## ESR 12- AV occupants perception of safety in relation to AV behavior



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#### Objectives

- Evaluate perceived safety and trust with AVs
- Capture perceived safety and trust with models
- Investigate how perceived safety and trust can be enhanced



Understand road-user behaviou r in AV interactions	dictability Using Neuroergono mics (UIm) ESR2 - Long Term Effects of Automation on User Behavior (TUM)	ng Interactions Between AVs an d VRUs Using AI (UGOT) ESR4 – Long Term Effects of A V Exposure on AV/VRU Interactions (Leeds)
Develop AV interface design str ategies	ESR5 - Developing more acce ptable, pleasant and transpare nt AV-kinematic cues for driver s (Leeds) ESR6 -Internal Interface for Tr ansparent and Agile Automati on (Ulm) ESR7 - Assessing AV Transpar ency (TUM) ESR8 - Human Factors in AI-b ase Automation Design (UGO T)	ESR9 – Assessing Interactions Between AVs/VRUs Using Virtu al/Augmented Reality (TU Delft) ESR10 – HMI on bicycles, Prom oting Transparent AV Interactio ns (TU Delft) ESR11 – Cooperative Interactio n Strategies Between AVs and Mixed Motorized Traffic (Ulm)
Assess safety in mixed traffic	ESR12 – AV Occupants Perce ption of Safety in relation to A V behaviour(TU Delft)	ESR13 - Computational AV/Ped estrian Interaction Models (Lee ds) ESR14 - Computational AV/Cyc list Interaction Models (Chalmer s) ESR15 - Safety Evaluation of A utomation Using Counterfactual Simulations (Chalmers)

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#### Simulator experiment I ~ Perceived safety and trust in merging and hard braking



 $PR = 9.384 - 2.473 \cdot \ln(MinGap) \\ -0.038 \cdot YDL - 0.201 \cdot BI + 0.470 \cdot GEN$ 

 $TRU = 8.780 - 6.265 \cdot MinTTC^{-1} + 0.016 \cdot YDL + 0.125 \cdot BI + 0.372 \cdot REP$ 

SHAPE-IT

#### Results and conclusions

- **Regression models** of perceived risk and trust
- Neighboring road users' **relative motion** significantly influence perceived risk and trust.
- **Experienced drivers** and **male drivers** are less sensitive to risk.
- **Pupil dilation** can indicate perceived risk if the event is sufficiently risky.
- The merging and braking events increased heart rate.

He, X., et al. (2022). Modelling perceived risk and trust in driving automation reacting to merging and braking vehicles. Transportation Research Part F.

#### Simulator experiment II ~ Can UI enhance perceived safety & trust in merging and hard braking?

	Baseline	Surrounding	Surrounding + Self-Action	
Baseline	-	-		-
Visual	-			
Visual + Auditory	-	<ul> <li>Merging vehicle detected"</li> </ul>	"Merging vehicle detected"	✓ Merging vehicle detected"

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#### **Results and conclusions**

- All UI enhance trust.
- The visual UI with acoustic maneuver information enhances trust most.
- With UI drivers **intervene** (brake) less.
- Drivers **gaze** at the road **less** with internal visual UI.
- UI affects **acceptance** more than trust and perceived safety

Kim, S.\*, He, X.\*, van Egmond, R., Happee, R. Design and Evaluation of a user interface enhancing trust in partially automated vehicles. (\*contribute equally; close to submission)

#### Real-time 2-D perceived risk modelling

- Regression perceived risk model (RPR) 1D (Based on Experiment I)
- Perceived probabilistic driving risk field model (PPDRF) 2D (Based on our previous research)
- Avoidance difficulty (AD) 2D

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#### Conclusions

- Perceived risk is **2-D** and **changes non-linearly** with distance
- Gaussian risk field is suitable to describe lateral perceived risk
- PPDRF supports that human drivers perceive risk by estimating collision **probability** and collision **severity.**

He, X., Happee, R., Wang, M. (2023). Computational perceived risk models in SAE level 2 driving automaton. [Conference presentation]

AV occupants perception of safety in relation to AV behavior - Oct. 4, 2022 - Xiaolin He



Kolekar et al., 2020

#### Online survey – large scale 2D perceived risk & trust data collection

 This study aims to collect large-scale perceived risk data and find the difference in various scenarios.



Subject vehicle reacting to merging vehicles



Subject vehicle reacting to lane change abortion

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Subject vehicle reacting to hard brake



#### Subject vehicle merging onto main road

How risky do you perceive the clip above?



#### Perceived risk slider after each video clip

# Thanks!

