Second International Conference on Driver Distraction and Inattention

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VISUAL – COGNITIVE ABILITIES AND PERFORMANCE IN DUAL TASK DRIVING

Theoretical Background

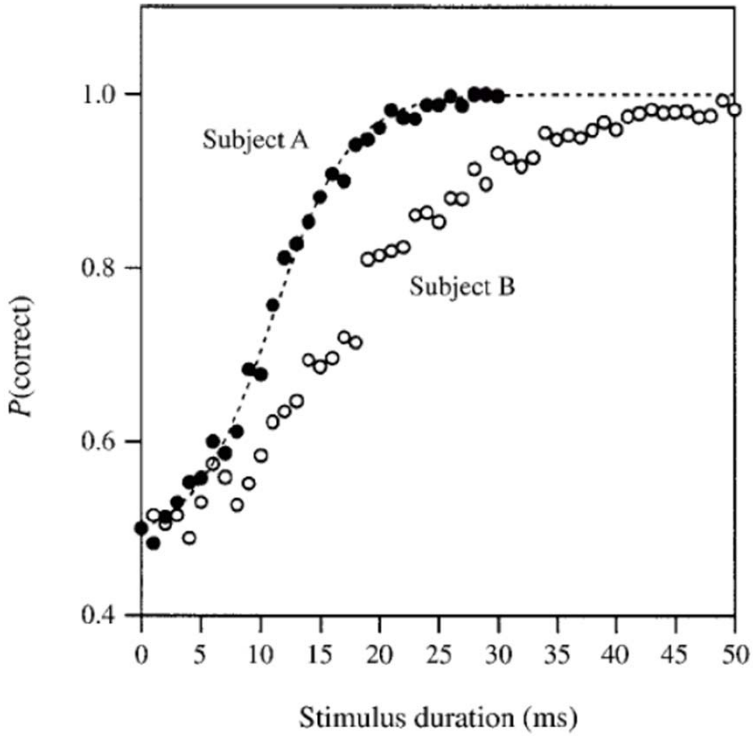
Initial position:

- Driving = complex and highly automated task
  - up to 90% of the critical informations are processed visually (cf. Sömen & Brenner-Hartmann, 2001)
- Driver models (e.g. Salvucci 2006, Chovan et al., 1994)
  - description of visual behavior
- Glance to the side mirror = essential component of each decision to change lanes → duration of glance as indicator? (Henning et al., 2009)
- Glances away from the road, e.g. two seconds rule (Zwahlen et al., 1988)
- Duration of glance plays a secondary role in the models
  - Problem: glance duration as a function of demand, efficiency, and accuracy of information processing
  - Information demand = constant, but speed of information processing varies interindividually (cf. Deary, 2000; Jensen, 2006; Vickers, Nettelbeck, & Willson, 1972)

Theoretical Background

Measurement of information processing

- Similar to classical psychophysics (Vickers et al., 1972):
  - Inspection Time (Pesta & Poznanski, 2008)
  - Most successful ‘elementary cognitive task‘ (ECT)
  - r_{korr} = -.5 to IQ (Grudnik & Kranzler, 2001)



Theoretical Background

Core hypothesis:

- Persons with high visual-cognitive abilities need less time to process information (Galley & Galley, 1999; Garaas & Pomplun, 2008)
  - Shorter duration of glance
  - Higher performance

Measurement:

- Glance duration to the secondary task and to the left outside mirror
- Performance in the driving task and secondary task

Method

Data collection

- N_1 = 28 (students M_{age} = 22.8 years, SD_{age} = 4.2 years; 21 female)
- N_2 = 51 (students M_{age} = 22.6 years, SD_{age} = 2.9 years; 34 female)
- Lane change in dual-task situations
- Experiments with driving simulator & Touch-Pad → for the secondary task

