

The effect of car-following on lateral guidance during cognitive load – A study conducted in the multi-driver simulation

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Distraction is one of the **most frequent causes for crashes**:

- 25% of all crashes (Wang, Knipling & Goodman, 1996)
- 65% of all near crashes ("100-car-study", Klauer et al., 2006)

Especially, visual distraction is detrimental

- voice-based solutions are implemented
- Less visual load, more cognitive load

Effects of cognitive load:

- Increase of reaction times
- Decrease in velocity
- Greater distances to preceding vehicles

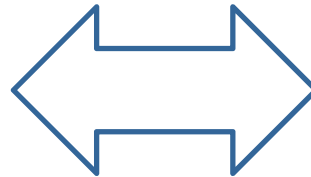


Effects of cognitive load on lateral control



Detrimental effects or a lack of effects

(e.g., Alm & Nilsson, 1995; Lambale, Kauranen, Laakso & Summala, 1999; Strayer & Johnston, 2001)



Positive effects

(e.g., Brookhuis, de Vries & de Waard, 1991; Engström, Johansson & Östlund, 2005; Horrey & Simons, 2007)

Explanations for positive effects:

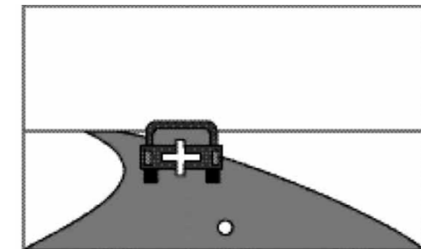
- Changed glance behavior (Victor, 2005)
- Virtual safety margin (Törnros & Bolling, 2005)
- Increased driver alertness (Brookhuis et al., 1991)

Confounding by car following?

Several studies showing positive effects introduce car following (e.g., Jamson & Merat, 2005; Liang & Lee, 2010)

→ Effects may be enhanced by car following

→ Preceding vehicle is used as reference for lane keeping (Salvucci & Gray, 2004)



Aim of this study:

Does car following modulate the effects of cognitive secondary tasks?

Driving station

- PC-game steering wheel and pedals
- 3x 22" flat screens

Software

- SILAB
- Recording of driving data (60Hz)

Communication & sound

- SILAB VoiceChat
- Via Headset



Country road course (length 25 km)

Various situations:

- Passing of parking cars
- Unforeseeable braking
- Different speed limits
- ...

“Platoon” driving:

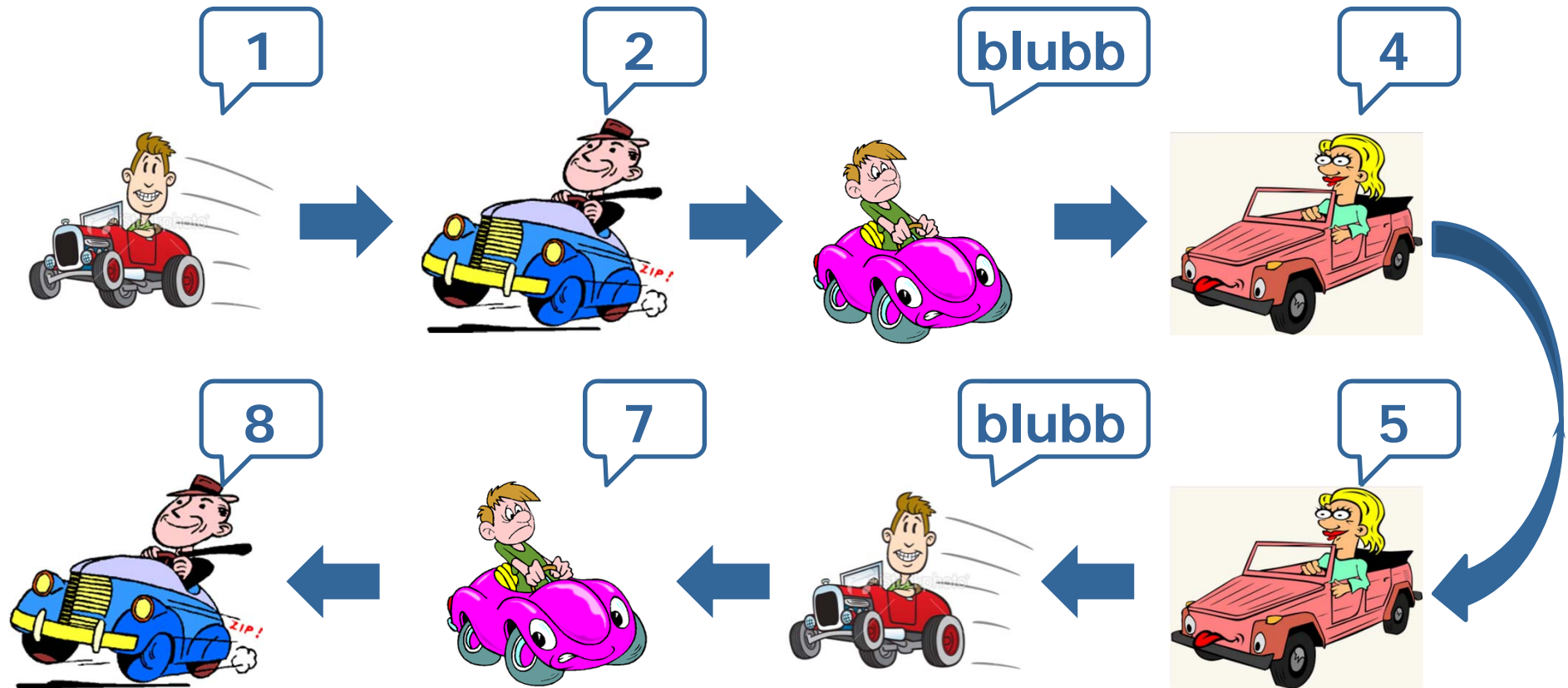
- Preserving of order
- No overtaking
- Time-headway approx. 2s



