

Influence of visual output devices on speed perception in car simulators

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Motivation & General Research Question

- The underestimation of speed in car simulators is a well known problem
- Speed assessment in simulation should be improved to enable more realistic user behavior
- Main categories that influence speed assessment are the technical factors of the visualization hardware, the visual characteristics of the scenario and additional sensory information
- Car simulator setups sometimes differ significantly, especially with regard to their output devices
- This leads to the Question:

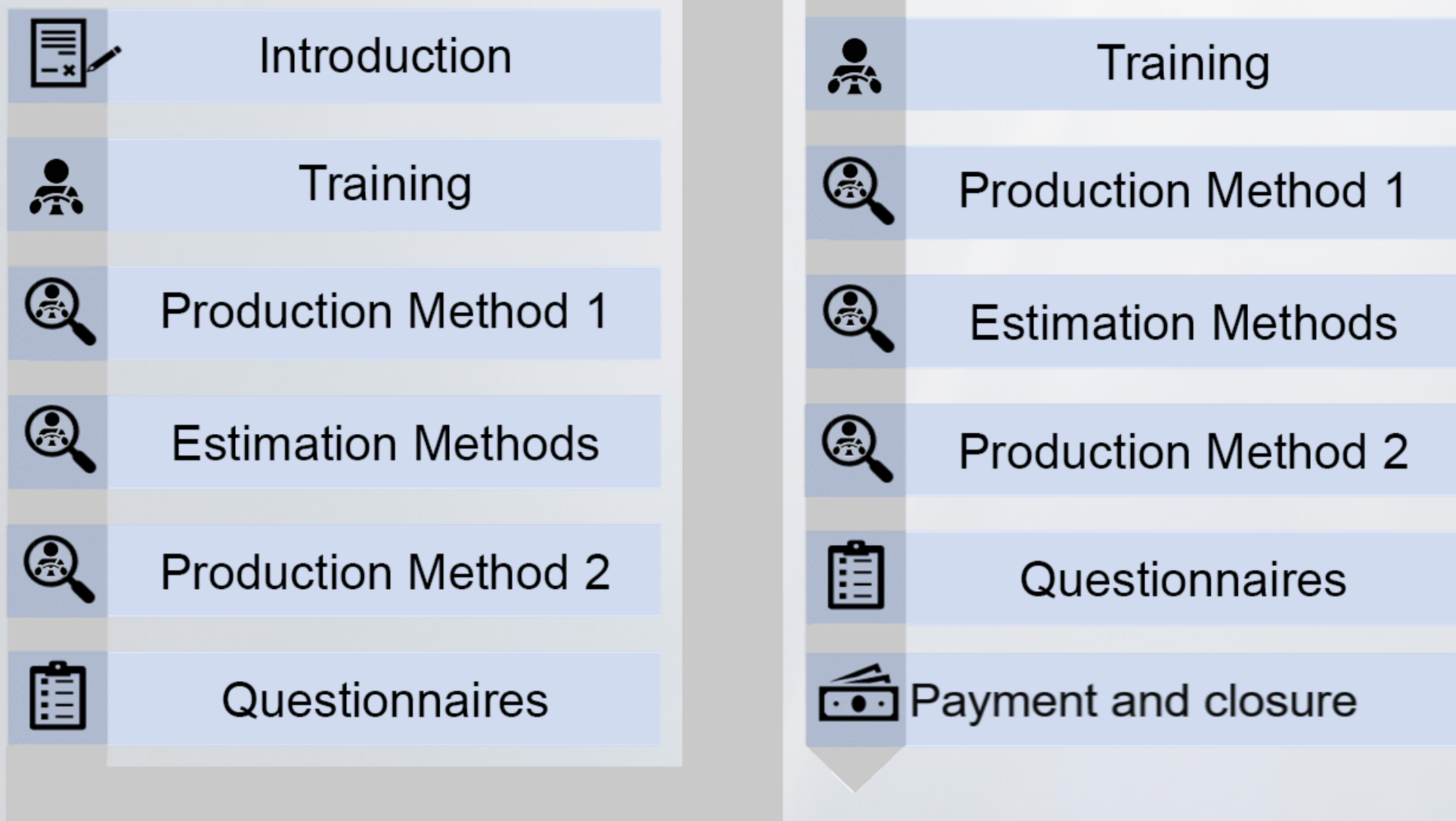
Do subjects generate similar data in different simulators when given the same scenario and task?



