Study on Camera Monitor Systems (Part 2)

- Analysis of Gaze Behaviour
- Study on Farsightedness

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Informal Group on Camera Monitor Systems in Reg. No. 46

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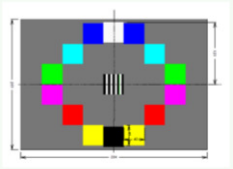
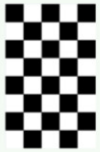
A look back: Presentation @ 2nd IG CMS meeting (Berlin)

Technical Aspects

- Field of vision
- General day and night characteristics
- Image properties
- Glare
- Adjustability of camera and display
- Reliability
- Weather
- Robustness
- Exchangeability
- Energy Consumption





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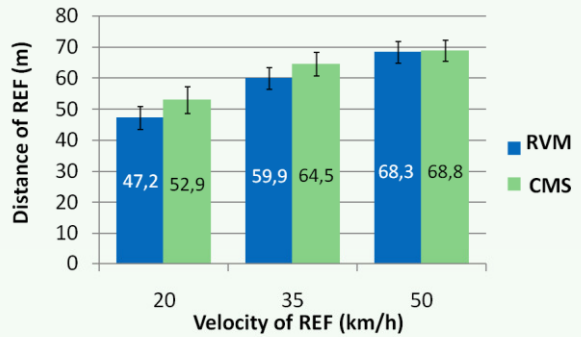
Results: „Last Safe Gap-Method“ (N=34, within subject)



- The faster the REF-vehicle, the larger the „last safe gap“ (F (2;66)= 39.752, p = .000)
- Tendency of larger gap using CMS (F (1;33) = 3.646, n.s. [p = .065])
- No interaction between velocity and used device (F (2; 66) = 1.187, n.s. [p = .310])

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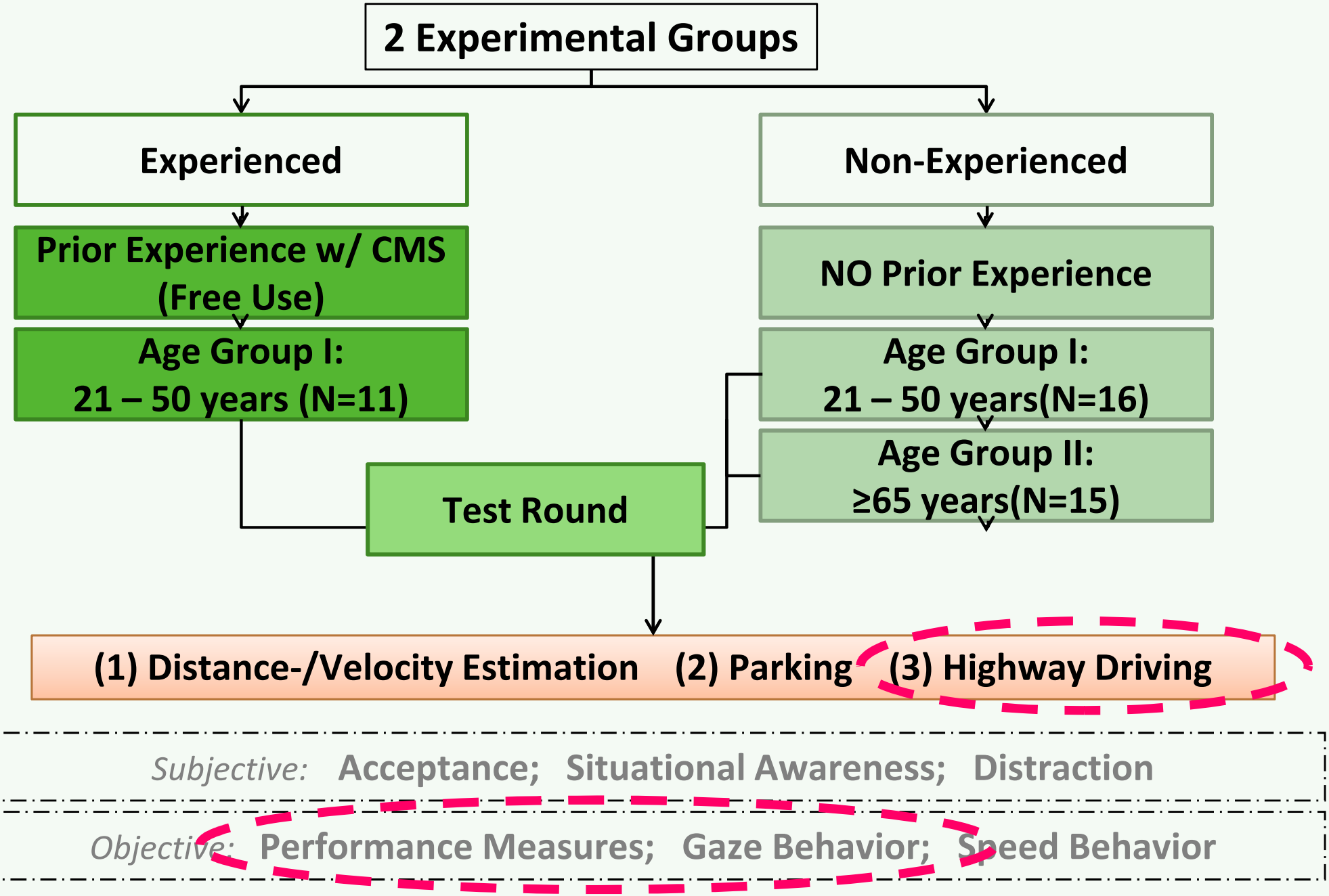
Both solutions show advantages and disadvantages.

Some disadvantages of the CMS could be addressed by the specification of technical requirements.

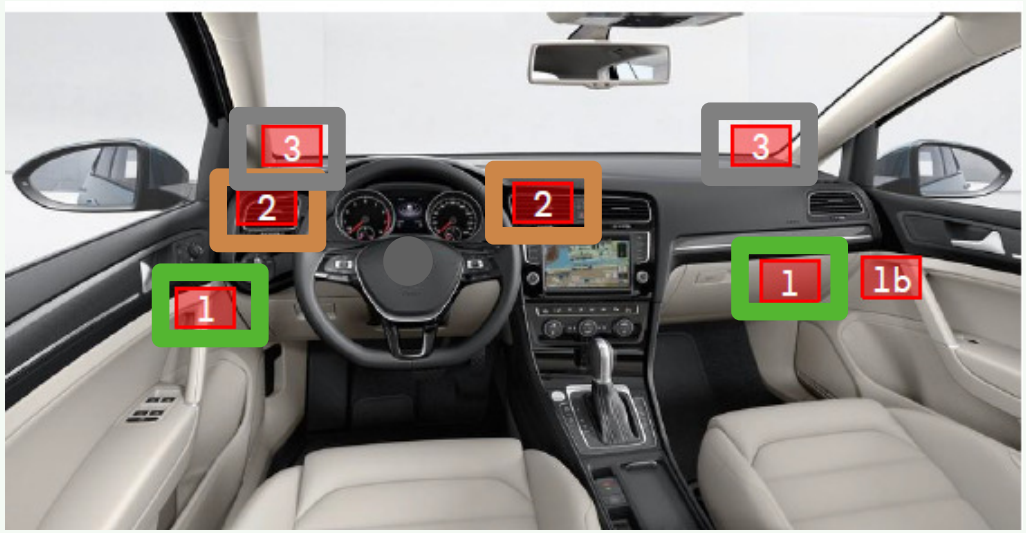
In general distances and velocities can be estimated by using the camera monitor system

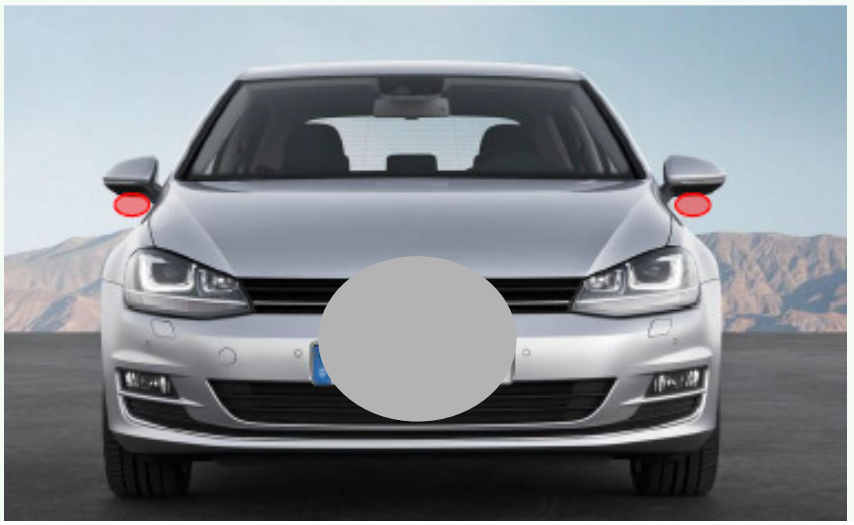
For the cases investigated there is no significant difference in comparison to using an outside rearview-mirror

