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Displaying Vehicle Driving Mode – Effects on Pedestrian Behavior and Perceived Safety

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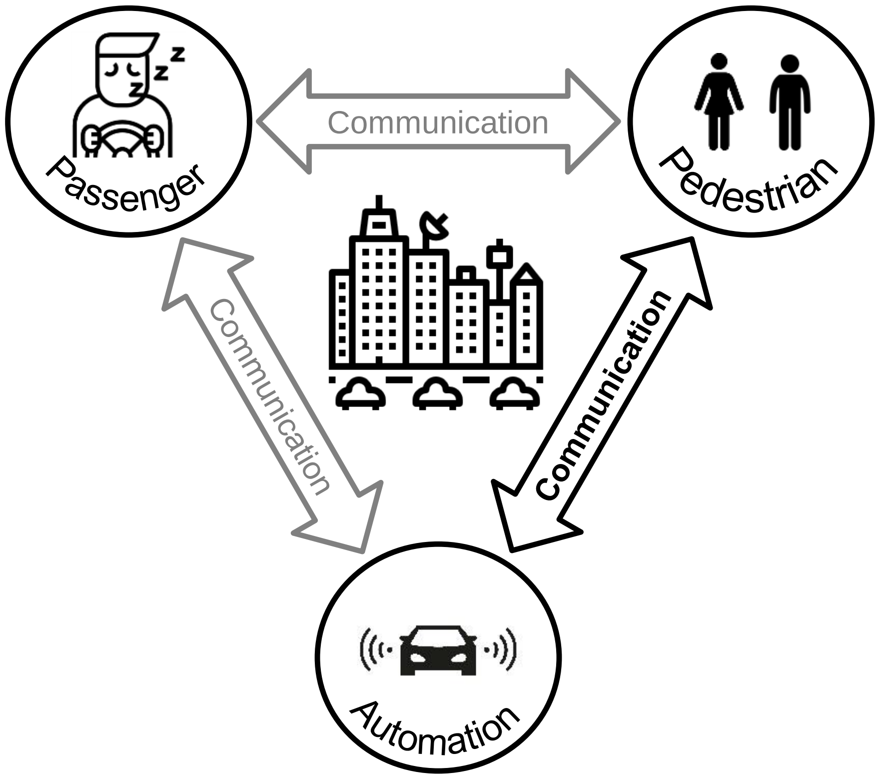
Agenda

- Introduction & Theoretical Background
- Method
- Results
- Discussion & Conclusion

INTRODUCTION

Introduction



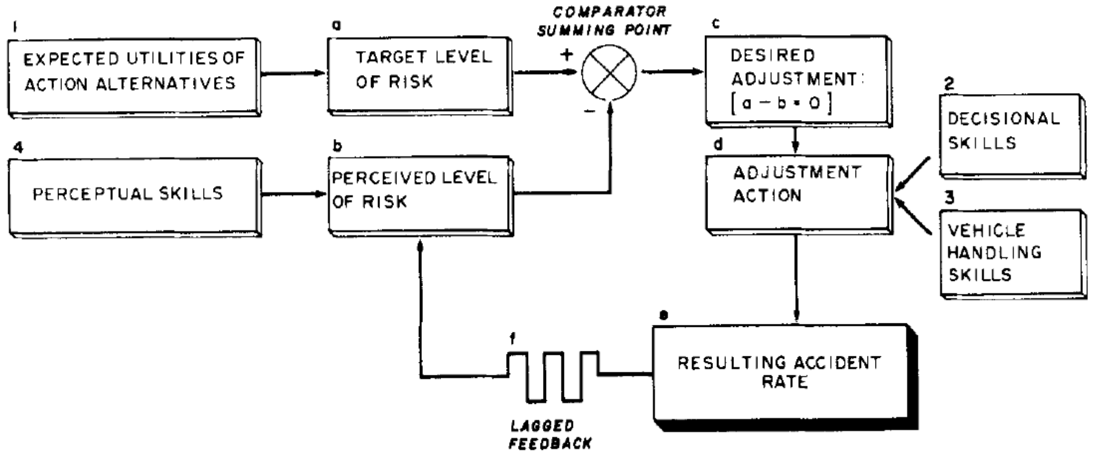
(Schieben et al., 2018)