Hypotheses

- **H1:** Speed estimates are expected to be more accurate with an HMD (Head-Mounted Display) than with a display setup
- **H2:** It is expected that estimations are more precise when test subjects do not have a forward velocity
- **H3:** Speed production is expected to be more accurate with an HMD than with a display setup
- **H4:** Presence is expected to be higher in HMD condition
- **H5:** Simulator Sickness is expected to be lower in display condition

Procedure



- Randomized VR and Display condition
- Production method = A given speed is reproduced
- Estimation method = Speed of overtaking vehicles is assessed
- Estimation method consists of several scenarios (static, dynamic)
- **Used HMD:** HTC Pro Eye with 3,5" OLED displays with 1440 x 1600 pixels per eye
- **Display setup:** 65" displays with a resolution of 3840 x 2160 p, arranged in a 90° angle

Virtual Environment & Main Scenarios



- Built with:
 - Trian3DBuilder
 - Unreal Engine 5
- 5 km long road with:
 - Four lanes
 - Grass verge
 - Basic vegetation
 - Framing noise barriers

- Depending on the scenario, test subjects started on different lanes and were overtaken by five identical-looking vehicles
- Own speed was 50 km/h, overtaking speeds were 80/100/120/130/180 km/h
- Order of estimation conditions as well as overtaking speeds were randomized

Sample

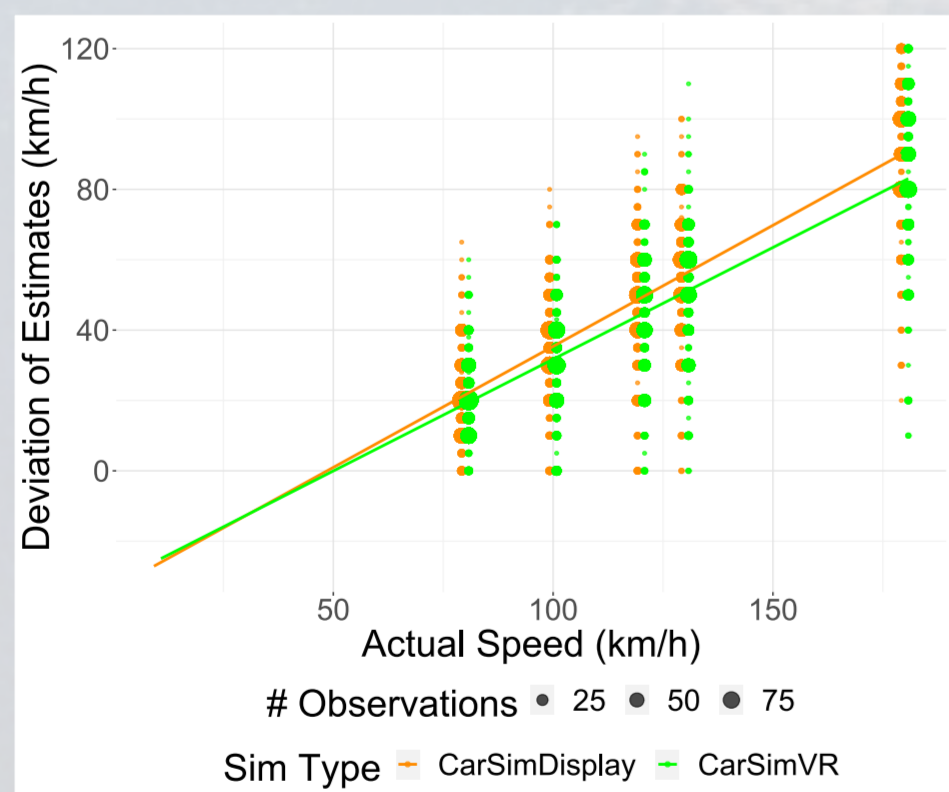
- Sample size = 32
- Female = 8
- Male = 24
- Diverse = 0
- ϕ 33 years (min. 19, max. 70)
- All, ϕ since 2007

Questionnaires

- Before simulator runs:
 - Immersive Tendencies Questionnaire (ITQ)
- Speed assessments during the experiment were recorded by the experimenter in a separate questionnaire
- After each simulator run:
 - Presence Questionnaire (PQ)
 - Simulator Sickness Questionnaire (SSQ)
 - Visual Comfort Questionnaire (VCQ)
- After whole testing phase:
 - Demographic Questionnaire

