Physiological changes reflecting carsickness symptoms occurrence in real driving conditions

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Motion sickness : Impact of vehicle dynamics

Vertical movements

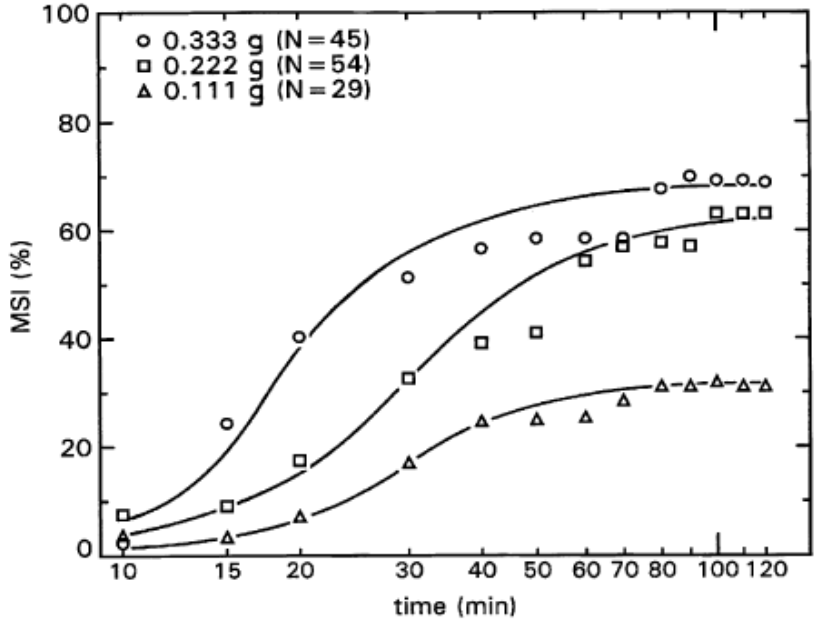
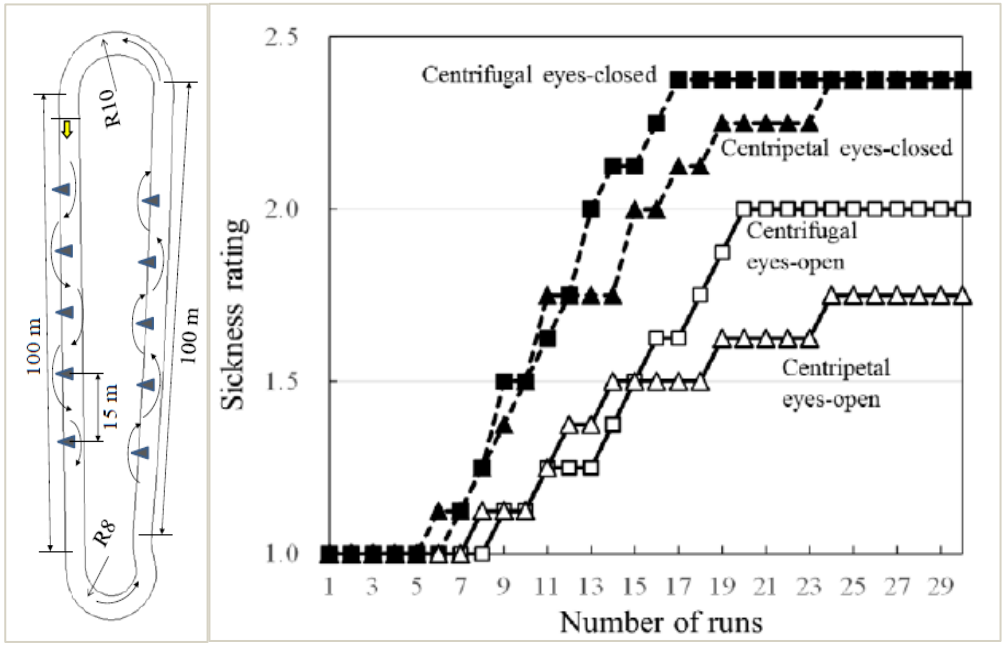


FIG. 2. Motion sickness incidence versus exposure time at one frequency of 0.25 Hz. (Adapted from Ref. 11.)

O'Hanlon & Mc Cauley, 1974

Lateral movements



Slaloms – Lateral movements (0.2 Hz, 2-3 m/s²)

Wada & Yoshida, 2015

- **Low frequency vertical movements and high acceleration levels induce motion sickness symptoms**
- **With only one acceleration level tested, low frequency lateral movements induce car sickness symptoms**

Motion sickness : Impact of vehicle dynamics

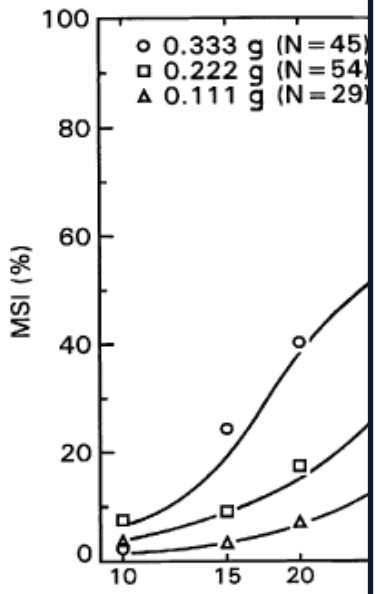
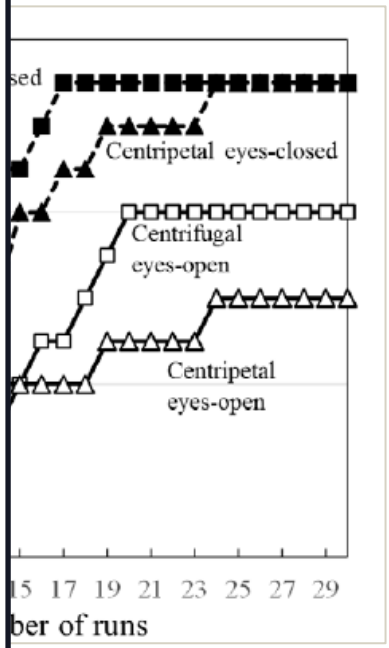


FIG. 2. Motion sickness incidenc
of 0.25 Hz. (Adapted from Ref.