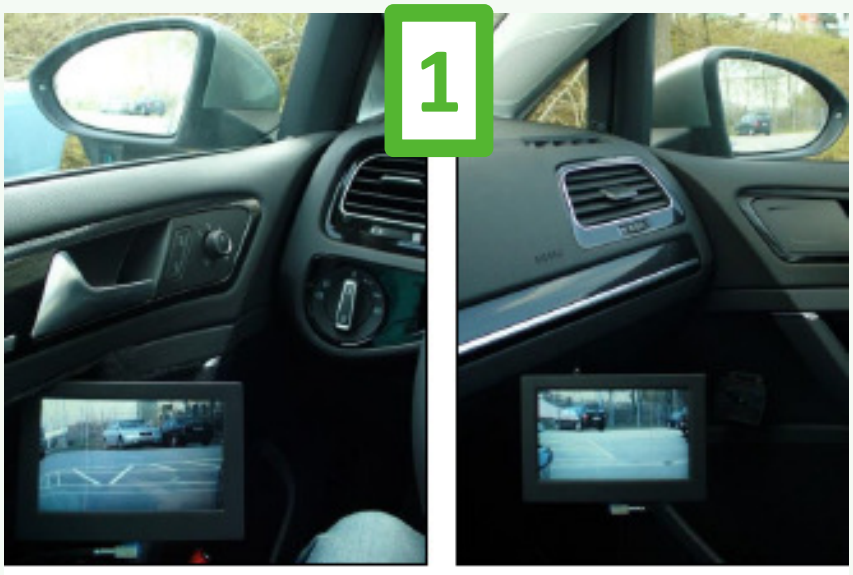
Study Design

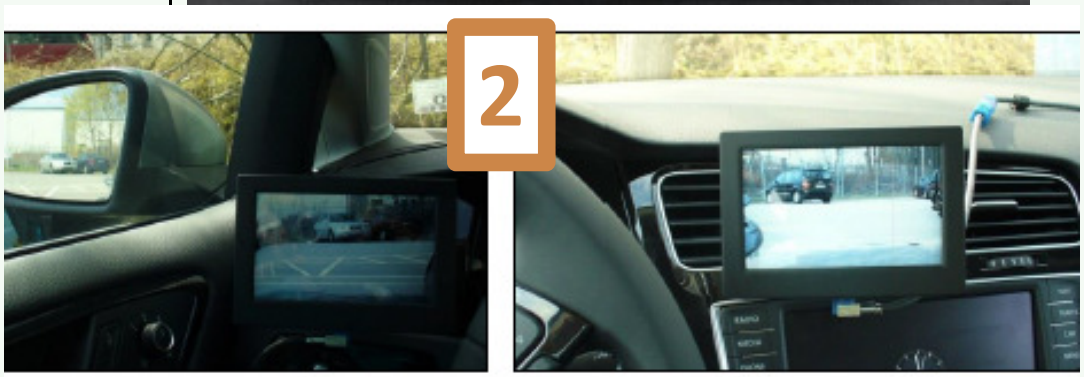


Display Positions



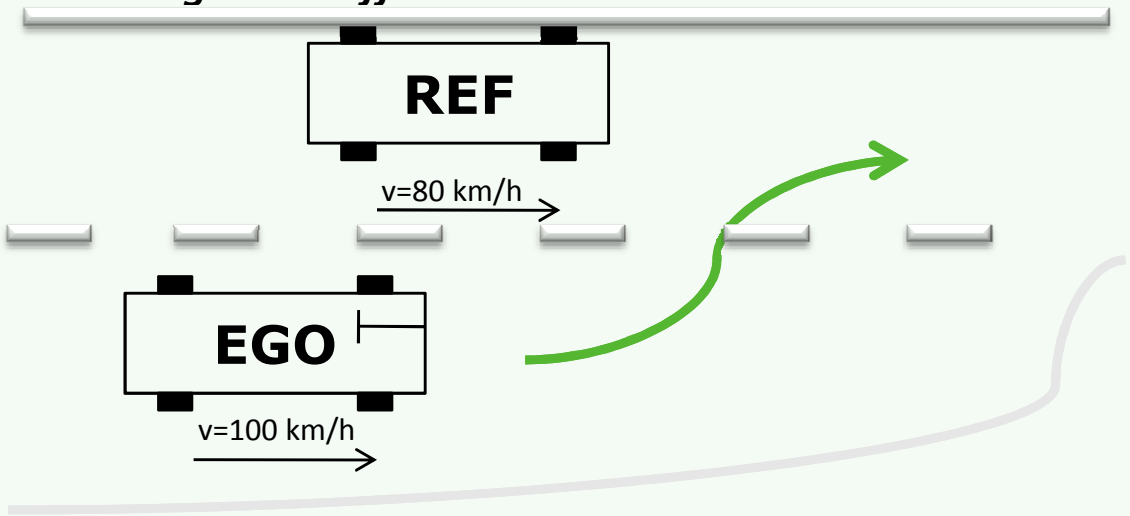




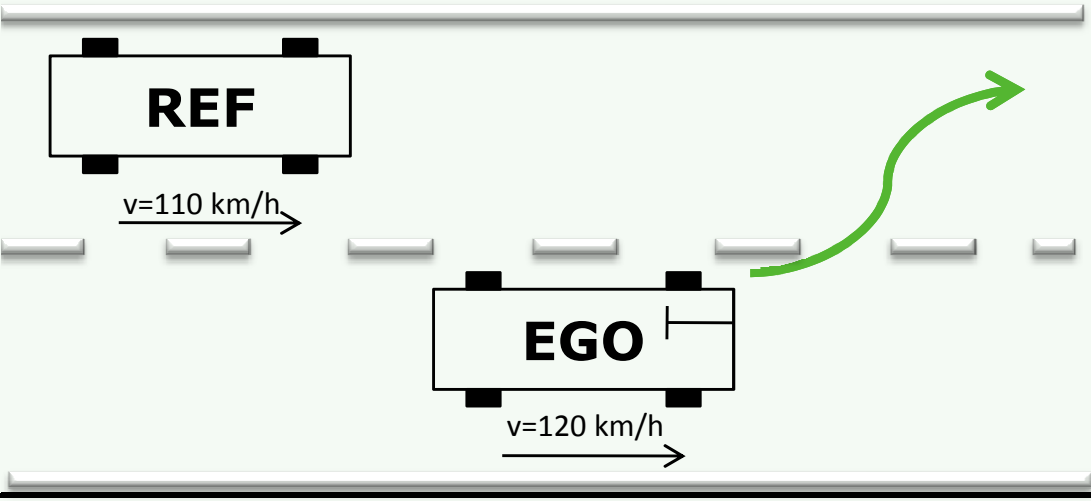


Highway Driving (Autobahn A4)

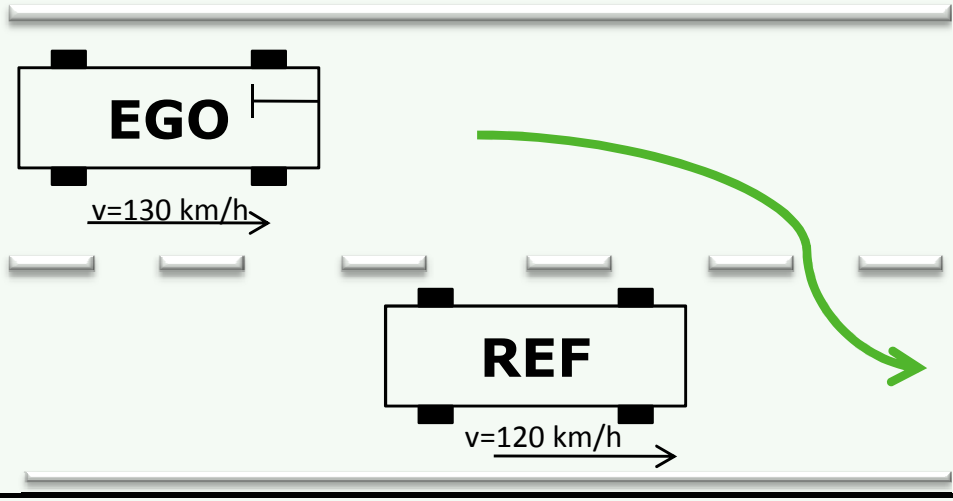
Filtering into traffic **Analysis: -15 to 0s**



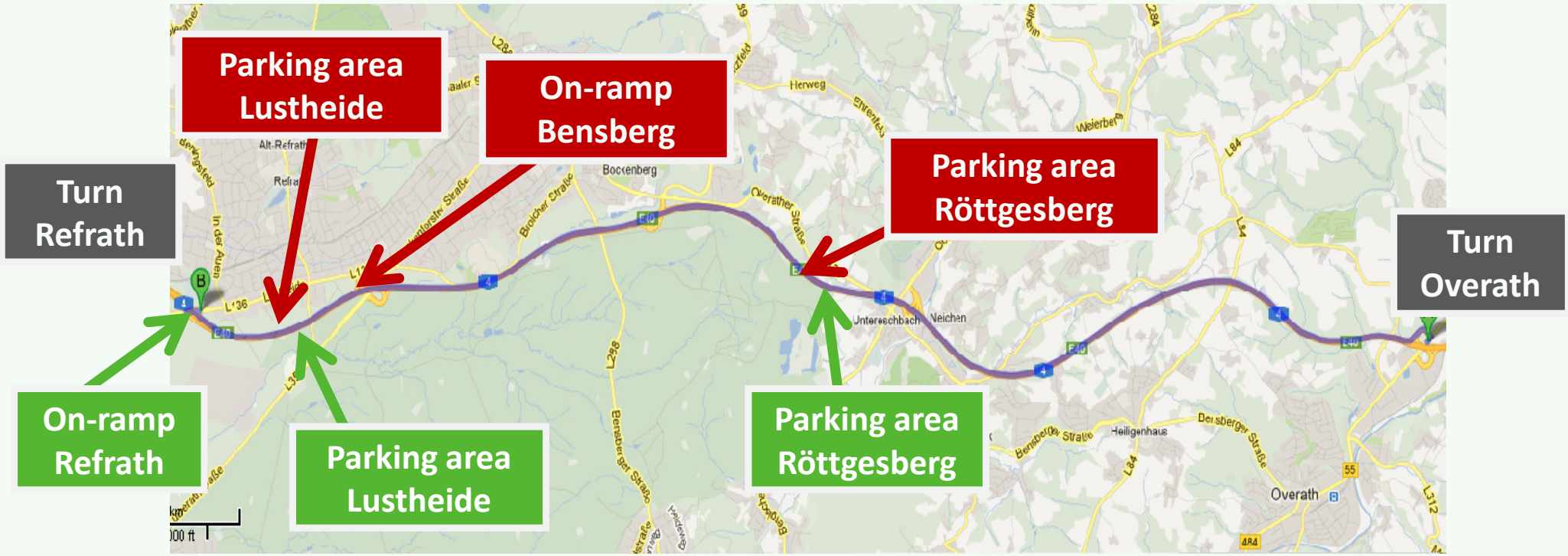
Lane change (start of overtakting maneuver) **-10 to 0s**



