



Cognitive Distraction and Drivers' Adaptation in Different Driving Manoeuvres in Real Traffic

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Increasing number of in-vehicle distraction sources

- Growing number of in-vehicle tasks and functions
 - in 1990 70% of in-car entertainment systems in US vehicles had less than 12 buttons, in 2001 only 35% of US vehicles (Dewar, 2002)
 - from 2000 to 2002 in the US six fold increase of cars sold with navigation systems fitted in
 - 66% of Finnish drivers use mobile phone while driving (Pöysti, et al. 2006)



Distraction as accident causation factor

- Performing such tasks while driving may lead to distraction
 - Physical – „Hands off the wheel“
 - Visual – „Eyes off the road“
 - Cognitive – „Mind off the road“
- Driver distraction is an important factor in accident causation (e.g. Stutts et al., 2001; Dingus et al., 2006)





Effects of cognitive distraction on driver performance

- Gaze concentration (e.g., Recarte & Nunes, 2003)
- Increase in response latencies (e.g., Patten et al., 2004)
- Reduced anticipation of braking requirements (Jamson et al., 2005)
- „Looked but failed to see“ (Brown, 2005)
- ...



Compensation of distraction effects

- Drivers seem to be aware of their distraction
 - Drivers can estimate their workload verbally online (Schießl, 2008)
 - Drivers delay start of in-vehicle task or reject it at all in demanding traffic situations (Rauch et al., 2008)
- Interview and observation studies indicate that drivers compensate in real traffic (Boyle & Vanderwolf, 2005; Esbjörnsson & Juhlin, 2003)
- Compensation behaviour also found under experimental settings (Brookhuis, et al., 1991; Strayer, et al., 2003; Ranney, et al., 2005)
 - e.g. increase in distance to lead car





Compensation depends in driving manoeuvre

- Horrey & Simons (2007) differentiate
 - steady-state manoeuvres (e.g., car following)
 - involve processes more on control level of driving
 - tactical manoeuvres (e.g., overtaking)
 - involve more processes on manoeuvre and navigation level
 - should be more vulnerable for cognitive distraction
 - if drivers aware of distraction they should compensate in both types of manoeuvres
- compensation found only for steady-state manoeuvres



Goal of the study

- Horrey & Simons (2007)
 - driving simulator study with only young drivers
- Older drivers seem to have different compensation strategies for distraction (Horberry, et al., 2006)
- Discrepancy to observational and interview studies due to sample and different risk perception in driving simulator?
- Influence of cognitive distraction on driving behaviour
 - with regards to steady-state and tactical manoeuvres
 - car following
 - Compensation behaviour
 - Older drivers vs. younger drivers

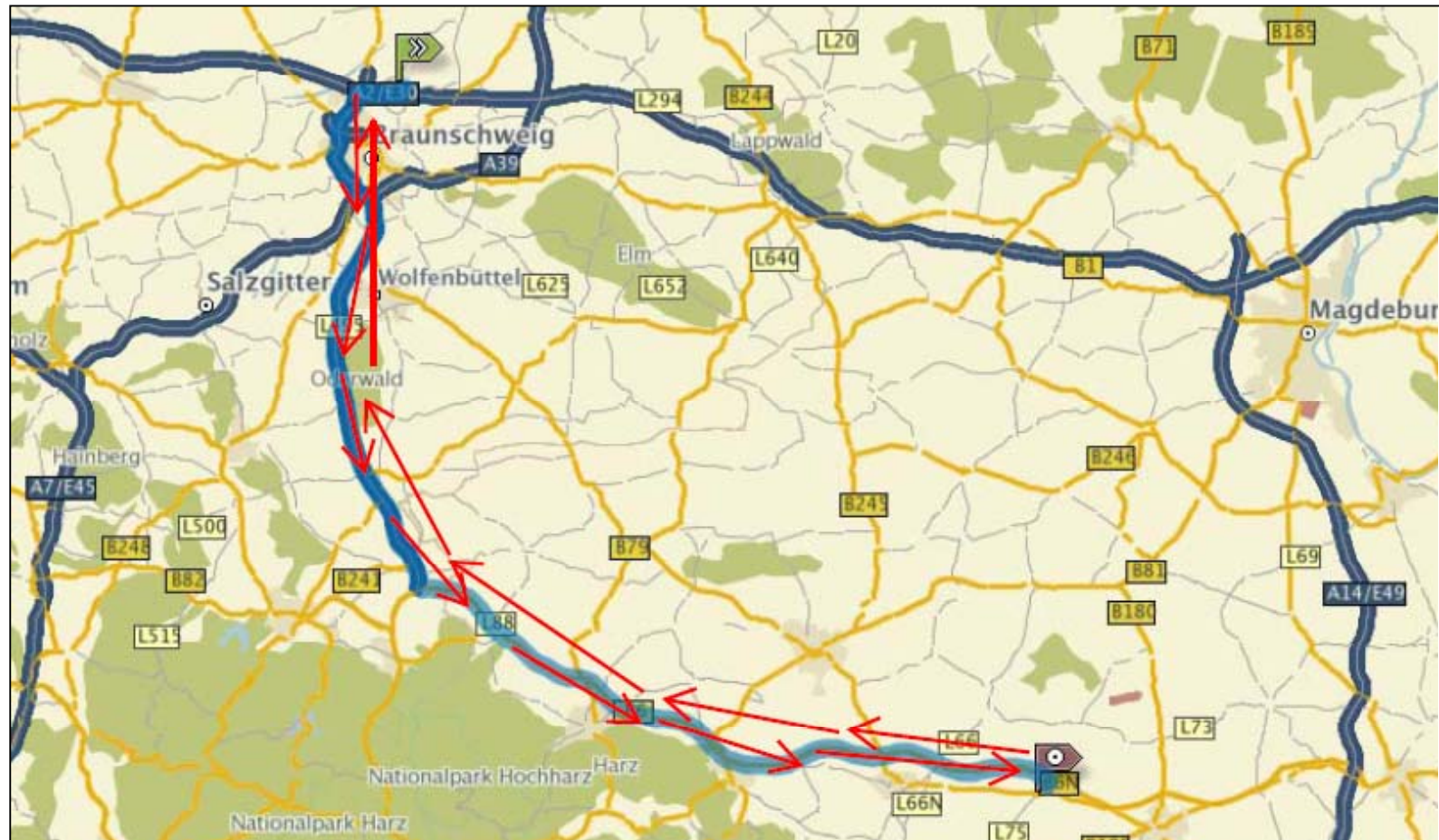


Experimental Design

- Participants:
 - 11 participants between 30-45 years
 - 11 participants older than 65 years
 - at least 6000 km per year driving experience



Selected Test Route



Selected test route (Germany)



Research vehicle ViewCar



Driver's gaze direction



Digital Video – Traffic scenario



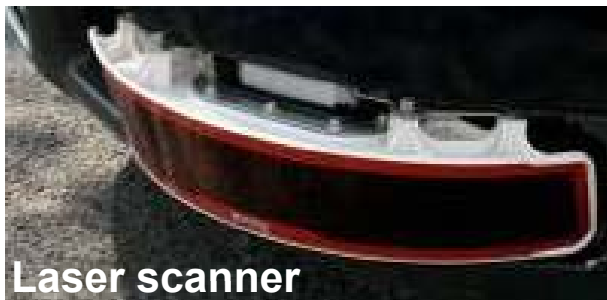
D-GPS



Radar



Lane detection



Laser scanner



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Secondary task

- participants had to perform a counting backwards task while driving
- started on average every 10 min for 1 min
- counting was paced by acoustic signal
 - one signal every 2 sec
 - 30 counting events per secondary task phase
- answer types
 - Correct answer (1),
 - Miscount (2),
 - Miscount with correction (3),
 - Drop (4),
 - Miss (5).



