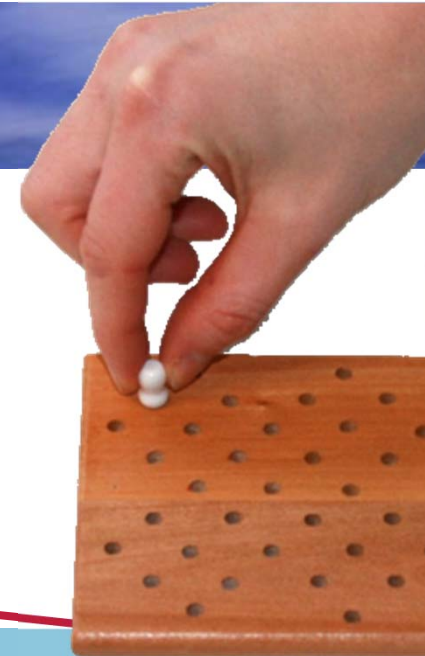
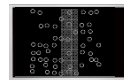




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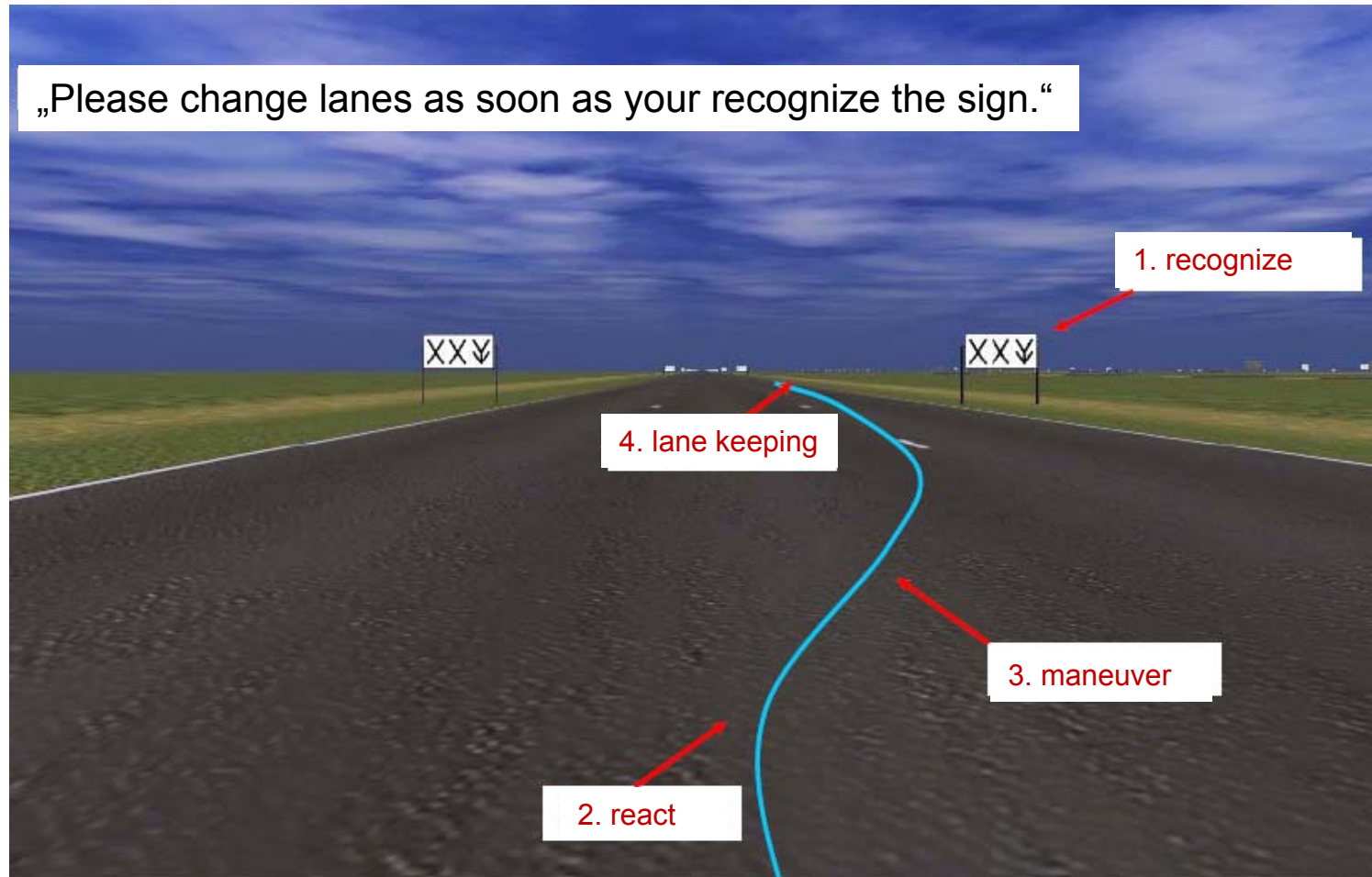
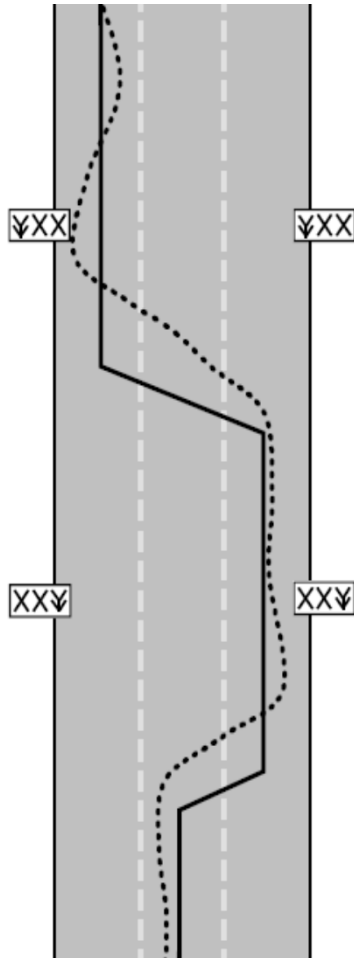
Performance assessment under visual, cognitive and haptic (manual) secondary task load - How to interpret Lane Change Task (LCT) results

Dr. Anja Katharina Huemer, Prof. Mark Vollrath

Driver Distraction & Inattention 2013, Göteborg, September 4-6 2013

Background: The Lane Change Task

Driving task for participants



Background: ISO 26022:2010

Objective of the LCT

ISO 26022:2010, p.1

“This Standard describes a dynamic dual-task method that **quantitatively measures human performance degradation** on a primary driving-like task while a secondary task is being performed. The result is an **estimate of secondary task demand**. [...]

The method is applicable to **all types of interactions** with in-vehicle information, communication, entertainment and control systems; **haptic, visual, haptic and auditory, and combinations thereof**. [...]

The objective of the present document is to provide a **valid, reliable and sensitive** laboratory method that **estimates the effect on driving performance** caused by the demand from in-vehicle information and communication systems.”

Where to start from?

Questions about test qualities

Validity

- Attempt to validate with alcohol effects showed very small effects in LCT

Huemer & Vollrath, 2010

Reliability

- Large differences between laboratories in baseline performance from 0.8m up to 1.6m
- Effects of instructions used
- Strong training effects

*Rognin, Alidra, Val, Lescoaut & Chalandon, 2007; Weir, Kwok & Peak, 2007
Petzoldt, Bär, Ihle, & Krems, 2010; Young, Lenné & Williamson, 2011; Huemer & Vollrath, 2012*

Sensitivity

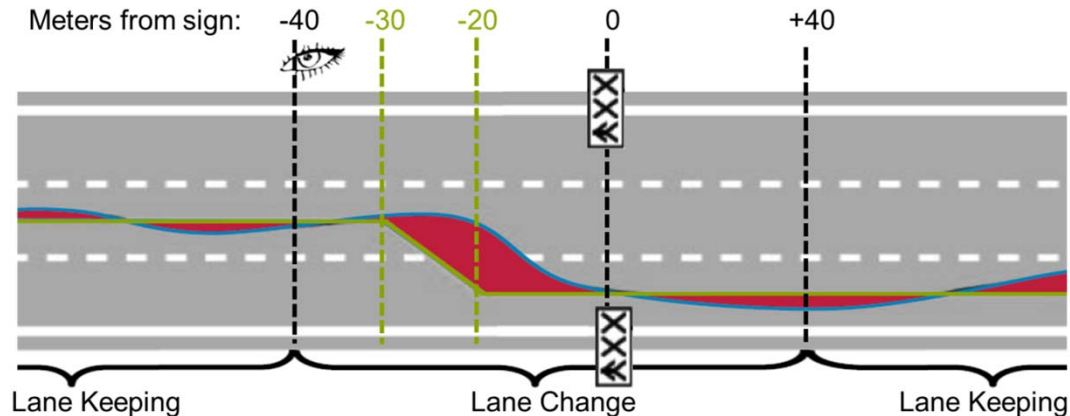
- Limited sensitivity for task demand level in mean deviation
- Mixed results for additional measures

Harbluk, Burns, Lochner & Trbovich, 2007; Bruyas et al. 2008; Young, Lenné & Williamson, 2011

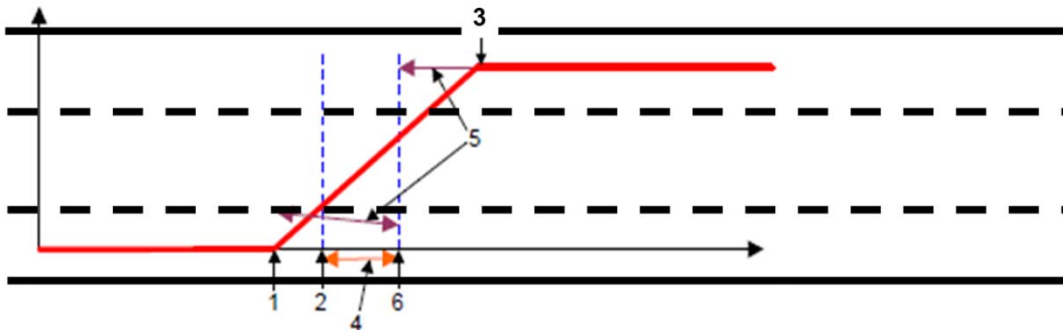
Driving parameters in the Lane Change Task

Basic & Adaptive Model

Basic Model



Adaptive Model (individual Lane Changes)



Metrics

- Mean Deviation MDEV
- MDEV Lane Keeping
- MDEV Lane Change
- SDLP for Lane Keeping
- Lane Change Initiation
- Erroneous / Missed Lane Changes

Research Questions

LCT metrics - What do they tell about secondary task demand?

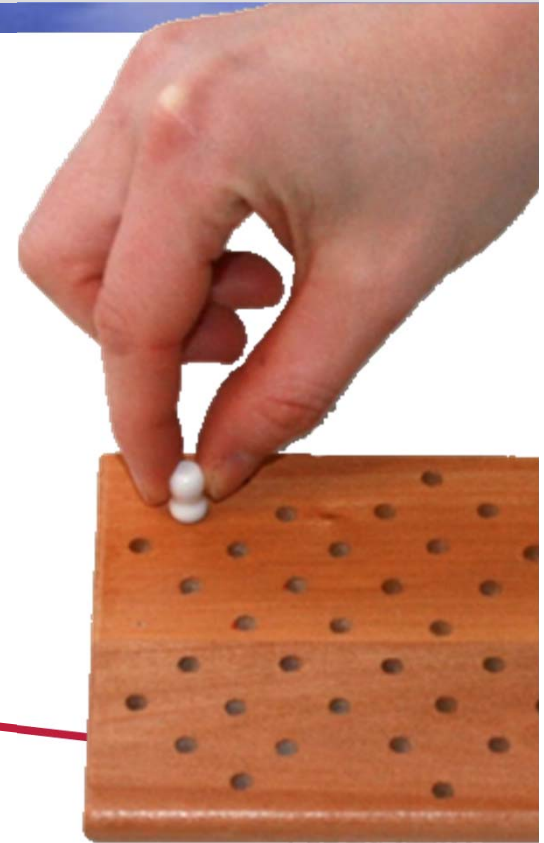
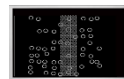
1. How do different analyses affect LCT results?

- Analyses Models: Basic vs. Adaptive

2. How do gaze, effort and performance interact?

- How does gaze behavior affect LCT performance?
- How does secondary task performance affect LCT performance?
- How are effort and subjective load incorporated?





