Joint driver-automation system design: Gradual action-oriented ambient stimuli

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AHFE 2015
Las Vegas

DLR

Motivation for a joint system design in automotive

Functions' and HMI integration is needed → Joint System (HaveIT)

Challenge: HMI-Design in automotive

- Usually “Inform, Warn, Intervene” interaction design is applied (InteractIVe 2012)
- HMI example for vehicle approach use-case:

We mean:

- **Inform**

- There is a vehicle in front. …object-related information

- **Warn**

- Vehicle in front is too close! …distance/urgency-related information

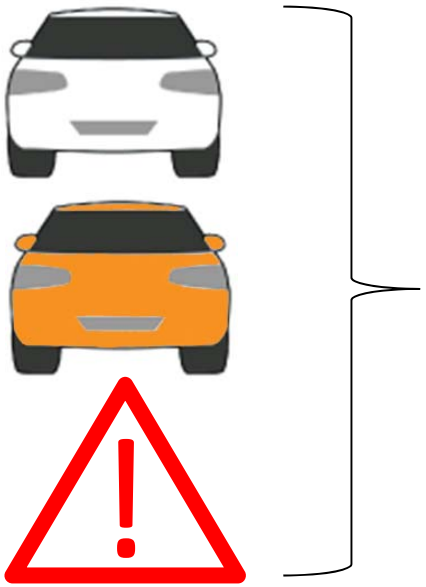
- **Intervene**

- Attention! Automation is braking! …task/action-related information

- **Mixing up several informational dimensions, which can be confusing for the driver**

Solution: Action-oriented stimuli for joint system design

- Why not using only the integrative **task/action-related** dimension?
- HMI Example for vehicle approach use-case:



But: Such design does not suit!

We could mean:

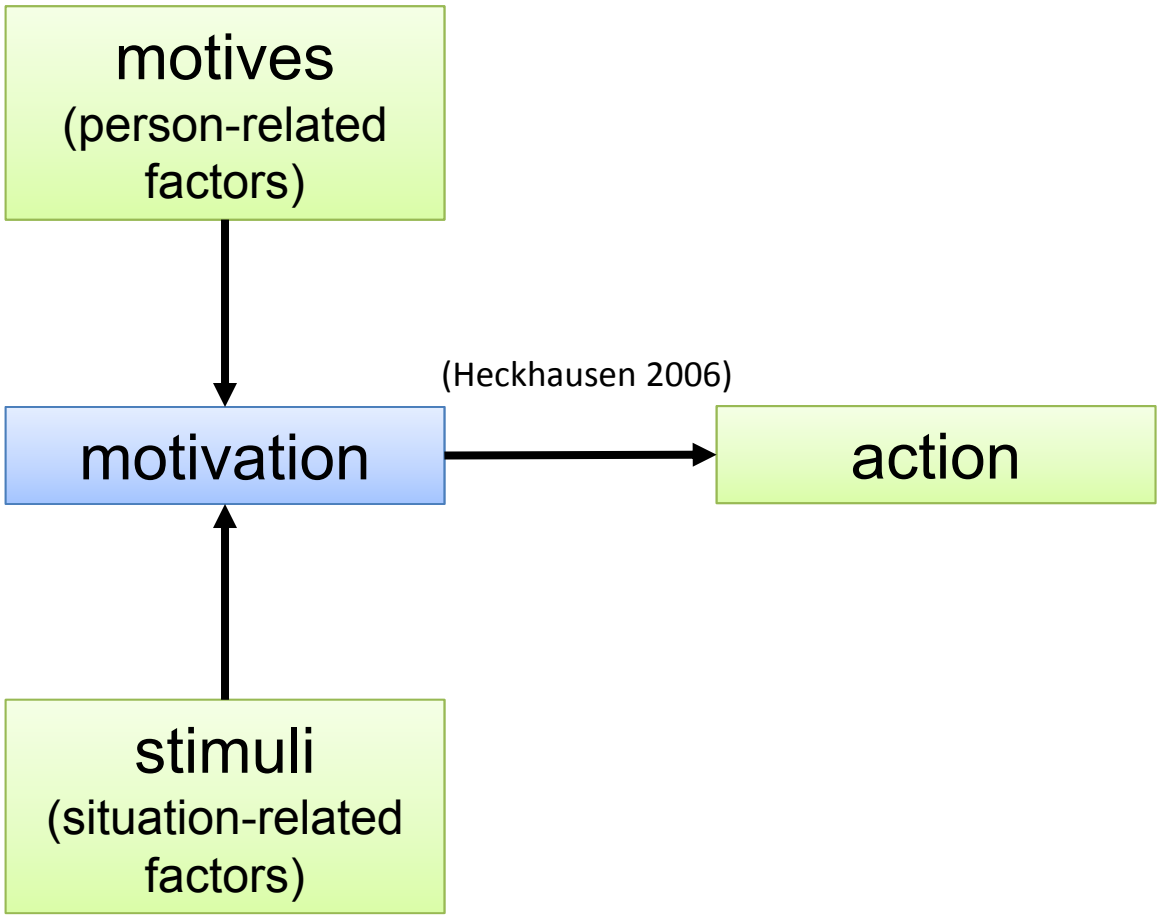
- You do what you do
- We should slow down