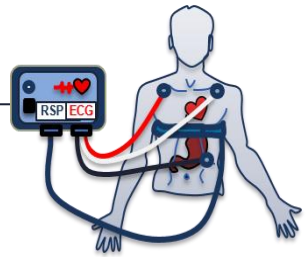
Being unable to predict the vehicle path increases car sickness symptoms occurrence

Rolnick & Lubow, 1991

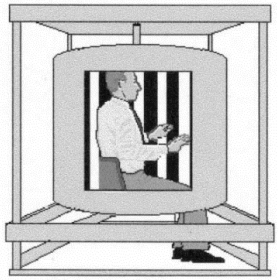


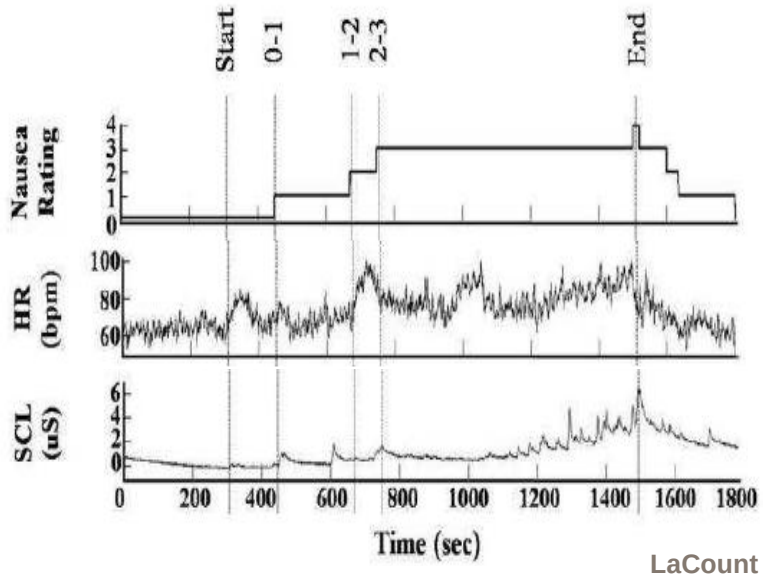
Wada & Yoshida, 2015

Motion sickness : Changes in physiological parameters



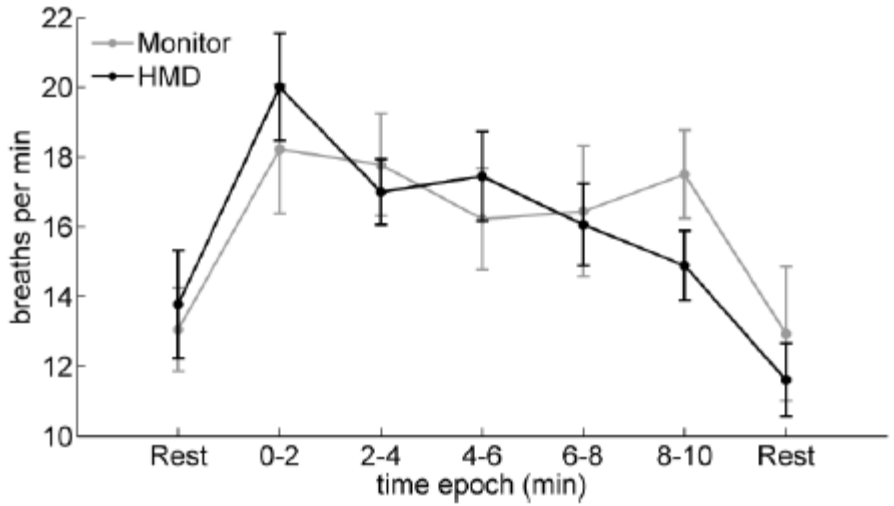
Cardiac and skin conductance activity





LaCount & al., 2013

Respiratory activity

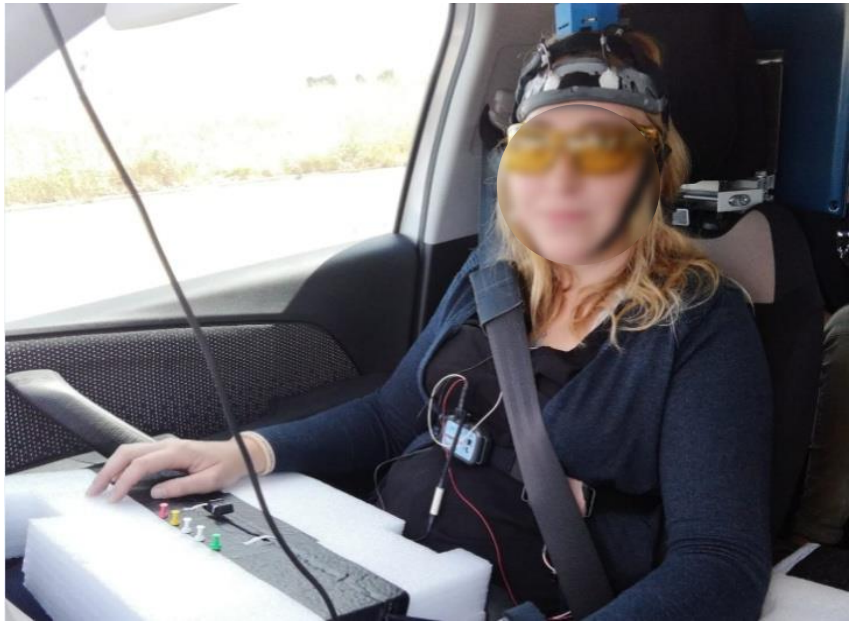


Dennison & al., 2016

Increase in skin conductance level, heart and respiratory rate with the emergence of symptoms

