Distinguishing carsickness sensitivity based on passengers' posture analysis according to vehicle dynamics

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Motion sickness : Frequency and Acceleration levels

In laboratory conditions, a critical threshold (0.16 - 0.20Hz) has been identified in the vertical axis

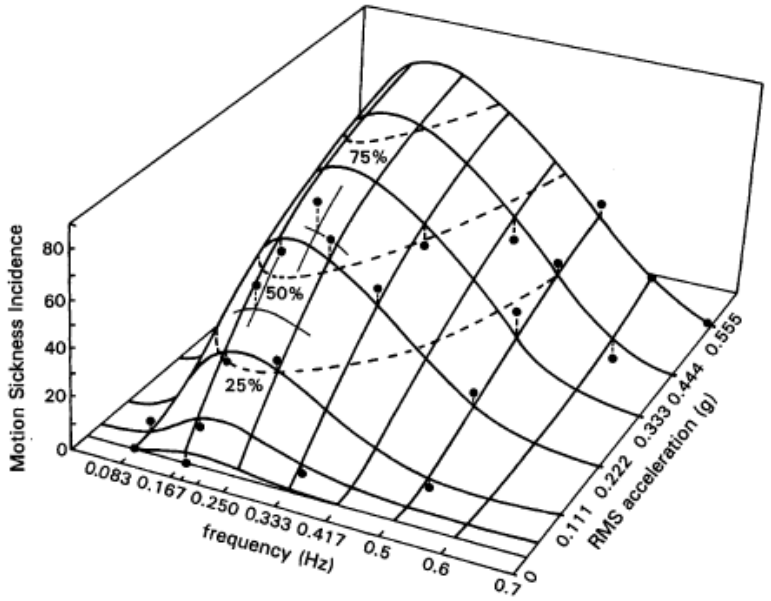


FIG. 1. Motion sickness incidence (%) after 2 h of endured motion versus frequency and acceleration. Each dot represents an observed average over 20 subjects. (Adapted from Ref. 11.)

O'Hanlon & Mc Cauley, 1974

The higher the acceleration level, the faster and more severe the symptoms

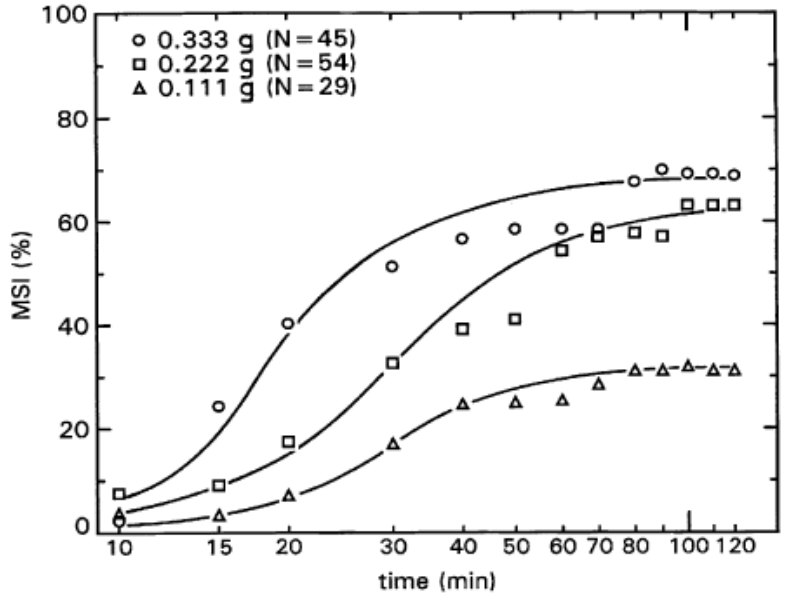
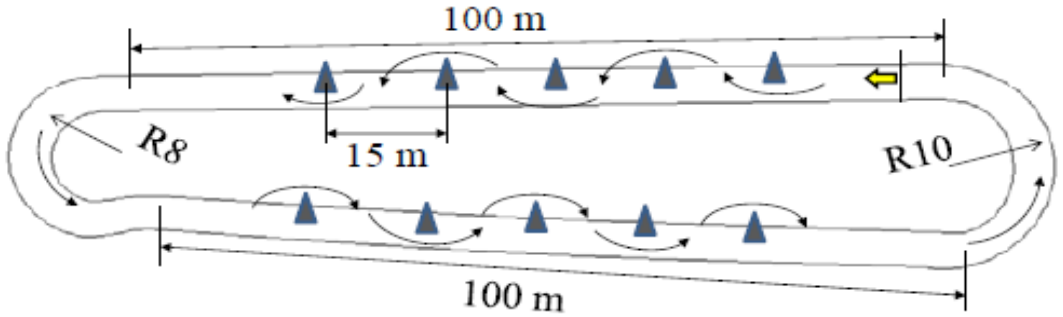


FIG. 2. Motion sickness incidence versus exposure time at one frequency of 0.25 Hz. (Adapted from Ref. 11.)

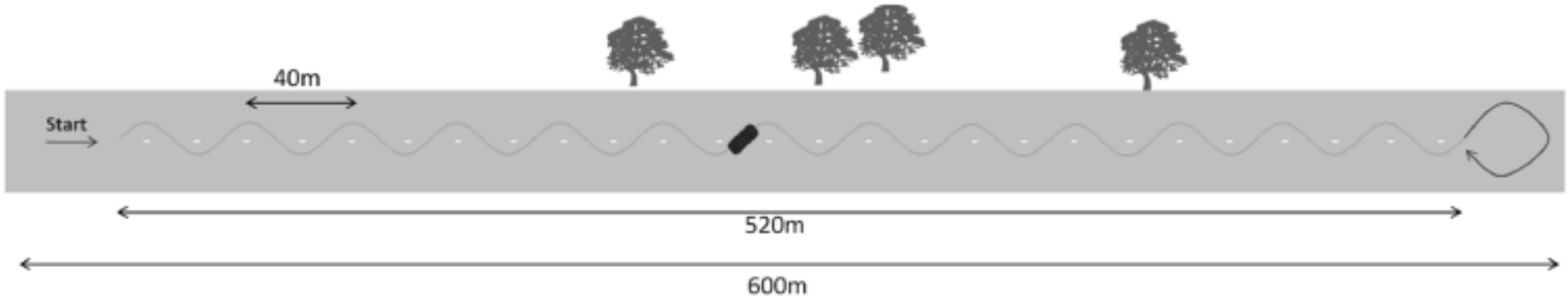
O'Hanlon & Mc Cauley, 1974

Motion sickness : Lateral oscillations in vehicle

In-vehicle tests confirmed the deleterious effects of these low-frequency movements in the lateral axis, using different configurations



