Motion sickness, simulator sickness, and automated vehicles

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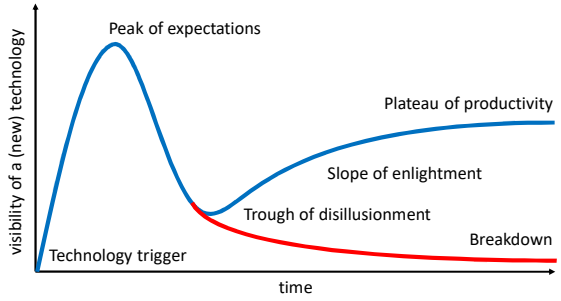
1st: Something different

- Or not ? -

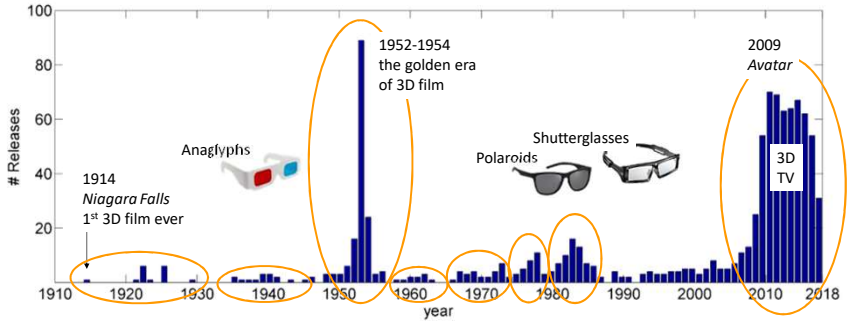
3D Films and the Gartner hype cycle

Gartner hype cycle



Cycle of repeated hype cycles

- e.g., 3D films -



Cycle of repeated hype cycles

- e.g., 3D films -

Why did these hypes fail repeatedly?

5-20% cannot "see" 3D
- stereoblindness, amblyopia, strabismus …

Virtual 3D ain't real (1)
- eyes move
- accommodation = fixed

} ≠ normal ⇒ ***headaches***

Virtual 3D ain't real (2)
- eyes "see" self-motion
- organs of balance don't feel

} ≠ normal ⇒ ***cybersickness***

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Cycle of repeated hype cycles

- e.g., 3D films -

Why did these hypes fail repeatedly?

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- stereoblindness

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Virtual 3D ain
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- organs of balance don't feel

} ≠ normal ⇒ ***cybersickness***

Could something similar apply to:
- driving simulators (simulator sickness) ?
- automated vehicles (carsickness) ?

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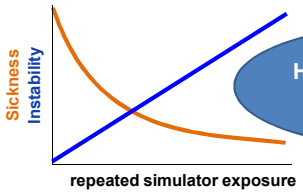
Driving simulators

Facts
- > 50% of trainings aborted due to simulator sickness = no exception
  - reduced transfer of training in those who are sick but do go on
- sickness relates to postural instability

(Kennedy & Stanney, 1996)



How do / should we deal with this ?

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Automated vehicles

Facts
- drivers don't get sick (expectation / anticipation)

https://www.youtube.com/watch?v=KJ-MPOUBNMA

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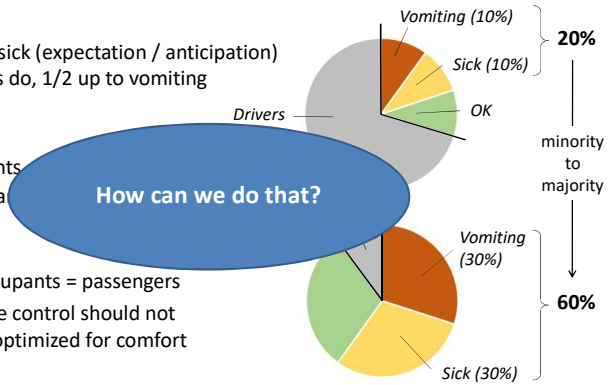
Automated vehicles

Facts
- drivers don't get sick (expectation / anticipation)
- 2/3 of passengers do, 1/2 up to vomiting