Lane change (end of overtakting man.) **-10 to 0s**



Highway Track: Refrath - Overath / Overath - Refrath (Filtering Situations on Autobahn)



Source: Google Maps

Dikablis Head-mounted Gaze Detection System

Source: Ergoneers GmbH

V i d e o s

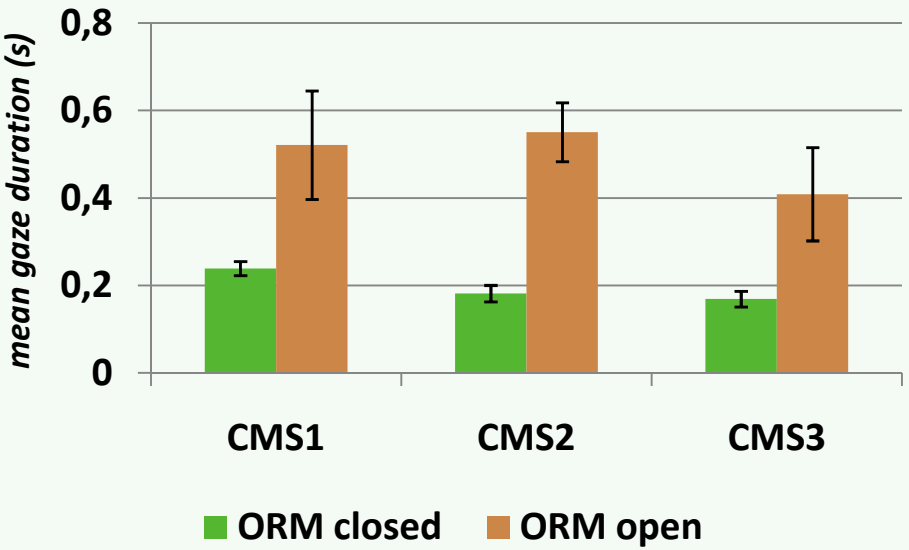
Research Questions

- Does gaze behaviour change when using a CMS in comparison to using an outside rear-view mirror?
- Dependent Varables:
  - **Number** of single glances
  - Mean **duration** of glances
  - **Maximum duration** of a single glance
- Areas of Interest (AOI) analyzed:
  - ORM, CMS1, CMS2, CMS3 (left and right depending on direction of maneuver)
  - ORM for all CMS conditions
  - Inside rear view mirror for all CMS conditions

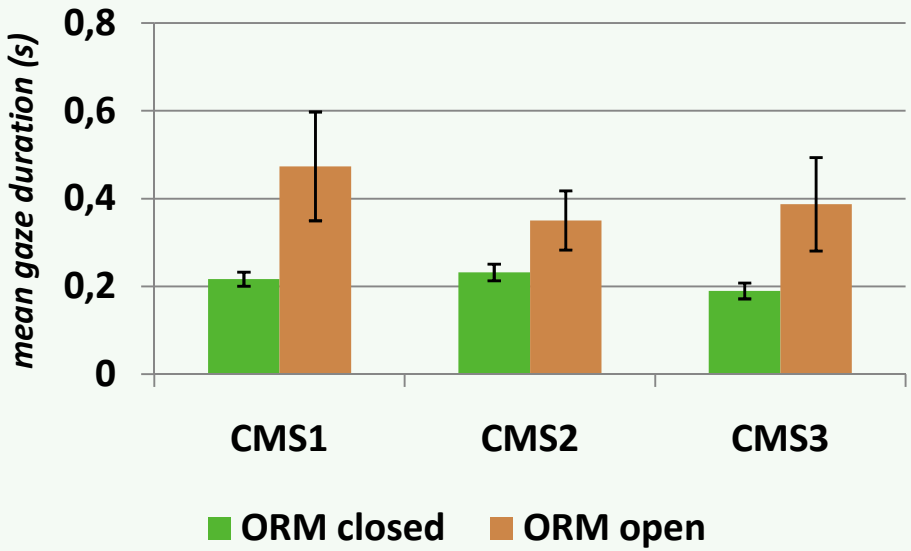
Reduction of Sample

- Gaze data of 11 subjects had to be discarded due to bad data quality or technical difficulties
- Seven subjects performed the CMS-conditions without the ORM being occluded.

Filtering: Mean Glance Duration ORM



Lane Change (left): Mean Glance Duration ORM

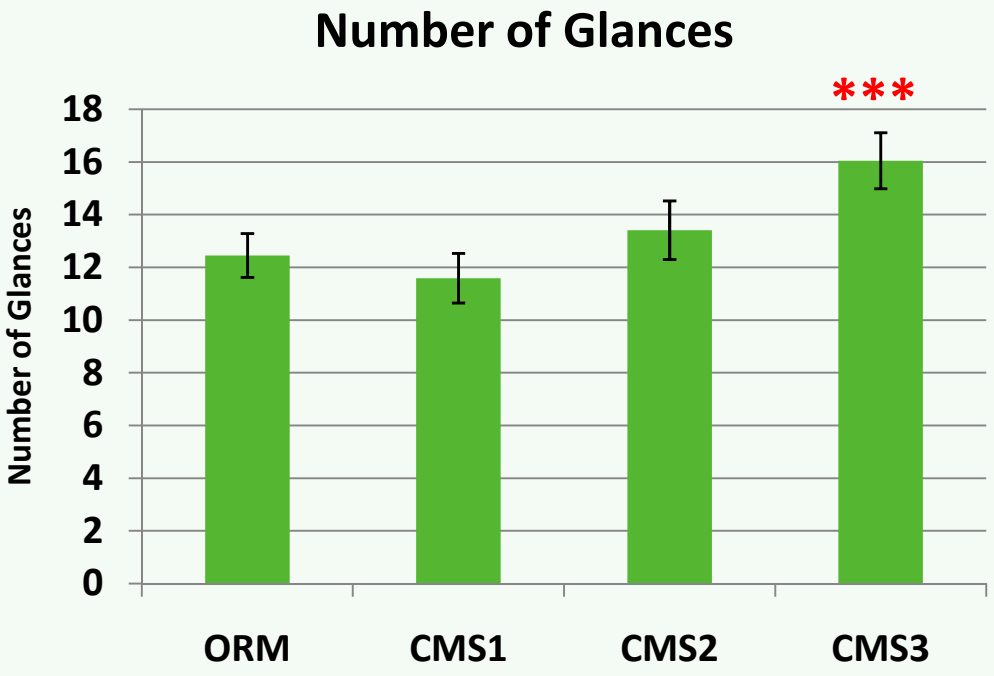


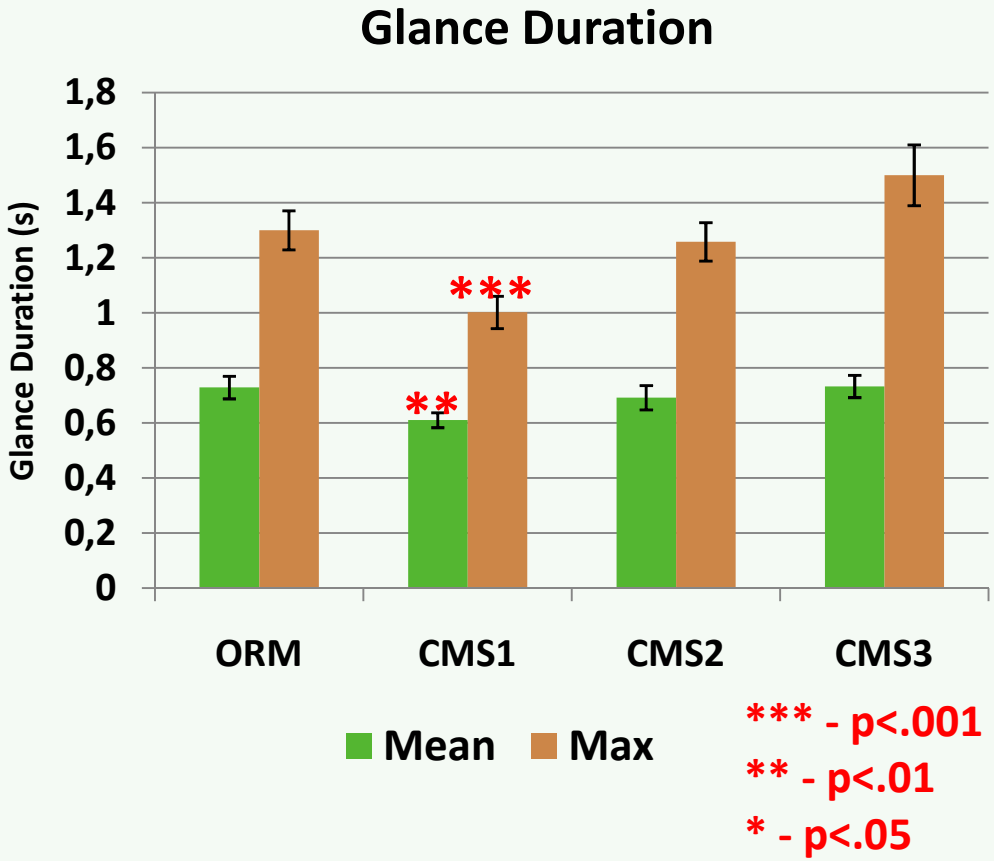
➢ Since there was a significant difference in mean duration of glances towards the ORM between these seven and the rest of the participants ($p<.001$), they were discarded from the final analysis.