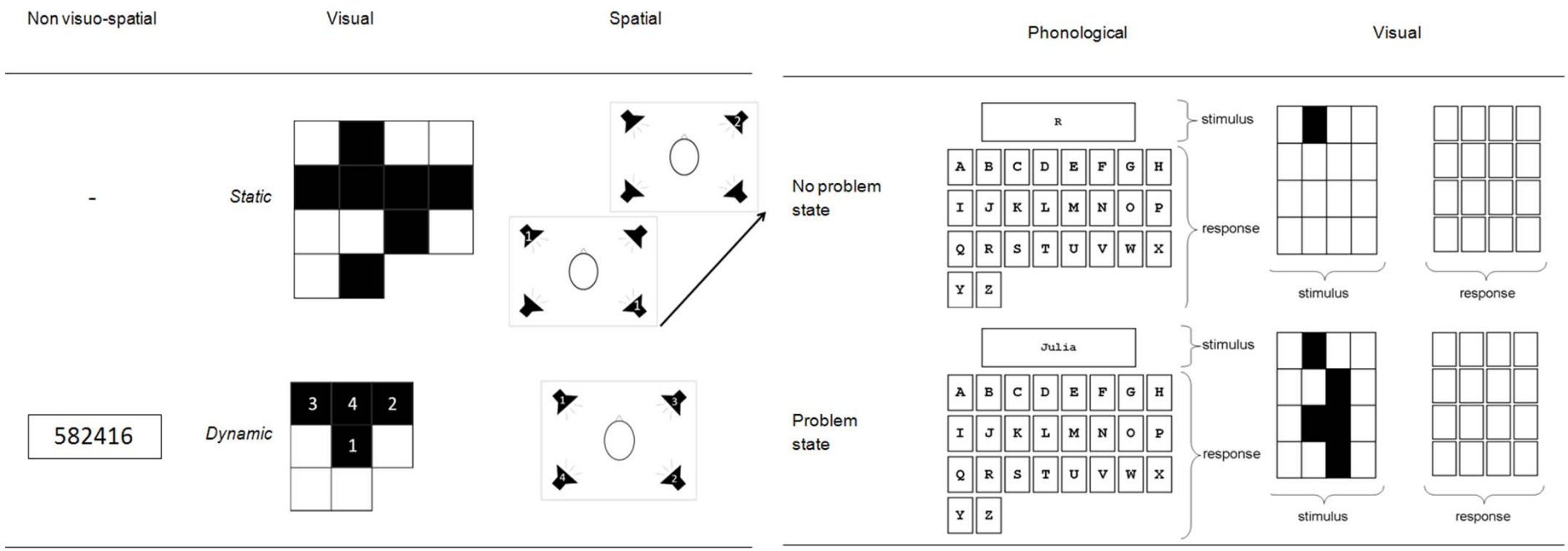
Visual-cognitive tests

- **Inspection Time** (Vickers et al., 1972)
- Raven APM, Short form (Bors & Stokes, 1998)
- Symmetry Span Test (Kane et al., 2004)
- Letter Rotation Task (Cooper & Shepard, 1973)

- Factor analysis for two further experiments (N_{Ges} = 112) → *g*-factor with 40 % clarified variance

Method

Secondary tasks:

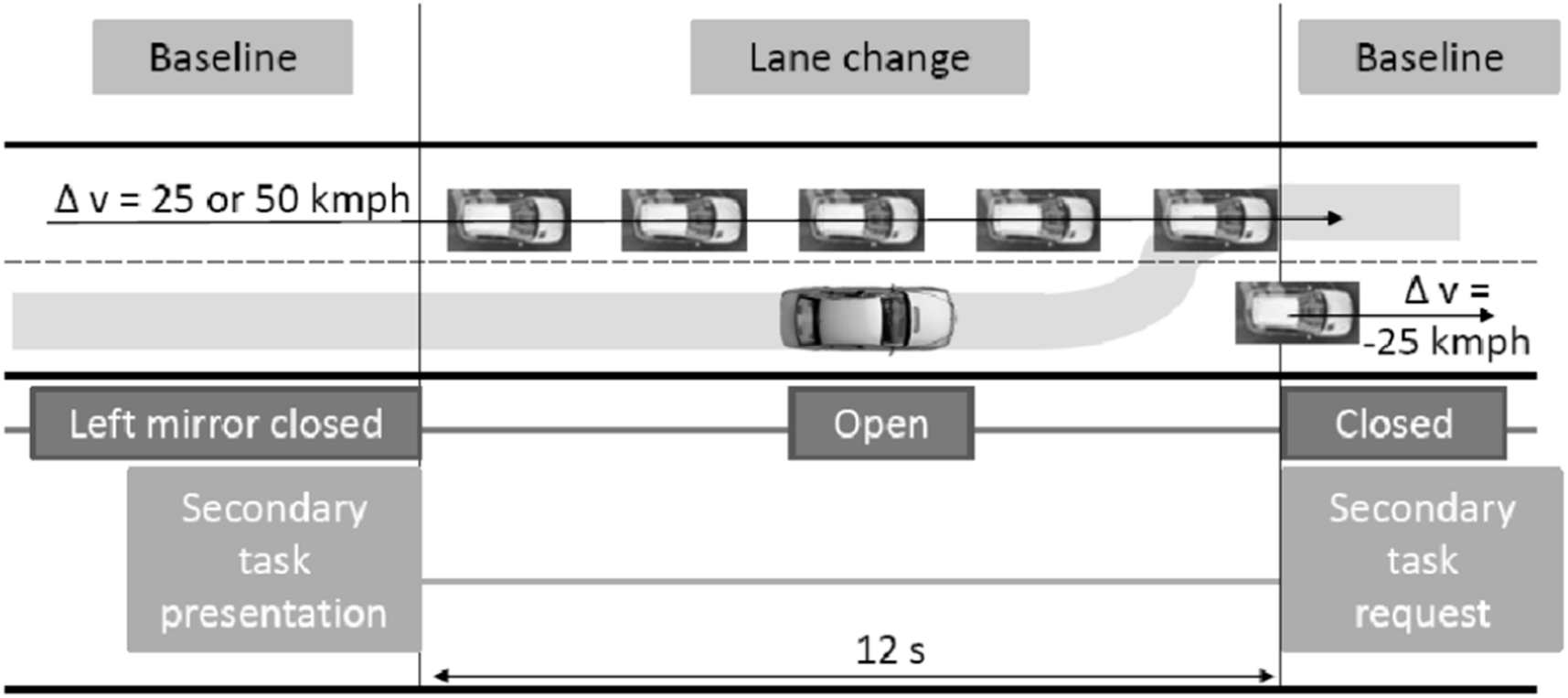


Experiment 1

Experiment 2

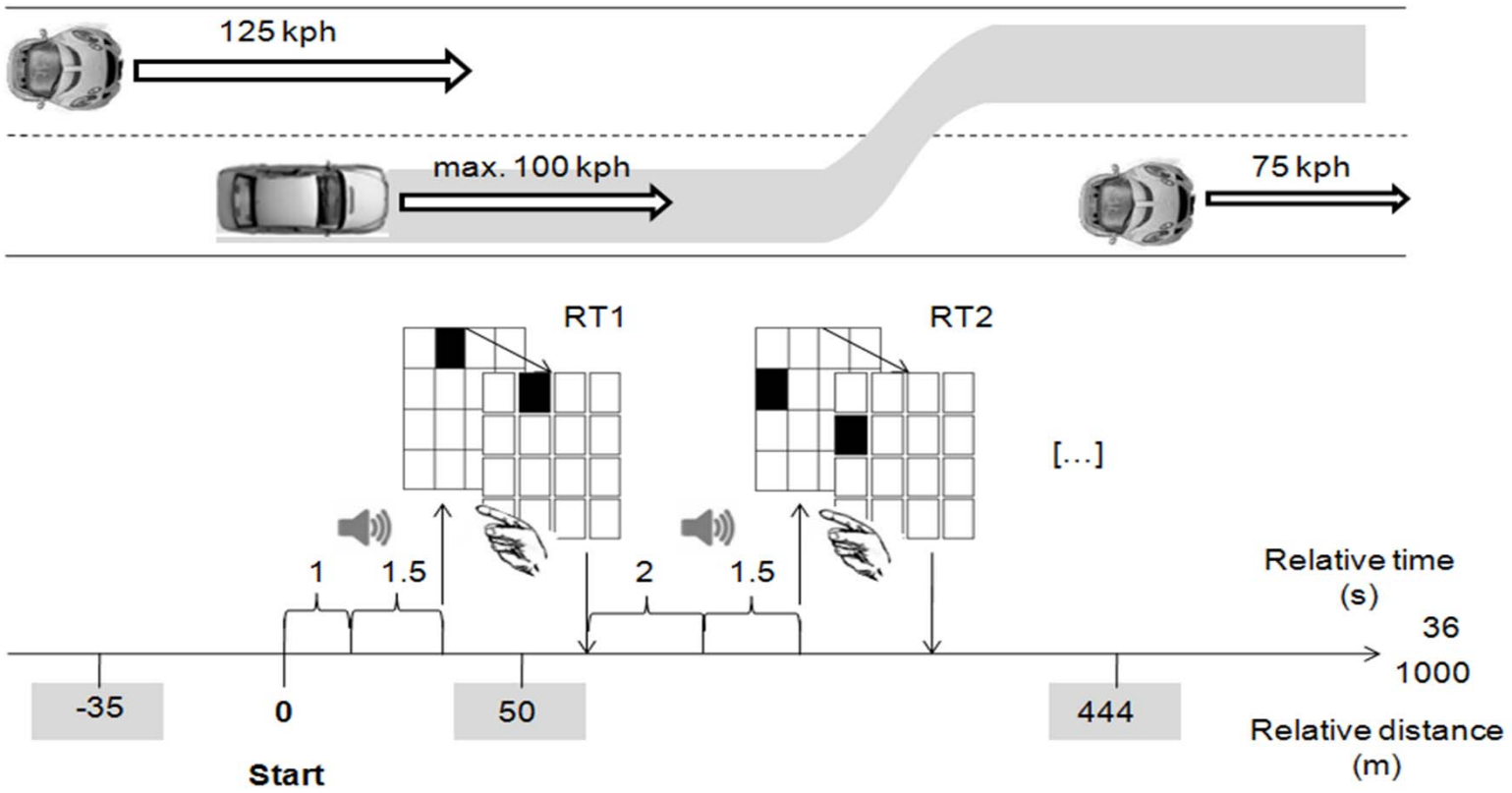
Method

Experiment 1:



Method

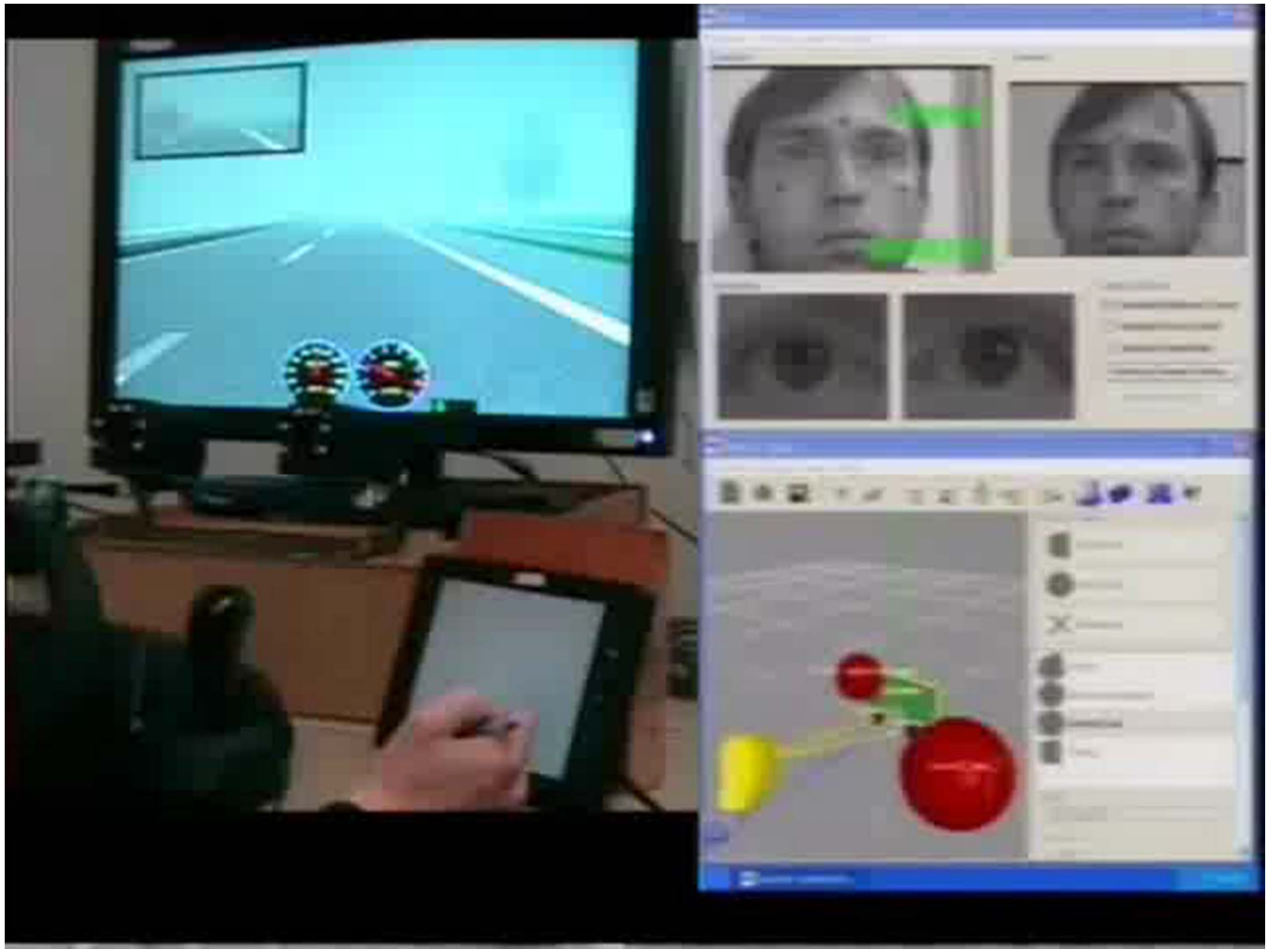
Experiment 2:



ST events	Launch ST	1st response ST	2nd response ST
Driving events	Trigger rearward traffic	Trigger SLV	Would reach SLV

