The effect of visual and cognitive distraction on the driving performance of older drivers – A driving simulator study

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Driver Distraction and Inattention (DDI), Gothenburg, 2013

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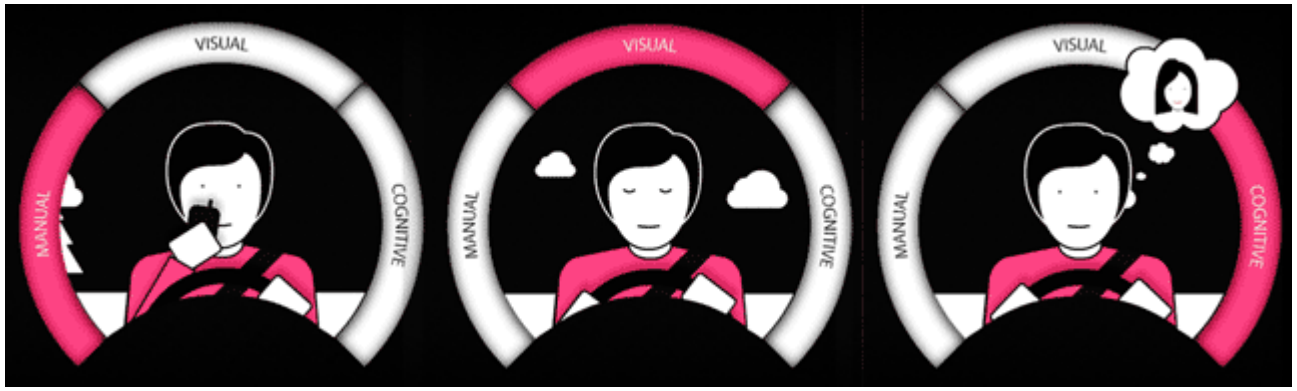
Introduction

- Our cognitive capacity is limited (Salthouse, 2004; Proctor & Van Zandt, 2008)

- Ageing:
  - Decline in cognitive capacity (Craik & Salthouse, 2000; Regan et al. 2009)
  - Decline in dual-task ability (Chaparro et al. 2005; Makishita & Matsunaga, 2008; McPhee et al. 2004; Stinchcombe, 2011; Thompson et al. 2012)
    - BUT inconsistent results: no age differences in effects of distraction (Horberry et al. 2006; Strayer & Drews, 2004)

Introduction

- Effect of distraction dependent on type (Engström et al. 2005; Törnros & Bolling, 2005):
  - Visual distraction: increase in SDLP, decrease in speed
  - Cognitive distraction: decrease in SDLP, no effect on speed
    - BUT dependent on driving measure under investigation: similar effects on detection of signs or critical events (Chaparro et al. 2005; Horberry et al. 2006; Maciej & Vollrath, 2009)



Introduction

- Effects of distraction in older drivers have only been investigated on-road or on speed-related measures in a driving simulator (Chaparro et al. 2005; Horberry et al. 2006)
  - ***The effect of visual and cognitive distraction has not yet been demonstrated for older drivers by using several specific driving measures derived from a driving simulator***

- Larger effects of distraction in older drivers might be due to decreased cognitive capacity to divide attention between concurrent tasks
  - ***Possible moderating effects on distraction of divided attention capacity have not yet been investigated in older drivers***

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Research questions

- Two studies:

1. What is the effect of visual distraction on the driving performance of olders drivers while taking into account divided attention capacity?

2. What is the effect of cognitive distraction on the driving performance of olders drivers while taking into account divided attention capacity?

