RUMBA

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

Supported by:

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„COMFORT-ZONE“ w.r.t. LATERAL ACCELERATION depending on automation level and driver state on country roads

Stefanie Horn, Dr. Hans-Joachim Bieg, Claus Marberger, Michael Schulz, Andreas Schultz, Erdi Kenar, Sabine Oßwalt, Dr. Andreas Korthauer (Robert Bosch GmbH)

1 | Motivation

PROBLEM

WHAT WE WANT TO SOLVE

Passenger Driving Comfort is influenced by various **factors** (driving behavior, dynamics, external circumstances, psychological, …)

Consequently, highly automated vehicles (HAVs) must adapt driving behavior accordingly to achieve comfort

BASIS

WHAT WE KNOW

Existing driver assistance functions for lateral control currently enable acceleration in curves of up to $\mathbf{a_y = 3.0\ m/s^2}$

There is a lack of research on comfort concerning lateral acceleration values

GAP

WHAT WE WANT TO LEARN

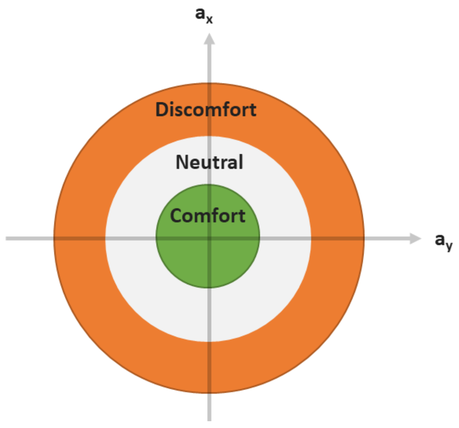
Establishing & investigating **thresholds** for HAVs regarding lateral acceleration in curves

- considering different curve radii
- in country road scenarios

2 | Research Questions

What is the “Comfort Zone” (threshold towards discomfort) w.r.t. lateral acceleration values in curve driving?

a_y = [2.0, 3.0, 4.0] m/s²



a) What impact do different **curve radii** have on comfort and a_y preferences?

b) What impact does the **passenger state** (w/wo NDRT) have on comfort in curve driving and a_y preferences?

c) What impact does the **automation level** (SAE L4, SAE L1) have on comfort in curve driving and a_y preferences?

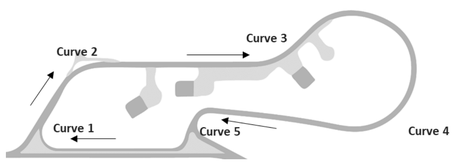
d) What **reliability** does the comfort rating have?

e) Is there a **match** between manual driving and the preferences for SAE L4.

3 | Method

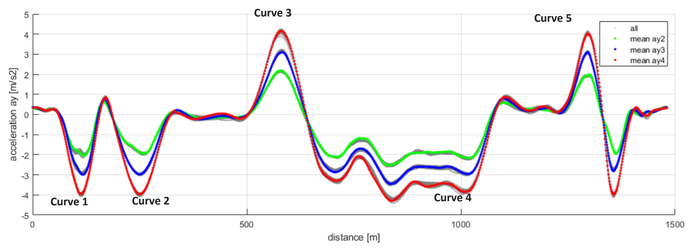
TEST-TRACK STUDY

TRIWO testcenter Pferdsfeld

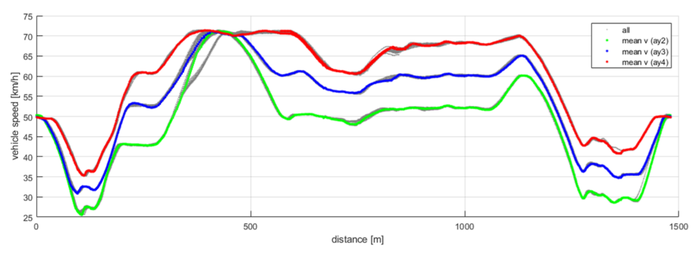


N = 40 novices
18 female, 22 male
Age M = 46.8 years (SD = 12.6)

LATERAL ACCELERATION PROFILE OF TEST-TRACK



SPEED PROFILE OF TEST-TRACK



WITHIN-SUBJECT DESIGN *balanced*

Block A |manual driving (SAE L0)

- 3 manual rounds

“In a way that the participants describe as normal driving for them.”

Block B |assistet driving (SAE L1)

- 2 rounds: 2 m/s²
- 2 rounds: 3m/s²
- 2 rounds: 4m/s²

randomized

Block C |automated driving (SAEL4)

- 2 rounds: 2 m/s² w/o NDRT
- 2 rounds: 2 m/s² w/ NDRT
- 2 rounds: 3m/s² w/o NDRT
- 2 rounds: 3m/s² w/ NDRT
- 2 rounds: 4m/s² w/o NDRT
- 2 rounds: 4m/s² w/ NDRT

Randomized, alternating w and w/o NDRT

MID-DRIVE EVALUATION

Repeated comfort rating after each curve (**curve 1-5**)

How would you rate the cornering speed you just experienced?