Final Sample for Gaze Analysis (N=24)

- **Age:**
  - M = 51.6; SD = 16.6
- **Age group:**
  - younger (<=51): 13
  - older (>= 64): 11
- **Gender:**
  - 12 male
  - 12 female

Filtering into Traffic: Glances to Rear Vision Device

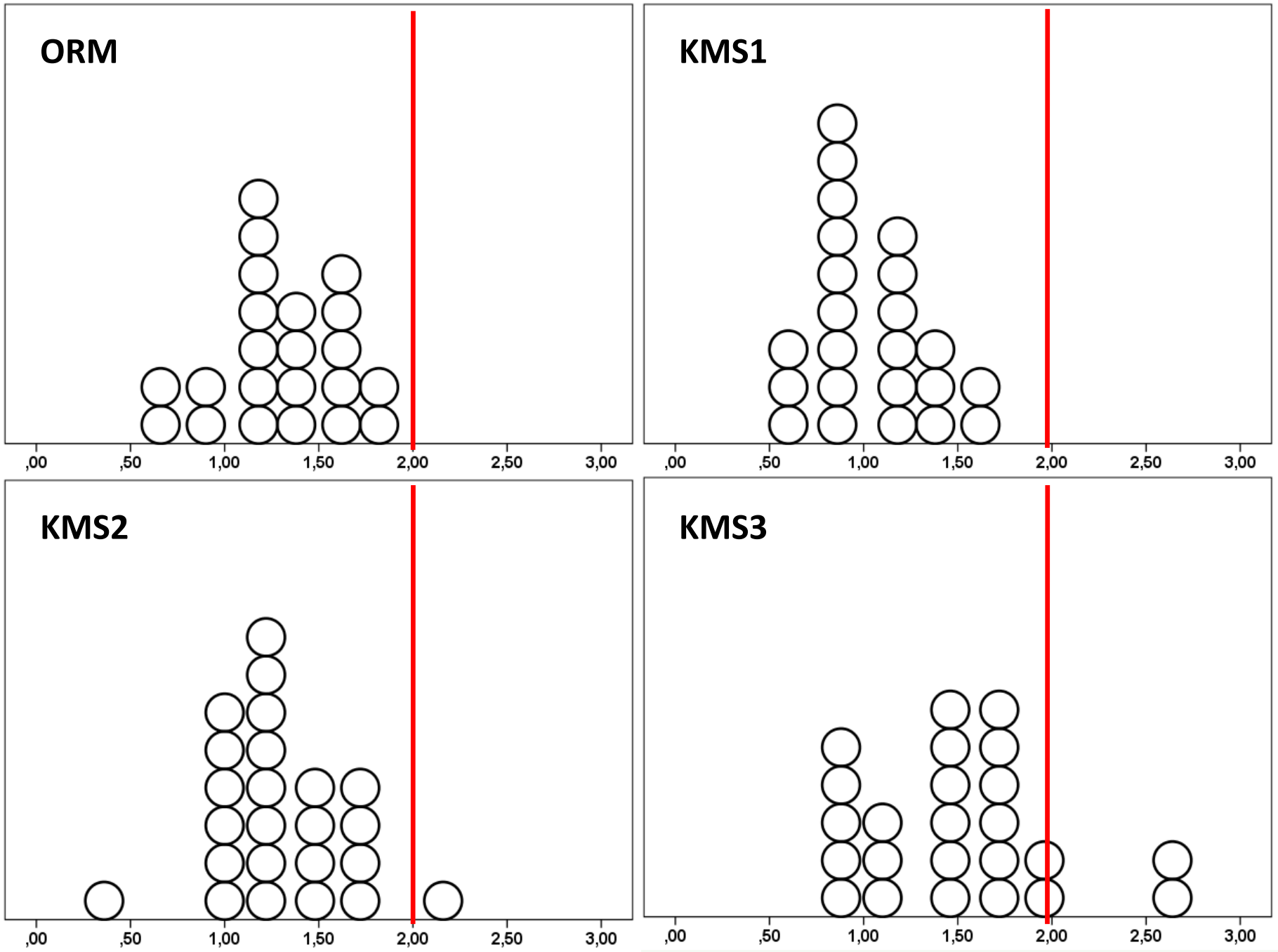




*** - p<.001
** - p<.01
* - p<.05

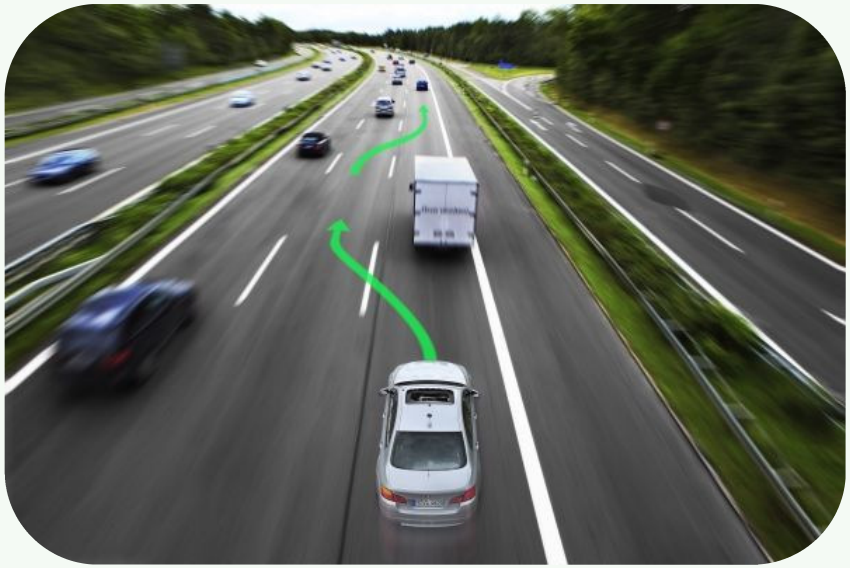
- Number of glances on CMS3 significantly higher than on ORM
- Mean as well as maximum glance duration is significantly reduced for CMS1

Maximum Glance Duration (Filtering)