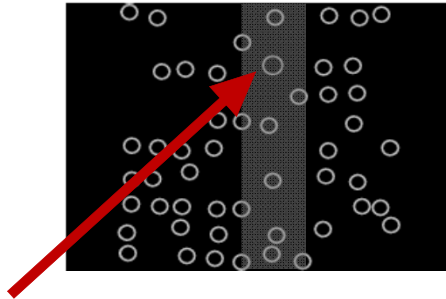
METHODS



Secondary Tasks

4 Tasks; 2 Difficulties

SuRT



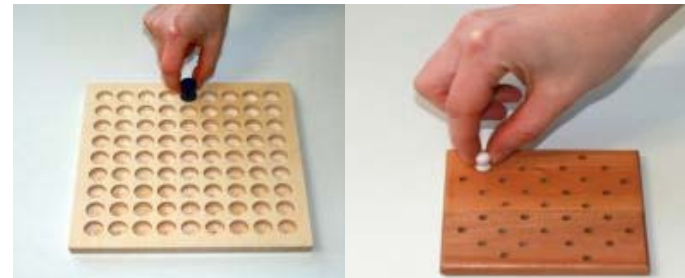
Cognitive Task

- Calculations

Critical Tracking Task



Haptic (manual) Task



Performance measures

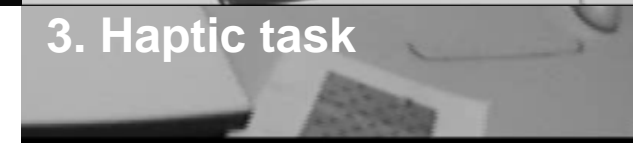
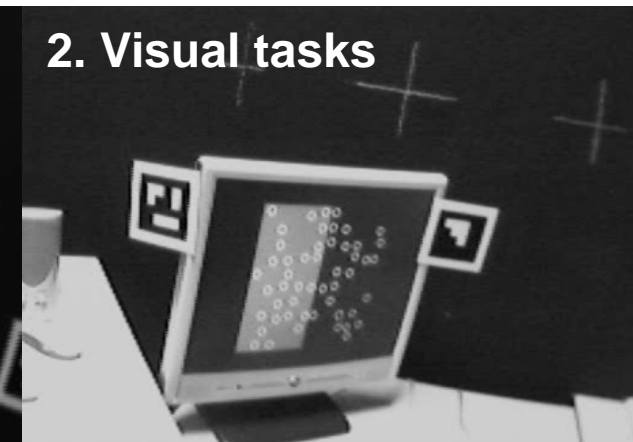
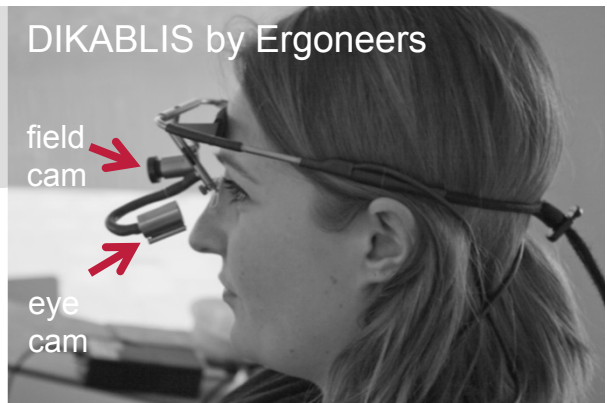
- Percentage of correct task completion z-transformed using single task performance of each task (easy)

Gaze Behavior

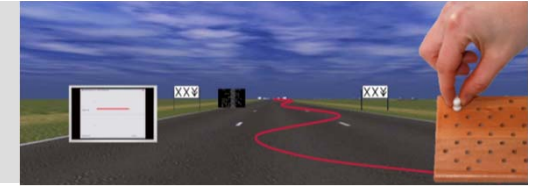
Data

3 Areas of Interest, for each

- Total Glance Time per AOI
- Mean Glance Duration per AOI
- Number of Glances per AOI
- Glance Proportion per AOI
- Glance Frequency into AOI



Demand, Subjects & Procedure



Subjective demand

- Rating of general, visual, & temporal demand, stress & tasks interference

Subjects

- 25 subjects (20♀; 5♂)
- Age: M=21.2 (SD=2.4) years

Training

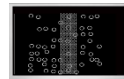
- 10 trials LCT
- 5 min training in each secondary task

Design

- Within Subject
- 2 experimental sessions

Procedure

- Baselines
 - LCT: before and after secondary tasks
 - Secondary tasks: 6 minutes single trial
- Balanced orders of secondary tasks
- For each secondary task: two trials of LCT with task



RESULTS

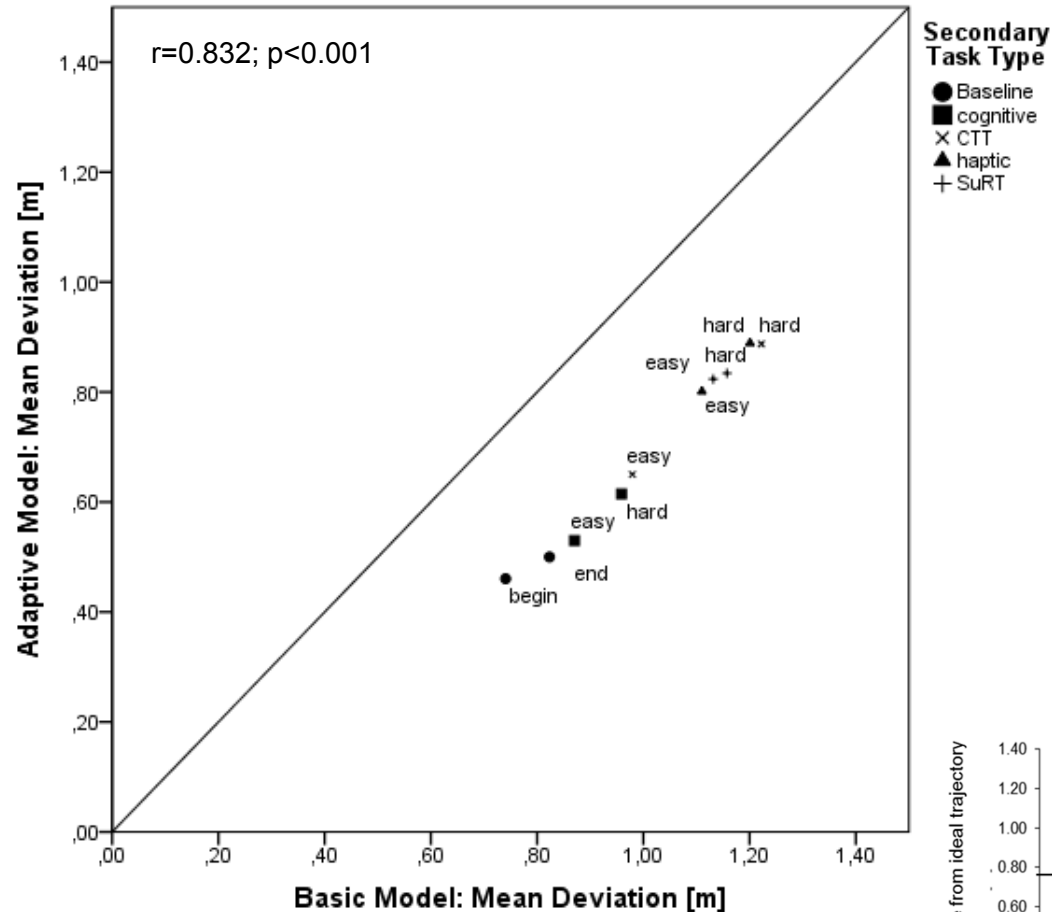
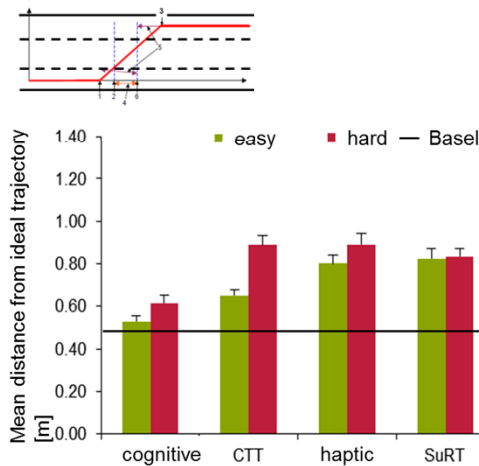
1. MODEL CHOICE



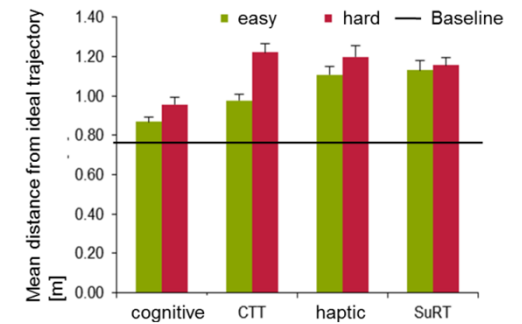
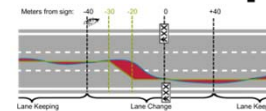
Results: Basic vs. Adaptive Model

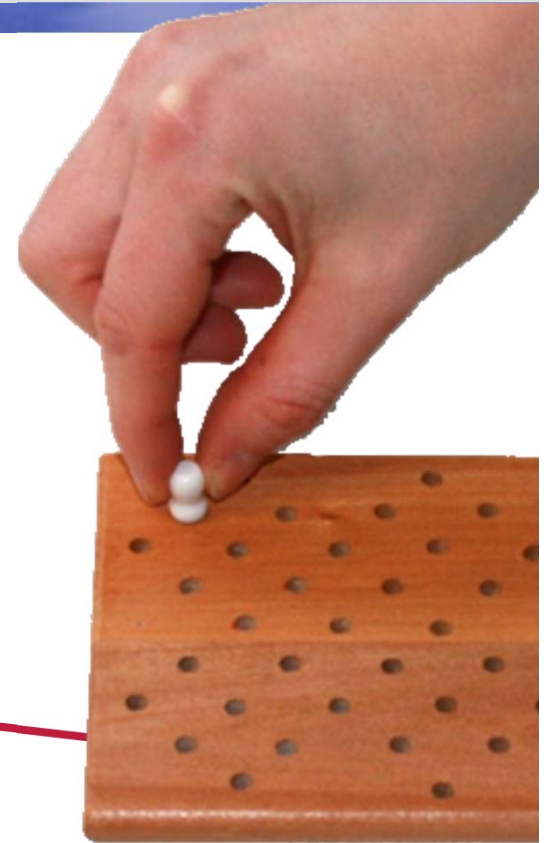
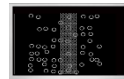
Correlation: Task Level

Adaptive Model



Basic Model





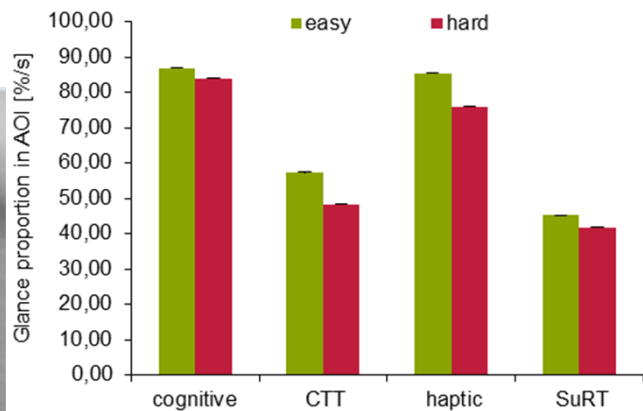
RESULTS

2. GAZE, SECONDARY TASK PERFORMANCE & DEMAND



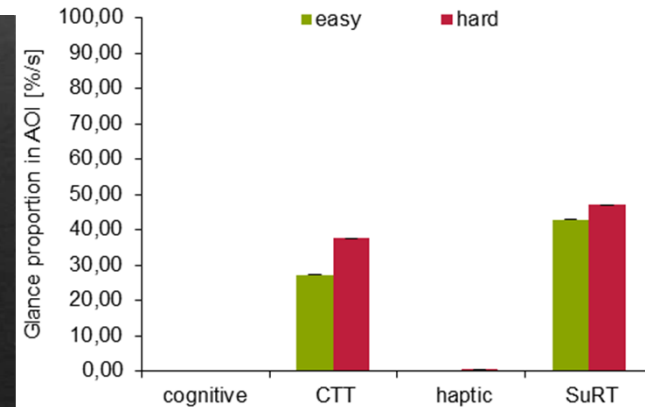
How visually demanding are the secondary tasks?