Wada et al., 2006



Kuiper et al., 2018

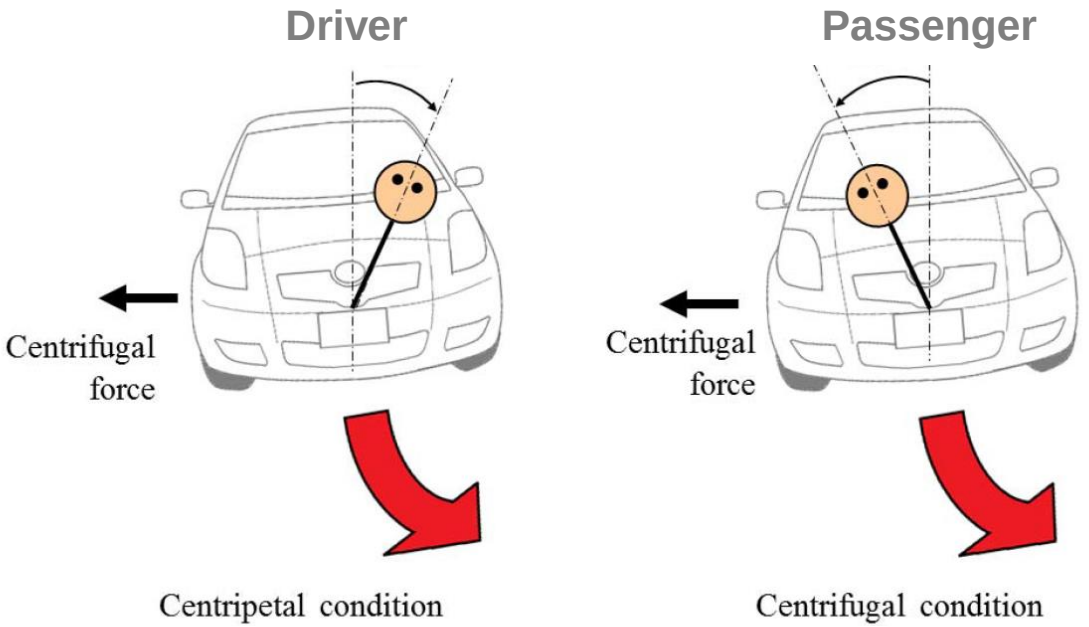
➡ **Nonetheless, only one acceleration level (2-3 m/s²) has been tested yet, using regular slaloms**

Motion sickness : Vehicle path prediction

Being unable to predict the vehicle path increases car sickness symptoms occurrence

Rolnick & Lubow, 1991

The driver does not have the same posture as the passenger

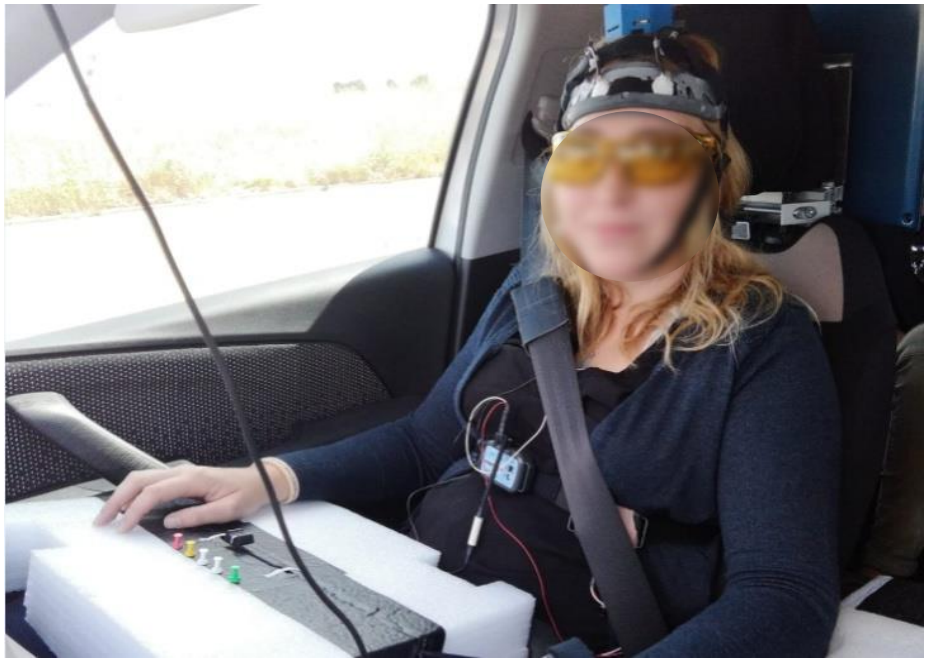


Wada et al., 2016

No information available yet on the movements of the passenger' chest, nor on driver' movements

Objectives

Evaluating the impact of the acceleration level and the unpredictability of vehicle path on passenger' carsickness sensitivity



We hypothesize that passenger' posture should reflect carsickness sensitivity:

