brelaud@renault.com - severine.brelaud@univ-lorraine.fr

