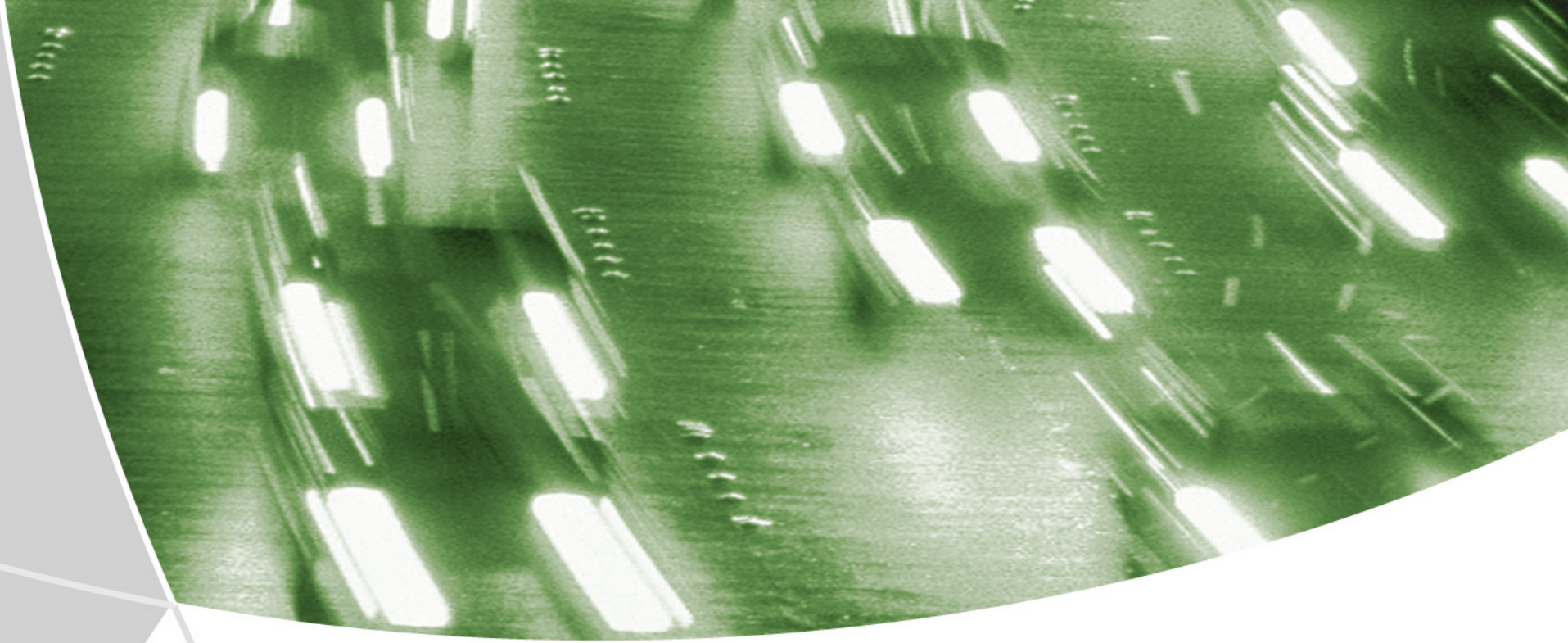


Do you feel the difference?

A motion assessment study

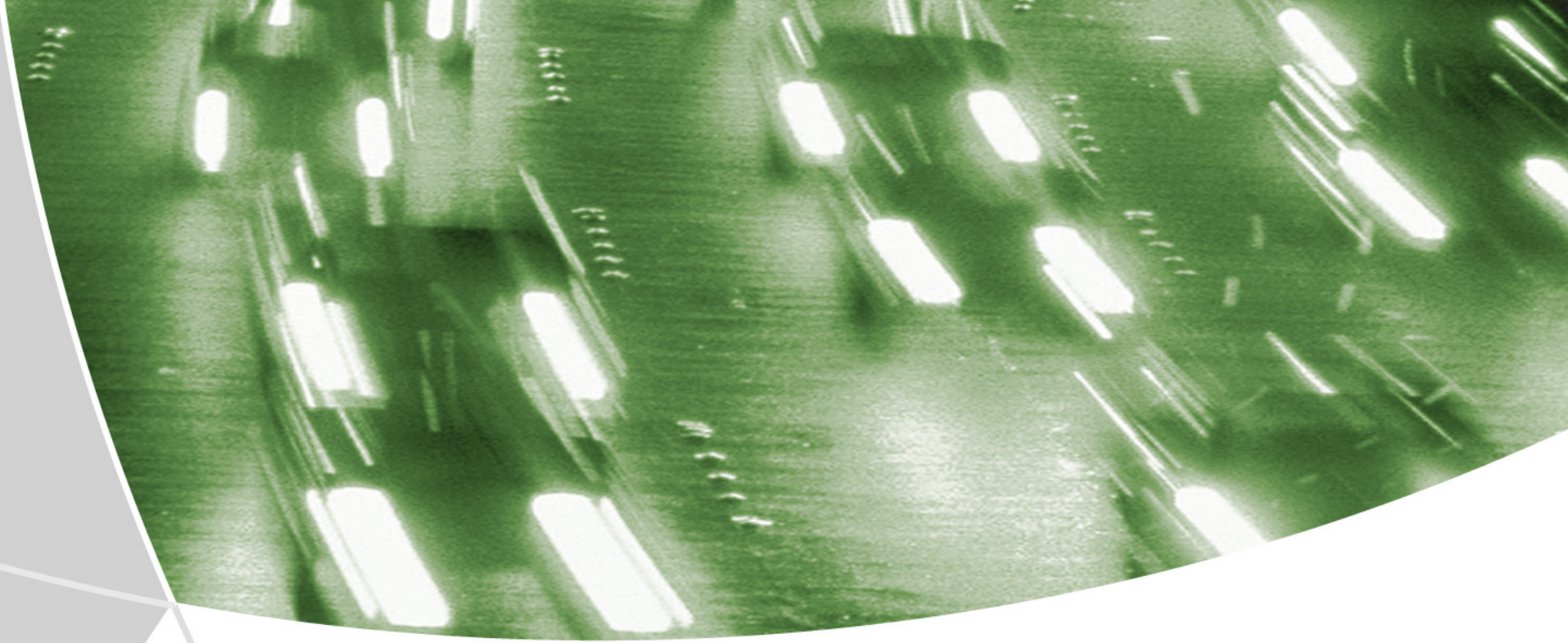
DSC Asia-Pacific, 01.06.06

M. Brünger-Koch, S. Briest, M. Vollrath

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Agenda

- Introduction
- Experiment Design
- Experiment Results
  - Braking
  - Curve Driving
  - General Findings
- Summary



Introduction

German Aerospace Center

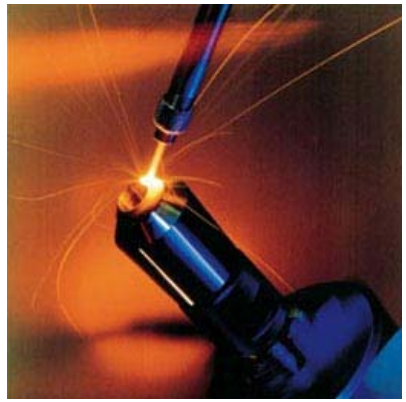
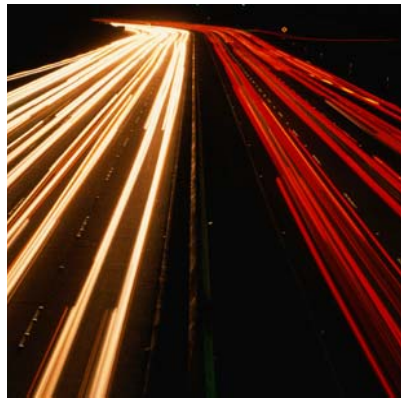
Exploratory Focuses

- aeronautics
- astronautics
- energy
- transportation

DLR numerical

- Budget:
  2004 1.194 m Euro
  2005 1.168 m Euro
- Scientific competence:
  Circa 5.100 employees, including about 2.300 scientists



