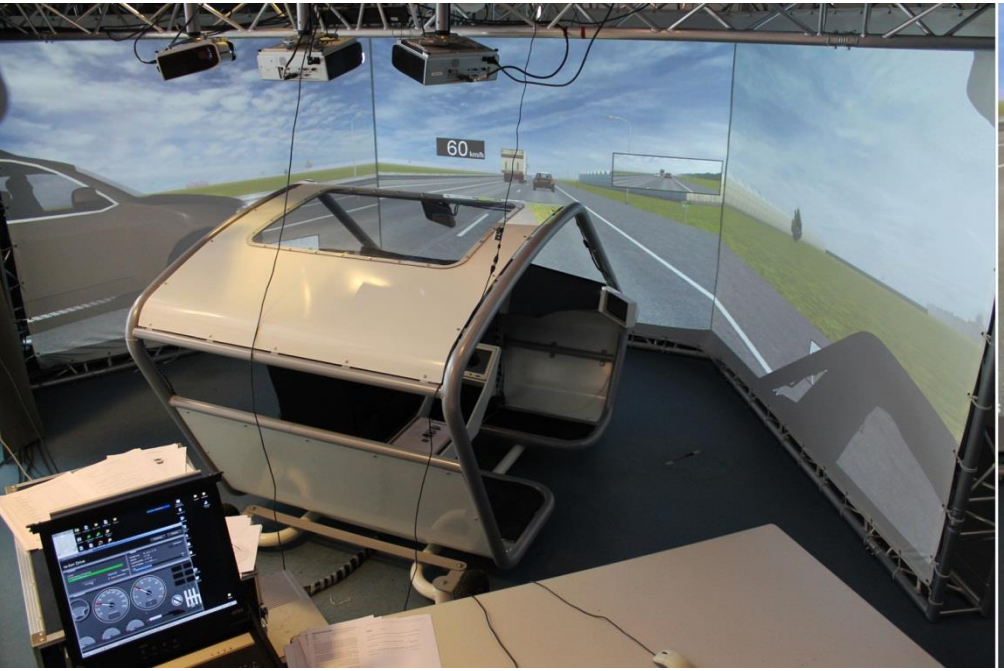
Retrieving human control after situations of automated driving