Participants

- Inclusion criteria:
  - Age: ≥ 70 year
  - No stroke or sequel or CVA past 4 months
  - MMSE: ≥25
  - Active drivers

- Sample size:
  - Visual distraction: 20 volunteers → 17 participants
    - Simulator sickness: 3 participants
  - Cognitive distraction: 57 volunteers → 35 participants
    - Simulator sickness: 19 participants
    - Inability: 3 participants

Participants

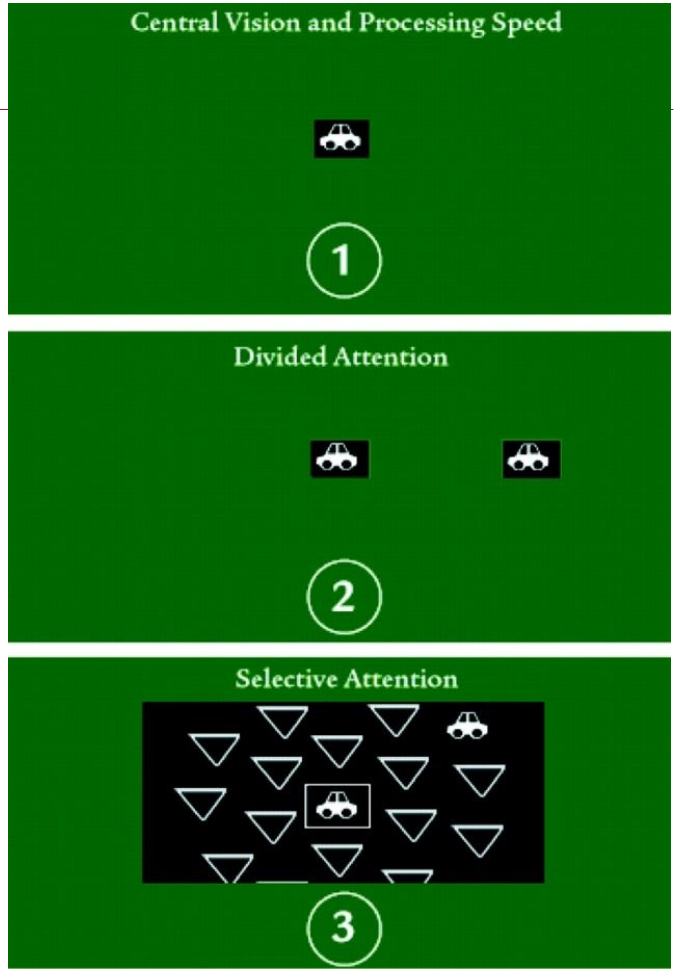
- Gender:
  - Visual distraction: 15 men, 2 women
  - Cognitive distraction: 28 men, 7 women

- Age:
  - Visual distraction:78.12 years
  - Cognitive distraction:75.69 years

- Driving experience:
  - Visual distraction: 14 608.00 km/year
  - Cognitive distraction: 11 198.53 km/year

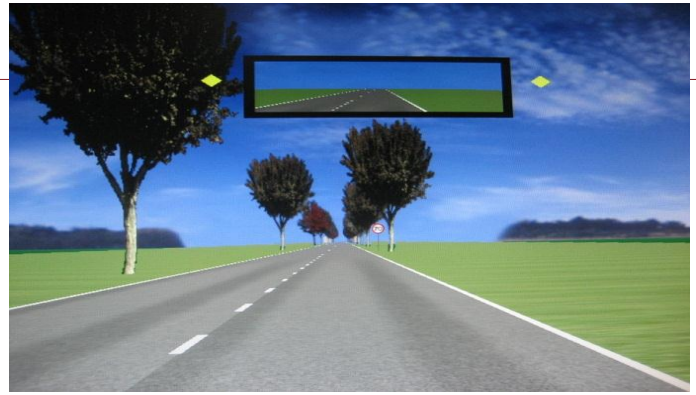
Tests

- Cognitive test (Jessa hospital):
  - Useful Field of View (UFOV)
    - UFOV-1 processing speed
    - UFOV-2 divided attention
    - UFOV-3 selective attention