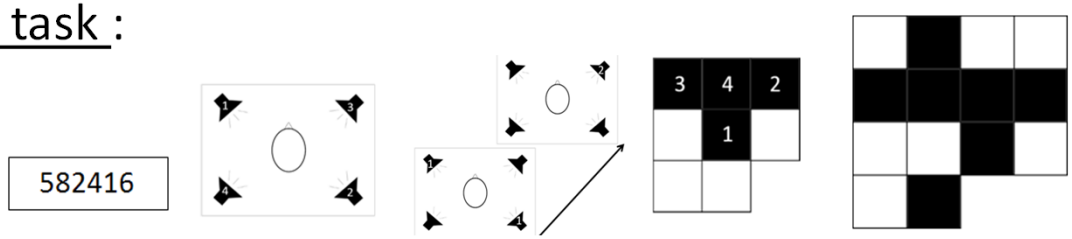
Method

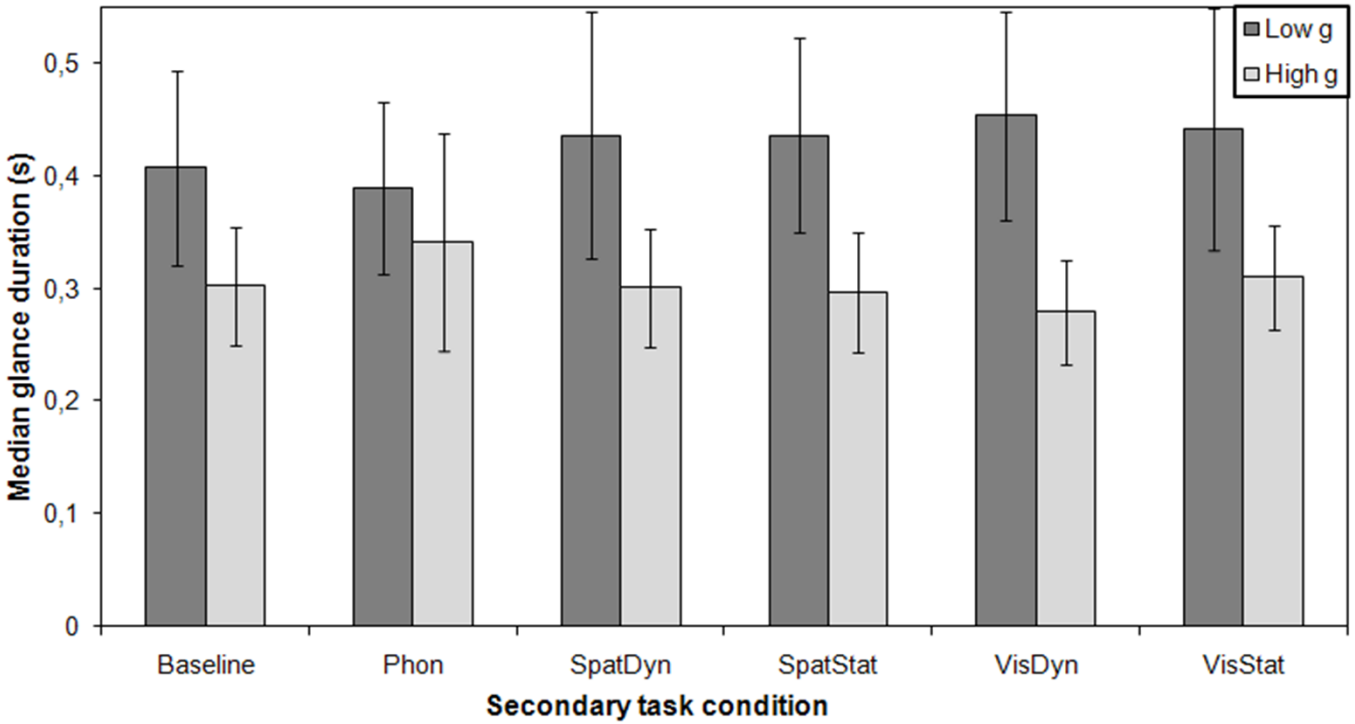
Experiment 2:



Results

Experiment 1, secondary task :