- External human-machine interfaces (eHMIs) are currently under development and evaluation (e.g. Ackermann et al., 2019)
- eHMIs can increase the time that pedestrians feel safe to cross when the vehicle is yielding (de Clerq et al., 2019)
- Research indicates that pedestrians do perceive differences between automated and traditional vehicles (Rodríguez Palmeiro et al., 2018)

Does displaying the vehicle driving mode of a driverless vehicle result in behavioral adaptation of pedestrians?

Theoretical Background: Behavioral Adaptation

Model of Risk Homeostatic



(Wilde, 1982)

- Monitoring and attunement of risk plays a major role in the formation of behavioral adaptation (Jiang et al., 1992)
- If a vehicle with a given system (e.g. an eHMI) provides an improved feeling of control compared to a vehicle without the system, the assumed risk reduction might be compensated by a change in pedestrian behavior (based on Vaa, 2013)

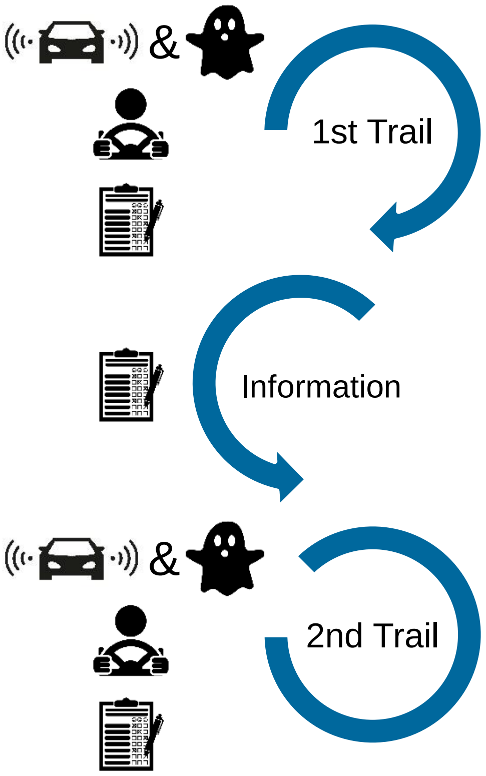
METHOD

Scenario & Procedure

Scenario

- Un-signalized crossing of a straight road
- No obstructions of visibility, no other traffic participants
- Vehicle drove with a constant speed of 30 km/h

Procedure



- Identification of the driving mode
- Participants' task: Observation of the passing vehicle

- Briefing & Evaluation
- Participants' task: Evaluation of the eHMI

- Measurement of pedestrian behavior and perceived safety
- Participants' task: "Crossing" of the road in front of the vehicle

Independent and Dependent Variables, Participants

Independent Variable



Dependent Variables

- Pedestrian behavior: Critical gap acceptance (Rodríguez Palmeiro et al., 2018)
- Perceived Safety: 5-point-scale
  I feel unsafe – I feel rather unsafe – Indifferent – I feel rather safe – I feel safe

Participants

28 participants (21 % female, mean age = 25.2 years, SD 2.86 years)

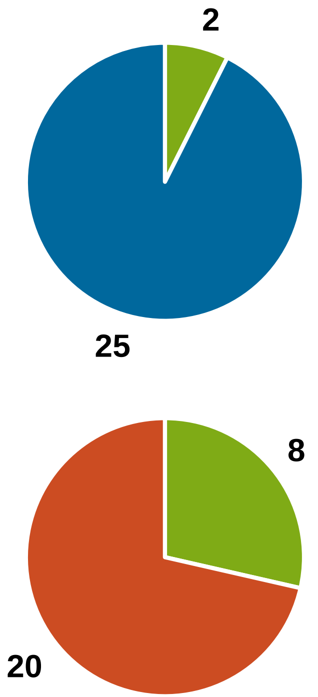
RESULTS

Identification of Vehicle Driving Mode

Reported Driving Conditions

Driverless Vehicle Condition (N = 27)

