SAFETY POTENTIAL OF DATA GLASSES FOR MOTORCYCLISTS

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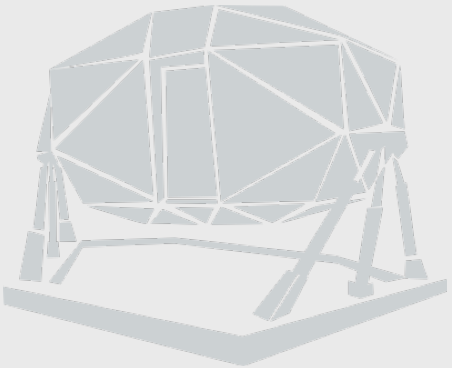
AGENDA



MOTIVATION

Could the use of data glasses potentially increase safety for motorcyclists?

How can this safety potential be assessed?

DEVELOPMENT OF AN INVESTIGATION METHOD

There are reliable methods known from the passenger car domain. (How) Can they be adapted to the motorcycle application?

APPLICATION OF THE METHOD AND STUDY RESULTS

Conduction of a participant study and evaluation of the safety potential of data glasses for motorcyclists.

CONCLUSION AND OUTLOOK

MOTIVATION

MOTIVATION

AVOIDING RIDER DISTRACTION

- Distraction from the forward road scene increases risk of being involved in an accident
  - E.g., approx. 300 out of 777 PTW accidents on Austrian highways (2012-2019) primarily caused by distraciton (ASFINAG, 2021)
  - Can be caused by searching for information in the vehicle's dashboard

- Solution in passenger cars: head-up display
  - Projection of relevant data onto the windscreen
  - Comparable solution likewise promising for PTWs?
    - → Typically no windscreen as projection surface.
- Alternative transparend display technology: data glasses

- Can data glasses increase safety for motorcyclists?
- How can this safety potential be investigated?

Data glasses to display information in the ‚natural' line of sight

DEVELOPMENT OF AN INVESTIGATION METHOD

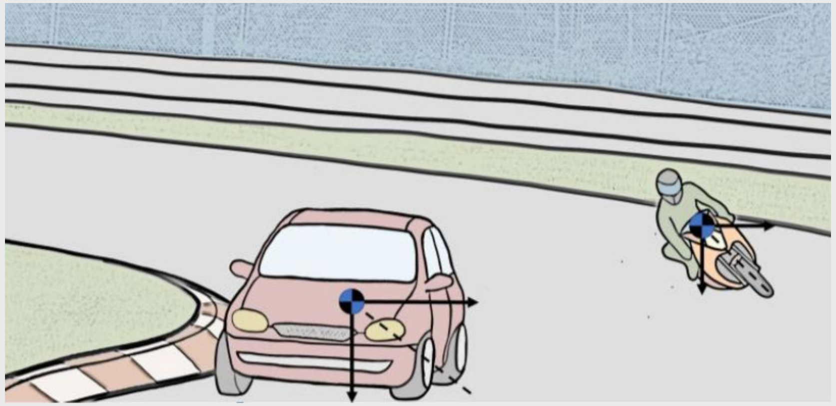
DEVELOPMENT OF AN INVESTIAGTION METHOD

SAFETY POTENTIAL OF DATA GLASSES FOR MOTORCYCLISTS

- Two research questions:
  - What is the potential safety benefit of using data glasses on a motorcycle?
  - Can the technology be used safely?
    (i.e. without causing new risks, e.g., distraction from the riding task)

- Established test methods?
  - For passenger cars!
    - → Development of assistance systems for passenger cars ahead of those in the PTW sector, same for test standards.

  - No direct applications to motorcycles without adaptions
    - → Riding task more complex due to single-track dynamics
    - → Larger dashboard downward angle



DEVELOPMENT OF AN INVESTIGATION METHOD

INITIAL ASSUMPTION

THEORY OF RESOURCE MODELS (WICKENS, 1980, 2008)

- Riders have limited amount of ressources
- Combination of primary riding task and other activities (secondary task) may not exceed resource limit
  - Requirement to completing riding task safely (Guth, 2017)

- Retrieving information from vehicle‘s dashboard can be regarded as a **secondary task** competing for visual ressources! (Will et al., 2018)

