DETECTION THRESHOLDS FOR MID-AIR INTERACTION. HOW SENSITIVE ARE WE DURING STRESSFULL TASKS?

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Motivation

- Mid-air gestural interfaces have reduced usability due to the lack of tactile feedback.
- Tactile feedback is important as it indicates spatial interaction borders or successful interactions.
- For the reintegration of mid-air feedback, vortex-canons and ultrasound-based feedback generate tactile feedback with no device attached to the hand.
- Both techniques generate weak feedback which is comparable to a whiff.
- Applications like in-vehicle interfaces or control rooms will comprise critical decision tasks in complex situations.
- Here, the combination of visual and haptic feedback is highly efficient and superior to visual- and acoustic feedback.
- However, to guarantee a reliable detection under conditions with normal to high workload it is necessary to analyse required feedback intensities of mid-air systems.

Summary

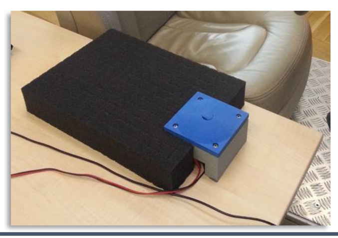
- Novel contactless interfaces like sound or gesture input create an instinctive interaction and are seen as natural interfaces.
- However, the absence of haptic feedback limits the usability.
- In theory, tactile feedback is useful when it is integrated under conditions with a high cognitive workload.
- It is necessary to determine detection thresholds and derive the feedback intensity for reliable feedback detection.
- This paper investigates the effects of feedback intensity and different workload conditions.
- A driving task is used to produce different workload conditions.
- During the driving task, the perception of tactile feedback is reported as a secondary task.
- Results indicate that a higher workload causes higher perception thresholds, especially for novices.

Method

Apparatus

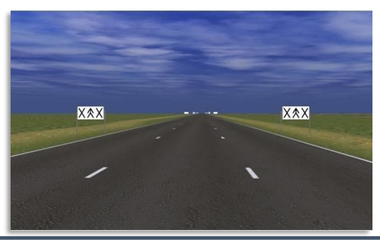
- Mobile driving simulator with a 60-inch screen and working instrument board.
- LCT–software with a variation in speed.
- Mid-air feedback was replaced by a touch system because state of the art prototypes do not deliver reliable feedback.
- The touch system uses an acoustic shaker and addresses the same receptors (meissner's corpuscles) as the vortex-canons.
- Participants carried Headphones to prevent distraction.
- On condition D participants heard an audio-clip, aligned to engine sound used in conditions A-C.


Driving simulator


Touch-based feedback system

Design

- 4 (conditions) x 8 (forces) factor within-subject design.
- Conditions:
  - LCT Baseline | 60 km/h driving – tactile feedback,
  - A | 60 km/h driving + tactile feedback,
  - B | 90 km/h driving + tactile feedback,
  - C | 120 km/h driving + tactile feedback,
  - D | no driving + tactile feedback.
- Eight different forces (0,0047N; 0,0107N; 0,0210N; 0,0315N; 0,0430N; 0,0536N; 0,0663N; 0,091N) derived from pre-test with four repetitions of each.
- Randomised order of appearance of the forces.
- DALI-questionnaire for workload assessment after each condition.