Results

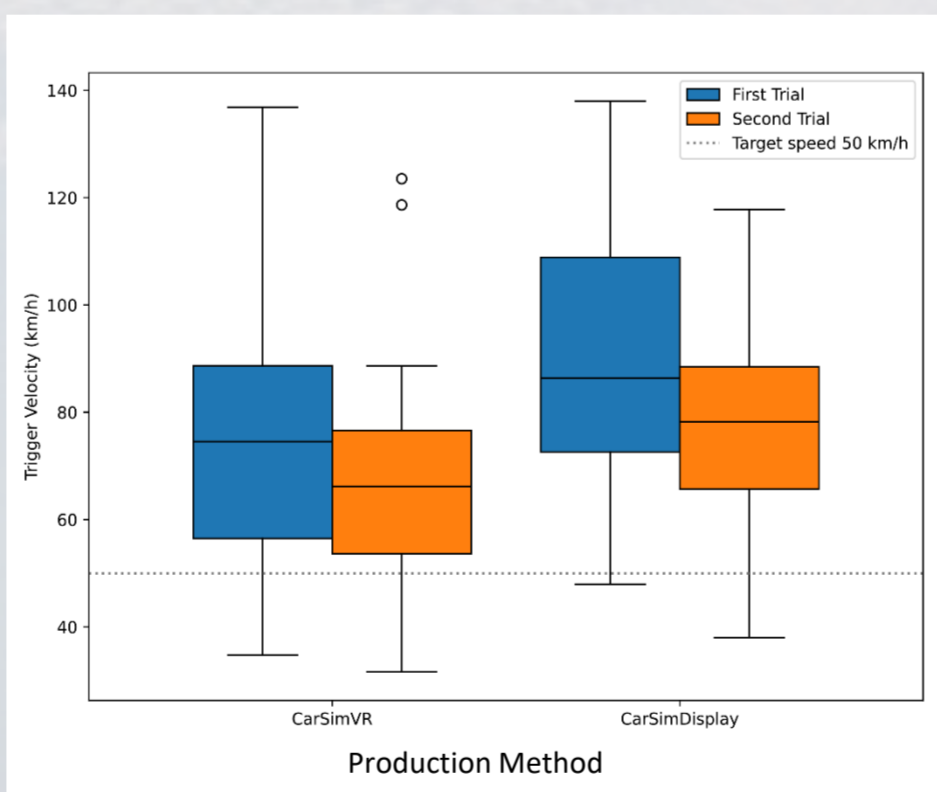
Hypothesis 1 ✓



Hypothesis 2 ✗

The evaluation of the static and dynamic condition revealed significantly higher deviations of the speed estimates in the static condition

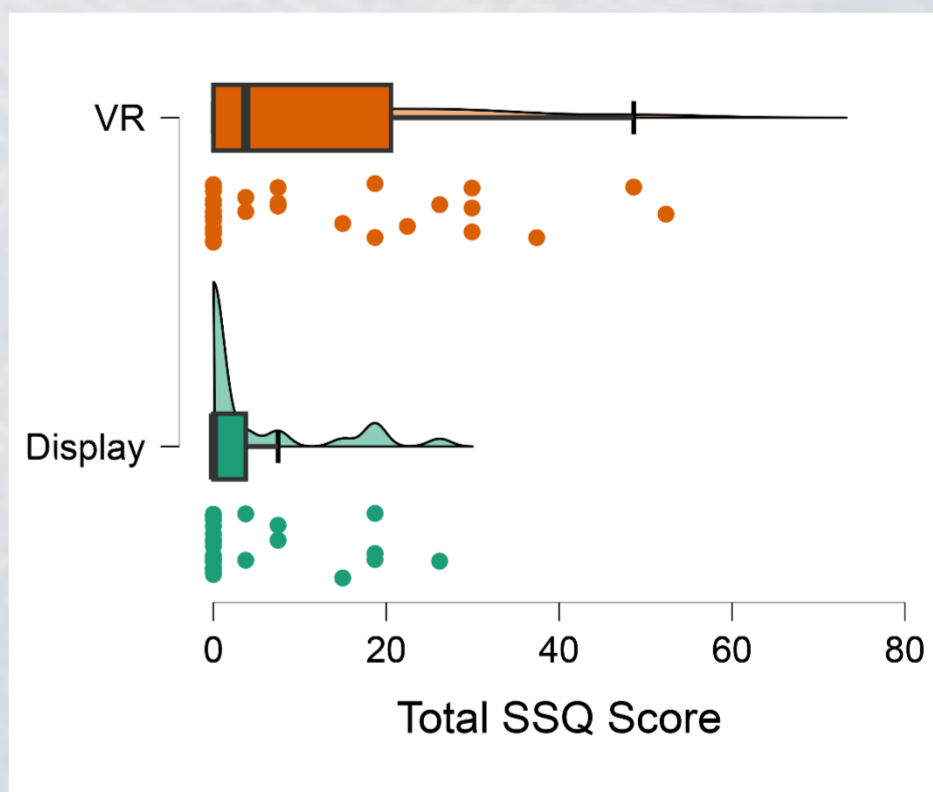
Hypothesis 3 ✓



Hypothesis 4 ✗

The results showed no significant differences in presence between the simulator conditions

Hypothesis 5 ✓



Discussion & Conclusion

- Speeds are estimated differently in different simulators
- Based on collected data it is to assume that the benefits of the HMD concerning accuracy in speed assessment decline with decreasing speeds
- It can be assumed that other traffic simulators like e.g. pedestrian or bike simulators are also effected, especially since they vary broadly by design
- This circumstance might affect multi-user-studies incorporating different kind of road users
- In further studies, aspects like geometrical field of view, depth perception and motion parallax effects will be taken into consideration