STELLANTIS

DRIVER MONITORING

BODY POSTURE AND PHYSIOLOGICAL INDICATORS FOR DROWSINESS DETECTION IN A PARTIAL AUTOMATED DRIVING

GAËTAN PERROTTE, ARTHUR PORTRON, CLÉMENT BOUGARD
AND JEAN-LOUIS VERCHER

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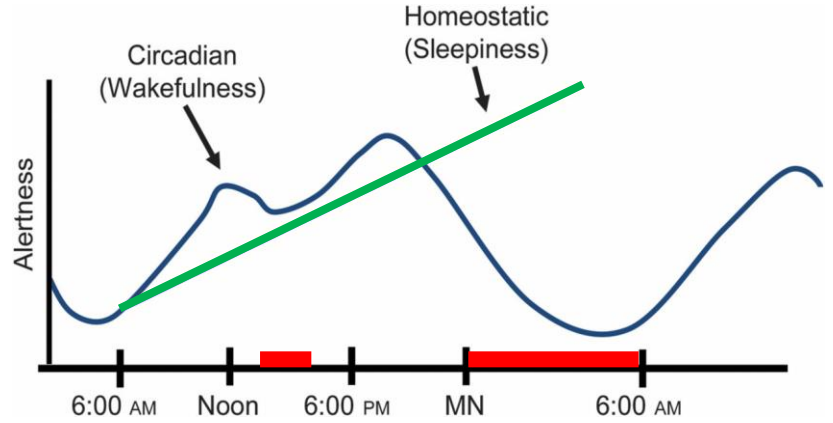
INTRODUCTION : DROWSINESS AT THE WHEELS

INTERNAL FACTORS

- Homeostatic process
  - Time awaken
  - Sleep debt
- Circadian process
  - Time of day



Molano and Vaughn (2014)

EXTERNAL FACTORS

- Monotonous or familiar environment
- Time spent while driving

MANUAL DRIVING

Driver Monitoring System mostly based on :

Driver-based data (video)

Blinks, PERCLOS, Head movements …

\+ Relevant and reliable

\- Acquisition quality may vary according to several factors: lighting conditions, glasses, ethnics...

Vehicle-based data

Lateral deviation, Lane crossing, Speed variability…

\+ Relevant and reliable
Always available

\- Detection of deep stages of drowsiness

PARTIAL AUTOMATED DRIVING

How to process monitoring ?

Driver-based data (video)

Drivers engaged in NDRTs will no longer facing the camera

Vehicle-based data

Driving operated by the car

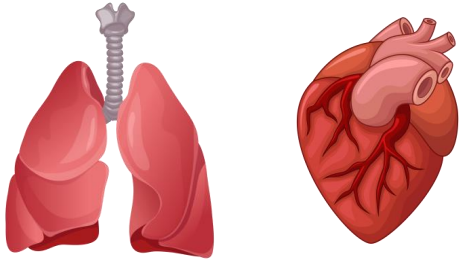
No more relevant in autonomous mode

Need to implement new DMS with new features

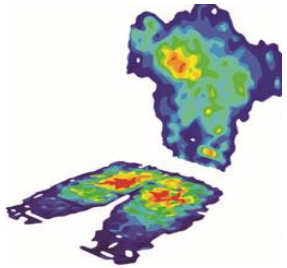
PARTIAL AUTOMATED DRIVING

How to process monitoring ?

Physiological data



Behavioral data



IN MANUAL DRIVING

- Change in heart rate (HR) and heart rate variability (HRV)
- Change in respiration rate (RR)
- Alert vs extremely sleepy ?

Buendia et al., 2019; Jacobé de Naurois et al., 2017 ; Persson et al., 2021

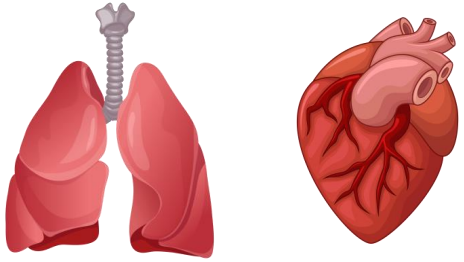
- Increase of the number of movements
- Shift of the center of pressure on the seat
- Alert vs intermediate stages ?

Itoh et al., 2017; Sunagawa et al., 2020

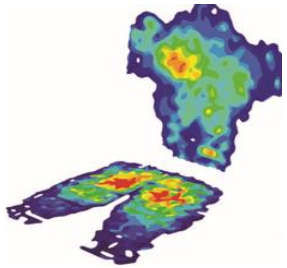
PARTIAL AUTOMATED DRIVING

How to process monitoring ?

Physiological data



Behavioral data



Can posture and physiology be used to detect **the full spectrum of drowsiness** ?

Can seat sensors be the solution to **maintain monitoring** in **any situation** ?