Currently
- 1/3 of all occupants
- that's why cars ca

Future
- 9/10 (?) of all occupants = passengers
- that's why AV ride control should not be sportive, but optimized for comfort



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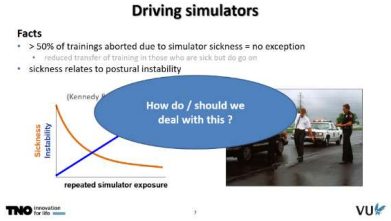

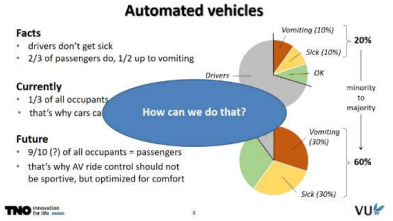

1st: By understanding motion sickness - What - Why / How -

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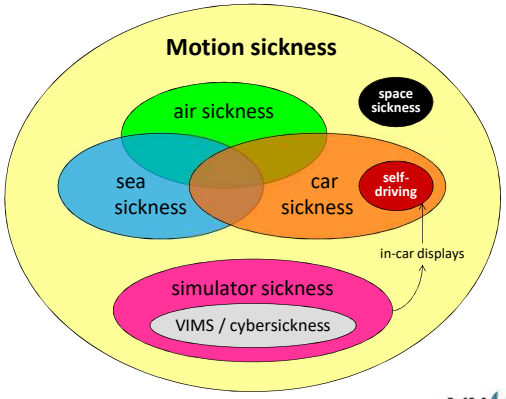
Motion sickness - What

- **camel sickness**
- **seasickness**
  - Greek "naus" = ship
- **airsickness**
- **car sickness**
  - driver rarely gets sick
  - passengers do!
- **space sickness**
  - no gravity!
- **simulator sickness**
  - fixed and moving base
  - in real ***no*** sickness
- **visually induced MS (VIMS)**
  - cinerama / cybersickness
  - always "fixed based"
  - computer displays / IMAX / VEs
  - (serious) gaming / internet



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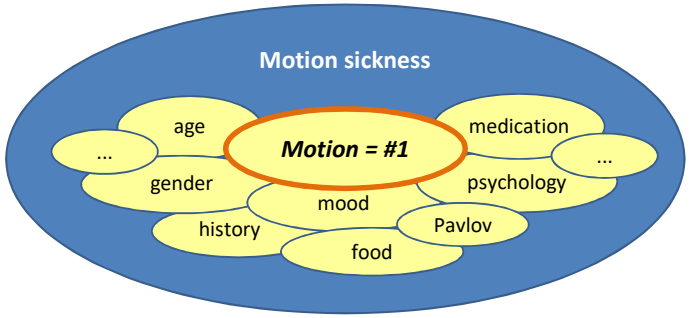
Motion sickness - What



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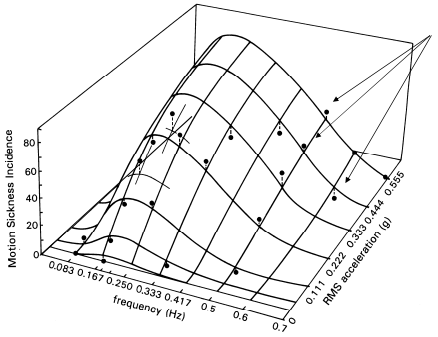
Motion sickness - What

Vertical sinusoidal motion (McCauley & O'Hanlon, 1970's)

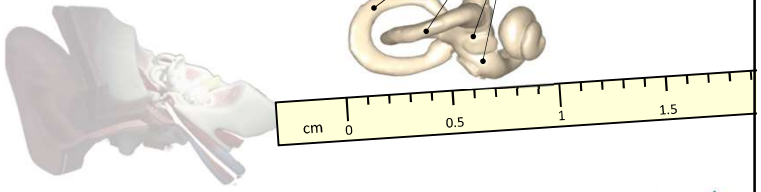


- % vomiters within 20 Ss and 2h
- ⇒ ΣSs > 500
- sickness peaks @ 0.16 Hz
- a(n arbitray) mathematical fit
- + obs. @ sea = ISO2631-1(1997)