Secondary task

Task: count commonly and rotationally in randomized order

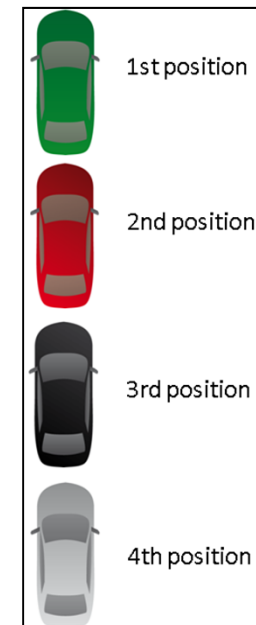
Difficulty: Numbers containing 3 or divisible by 3 → „blubb“



Study design: Mixed 4x2 experimental design

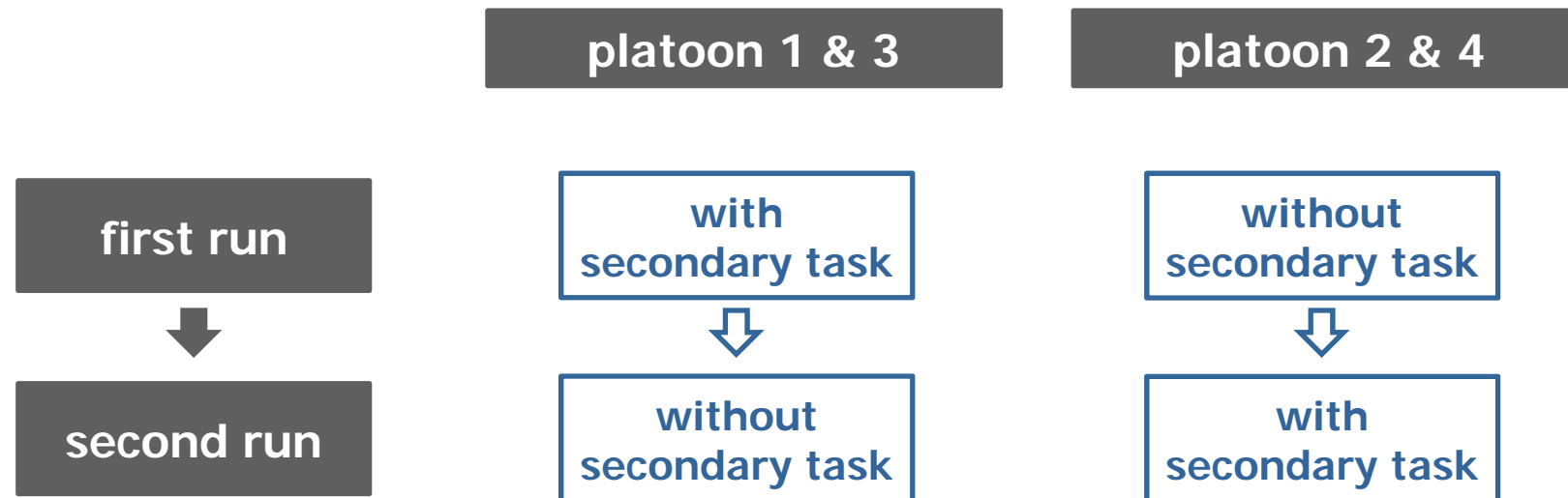
Between-Factor: Position

- Position 1: No preceding vehicle
- Position 2: One preceding vehicle
- Position 3: Two preceding vehicles
- Position 4: Three preceding vehicles



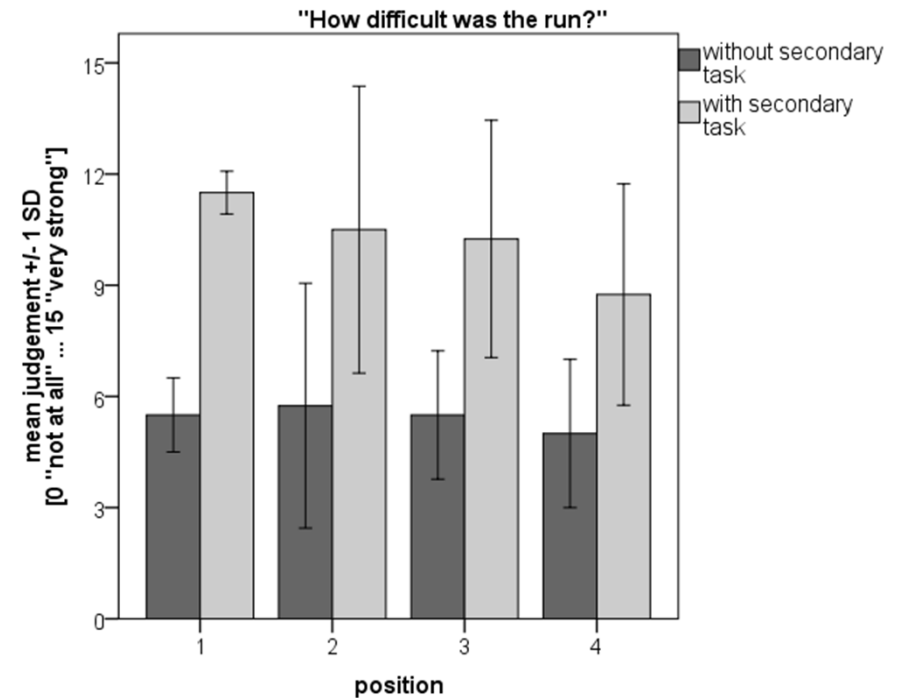
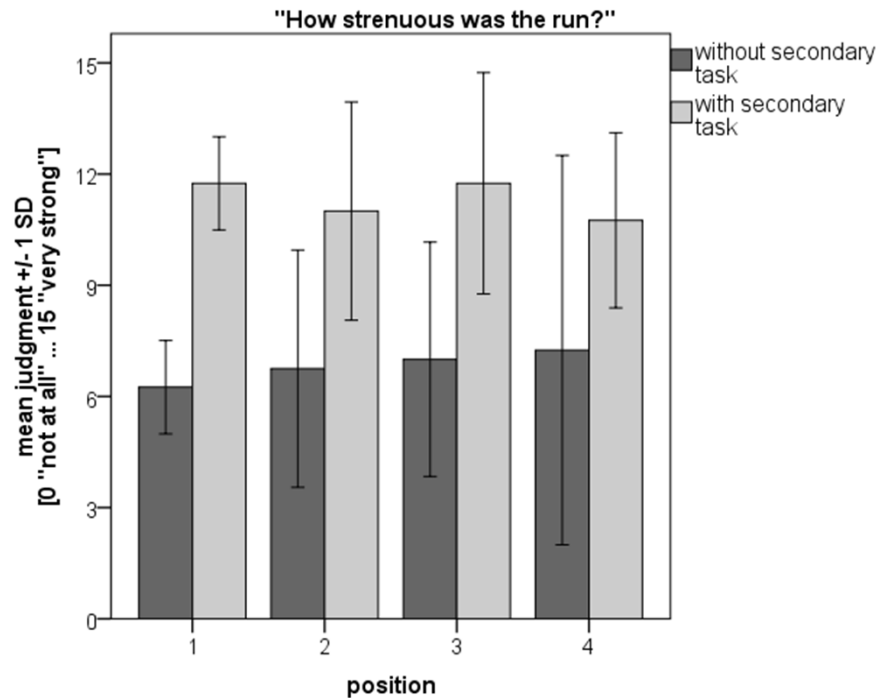
Within-Factor: Secondary task