How to measure Situation Awareness



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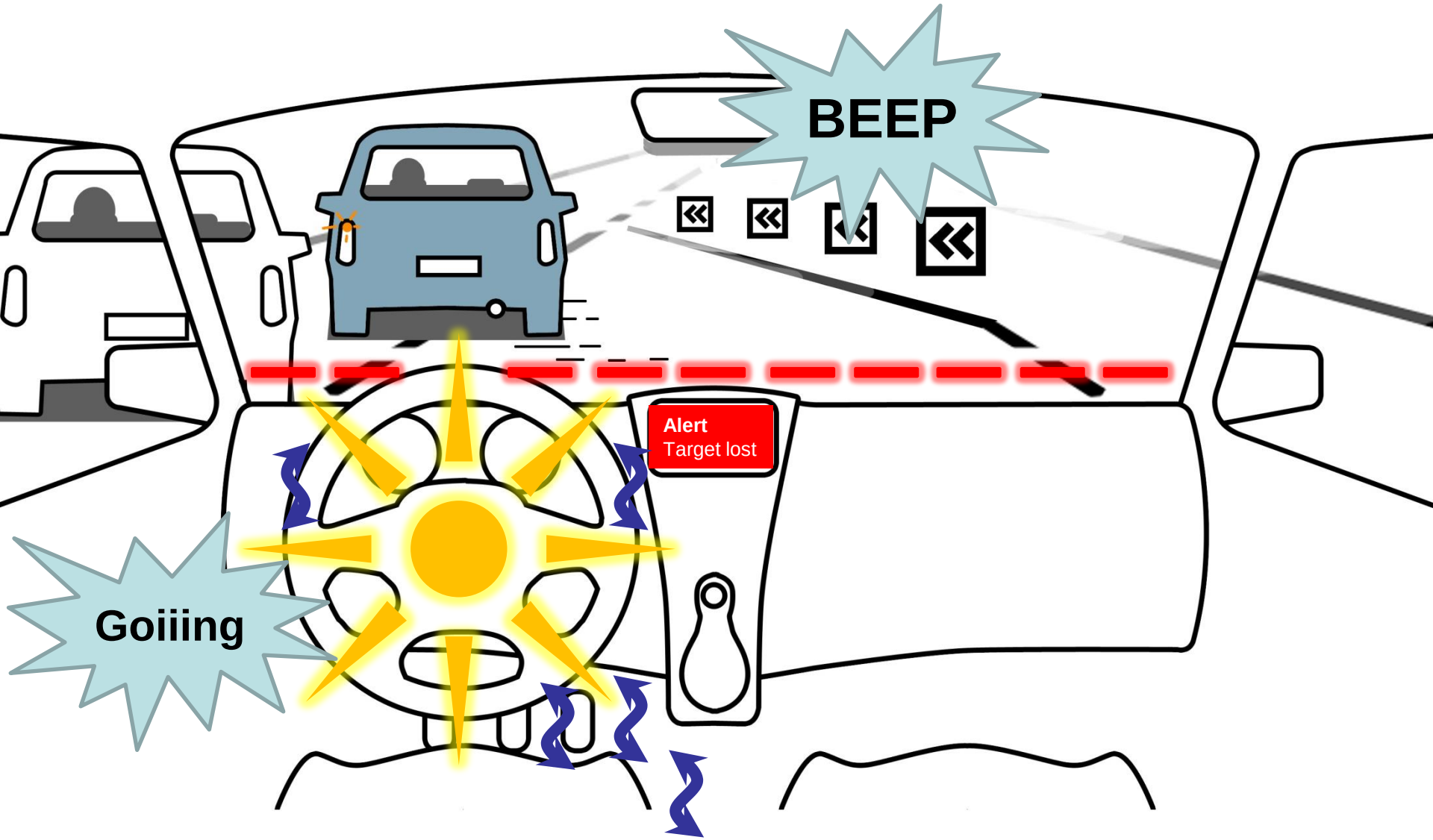


Transitions to retrieve (human) control might regularly occur. Many scenarios: Cut-in, targeted vehicle merges out, $v_{av.}$ oscillates around 60km/h, road work, etc.

What interface does support the transitions in those situations?

Background

- During automation, the driver is not actively involved in the control-loop causing problems to take over control
- Eventually an interface should be optimized to support drivers in taking over control as successful as possible.
  - A prerequisite for successful take over is Situation Awareness (SA)
  - SA = level of a person's awareness of a situation, and how his actions will impact how the situation develops
    (1) the observed presence or absence of elements in the situation;
    (2) the participants' comprehension of the meaning of these elements;
    (3) anticipated future state of the elements

  ➢ Within a design process the influence an interface type has on the extent and time in which SA is gained, should be assessed.

- To assess this influence of interface type on SA, it should first be evaluated what method for measuring SA is most suitable.
  ➢ Focus within this research: developing an **assessment frame-work**

Situation Awareness Measurement methods

Freeze probe techniques
- Queries relate to probes within a simulation which is temporarily being ‘freezed’
- SAGAT (Endsley) is most commonly used.

Real-time probe techniques
- Expert administrates probes real-time
- Typical application is for non time-critical supervisory tasks