Motion sickness - What

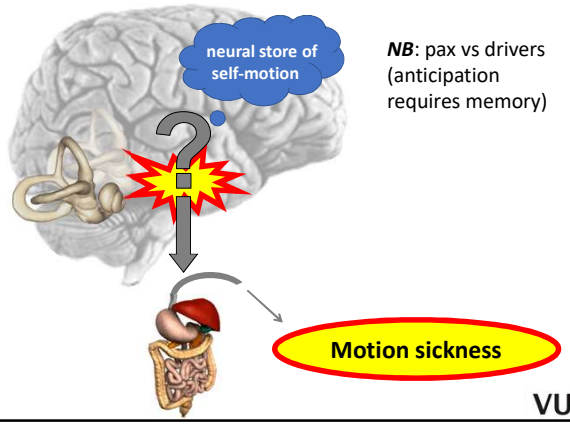
Key = organs of balance

- people ***without*** functioning organs of balance (e.g., deaf mutes) do ***not*** suffer from motion sickness ...
- ***NB1***: **not** even from **VIMS**
- ***NB2***: **blind** people **do** suffer
  - as do sighted people with eyes closed



Motion sickness - Why / How

NB: people without ...



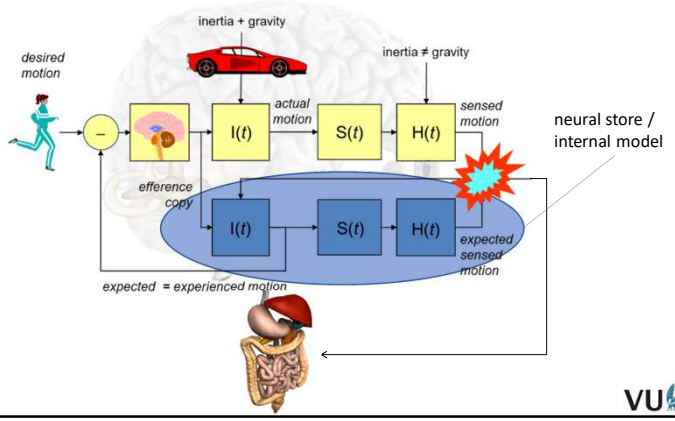
NB: pax vs drivers (anticipation requires memory)

Motion sickness - Why / How

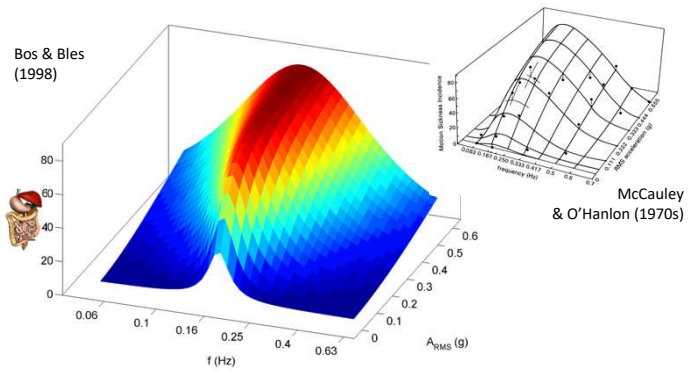
Framework = control of self-motion

NB1: sickness relates to postural stability

NB2: anticipation requires memory



Motion sickness



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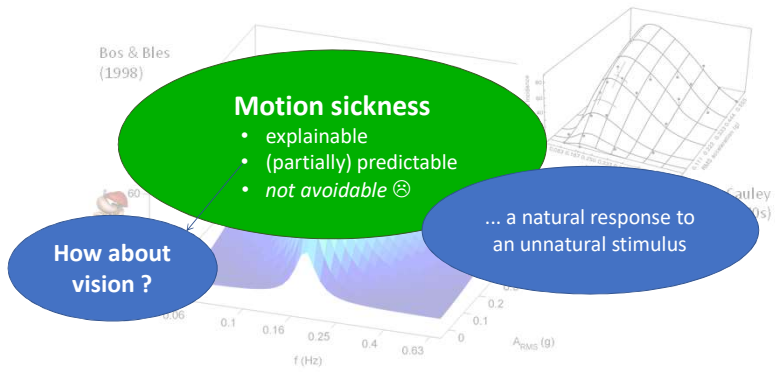
Motion sickness