- Run without secondary task
 - Run with secondary task
- Runs occurred in counterbalanced order



N=16 (4 platoons consisting of n=4 drivers)

- Sex: 6 female, 10 male
- Age: 23-40 years; m=30.8 years



Driving with secondary task is rated as more negative:

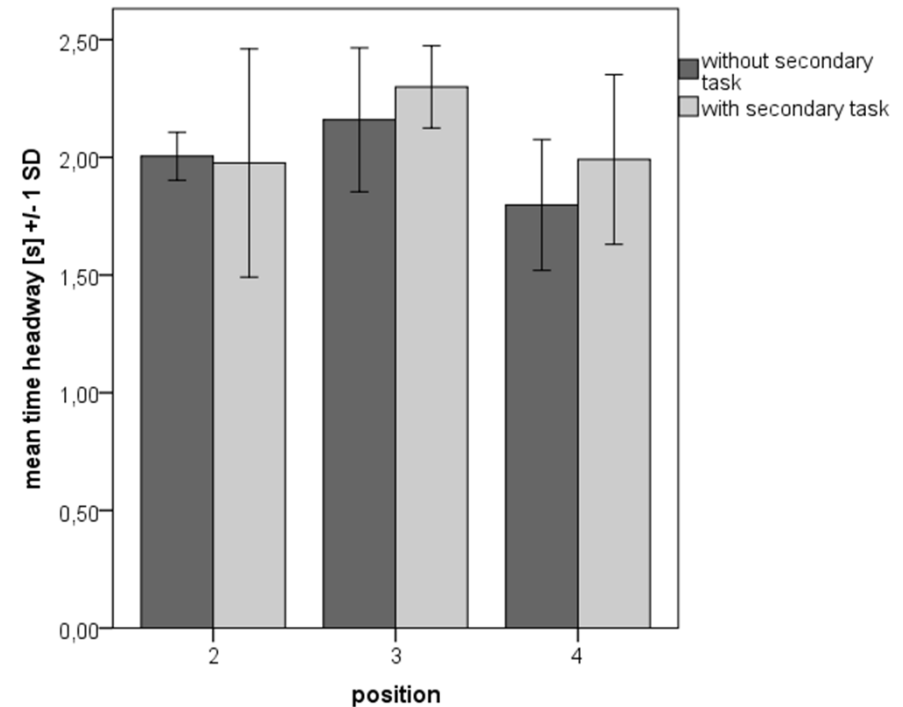
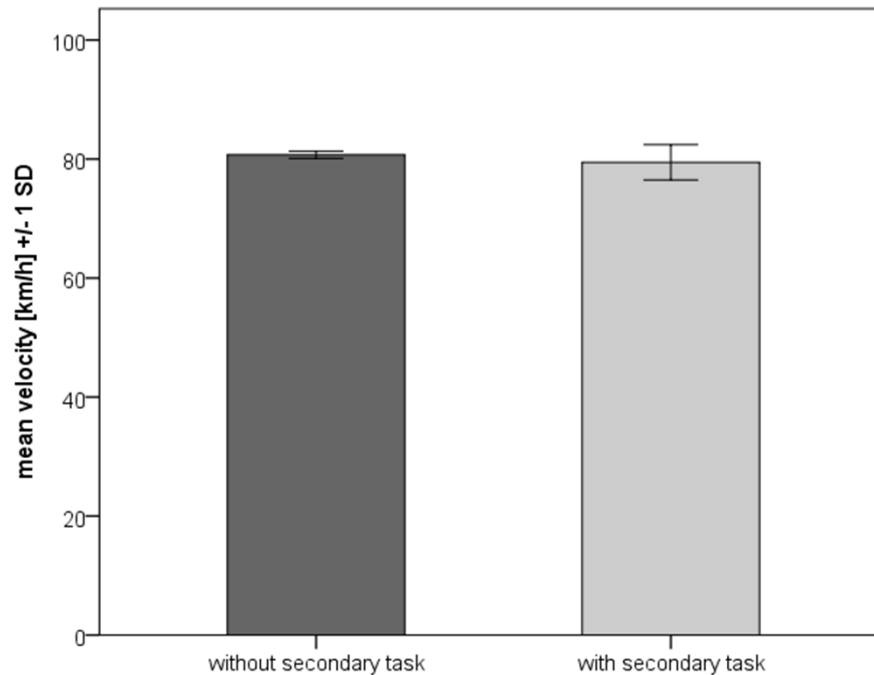
- More strenuous ($F(1;12)=32.000$; $p<.001$; $\eta^2=.727$)
- More difficult ($F(1;12)=45.260$; $p<.001$; $\eta^2=.790$)
- Less safe ($F(1;12)=12.520$; $p=.004$; $\eta^2=.511$)

Did you drive with the secondary task in another way than without the secondary task?

11 of 16 participants: **less or changed attention on driving**, e.g.

“With the secondary task,

- ...I was oriented mostly towards the preceding vehicle.”
- ...I realized nothing of driving due to the counting task.”
- ...I was totally unaware of driving. Instead of, I followed the preceding vehicle automatically.”
- ...I was less attentive. I was more concentrated on counting than on driving.”