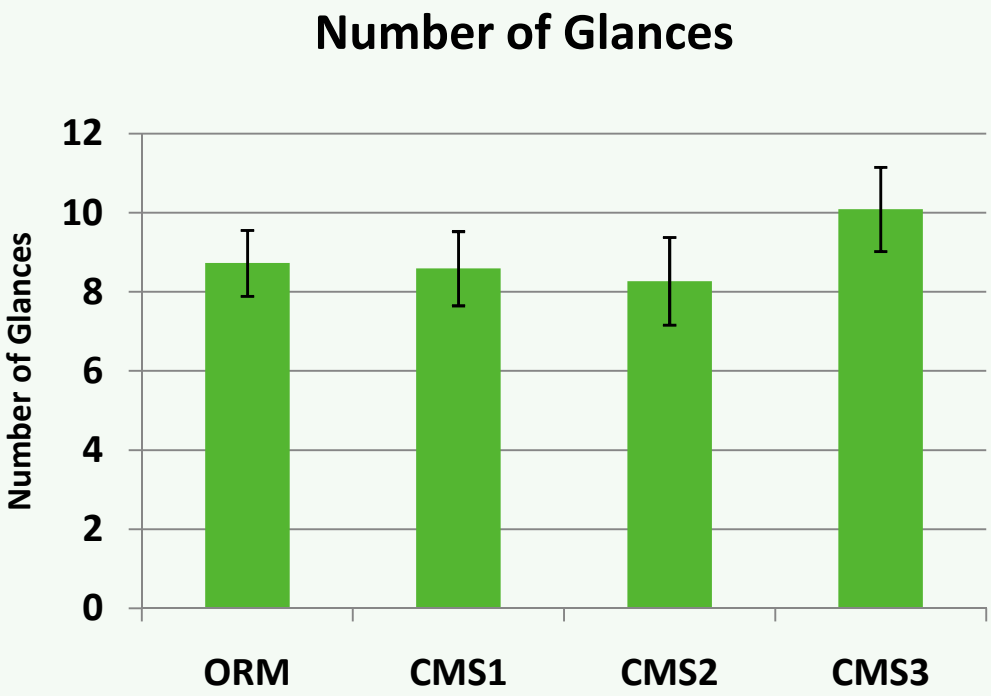
Duration of Overtaking Maneuver

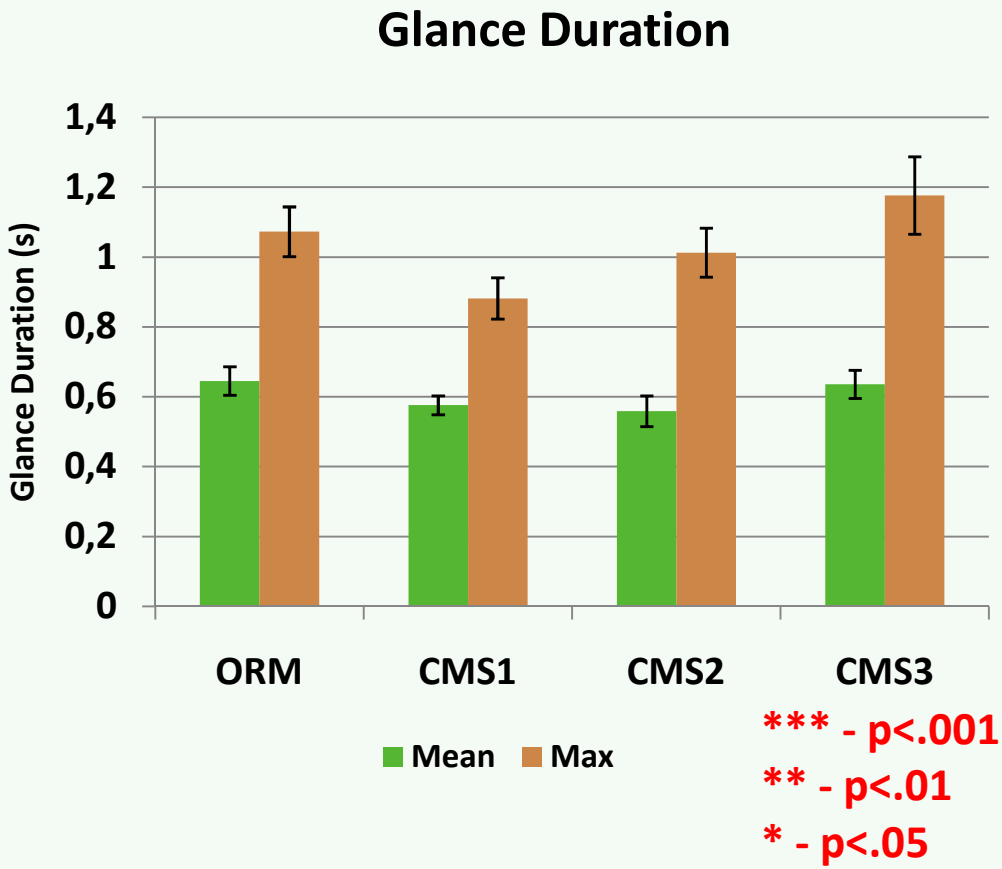
- An overtaking maneuver on average took about **16 seconds** from leaving the own lane until it was completed.
- Neither the system used nor the age group excerted a significant influence on the duration of the overtakting maneuver.



Source: http://m2m-magazin.de/wp-content/uploads/2013/11/BMW-ConnectedDrive4_600.jpg

Lane Change (left): Glances to Rear-Vision Device

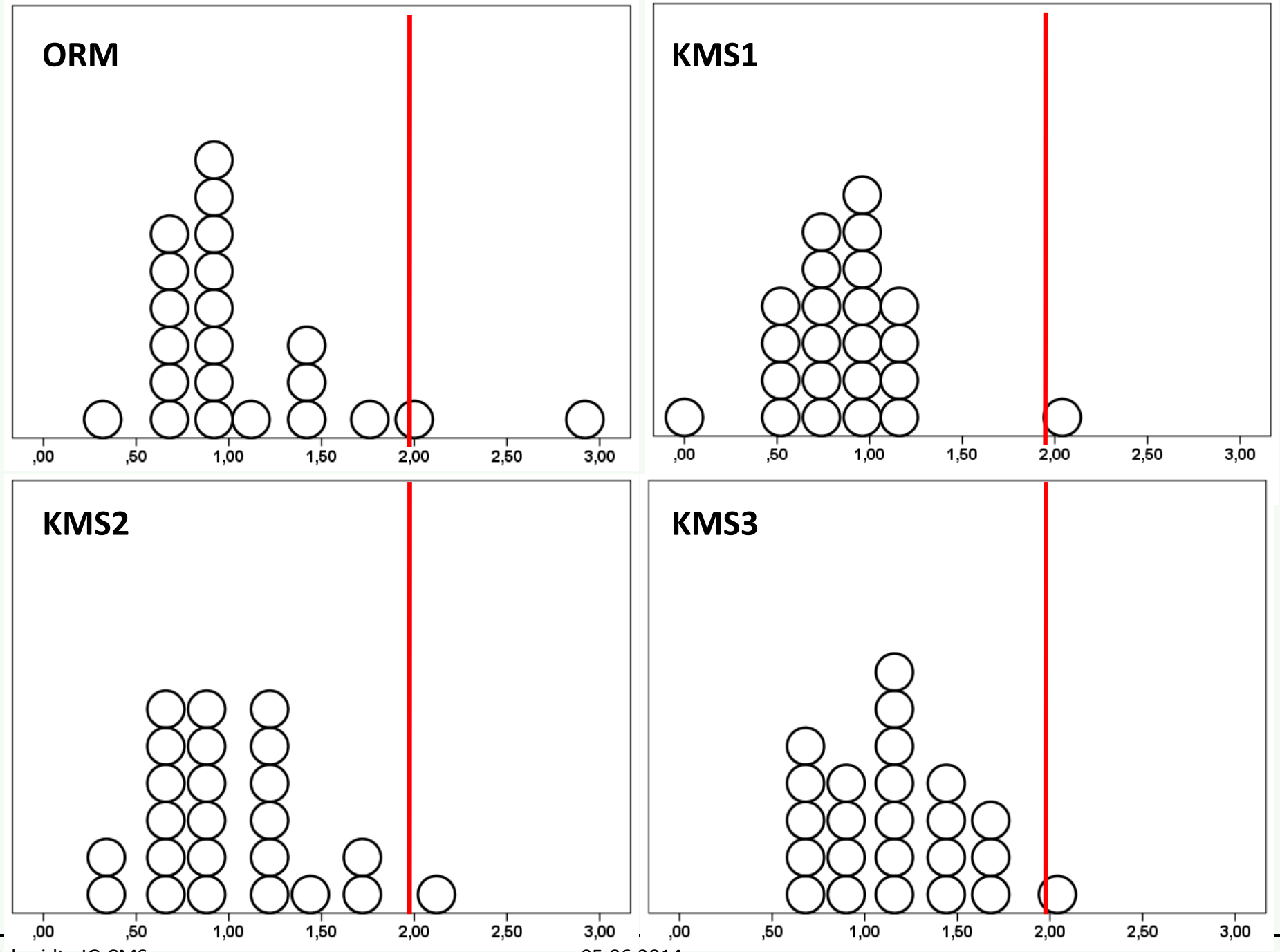




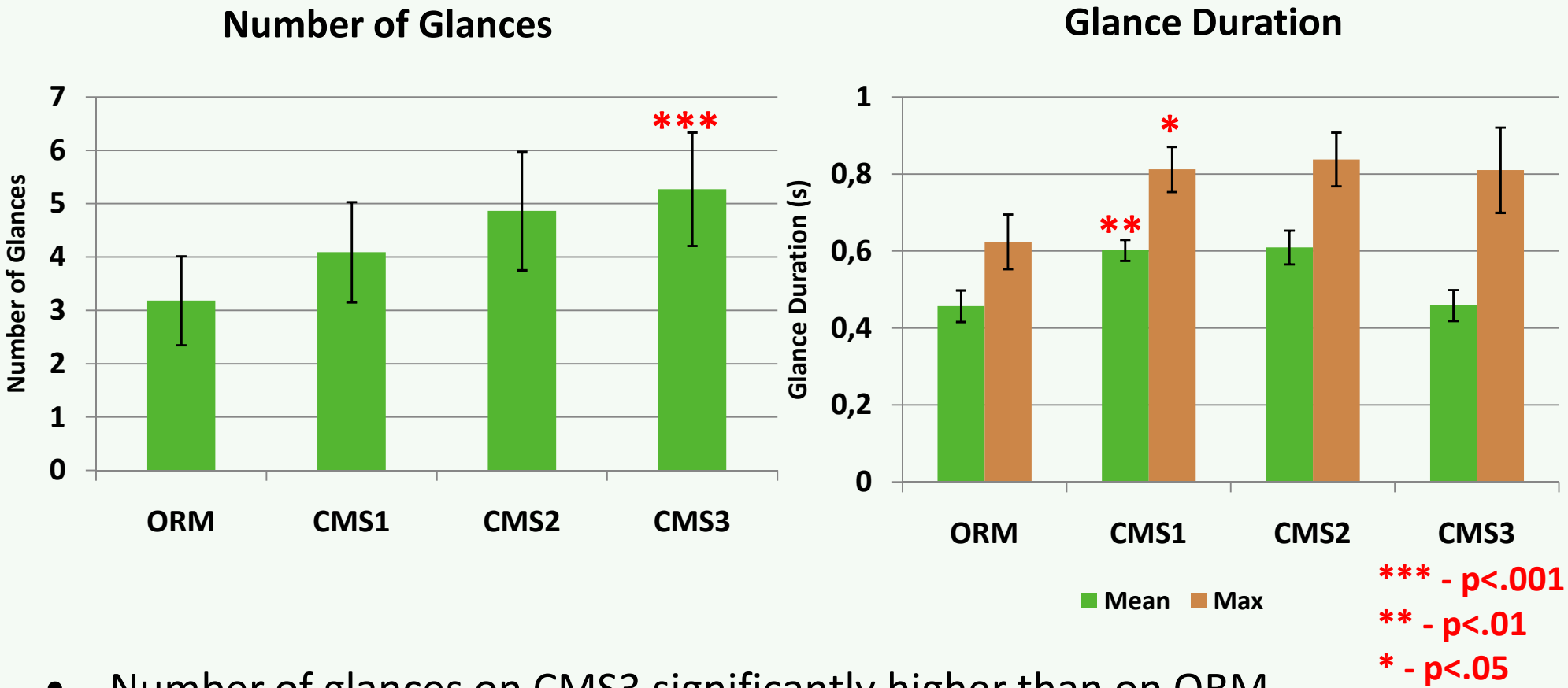
*** - p<.001
** - p<.01
* - p<.05

- There are no significant differences between any of the CMS conditions and the ORM condition.