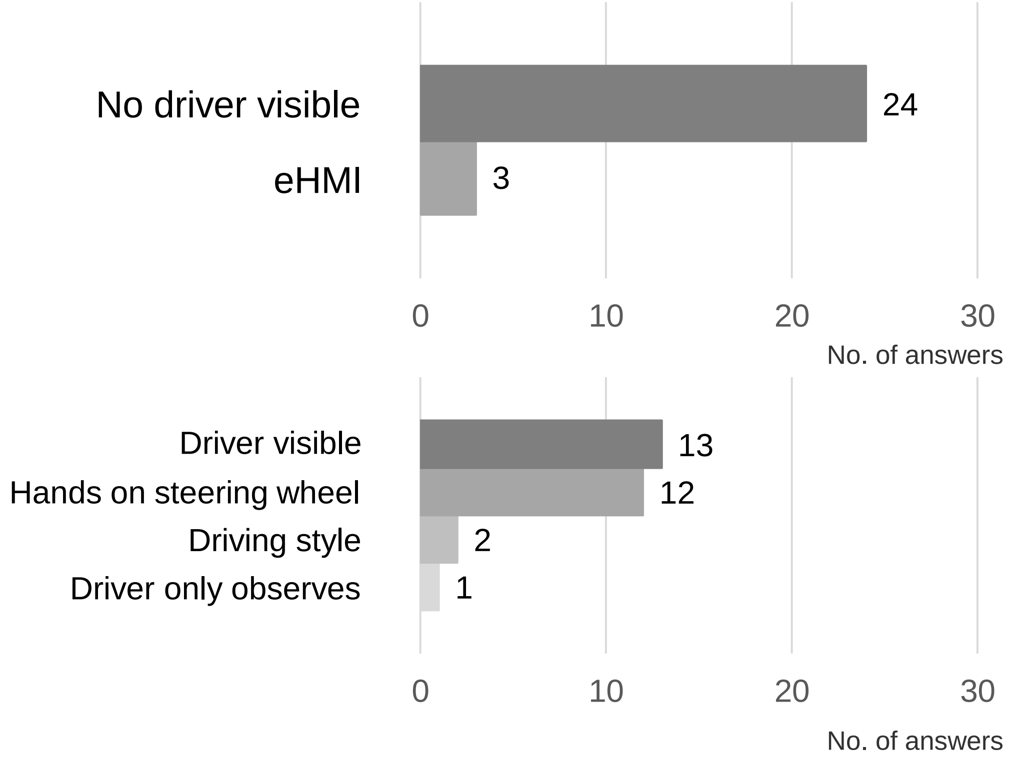
Human-operated Vehicle Condition (N = 28)



driverless* autonomous* human-operated*

How did you (first) recognize this?

(Single choice)



* Participants were introduced to the terms before the experiment started.