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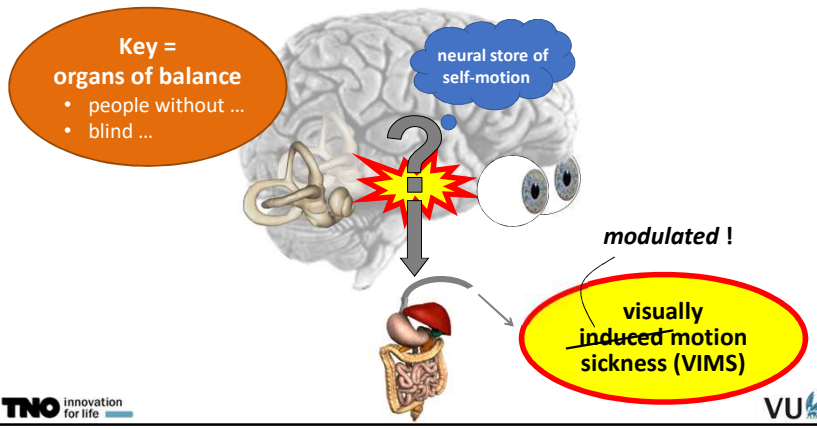
Motion sickness



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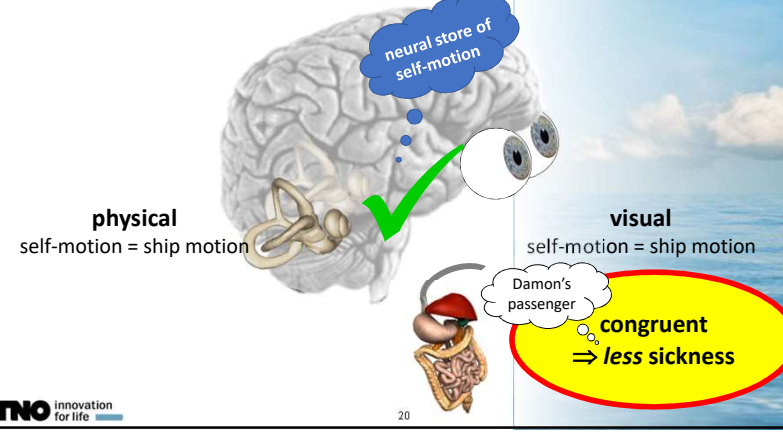
Visually modulated motion sickness ($^1/_4$)



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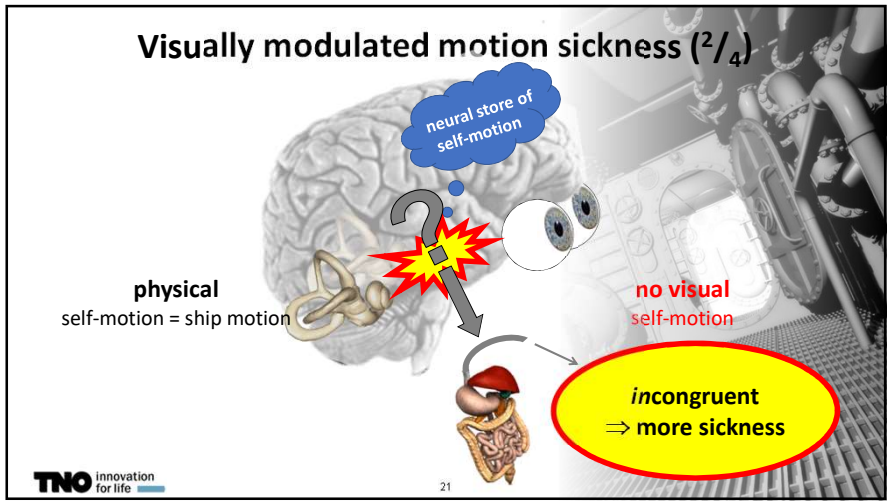