Objectives

In real driving conditions : evaluating the impact of the acceleration level and the unpredictability of vehicle path on passengers' physiological parameters and carsickness sensitivity



We hypothesize that :

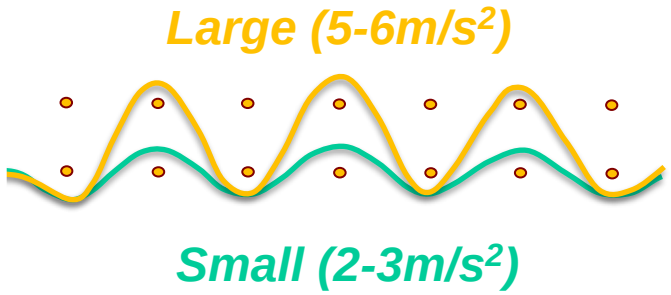
- **passengers' carsickness sensitivity will increase with the higher acceleration level of the car and their incapacity to predict vehicle path**
- **passengers' physiological parameters will change with carsickness symptoms occurrence**

Procedure

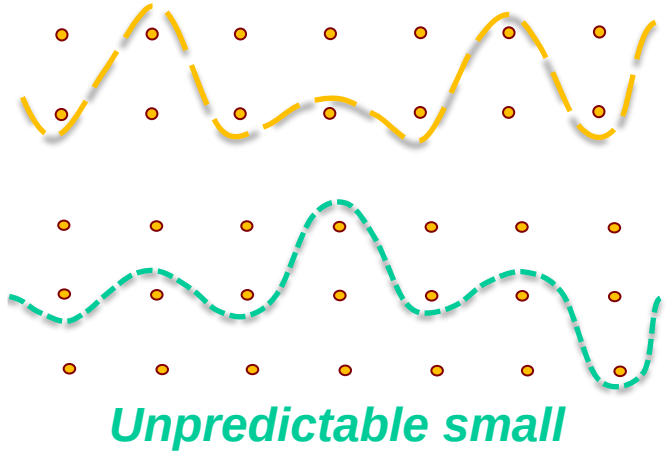
4 conditions

Speed : *35 km/h*

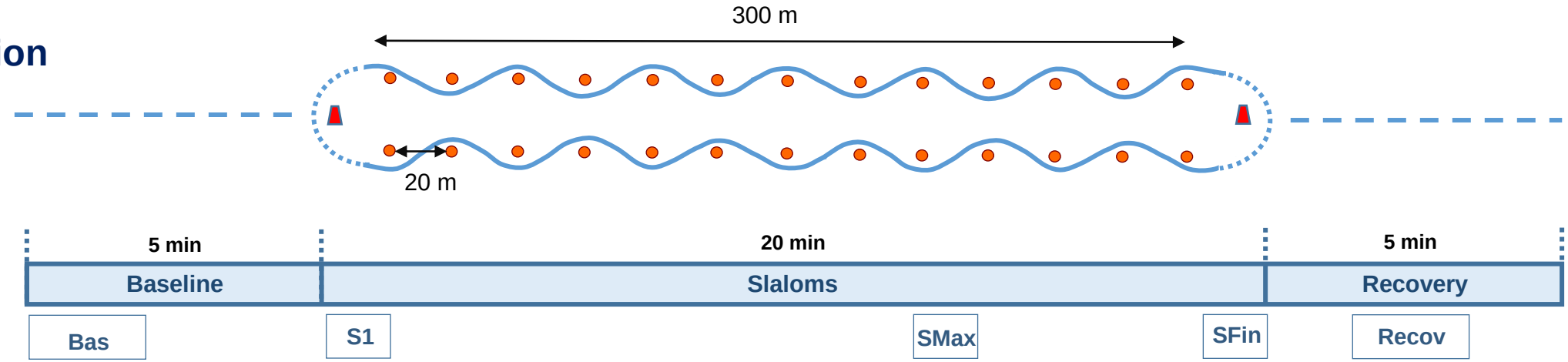
Acceleration level



Incapacity to predict vehicle path



Test session



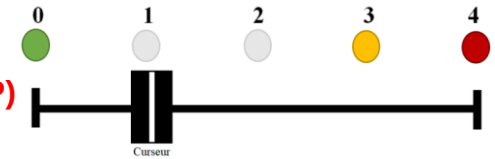
Procedure

Participants

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

Subjective ratings

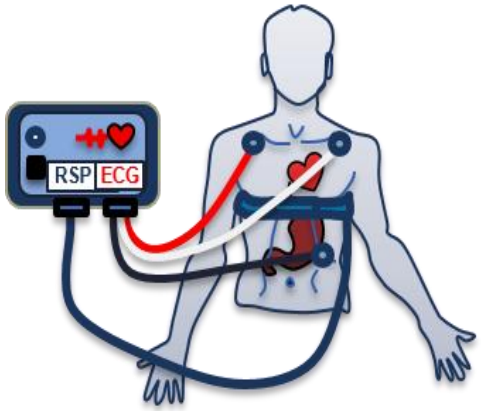
0. **No symptoms**
1. Mild symptoms
2. Mild symptoms without nausea
3. **Mild nausea**
4. **Mild to moderate nausea (STOP)**