Institutes and services of the DLR
Sites

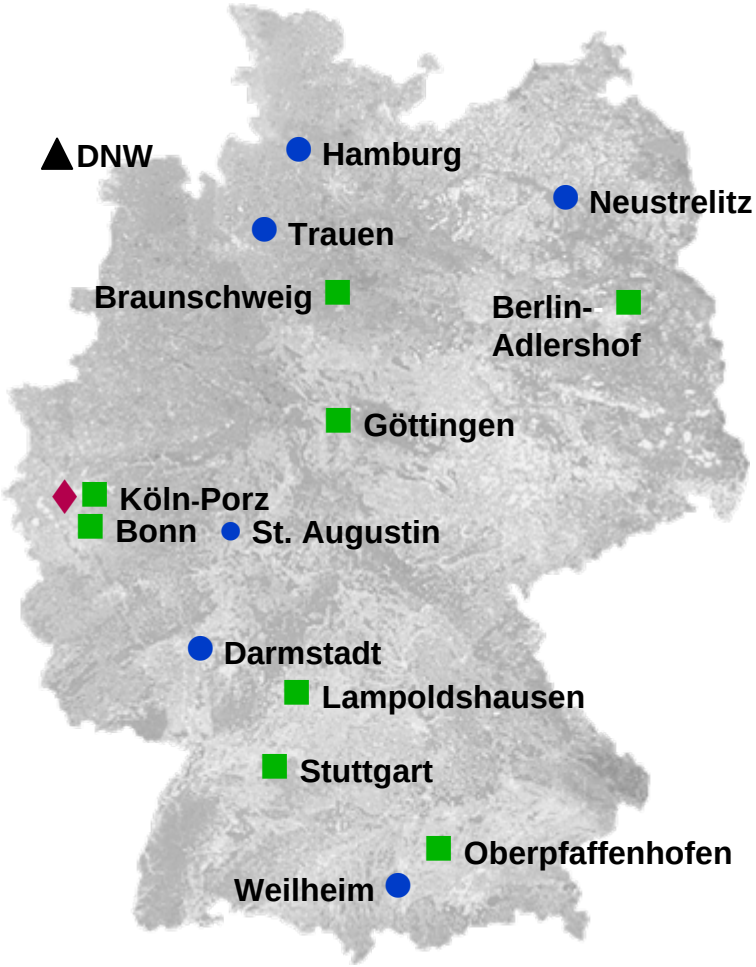
31 research institutes and scientific/technical facilities at

- 8 sites
- 6 outposts

Offices abroad in Brussels, Paris und Washington.

DLR participates in:

- European Transonic Wind Tunnel (ETW)
- German-Dutch Wind Tunnels (DNW)



Institute of Transportation Systems

Residence: Braunschweig

Since: March 2001

Director: Prof. Dr.-Ing. Karsten Lemmer

Employees: Presently 59 employees from various scientific disciplines

Range of tasks

- Basic research
- Creating concepts and strategies
- Prototype development

Fields of Research

- Automotive
- Railway Systems

Technical Equipment

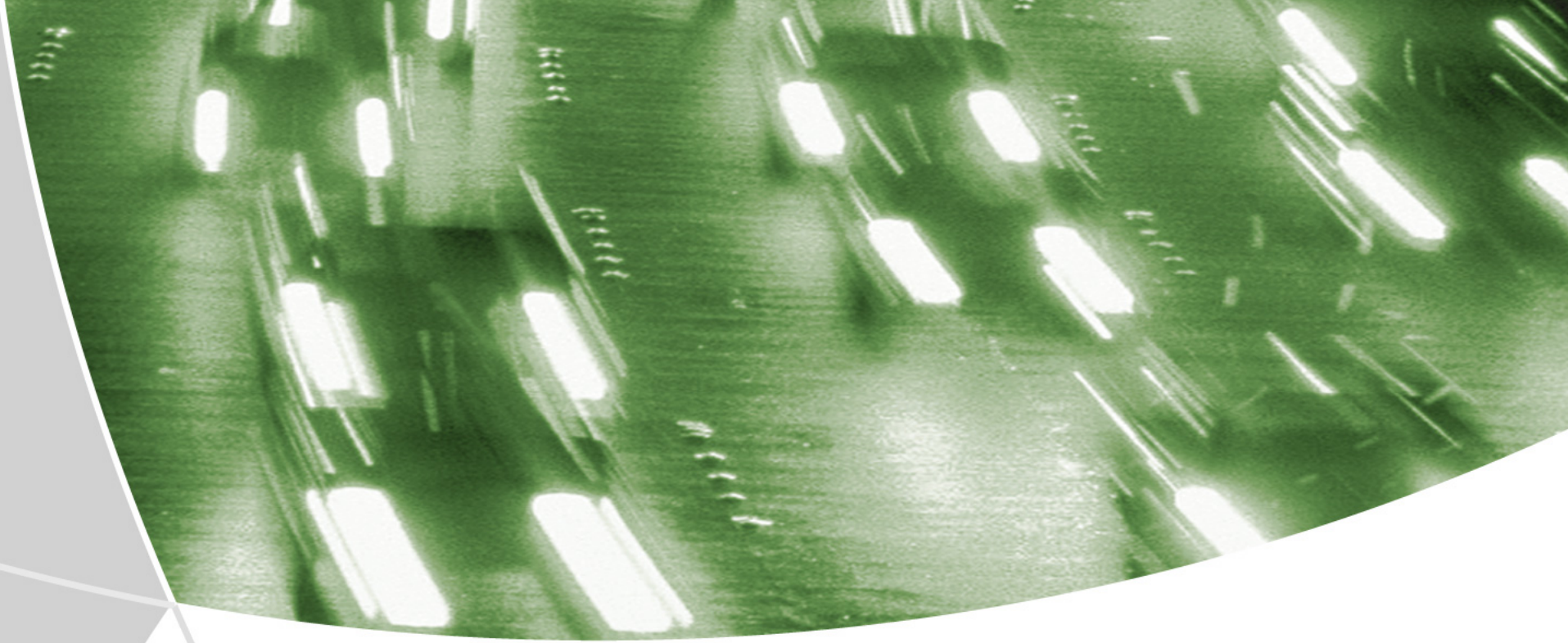
ViewCar

VR-Lab

Simulator

Simulator limits

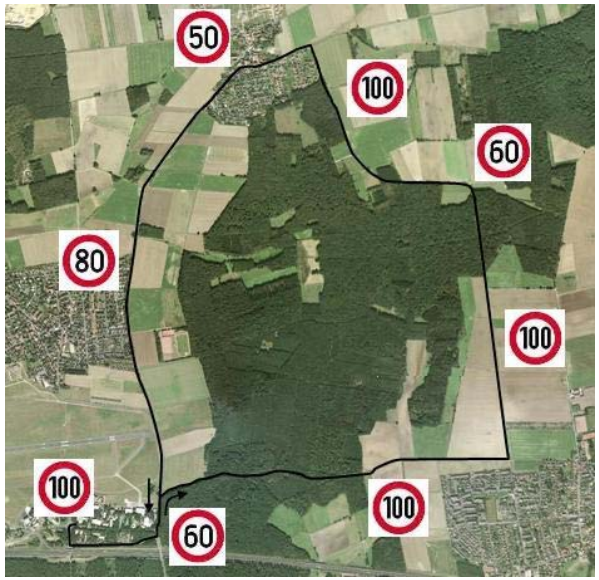
	Position	Acceleration		Position	Acceleration
Surge	±1,5 m	±10 m/s²	**Roll**	±21 °	±250 °/s²
Sway	±1,4 m	±10 m/s²	**Pitch**	±21 °	±250 °/s²
Heave	±1,4 m	±10 m/s²	**Yaw**	±21 °	±250 °/s²

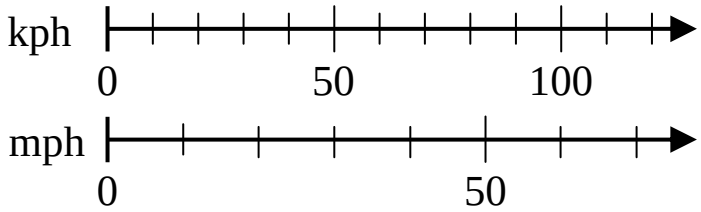


Experiment Design

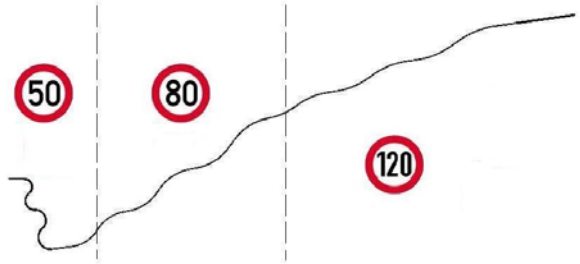
Experiment Design
Track Design

- S1 (virtual) vs. R (real)