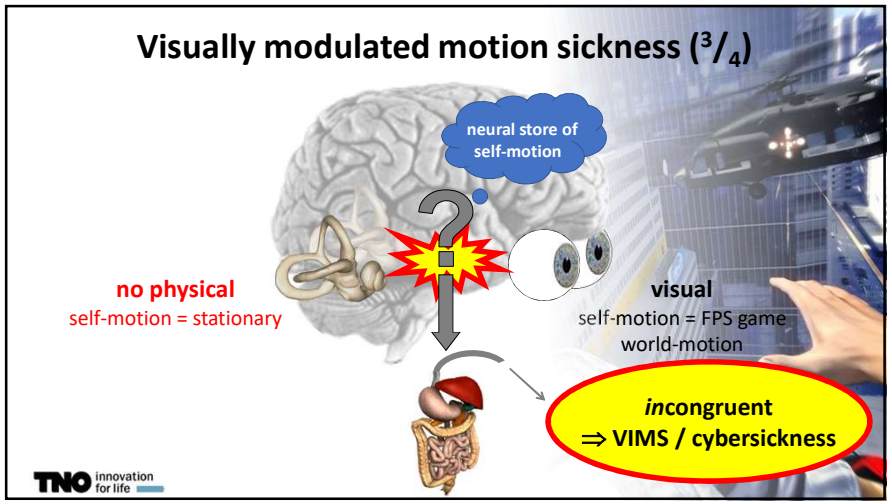

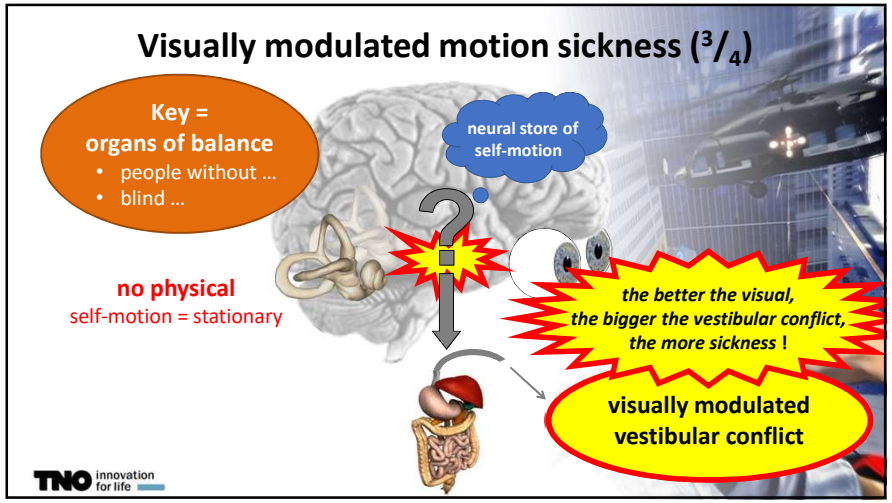

The better the visual, … the more sickness

Field of view (FOV)

- in general: the larger (better) the more sickness
- holds for viewer/screen configuration = external FOV (eFOV)
- but there is also an internal FOV (iFOV) or “zoomfactor”

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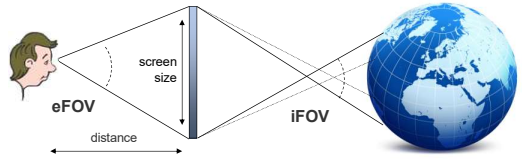
The better the visual, ... the more sickness



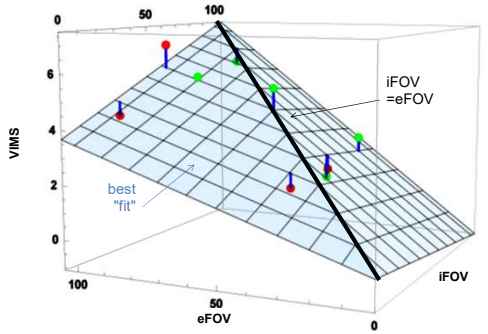
Van Emmerik et al. (2011)

e.g. small iFOV

e.g. large iFOV

Q: VIMS min or max when iFOV = eFOV ?