Vehicule measurements

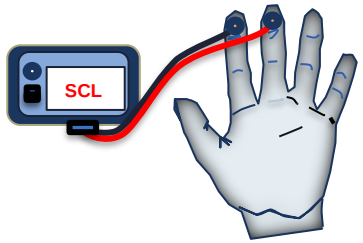
- **C4 Picasso**
- Longitudinal and lateral acceleration
- Speed

Physiological measurements



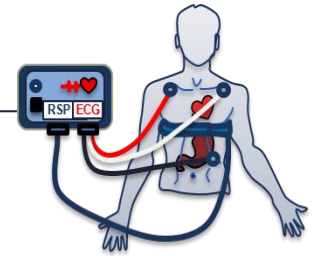
Respiratory activity (cycle/min)
- *Maximal inspiratory amplitude (UA)*
- *Maximal expiratory amplitude (UA)*

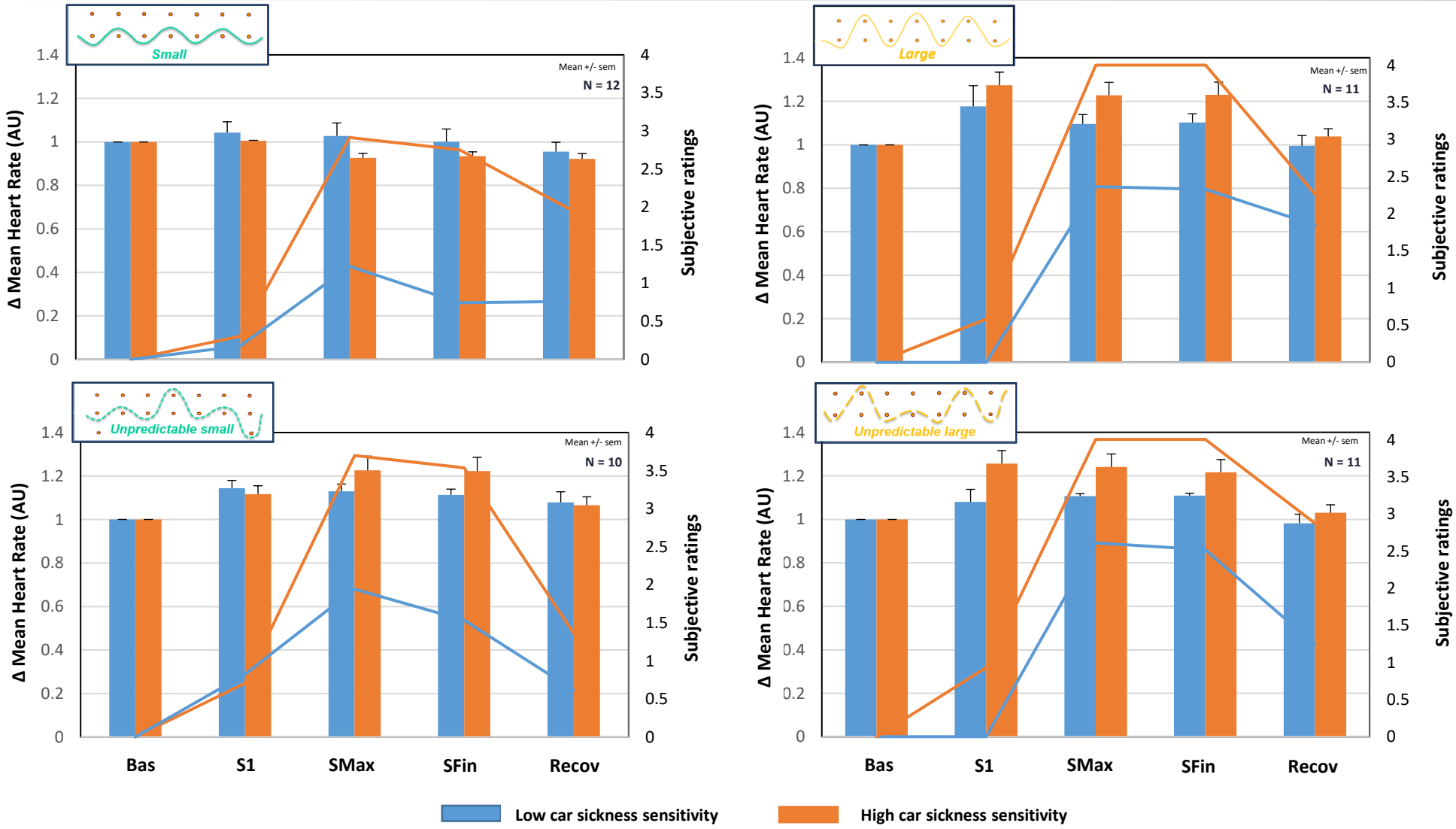
Cardiac activity (µV)
- *Mean heart rate (bpm)*
- *Heart rate variability (bpm)*