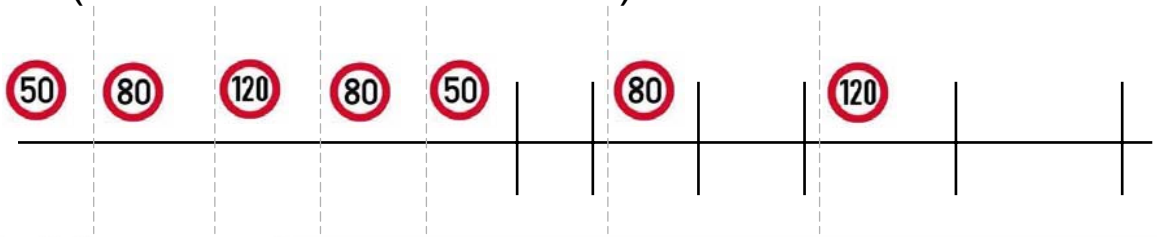




- S2 (curve driving)



- S3 (acceleration/deceleration)



Experiment Design
Parameter Variation

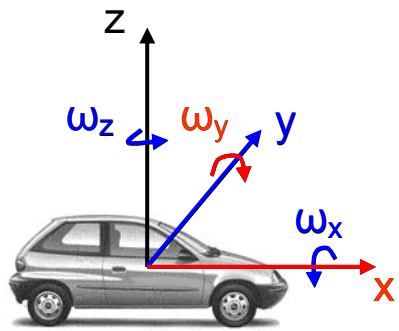
- Acceleration vector for different manouevres
  - Curve driving:

    a_y, w_x, w_z
  - Braking:

    a_x, ω_y

$$\bar{a} = \begin{bmatrix} a_x \\ a_y \\ a_z \end{bmatrix}$$

$$\bar{\omega} = \begin{bmatrix} w_x \\ w_y \\ w_z \end{bmatrix}$$



- Here: no common components (DoF).

  ⇒ Different parameters for tuning (CWA)

Manoeuvre	*Parameter Set-up* a	b	c
Curve Driving			
Braking			

1: Original tuning
2: DLR tuning

Experiment Design
Effect of Parameter Sets I

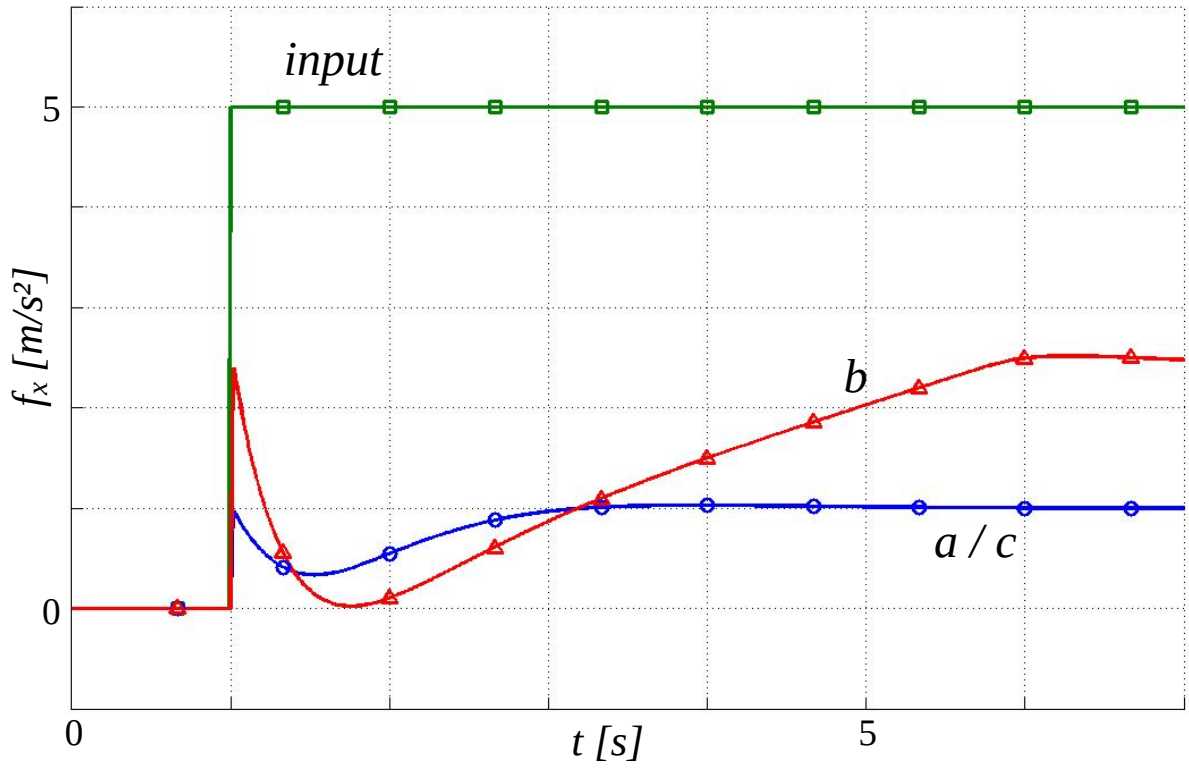
- Set a and c vs. b – accelerating and braking

set a / c

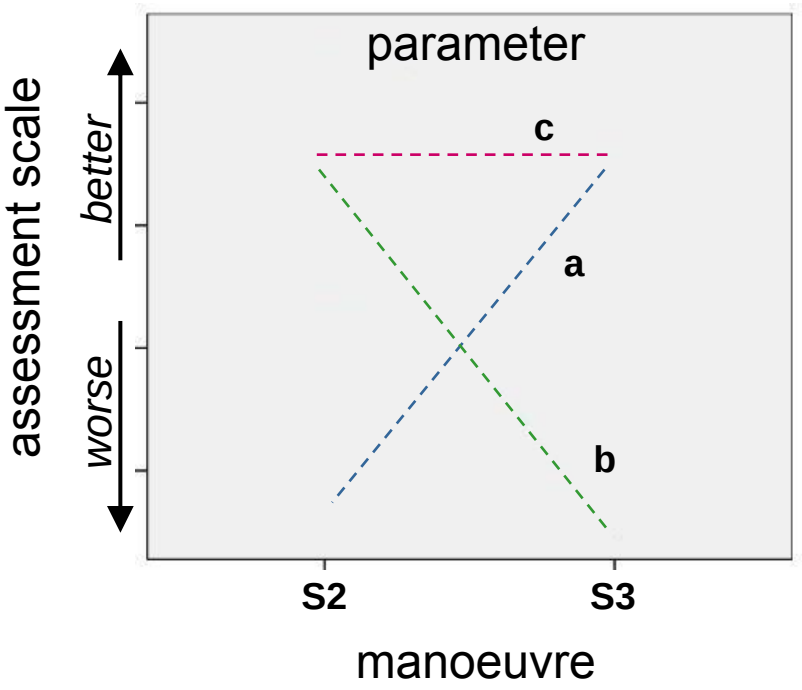
set b

Experiment Design
Effect of Parameter Sets II

- Set a and c vs. b – step input response (f_x)