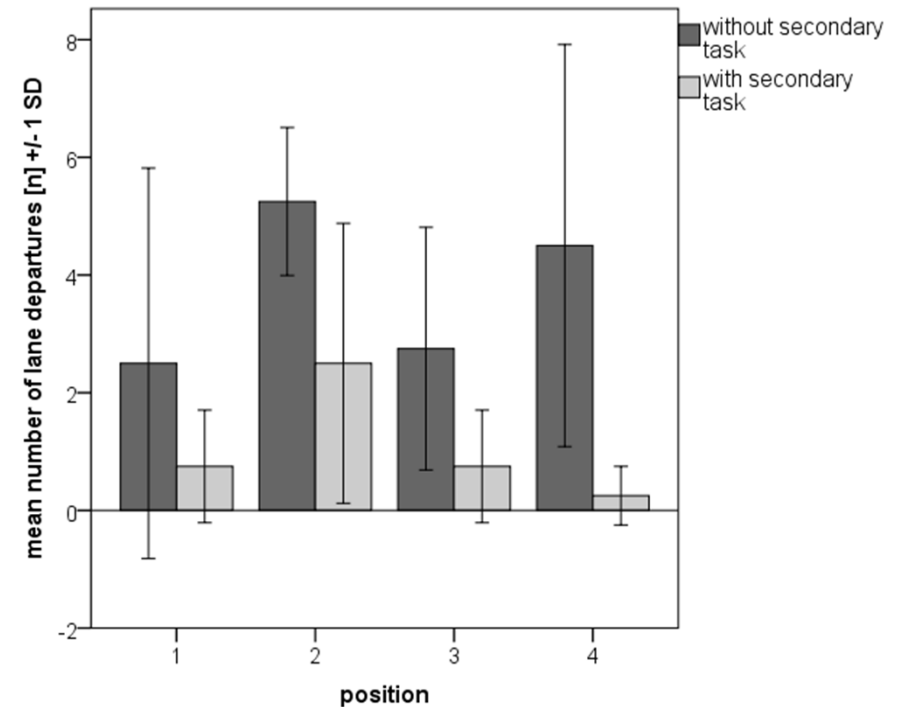
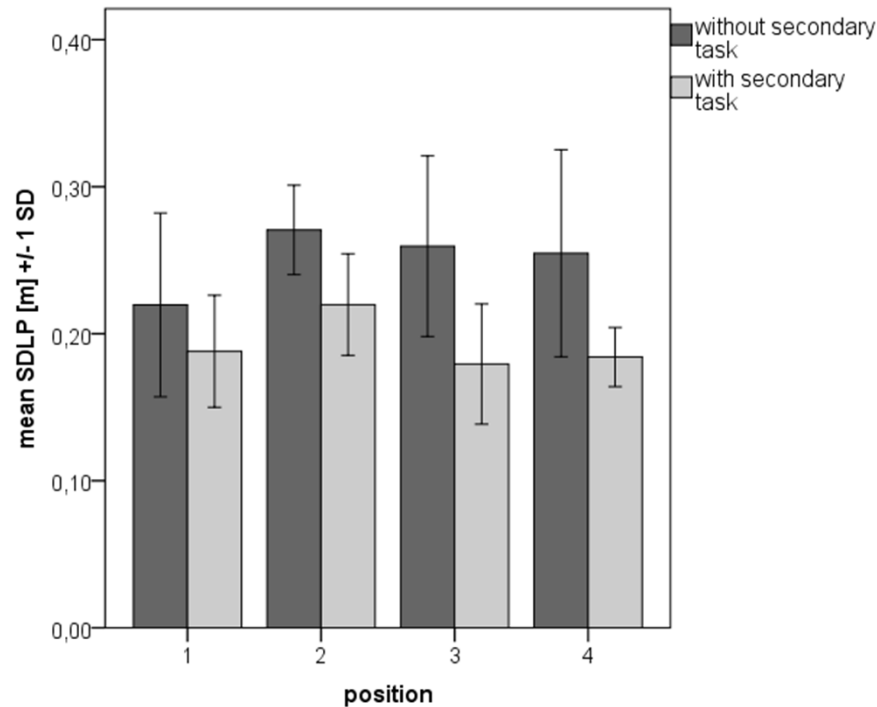
The secondary task has no effects concerning longitudinal control:

- Mean velocity
- Mean time headway
- Standard deviation of time headway

no inferential test (n=4)