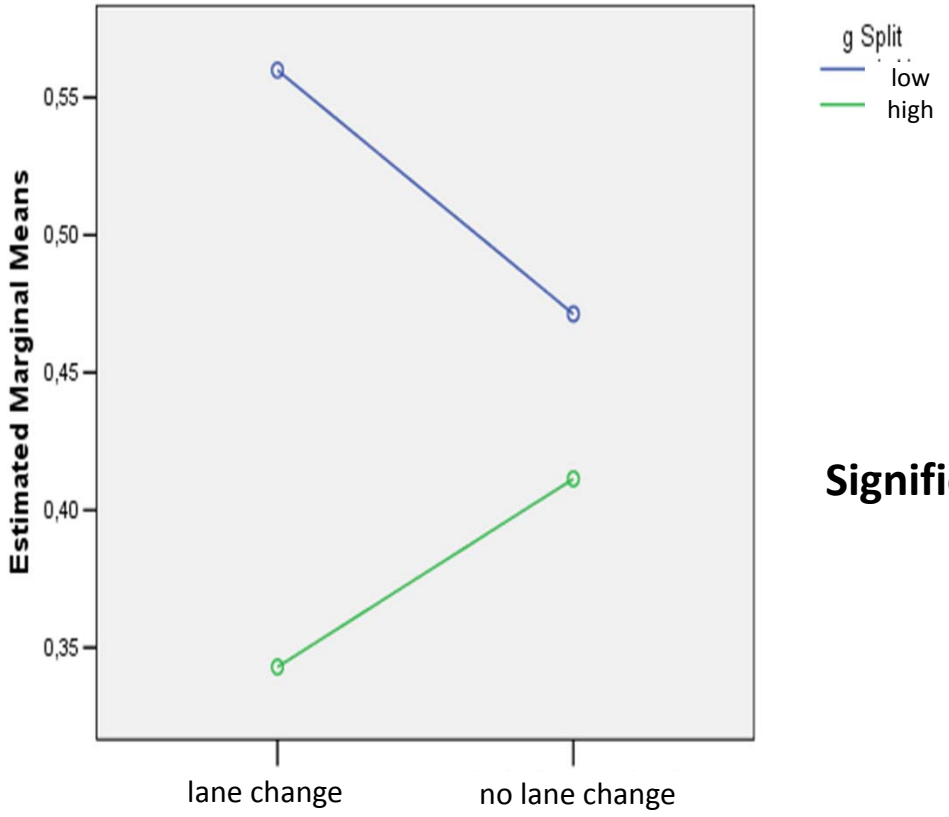




Hedge's g = 0.77, 95% CI [-0.01, 1.53]	g_{ES} = 0.29, [-0.46, 1.03]	g_{ES} = 0.82, [0.04, 1.59]	g_{ES} = 1.01, [0.21, 1.79]	g_{ES} = 1.25, [0.43, 2.06]	g_{ES} = 0.84, [0.05, 1.61]

Results

Experiment 1, driving task :

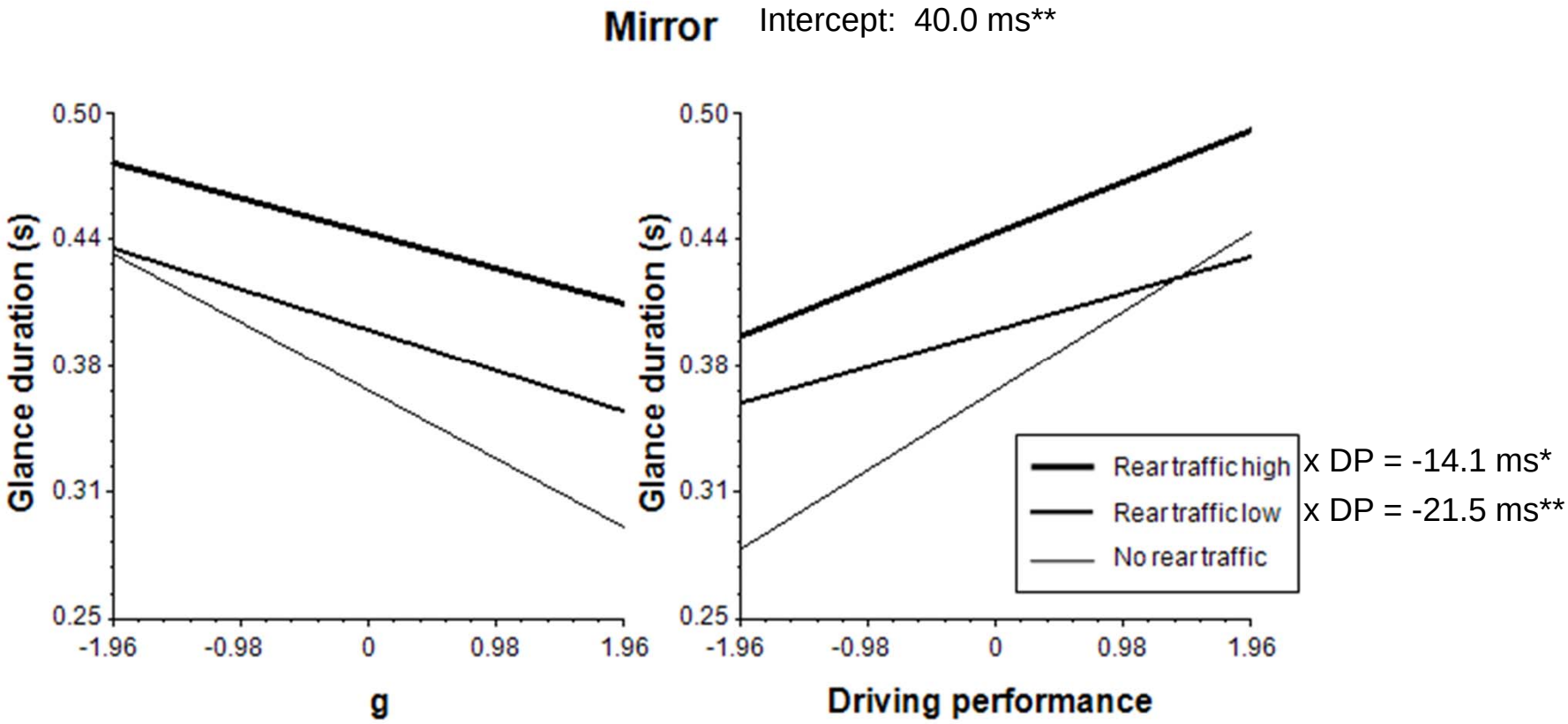


Median duration of first glance to left mirror (> 0.1s)

Significant interaction $p < .05$

Results

Experiment 2:



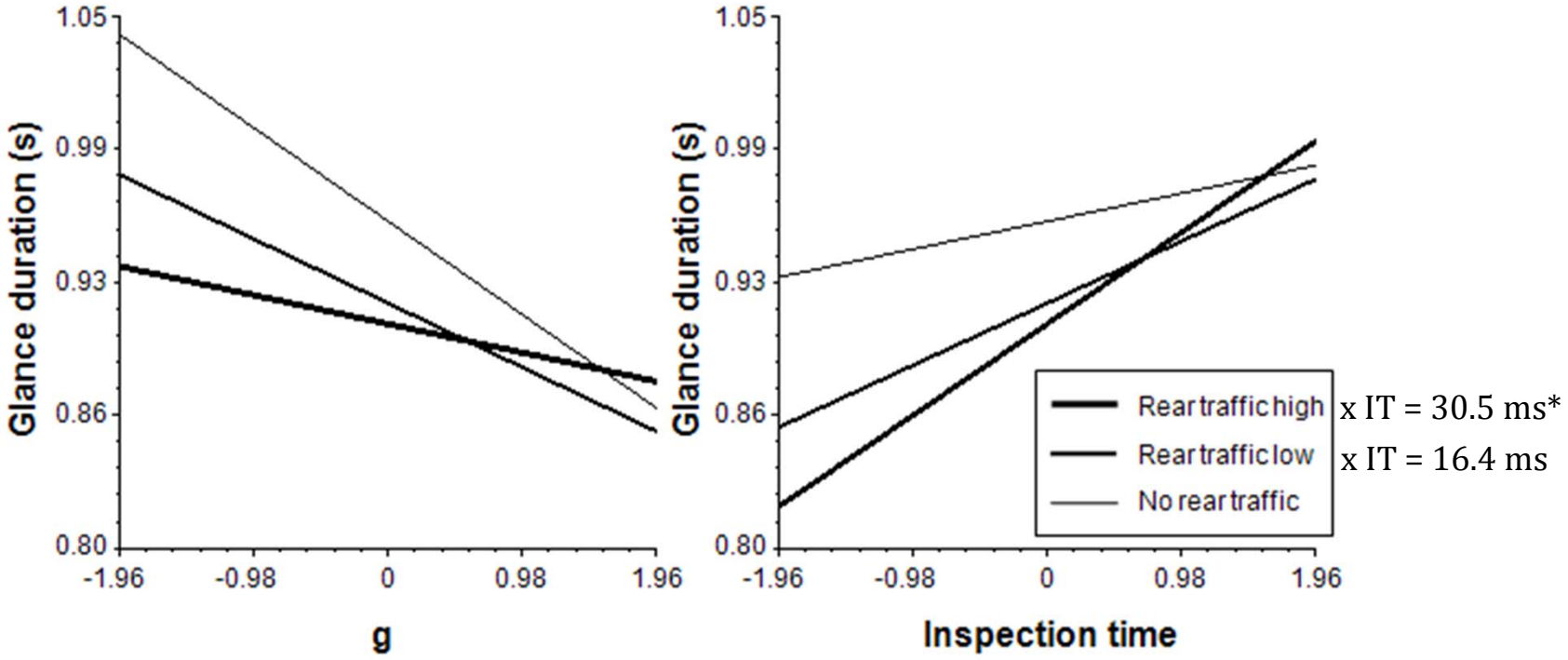
Results

Experiment 2:

Intercept: -38.7 ms

Touch pad

Intercept: 13.5 ms



x IT = 30.5 ms*

x IT = 16.4 ms

Results

Experiment 2:

	Driving			Secondary Task			
CAM	Collision	Time for Run	Comb	% Corr	Mean RT	Comb	Total Perf
IT	.20	.01	-.14	-.10	**.35***	**-.30***	**-.29***
Raven	**-.40****	-.24	**.43****	**.36****	-.13	**.33***	**.51****
SymSpan	-.07	**-.35***	**.28***	.19	-.24	**.29***	**.39****
LRT	-.02	.08	-.04	.26	.06	.14	.07
g	**-.34***	**-.31***	**.43****	**.41****	-.27	**.45****	**.59****

Correlations of the Cognitive Ability Measures (CAM) With the Task Performance Measures

Note. Comb = combined index of the accuracy and speed measures, % Corr = percentage of tasks solved correctly, RT = response time, Total Perf = total performance, combined index of driving and secondary task performance, SymSpan = Symmetry Span Test, IT = inspection time, LRT = Letter Rotation Task.

* $p < .05$. ** $p < .01$.