  - Task should be designed to demand minimal workload

- Combination of tree approaches from passenger car sector and adaption to motorcycles
  - Lane Change Test (ISO 26022)
    - → Influence of **secondary (visual) task** on performance in **primary (riding) task**
  - Detection Response Task (ISO 17488)
    - → Influence of **secondary (visual) task** on perception of **other relevant (visual) stimuli**
  - NASA Task Load Index (Hart & Staveland, 1988)
    - → Assessment of subjectively experienced workload

DEVELOPMENT OF AN INVESTIAGTION METHOD

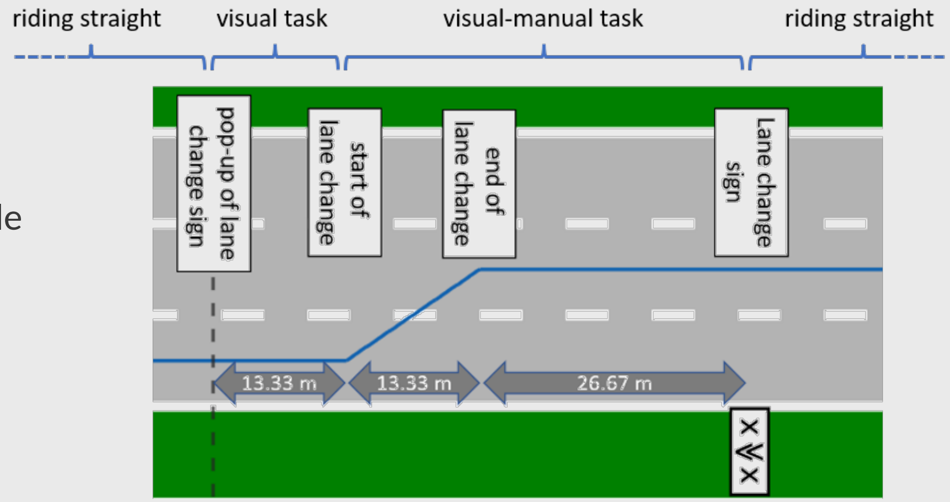
ADAPTION OF PASSENGER CAR STANDARDS TO MOTORCYCLES

LANE CHANGE TEST (LCT) – ISO 26022

- Dual task method
- Influence of **secondary (visual) task** on performance in **primary (riding) task**

- Primary riding task: Lane changes on a straight three-lane road according to signs
  - Lane change sign turns up (TTA: 2.4 s) → mainly peripheral visual task (600 ms)
  - Lane change → visual-manual demand (600 ms)
  - After passing sign: riding straight until next sign turns up

- Adaptions for motorcycle test case
  (due to differences in the demand of the riding task)
  - Increasing experiment velocity from 60 km/h to 80 km/h
    - → Avoid high amount of workload due to stabilization of vehicle
    - → Use of self-stabilizing effect
  - Adaption of test track sections to keep reaction times



DEVELOPMENT OF AN INVESTIAGTION METHOD

ADAPTION OF PASSENGER CAR STANDARDS TO MOTORCYCLES

LANE CHANGE TEST (LCT) – ISO 26022

- Secondary task: Reaction to displayed information
  - Comparing data glasses to standard head down display
  - Turn-by-turn indications displayed on respective display technology
  - Required action: pull high beam lever (no reaction to specific content)

Turn-by-turn indication on the dashboard

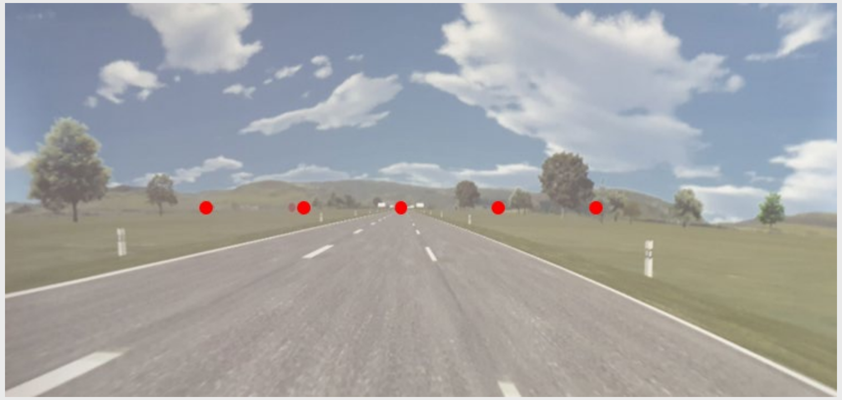
- Four secondary task conditions:
  - *Baseline:* only LCT, no secondary task, riders wear no data glasses
  - *Dashboard:* LCT while completing secondary task on dashboard, riders wear no data glasses
  - *Data glasses:* LCT while completing secondary task in data glasses, dashboard covered
  - *Dashboard & data glasses:* LCT while completing secondary task with information displayed on dashboard and in data glasses