  …because of object in front
- We have to brake strongly!

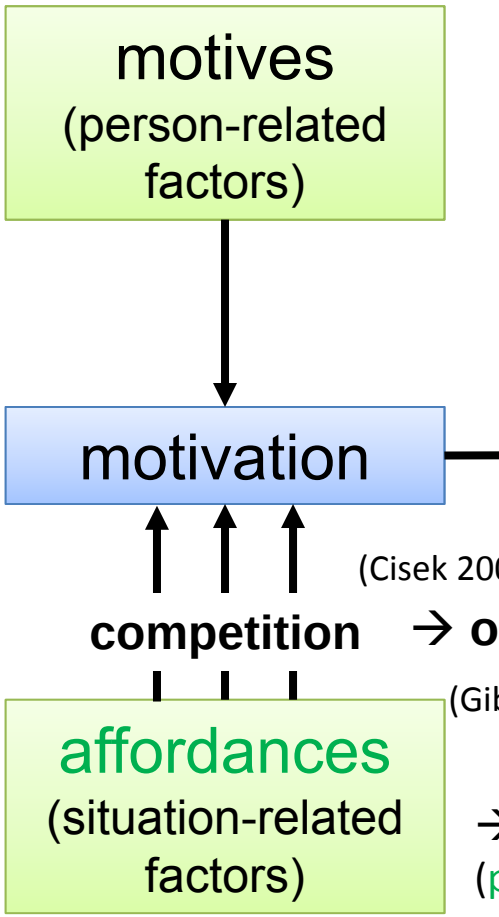
  …because of object in front

- **This task/action-oriented semantics can be more comprehensible**

Action-oriented stimuli: Motivational view



Action-oriented stimuli: Ecological view



Main idea: **Participate to the affordances competition while designing HMI**

(Cisek 2007)

competition → opportunity to influence the driver

(Gibson 1979)

affordances (situation-related factors)

→ action possibilities with valences (positive/negative) 'hidden' in the environment

Gradual action-oriented stimuli: Taxonomy

Action/Manipulation	
Limitation …of action opportunities	**Expansion** …of action opportunities
Prevention …of wrong actions	**Activation** …of correct actions
Inhibition …of wrong actions	**Support** …of correct actions
Prohibition …of wrong actions	**Enforcement** …of correct actions

compatible to…

- Inform
- Warn
- Intervene

Taxonomy testing for ambient visual stimuli

Ambient Display:

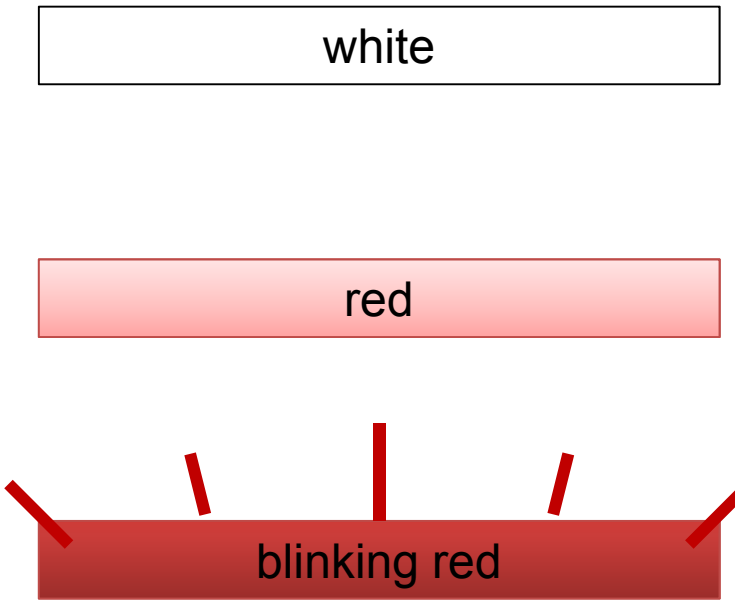
360° LED-Strip with any color and dynamics