Self-rating techniques
- A subjective rating of SA:
- most common: SART

Performance measures
- Indirect measure: e.g. lane position or TTC

Methods for measuring Situation Awareness

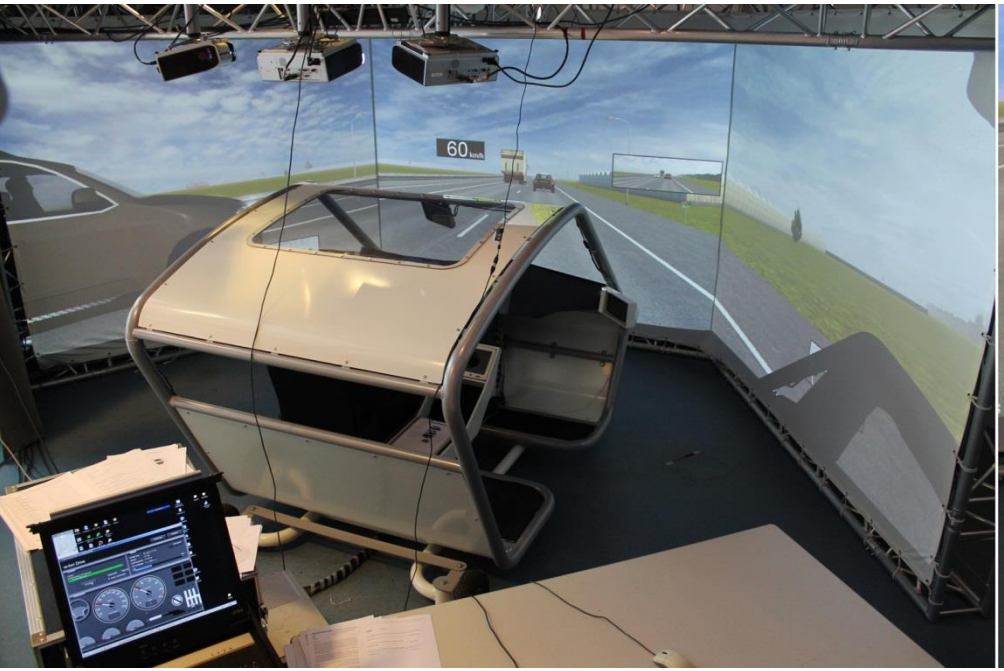
SART: Situation Awareness Rating Technique

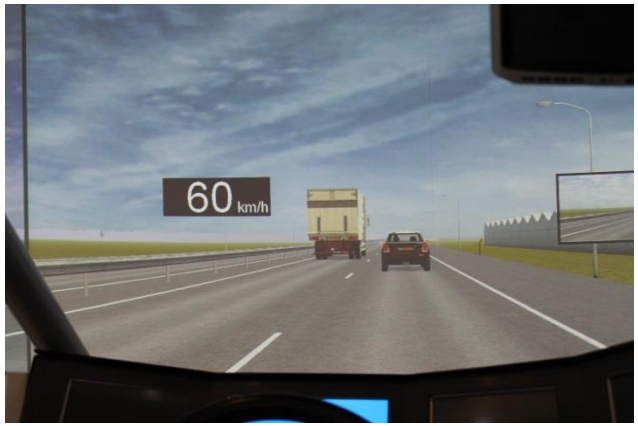
- A subjective rating of SA representing the 3 levels of SA
- Using a rating scale with 10 dimensions
- Filled out by the participants (ambiguous whether their judgement is ‘correct’)
- Appears to be most commonly used

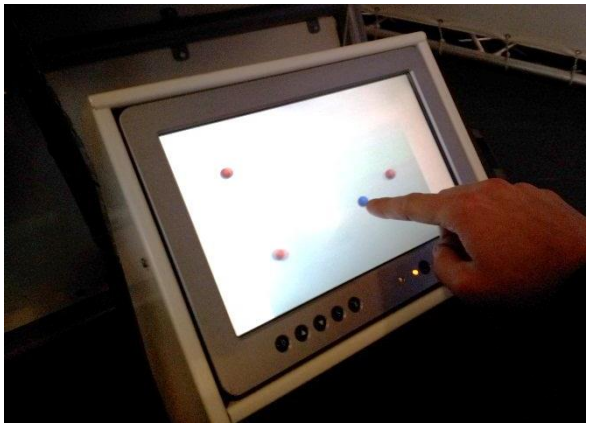
SAGAT (Situation Awareness Global Assessment Technique)

- Question construction is tailored per experiment (no standardized questionnaire)
- For each task, SAGAT questions must be developed to fully probe the situation awareness construct on all three levels.
- SAGAT requires tests in which tasks are being ‘freezed’
- The number of questions presented during each freeze should be kept small to minimize interference effects in working memory.
- Examples of questions: What type of car was behind (car, truck, van)?; What was the particular colour of neighbouring vehicle?; What was the reason for take-over?; etc.