Changes in Perceived Safety

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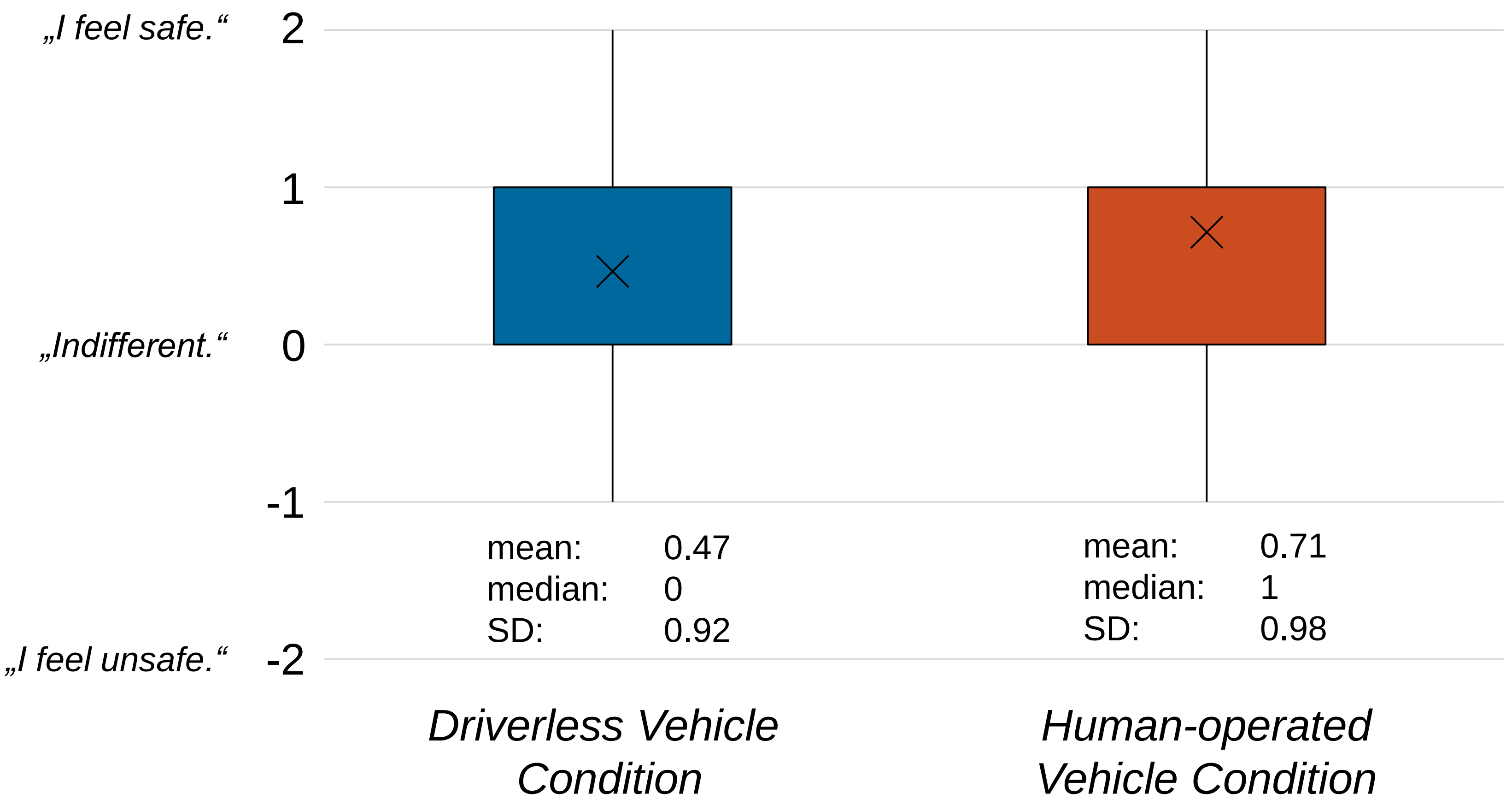
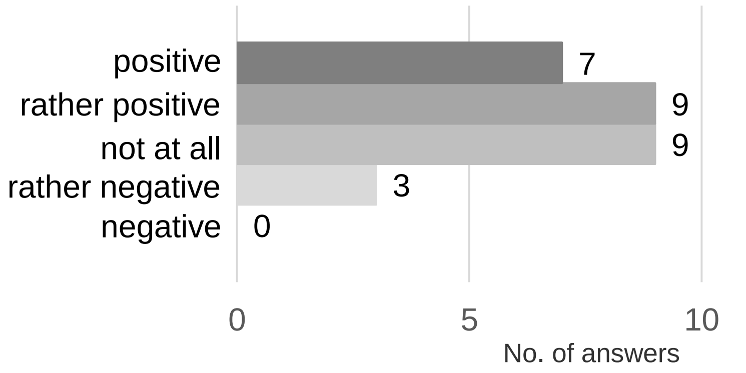
Perceived Safety (N = 28)