Glance Proportion per AOI

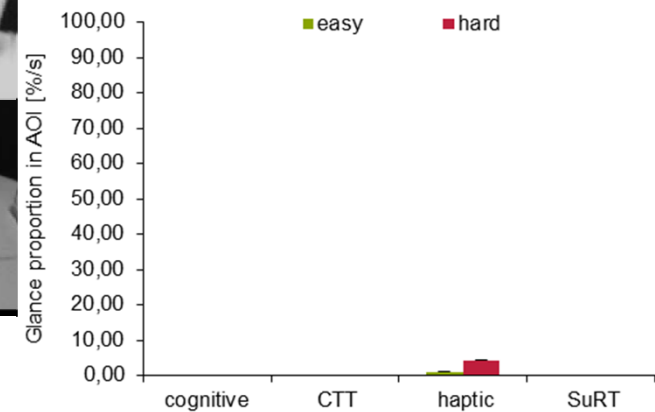


1. LCT

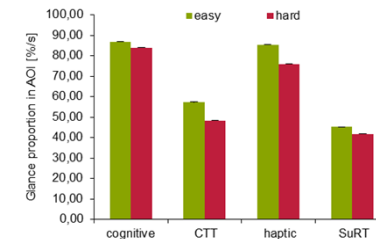
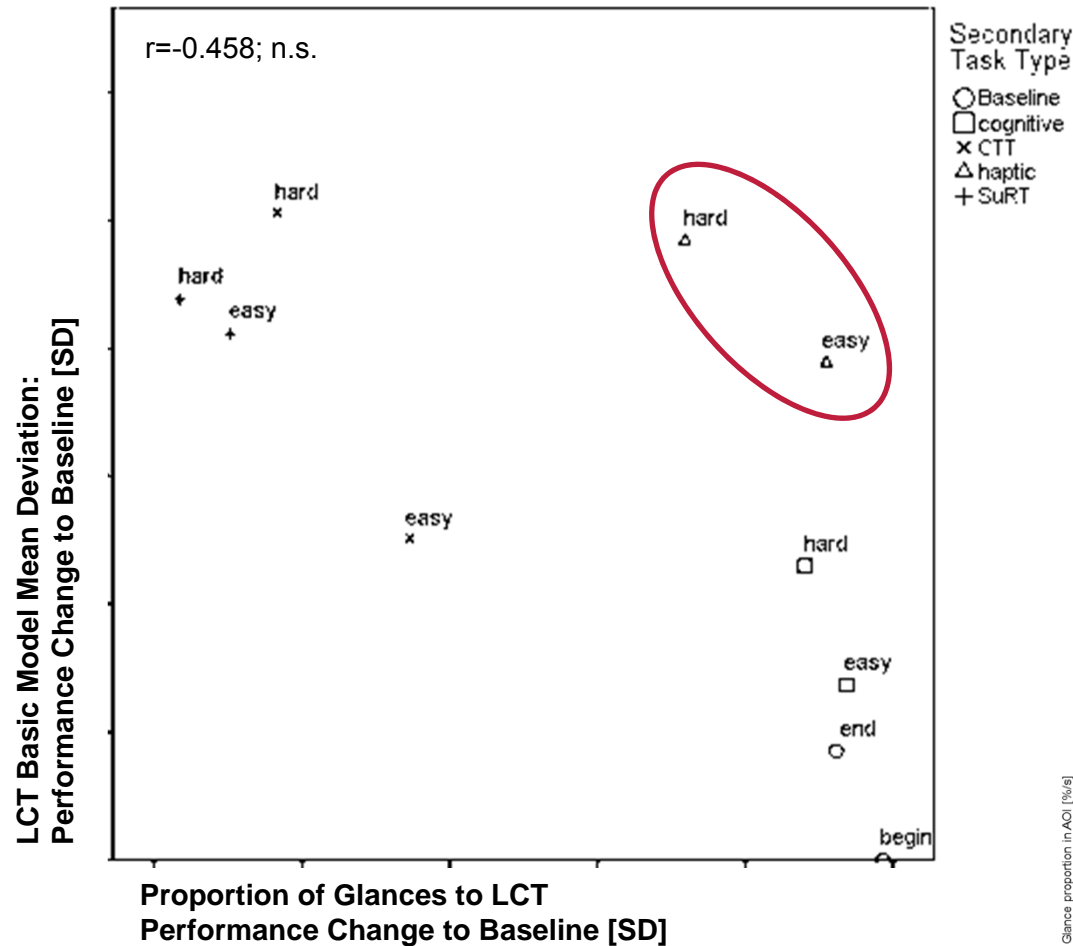
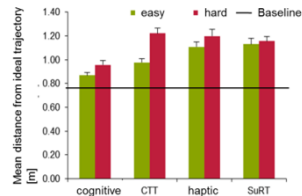
2. Visual tasks



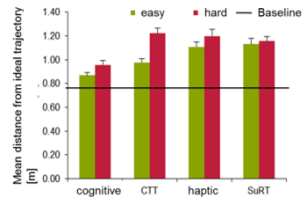
3. Haptic task



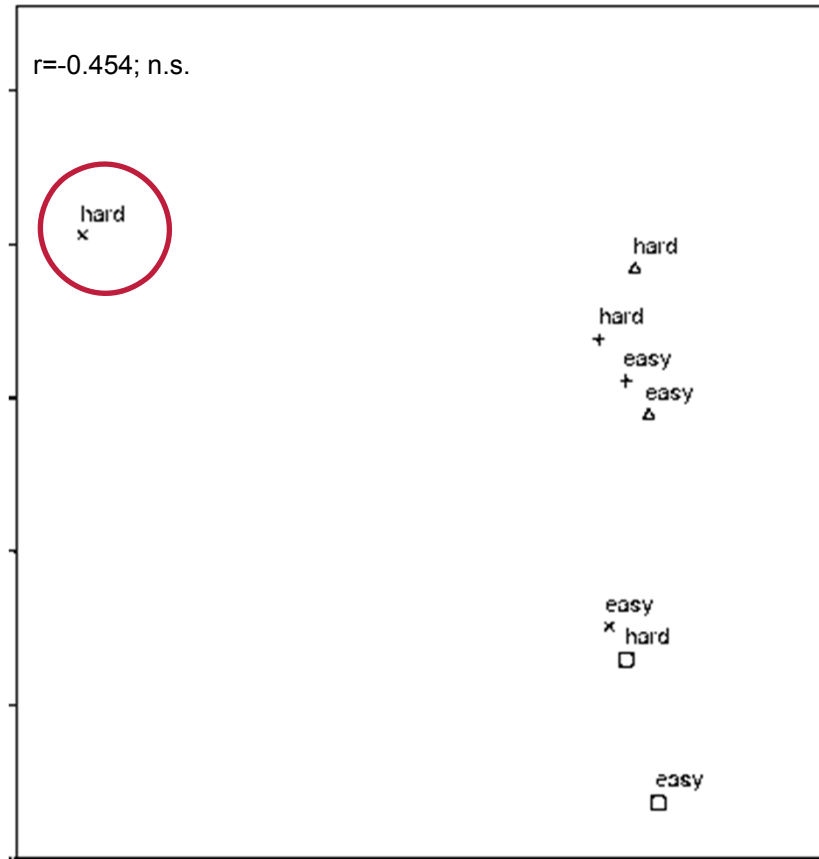
Does gaze behavior predict LCT performance?



How do LCT performance and secondary task performance interact?



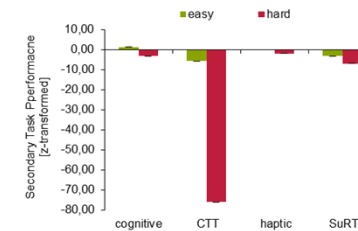
LCT Basic Model Mean Deviation:
Performance Change to Baseline [SD]



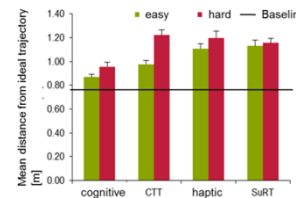
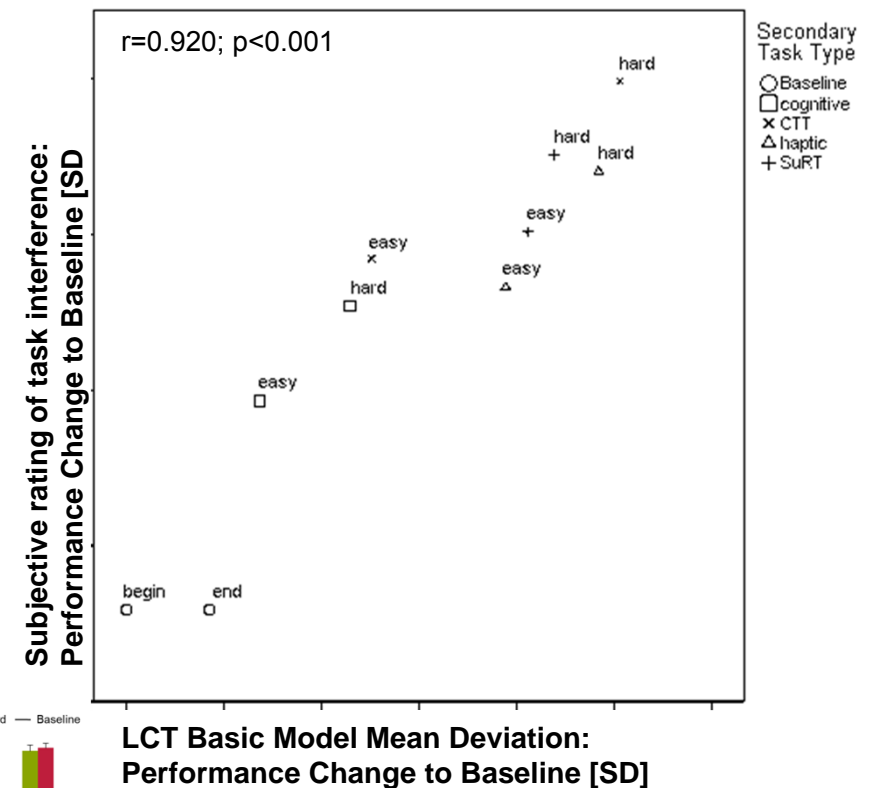
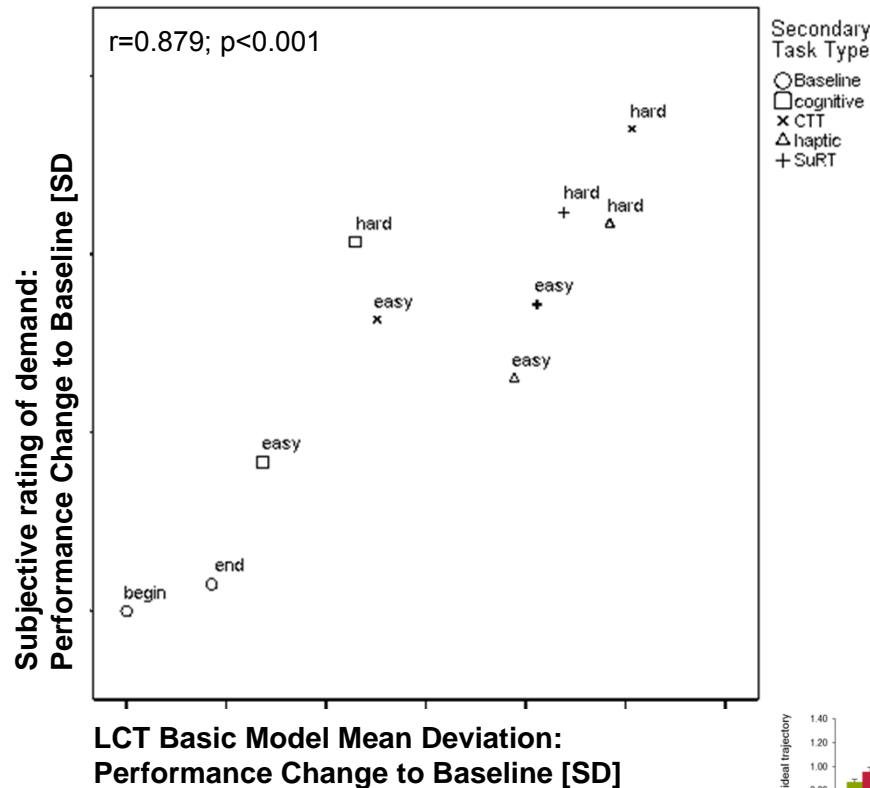
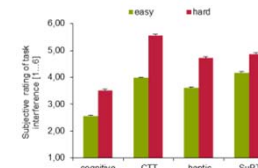
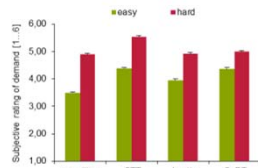
Secondary Task Performance:
Change to Baseline [SD]