SIMULATOR STUDY
A L2 level of automation

13h30 — 16h

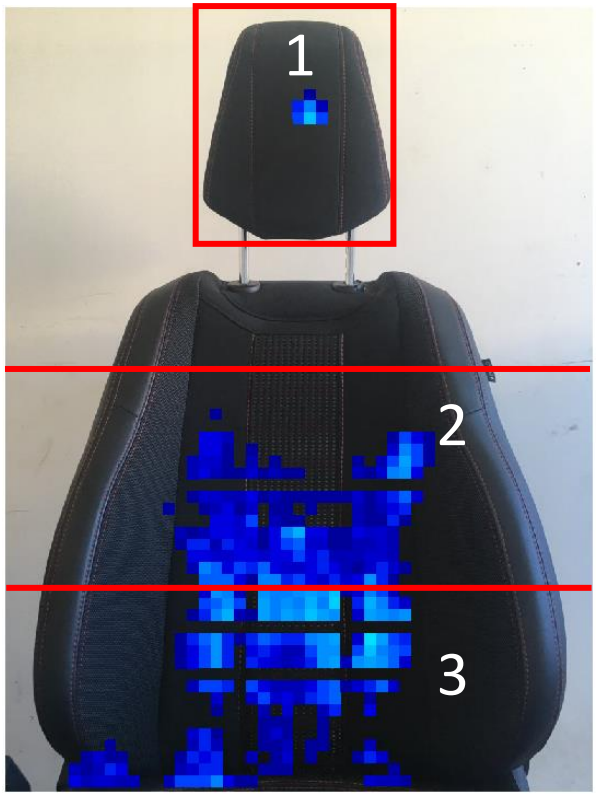
Pre-phase | **Test phase** | **Post-phase**

N = 22 drivers

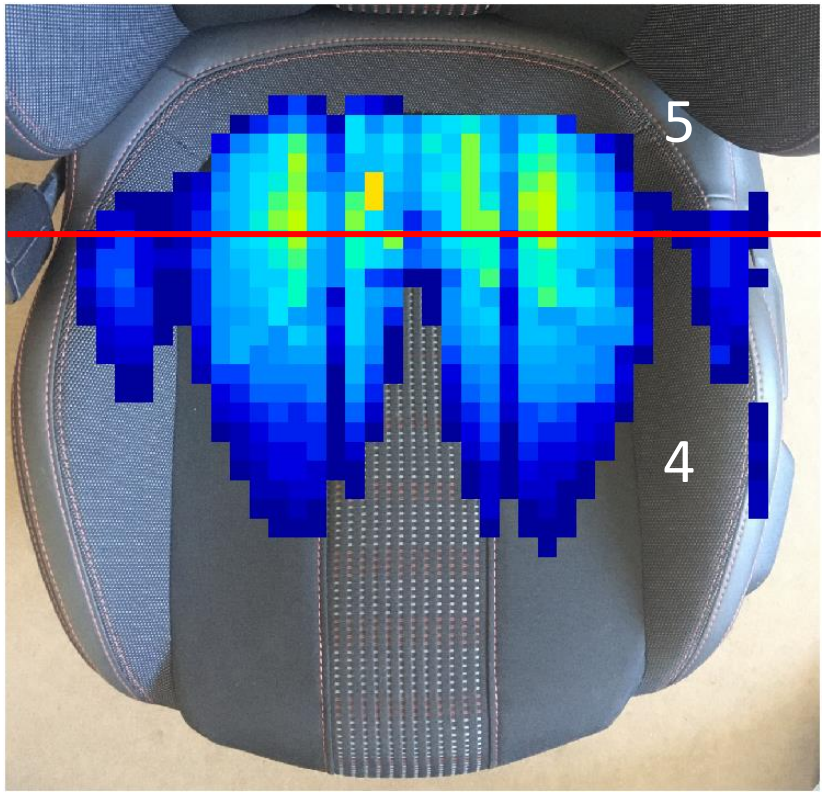
Manual Driving (5min)	Autonomous Driving (1h30)	Manual Driving (5min)

No traffic (1h)	Traffic Jam (10min)	No Traffic (20min)

POSTURAL INDICES



1 : Headrest
2 : Upper zone of the backrest
3 : Lower zone of the backrest



4 : Anterior of the seat
5 : Posterior of the seat

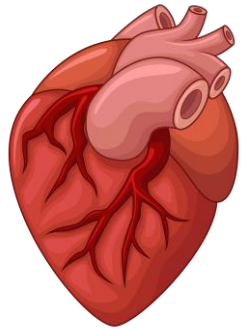
Static features

- Center of pressure (**COP**) position
- Contact surface (**CS**) over the zones
- Percentage of use of the headrest

Dynamic features

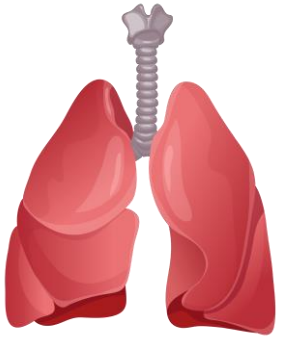
- Number of movements on seat and backrest