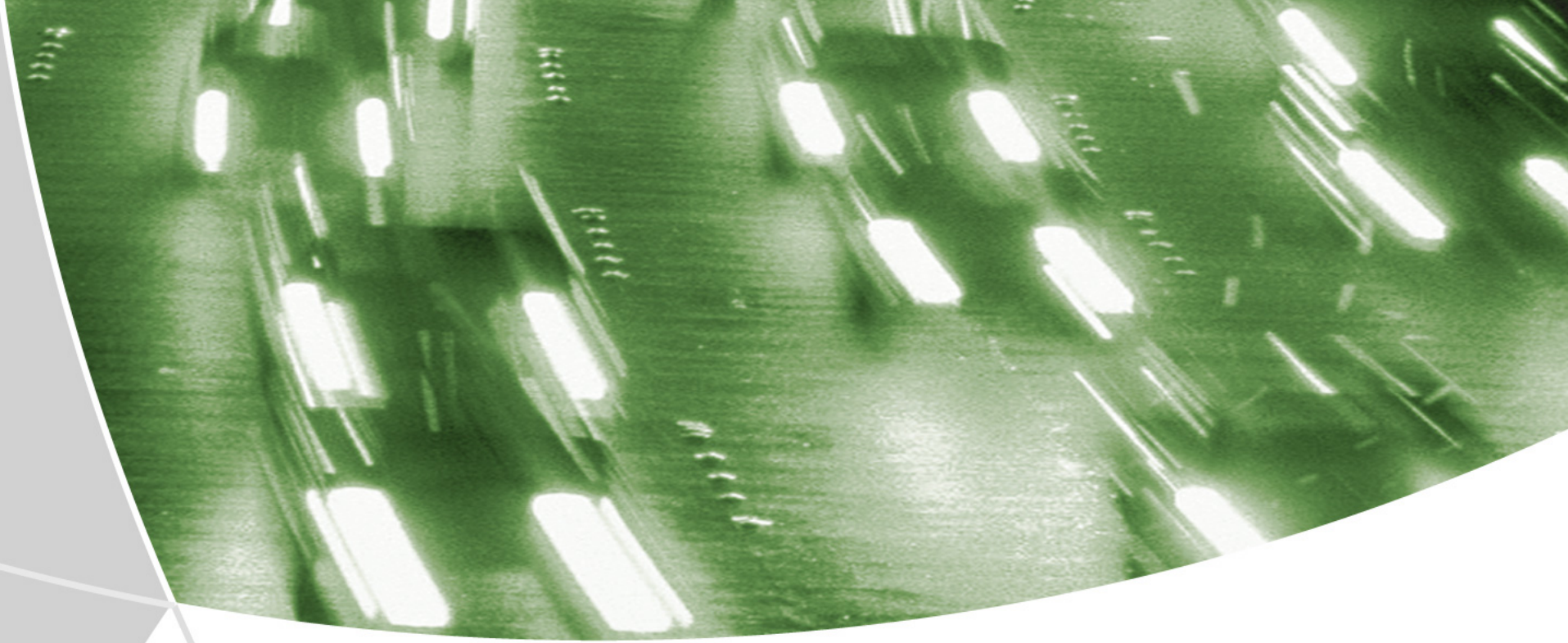


Experiment Design
Hypothesis



Hypothesis 1:
a is bad for curve driving

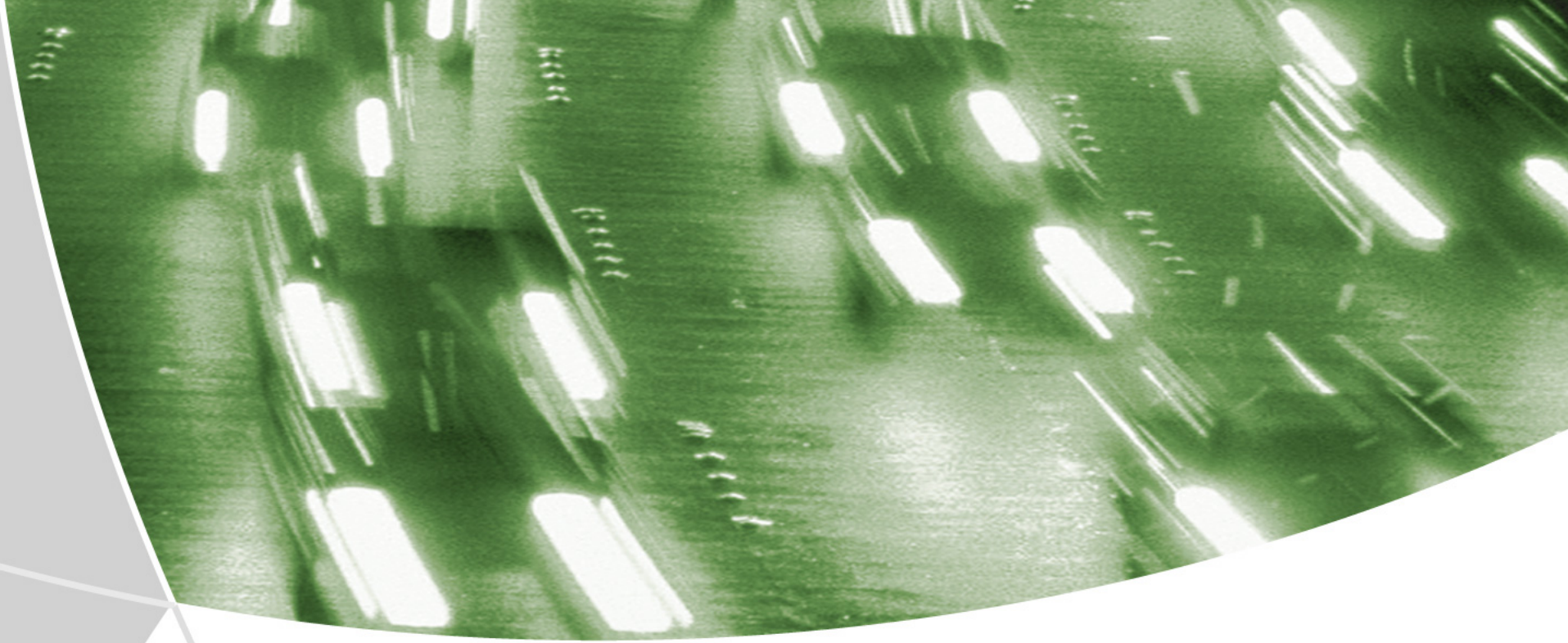
Hypothesis 2:
b is bad for braking



Experiment Results

Analytic Methods
Overview

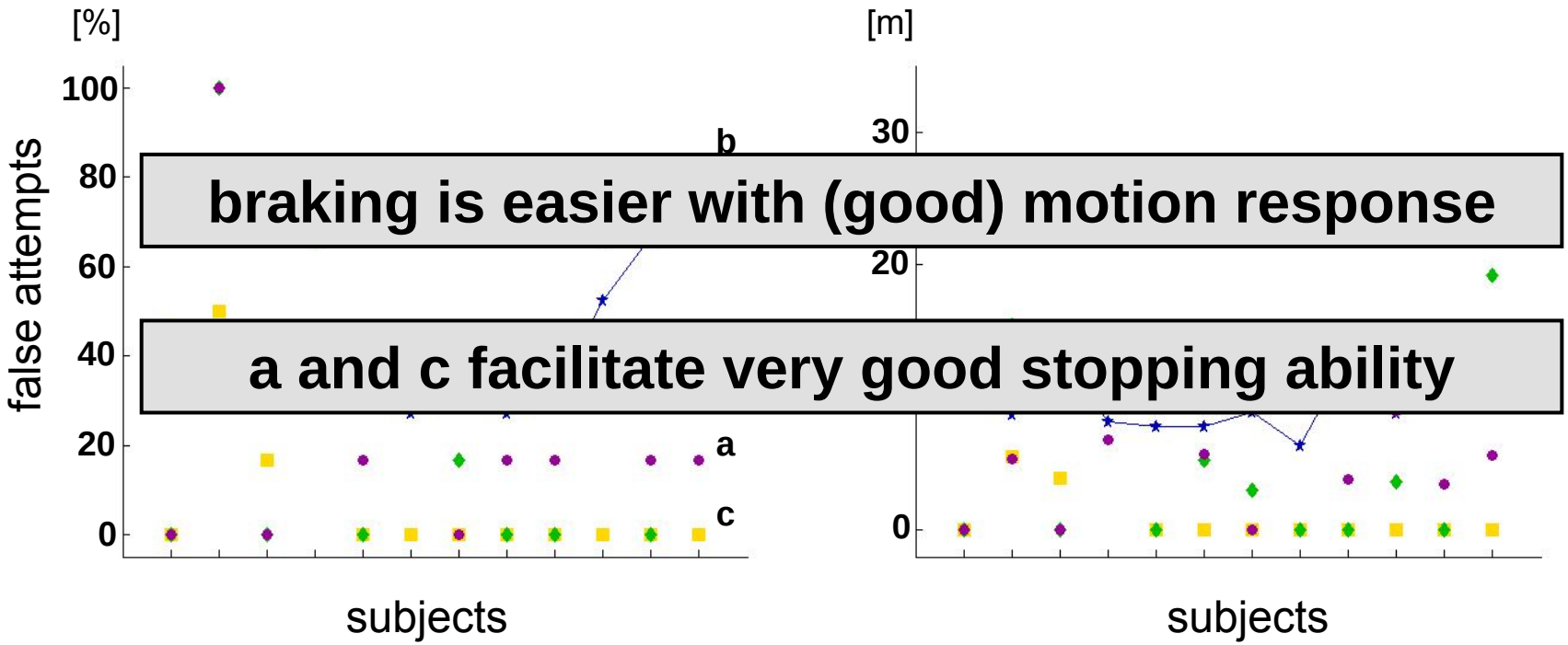
- Analytic focus
  - Braking
  - Curve driving
  - Virtual vs. real
  - Simulator sickness
- Data sources
  - Recorded data (objective assessment)
  - Questionnaires (subjective assessment)
- Independent variables
  - Parameter set — a, b, c
  - Speed zone — 50, 80, 120 [kph]