Recorded measures

- Secondary task performance
- Driving performance
 - observational data by experimenter
 - driving performance measured by ViewCar measurement platform



Recorded Driving Errors

| | |
|--|-----------------------------------|
| Delayed lane change | No use of indicator right |
| Hesitation during lane change | No use of indicator left |
| Driver aborts lane change | No/insufficient glances |
| Illegal crossing of centre line | Too small frontal distance |
| Driver endanger road users | Too small lateral distance |
| Lane keeping unsteady | Speed limit exceeded |
| Lane keeping too far right | Speed too high (situation) |
| Lane keeping too far left | Speed too low (situation) |
| Lane exceedence | Late braking |
| | Abrupt braking |



Procedure

- Administration of initial questionnaires (30 - 45 min)
- Familiarization drive (10 -15 min)
- Test drive (90 - 120 min), alternating phases WITH and WITHOUT secondary task
- Administration of final questionnaires (30 – 45 min)



Results

Performance in secondary task

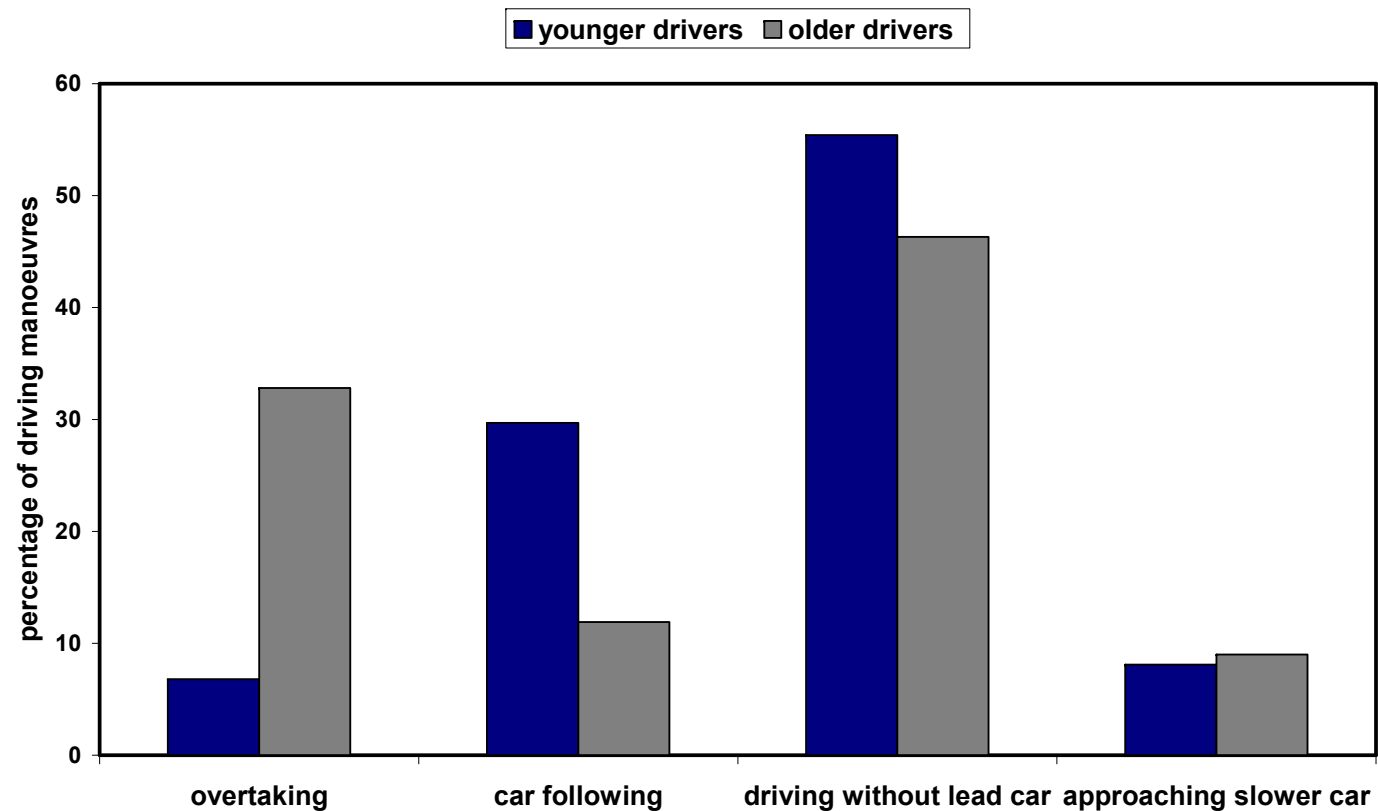


Number of errors in secondary task

| | younger drivers | older drivers |
|--------------------------|-----------------|---------------|
| error | | |
| correct answer | 3840 (85.4%) | 2951 (81.3%) |
| miscount | 74 (1.6%) | 67 (1.8%) |
| miscount with correction | 39 (0.9%) | 37 (1.0%) |
| drop out | 69 (1.5%) | 81 (2.2%) |
| miss | 476 (10.6%) | 494 (13.6%) |



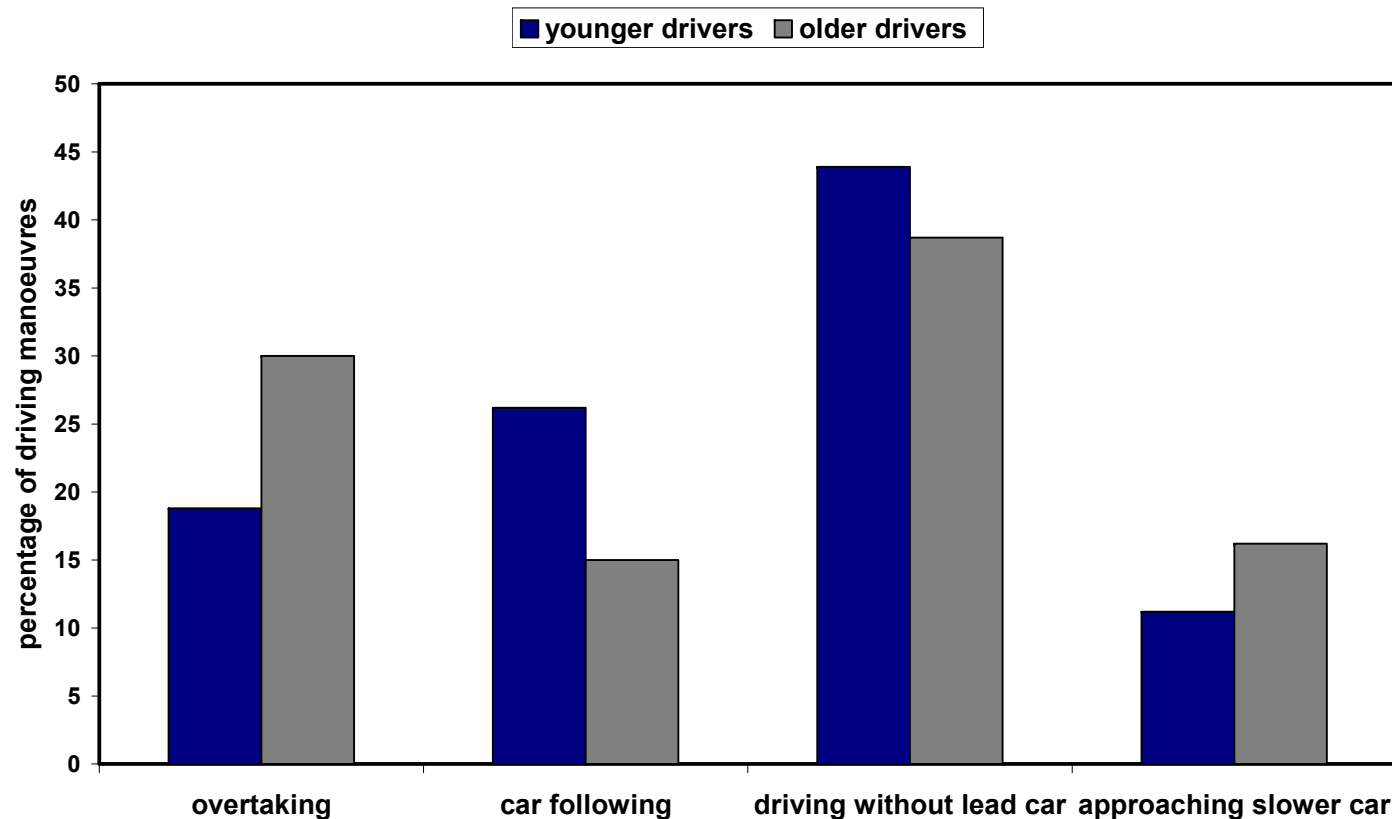
Percentage of driving manoeuvres for error category « miscount »



Older drivers miscount while overtaking
younger drivers miscount while car following



Percentage of driving manoeuvres for error category « miss »