Skin conductance activity (µS)
- *Skin conductance level (µS)*

Physiological measurements : Mean heart rate

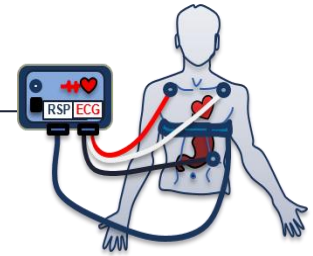


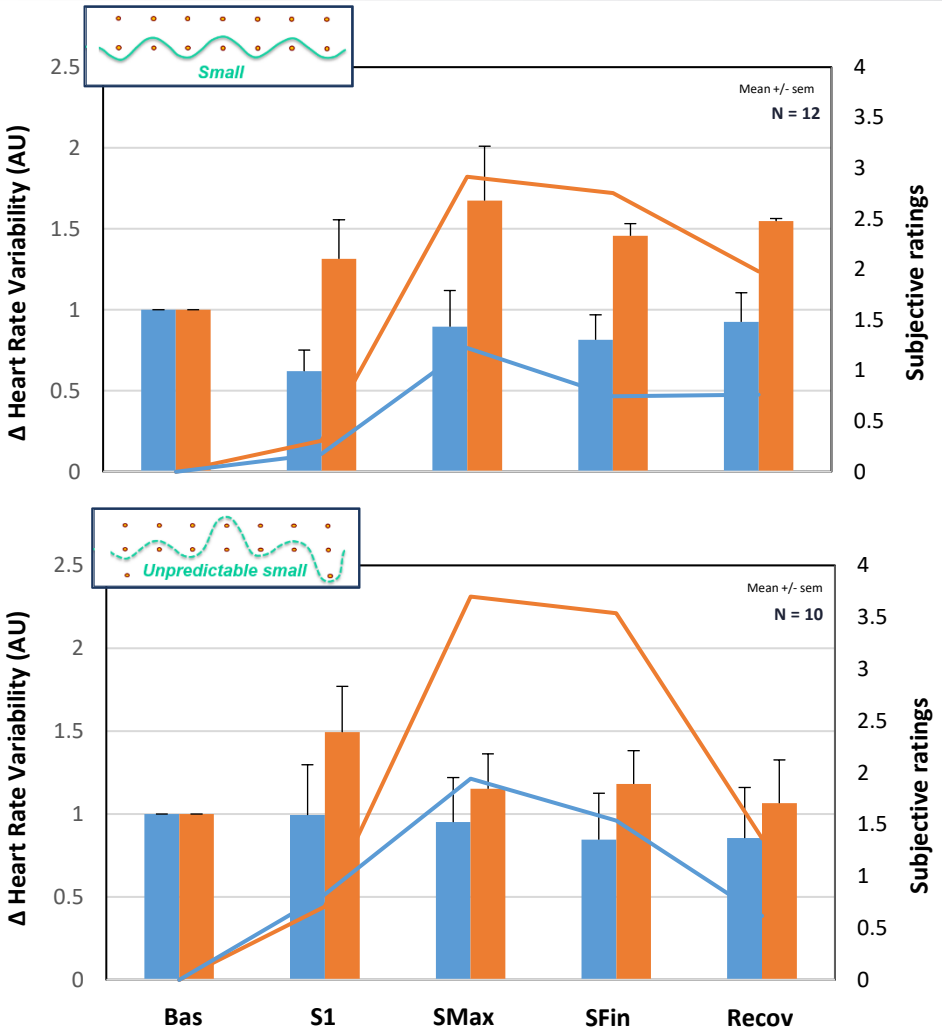


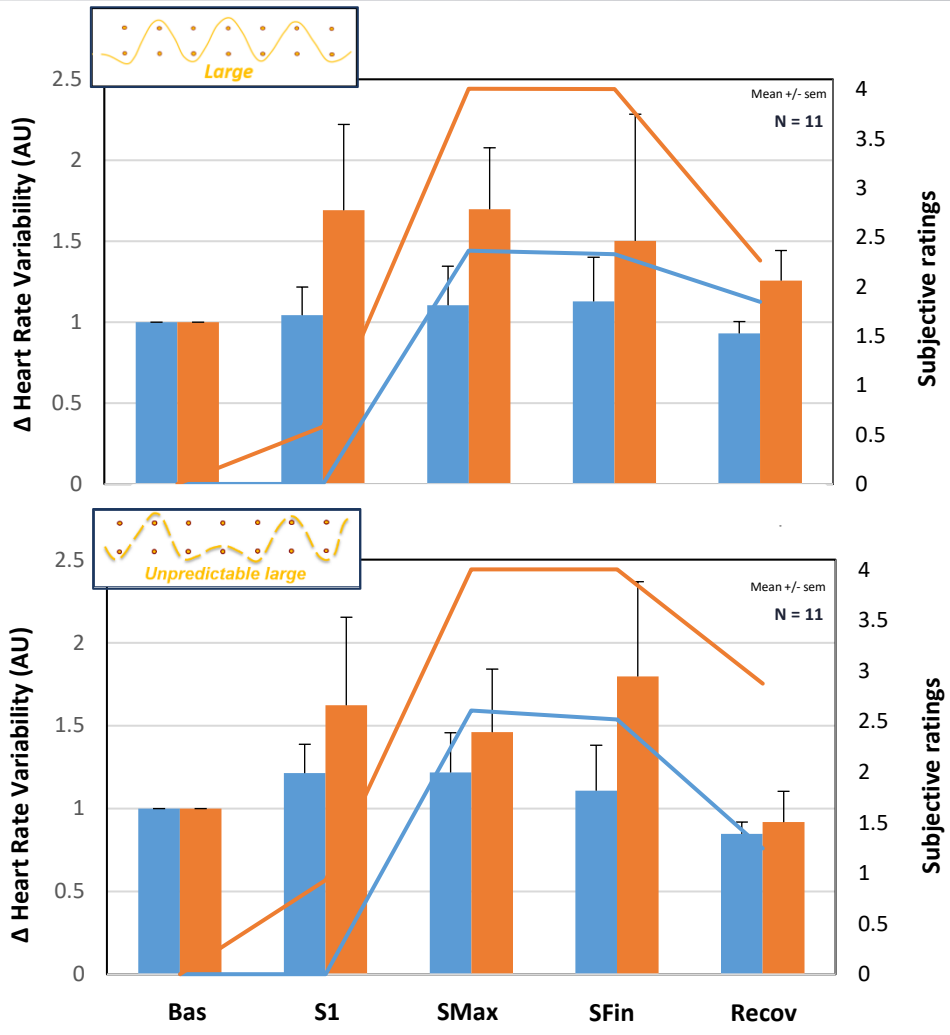
➡ **Low increase for both group** (Low and High CS sensitivity) **during the slalom phase**