PHYSIOLOGICAL INDICES



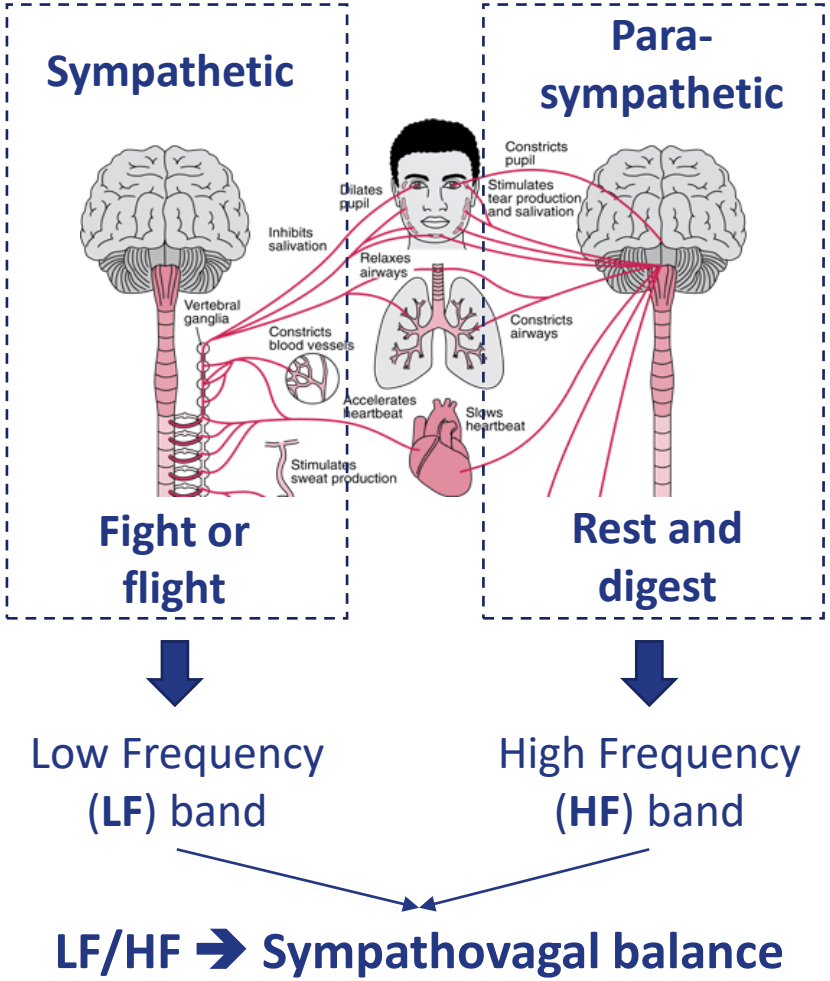
Cardiac features

- Heart rate (HR)
- Heart Rate Variability
  - Time domain
  - **Frequency domain**



Respiratory features

- Respiratory rate (RR) and amplitude



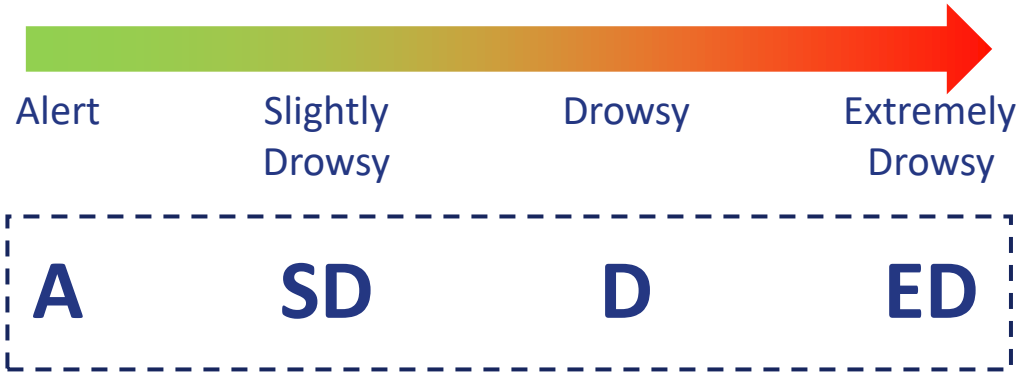
DRIVERS' STATE CLASSIFICATION

François et al. 2016

phasya

Acquired by

tobii



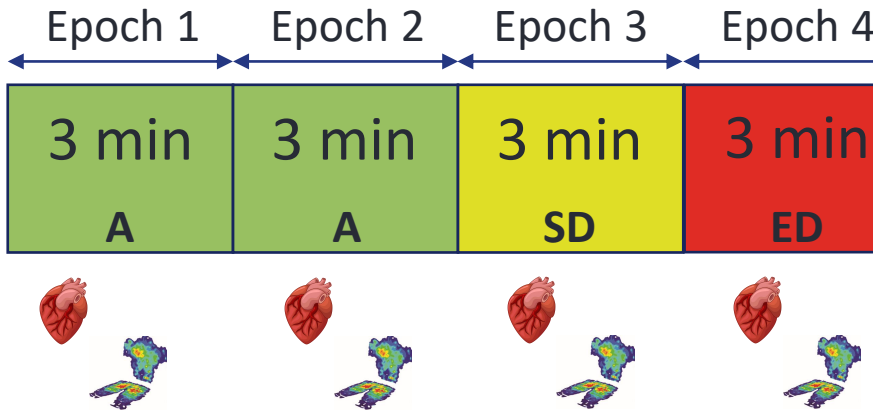
- **Percentage of Eye Closure (PERCLOS70) ➔ GOLD STANDARD**
- Blinks (duration and frequence)
- Others ocular parameters