DEVELOPMENT OF AN INVESTIAGTION METHOD

ADAPTION OF PASSENGER CAR STANDARDS TO MOTORCYCLES

DETECTION RESPONSE TASK (DRT) – ISO 17488

- Influence of **secondary (visual) task** on perception of **other relevant (visual) stimuli**
- Simulation of risk stimuli in peripheral field of view
  - → Measure riders‘ visual detection and response ability to evaluate workload
- Display of computer-generated elements in the scenery
  - → Red-couloured circles appear randomly (one at a time)
  - → Five possible positions along the horizon (0° centre, +/−8.3° and +/−16.7°)
- Rider reaction: pressing a button with the left thumb
  - → Succesful detection while circle is displayed
  - → Reaction time



Stimuli positions at the horizon

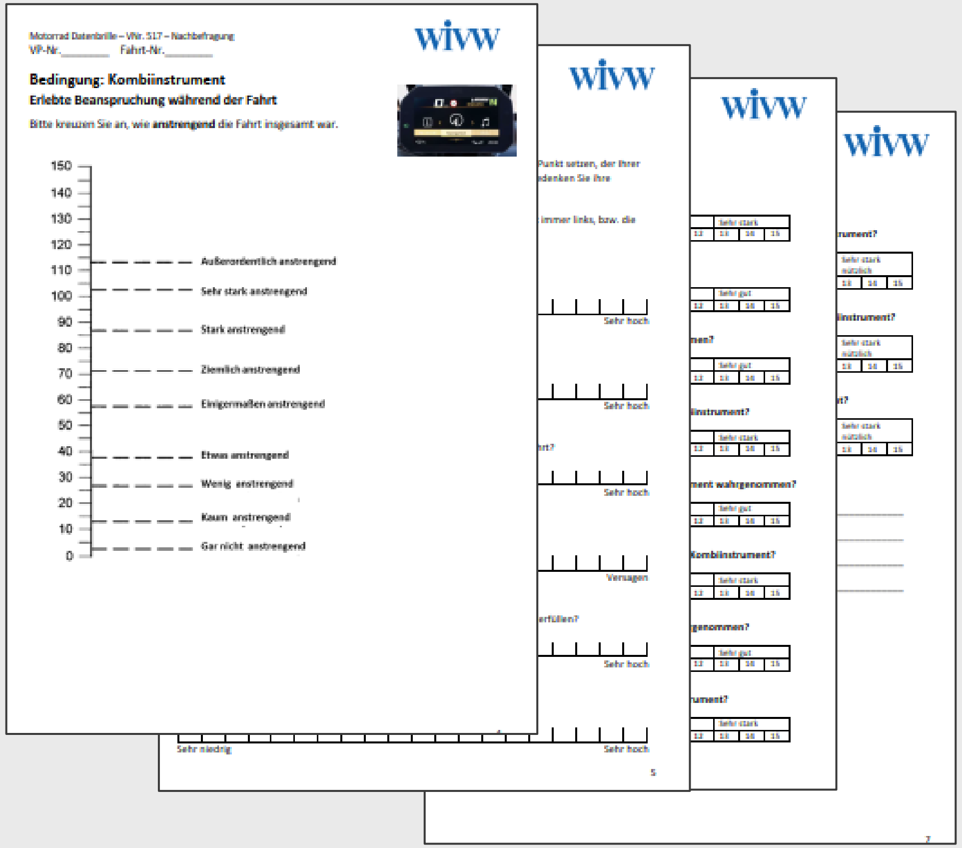
DEVELOPMENT OF AN INVESTIAGTION METHOD

ADAPTION OF PASSENGER CAR STANDARDS TO MOTORCYCLES

SUBJECTIVE WORKLOAD ASSESSMENT (NASA TLX)

- Assessment of subjectively experienced workload

- Questionnaire after each condition
- Six different subscales
  - → Mental demand
  - → Physical demand
  - → Temporal Demand
  - → Performance
  - → Effort
  - → Frustration