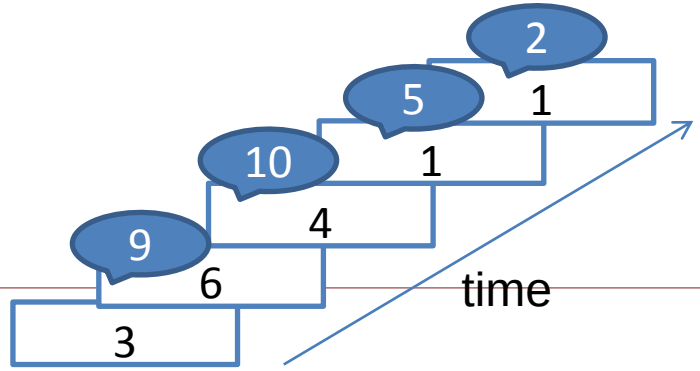


- Driving test (Transportation Research Institute):
  - Fixed-based medium-fidelity driving simulator (STISIM M400; Systems Technology Incorporated) with a 180° field of view seamless curved screen

Driving test

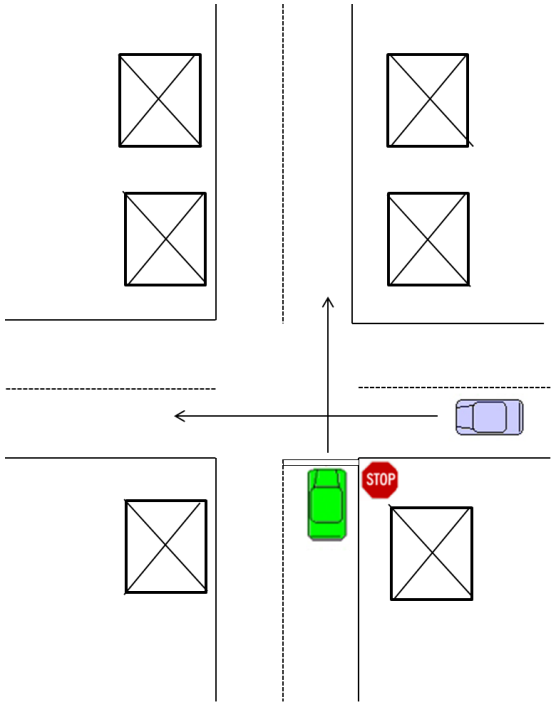


- 2 rides (17 km):
  - Ride without distraction
  - Ride with distraction:
    - Visual distraction:
      - Detection response task: react when the yellow-coloured diamond shapes turn red
    - Cognitive distraction:
      - Paced Auditory Serial Addition Test (PASAT-3): Add serial pairs of randomized digits so that each digit was added to the digit immediately preceding



Scenario in driving simulator

- Circumstances:
  - Daylight and good weather conditions
  - Inner-city (50 km/h) sections
  - Outer-city (70, 90 km/h) sections
  - Highway (120 km/h) sections



- Several traffic situations:
  - Inner-city section: Intersections with a stop sign
  - Outer-city section: Leading vehicle driving 10 km/h beneath speed limit

Driving measures

- Specific driving measures:
  - Mean speed
  - Following distance
  - Standard Deviation of Lateral Position (SDLP)
  - Complete stops at stop signs
  - Crashes

Work in progress:

- Specific driving measures:
  - Detection and reaction time to road hazards
  - Detection and reaction time at intersections

Analysis

- Descriptives:
  - UFOV scores
  - Performance distracting tasks

- Repeated measures analyses of covariance (ANCOVA) separately for each type of distraction and each dependent driving measure
  - Within-subjects factor(s): distraction (and speed limit)
  - Covariate: UFOV divided attention capacity

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Descriptives UFOV

	Sample with visual distraction	Sample with cognitive distraction
UFOV-1	38.79 (33.33)	31.45 (25.82)
UFOV-2	187.67 (141.30)	140.41 (111.62)
UFOV-3	322.55 (131.61)	258.53 (111.18)