Experiment Results
Braking

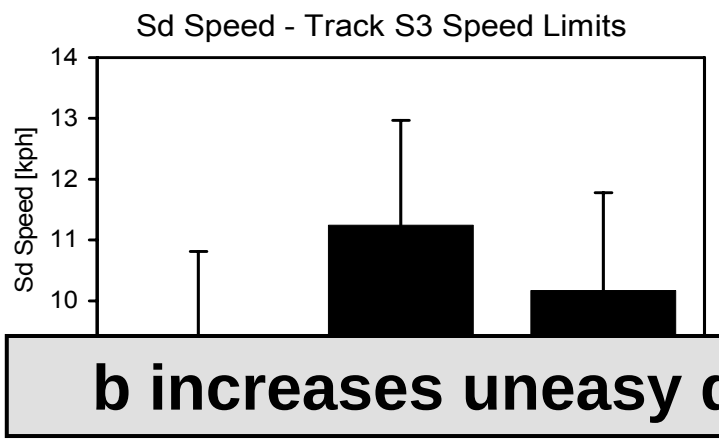
Braking
Accurate Stopping Ability

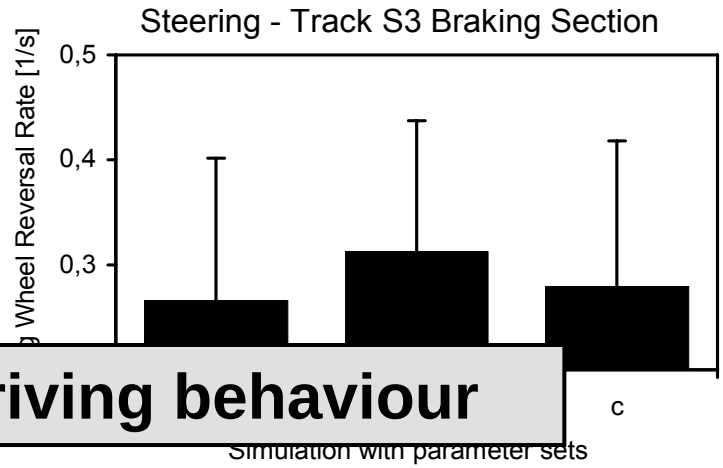
- task: stop at stopping line
- measure: DTI (distance to intersection) → false for abs(DTI) > 3m