Older drivers miss while overtaking
younger drivers miss while car following



Results

Driving performance



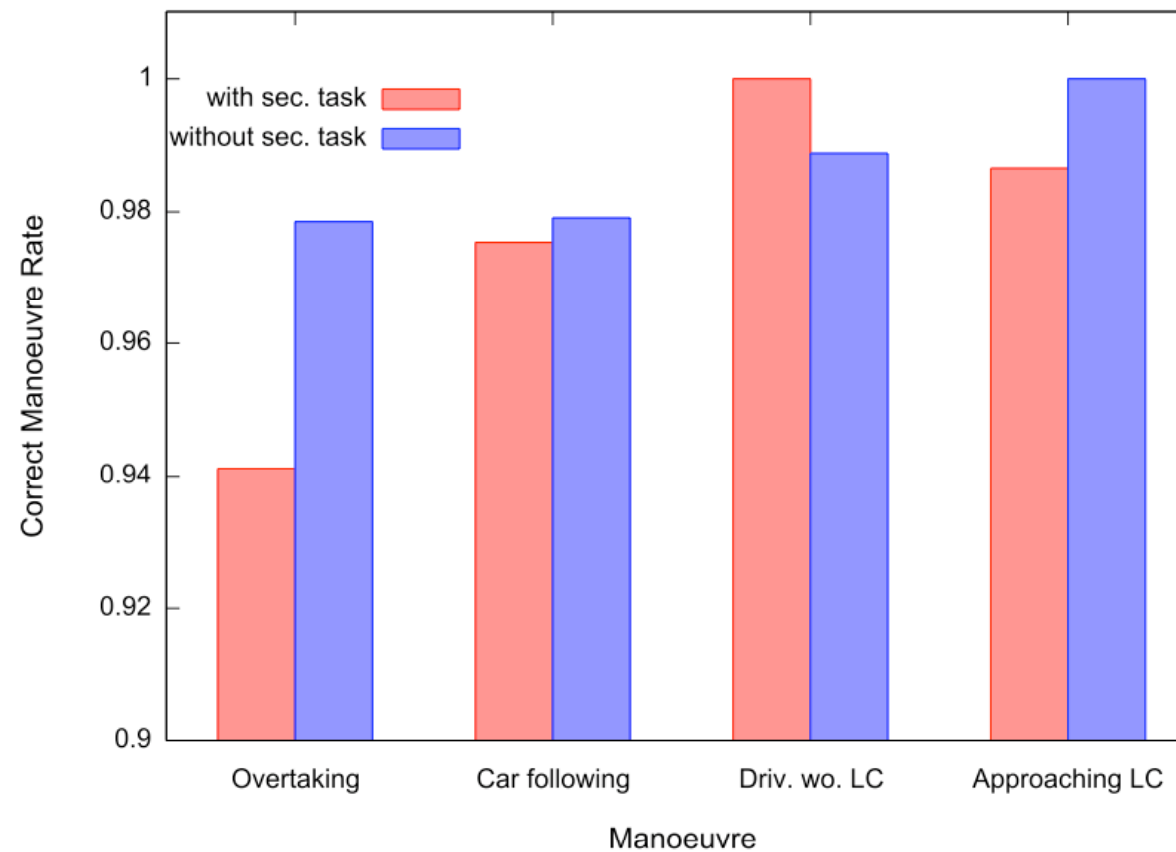
Number of manoeuvres with and without secondary task

| | younger drivers | | older drivers | |
|------------------------------|------------------------|---------------------|------------------------|---------------|
| | without secondary task | with secondary task | without secondary task | with sec task |
| overtaking | 515 | 61 | 548 | 93 |
| car following | 462 | 122 | 437 | 111 |
| free driving | 268 | 71 | 266 | 76 |
| approaching a slower vehicle | 339 | 70 | 375 | 53 |
| approaching a traffic light | 37 | 8 | 32 | 3 |
| change lane right | 44 | 10 | 36 | 3 |
| change lane left | 49 | 3 | 42 | 1 |





Younger drivers – Driving errors



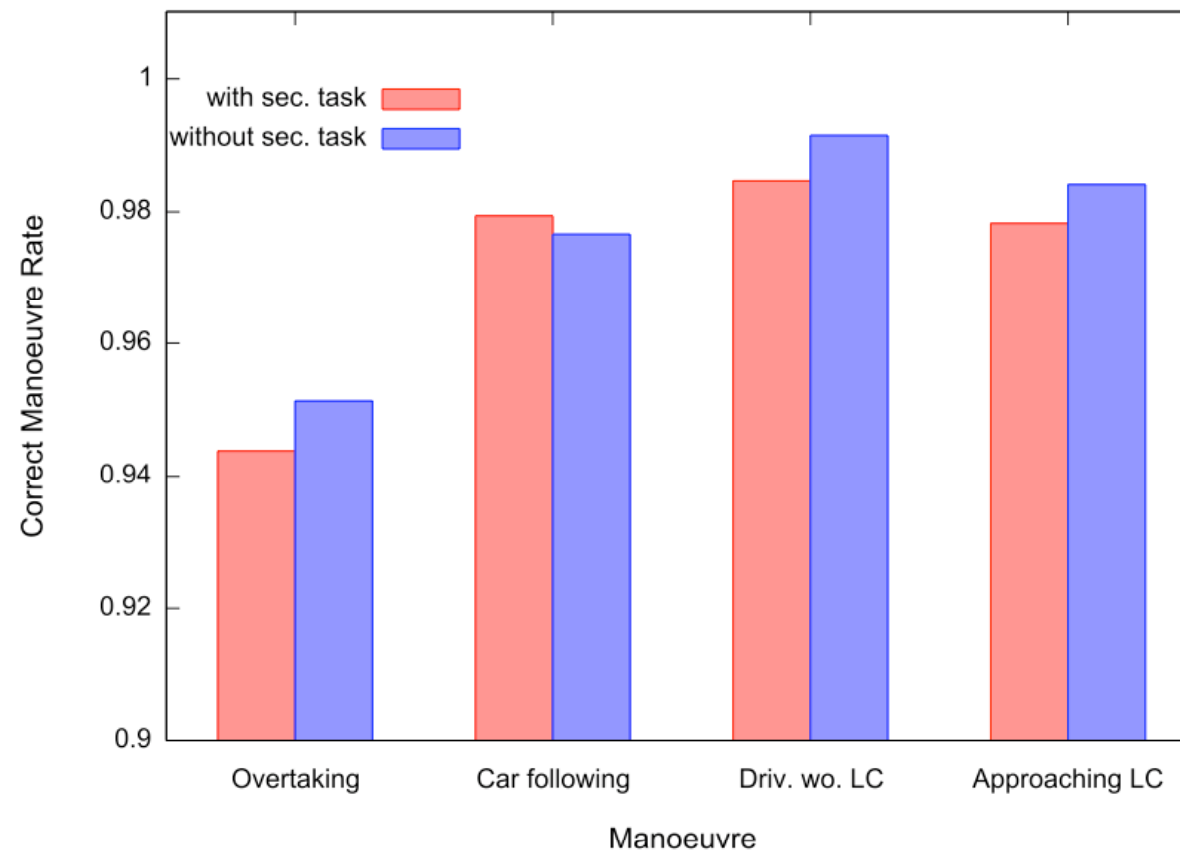


Younger drivers – Driving errors

- main error in overtaking:
 - indicator not used
 - with secondary task: 6%
 - without secondary task: 1%



Older drivers – Driving errors



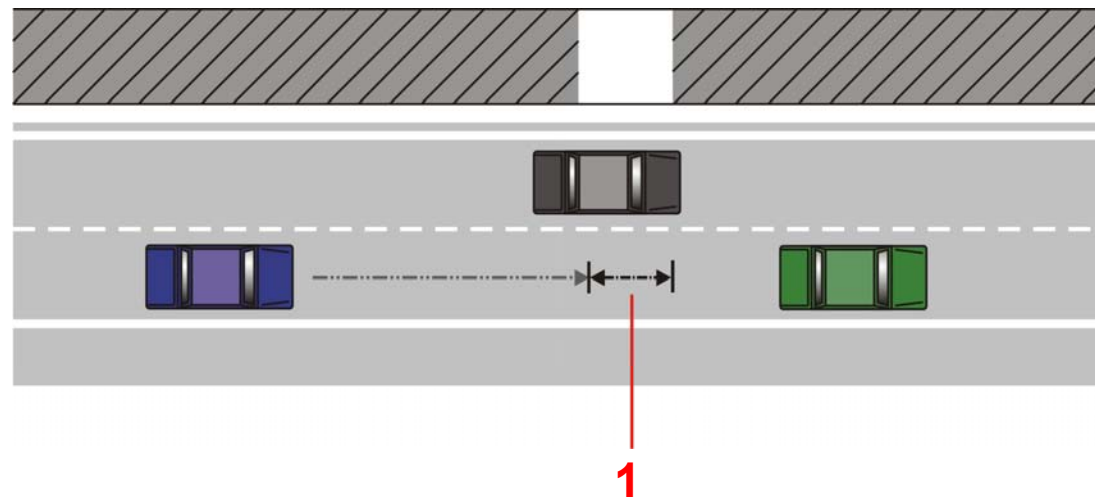


Older drivers – Driving errors

- main error in overtaking:
 - indicator not used
 - with secondary task: 5%
 - without secondary task: 2%
 - driving too far to the right
 - with secondary task: none
 - without secondary task: 1%