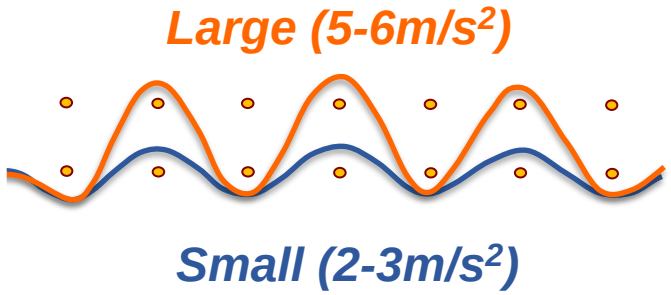
- Their posture will differ from drivers' posture
- This difference may be stressed out by the acceleration level of the car and their incapacity to predict vehicle path

Procedure

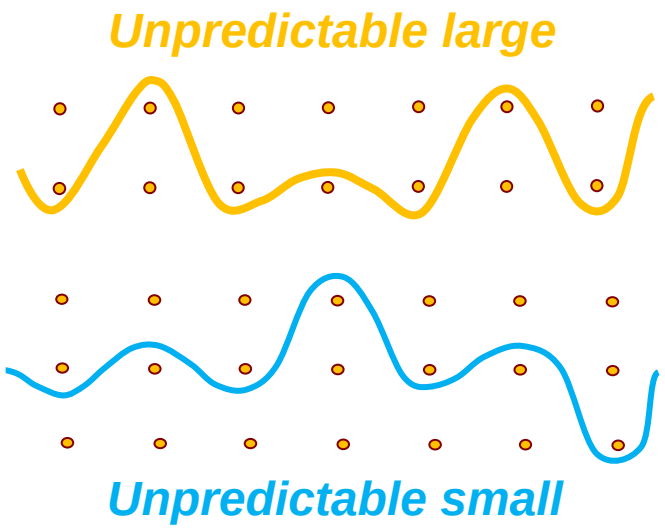
4 conditions

Speed : ***35 km/h***

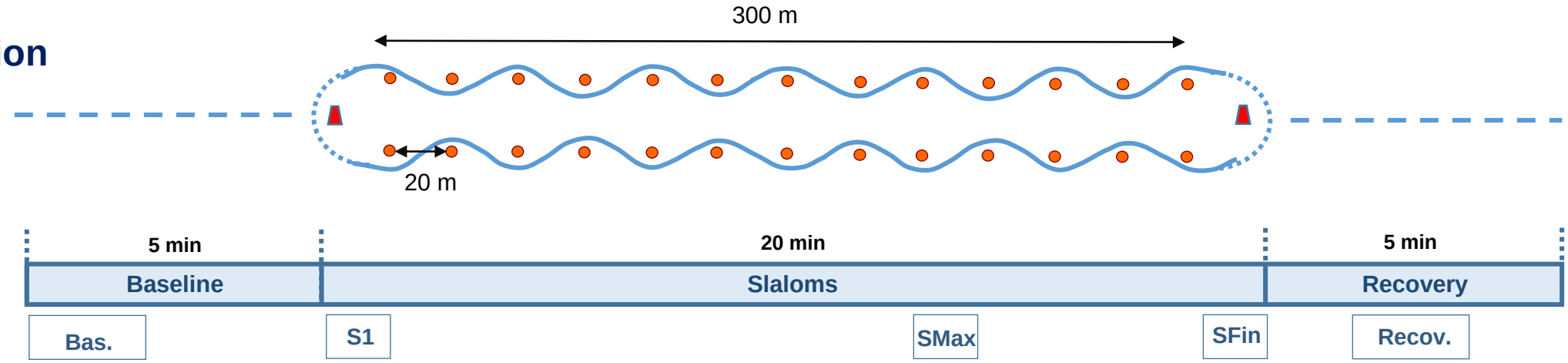
Acceleration level



Incapacity to predict vehicle path



Test session



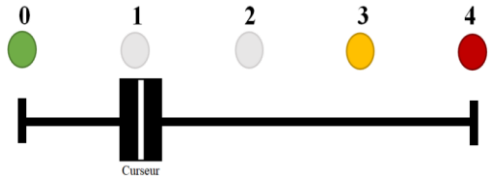
Measurements

Participants

- 24 participants
  - 12 Small / Unpredictable Small
  - 12 Large / Unpredictable Large
- 12 men / 12 women
  - 39,3 ± 9 yo

Subjective ratings

0. **No symptoms**
1. Mild symptoms
2. Mild symptoms without nausea
3. **Mild nausea**
4. **Mild to moderate nausea (STOP)**



Posture analysis

- Accelerometer fixed on the passenger' chest
- Accelerometer fixed on the driver' chest

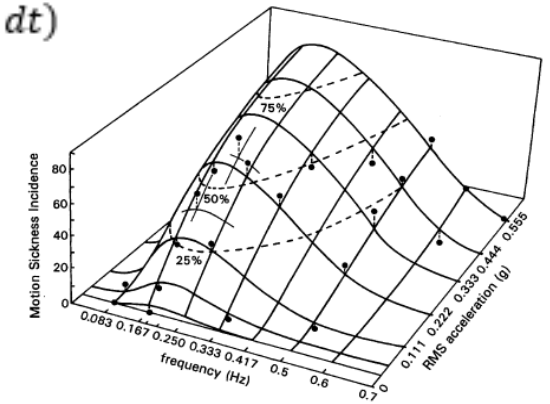
Vehicule measurements

- **C4 Picasso**
- Longitudinal and lateral acceleration
- Speed
- Steering wheel angle