Secondary Task Type

- Baseline
- cognitive
- x CTT
- △ haptic
- + SuRT

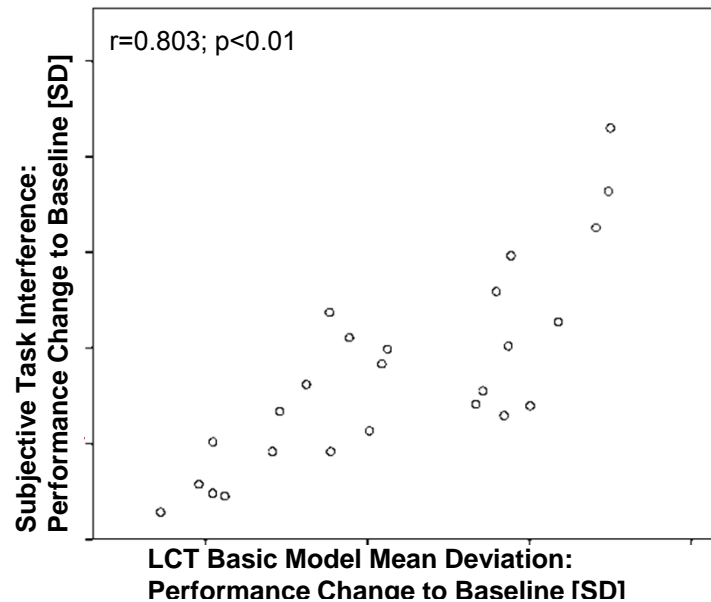
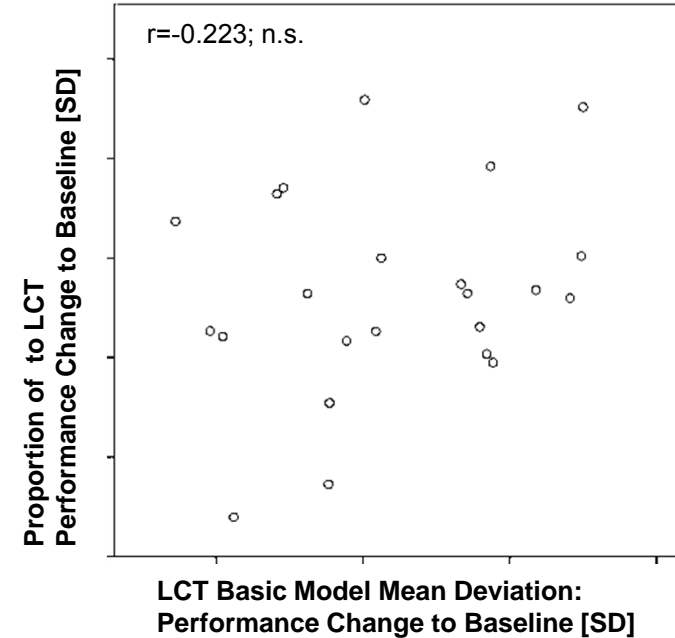
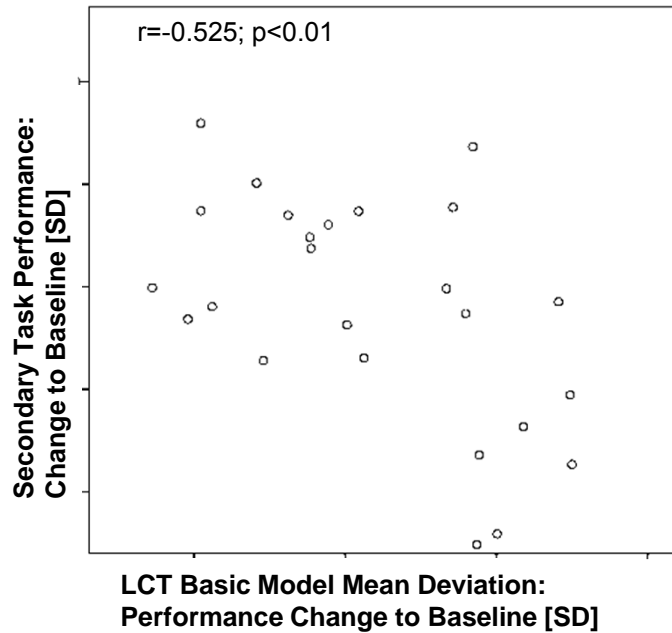


Can subjects assess their performance?



Subjects' effects: Are there individual strategies?

Task Performance, Gaze Behavior & Effort



Summary & Conclusions

1. Model choice & sensitivity

- Basic model is sufficient
- Follow the ISO protocol with trained participants

2. LCT performance, secondary task, gaze & subjective demand

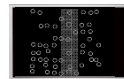
- LCT performance is not predicted by visual behavior alone
- Secondary task performance does not influence LCT performance between tasks
- Subjective ratings of demand are related to LCT performance
- Individual strategies in prioritizing tasks
- LCT does not only show visual distraction, but also manual and cognitive

Next steps

- What task characteristics determine prioritization?
- Which individual characteristics determine prioritization?



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Thank you for your attention!

Dr. Anja Katharina Huemer, Prof. Mark Vollrath

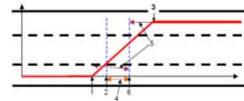
a.huemer@tu-braunschweig.de

Driver Distraction & Inattention 2013, Göteborg, September 4-6 2013

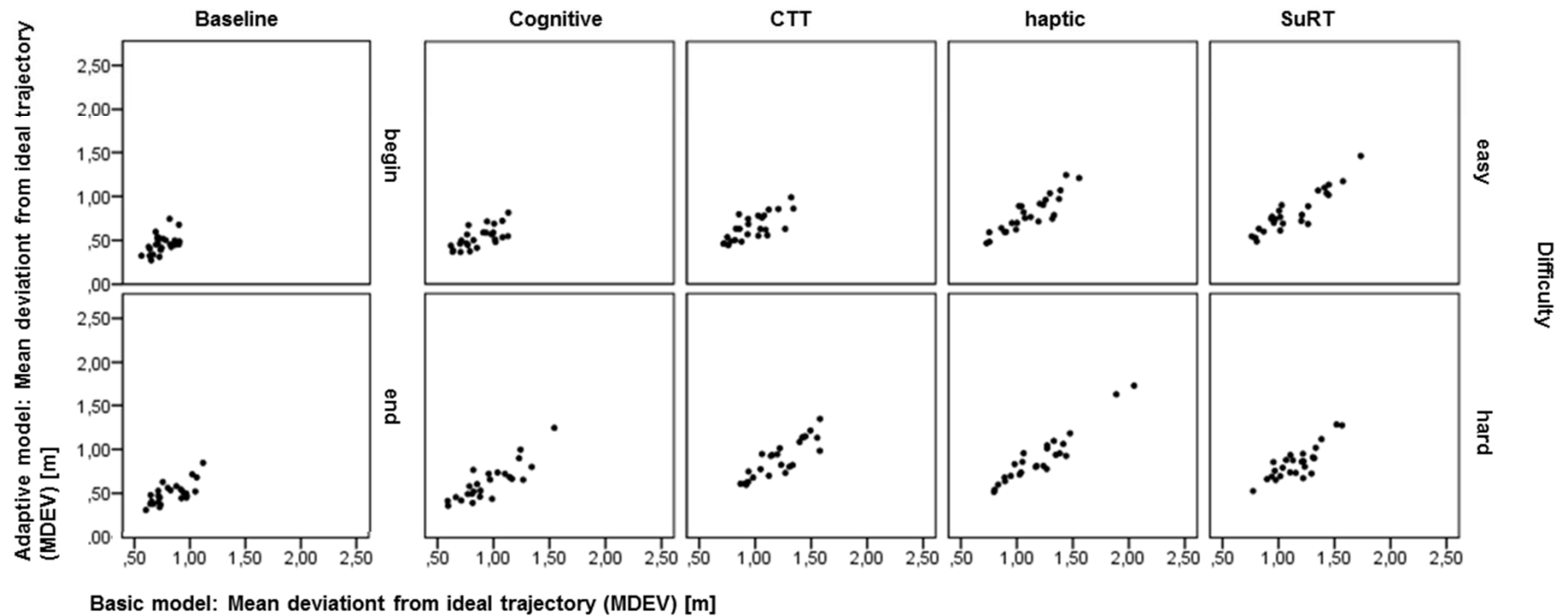
Results: Basic vs. Adaptive Model

Correlation: Individual Level

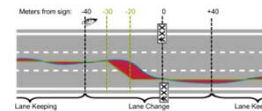
Adaptive Model



Secondary Task



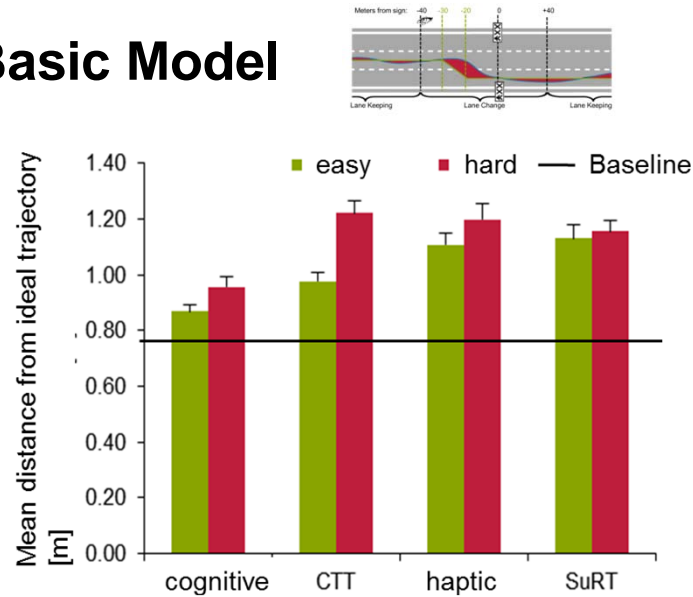
Basic Model



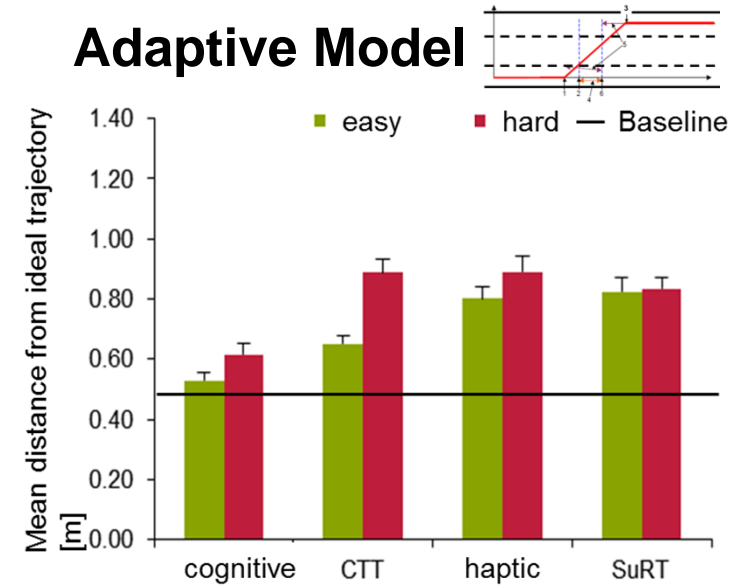
Results: Basic vs. Adaptive Model

Effects don't differ between models

Basic Model



Adaptive Model



Difference to Baseline p-Values of t-Tests, Effects size r

Analysis Type		cognitive		CTT		haptic		SuRT	
		easy	hard	easy	Hard	easy	hard	easy	hard
Original Basic	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	r	0.819	0.683	0.864	0.712	0.815	0.669	0.759	0.713
Original Adaptive	p	0.073	0.021	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	r	0.663	0.382	0.576	0.428	0.431	0.308	0.393	0.398

p<0.01; p<0.05

Analysis Type

Task type	Basic model		Adaptive model	
	p	r	p	r
Cognitive vs. CTT	<0.001	0.664	<0.001	0.343
Cognitive vs. haptic	<0.001	0.763	<0.001	0.580
Cognitive vs. SuRT	<0.001	0.592	<0.001	0.653
CTT vs. haptic	0.092	0.803	0.021	0.521
CTT vs. SuRT	0.098	0.817	0.033	0.518
haptic vs. SuRT	0.700	0.840	0.770	0.495
Task difficulty (easy vs. hard)				
Cognitive	0.001	0.927	<0.001	0.790
CTT	<0.001	0.854	0.033	0.429
Haptic	0.008	0.867	0.018	0.468
SuRT	0.485	0.779	0.007	0.527

p<0.01; p<0.05

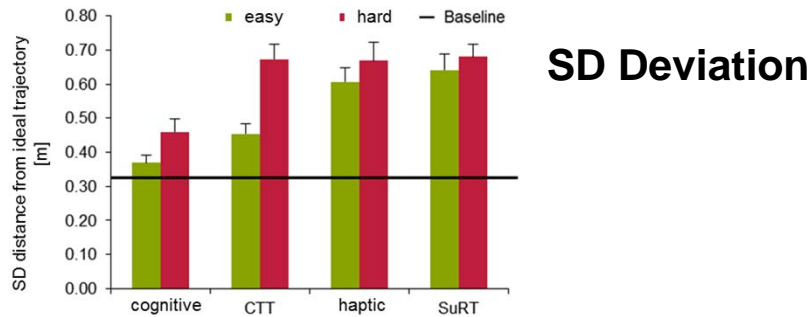


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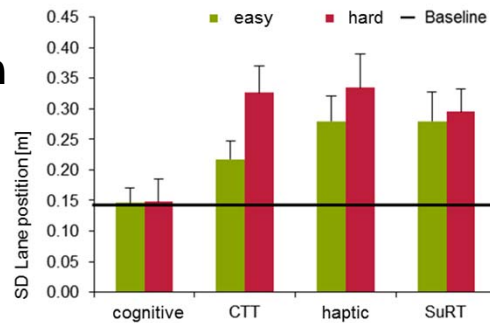
Results: Additional Metrics

Additional information is found in...