Analysis of following manoeuvre

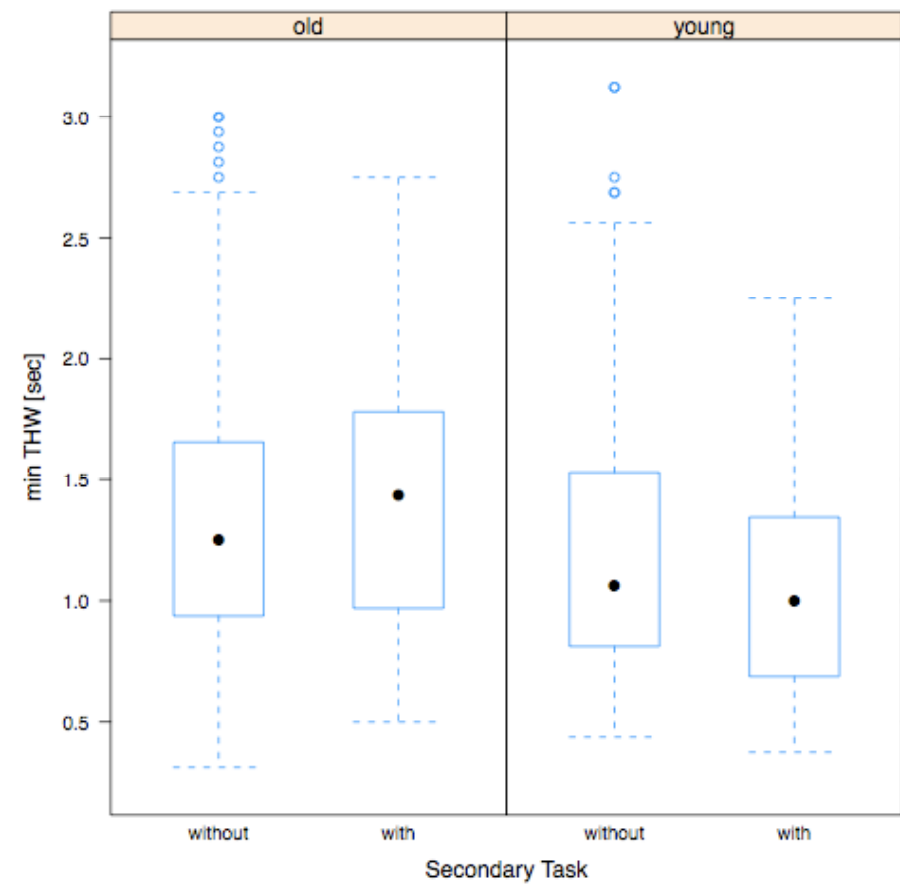
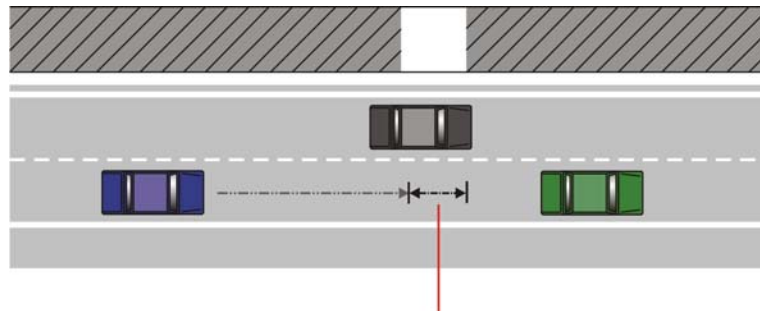


➤ 1: Begin of manoeuvre (no relevant relative velocity to front car detected)



Analysis of following manoeuvre

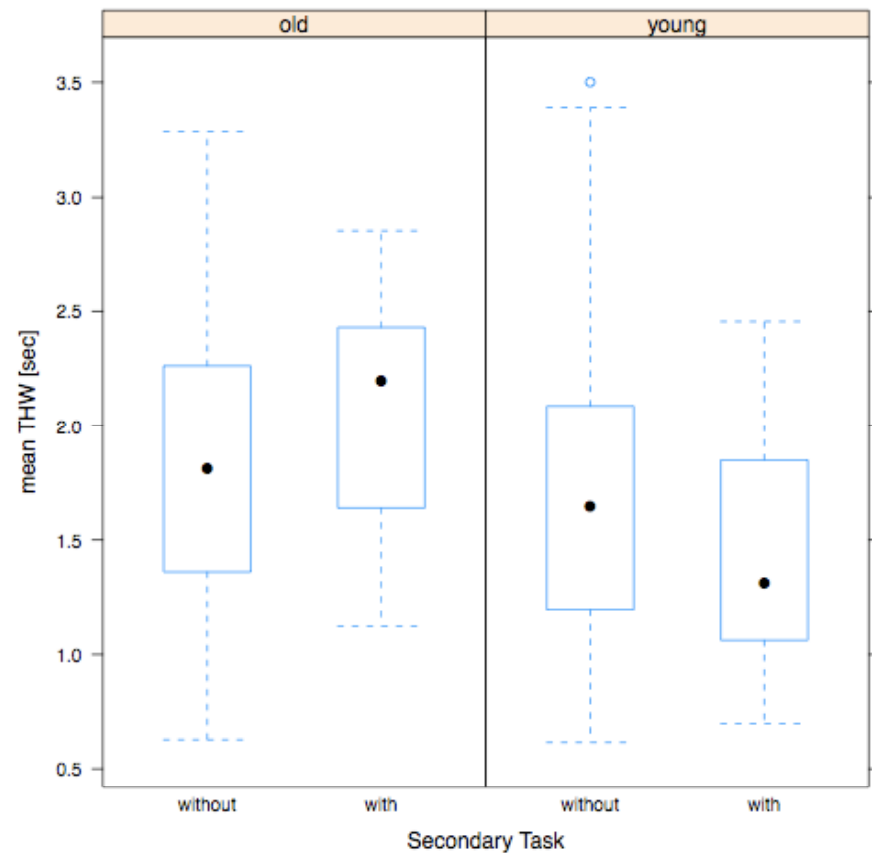
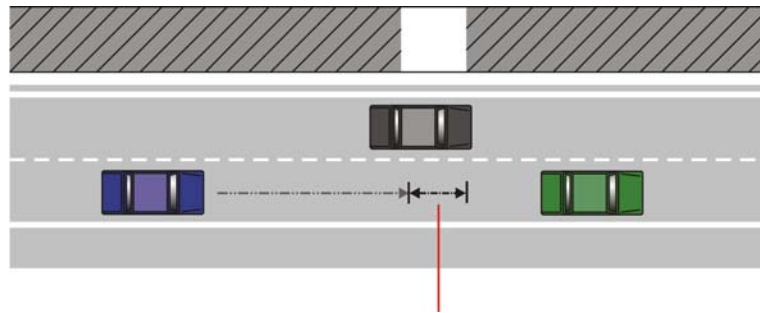
Min. THW