Braking
Track Statistics

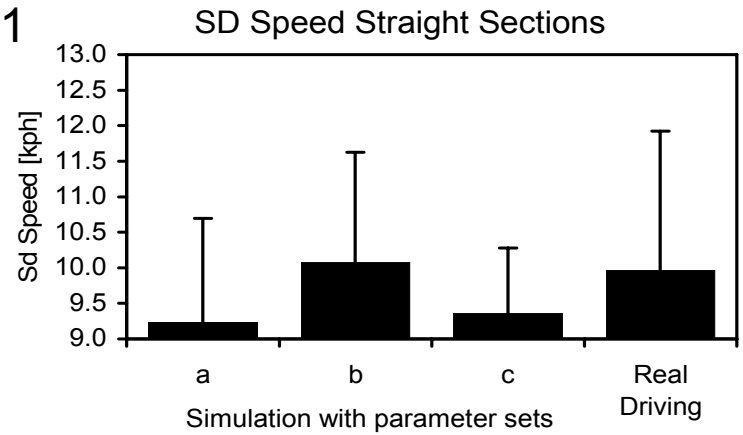
- S3



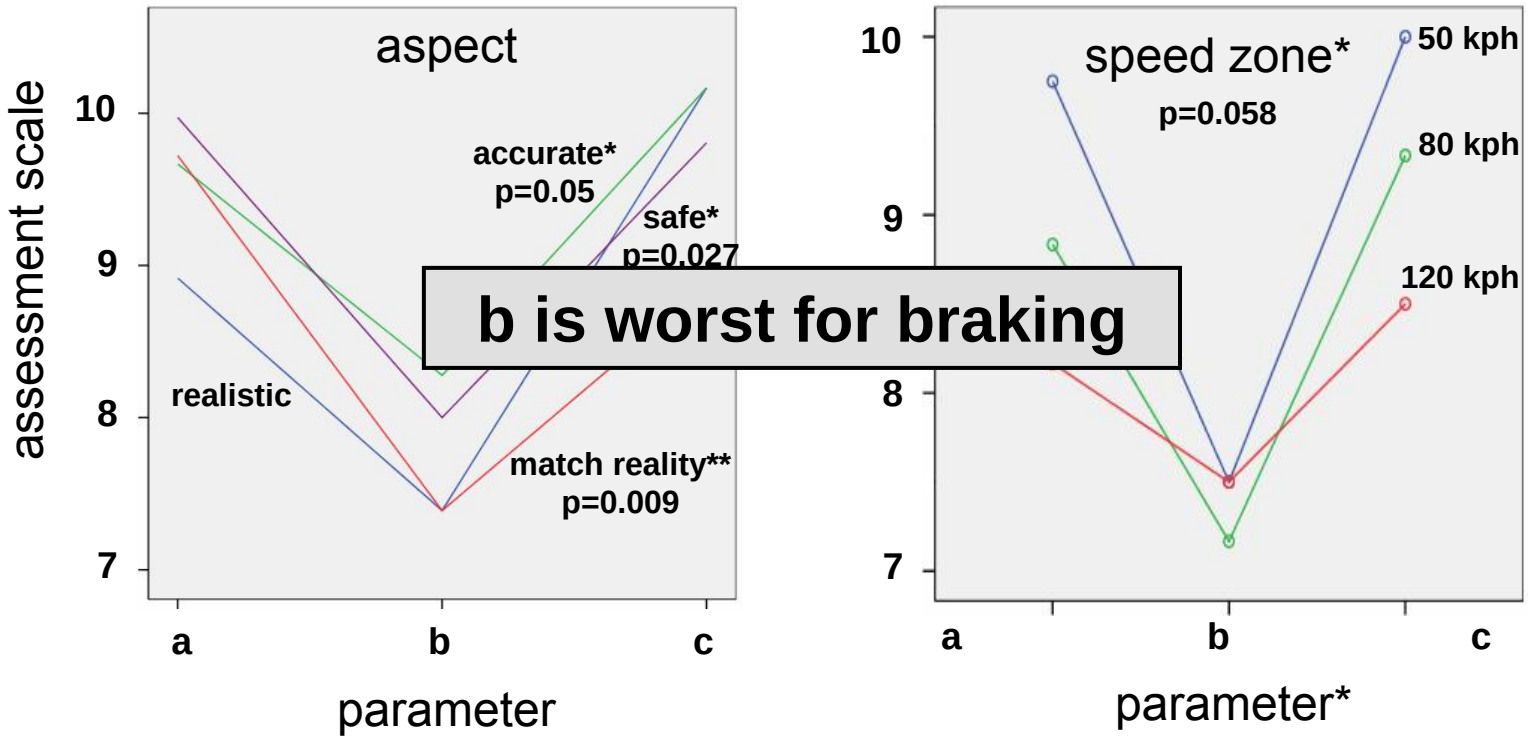


b increases uneasy driving behaviour

- S1

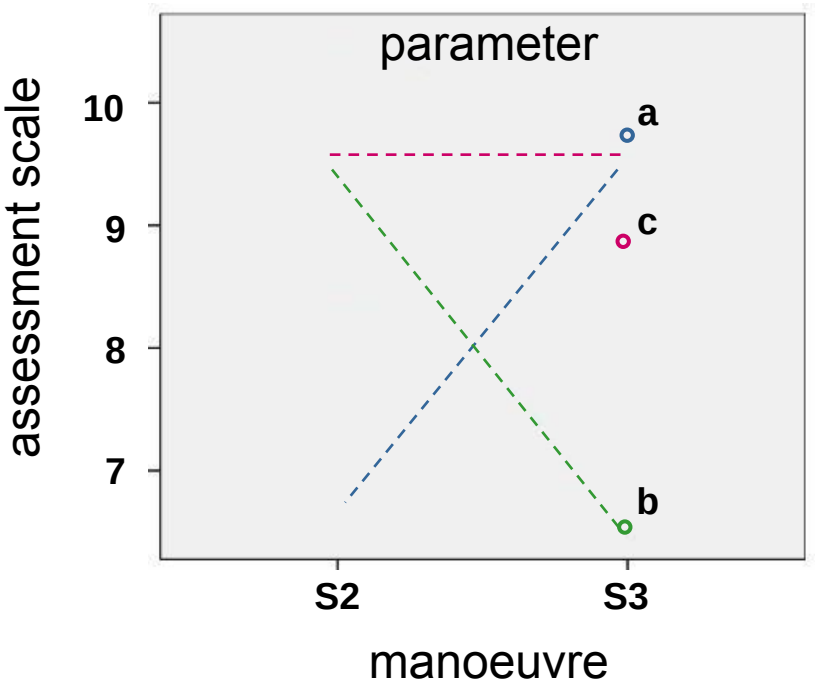


Braking
Assessment



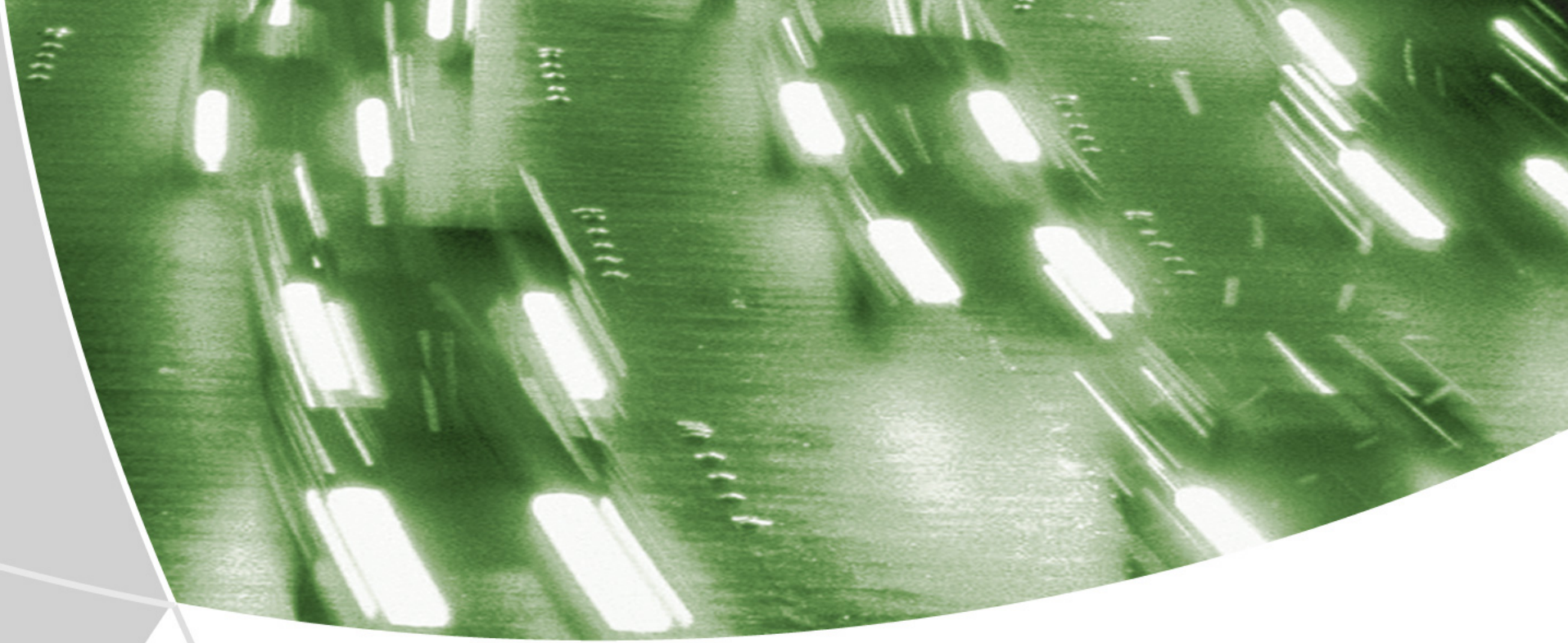
Braking
Hypothesis Check

How well do the movements match reality?



Hypothesis 1:
a is bad for curve driving

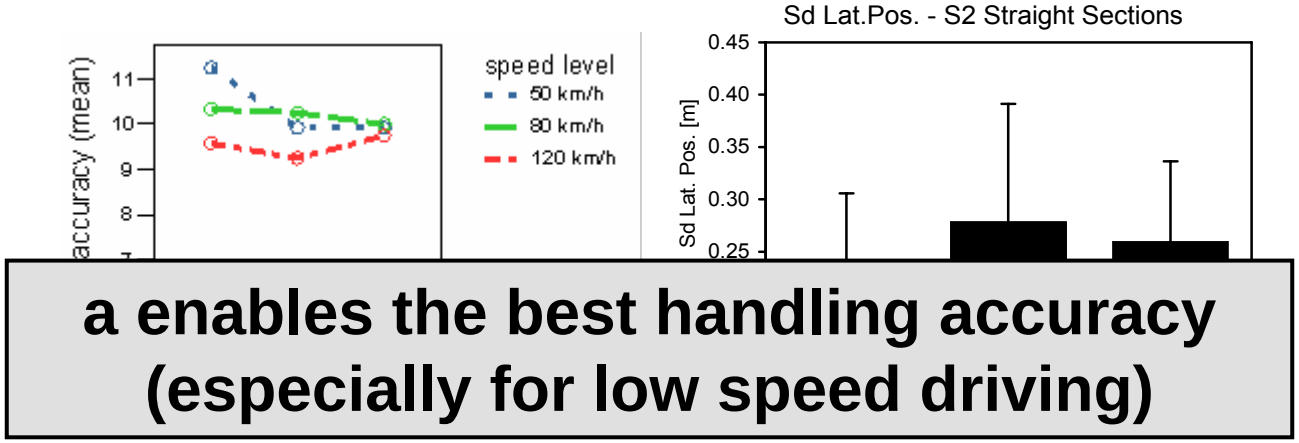
Hypothesis 2:
b is bad for braking ✓



Experiment Results
Curve Driving

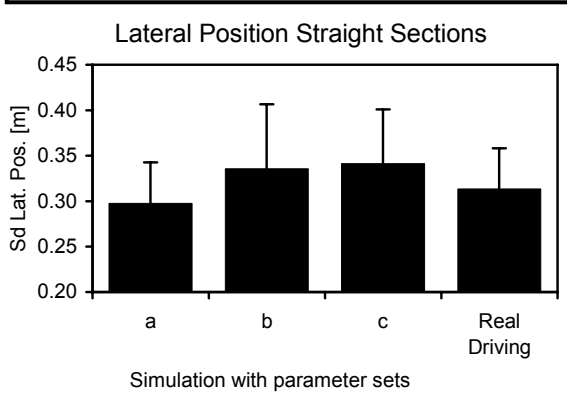
Curve Driving
Handling Accuracy

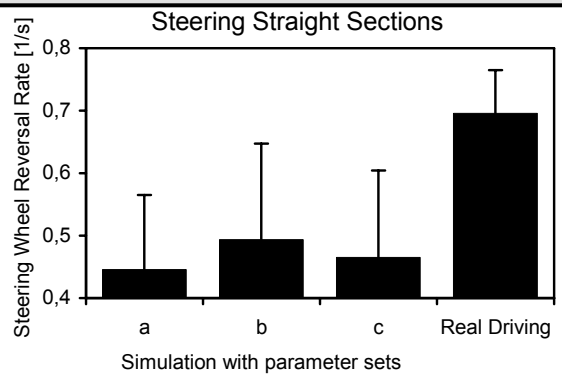
- S2



a enables the best handling accuracy (especially for low speed driving)