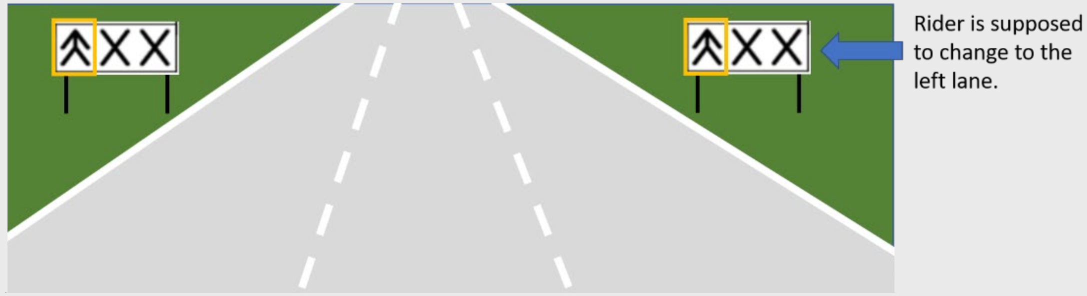
APPLICATION OF THE METHOD
AND STUDY RESULTS

APPLICATION OF THE METHOD AND STUDY RESULTS

PARTICIPANT STUDY

- Motorcycle Simulator
  - BMW F 800 S mockup
  - 6 DoF motion platform
  - Fully realistic controls
  - 220° cylindrical screen, Ø 4.5 m, ↕ 2.8 m
  - Sound via transducers attached to helmet
  - Shaker below seat

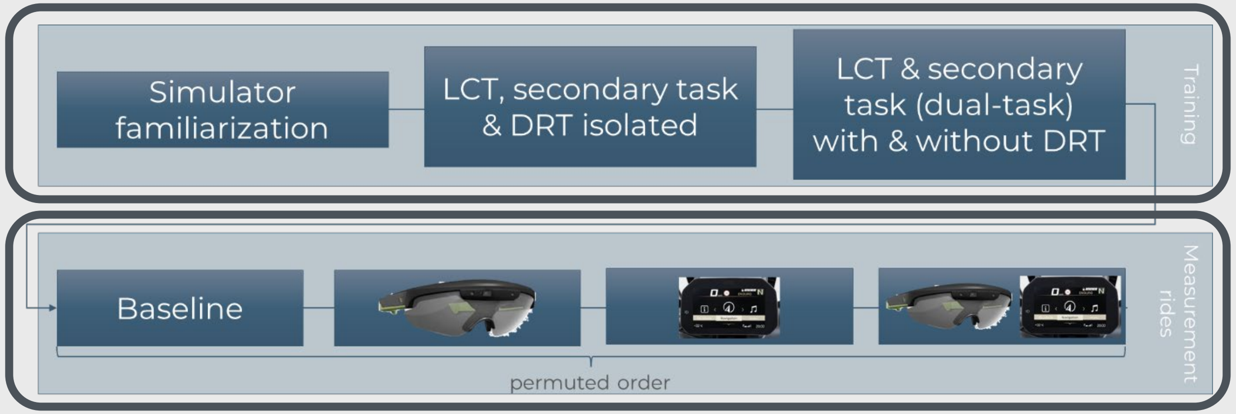
- Test course for each condition: 3 blocks with 18 lane changes each (→ 54 lane changes per condition)
  - Balanced number of single and double lane changes per block
  - Approx. 180 s per block
  - 2 blocks without DRT, last block with DRT



APPLICATION OF THE METHOD AND STUDY RESULTS

PARTICIPANT STUDY

- Study procedure:
  - Welcome, informed consent, data privacy statement
  - Simulator familiarization, practice tasks
  - Measurement rides, questionnaire after each condition
  - Final inquiry



- Study with 24 Participants
  - From WIVW participant panel: non-professional riders, previously trained on the simulator
  - Wide range of ages and level of riding experience
  - *n* = 4 female

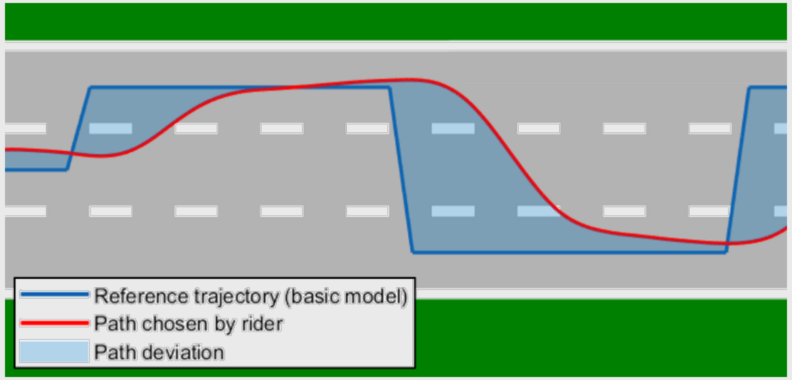
	Mean	***Standard deviation***	***Minimum***	***Maximum***
Age in years	35	10	19	59
Motorcycle mileage covered during the last 12 months in km	4,604	3,261	900	12,000
Motorcycle lifetime mileage in km	68,174	63,562	6,000	300,000