Communication:

By peripheral signals

Ambient visual avoidance design

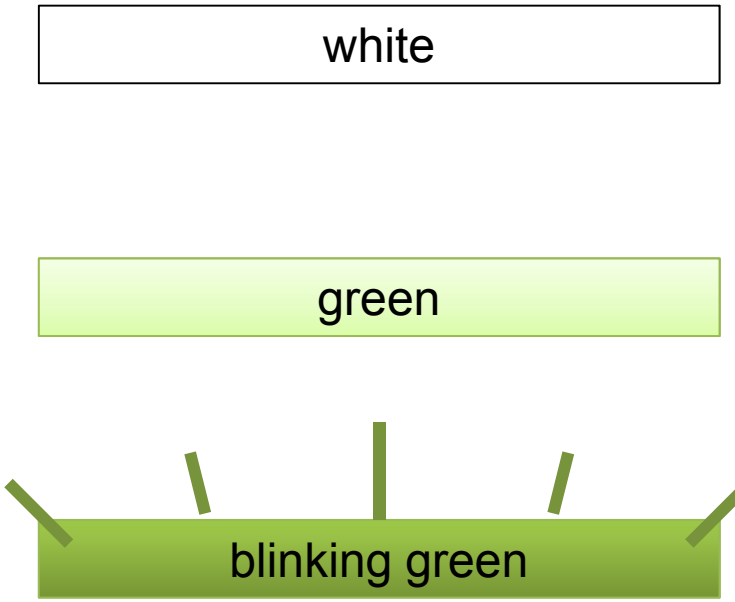
- Example for the vehicle approach/lane blocked use-case
  - You do what you do
  - You should brake/not steer
  - You must brake/not steer!



Ambient visual avoidance in different use-cases

Ambient visual affordance design

- Example for the vehicle approach (lane blocked) use-case
  - You do what you do
  - You can accelerate (steer)
  - You must accelerate (steer)!



Ambient visual affordance in different use-cases

Experimental setup

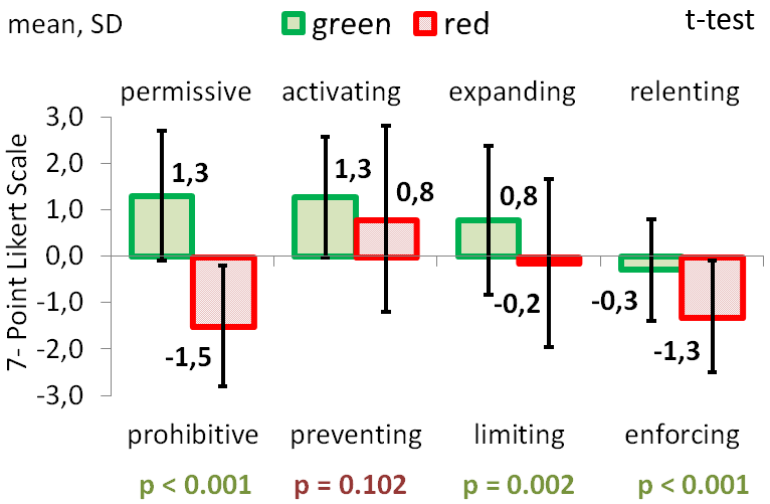
- 21 participants (10♂ + 11♀, age 38,3 SD=15,8 min 19 max 64) in IDeELab at DLR
- Exposure to different ambient signals in different use-cases
- Do participants comprehend ambient visual signals according to the proposed action-oriented taxonomy?
- Is there a difference between affordance/ avoidance on longitudinal/lateral axis?

Questionnaire (extraction):

How do you **comprehend** that signal?