Lane Keeping



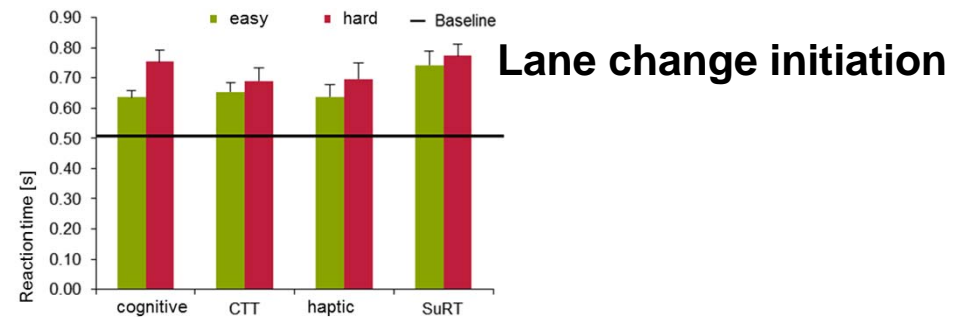
SD Lane Position



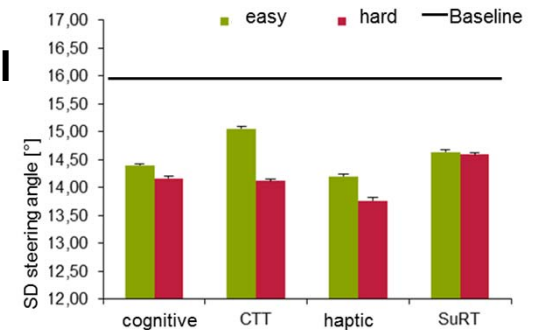
		Difference to Baseline p-Values of t-Tests, Effects size r							
		cognitive		CTT		haptic		SuRT	
Lane Keeping		easy	hard	easy	hard	easy	hard	easy	hard
SD Deviation	p	0.034	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	r	0.331	0.111	0.667	0.507	0.754	0.561	0.616	0.825
SDLP	p	0.075	0.119	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	r	0.778	0.638	0.524	0.510	0.563	0.637	0.458	0.570

p<0.01; p<0.05

Lance Change



SD Steering Wheel



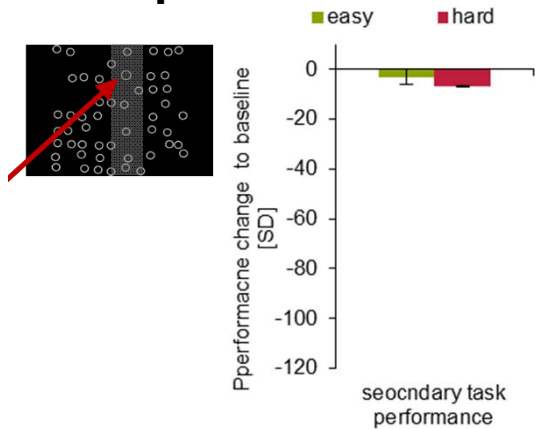
		Difference to Baseline p-Values of t-Tests, Effects size r							
		cognitive		CTT		haptic		SuRT	
Lane Change		easy	hard	easy	hard	easy	hard	easy	hard
SD Steering Angle	p	0.002	0.002	0.110	<0.001	<0.001	<0.001	0.005	0.002
	r	0.888	0.838	0.915	0.851	0.894	0.875	0.894	0.913
Lane Change Initiation	p	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	r	0.843	0.804	0.763	0.660	0.886	0.794	0.696	0.680

p<0.01; p<0.05

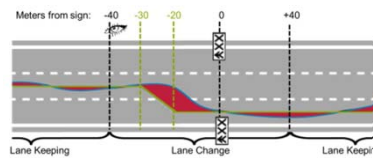
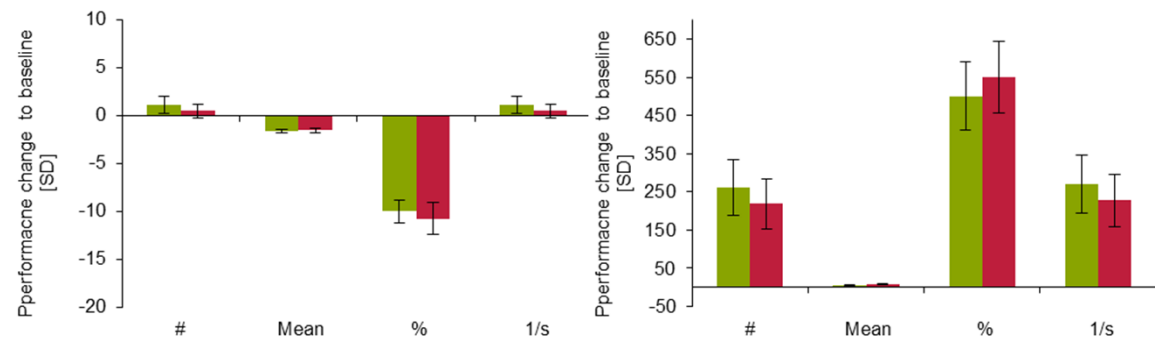
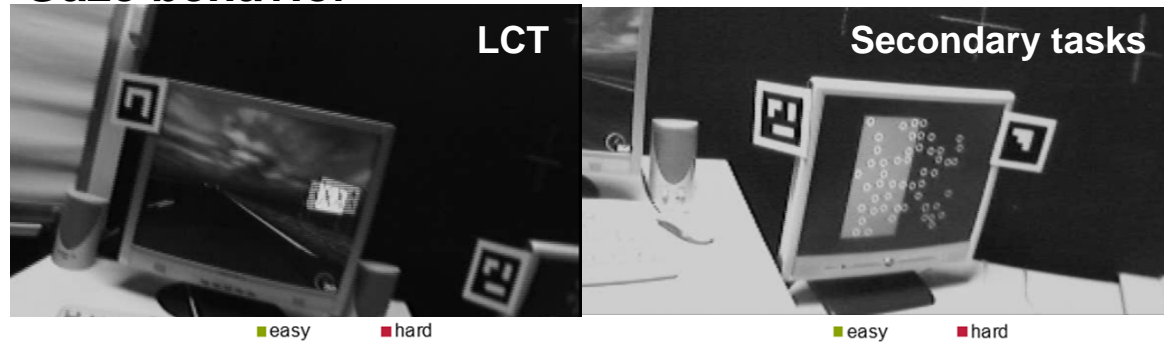
Performance Changes: SuRT

Dual task compared to single task easy

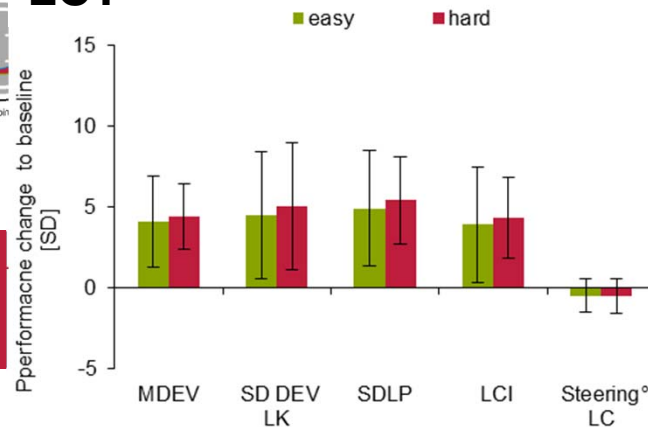
Task performance



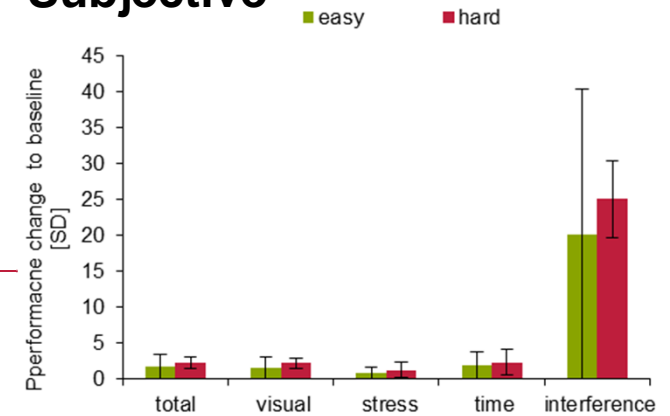
Gaze behavior



LCT



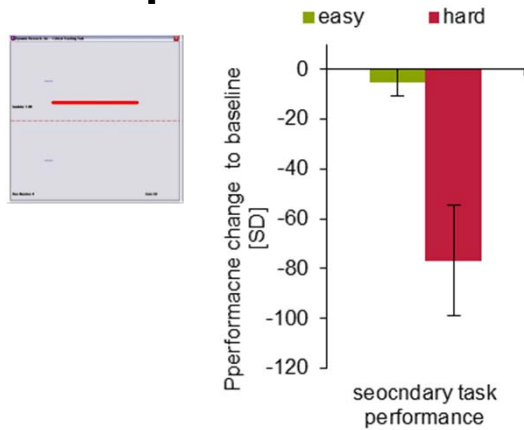
Subjective



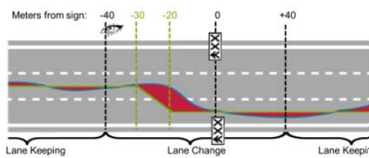
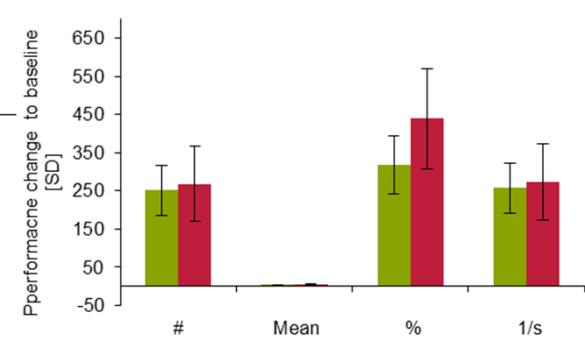
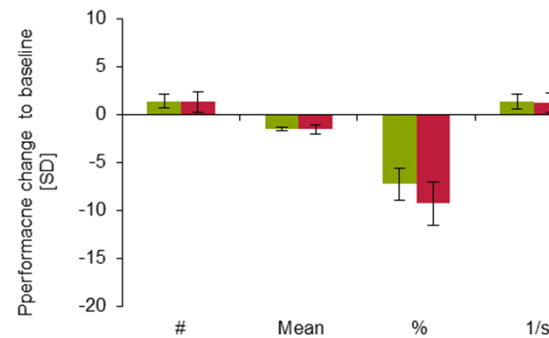
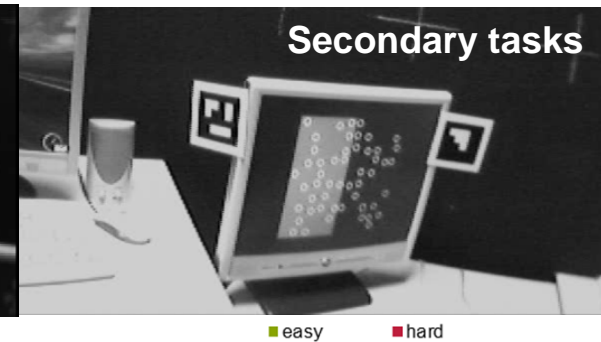
Performance Changes: CTT