APPLICATION OF THE METHOD AND STUDY RESULTS

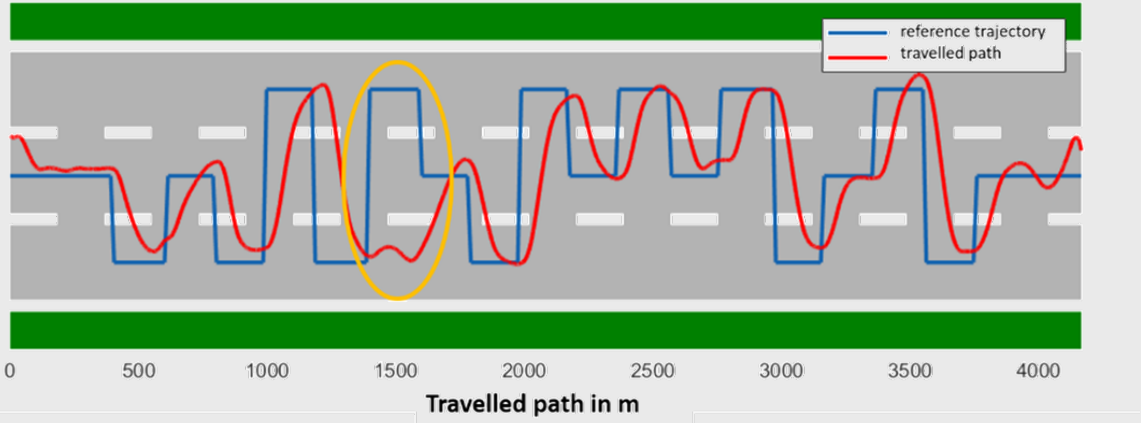
DATA ANALYSIS

INFLUENCE OF SECONDARY TASK ON LCT

- Path deviation measure
  - Reference trajectory: basis model (ISO 26022)
  - Average deviation over length of test track



- Success of lane changes
  - Indicated lane is reached before next sign pops up

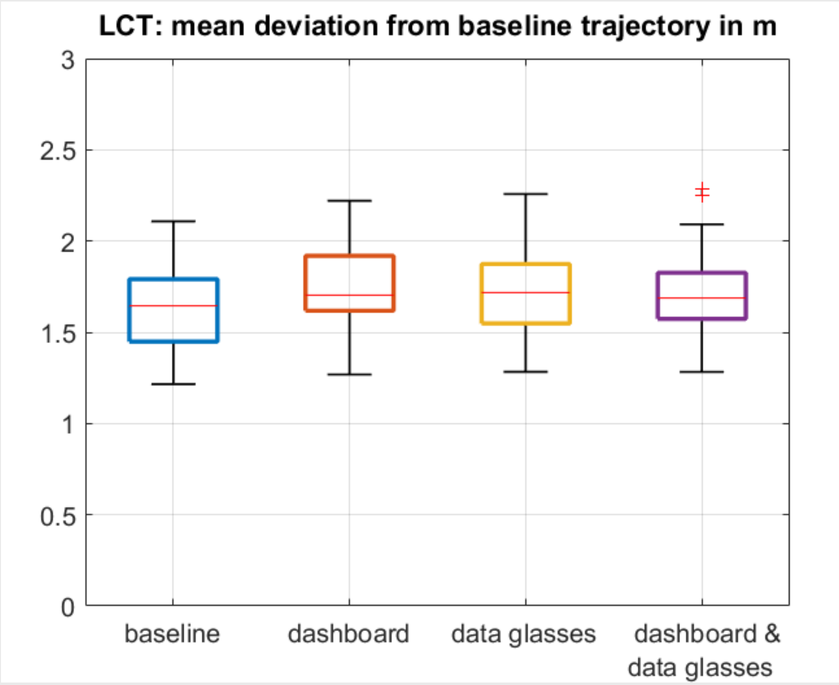


APPLICATION OF THE METHOD AND STUDY RESULTS

DATA ANALYSIS

INFLUENCE OF SECONDARY TASK ON LCT - RESULTS

- Path deviation measure
  - Higher deviations in sencondary task conditions



- Success of lane changes
  - Selection of wrong lane occurs very seldomly for all conditions (0.3 – 0.6 %)

		wrong lane
		proportion
display technology	baseline	4/1296
	dashboard	8/1296
	data glasses	6/1296
	dashboard & data glasses	7/1296

