RUMBA

Achieving a positive user experience through user-friendly design of the vehicle interior for automated driving functions

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Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

# Non-driving related task engagement in highly automated vehicles: **How to mitigate emerging motion sickness?**

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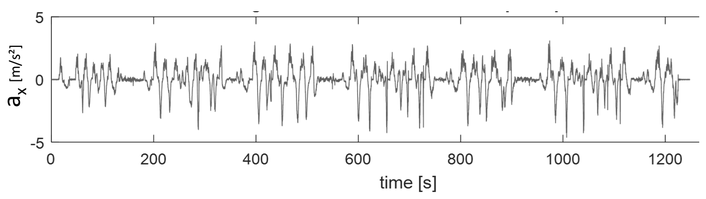
## 1 | Introduction

- Passengers in highly automated vehicles may develop motion sickness when engaging in non-driving related tasks. What can we do about it?
- Published studies confirm effectiveness of selected countermeasures (e.g. Karjanto et al., 2018; Kuiper et al., 2020 or Bohrmann & Bengler, 2019) or indicate (unexpected) ineffectiveness of countermeasures (e.g. Golding et al., 2003)
- Objective of this study: Replication of existing findings and comparison of three countermeasures in terms of effectiveness to mitigate motion sickness in a highly controlled, yet realistic experimental setting

## 2 | Method

- N = 28 test participants (50/50 % female/male), aged between 23 and 47 years
- Pre-screened participants for increased susceptibility to motion sickness (mean susceptibility according to Golding (2006) representing the 75th percentile of population)
- Ride in automated vehicle on test track with highly reproducible fore-aft acceleration profile:




- Non-driving related task: Reading text on a handheld tablet
- Within-subject design with counterbalanced order of test conditions
- Independent variable: Type of countermeasure (see top right)
- Dependent variable: Differences between pre- and post-drive motion sickness scores measured by the Motion Sickness Assessment Questionnaire (MSAQ) according to Gianaros et al., 2001 (Delta MSAQ)

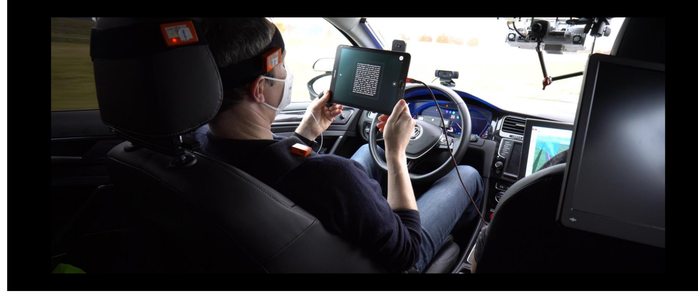
## 3 | Countermeasures

**No countermeasure** (control condition)

**Dynamic seat adjustments** (during accelerations)

**Visual anticipatory cues** (preview of 1.3 s)

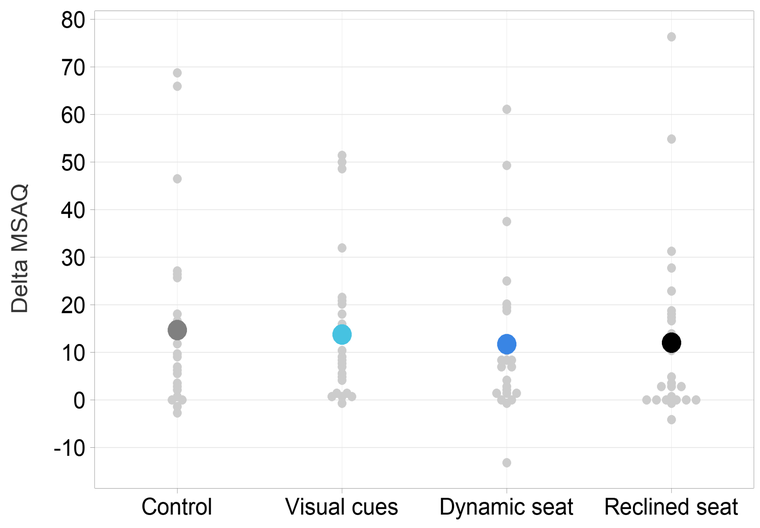

**Reclined seating** (increase of backrest angle by 15°)



## 4 | Results

### General effects on motion sickness mitigation

- Distribution of individual Delta MSAQ scores (coloured circles indicate the mean value):




- No statistically significant differences in increase of MSAQ scores (Delta MSAQ) between test conditions ($\chi^2(3) = 4.79$, $p = 0.188$, $N = 28$)

### Inter-individual differences

- Individual impact of countermeasures compared to the control condition (in terms of differences between Delta MSAQ scores):

| ID | Visual cues | Dynamic seat | Reclined seat |
|---|---|---|---|
| 1 | -2.08 | -4.86 | -5.56 |
| 2 | -0.69 | 0.00 | 0.00 |
| 3 | -6.25 | -5.56 | -18.06 |
| 4 | 4.17 | -9.72 | -13.89 |
| 5 | -17.36 | -16.67 | -34.72 |
| 6 | 10.42 | 13.89 | 6.25 |
| 7 | -16.67 | -6.94 | -9.72 |
| 8 | 6.25 | 4.17 | 4.17 |
| 9 | 2.08 | -2.78 | -6.94 |
| 10 | -1.39 | -0.69 | -2.08 |
| 11 | 2.78 | 0.00 | 0.00 |
| 12 | -4.17 | 6.94 | 4.86 |
| 13 | 9.03 | 13.19 | -2.78 |
| 14 | -11.81 | -38.89 | -2.78 |
| 15 | -8.33 | -24.31 | -8.33 |
| 16 | 20.14 | -12.50 | -11.81 |
| 17 | -22.92 | -14.58 | -13.19 |
| 18 | -2.08 | 5.56 | -2.78 |
| 19 | 1.39 | 2.08 | 27.78 |
| 20 | 3.47 | 0.69 | 0.69 |
| 21 | -17.36 | -31.25 | 7.64 |
| 22 | 6.94 | 4.86 | 1.39 |
| 23 | -5.56 | -6.25 | -6.25 |
| 24 | 10.42 | 0.69 | -6.94 |
| 25 | 3.47 | 14.58 | 8.33 |
| 26 | -0.69 | 15.97 | 7.64 |
| 27 | 6.25 | 0.69 | 0.00 |
| 28 | 3.47 | 9.72 | 2.08 |

- All countermeasures seem to mitigate motion sickness for some participants, but increase it for others compared to the control condition

## 5 | Discussion

- On average, no effect of any countermeasure: Study does not replicate effects from reference studies (see introduction):
  - Visual cues: inappropriate HMI modality?
  - Dynamic seat adjustment and reclined seating: inadequate implementation of countermeasure?
- Large interindividual differences in how participants respond to a countermeasure:
  - Personalized effectivity?
  - Impact of placebo effect?
  - Reliability of individual response?

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https://projekt-rumba.de/