- UFOV-1: Normal central vision but somewhat slowed processing speed
- UFOV-2: Some difficulty with divided attention
- UFOV-3: Normal selective attention ability

Descriptives performance – distracting tasks

- During driving:
  - Visual task:
    - 91.76% correct (SD: 7.62%)
    - 8.24% missed (SD:7.62%)
  - Cognitive task:
    - 62.49% correct (SD: 17.23%)
    - 23.37% missed (SD: 15.77%)

Visual distraction

- **Mean speed**: no difference with distraction (M=64.37, SE=2.07) vs. without distraction (M=64.78, SE=1.29), p=.83

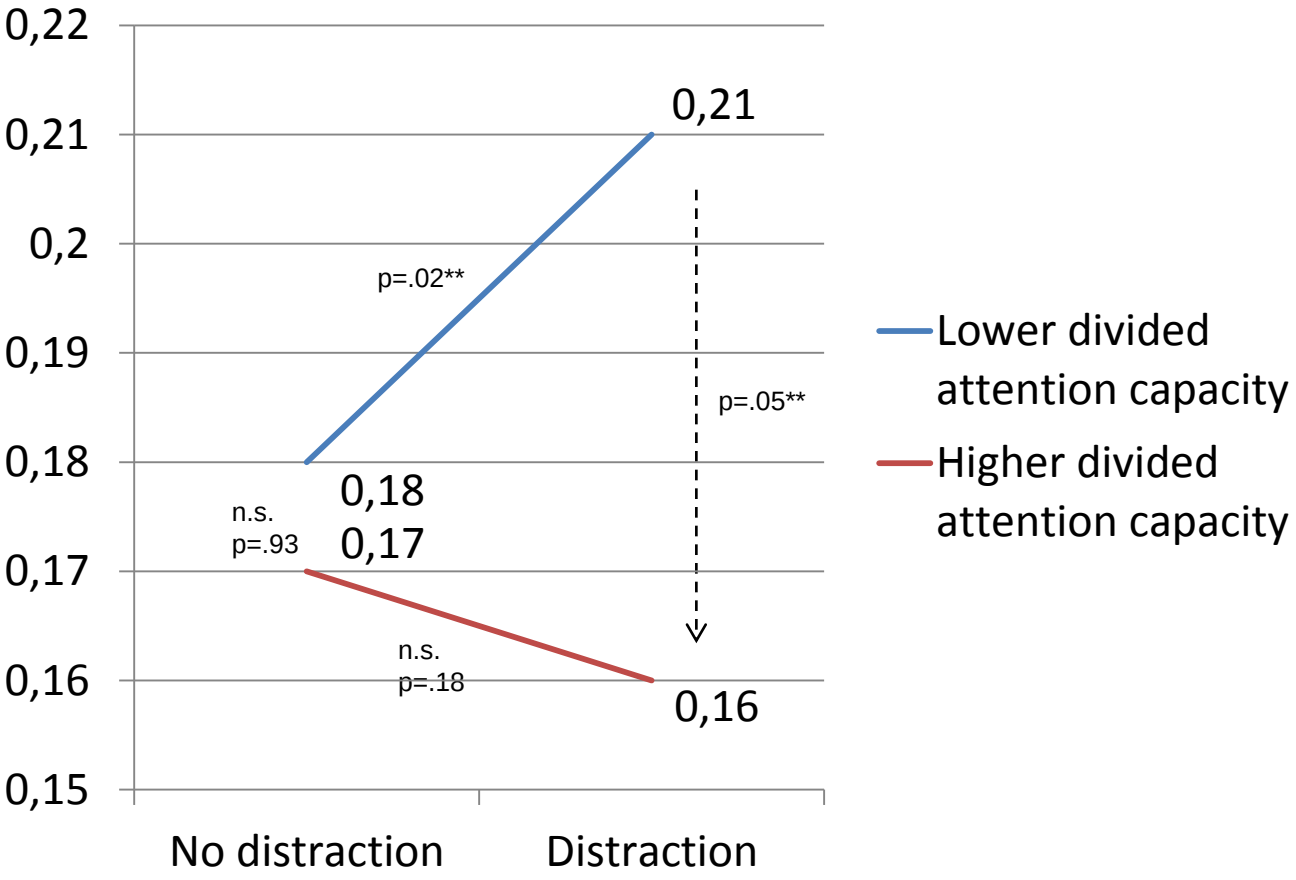
- **Following distance**: no difference with distraction (M=100.37,SE=12.68) vs. without distraction (M=91.13, SE=8.89), p=.51