APPLICATION OF THE METHOD AND STUDY RESULTS

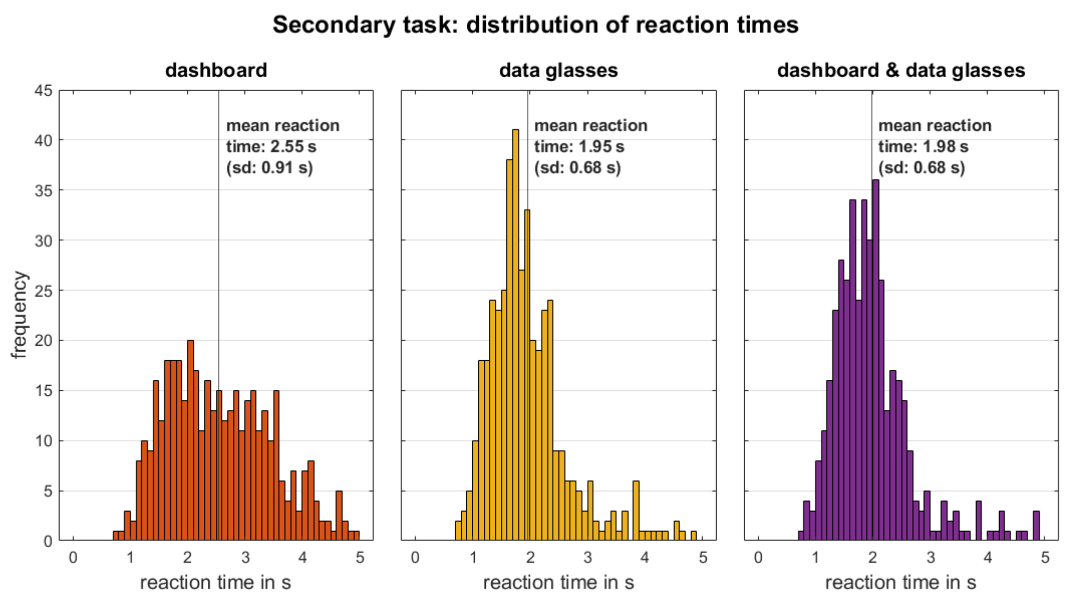
DATA ANALYSIS

SECONDARY TASK PERFORMANCE - RESULTS

- Reaction time
    - Time between change of turn-by-turn indication and rider pulling high beam lever
    - → Significantly faster with data glasses
    - → Especially reduction of very long reaction times

- Success in recognizing indicators
    - Number of missed changes
    - → Least missings with data glasses only (1.8 %)
    - → 6.5 % for dashboard
    - → 4.4 % for dasboard & data glasses

		turn-by-turn indicators	
		missed	***recognized***
display technology	dashboard	28	404
	data glasses	8	424
	dashboard & data glasses	19	413