Apparatus / Simulator environment

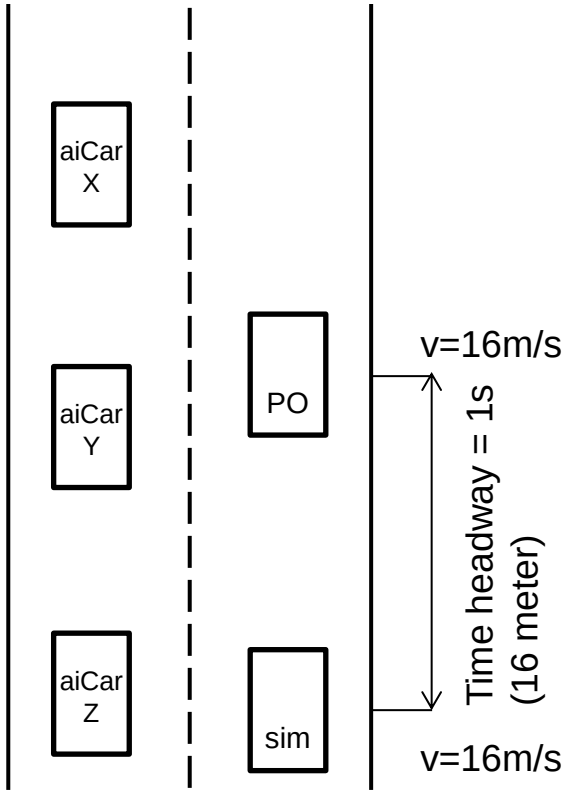




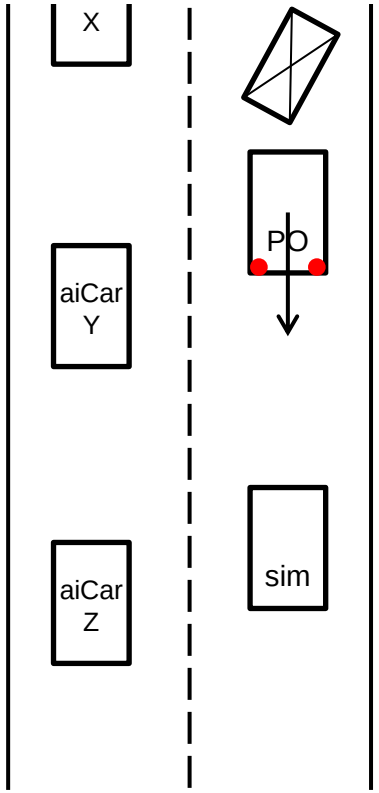


Driving simulator with simulated motorway. Below right: secondary task

Criticality conditions (available time for take-over)



t=0



a= -8m/s^2

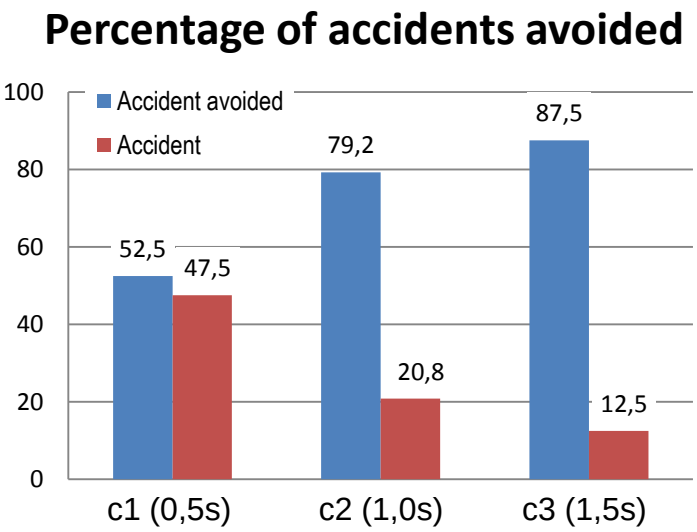
(v=16m/s, as long as driver does not intervene)

Without intervention in 2,20s an accident will occur (for this example)

t=x (Target vehicle starts emergency brake)