- clearly too fast
- too fast
- rather too fast
- optimal
- rather too slow
- too slow
- clearly too slow

REPEATED MEASUREMENTS

All conditions were randomly experienced and assessed twice

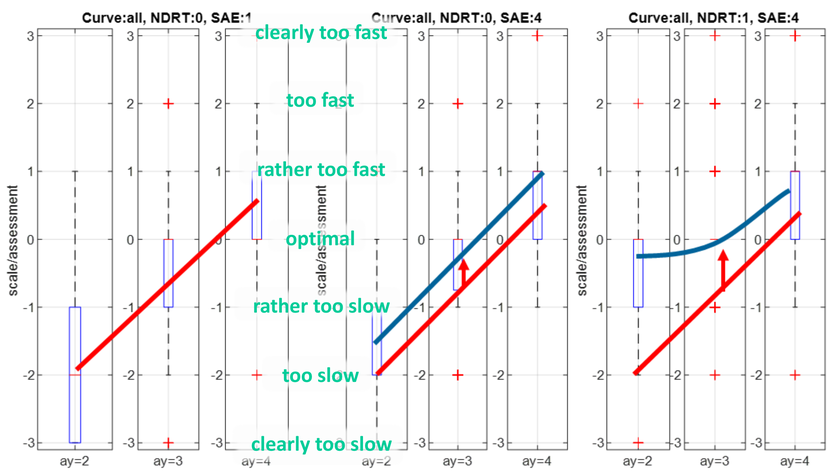
NON-DRIVING RELATED TASKS (NDRT)

Surrogate Reference Task from DLR on handheld device

4 | Results & Discussion

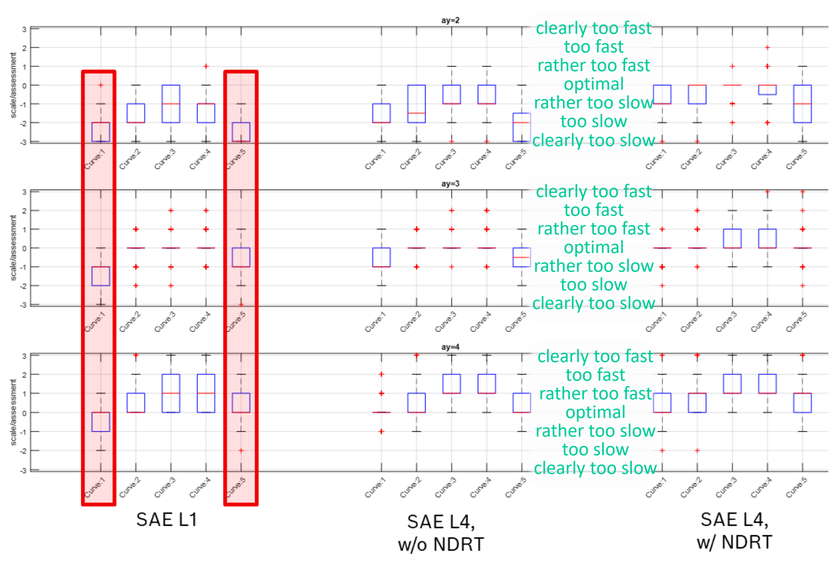
COMPARING RATINGS FOR SAE L1 & SAE L4 w.r.t. AY

- **In general:** a_y = 2m/s² rated too slow, a_y = 4m/s² rated too fast
- **Differences** between the conditions:
  - Desire for greater dynamics for SAE L1 compared to SAE L4
  - With NDRT:
    ratings for different vehicle dynamics become more similar
    Surprisingly, many participants found 4m/s² to be optimal

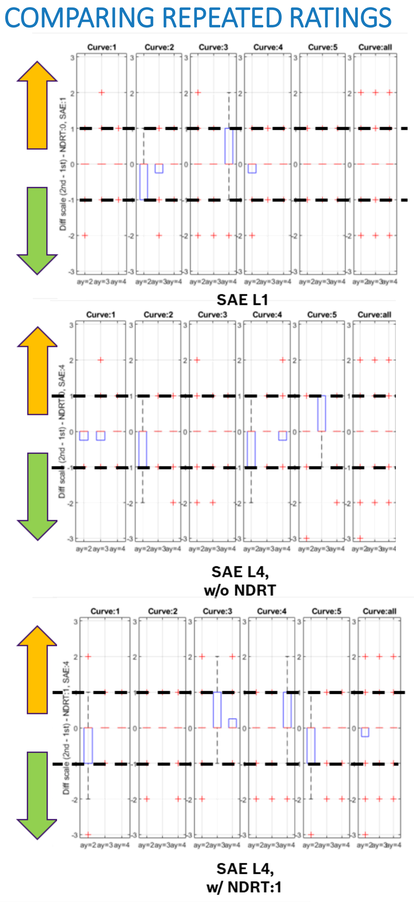


COMPARING RATINGS FOR SAE L1 & SAE L4 w.r.t. CURVE RADIUS

- Preferences depend on the curve, especially with **SAE L1**
- Tendency for **curves 1, (2), and 5** to be rated as too slow
  - smallest curve radius → lowest speed → influence of speed
  - (Influence of peripheral buildings)
  - (Influence of acceleration/deceleration before curve)
- **With NDRT**, differences in assessment are reduced



COMPARING REPEATED RATINGS



- **No systematic effects** from repeated measurements can be seen
- Tends to be spread **between -1..+1** scale points

SUMMARY

- Most preferred a_y can be assumed around 3.0 m/s² for SAE L4, and ranges from 3.0 and 4.0 m/s² for SAE L1
- Passenger distraction (NDRT) during SAE L4 results in less differentiable ratings of varying curve dynamics
- The smaller the curve radius (and thus vehicle speed), the greater the lateral dynamics that are preferred
- Ratings appear to be consistent over of time, with only minor unsystematic deviations