- **Complete stops**: no difference with distraction (M=0.41, SE=0.10) vs. without distraction (M=0.53, SE=0.08), p=.28

- **Crashes**: increase with distraction (M=0.88, SE=0.26) vs. without distraction (M=0.46, SE=0.15), **p=.083**

Visual distraction

- **SDLP**: interaction between distraction and divided attention capacity, **p=.042**:



Cognitive distraction

- **Mean speed**: interaction between distraction and speed limit, ***p*=.067:**
  - **Speed limit 50 km/h**: decrease with distraction (M=39.66, SE=1.15) vs. without distraction (M=41.13, SE=1.03), **p=.04**
  - Speed limit 70 km/h: no difference with distraction (M=51.04, SE=1.56) vs. without distraction (M=52.44, SE=1.33), p=.39
  - Speed limit 90 km/h: no difference with distraction (M=73.84, SE=3.70) vs. without distraction (M=75.37, SE=2.95), p=.67
  - **Speed limit 120 km/h**: decrease with distraction (M=73.19, SE=3.42) vs. without distraction (M=80.20, SE=2.43), **p=.01**

Cognitive distraction

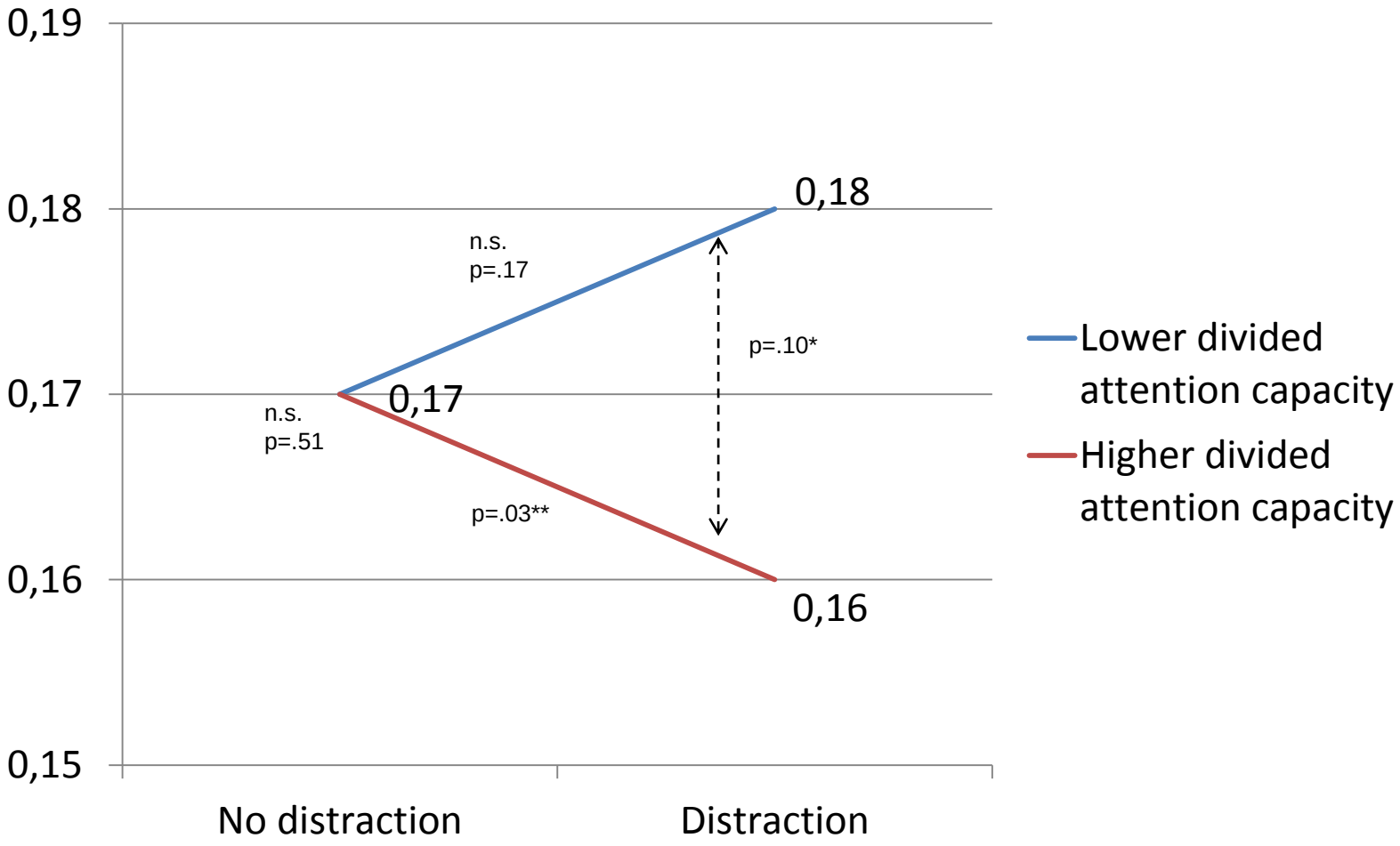
- **Following distance**: no difference with distraction (M=117.90, SE=13.01) vs. without distraction (M=110.38, SE=10.57), p=.57

- **Complete stops**: less with distraction (M=0.37, SE=0.07) vs. without distraction (M=0.56, SE=0.07), **p=.011**

- **Crashes**: increase with distraction (M=1.26, SE=0.30) vs. without distraction (M=0.67, SE=0.15), **p=.053**

Cognitive distraction

- **SDLP**: interaction between distraction and divided attention capacity, **p=.063**:



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Summary:

- Visual distraction:
  - Crashes increase with distraction