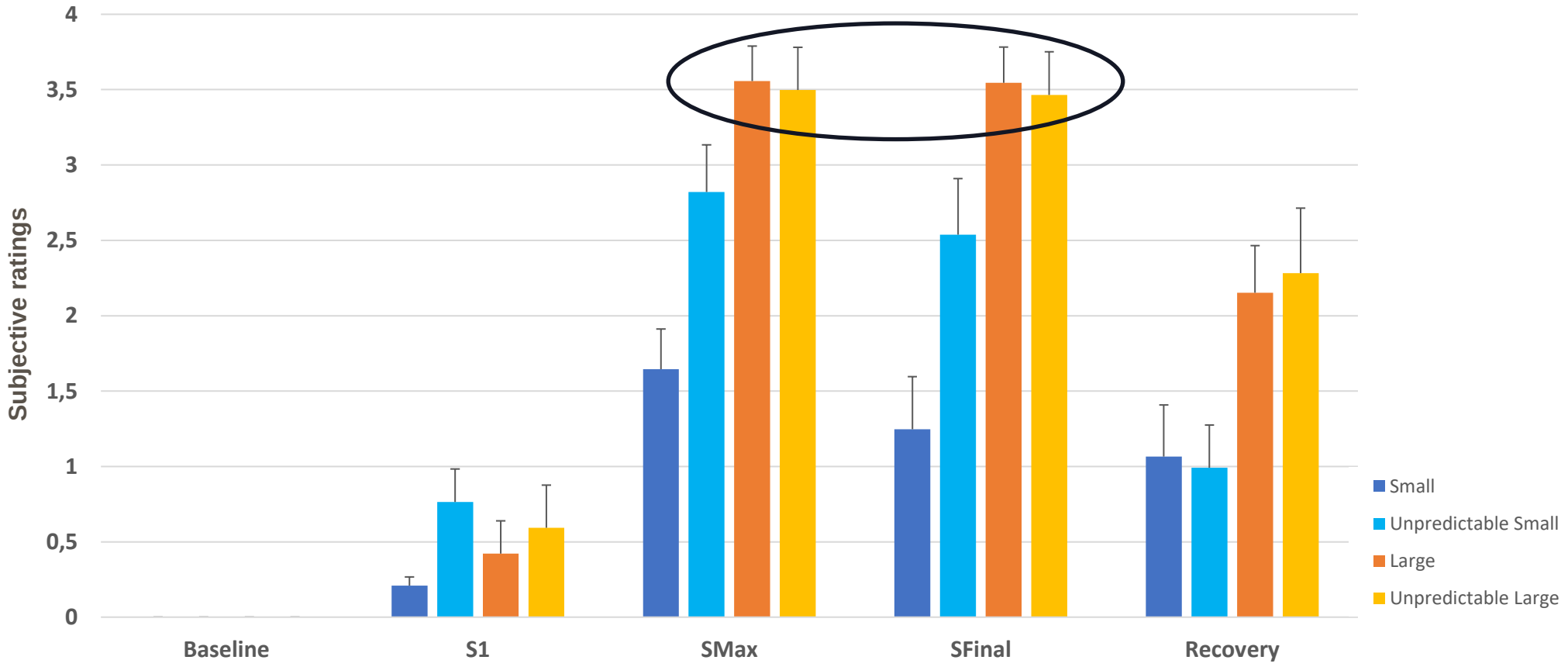
Dynamics calculation

MSDV: $f(a(t)) = \sqrt{\int (a(t)^2 \times dt)}$

a = acceleration; t = time of exposure



Subjective ratings



Low frequency (0.17 - 0.2Hz) lateral movements are critical in real driving conditions
Every participant became sick during the test to some extent, mostly in the large slaloms
Lower subjective ratings in recovery for small slaloms

Subjective ratings / vehicle dynamics

MSDV: $f(a(t)) = \sqrt{\int (a(t)^2 \times dt)}$

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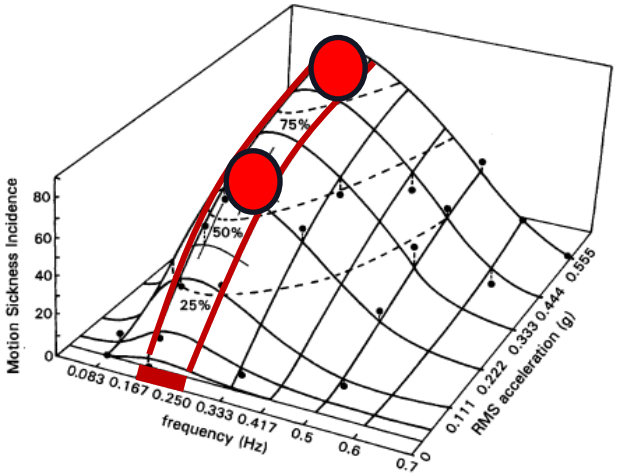