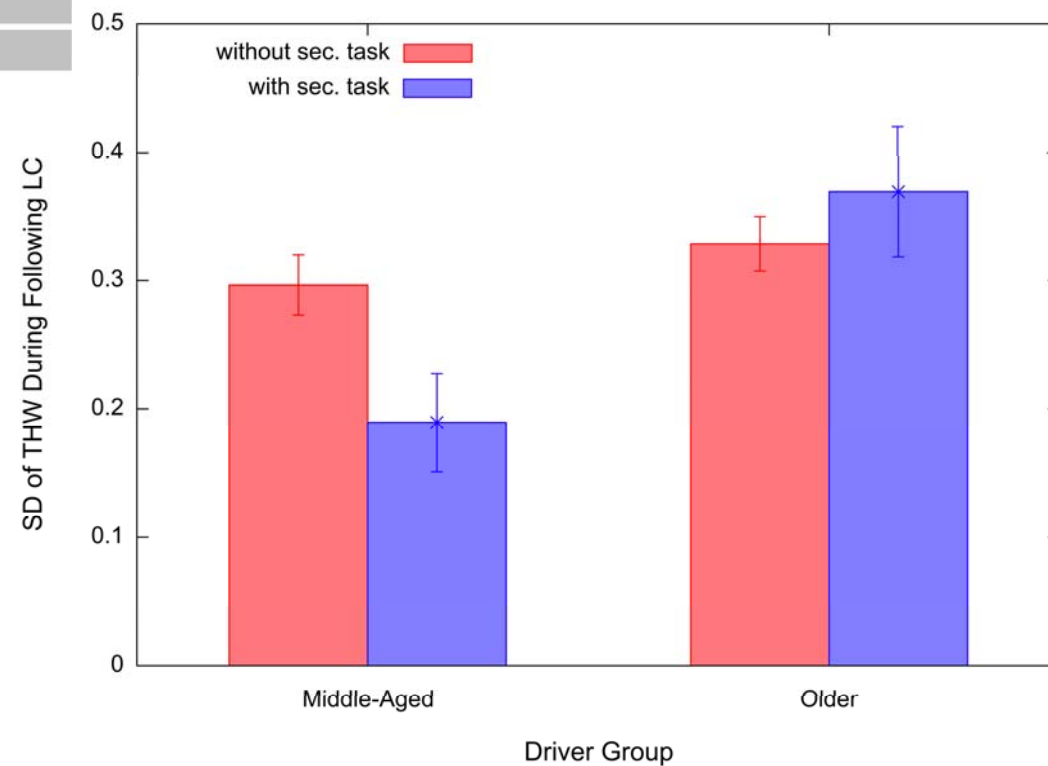
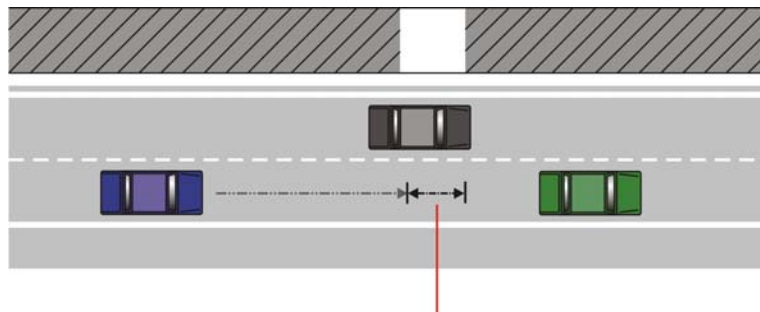
Analysis of following manoeuvre

Mean THW



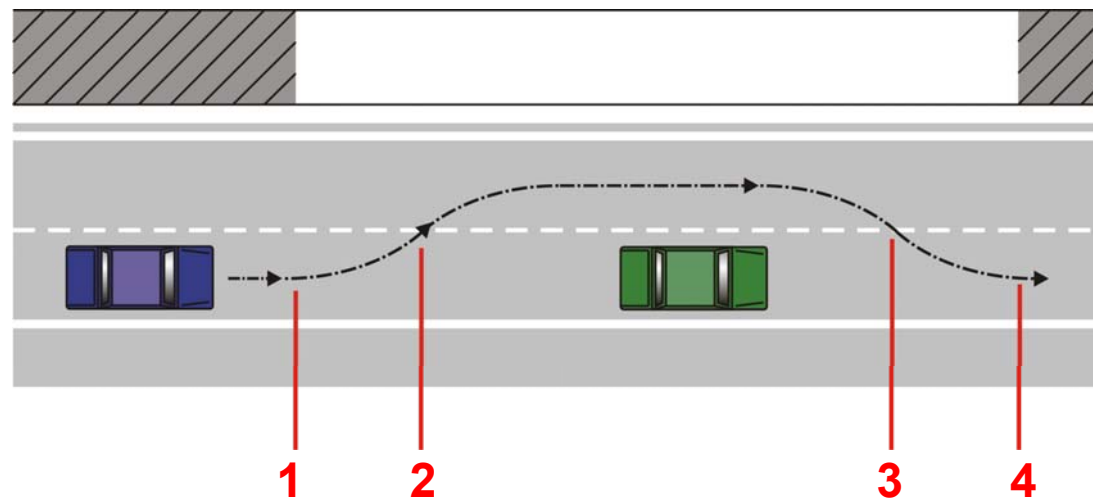


Analysis of following manoeuvre SD of THW





Analysis of overtaking manoeuvre

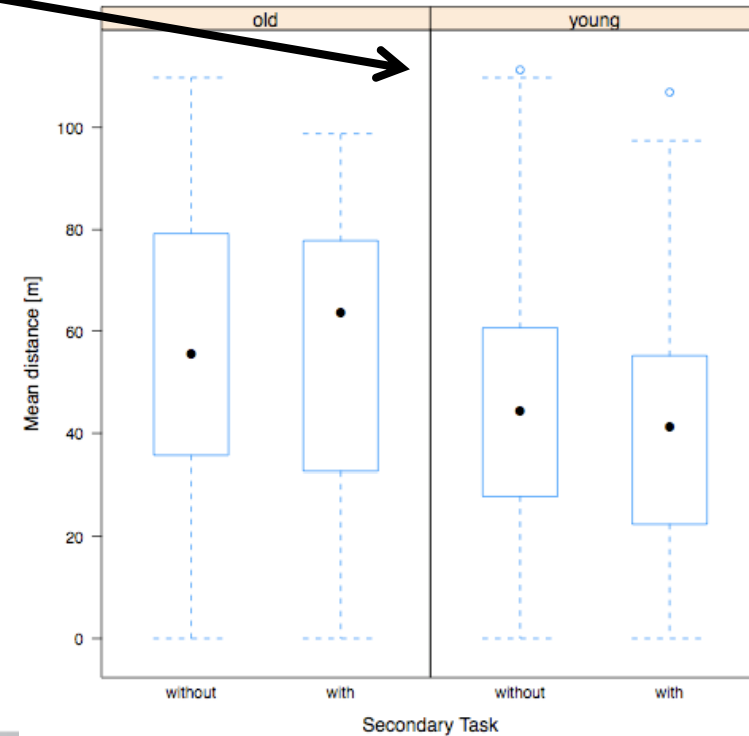
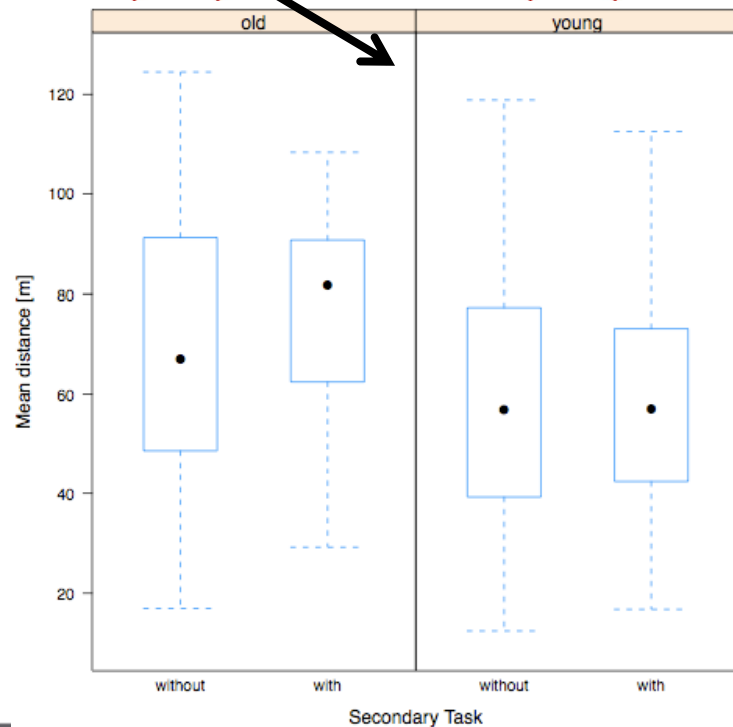
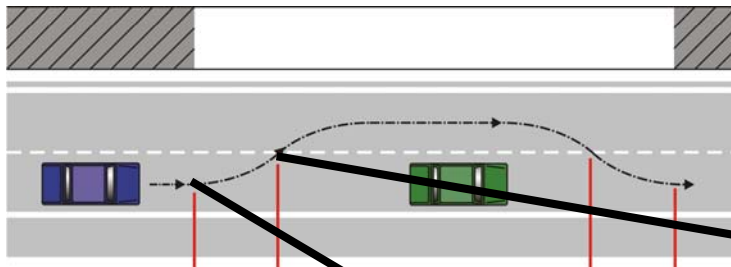


- 1: Begin of manoeuvre (driver begins to steer left)
- 2: Lane Change left
- 3: Lane change right
- 4: End of manoeuvre (stabilization on right lane)