Dual task compared to single task easy

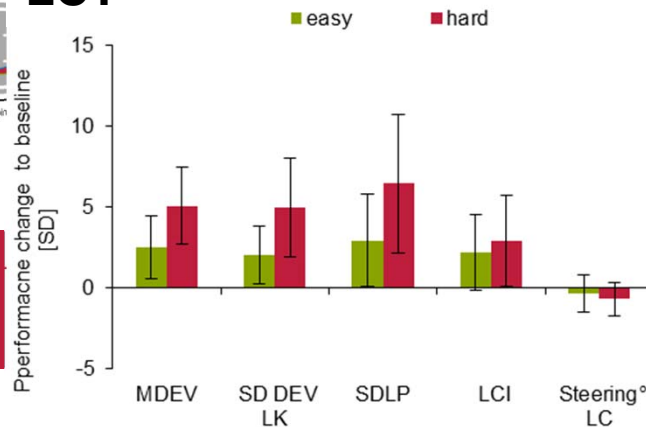
Task performance



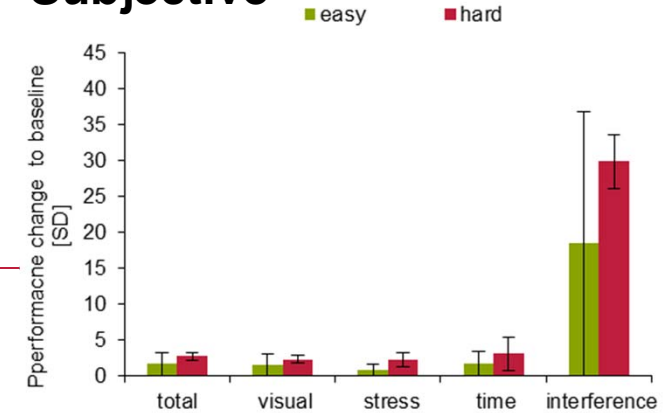
Gaze behavior



LCT



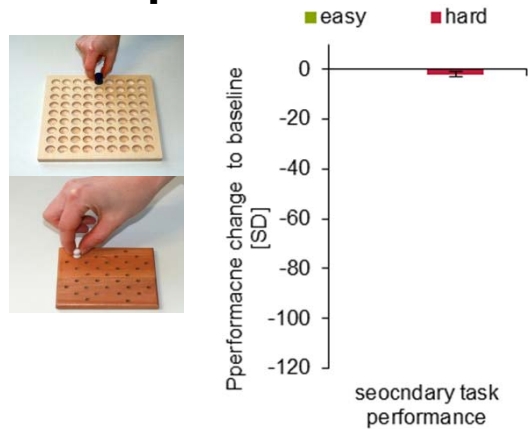
Subjective



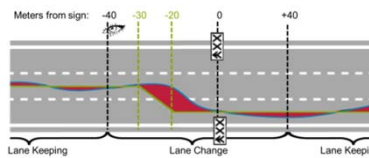
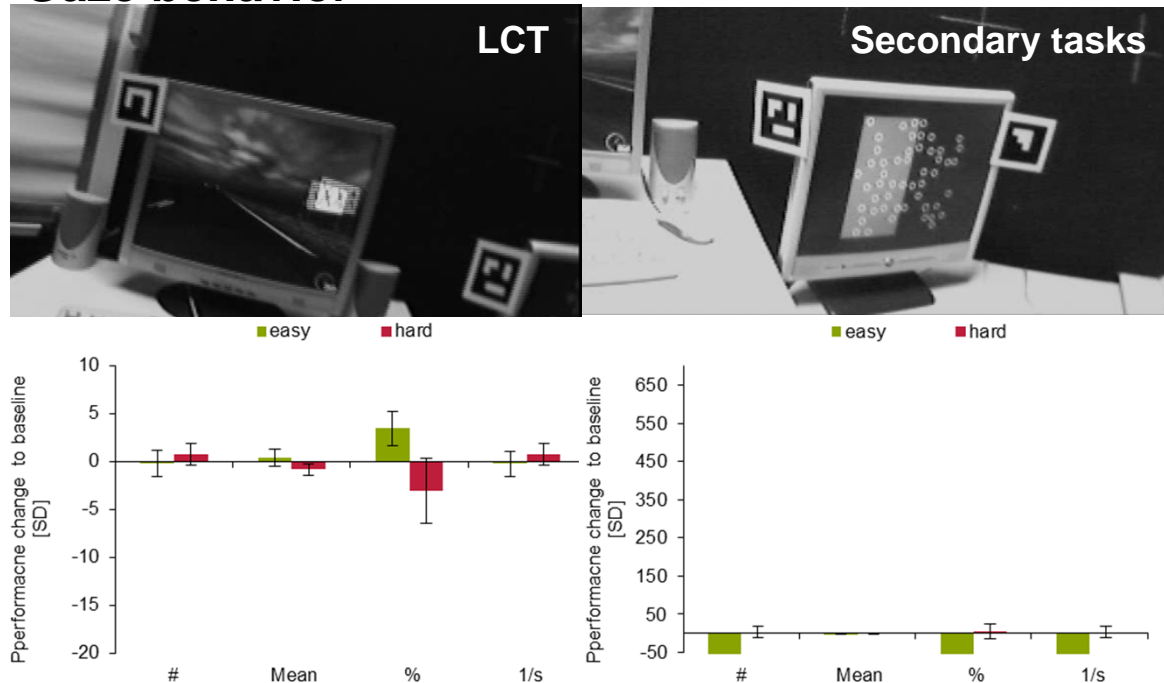
Performance Changes: Haptic Task

Dual task compared to single task easy

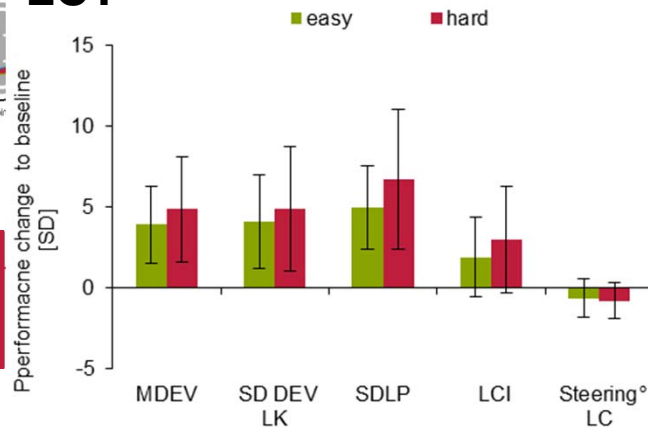
Task performance



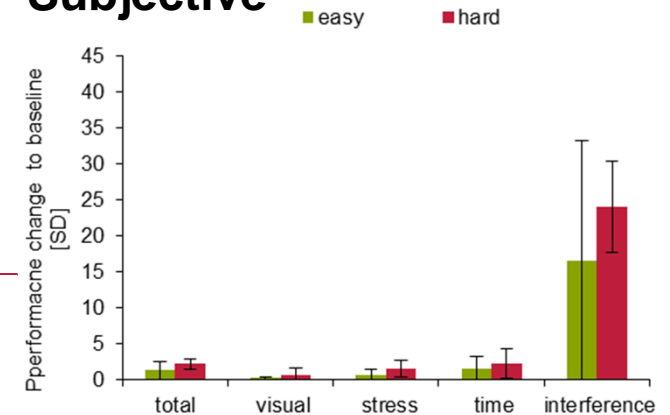
Gaze behavior



LCT



Subjective

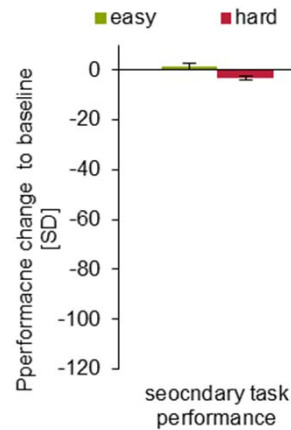


Performance Changes: Cognitive Task

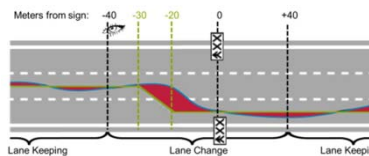
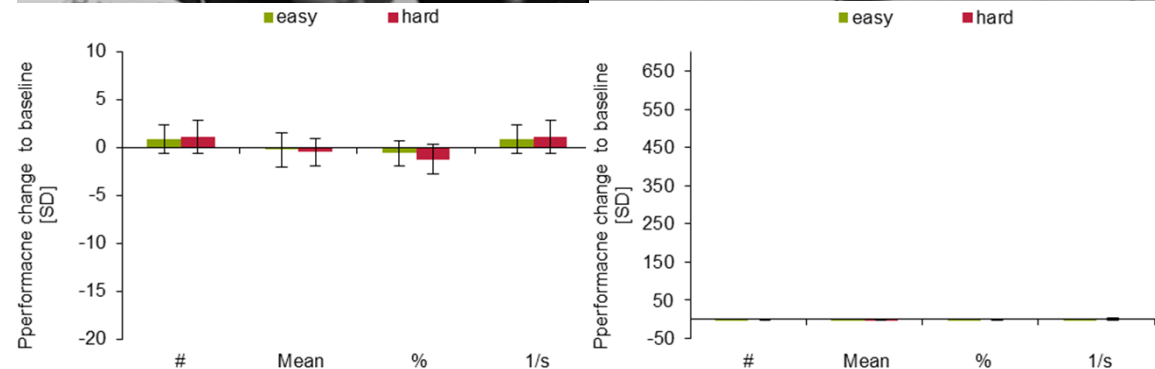
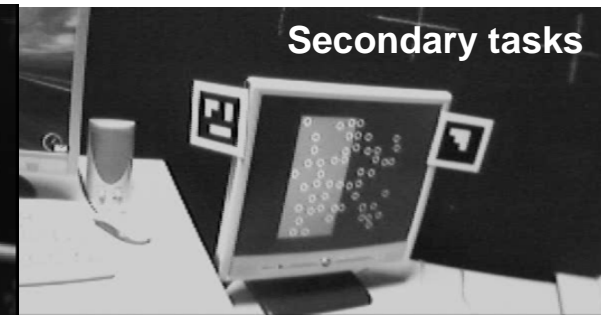
Dual task compared to single task easy