Time headway	**0:50s**	**1:00s**	**1:50s**	**No emergency**
Without intervention, accident within…	*1:50s*	*2:20s*	*2:80s*	
Driving on left lane	*Conditions in random order for each participant*			
Driving on right lane				

Successfulness vs. criticality (available time) of take-over

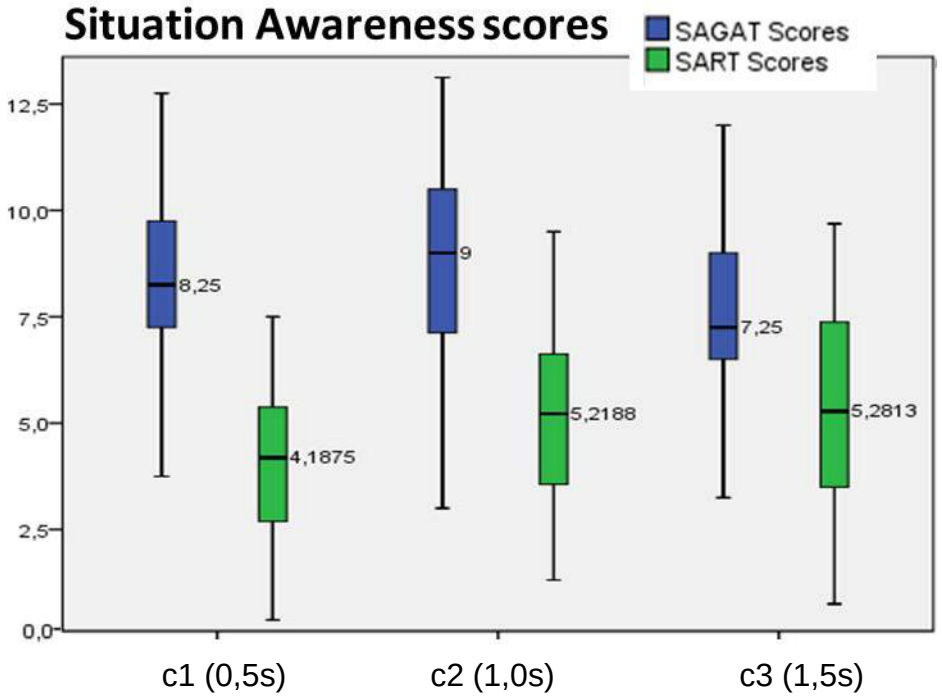


"least time" << Time-conditions (s) >> "most time"

- Positive correlation between successfulness and criticality (r = 0.541, p<0.001)
- Unsuccessful take-over ("Accident") occurs most often during the most critical time condition (0,5s); the least critical condition has the highest success-rates.
- Even the highest critical situations were manageable to some degree.

➢ Chosen levels of criticality influenced driving performance; although criticality was high in all conditions