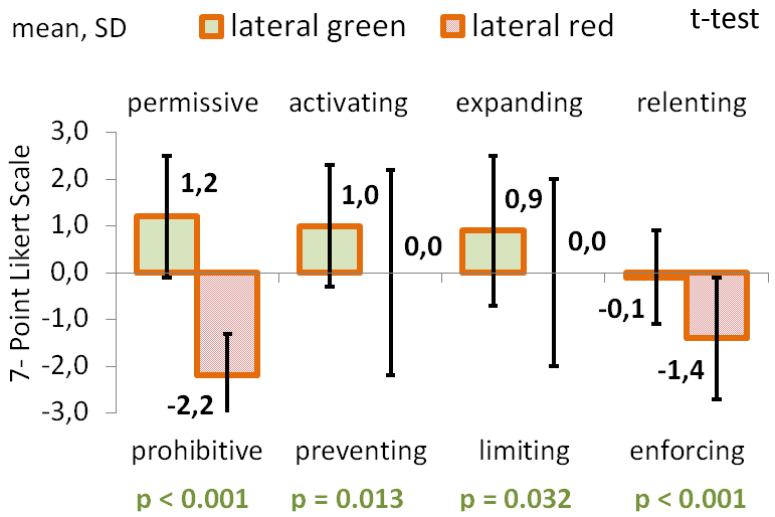
limiting	☐ ☐ ☐ ☐ ☐ ☐ ☐	expanding
activating	☐ ☐ ☐ ☐ ☐ ☐ ☐	preventing
relenting	☐ ☐ ☐ ☐ ☐ ☐ ☐	enforcing
permissive	☐ ☐ ☐ ☐ ☐ ☐ ☐	prohibitive

Results and discussion



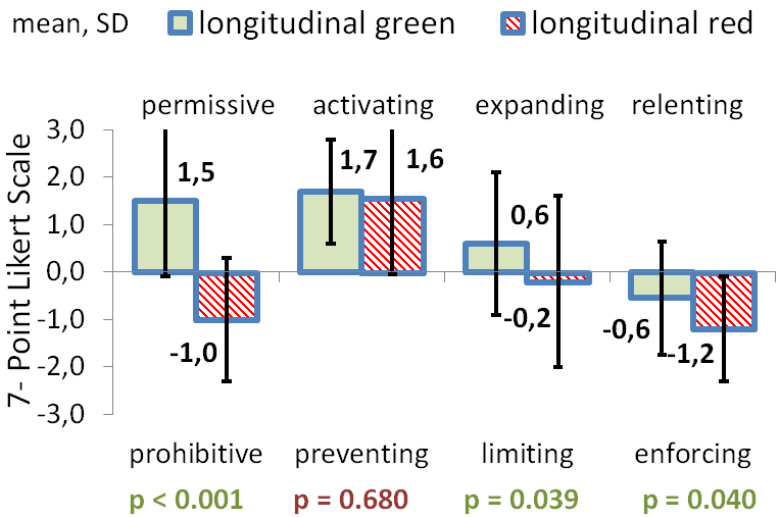
- Participants differentiate between
  - affordance:
    - permissive, expanding, less enforcing
  - avoidance:
    - prohibitive, limiting, enforcing
- But: affordance as well as avoidance are **similarly activating**
- Weak appearance of ‘preventing’
- → …seems to be possible to design within affordance/avoidance taxonomy

Results and discussion



- Lateral green signals are differently comprehended than lateral red signals
- …meeting the proposed taxonomy

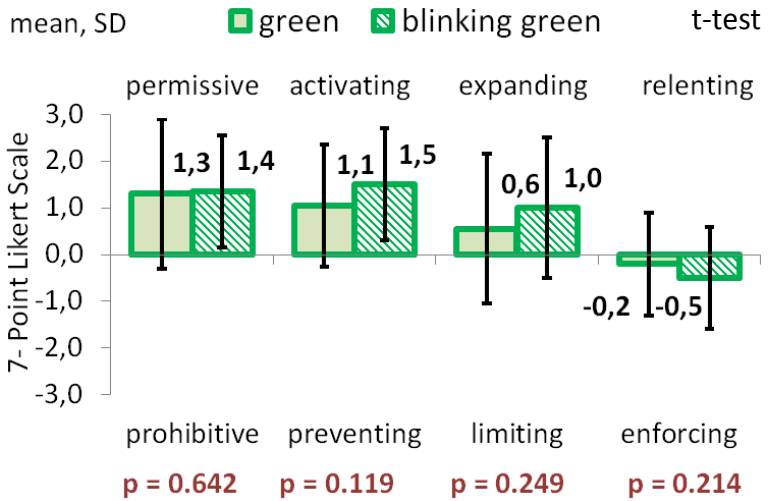
- → …possible to design within proposed taxonomy on the lateral axis