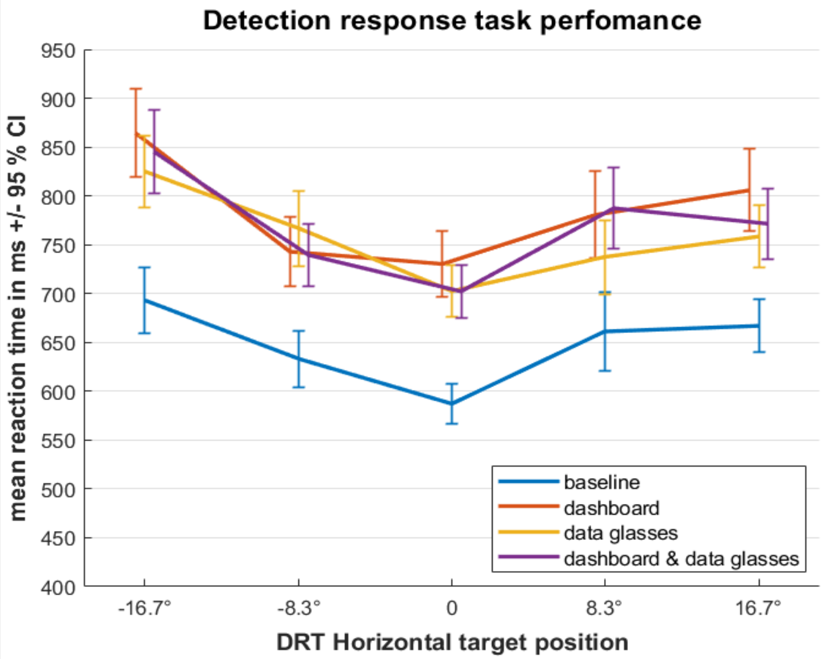


APPLICATION OF THE METHOD AND STUDY RESULTS

DATA ANALYSIS

WORKLOAD ASSESSMENT DRT - RESULTS

- Reaction times
  - Considerably increased workload while performing secondary task
  - Outer positions slightly faster with data glasses



- Success of detecting stimuli
  - Confirms higher workload
  - About twice as many missings in secondary task conditions

		missings
		proportion
display technology	baseline	32/1081
	dashboard	69/1085
	data glasses	54/1083
	dashboard & data glasses	69/1084

APPLICATION OF THE METHOD AND STUDY RESULTS

DATA ANALYSIS

WORKLOAD ASSESSMENT NASA TLX - RESULTS

- Subjective assessment
  - Scale from 1 (very low) to 20 (very high), performance inverted: 1 (perfect) to 20 (failure)
  - → Increased workload for secondary task conditions
  - → Strength of data glasses compared to dashboard can be shown (**bold**: statistically significant deviations)
  - → Majority of riders (15/24) prefer data glasses when both technologies are available (only one prefers dashboard)

		Mean (standard deviation) on the NASA-TLX sub scales					
		mental	*physical*	*temporal*	*perfor-mance*	*effort*	*frustration*
Condition	baseline	6,13 (3,76)	4,75 (3,11)	4,62 (3,08)	3,67 (2,22)	8,46 (4,61)	2,96 (2,71)
	dashboard	12,08 (4,46)	7,42 (4,37)	9,67 (4,64)	5,50 (3,16)	12,08 (5,12)	4,00 (2,72)
	data glasses	**8,25 (4,70)**	6,58 (4,24)	**6,63 (3,83)**	4,62 (2,96)	10,46 (5,21)	3,21 (2,55)
	dashboard & data glasses	**10,04 (4,73)**	7,17 (4,92)	**7,21 (4,24)**	4,96 (3,57)	10,13 (5,23)	3,58 (2,78)

CONCLUSION AND OUTLOOK

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SAFETY POTENTIAL OF DATA GLASSES FOR MOTORCYCLISTS

- Riding performance – LCT
  - Secondary task influences riding performance in general
  - No significant difference between display technologies
    → Data glasses neither reduce nor increase the effect

- Information recognition – secondary task
  - Reactions with data glasses on average 20 % faster
    → Probably because information is displayed closer to natural line of sight (comparably to to HUD solutions in passenger cars)

- Workload – DRT (objective)
  - retrieving and processing information adds considerable amount of workload
  - Recognition of stimuli in periphery slightly faster and less missings with data glasses
    → Gazes away from forward road scene when glancing to dashboard

- Workload – NASA TLX (subjective)
  - Confirms DRT results, particularly for mental and temporal load