Based on Chang et al., 2022

DATA SLICING AND NORMALIZATION

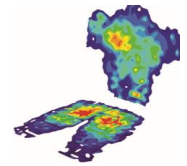
13h30 — 16h

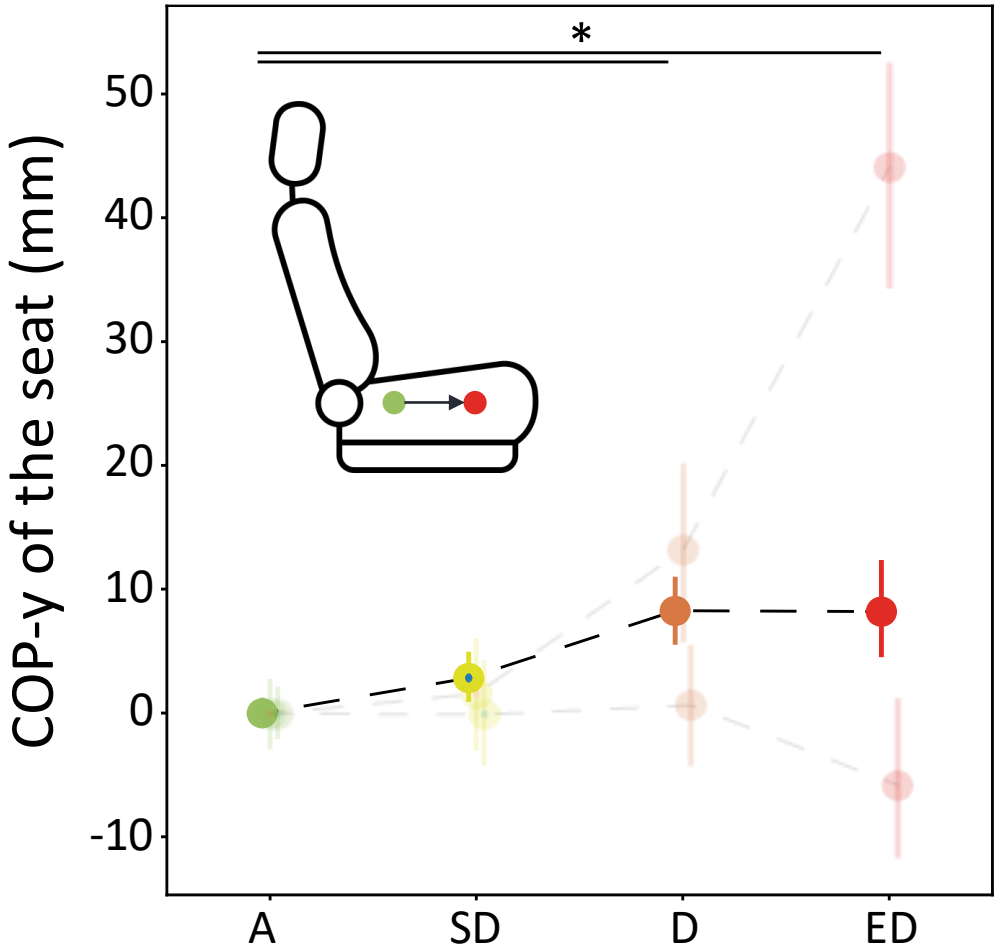
Pre-phase | **Test phase** | **Post-phase**

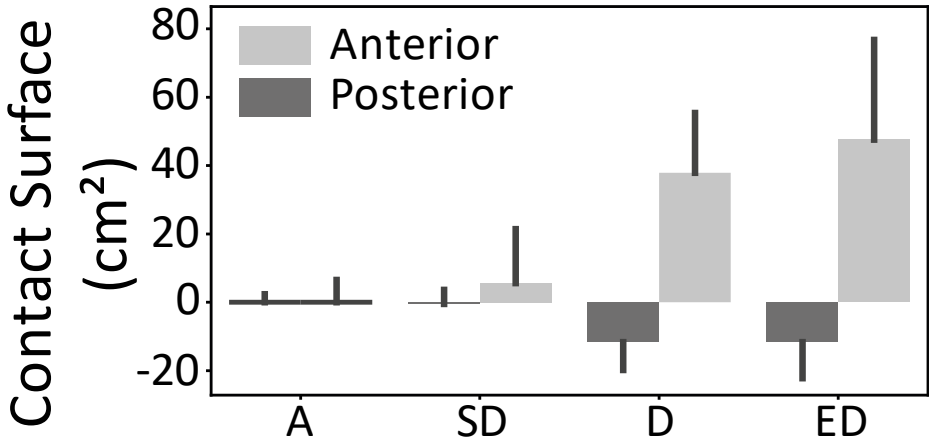


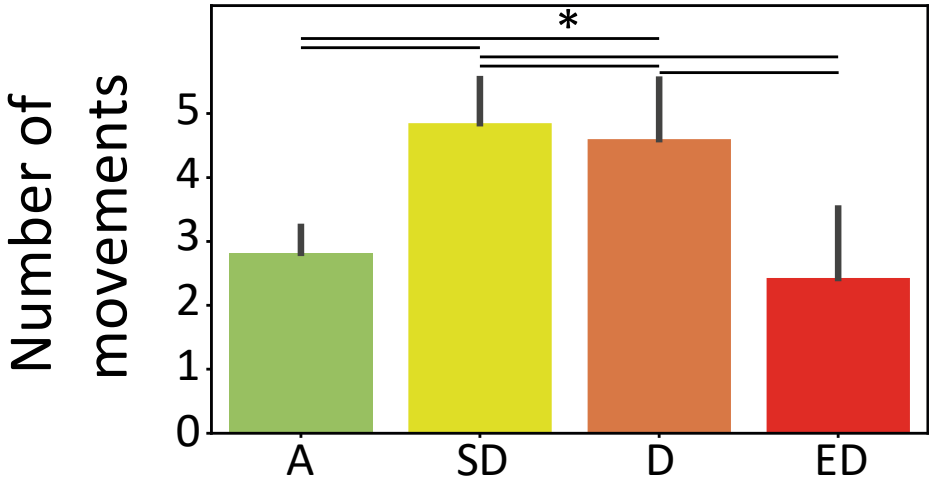
Normalization for all epochs ➔ Mean of **ALERT** epochs (Persson et al., 2021)