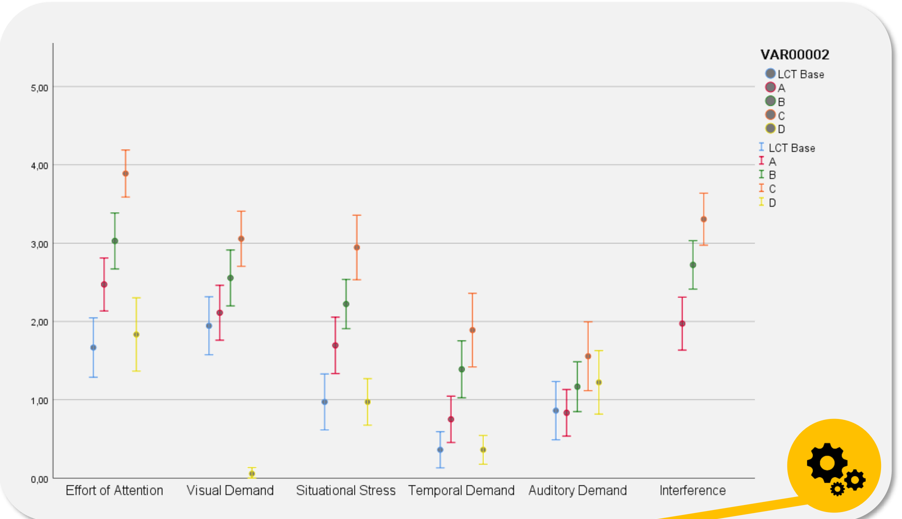

Lane change task

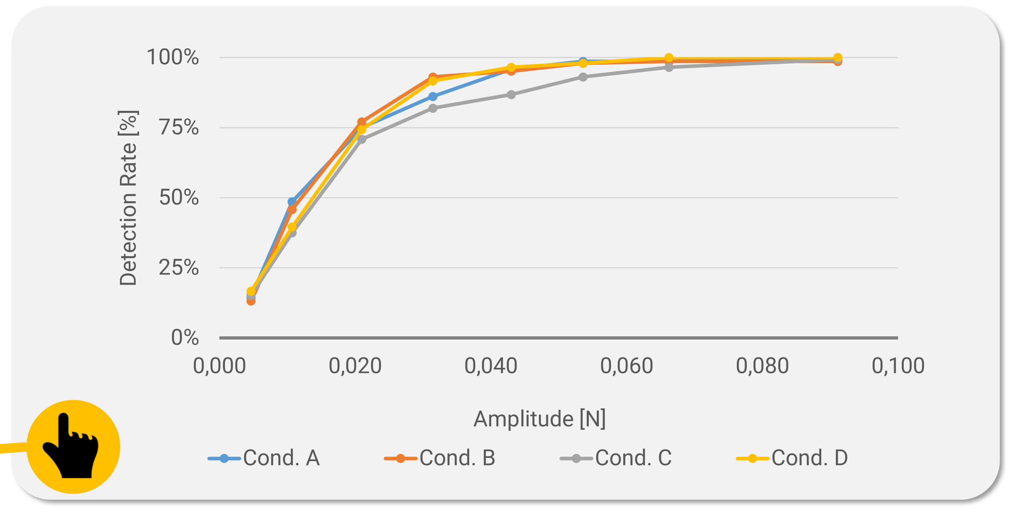
Results

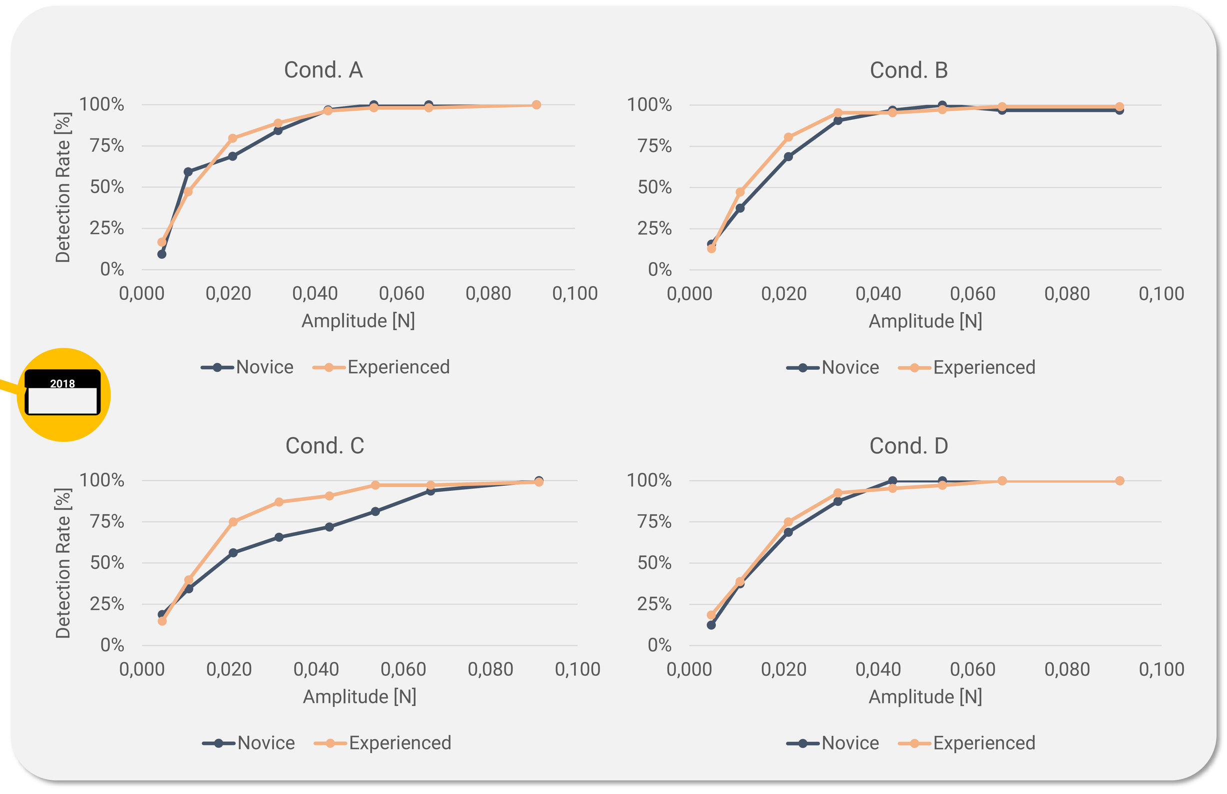
18+
M = 27,33 a
SD= 3,4 a

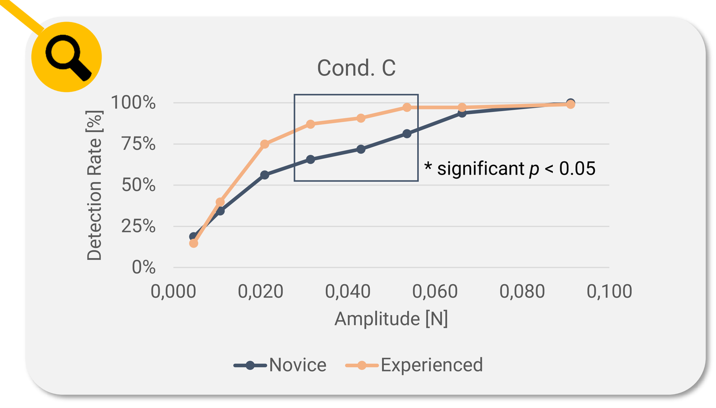
36 < 14 / 22

2018
M = 10,509.72 km/a
Range: 0 km/a – 25,000 km/a









Discussion

- For low to normal workload conditions, no adaptation of the feedback intensity is necessary.
- Under high workload, detection rates decrease, especially for novices.
- Here, the system should provide increased feedback intensities.
- No correlation between experience and workload as well as detection threshold and workload could be found.
  - Which factor does impact the detection threshold?
  - At which scale does workload impact the detection rate?
- To limit the deviation for the single forces, more repetitions per force will be used in further studies.
- In the following studies, the touch-based feedback system will be replaced with a sophisticated mid-air feedback system.
- Afterwards, it will be analysed if the psychometric functions are equal.

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