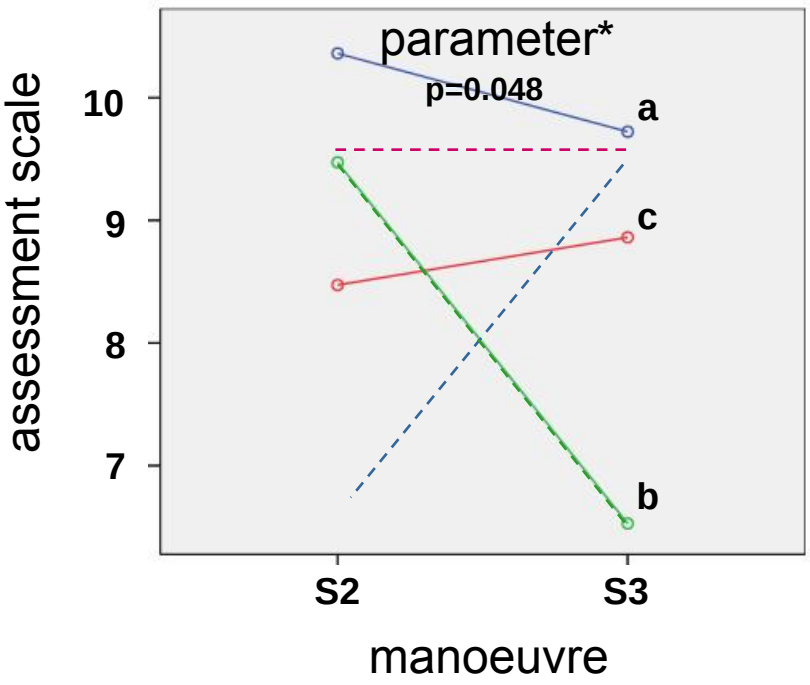
- S1





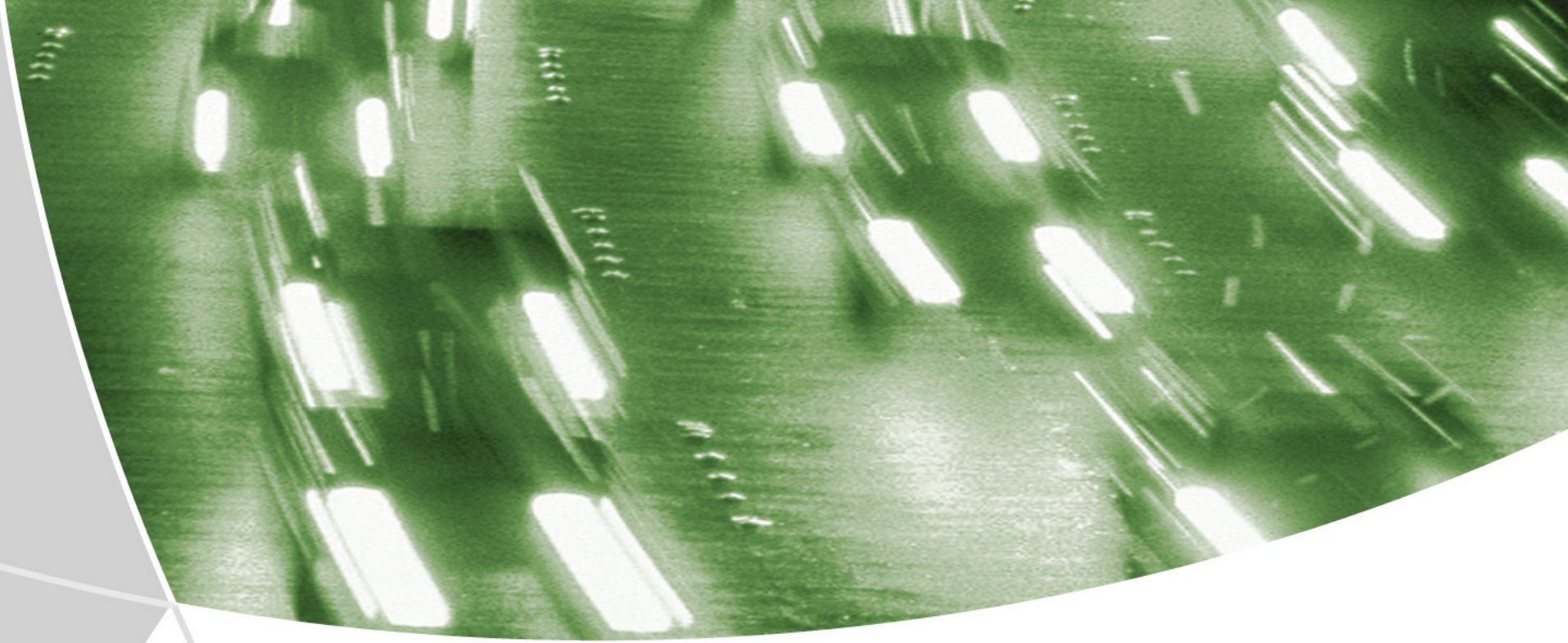
Curve Driving
Hypothesis Check

How well do the movements match reality?