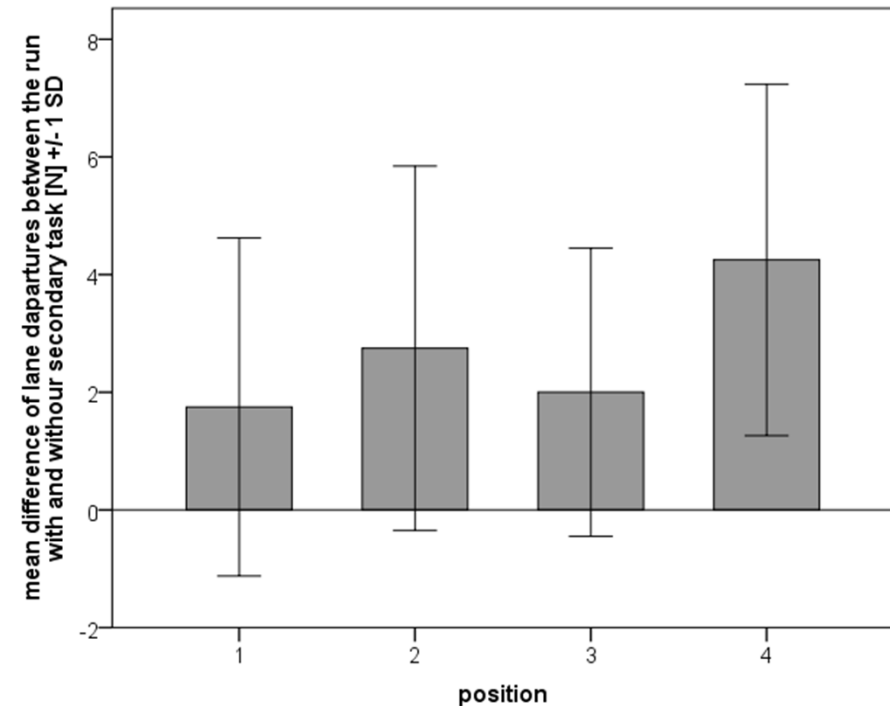
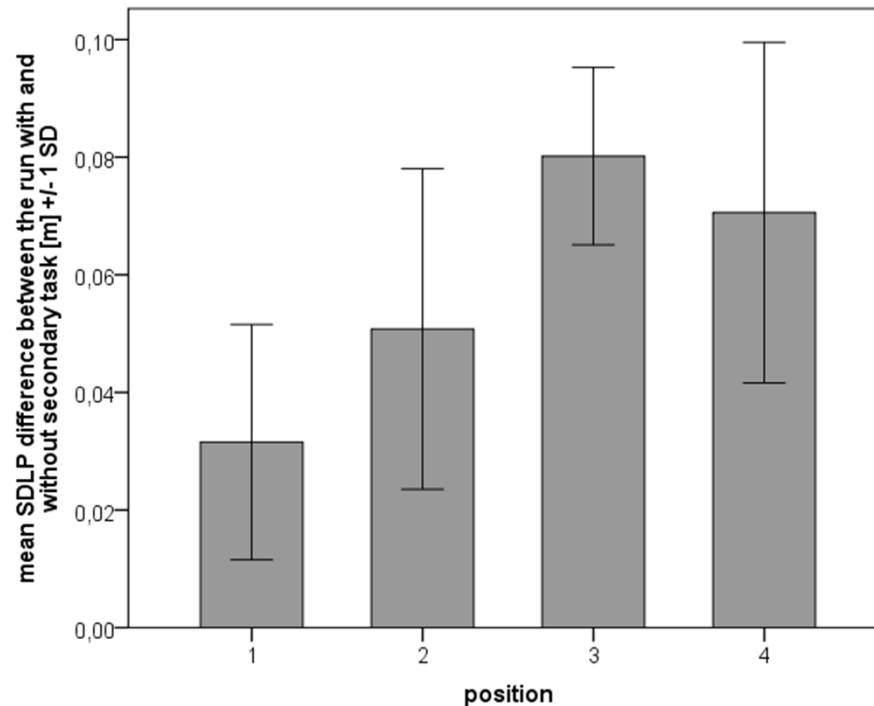
(F(1;9)=0.810; p=.392; eta²=.083)

(F(1;9)=0.801; p=.394; eta²=.082)



The secondary task goes along with positive effects:

- Decreased SDLP ($F(1;12)=24.597$; $p<.001$; $\eta^2=.672$)
- Less lane departures ($F(1;12)=14.115$; $p=.003$; $\eta^2=.540$)



Benefit of the secondary task might increase with position.

→ Car following enhances the effect of the secondary task

Main effects of the secondary task:

- Judgments: Negative effects
- Longitudinal control: No effects
- Lateral control: Enhanced lateral guidance

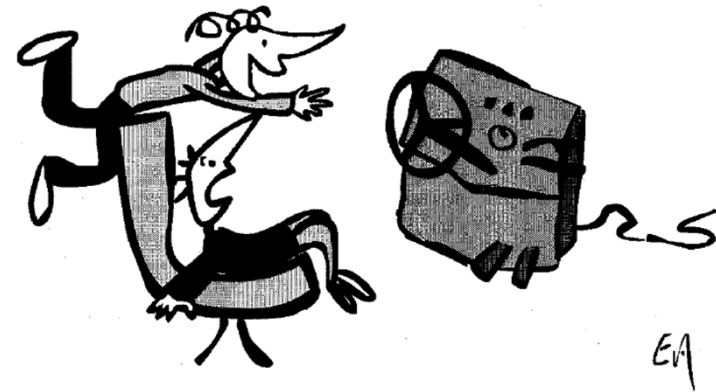
Position effect:

- Judgments/ longitudinal control: No effects
- Lateral control: Benefit increases with position (=number of preceding vehicles)

Implications:

- Car following enhances the effect of the secondary task on lateral control
- Danger of overestimated effects

*Tack för er
uppmärksamhet!*



THE MULTI-DRIVER SIMULATOR

For further information please contact:
muehlbacher@psychologie.uni-wuerzburg.de

Drivers' judgments

- **After each run: Inquiry in closed form concerning the run**
 - How strenuous was the run?
 - How difficult was the run?
 - How safe was the run?
- **At the end of the session: Inquiry in open form to compare the two runs**
 - Did you drive with the secondary task in another way than without the secondary task?