SEAT FEATURES







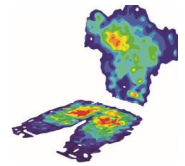


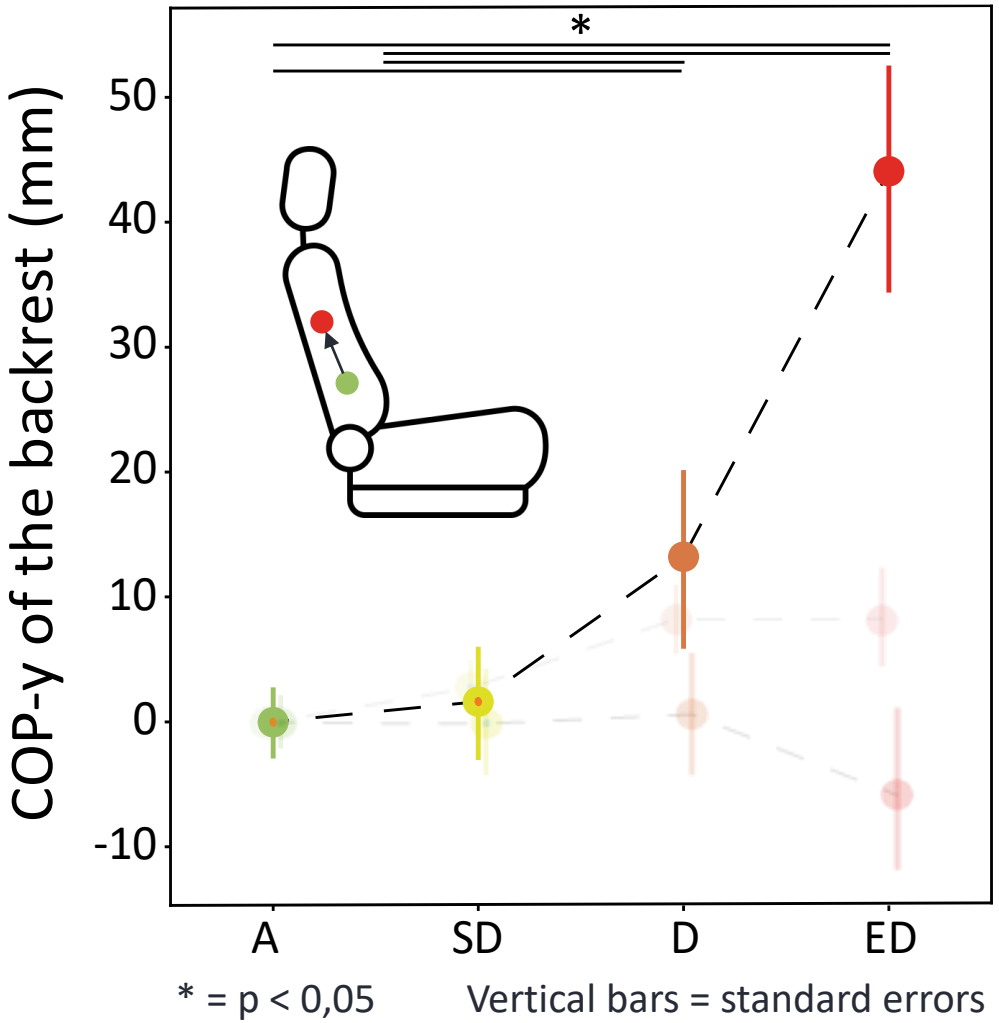
* = p < 0,05 Vertical bars = standard errors