Situation awareness vs. criticality of take-over

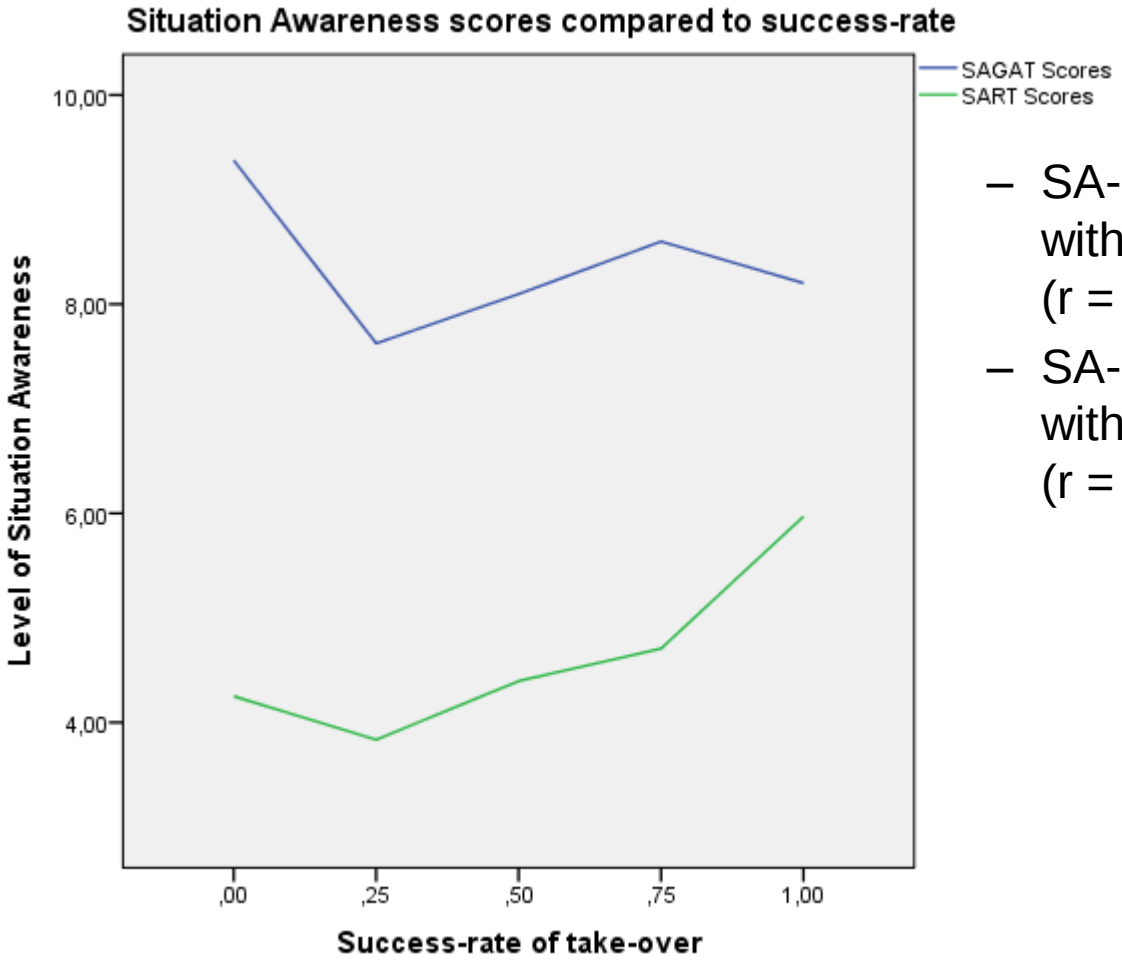


"least time" << Time-conditions (s) >> "most time"

- Criticality correlates with SA-SART ($r = 0.284$, $p = 0.004$)
- No significant correlation between Criticality and SA-SAGAT ($r = -0.169$, $p = 0.089$).

- SART correlates with criticality as was expected
- ➢ Participants in the less critical conditions were better able to divide their attention between observing the traffic and controlling their own vehicle.
- Insignificant negative correlation between SAGAT and criticality, *contrary to expectations*

Situation awareness vs. successfulness of take-over



- SA-SART is positively correlated with success-rate ($r = 0.323$, $p = 0.002$)
- SA-SAGAT shows no correlation with success-rate ($r = 0.020$, $p = 0.852$)

➢ *SART scores confirm assumption when SA increases, so does the chance for a successful take-over.*

Suitability of methods for measuring situation awareness

- Contrary to expectations the objective SAGAT-method showed no correlation with available time, nor to success rate, for taking over control.
- ➢ At least one of the measures is providing a false level of SA
- ➢ The SART questionnaire has shown some promising results for use in the current set-up, and according to expectations

- Based on the weak and *negative* correlation between Criticality and SA-SAGAT, we presume that the **moment of probe-taking** –and probably the probes themselves- have **influenced SAGAT-scores**.
- ➢ Possible explanation; Within the least critical time condition, the traffic is more changeable probably resulting in ambiguity where the probes referred to. Hence, more wrong SAGAT-answers

Main conclusion & future work

- Using SART for measuring SA within time-critical situations of taking over control is at least a secure consideration

- Continue to also consider SAGAT
  - Objectiveness of measurement method remains valuable reason
  - Improve how SAGAT is been applied
    - Especially moment of probe-taking
    - First attempts are promising

Recommendation:

- Improve diversity in situations which require take-over to avoid habituation

Thank you for your attention

For more information, comments or suggestions, please contact:
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