➡ **Return to basic levels during the recovery phase**

Physiological measurements : Heart rate variability







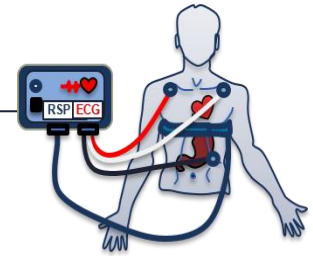
Low car sickness sensitivity

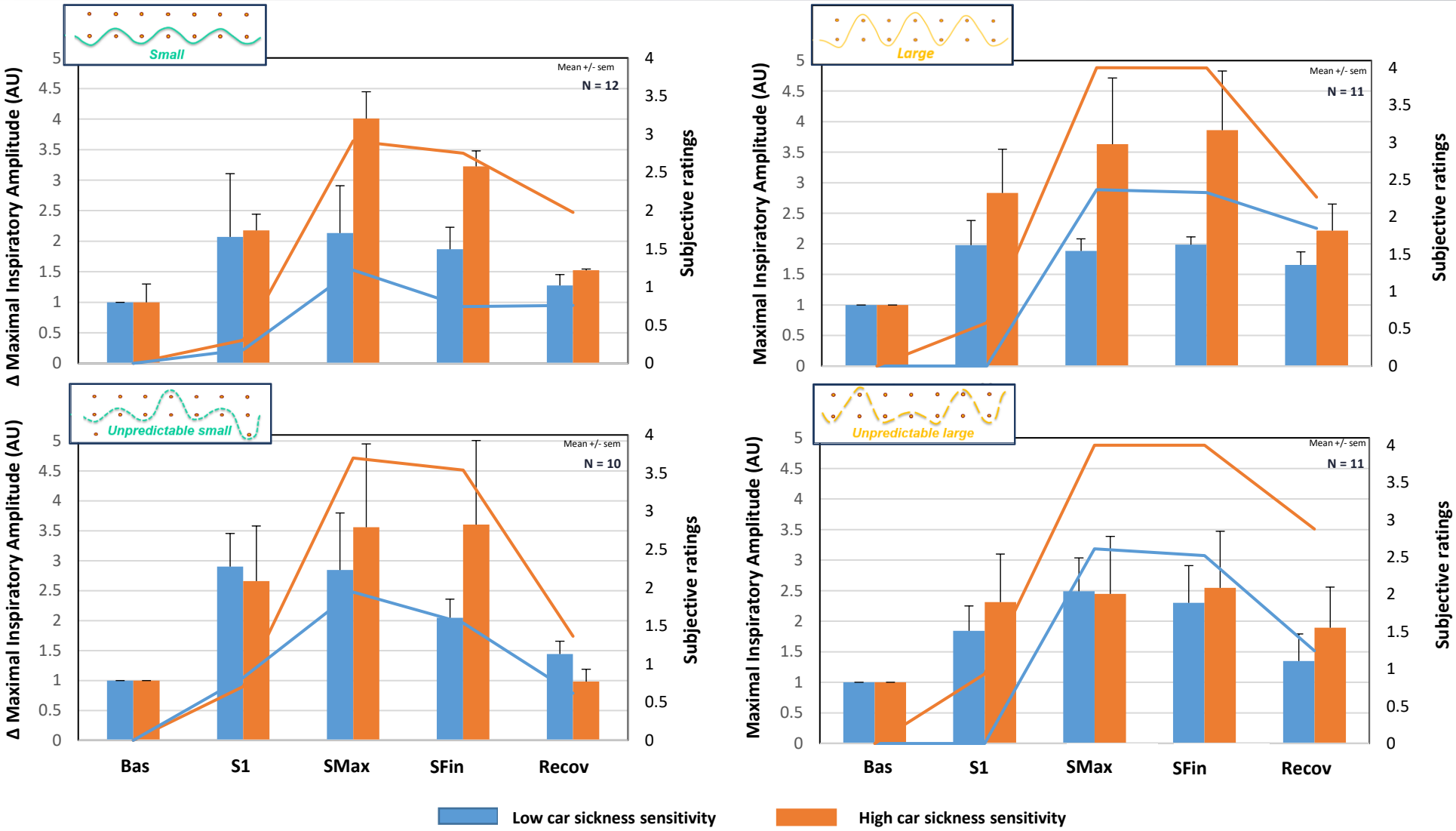
High car sickness sensitivity

➡ During the slalom phase:
- Increase for the high CS sensitivity group
- Low changes for the CS low sensitivity group

➡ Return to basic levels during the recovery phase except for the small condition (High CS sensitivity group)

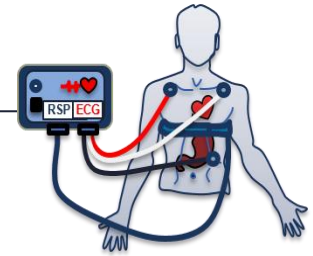
Physiological measurements : Maximal inspiratory amplitude