Participants did not perceive the driverless vehicle as less or more safe than the human-operated vehicle.
(|T| = 1.022, df = 27, *p* = .316)

How did the eHMI affect your perceived safety? (N = 28)



Changes in Pedestrian Behavior

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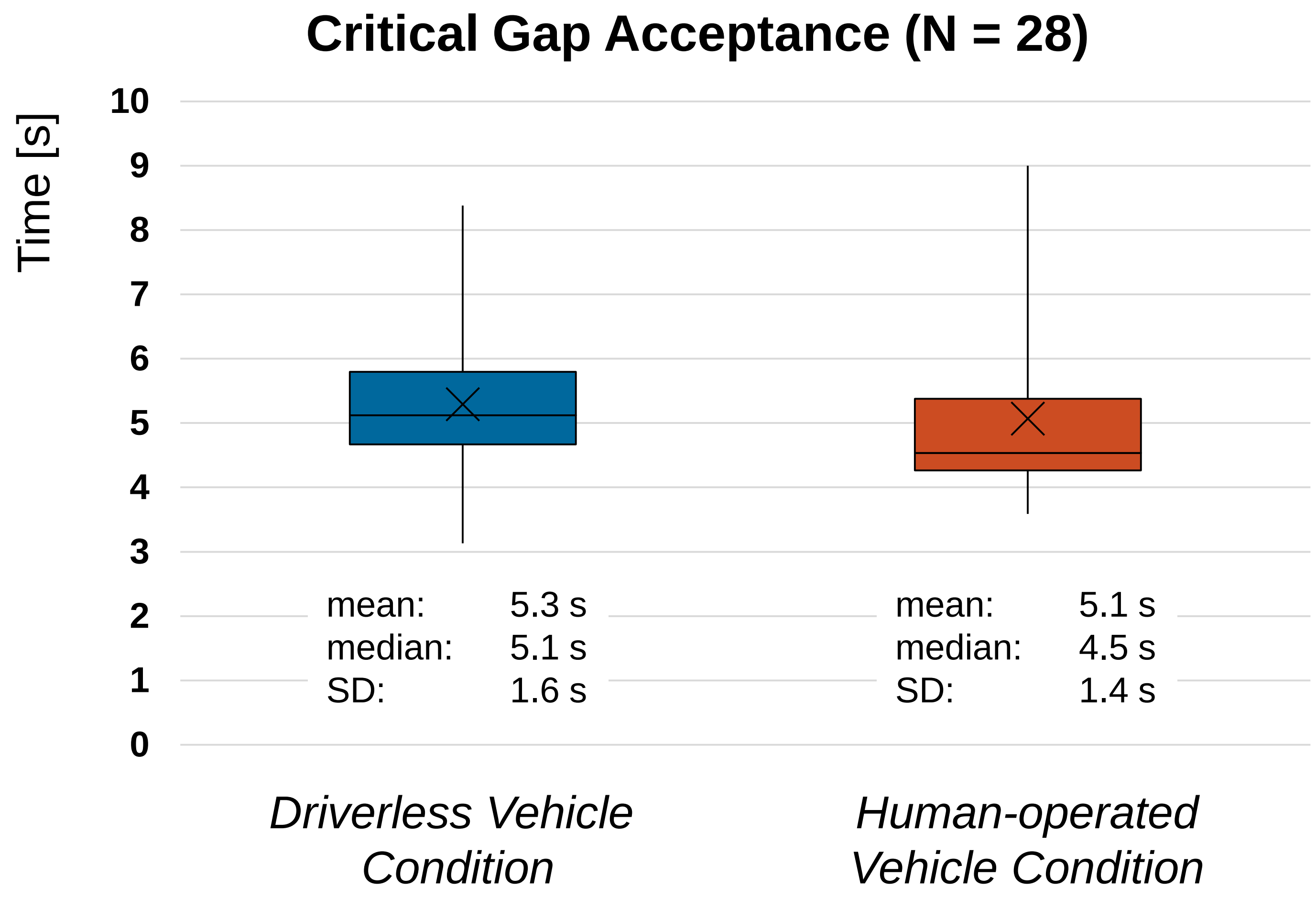