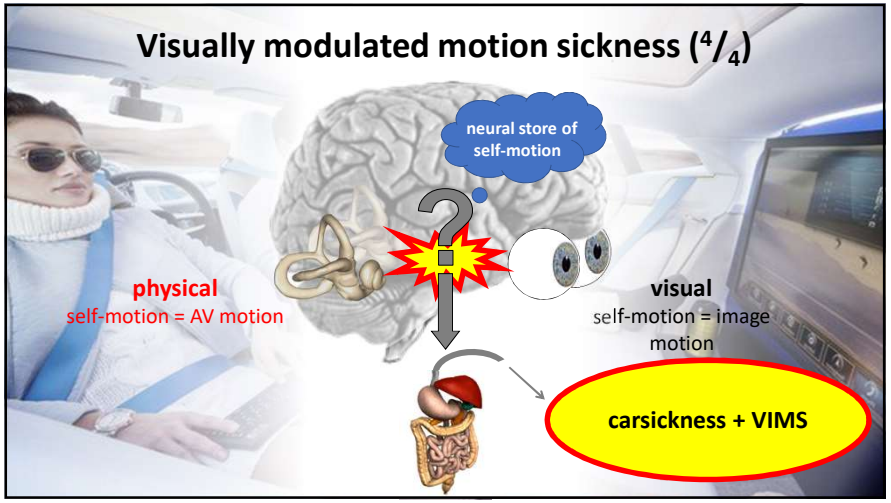
The better the visual, ... the more sickness



N = 60 Ss

A: VIMS max when iFOV = eFOV !

Visually modulated motion sickness ($^4/_4$)



Driving simulators

Facts
- > 50% of trainings aborted due to simulator sickness = no exception
- sickness relates to postural instability

How do / should we deal with this ?

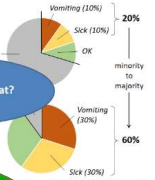
Automated vehicles

Facts
- drivers don't get sick
- 2/3 of passengers do, 1/2 up to vomiting

Currently
- 1/3 of all occupants
- that's why cars ca

Future
- 9/10 (?) of all occupants = passengers

How can we do that?



1st:
By understanding motion sickness

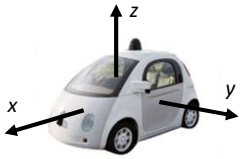
2nd:
Based on this understanding: optimizing
- motion cueing algorithms (MCAs, simulators)
- ride control systems (RCSs, AVs)

Optimising MCAs and RCSs

- By minimizing sickness -

Knowledge required about

- longitudinal motion (x, accelerating & braking)
- lateral motion (*y*, steering/cornering)
- vertical motion (*z*, suspension)
- visual factors



However, current motion sickness knowledge

- largely limited to vertical (*z*) ship motion
  - ISO2631-1 (1997), not validated for
    - car motion
    - visual factors

Therefore …

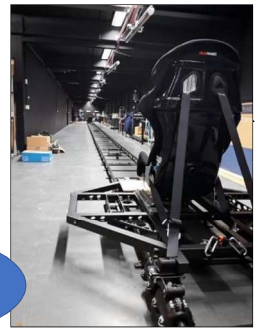
Optimising MCAs and RCSs

- By minimizing sickness -

Joint Industry Project proposed to study

- longitudinal motion (x, accelerating & braking)
- lateral motion (*y*, steering/cornering)
- vertical motion (*z*, suspension)
- visual factors
- TNO (NL) + Coventry University (UK)
- Precompetitive (fundamental / low TRL)
- using
  - a 45 m linear sled
  - a test track
  - on road data

Industry partners still welcome



Motion sickness, simulator sickness, and automated vehicles

Then: motion sickness

- explainable
- predictable
- *not avoidable* ☹
- **manageable** ☺

… a natural response to an unnatural stimulus

By optimization of

- motion cueing algorithms (simulators)
- ride control systems (AVs)

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Some references

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