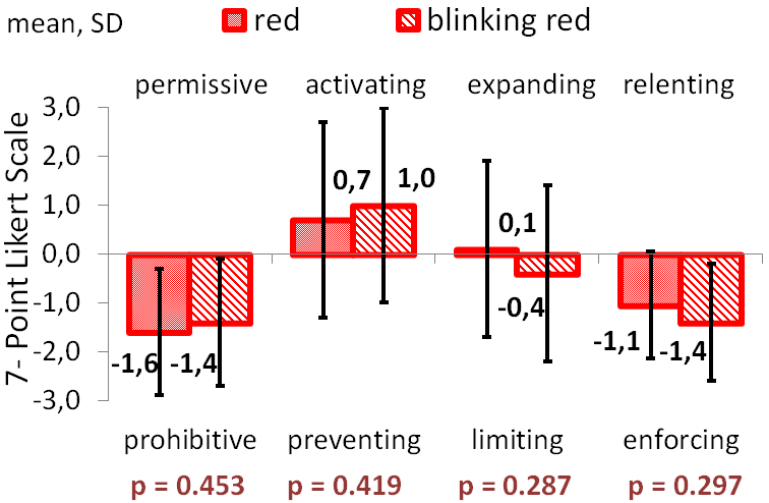


- Longitudinal green signals are differently comprehended than longitudinal red signals
- Exception: both are activating
- However, meeting the proposed taxonomy

- → …possible to design within proposed taxonomy on the lateral axis

Results and discussion





- No significant difference between green and blinking green
- However, blinking green shows a tendency ($p < 0.25$) to be more activating, expanding and enforcing

- → Further investigation is necessary, e.g. adding multimodality

- No significant difference between red and blinking red
- However, blinking red shows a slight tendency ($p < 0.30$) to be more limiting and enforcing

- → adding multimodality

Summary and outlook

- It seems to be possible designing joint systems within proposed gradual action-oriented taxonomy
- However, the taxonomy should be revised
  - e.g. because of weak appearance of ‘preventing’ in subjective data
- Ambient signal comprehension can depend on signal direction and the use-case

- Improvement of the ambient signals and joint system design according to the experimental results
- Another simulator environment + adding multimodality
- Full usability experiment results will be published at HFES Europe, Groningen, the Netherlands: October 14-16, 2015

Sources

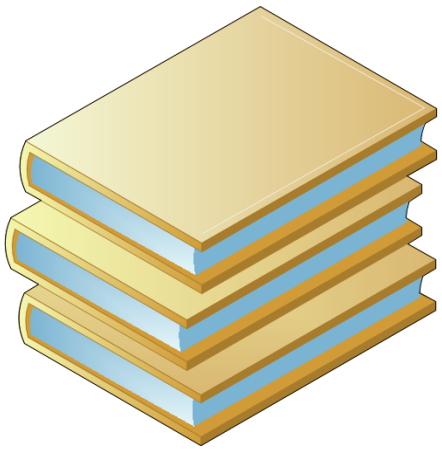
(1) HAVEit Community (2014): http://www.haveit-eu.org/

(2) InteractIVe Community (2012): *IWI Strategies.* Deliverable D3.2 for EU-Project „InteractIVe“

(3) Heckhausen, J. & Heckhausen, H. (Hrsg.) (2006): Motivation und Handeln, Heidelberg Springer Medizin, pp. 108

(4) Gibson, J. J. (1979): The ecological approach to visual perception. Boston, MA: Houghton Mifflin.

(5) Cisek, P. (2007): Cortical mechanisms of action selection: the affordance competition hypothesis. Phil. Trans. R. Soc. B 2007 362, 1585-1599, doi: 10.1098/rstb.2007.2054



Thank You

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