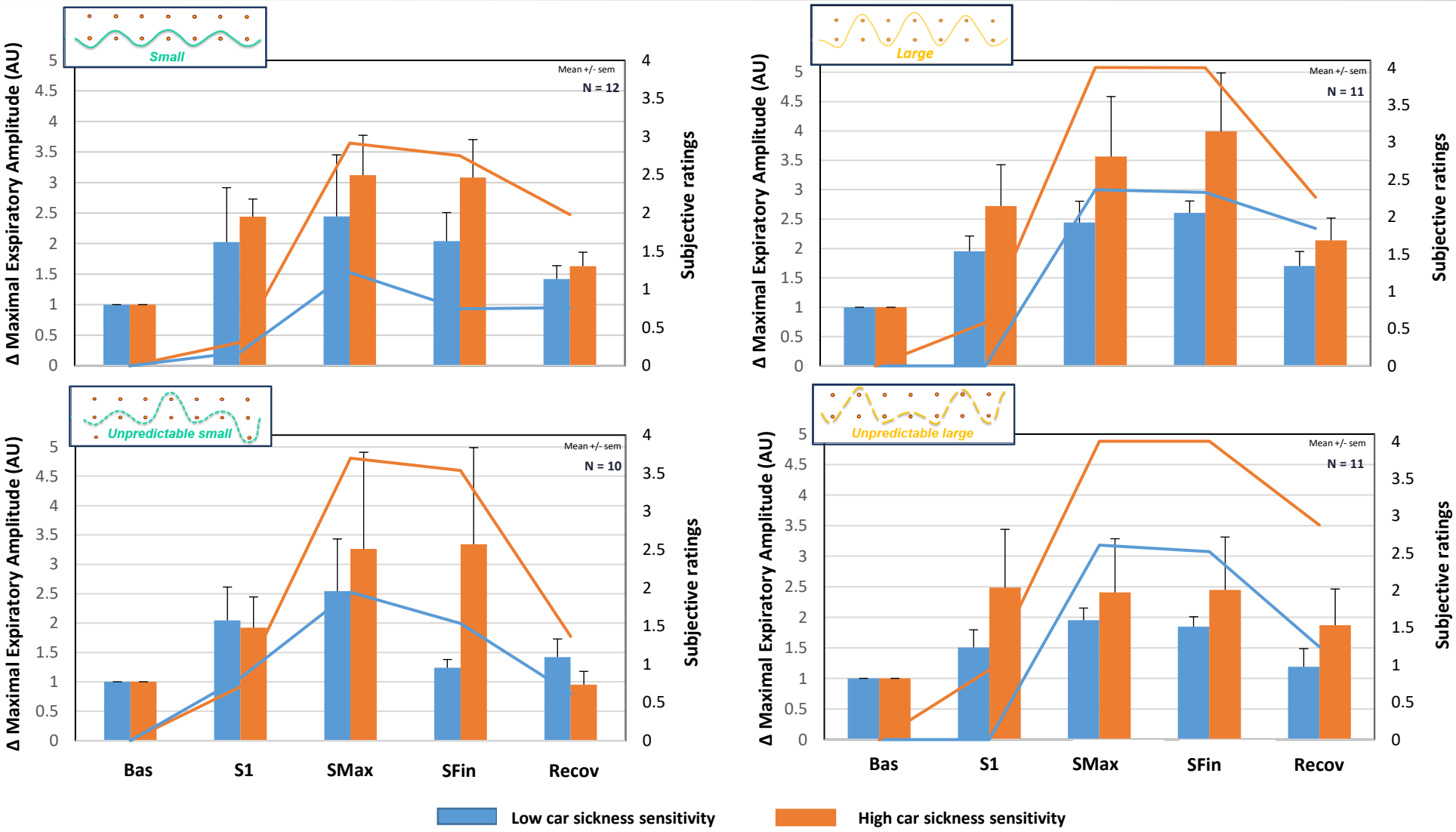




- During the slalom phase:
  - High increase for the high CS sensitivity group
  - Lower increase for the low CS sensitivity group
- Decrease for both group during the recovery phase

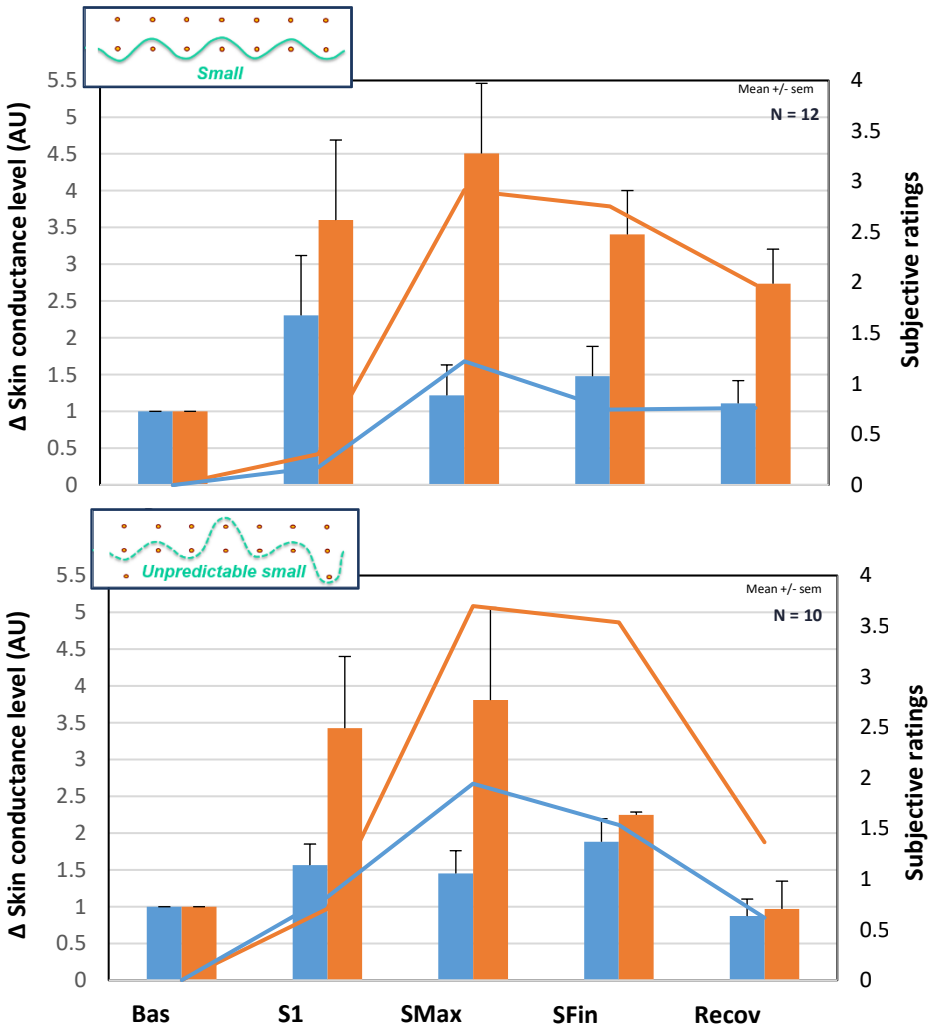
Physiological measurements : Maximal expiratory amplitude