Maximum Glance Duration (Lane Change - left)

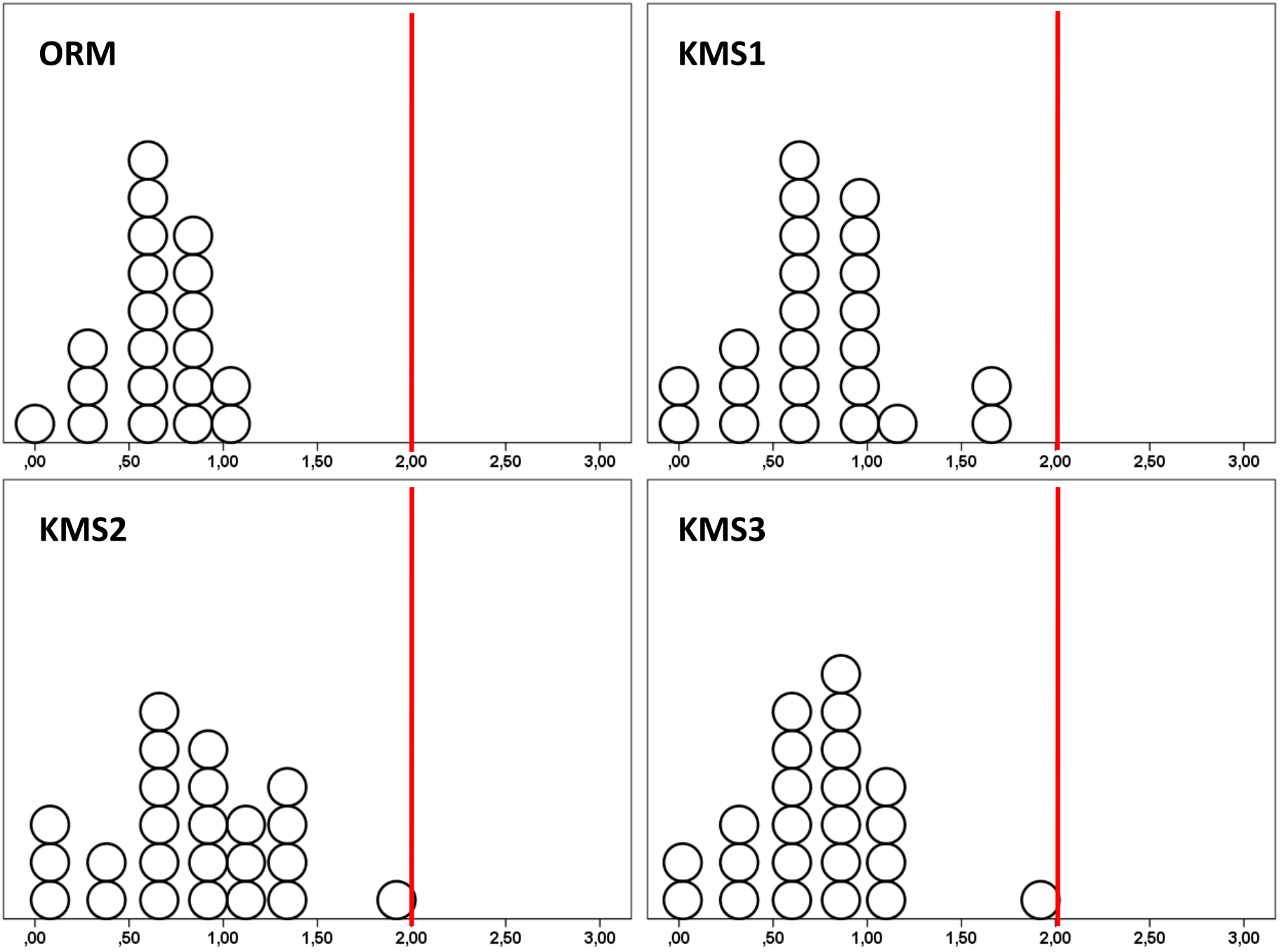


Lane Change (right): Glances to Rear-Vision Device



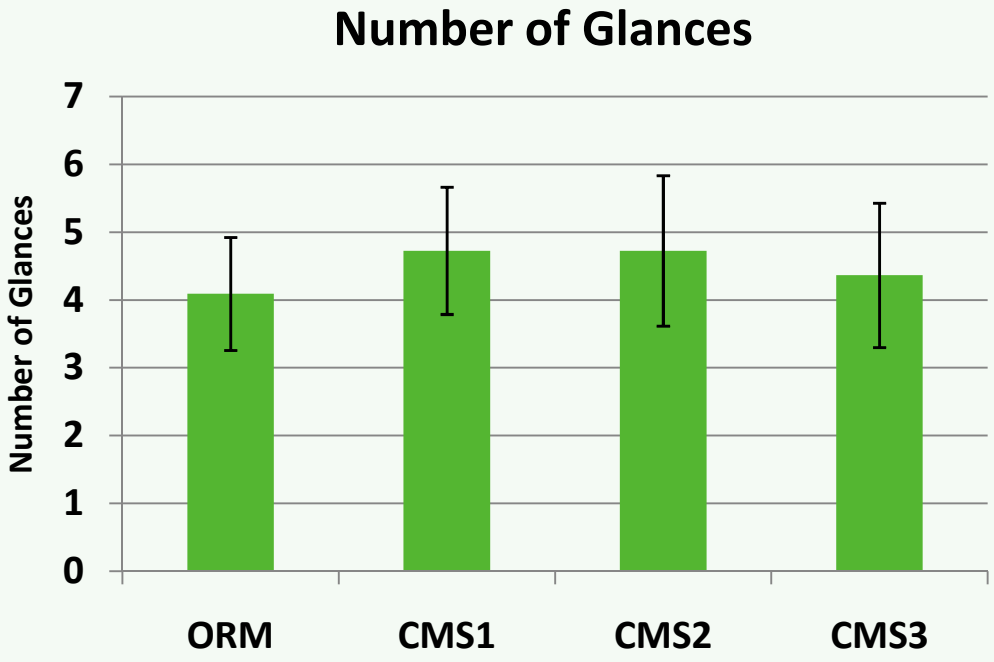
- Number of glances on CMS3 significantly higher than on ORM
- Mean as well as maximum glance duration is significantly increased for CMS1 (tendency for CMS2 and CMS3)

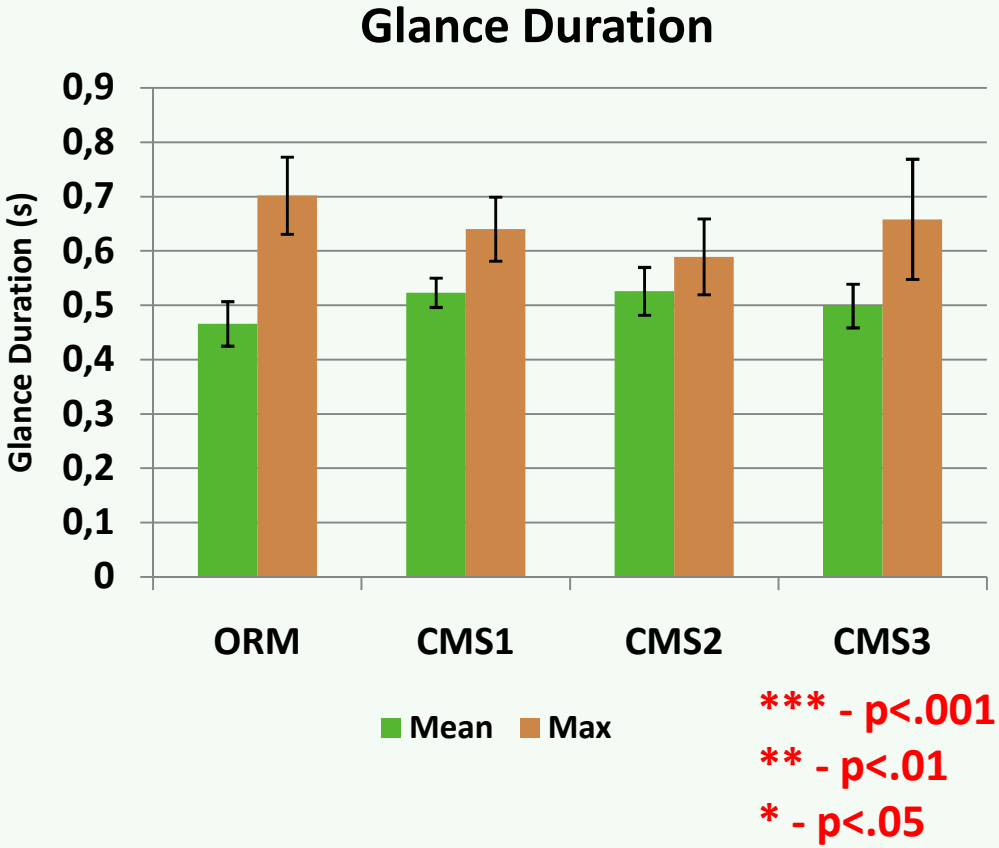
Maximum Glance Duration (Lane Change - right)