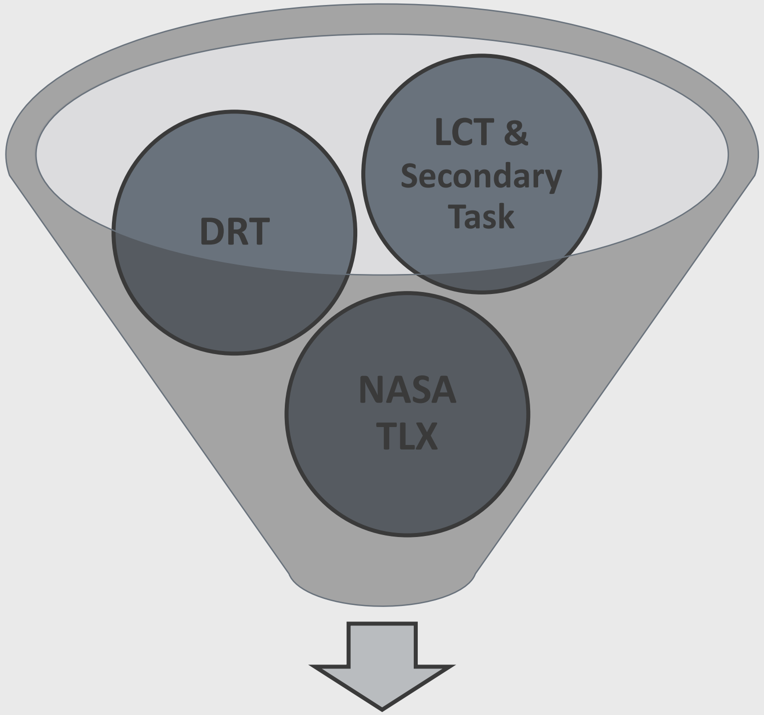
CONCLUSION AND OUTLOOK

INVESTIGATION METHOD

- Combination of well-established standards from passenger car domain
  - Adaptions for motorcycle test case
  - Applied to the investigation on the safety potential of data glasses for motorcyclists on a motorcycle riding simulator

  → Method proved to be applicable

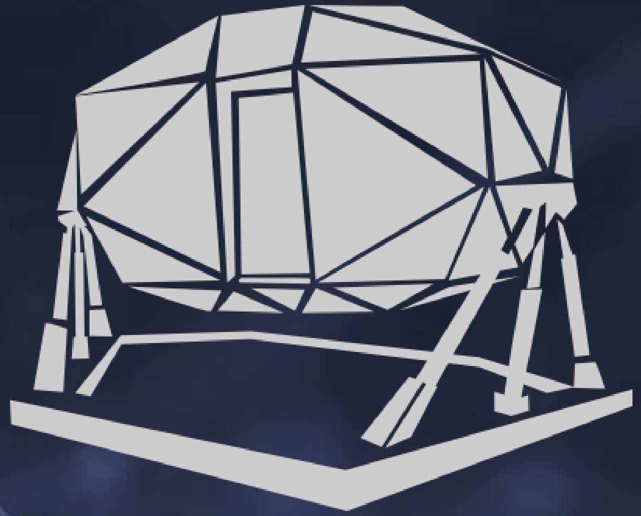
  → Plausible results, showing differences between the display technologies



- The successful implementation of the method is an important result!
  Being based on well-established standard methods, it could be a basis for future investigations of other new (assistance) systems.

  Allowing to evaluate motorcycle assistance systems in a safe simulator environment with relatively low effort, as it is already common procedure in the passenger car domain, the method could help to accelerate bringing modern assistance systems into the market.

Thank you for your attention!



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REFERENCES [1]

- ASFINAG (2021): Immer mehr Motorrad-Unfälle durch Ablenkung. Retrieved from https://oe3.orf.at/stories/3014035/.
- Guth, S. (2017): Absicherungsmethode von Anzeigekonzepten zur Darstellung fahrfremder Informationen mittels eines Motorrad-Fahrsimulators. (PhD-Thesis), Technische Universität Darmstadt, Darmstadt.
- Hart, S.G. & Staveland, L.E. (1988): Development of NASA TLX (task load index): results of empirical and theoretical research, Adv. Psychol., 52, pp. 139–183
- ISO (2010): ISO 26022: Road vehicles — Ergonomic aspects of transport information and control systems — Simulated lane change test to assess in-vehicle secondary task demand. International Organization for Standardization, Geneva, Switzerland.
- ISO/TS, (2016): ISO 17488:2016: Road Vehicles–Transport Information and Control Systems – Detection-Response Task (DRT) for Assessing Attentional Effects of Cognitive Load in Driving. International Organization for Standardization, Geneva, Switzerland.

REFERENCES [2]

- Wickens, C. D. (1980): The structure of attentional resources. In R. S. Nickerson (Ed.), Attention and performance (pp. 239–257). Hillsdale, NJ: Erlbaum.
- Wickens, C. D. (2008): Multiple resources and mental workload. Human Factors, 50(3), 449–455. https://doi.org/10.1518/001872008X288394.
- Will, S.; Hammer, T.; Köbe, M.; Liebick, T.; Maruyama, K.; Onoue, T.; Purschwitz, A. (2018): Powered Two-Wheeler HMI Design for Cooperative Intelligent Transport Systems (C-ITS). Paper presented at the 12th International Motorcycle Conference, 01.10. - 02.10.2018, Cologne, Germany.