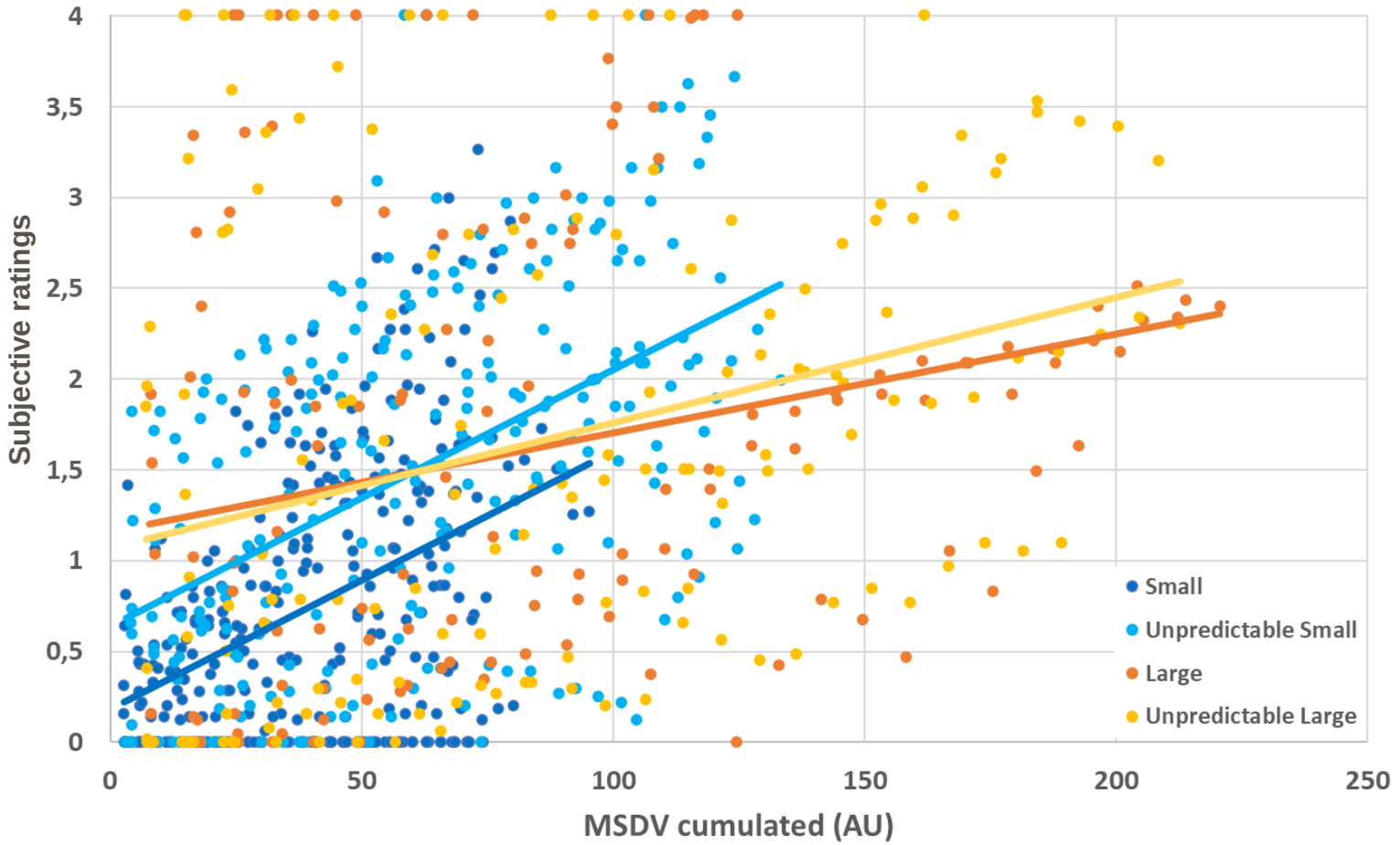

Large inter-individual variability

Some participants rapidly scored at the maximum level (large/unpredictable large)

Subjective ratings / vehicle dynamics