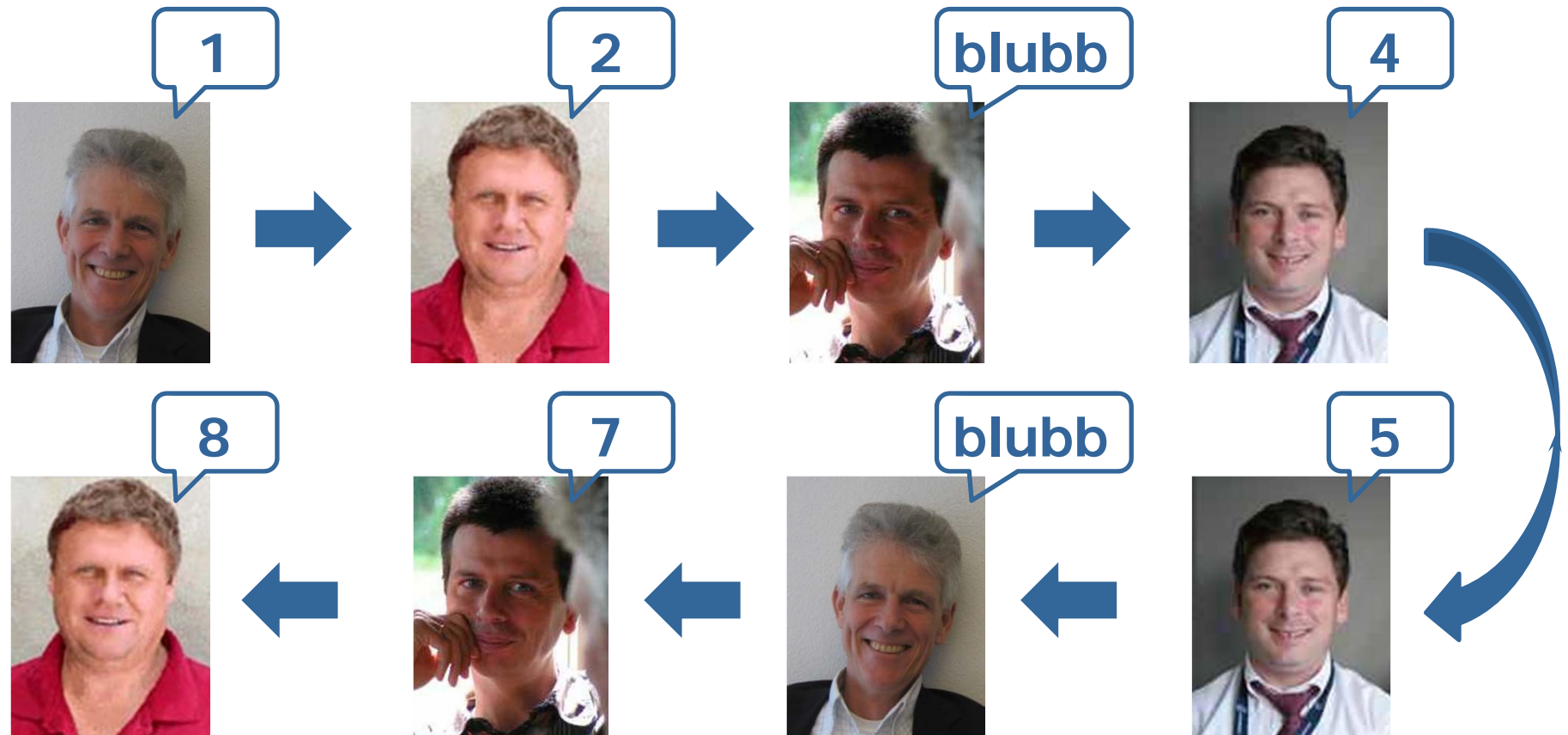
Driving data

- **Velocity**
- **Time-headway**
- **Lateral position**
- **Lane departures**

Secondary task

Task: count commonly and rotationally in randomized order

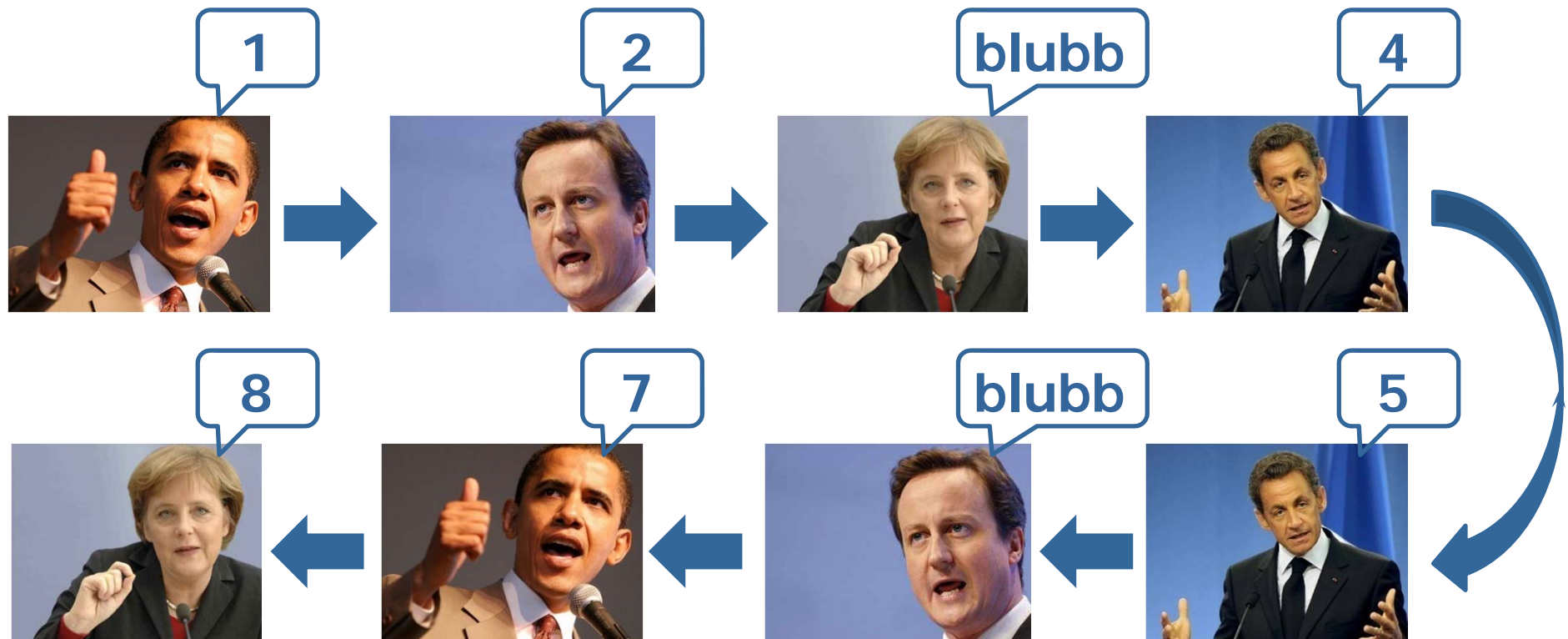
Difficulty: Numbers containing 3 or divisible by 3 → „blubb“