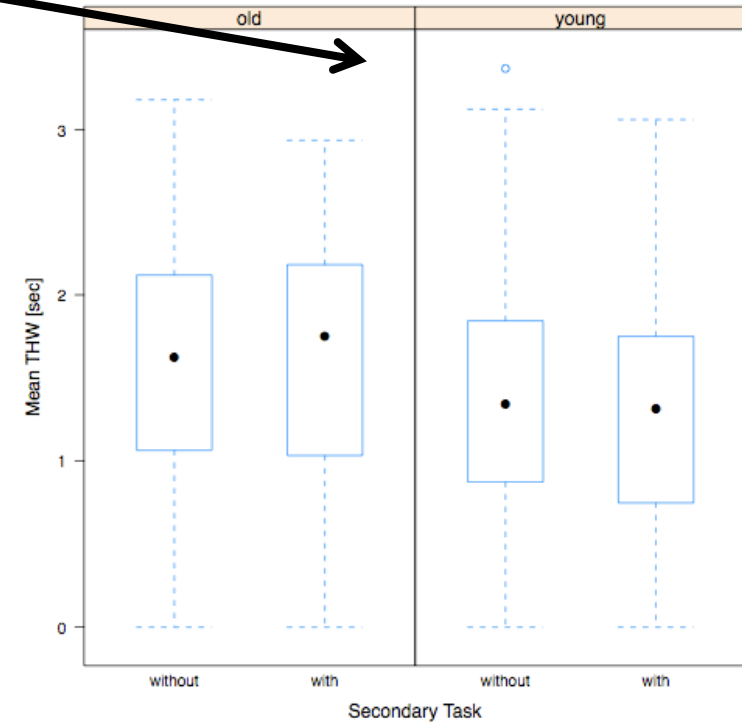
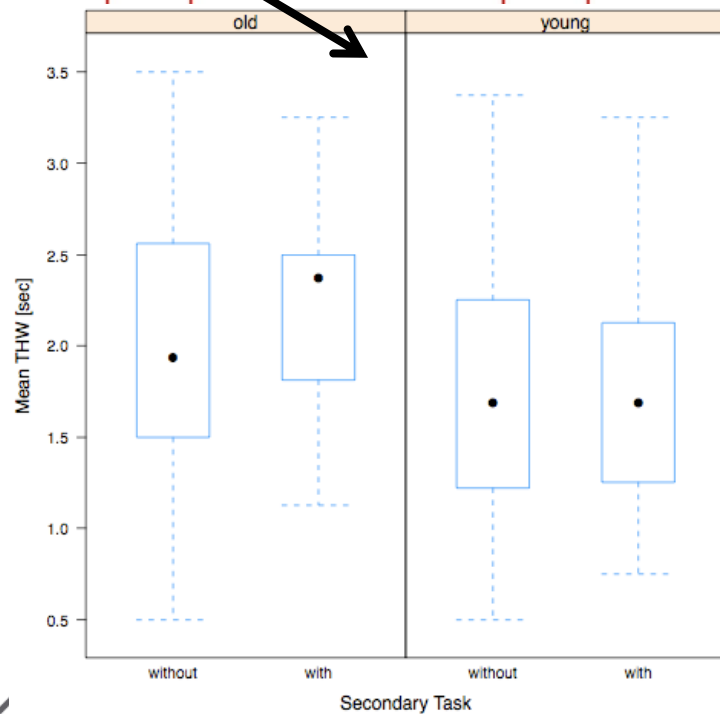
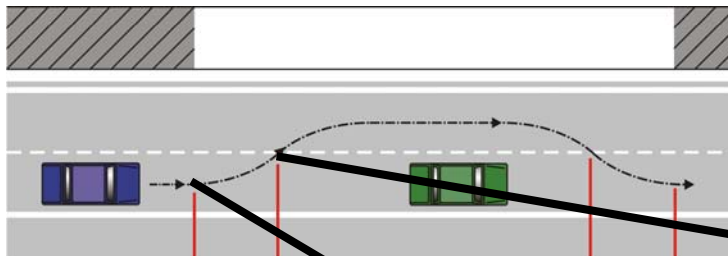
Analysis of overtaking manoeuvre

Distance to LC





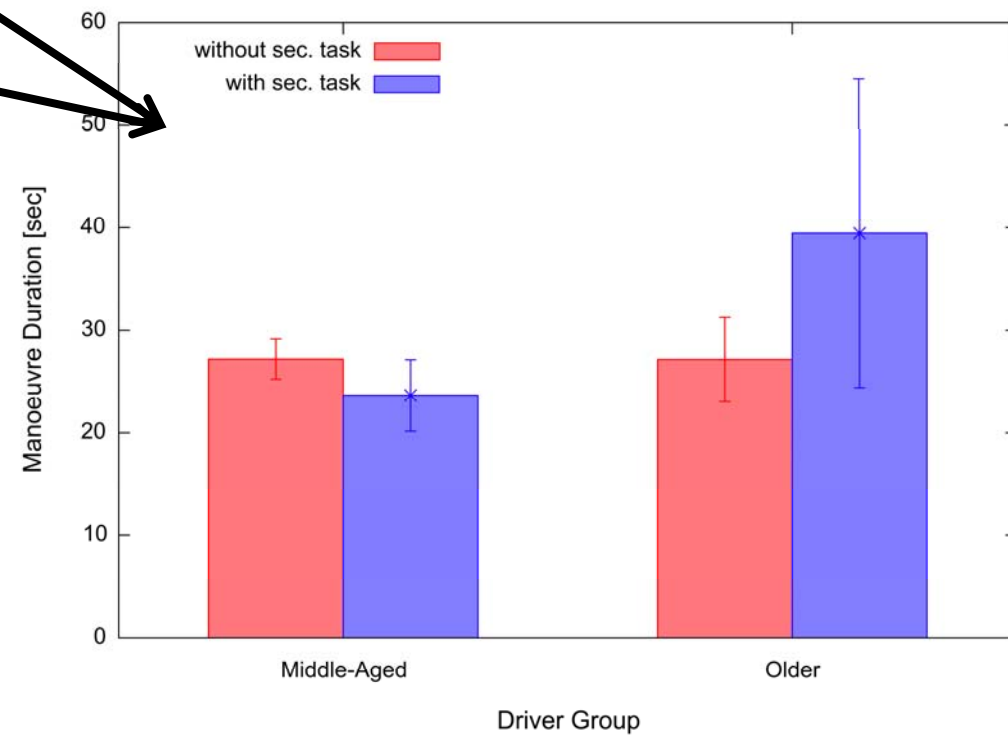
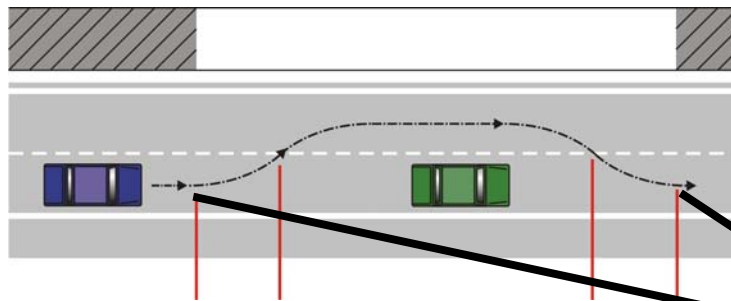
Analysis of overtaking manoeuvre THW to LC





Analysis of overtaking manoeuvre

Duration of overtaking





Summary of results

- not much difference in sec. task performance => no trade-off
- only few errors while driving both with and without sec. task
- some indication for compensation behaviour during car following in older driver group, none for younger drivers
 - greater mean THW with sec. task
- during overtaking no indication of compensation, just age effects
- confirming results of Horrey & Simons (2007)





Thank you very much!