MSDV: $f(a(t)) = \sqrt{\int (a(t)^2 \times dt)}$

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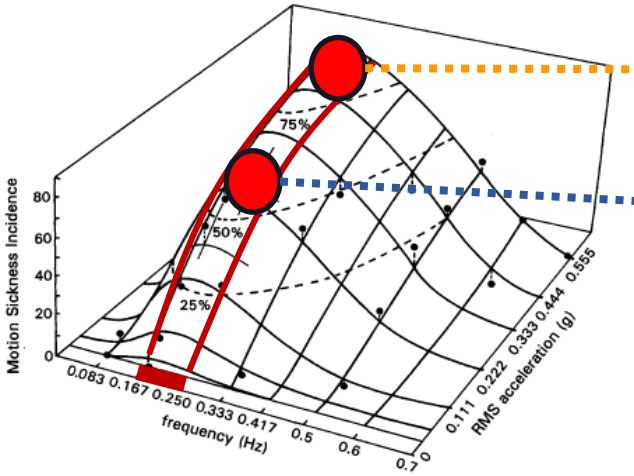
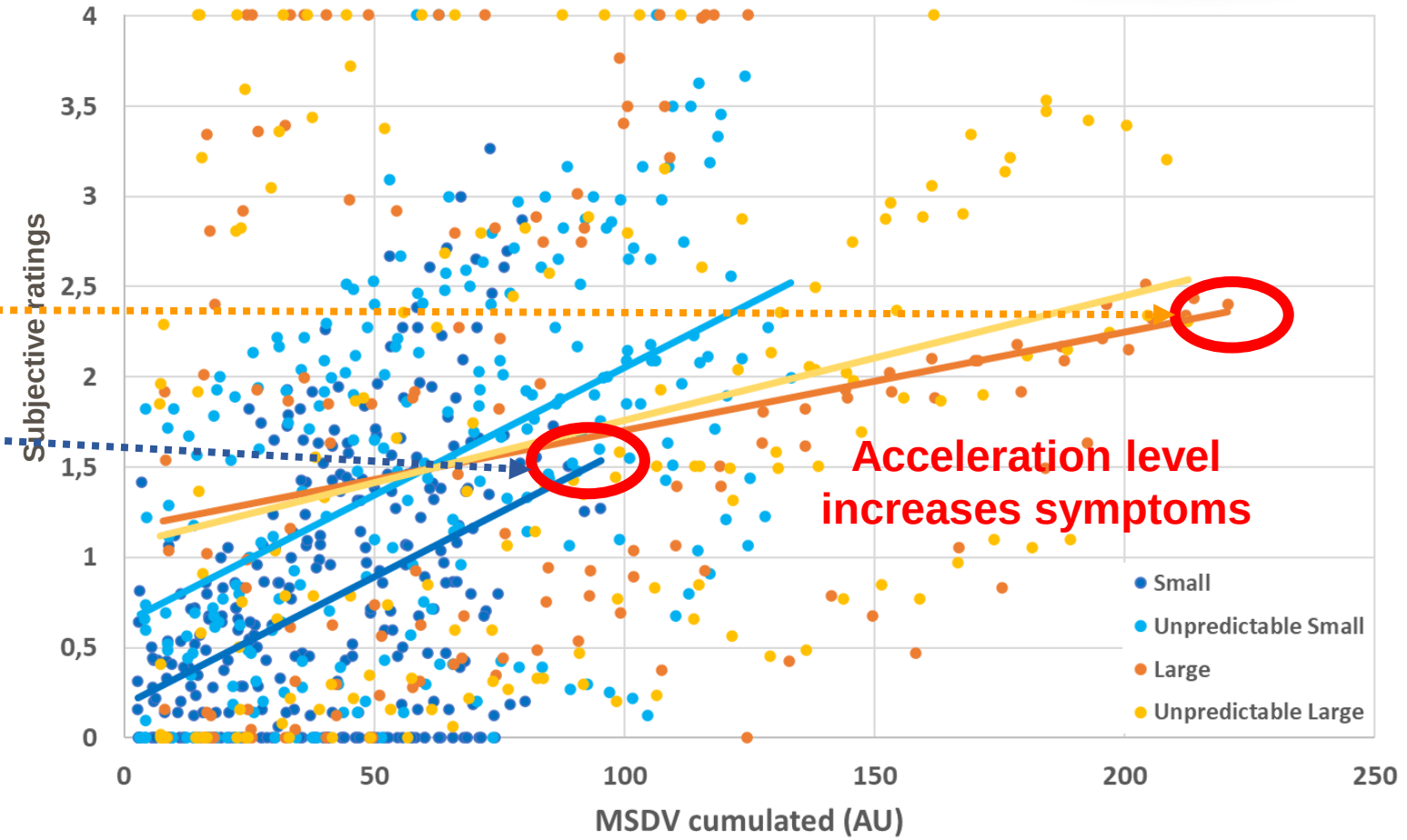