Participants did not choose statistically significantly different critical gaps when facing a driverless vehicle compared to a human-operated vehicle.
(|T| = 1.192, df = 27, p = .224)

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DISCUSSION & CONCLUSION

Discussion

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Does displaying the vehicle driving mode of a driverless vehicle result in behavioral adaptation of pedestrians?

Results

- The perspective from which a vehicle communicates (ego- vs. allocentric, see Bazilinskyy et al., 2019) will play an important role
- Results of this research show a positive evaluation of the eHMI used. However, the mere presence of the eHMI could lead to mode confusion

Method

- Not all vehicle conditions were considered in the design of the study
- The number of interactions was limited and therefore the opportunity of learning
- Scenario was not valid (also due to ethical guidelines)

Discussion

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Theory

- A reduction in the perceived risk when crossing a road in front of a labeled driverless vehicle could result in behavioral adaptation of pedestrians
- Prior research indicates that pedestrians perceive driverless vehicles as less risky compared to human-operated vehicles (Hulse et al., 2018)

Conclusion

- The eHMI displaying the vehicle automation status did not influence pedestrians perceived safety and behavior.
- The theoretical framework of behavioral adaptation seems promising to study the effects of eHMIs on pedestrian safety.
- Pedestrian behavior (beyond critical gap acceptance) should be taken into account more extensively.

References

- Ackermann, C., Beggiato, M., Schubert, S., & Krems, J.F. (2019). An experimental study to investigate design and assessment criteria: What is important for communication between pedestrians and automated vehicles? *Appl Ergon,* 75, 272-282.
- Bazilinskyy, P., Dodou, D., & Winter, J. de (2019). Survey on eHMI concepts: The effect of text, color, and perspective.
- Clerq, K. de, Dietrich, A., Núñez Valesco, J.P., Winter, J. de, & Happee, R. (2019). External Human-Machine Interfaces on Automated Vehicles: Effects on Pedestrians Crossing Decisions. Hum Factors (in press).
- Hulse, L.M., Xie, H., & Galea, E.R. (2018). Perceptions of autonomous vehicles: Relationships with road users, risks, gender and age. *Saf Sci*, 102, 1-13.
- Jiang, C., Underwood, G., & Horwarth, C.I. (1992). Towards a theoretical model for behavioural adaptations to changes in the road transport system. *Transport Rev* 12, 253-263.
- Rodríguez Palmeiro, A., Kint, S van der., Vissers, L., Farah, H., Winter, J.C.F. de, & Hagenzieker, M. (2018). Interaction between pedestrians and automated vehicles: A Wizard of Oz experiment. *Transp Res Part F Traffic Psychol Behav,* 58, 1005-1020.
- Schieben, A., Wilbrink, M., Kettwich, C., Madigan, R., Louw, T., & Merat, N. (2019). Designing the interaction of automated vehicles with other traffic participants: design considerations based on human needs and expectations. *Cogn Technol Work,* 21, 69-85.
- Vaa, T. (2013). Psychology of Behavioural Adaptation. In: Rudin-Brown, C.M., Jamson, S.L. (eds.) *Behavioural Adaptation and Road Safety* (S. 207-226). CRC Press, Boca Raton, FL.
- Wilde, G.J.S. (1982). The Theory of Risk Homeostasis: Implications for Safety and Health. *Risk Analysis*, 2(4), 209-225.