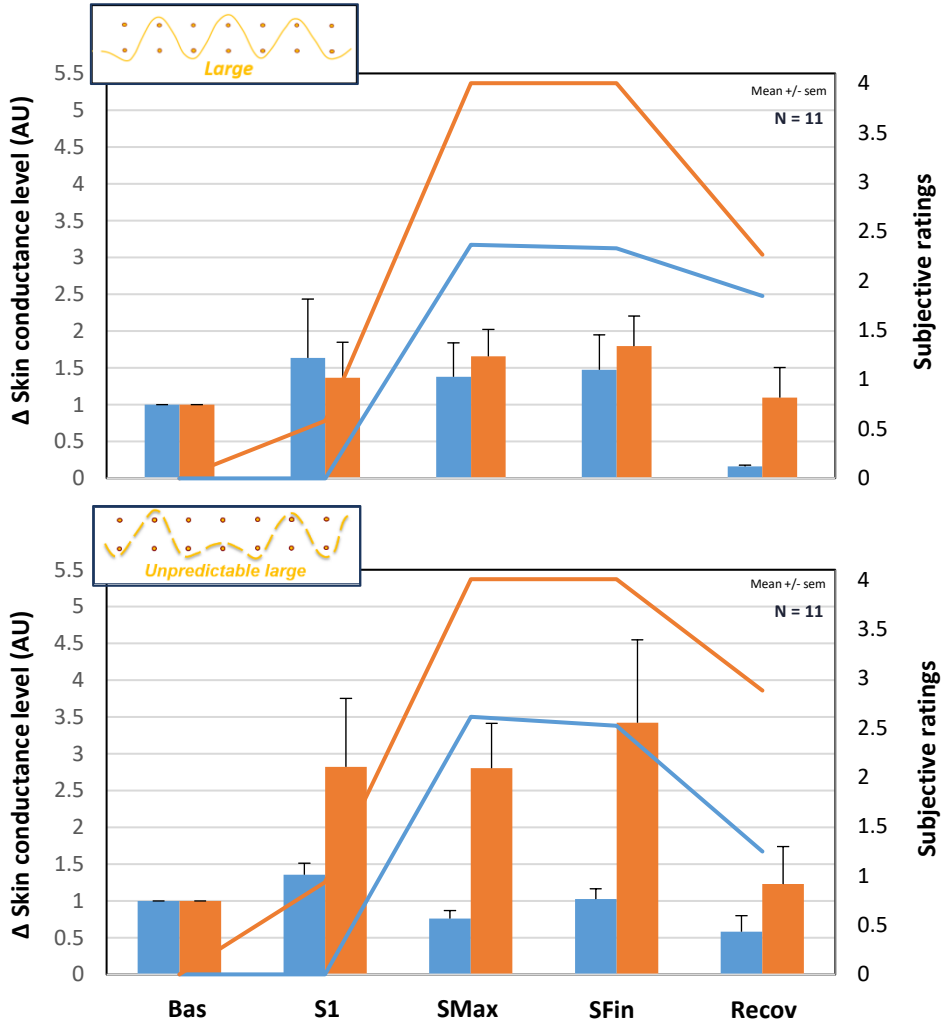




- During the slalom phase:
  - High increase for the high CS sensitivity group
  - Lower increase for the low CS sensitivity group
- Decrease for both group during the recovery phase

Physiological measurements : Skin conductance level





Low car sickness sensitivity

High car sickness sensitivity

- During the slalom phase in all conditions except large :
  - High increase for the high CS sensitivity group
  - Low increase for the low CS sensitivity group
- Decrease for both group during the recovery phase except for the small condition (High CS sensitivity group)

Conclusion & perspectives

✓ **Passengers' carsickness sensitivity increase with the higher acceleration level of the car and their incapacity to predict vehicle path**

Higher subjective ratings in the large condition than in the small condition

Higher subjective ratings in unpredictable conditions than in regular conditions

✓ **Passengers' physiological parameters change with carsickness symptoms occurrence**

Increase in heart rate variability, maximal inspiratory and expiratory amplitude, skin conductance level related to subjective ratings

✓ **Large inter-individual variability regarding subjective ratings and physiological parameters**

Further analysis needed with larger samples and in various driving conditions

Interest for machine learning process to detect early stages of carsickness occurrence

Thank you, any question?

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