Task performance

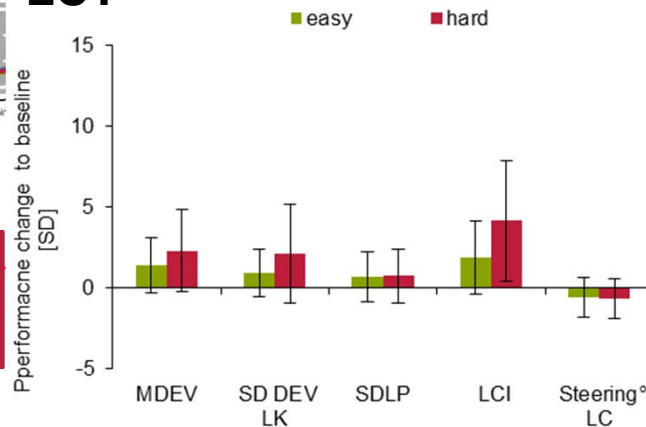
+ 2
- 7



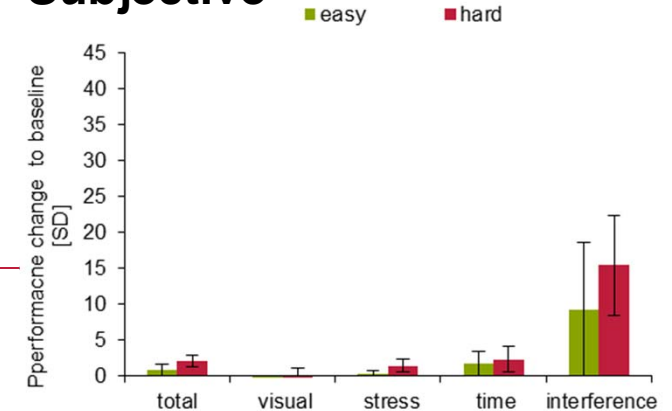
Gaze behavior



LCT

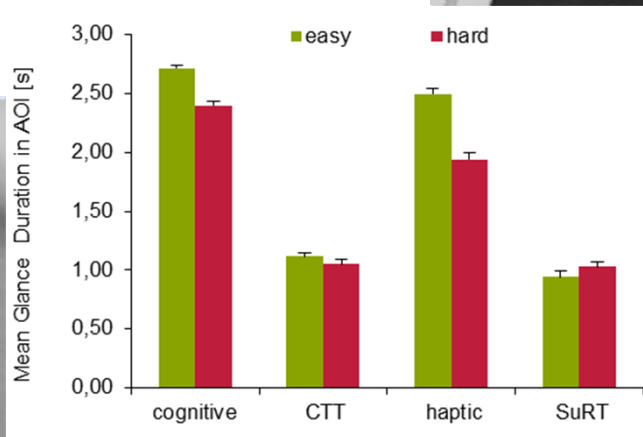


Subjective



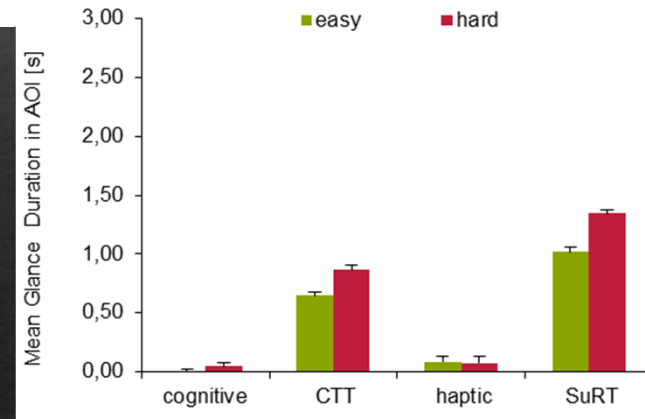
Results: Gaze

Mean Glance Duration per AOI

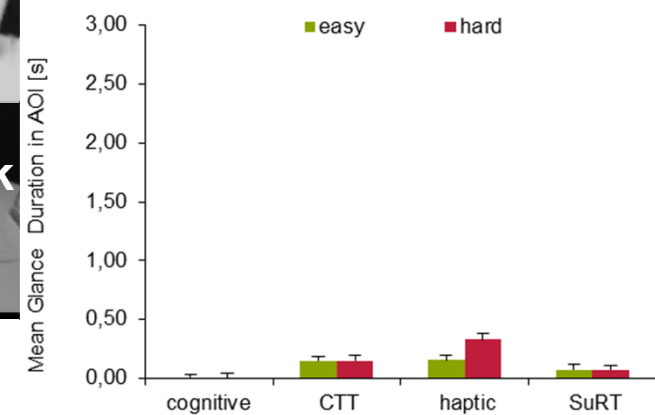


1. LCT

2. Visual tasks

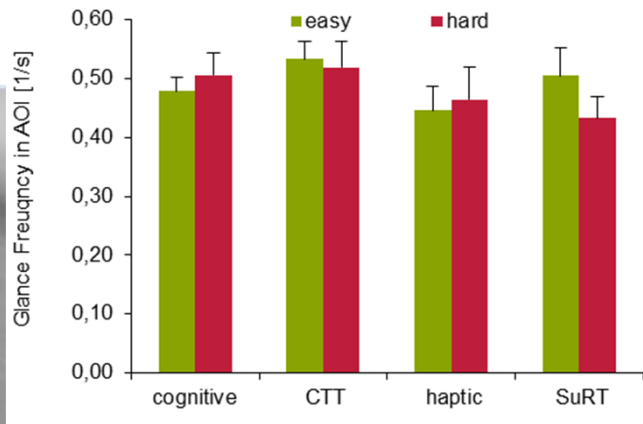


3. Haptic task



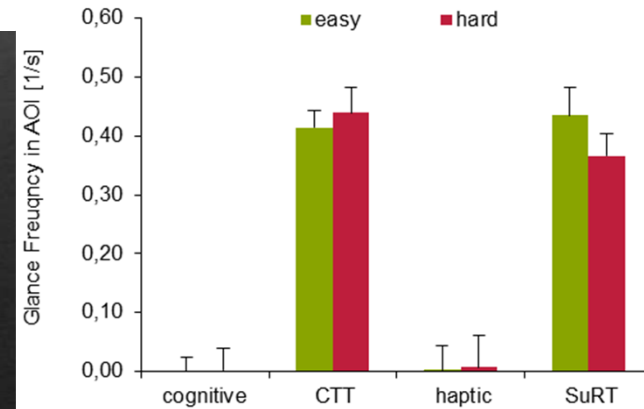
Results: Gaze

Glance Frequency into AOI

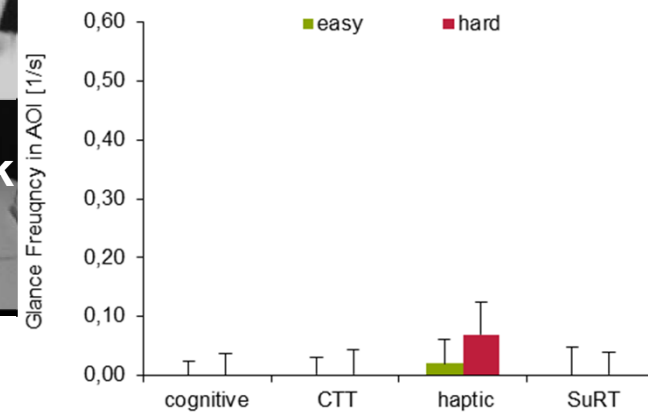


1. LCT

2. Visual tasks

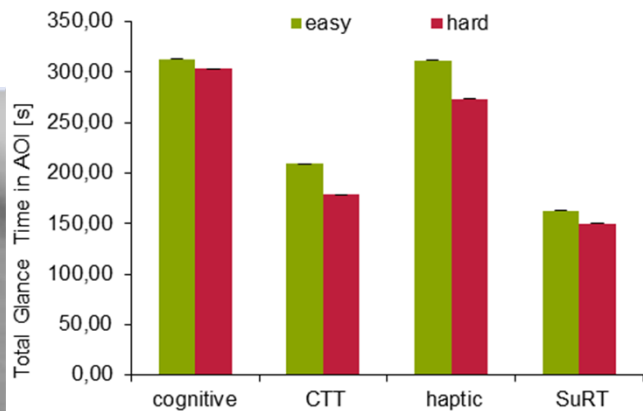


3. Haptic task



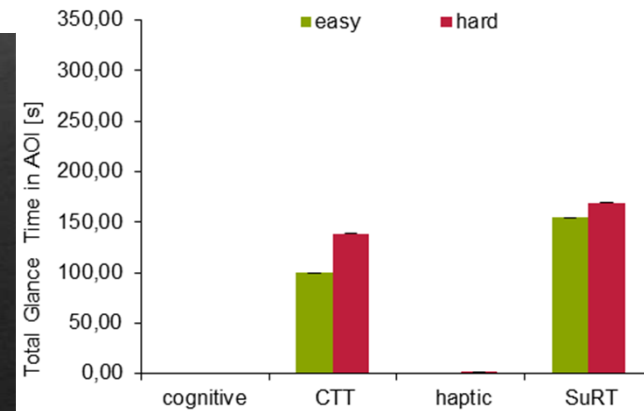
Results: Gaze

Total Glance Time per AOI

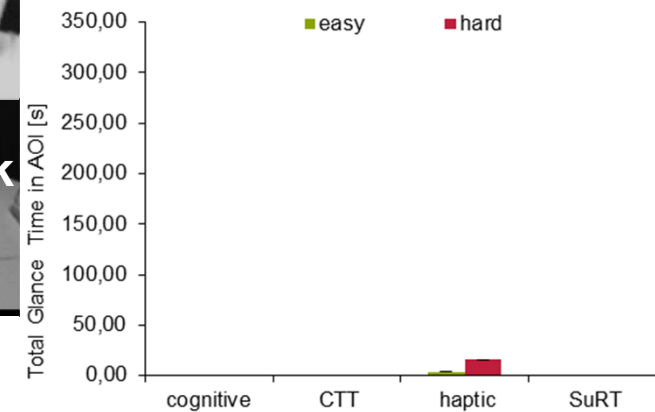


1. LCT

2. Visual tasks

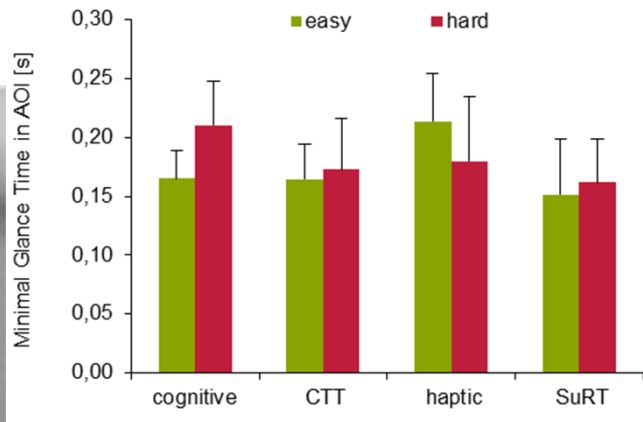


3. Haptic task



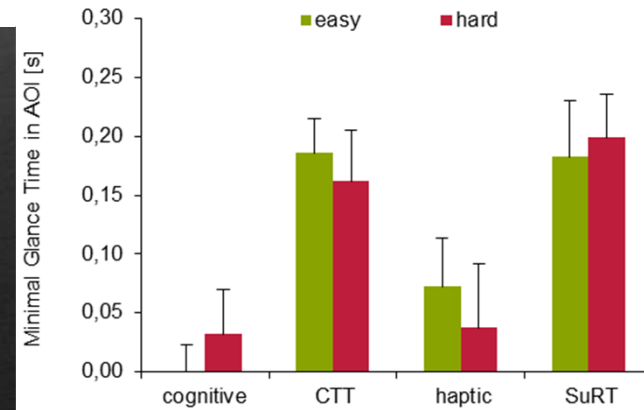
Results: Gaze

Minimal Glance Time per AOI

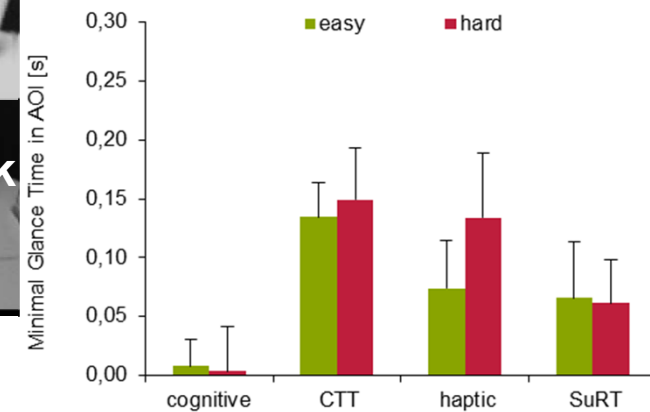


1. LCT

2. Visual tasks

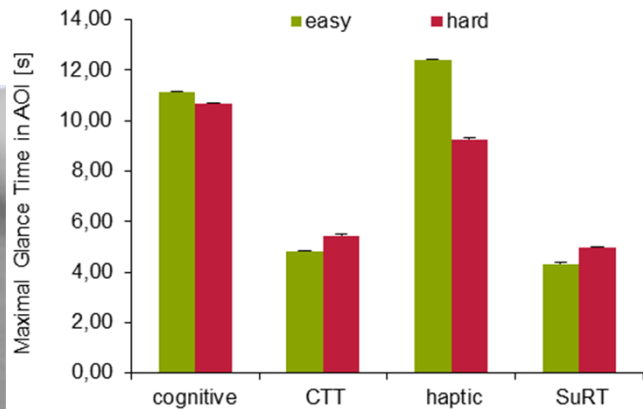


3. Haptic task



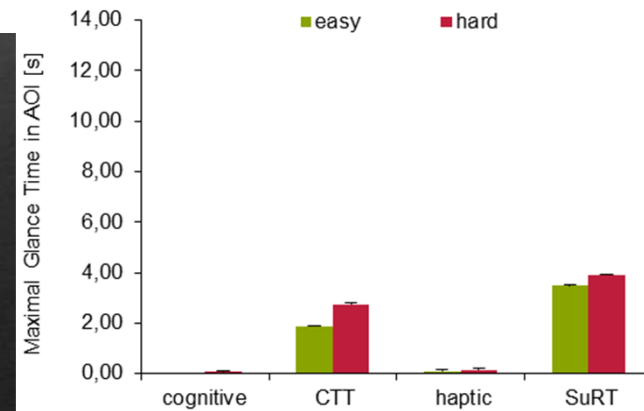
Results: Gaze

Maximal Glance Time per AOI

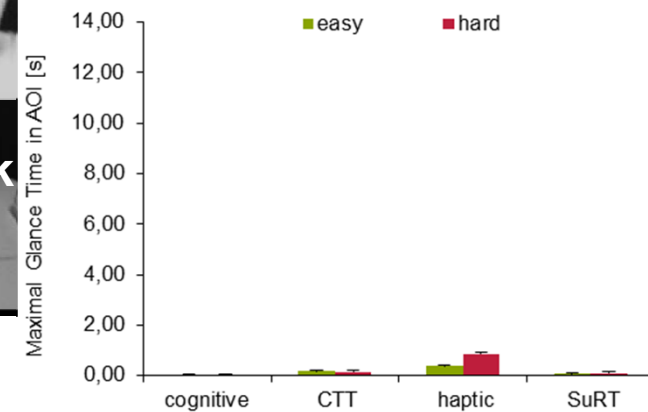


1. LCT

2. Visual tasks

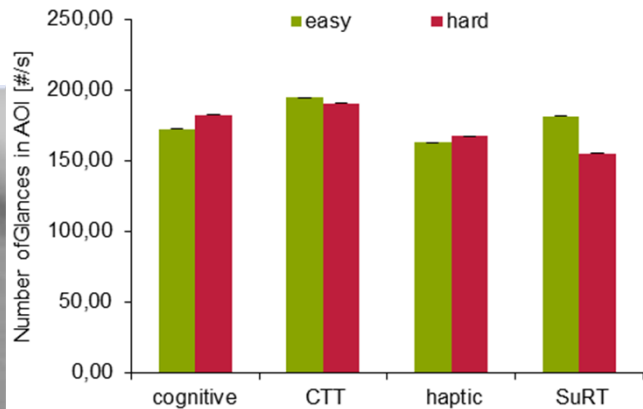


3. Haptic task



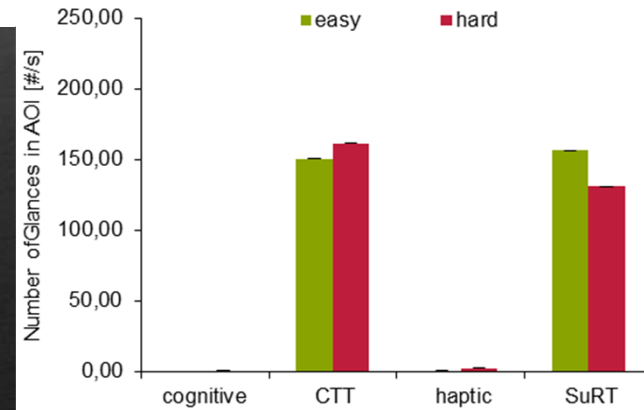
Results: Gaze

Number of Glances per AOI

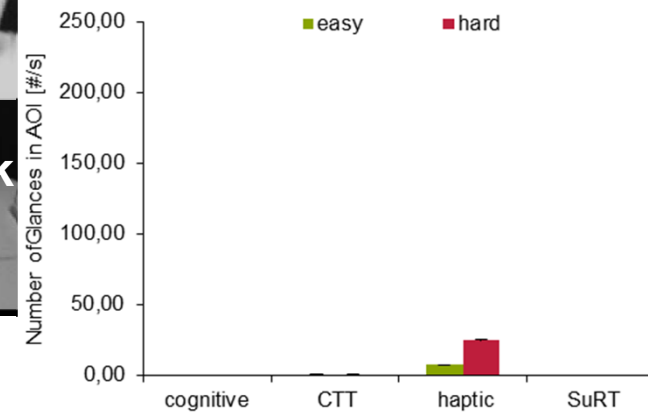


1. LCT

2. Visual tasks

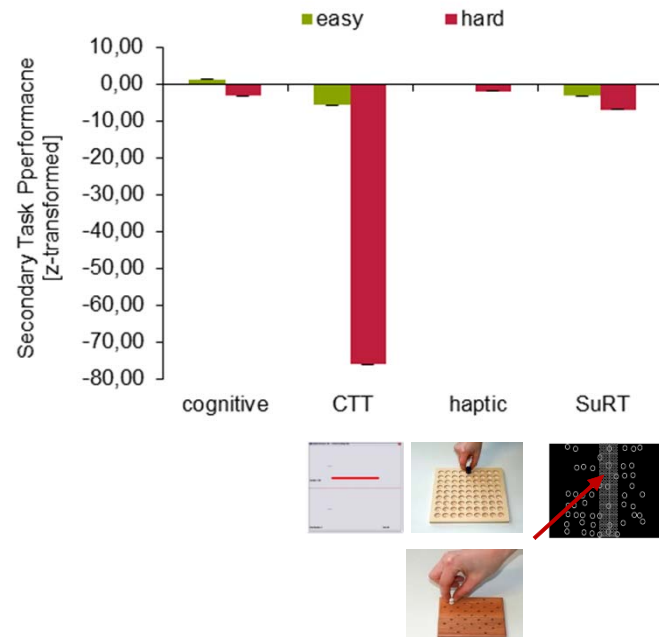


3. Haptic task

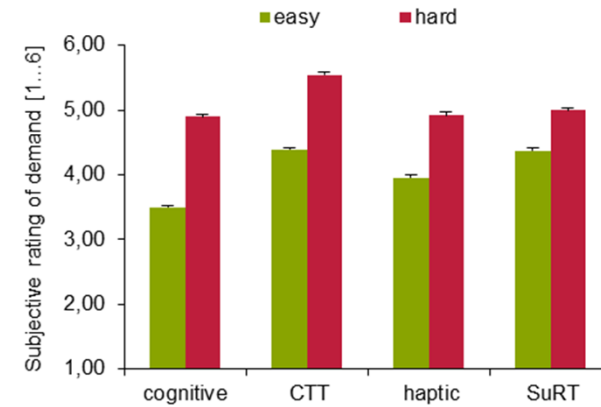


Secondary Task Performance & Subjective Demand

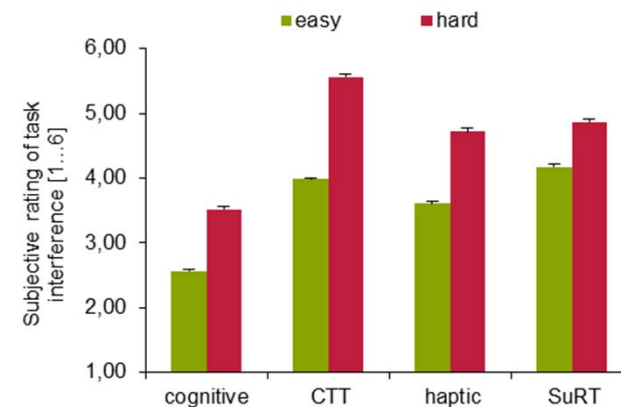