Shift of center of pressure in upper position

Inverted U-Shape between movements on seat and drowsy states

BACKREST FEATURES





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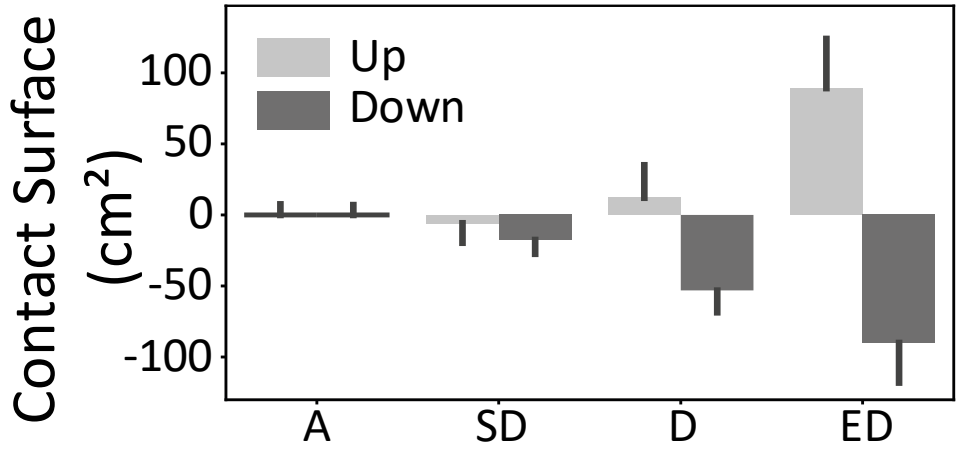
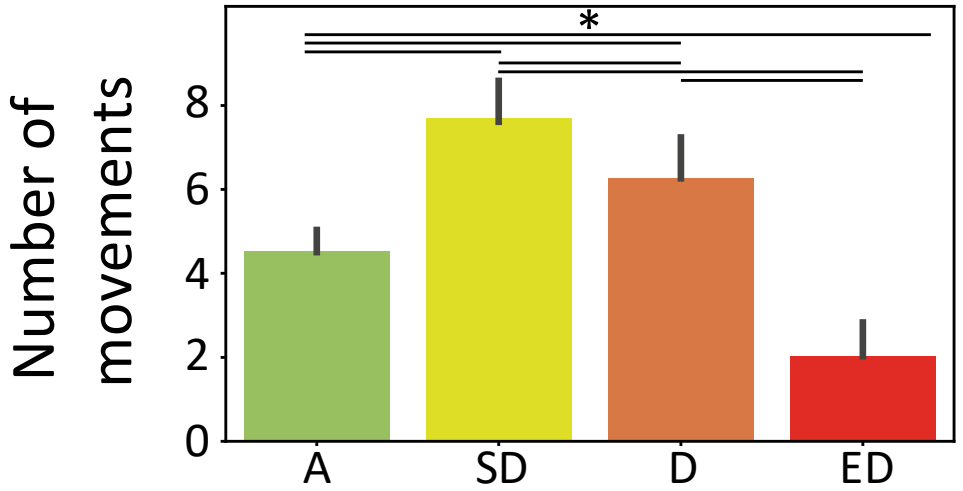
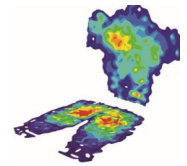


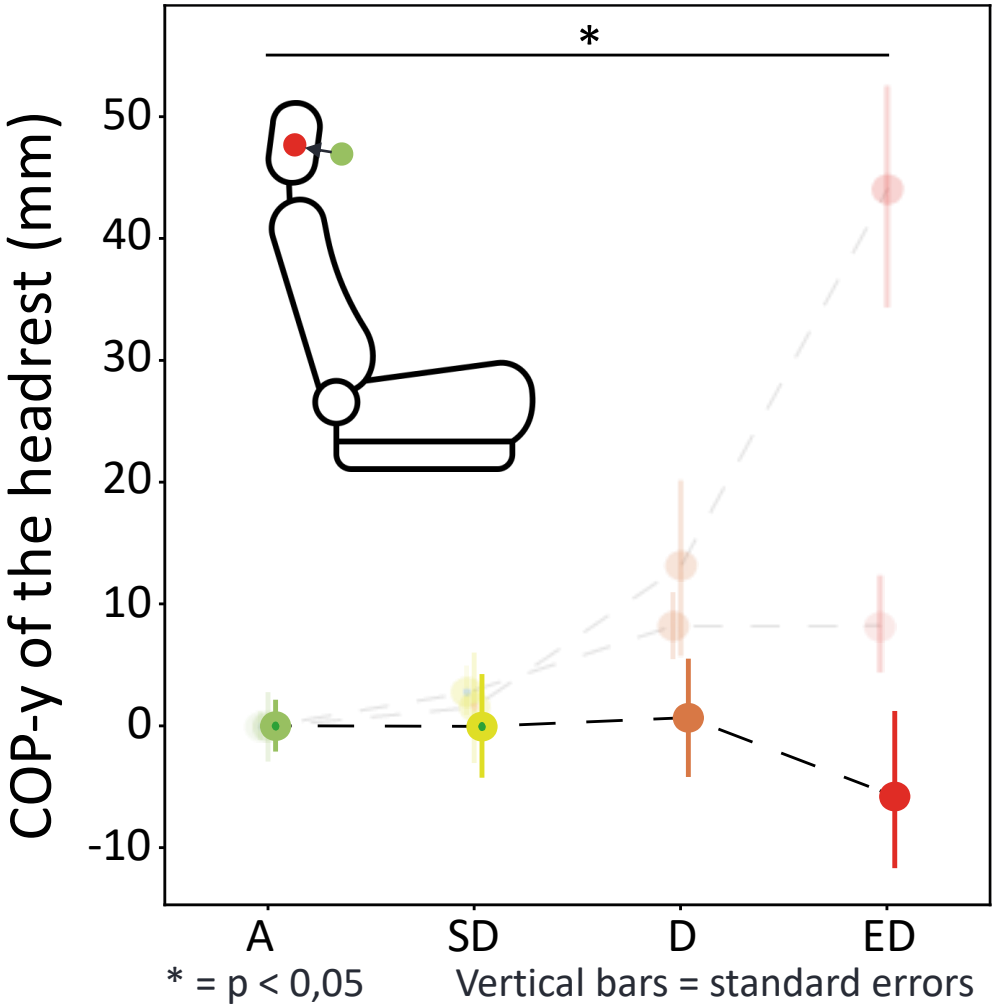
Shift of center of pressure in upper position