  - Divided attention capacity moderates the effects of distraction on SDLP:
    - SDLP increases with distraction, but only in those with low divided attention capacity (median split; no effect in high capacity)
- Cognitive distraction:
  - Speed decreases with distraction for speed limits 50 km/h and 120 km/h
  - Complete stops decrease with distraction
  - Crashes increase with distraction
  - Divided attention capacity moderates the effects of distraction on SDLP:
    - SDLP decreases with distraction, but only in those with high divided attention capacity (median split; no effect in low capacity)

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Discussion

- Effect of visual distraction on crashes; effect of cognitive distraction on speed, crashes and complete stops:
  - Low demanding driving task
    - Attentional demand increases with road complexity (Stinchcombe et al. 2011): straight roads vs. intersections or lane-changes
  - Low demanding visual secondary task
    - Alternative: Paced Visual Serial Addition Test (PVSAT)
- The effect of both types of distraction on SDLP was moderated by divided attention capacity.
  - Lavie's load theory: those with a low dual-tasking capacity (i.e. divided attention), are more susceptible to distractor interference (Lavie et al. 2004).
  - In line with other research (Engström et al. 2005; Törnros & Bolling, 2005): decrease of SDLP with cognitive distraction, increase of SDLP with visual distraction.
- Signs of compensatory behavior, i.e. mean speed

Thank you for your (divided) attention!

Questions?

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