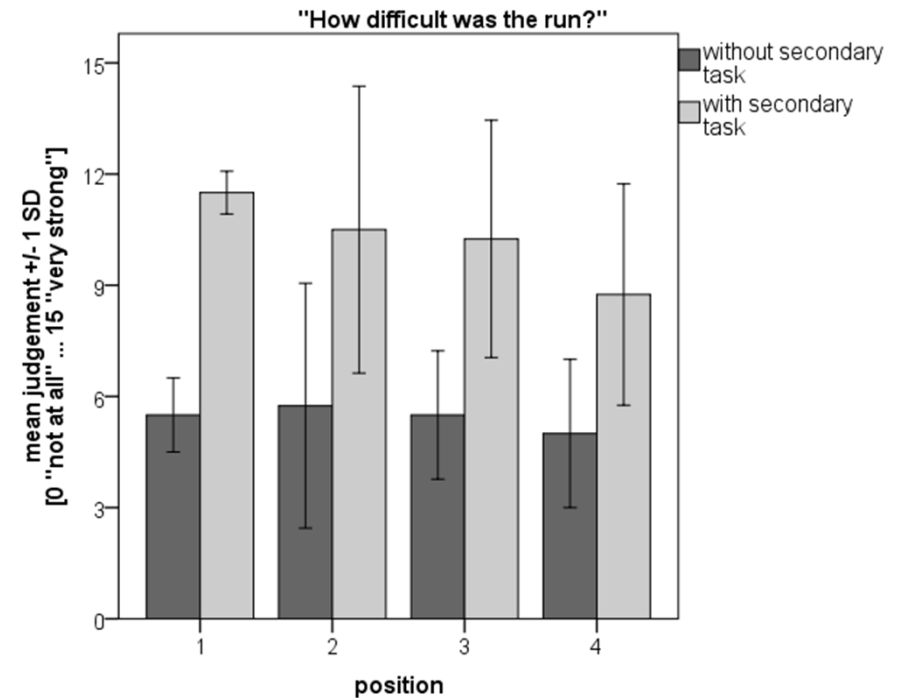
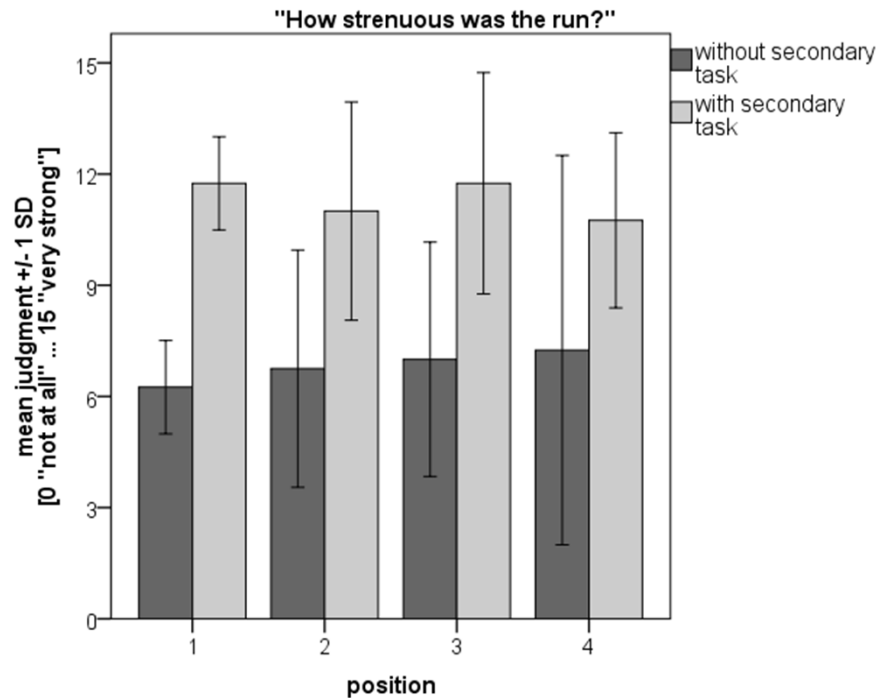