Use of Inside Rear-view Mirror

- 13 participants used the inside rear-view mirror in all conditions during filtering
- There was no significant effect of vision device on use of inside rear-view mirror

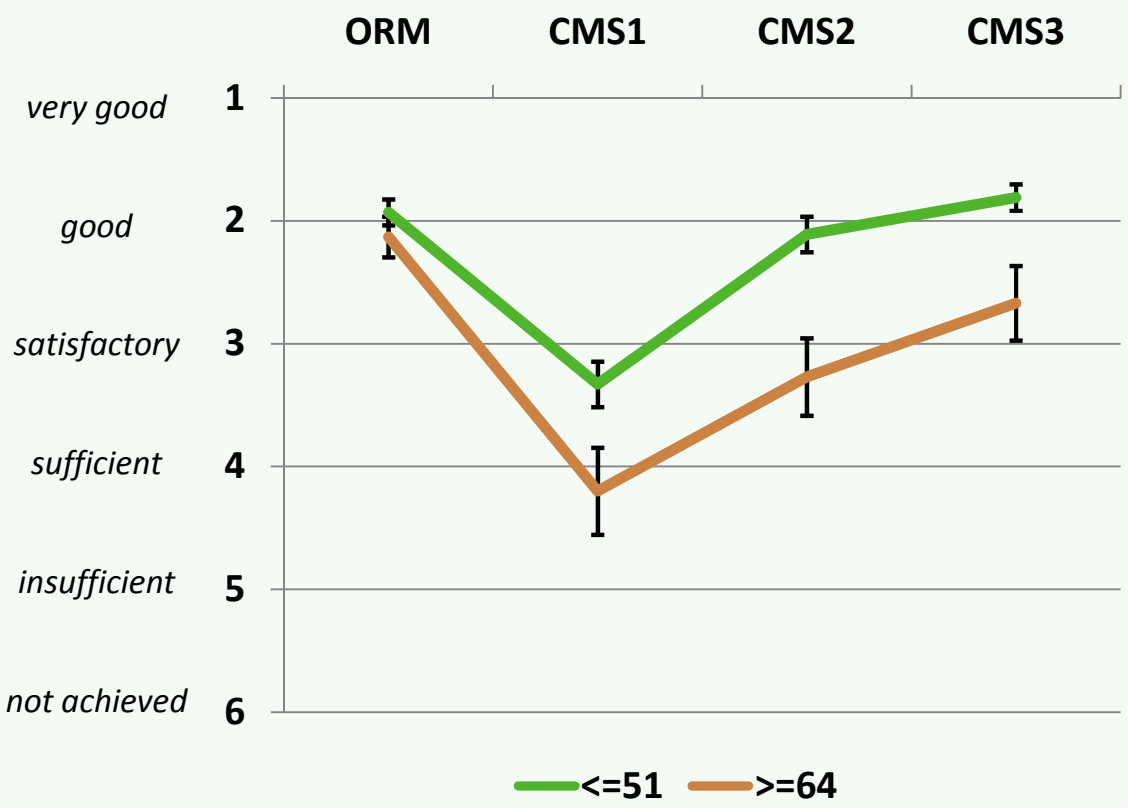




*** - p<.001
** - p<.01
* - p<.05

Performance Measures (assessed by investigator)

How good was the driver‘s performance during filtering and overtaking?



- There are significant main-effects of device used and age as well as an interaction between the two factors:
  - CMS1 scores low for younger as well as older drivers.
  - CMS2 and 3 score lower than ORM only for older drivers

Critical Situations (assessed by investigator)

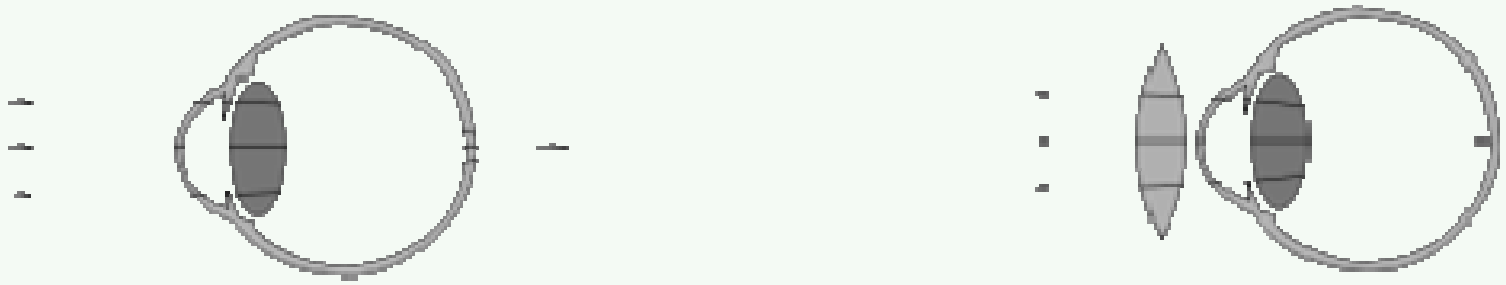
	ORM	CMS1	CMS2	CMS3	Total
Filtering	4	9	7	6	26
Overtaking	5	3	5	3	16
# subjects	*40*	*39*	*40*	*40*	

- For both driving situations a McNemar-Test did not reveal any significant differences between CMS-conditions and ORM.

Summary of Results

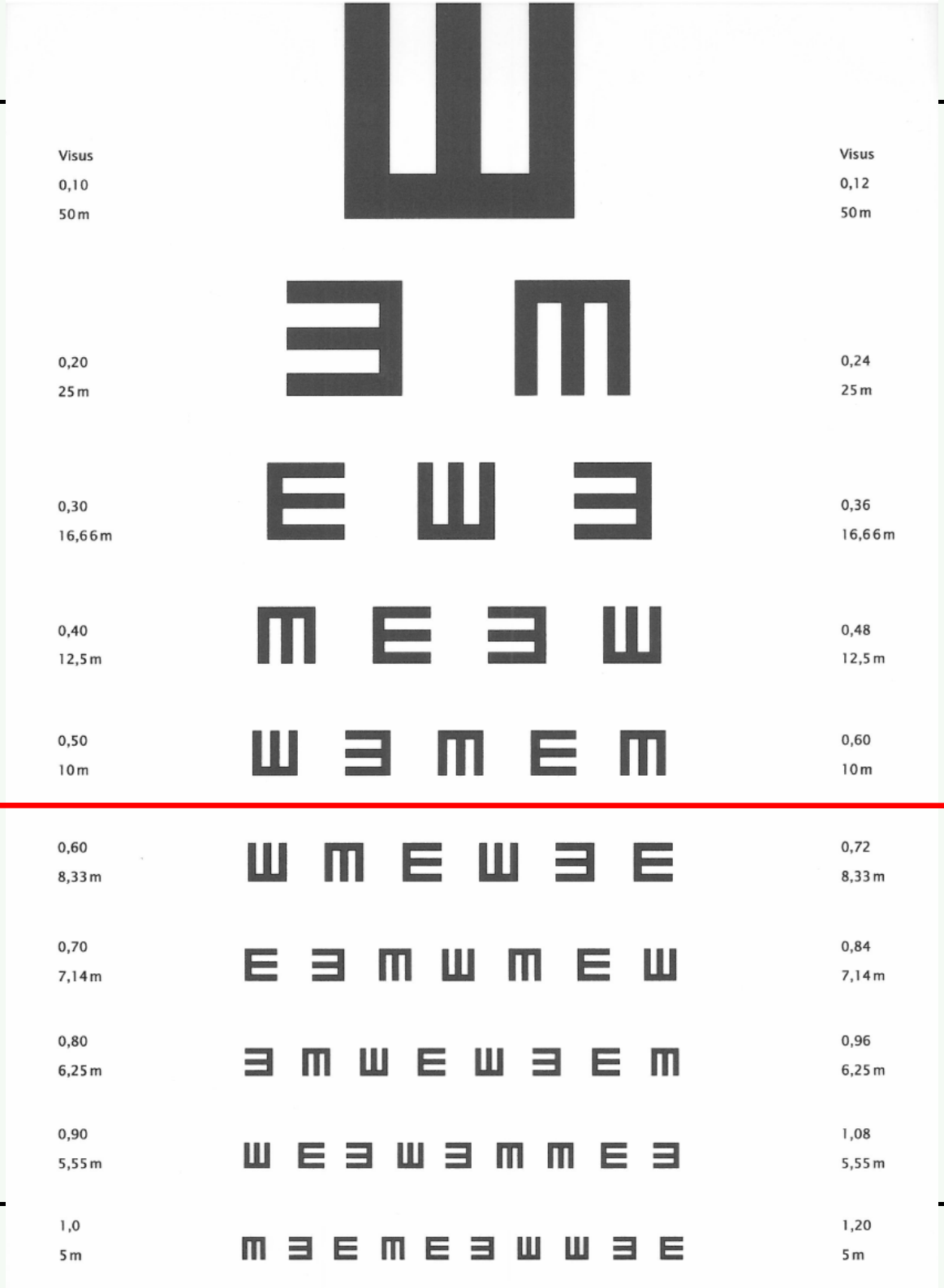
- During real highway driving situations (filtering into traffic, lane change) the CMS is used in a comparable way as an outside rear-view mirror.
- There seems to be a slight reduction in glance duration for the left CMS1, possibly due to the low position (distraction)
- A slightly larger number of glances to CMS3 (left and right) might be due to its position in the regular field of view
- Driving performance during filtering and overtaking as judged by the investigator was worst for CMS1. For elderly all three CMS positions score significantly lower than the ORM.