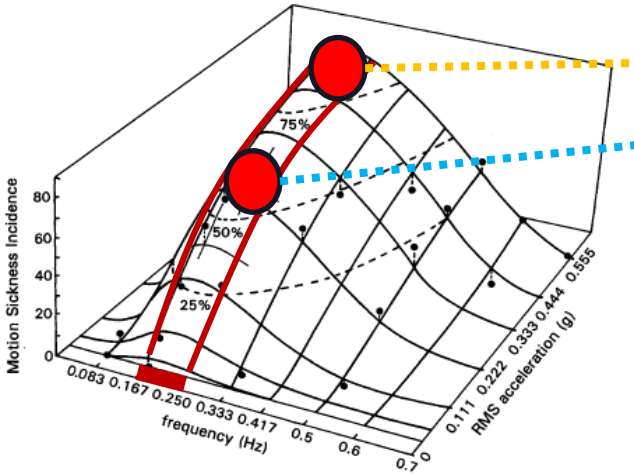


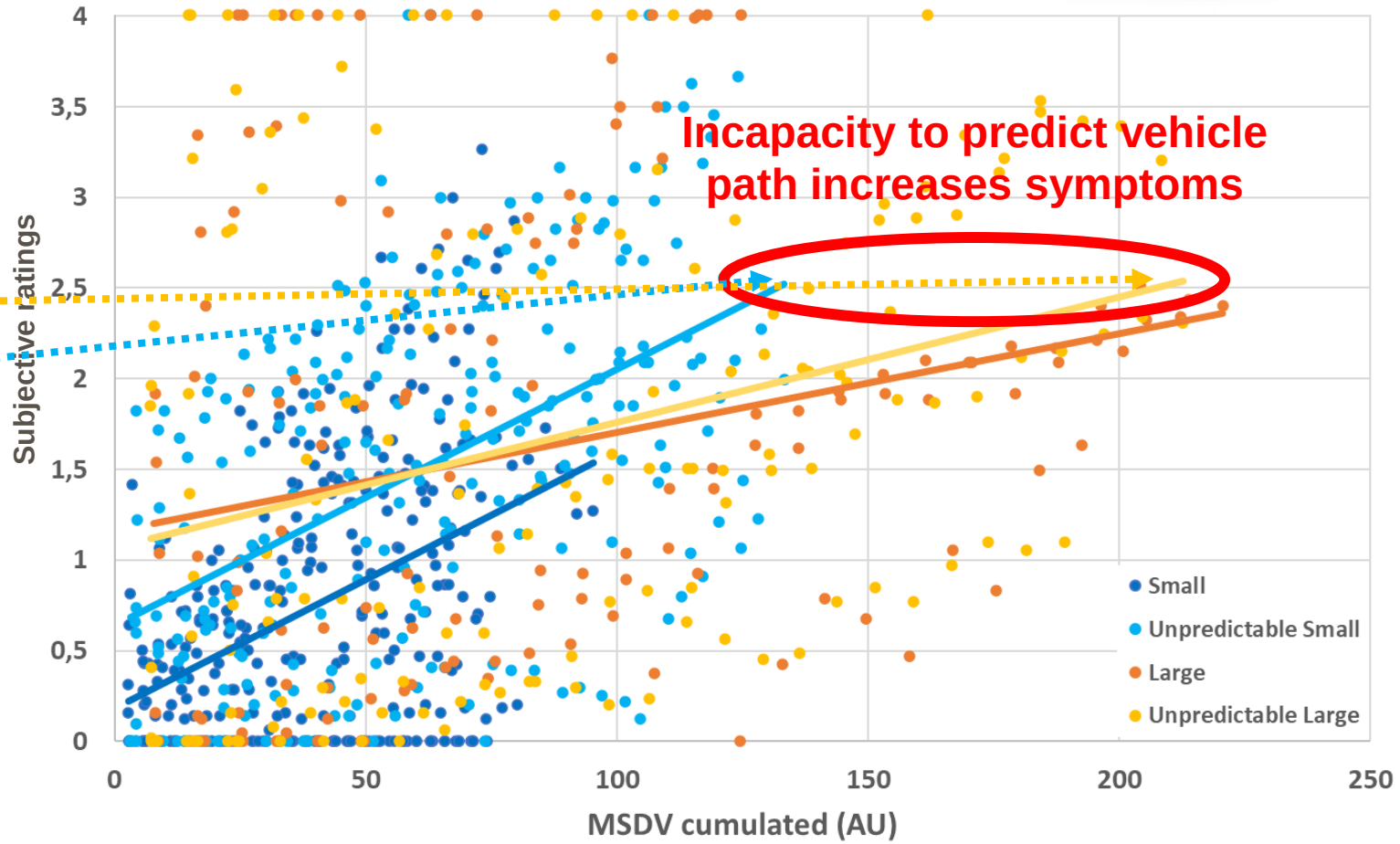
Influence of the acceleration level

Subjective ratings / vehicle dynamics

MSDV: $f(a(t)) = \sqrt{\int (a(t)^2 \times dt)}$

a = acceleration; t = time of exposure



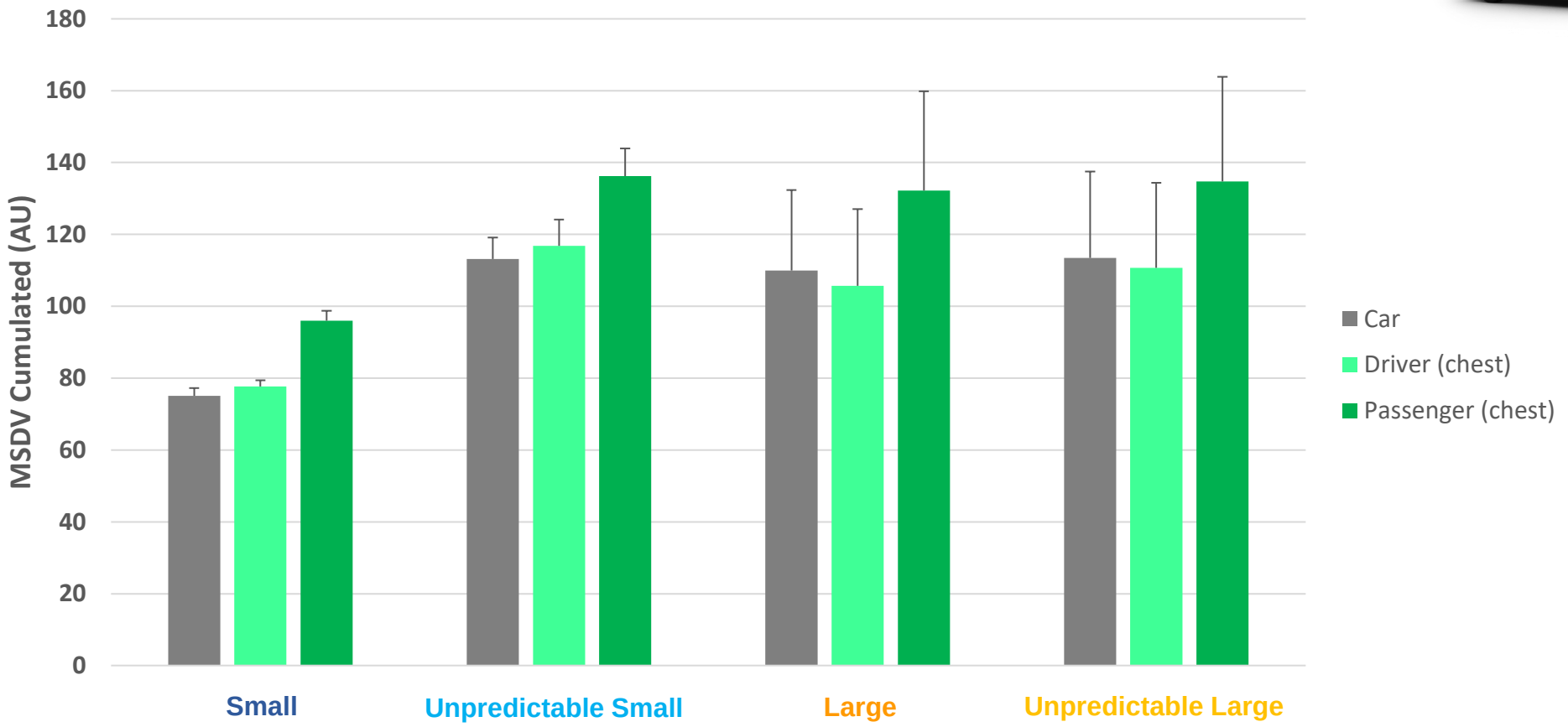


Incapacity to predict vehicle path increases symptoms

Higher scores in unpredictable slaloms

Unpredictable Small, also a slight increase in MSDV, but not the case for Unpredictable Large