Summary of results

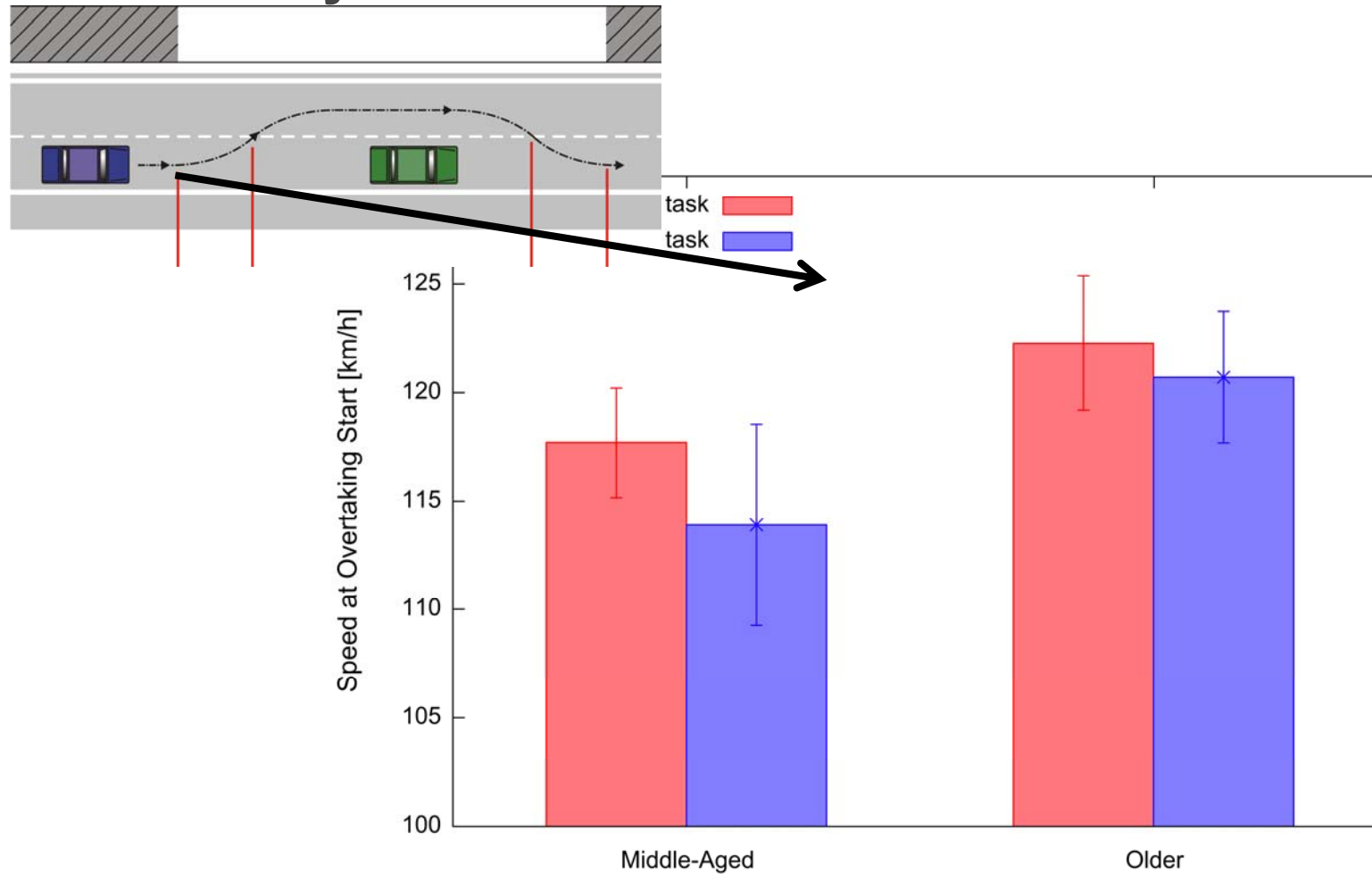
- not much difference in sec. task performance => no trade-off
- only few errors while driving both with and without sec. task
- cognitive distraction leads to
 - longer duration of overtaking manoeuvre
 - smaller variance in distance keeping for middle-aged drivers
 - greater variance in distance keeping for older drivers





Analysis of overtaking manoeuvre

Velocity at start





Backup-Folien



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Definition of driving manoeuvres

- **Free driving (FD):** driving without a lead car. The own car is driving on a street and follows its course, there is no lead car (or there is a lead car but too far away to influence driver's behaviour, e.g. TTC to lead car ≥ 5 sec).
- **Approaching a Slower Vehicle (ASV):** The own car is approaching a slower lead car driving on the same lane. The car should reduce its speed to adjust to the lead car's speed.
- **Approaching a Traffic Light (ATL):** The own car is approaching a traffic light that turns yellow or red or is already red. That is, it signals the driver to stop. If the traffic light is green the manoeuvre is more like driving with or without lead car.
- **Car Following (CF):** The own car is following a lead car; own car and lead car have about the same speed.
- **Overtaking (O):** The own car is overtaking one or more other vehicles driving with less speed than the own car. Thereby the own car performs a lane change to the left, passing the slower vehicle(s) (not staying for more than 10 s in the left lane, otherwise, it would be considered as a lane change left) and then performing a lane change to the right again.
- **Change Lane Left / Right (CLL/CLR):** The own car changes on a multi-lane street to the left or to the right adjacent lane. This lane change can be due to a slower vehicle on the starting lane that will be passed during the manoeuvre (i. e. being a lane change to the left), but only if this manoeuvre is not completed with a lane change to the right within the next 10 seconds. Otherwise, in this case it would be an overtaking manoeuvre.





Driver Anger Scale

| | none at all 1 | a little 2 | some 3 | much 4 | very much 5 | |
|-----|------------------|---------------|-----------|-----------|----------------|--------------------------|
| 1. | | | | | | <input type="checkbox"/> |
| 2. | | | | | | <input type="checkbox"/> |
| 3. | | | | | | <input type="checkbox"/> |
| 4. | | | | | | <input type="checkbox"/> |
| 5. | | | | | | <input type="checkbox"/> |
| 6. | | | | | | <input type="checkbox"/> |
| 7. | | | | | | <input type="checkbox"/> |
| 8. | | | | | | <input type="checkbox"/> |
| 9. | | | | | | <input type="checkbox"/> |
| 10. | | | | | | <input type="checkbox"/> |
| 11. | | | | | | <input type="checkbox"/> |
| 12. | | | | | | <input type="checkbox"/> |
| 13. | | | | | | <input type="checkbox"/> |
| 14. | | | | | | <input type="checkbox"/> |





Locus of Control

| | | Not at all possible | | Neither possible nor impossible | | Highly possible |
|-----|---|---------------------------|---|------------------------------------|---|--------------------|
| 1. | Whether or not I get into car accident depends mostly on shortcomings in my driving skills | 1 | 2 | 3 | 4 | 5 |
| 2. | Whether or not I get into car accident depends mostly on my own risk-taking while driving | 1 | 2 | 3 | 4 | 5 |
| 3. | Whether or not I get into car accident depends mostly on shortcomings in other drivers' driving skills | 1 | 2 | 3 | 4 | 5 |
| 4. | Whether or not I get into car accident depends mostly on other drivers' risk-taking while driving | 1 | 2 | 3 | 4 | 5 |
| 5. | Whether or not I get into car accident depends mostly on bad luck | 1 | 2 | 3 | 4 | 5 |
| 6. | Whether or not I get into car accident depends mostly on dangerous roads | 1 | 2 | 3 | 4 | 5 |
| 7. | Whether or not I get into car accident depends mostly on if I drive often with too high speed | 1 | 2 | 3 | 4 | 5 |
| 8. | Whether or not I get into car accident depends mostly on if other drivers drive often with too high speed | 1 | 2 | 3 | 4 | 5 |
| 9. | Whether or not I get into car accident depends mostly on if I drive too close to the car in front | 1 | 2 | 3 | 4 | 5 |
| 10. | Whether or not I get into car accident depends mostly on if other drivers drive too close to my car | 1 | 2 | 3 | 4 | 5 |
| 11. | Whether or not I get into car accident depends mostly on fate | 1 | 2 | 3 | 4 | 5 |
| 12. | Whether or not I get into car accident depends mostly on bad weather or lighting conditions | 1 | 2 | 3 | 4 | 5 |
| 13. | Whether or not I get into car accident depends mostly on a mechanical failure in the car | 1 | 2 | 3 | 4 | 5 |
| 14. | Whether or not I get into car accident depends mostly on other drivers driving under influence of alcohol | 1 | 2 | 3 | 4 | 5 |
| 15. | Whether or not I get into car accident depends mostly on other drivers' dangerous overtaking | 1 | 2 | 3 | 4 | 5 |
| 16. | Whether or not I get into car accident depends mostly on my own dangerous overtaking | 1 | 2 | 3 | 4 | 5 |
| 17. | Whether or not I get into car accident depends mostly on coincidence | 1 | 2 | 3 | 4 | 5 |



Sensation Seeking

Geben Sie bitte an, ob die folgenden Aussagen auf Sie zutreffen, und kreuzen Sie entsprechend "JA" oder "NEIN" an.