Discussion

Core hypothesis - Persons with high visual-cognitive abilities need less time to process information (cf. Deary, 2000; Jensen, 2006):

- Shorter glance duration to the mirror = same driving performance
- Higher performance in driving task and/or secondary task
- Strategically increased glance duration to touchpad if informational demands increase (higher glance duration with higher g)

Implications

- Cognitive abilities influence strategies to distribute attention
- *g*: general abilities of information update, information reproduction, and cognitive performance in dual-task situations, IT explains incremental variance for situations with high visual competition (see Chaiken, 1994; Deary, McCrimmon, & Bradshaw, 1997)

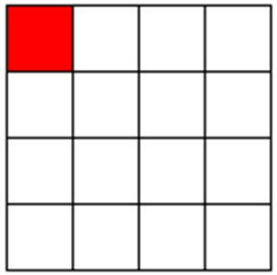
- *Practical implications:*
  - **g/IT** provide important indicators for the performance during dual-task situations
  - Glance duration as outcome variable is **not independent** from the person
  - **IT** may improve prediction of explanatory models on the individual level (i.e., personalization)

- **Thank you for your attention!**
  - **matthias.henning@psychologie.tu-chemnitz.de**

Back-up

Cognition tests – SM

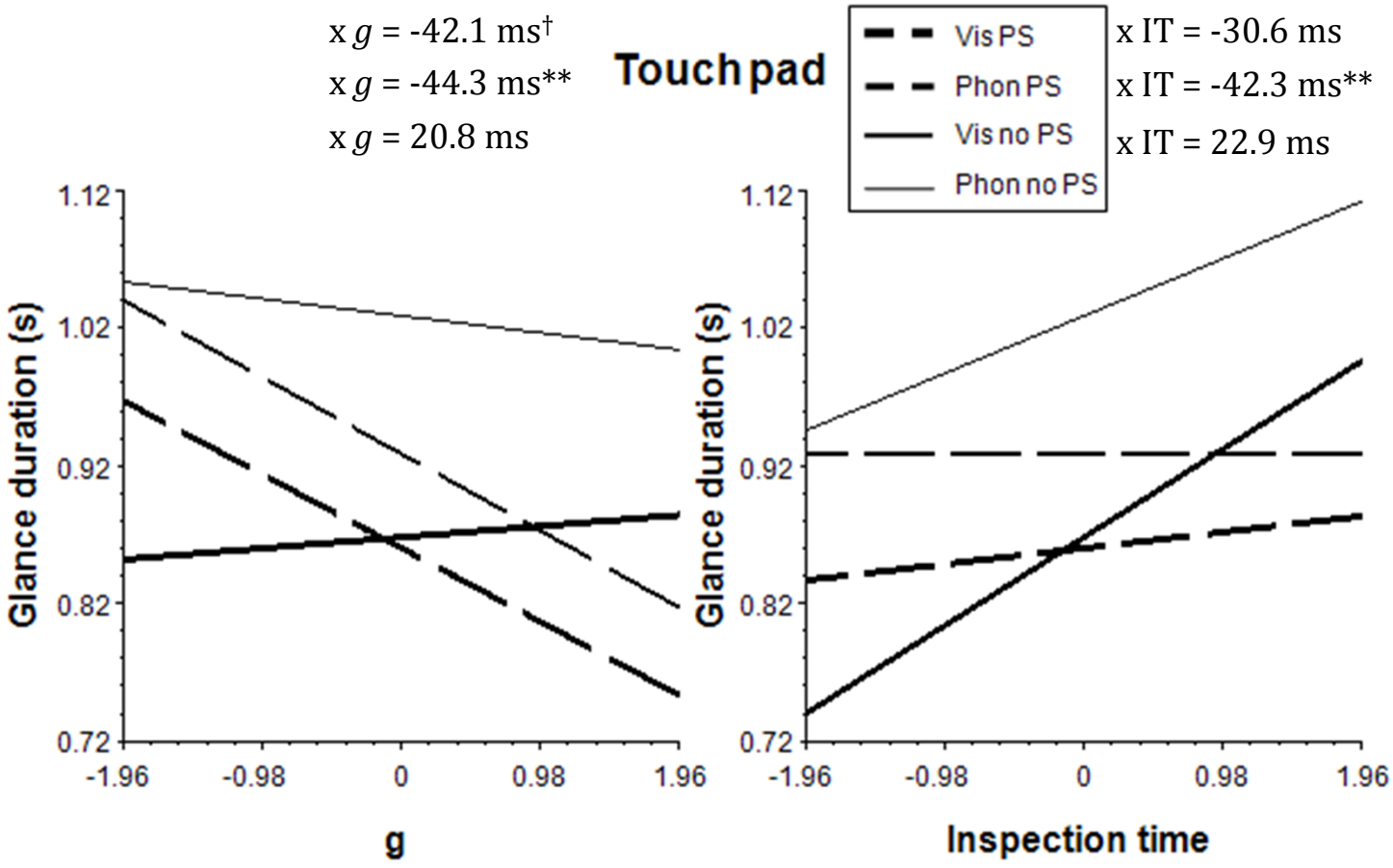
- Symmetry Span (Kane, 2004)



Method

Experiment 1:

Results


x g = -42.1 ms†
x g = -44.3 ms**
x g = 20.8 ms
Touch pad
Vis PS
Phon PS
Vis no PS
Phon no PS
x IT = -30.6 ms
x IT = -42.3 ms**
x IT = 22.9 ms
Glance duration (s)
1.12
1.02
0.92
0.82
0.72
-1.96
-0.98
0
0.98
1.96
g
Inspection time