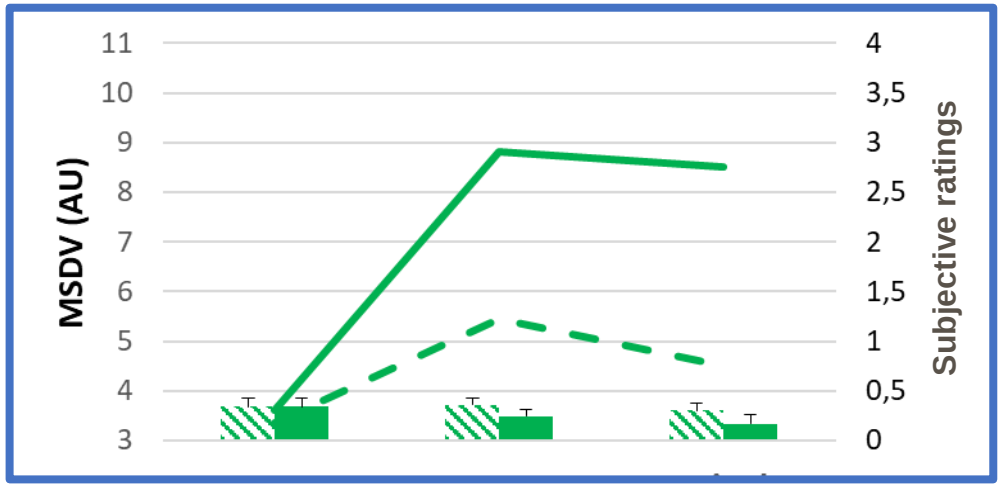
Car, driver, and passenger movements



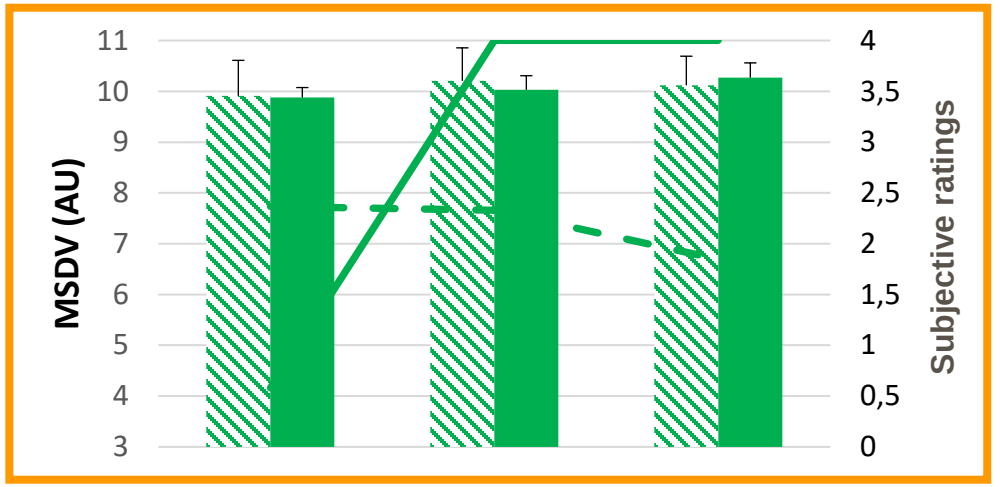
Drivers, who rarely feel sick, have limited movements (close to the vehicle movements quantity)
In contrast, passengers have important movements in every condition (postural instability?)

Passenger' movements (chest) / carsickness sensitivity

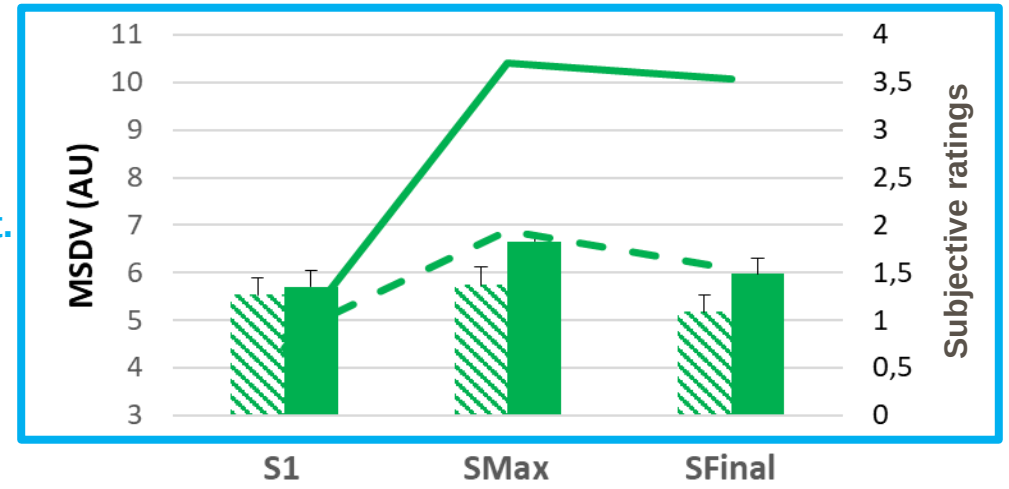
Small



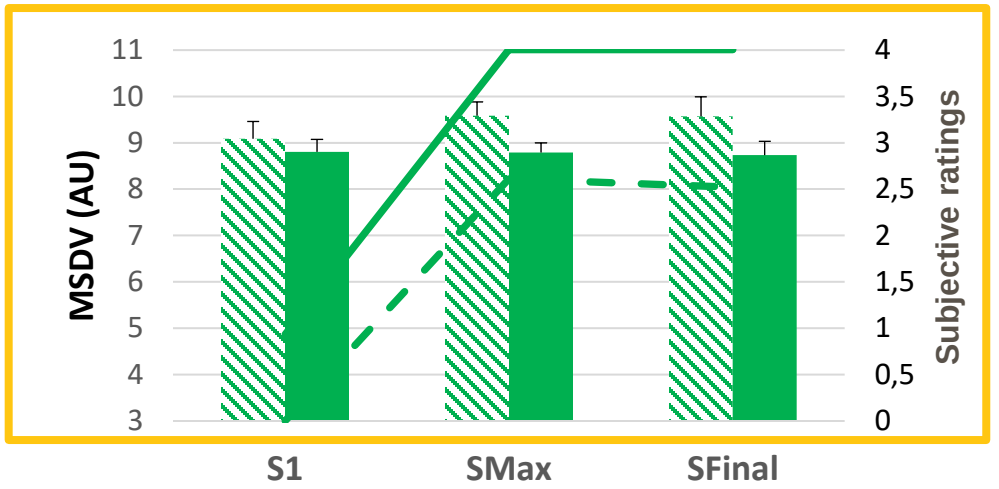
Large



Unpredict. Small



Unpredict. Large



Low carsickness sensitivity High carsickness sensitivity

Conclusion & perspectives

✓ **Influence of the acceleration level**

- Large slaloms induced higher symptoms

✓ **Being able to predict car movements limits symptoms severity**

- Driver was not affected
- Driver' movements were limited regarding passenger' movements
- Unpredictable slaloms induced higher carsickness ratings

✓ **Symptoms gravity does not seem to be linked to movement quantity (chest)**

✓ **Our results suggest the influence of further criteria:**

- Head movements (on going analysis)
- Delay between car and passenger movement
- Mental stress, anxiety

Thank you, any question?

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