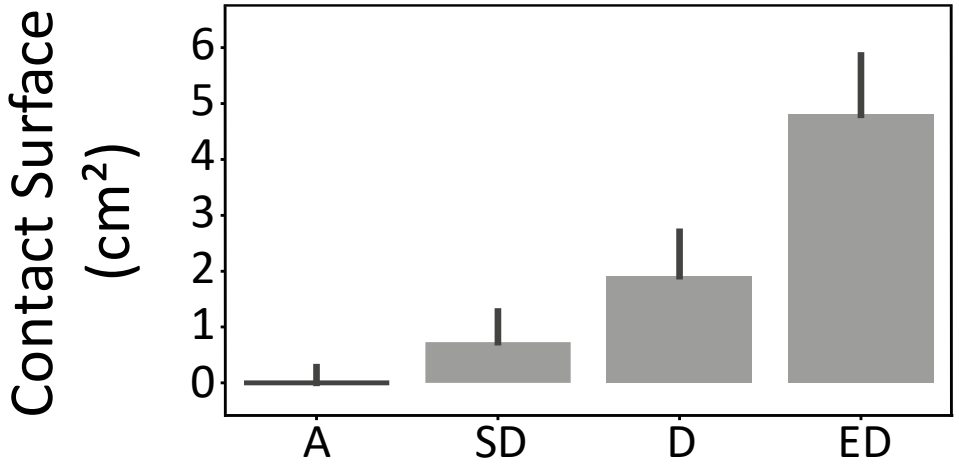


Inverted U-Shape between movements on backrest and drowsy states

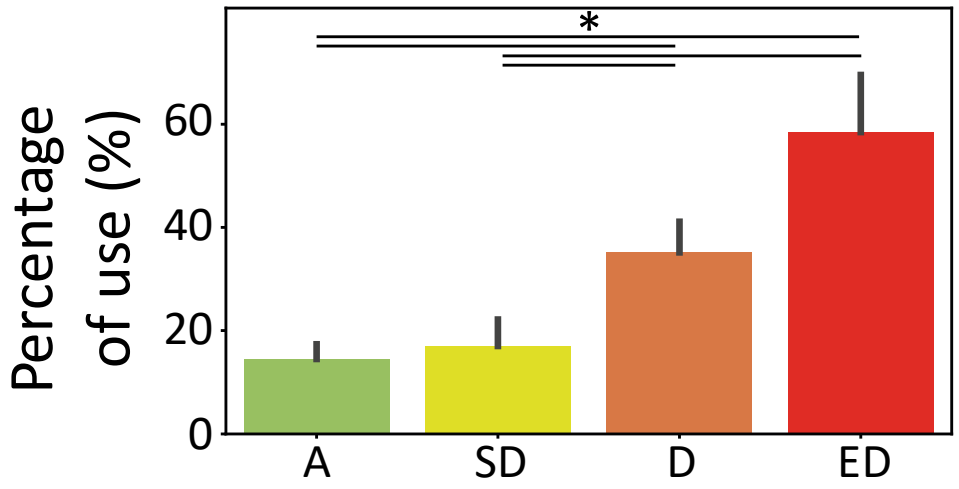
HEADREST FEATURES





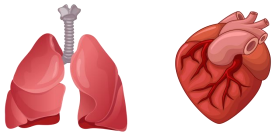


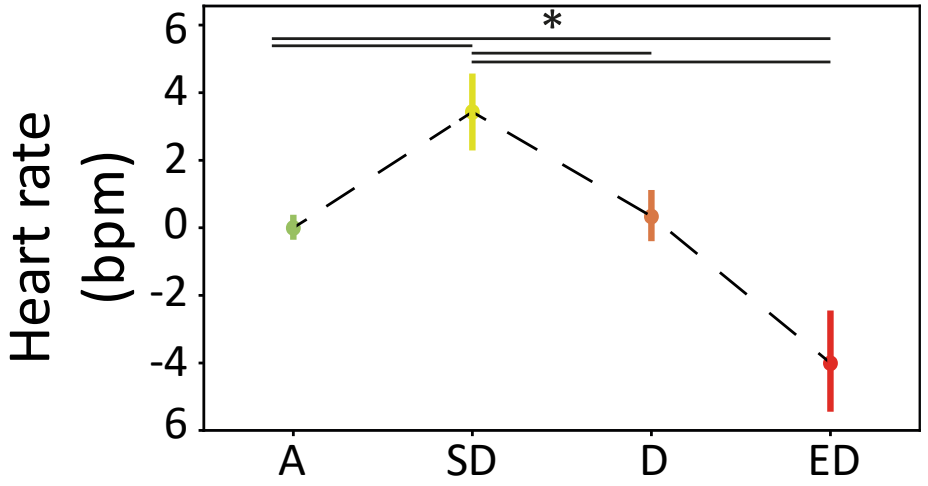
Increase of contact surface on headrest

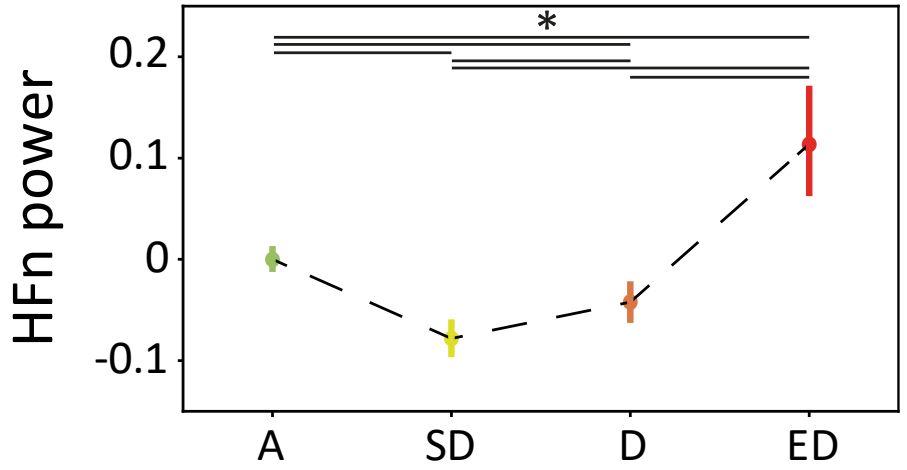


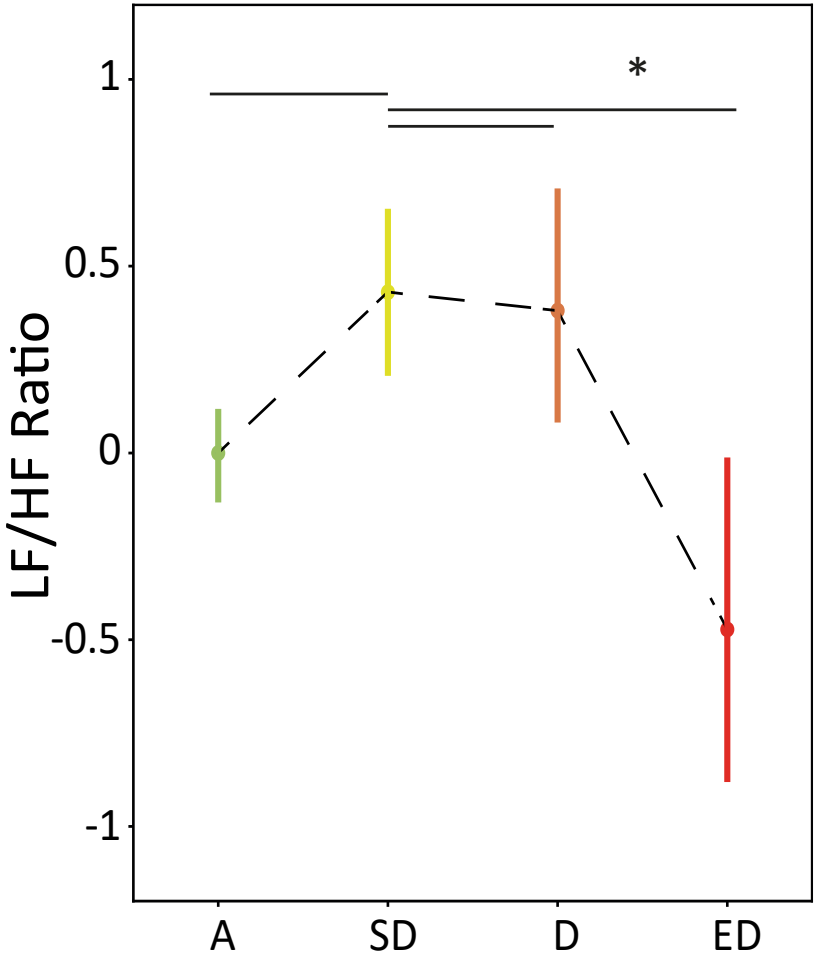
Increase of percentage of time contact of headrest

PHYSIOLOGICAL FEATURES









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U-Shape between HF Power and drowsy states

Inverted U-Shape betwen HR and LF/HF ratio and drowsy states

DROWSINESS AT THE WHEELS
Conclusions from our L2 study

SLIGHTLY DROWSY

- ✓ Increase of number of movements with the emergence of drowsiness at the wheels
- ✓ Increase of heart rate and LF/HF Ratio ➔ Decrease parasympathetic activity of the driver

Struggle to stay awake ?

VERY DROWSY OR ASLEEP

- ✓ Decrease of number of movements
- ✓ Decrease of heart and LF/HF Ratio ➔ Increase parasympathetic activity of the driver
- ✓ Sagging on the seat and use of the headrest more frequent

IN A REAL WORLD ?
Let’s talk about other states

DISTRACTED

- ✓ Impact cognitive load on physiological indicators (e.g. Hidalgo-Muñoz et al., 2019).
- ✓ Posture recognition for NDRTs (e.g. Zhao et al., 2021) and potentially associated movements (hypothesis)

RELAXED

- ✓ No movements on the seat and the backrest (hypothesis)
- ✓ Physiological indicators of relaxed state different than in alseep state (e.g. Wörle et al., 2019)
- ✓ Relaxed non-driving posture ➔ cue for prediction ?

TAKE HOME MESSAGE

- **Postural** and **physiological** indicators could be **alternatives** to detect drowsiness at the wheels (even in **intermediates stages**) ➔ Need a classifier validation

- **L2 mode** allows to characterize the **extreme state** of drowsiness at the wheels (which is limited in manual driving) ➔ Need to better understand **the dynamic** of drowsiness in autonomous modes

- **Relevance** of indicators to **other states of inattention** (e.g. relaxed) ?

THANK YOU FOR YOU ATTENTION !

Questions ?

Please feel free to contact me at : gaetan.perrotte@stellantis.com