Hypothesis 1: a is bad for curve driving ✗

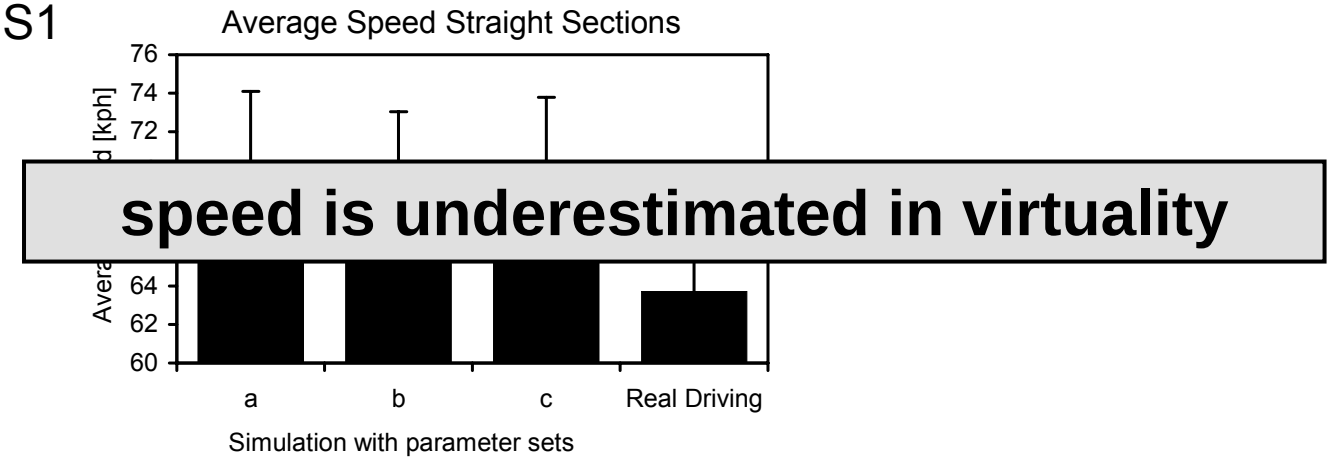
Hypothesis 2: b is bad for braking ✓



Experiment Results
General Findings

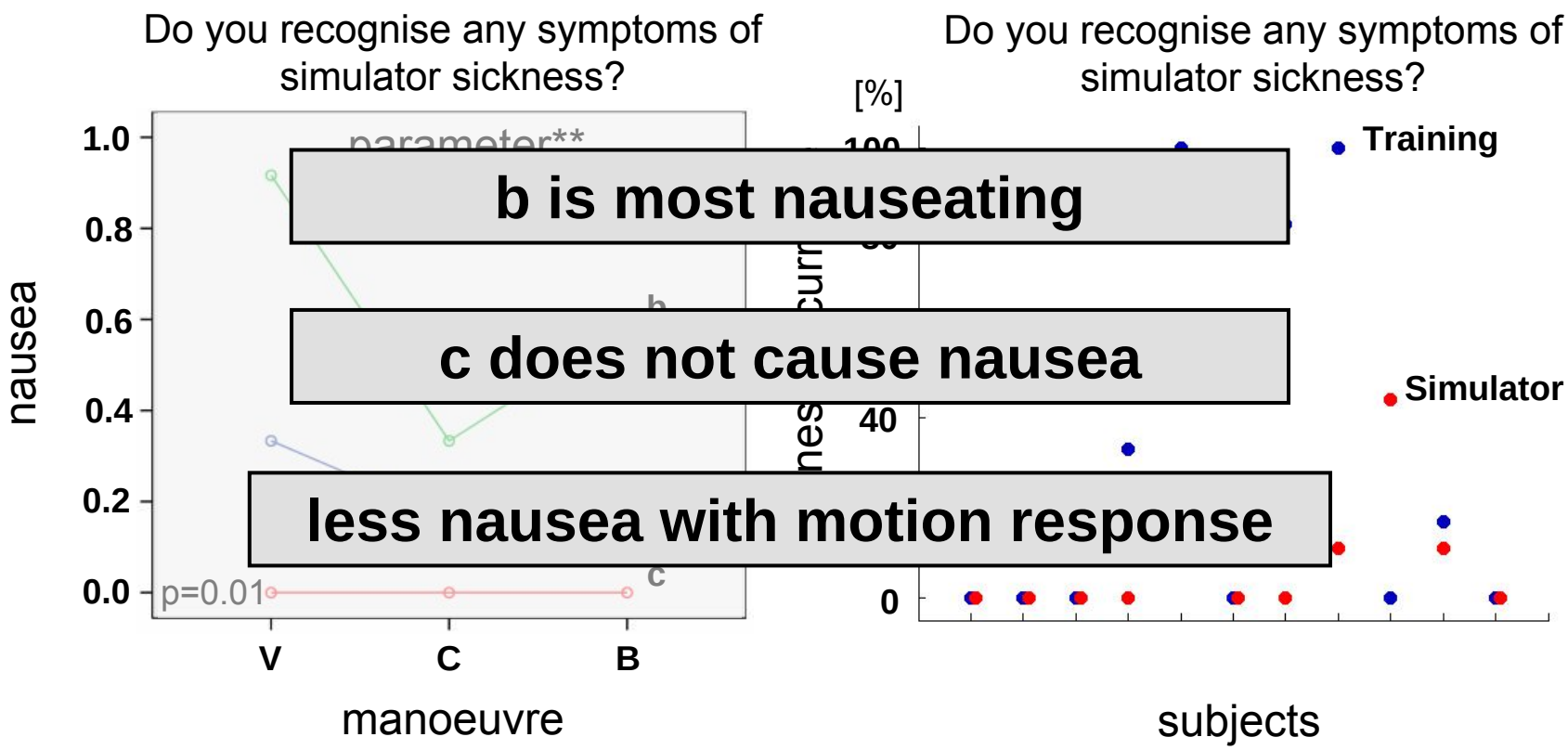
General Findings
Virtual vs. Real

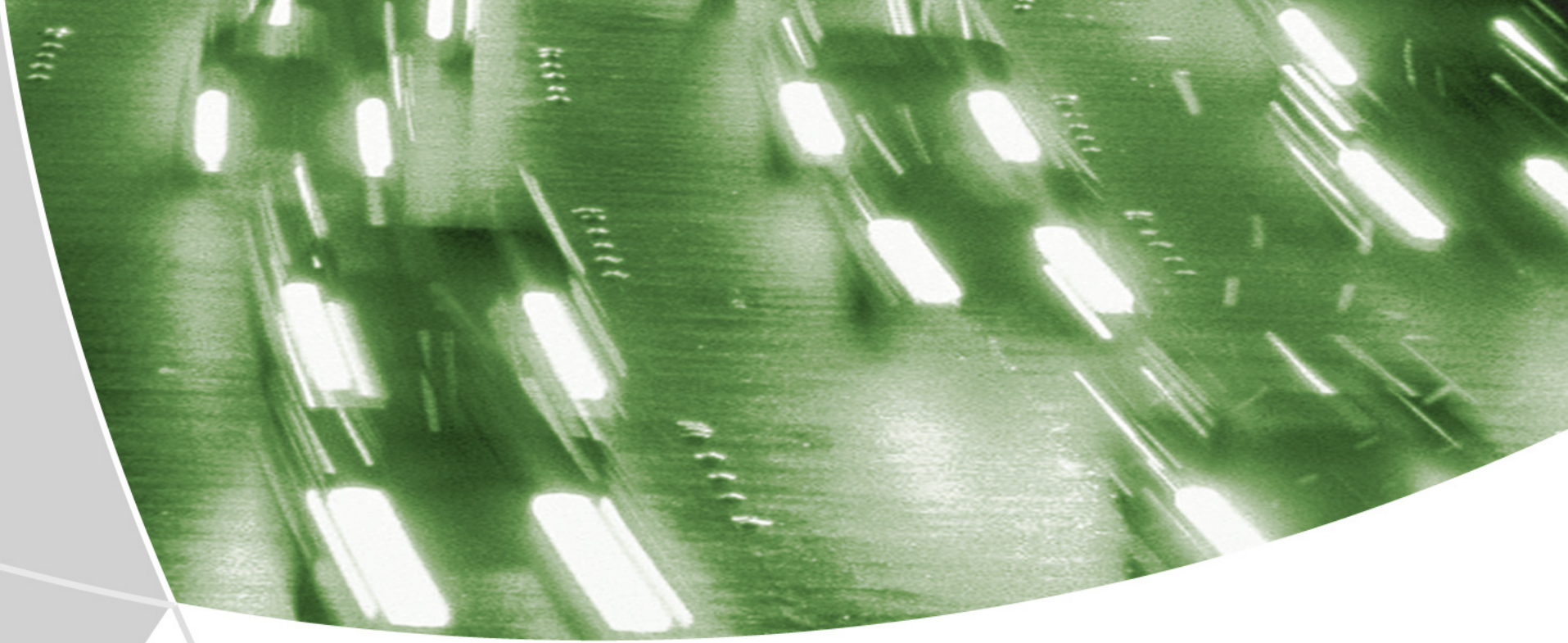
- S1



Experiment Results

Simulator Sickness - main effect parameter

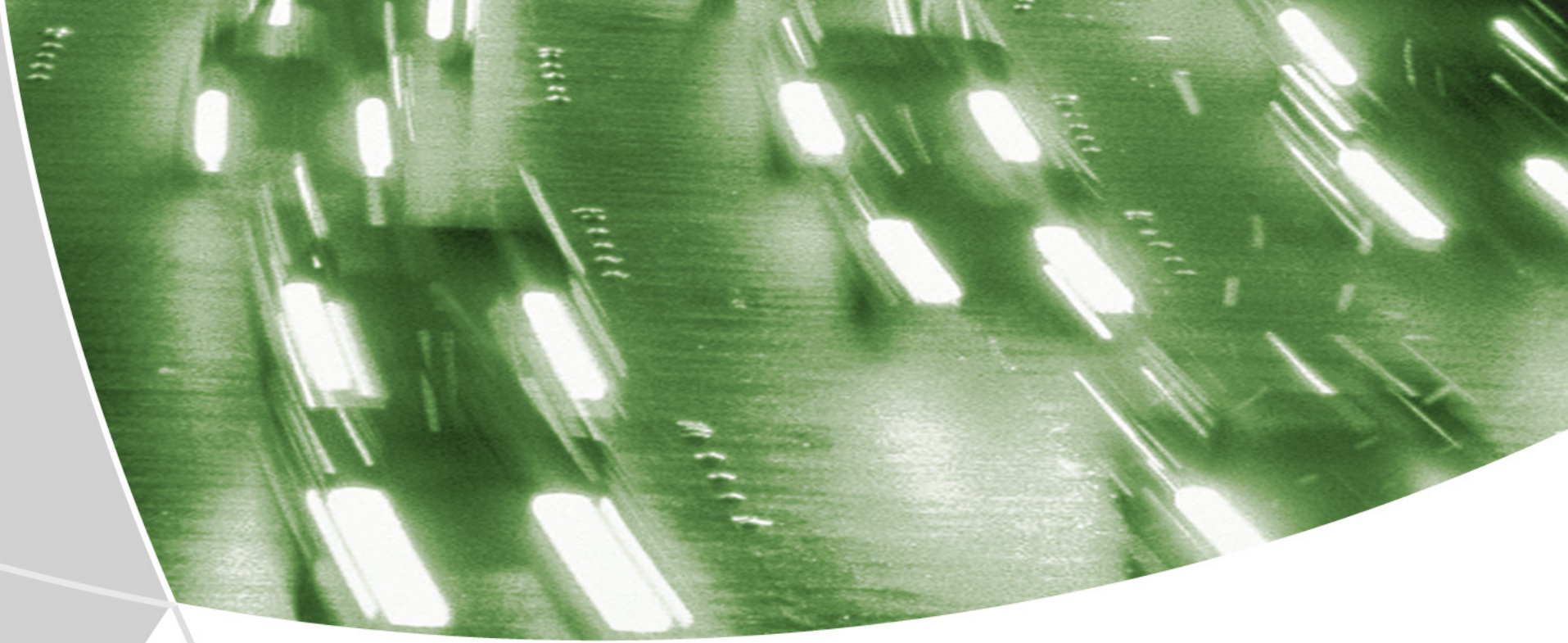




Summary and Discussion

Summary

- Braking
  - b is worst for braking
- Curve driving
  - a is best for curve driving
- Virtual vs. real
  - speed is underestimated in virtuality
- Simulator sickness
  - good motion response decreases simulator sickness
- Objective vs. Subjective
  - identical effects were measured



Thank you for your attention!

martin.bruenger-koch@dlr.de