| | | | |
|----|---|-----------------------------|-------------------------------|
| 1 | Ich wünsche mir oft, ich könnte Bergsteigen. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 2 | Ich mag wilde ausgelassene Partys. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 3 | Ich tue manchmal gern Dinge, die etwas riskant sind. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 4 | Ich erkunde eine fremde Stadt oder einen fremden Stadtteil gern selbst, auch wenn ich mich dabei verirre. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 5 | Es ist mir langweilig, immer dieselben alten Gesichter zu sehen. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 6 | Ich würde gern Wasserski laufen oder surfen. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 7 | Ich bin gern "high" (durch Alkohol etc.). | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 8 | Ich finde, ein Mensch, von dem man immer weiß, was er tun wird, muss langweilig sein. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 9 | Ich würde gern Drogen probieren, die einen Verrücktes sehen oder hören lassen. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 10 | Ich würde gern auf eine Reise gehen, bei der ich heute nicht weiß, was morgen geschieht. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 11 | Ich finde, eine Party gelingt immer, wenn man nur für genug Getränke sorgt. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 12 | Ich bevorzuge Freunde, die aufregend und unberechenbar sind. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 13 | Ich würde gern mal Fallschirmspringen. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 14 | Ich würde gern "ausgeflippte" Freunde haben. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 15 | Ich finde, man sollte schon viel mit Frauen/Männern zusammen gewesen sein, bevor man heiratet. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |



| | | | |
|----|---|-----------------------------|-------------------------------|
| 16 | Ich werde beim Anfang, wenn ich längere Zeit zu Hause bleiben muss. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 17 | Ich finde, es gibt nichts Schlimmeres als langweilig zu sein. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 18 | Ich sehe mir gerne die Sex-Szenen in Filmen an. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 19 | Ich glaube, es muss ein ganz herrliches Gefühl sein, auf Skiern ganz schnell einen hohen Berg hinunterzufahren. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |
| 20 | Ich finde, man sollte sich ganz außergewöhnlich kleiden, auch wenn es auf andere merkwürdig wirkt. | <input type="checkbox"/> ja | <input type="checkbox"/> nein |



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15/12/2009



Conscientiousness

| Ich sehe mich als Mensch, der oder die... | | 1 | 2 | 3 | 4 | 5 |
|---|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| 1 | Aufgaben gründlich erledigt. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2 | tüchtig ist und flott arbeitet. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 3 | Pläne macht und diese auch durchführt. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4 | zuverlässig ist und gewissenhaft. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 5 | nicht aufgibt, ehe die Aufgabe erledigt ist. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 6 | leicht ablenkbar ist, nicht bei der Sache bleibt. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 7 | etwas achtlos sein kann. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 8 | bequem ist und zur Faulheit neigt. | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

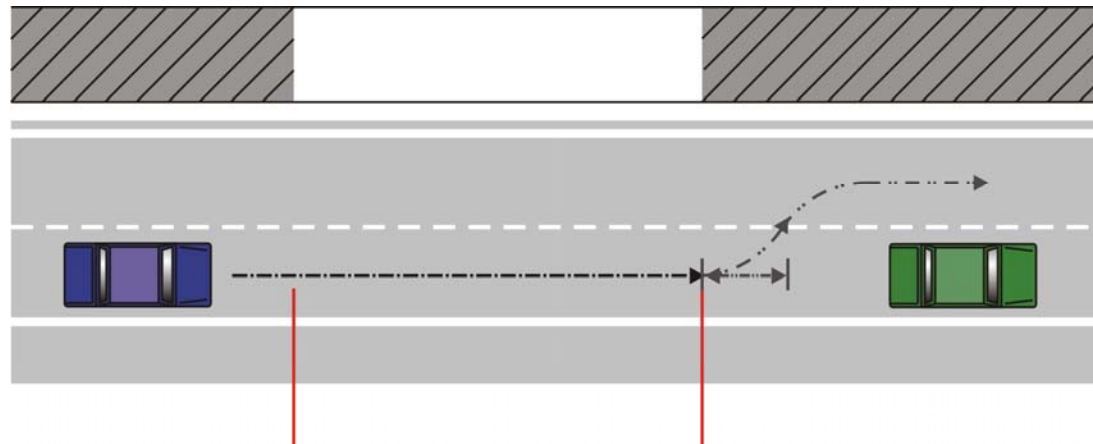


Tabellenvorlage

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Analysis of approaching manoeuvre



- 1: Begin of manoeuvre (front vehicle detected in video stream)
- 2: End of manoeuvre (video rating for manoeuvre changes to car following or overtaking)





Experimental Design

| | Age: 30-45 | Age: 65+ | Σ |
|----------|------------|----------|----------|
| Spain | n=10 | n=10 | n=20 |
| Germany | n=11 | n=11 | n=22 |
| Σ | n=21 | n=21 | N=42 |





Questionnaires

➤ **Driver Anger Scale (DAS) – 14 items**

- Instruction:

- Imagine that each traffic situation described below was actually happening to you and rate the amount of anger that would be provoked ➡

➤ **Traffic Locus of Control (T-LOC) – 17 items**

- Instruction:

- In this scale, you will find a list of possible causes of accidents. Please indicate on a scale how possible it is that those sixteen reasons had caused or would cause an accident when you think about your own driving style and conditions. ➡

➤ **Sensation Seeking Scale (SSS) – 20 items**

- Instruction:

- Please state if the following answers apply to you and answer with yes or no ➡








➤ **Conscientiousness (BFI) – 8 items**

- Instruction:

- In this block you will find a list of possible statements describing you as a person. Please read them carefully and decide if this statements apply to you ➡



Driver Observation Sheet

| | | SC1 | SC2 | SC3 | SC4 | SC5 | SC6 | SC7 | SC8 | SC9 | SC10 | SC11 | SC12 | SC13 | SC14 | SC15 | SC16 | SC17 | SC18 | SC19 | SC20 |
|---|---------------------------------|---|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|------|------|------|------|------|
| TIME | start | | | | | | | | | | | | | | | | | | | | |
| | end | | | | | | | | | | | | | | | | | | | | |
| SCENARIO | Overtaking | | | | | | | | | | | | | | | | | | | | |
| | Car following | | | | | | | | | | | | | | | | | | | | |
| | Driving without lead car | | | | | | | | | | | | | | | | | | | | |
| | Approaching a slower car | | | | | | | | | | | | | | | | | | | | |
| | Approaching a traffic light | | | | | | | | | | | | | | | | | | | | |
| | Change lane right | | | | | | | | | | | | | | | | | | | | |
| | Change lane left | | | | | | | | | | | | | | | | | | | | |
| | Forced situation? | | | | | | | | | | | | | | | | | | | | |
| Road works? | | | | | | | | | | | | | | | | | | | | | |
| TRAFFIC | low | | | | | | | | | | | | | | | | | | | | |
| | moderate | | | | | | | | | | | | | | | | | | | | |
| | high | | | | | | | | | | | | | | | | | | | | |
| | congestion | | | | | | | | | | | | | | | | | | | | |
| WEATHER | fair | | | | | | | | | | | | | | | | | | | | |
| | rain | | | | | | | | | | | | | | | | | | | | |
| | snow | | | | | | | | | | | | | | | | | | | | |
| | fog | | | | | | | | | | | | | | | | | | | | |
| | Delayed lane change | | | | | | | | | | | | | | | | | | | | |
|  | Hesitation during lane change | | | | | | | | | | | | | | | | | | | | |
| | Driver aborts lane change | | | | | | | | | | | | | | | | | | | | |
| | Illegal crossing of centre line | | | | | | | | | | | | | | | | | | | | |
| | Driver endanger road users | | | | | | | | | | | | | | | | | | | | |
| | Lane keeping unsteady | | | | | | | | | | | | | | | | | | | | |
|  | Lane keeping too far right | | | | | | | | | | | | | | | | | | | | |
| | Lane keeping too far left | | | | | | | | | | | | | | | | | | | | |
| | Lane exceedence | | | | | | | | | | | | | | | | | | | | |
|  | No use of indicator right | | | | | | | | | | | | | | | | | | | | |
| | No use of indicator left | | | | | | | | | | | | | | | | | | | | |
|  | No/insufficient glances | | | | | | | | | | | | | | | | | | | | |
|  | Too small frontal distance | | | | | | | | | | | | | | | | | | | | |
| | Too small lateral distance | | | | | | | | | | | | | | | | | | | | |
| | Speed limit exceeded | | | | | | | | | | | | | | | | | | | | |
|  | Speed too high (situation) | | | | | | | | | | | | | | | | | | | | |
| | Speed too low (situation) | | | | | | | | | | | | | | | | | | | | |
|  | Late braking | | | | | | | | | | | | | | | | | | | | |
| | Abrupt braking | | | | | | | | | | | | | | | | | | | | |
| LEGEND | | | | | | | | | | | | | | | | | | | | | |
| w | with secondary task | | | | | | | | | | | | | | | | | | | | |
| o | without secondary task | | | | | | | | | | | | | | | | | | | | |
| EXTRA HINTS | | Weather conditions are only listed in case of changes and additional notes are placed on the backside | | | | | | | | | | | | | | | | | | | |





Analysis of following manoeuvre