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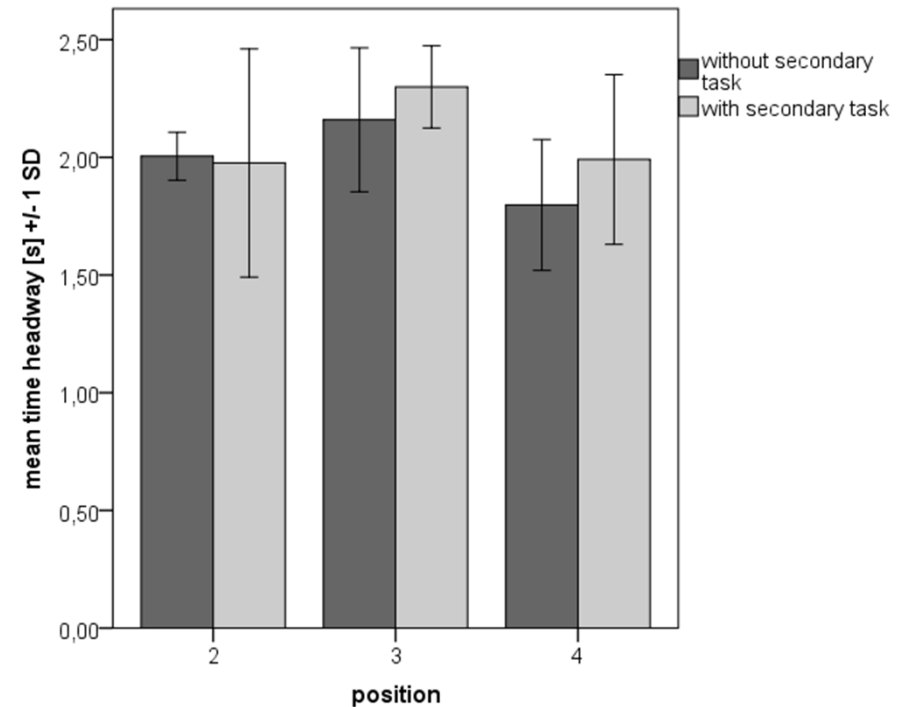
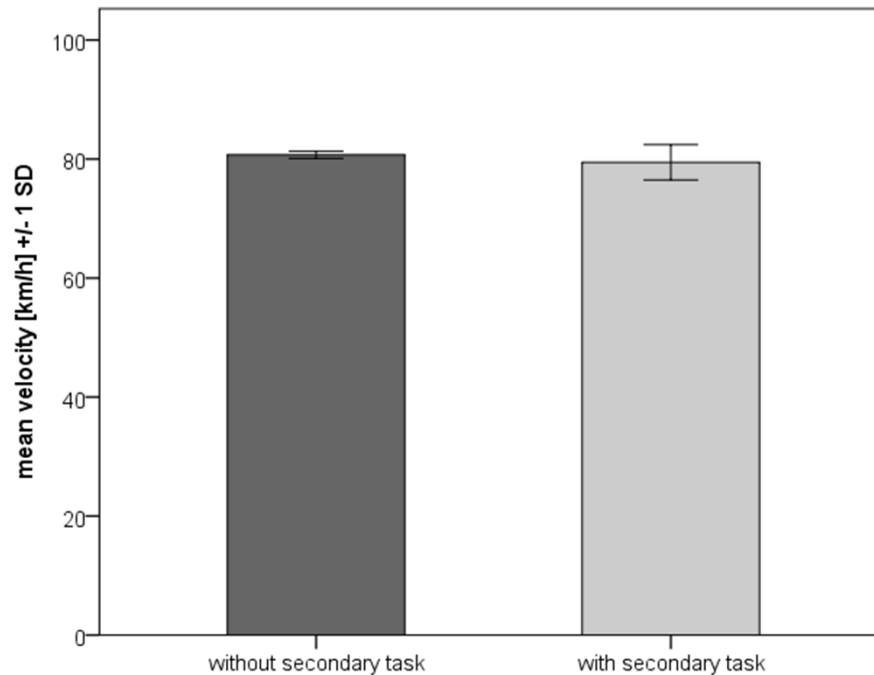
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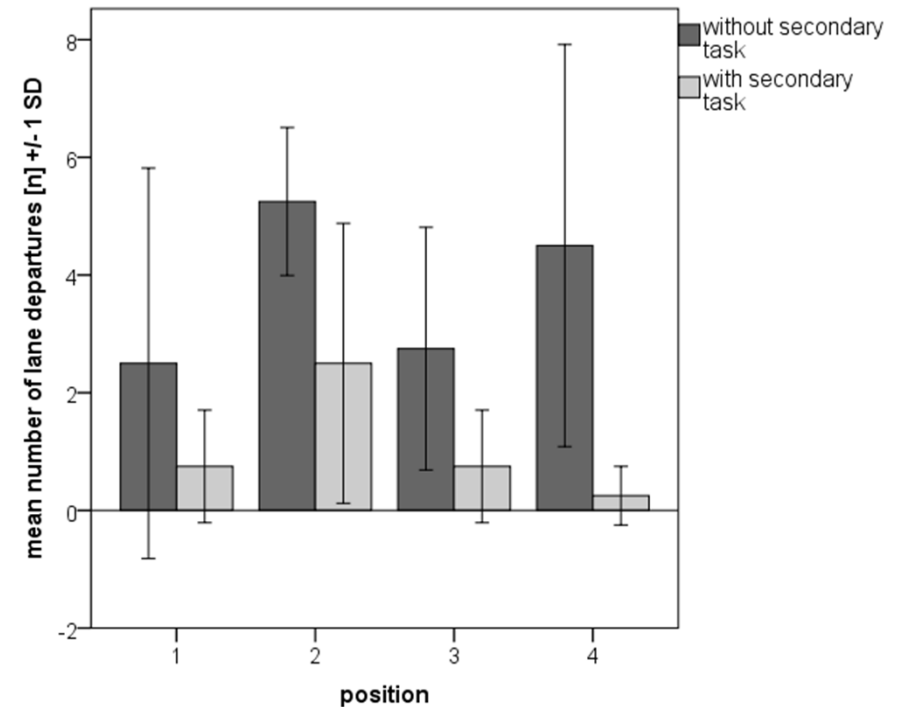
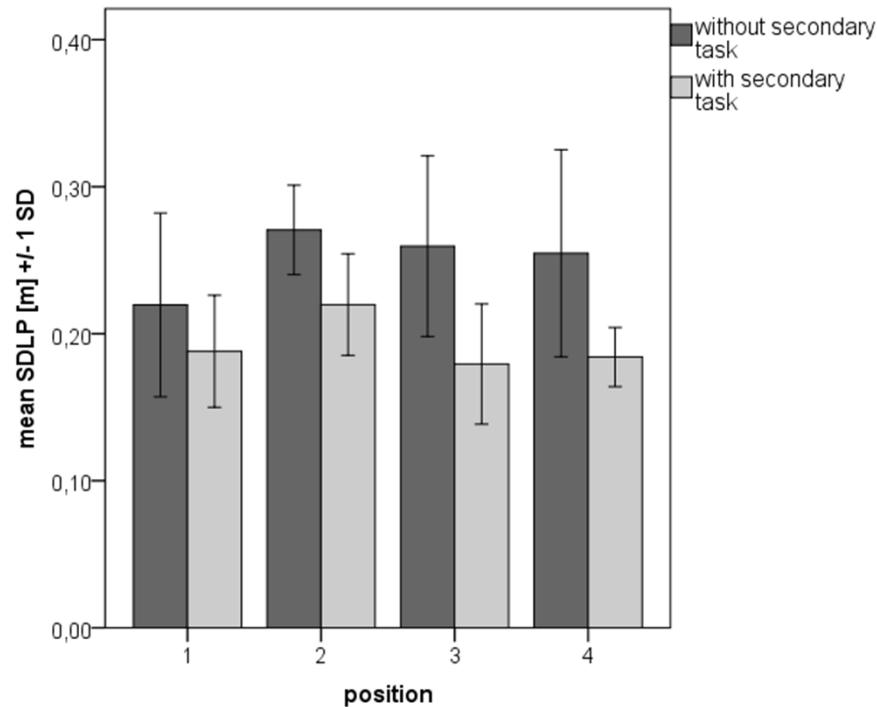
Driving with secondary task is rated as more negative:

- More strenuous ($t(15)=6.114$; $p<.001$) ($F(1;12)=32.000$; $p<.001$; $\eta^2=.727$)
- More difficult ($t(15)=6.245$; $p<.001$) ($F(1;12)=45.260$; $p<.001$; $\eta^2=.790$)
- Less safe ($t(15)=3.090$; $p=.007$) ($F(1;12)=12.520$; $p=.004$; $\eta^2=.511$)



The secondary task has no effects concerning longitudinal control:

- Mean velocity no inferential test (n=4)
- Mean time headway (t(11)=0.958; p=.359)
- Standard deviation of time headway (t(11)=0.910; p=.382)



The secondary task goes along with positive effects:

- Decreased SDLP (t(15)=5.038; p<.001)
- Less lane departures (t(15)=3.909; p=.001)