Secondary Task Performance



Subjective demand



Subjective task interference



Summary: Metrics

What effect for which type task?

Cognitive Task

- Smallest effects
- Best differentiation in Reaction Time while lane change & SD Deviation while lane keeping

Haptic Task

- Strong deterioration in performance
- Best differentiation in lane keeping metrics

CTT

- Strong deterioration in performance for hard condition
- Best differentiation in lane keeping metrics

SuRT

- Strong deterioration in all performance measures



Cognitive demands

Visual demands

Haptic demands

Reaction Time while lane change

Lane keeping performance

All performance deteriorated

Effect less specific in Reaction Time



Conclusions

How to analyze LCT data

1. Data base - Original, Distance based, Time based?

- No significant differences

2. Analysis model - Basic vs. Adaptive?

- Smaller absolute deviations in adaptive model
- Only very small changes in effect sizes

3. Metrics - Phases (Lane Keeping, Lane Changes)?

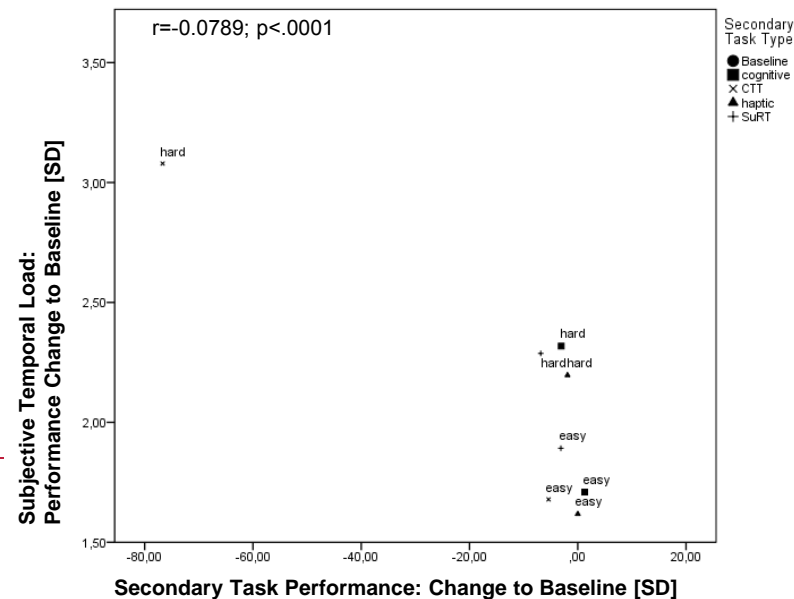
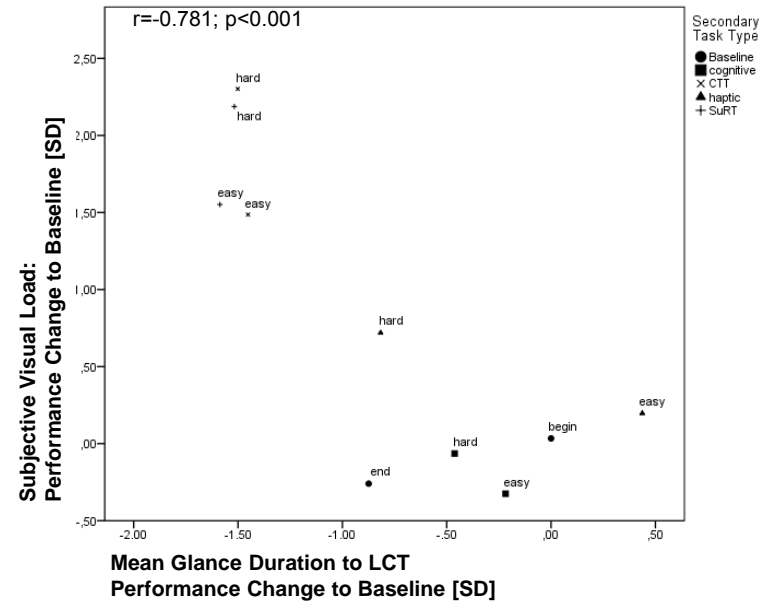
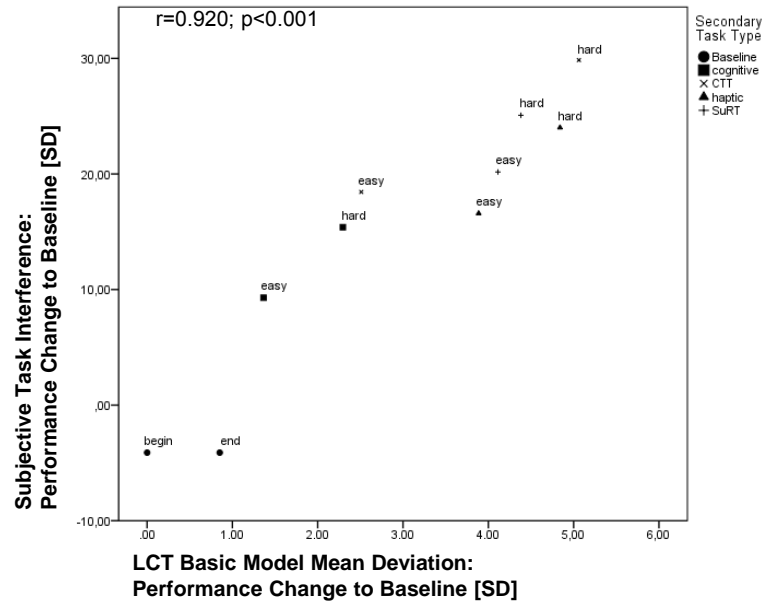
- Effects of secondary tasks' components are to be found in different amounts in different parameters

Recommendations

- Analysis according to Basic Model is sufficient
- Lane keeping and lane changes should be analyzed separately
- Additional metrics should be used
 - SD Deviation, SD Lane Position, Reaction Time in Lane Changes

Task Performance, Gaze Behavior & Effort

Tasks' Effects



How do LCT performance and secondary task performance interact?