Influence of Farsightedness (Hyperopia / Presbyiopia)



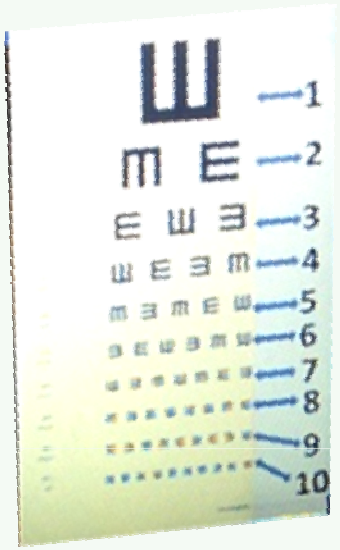
- Outside Rearview Mirror: Focus on real distance of object (far vision)
- CMS: Focus on distance of monitor (near vision)
- Accomodation from far to near distance takes time and might lead to fatigue.
- Positive aspects like reduction of gare, reduced blind spot, and information closer to central field of view might have to be taken into account.
- **Study: Is there a difference in visual acuity for farsighted (normal sighted / corrected to normal sighted) drivers between devices used for rear vision?**

Snellen Test Chart



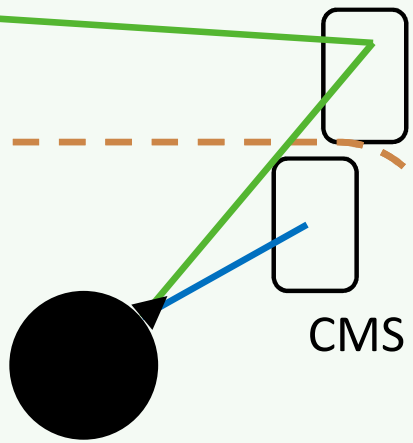
visual acuity ≈ .7

Test Setting



Considering the magnification factor of the ORM the distance chart - ORM -occular reference point (ORP) corresponded to the standardized distance for the test chart.

d ≈ 3,60 m



d (ORP - CMS)	
Mean	59,85
Min	50,00
Max	69,00
SD	3,9

Image shown via CMS

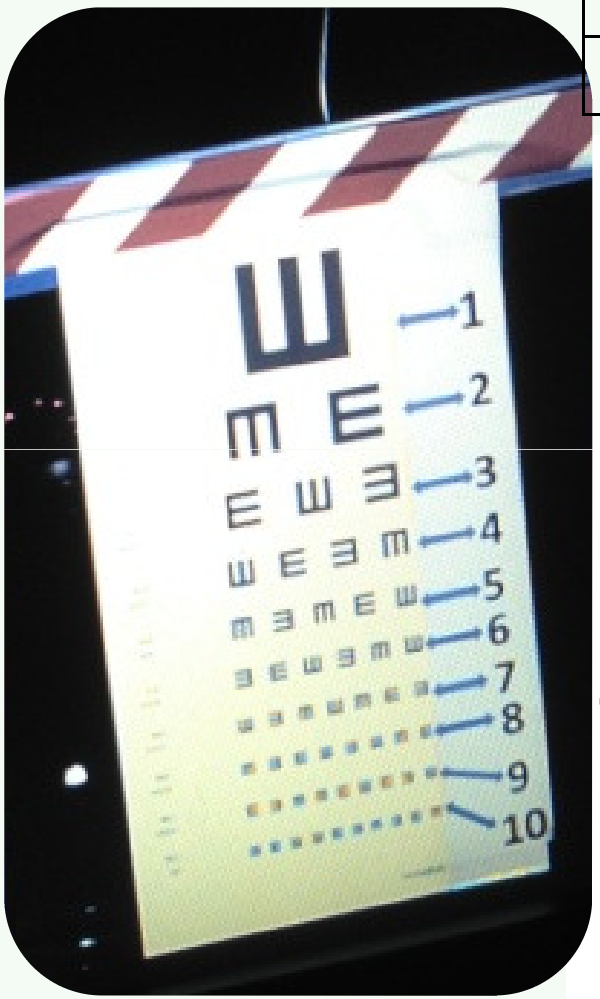
Participants

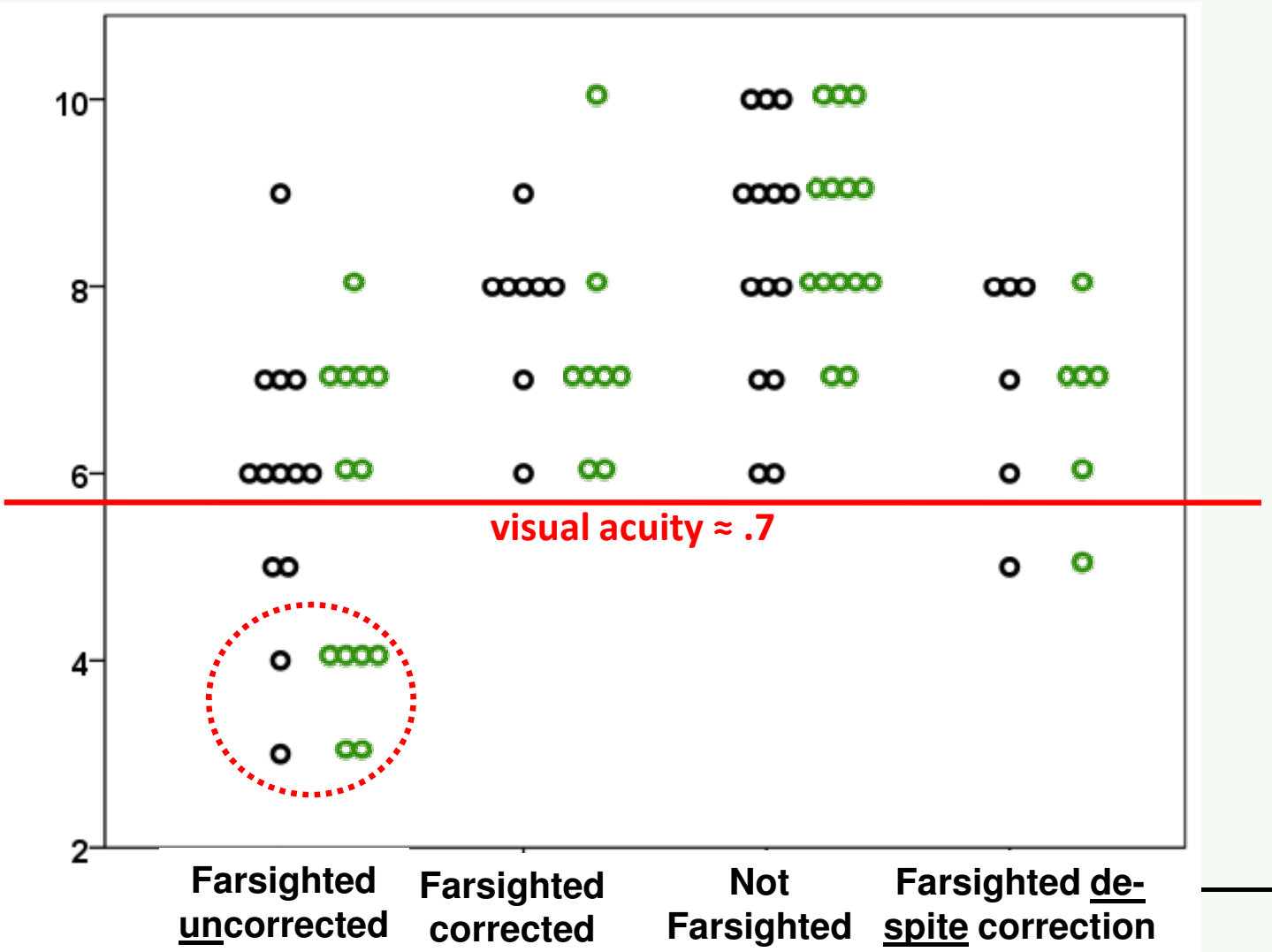
- 50 Participants tested
- 3 participants were excluded from analysis because they did not meet the criterion of .7 visual acuity
- 1 participant was excluded because - despite not being diagnosed as farsighted - he did not identify the visual stimuli in any condition.

		reported by participant			
		farsighted uncorrected	**farsighted corrected**	**not farsighted**	**sum**
test result (25cm)	**not farsighted**	~~1~~	8	14	23
	farsighted	13	6	~~4~~	23
sum		14	14	18	46

Outside Rear-view Mirror vs. Camera-Monitor-System

N(total)	13	8	14	6
M(age)	52,6	56,0	31,7	52,0
N(male)	5	5	14	2
M(row)	5.9 vs. 5.4	7.8 vs. 7.3	8.3 vs. 8.6	7.0 vs. 6.7





Summary of Results

- The use of a CMS leads to a shift in visual acuity for farsighted drivers (although the oldest participants was only 64 years old)
- This is not the case for drivers who do not have any visual deficiencies.
- The issue should be investigated closer and be considered in future discussion.

- More extensive studies are needed, taking into account:
  - different monitor positions / distances
  - include „real“ elderly drivers (>65 years)
  - different degrees of farsightedness with different corrections (in order to derive thresholds, investigate appropriate measures)
  - real driving situation should be considered
  - gaze analysis in oder to take into account accomodation times

Next steps

- Finalisation of analysis
- Study on the use of CMS in heavy goods vehicles (technical and HMI)
- Support of discussion in IG CMS
- Final report expected in late summer 2014 (will be translated into English language)