RAINVISION

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Results of WP3 – Track Tests
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European Commission
Mobility & Transport

Overview

Research aim

Experiment Description

Results

Conclusions

Research aim

"Study the impact of the visibility of different pavement markings in different conditions (night time driving in wet and rainy circumstances), also taking into account different age groups"

Experimental design

Participants drove on a test track, containing several typical road characteristics, like left and right bends or a straight road. Drivers performance was investigated in three test conditions:

Condition I: Baseline, non-reflective lane marking (priming material)

Condition II: Site equipped with marking material I
(standard marking product, no wet reflectivity performance product)

Condition III: Site equipped with marking material II
(enhanced wet night visibility performance product)

Drivers took several runs through specifically chosen road sections, completing the track in 3 different night time driving situations:

dry, (1), wet (2) and wet & rainy (3)

Participants were asked to drive as normally as they could in respective track conditions.

Experimental design *(cont.)*

To ensure comparability with the described design of WP 2, three age groups were analysed: 20-40 year, 41-60 year and 61+ years old drivers, both male and female, actual & planned (in brackets) sample:

Age group	**20-40 years**		**41-60 years**		**61 years and over**	
	male	female	male	female	male	female
n=88 (90)	17 (15)	15 (15)	15 (15)	16 (15)	15 (15)	10 (15)

Condition I (no marking) was considered to be the baseline condition, i.e. the drivers´ performance in other conditions were compared.

To avoid results only due to sequence of condition (positional effects), half of the sample (group A) completed the baseline condition at first, then test condition II and III. The other half of the sample (group B) started with condition II and III and completed the baseline condition at the end. There were no positional effects as the speed performance in the baseline conditions of group A and B was not (statistically) different.

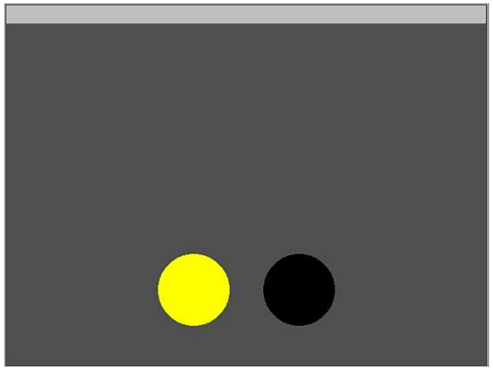
	Condition		
	baseline	**marking material I**	**marking material II**
Group A	test day 1	test day 2	test day 3
Group B	test day 3	test day 1	test day 2

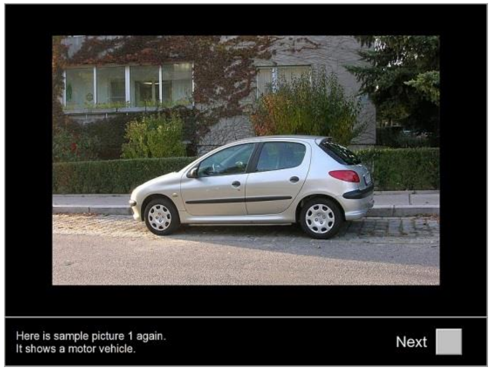
Participant selection

To avoid biased results, test subjects were specifically pre-selected by means of

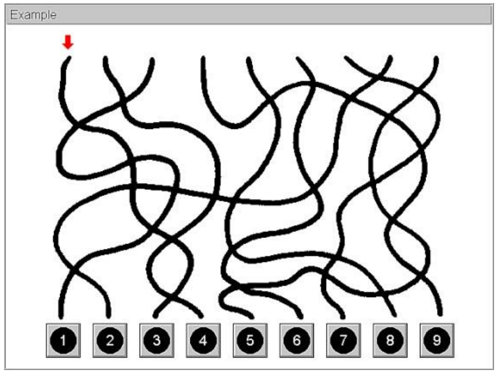
- reactivity
- tachystoscopic and
- visual structuring abilities

in order to provide homogenous test groups.

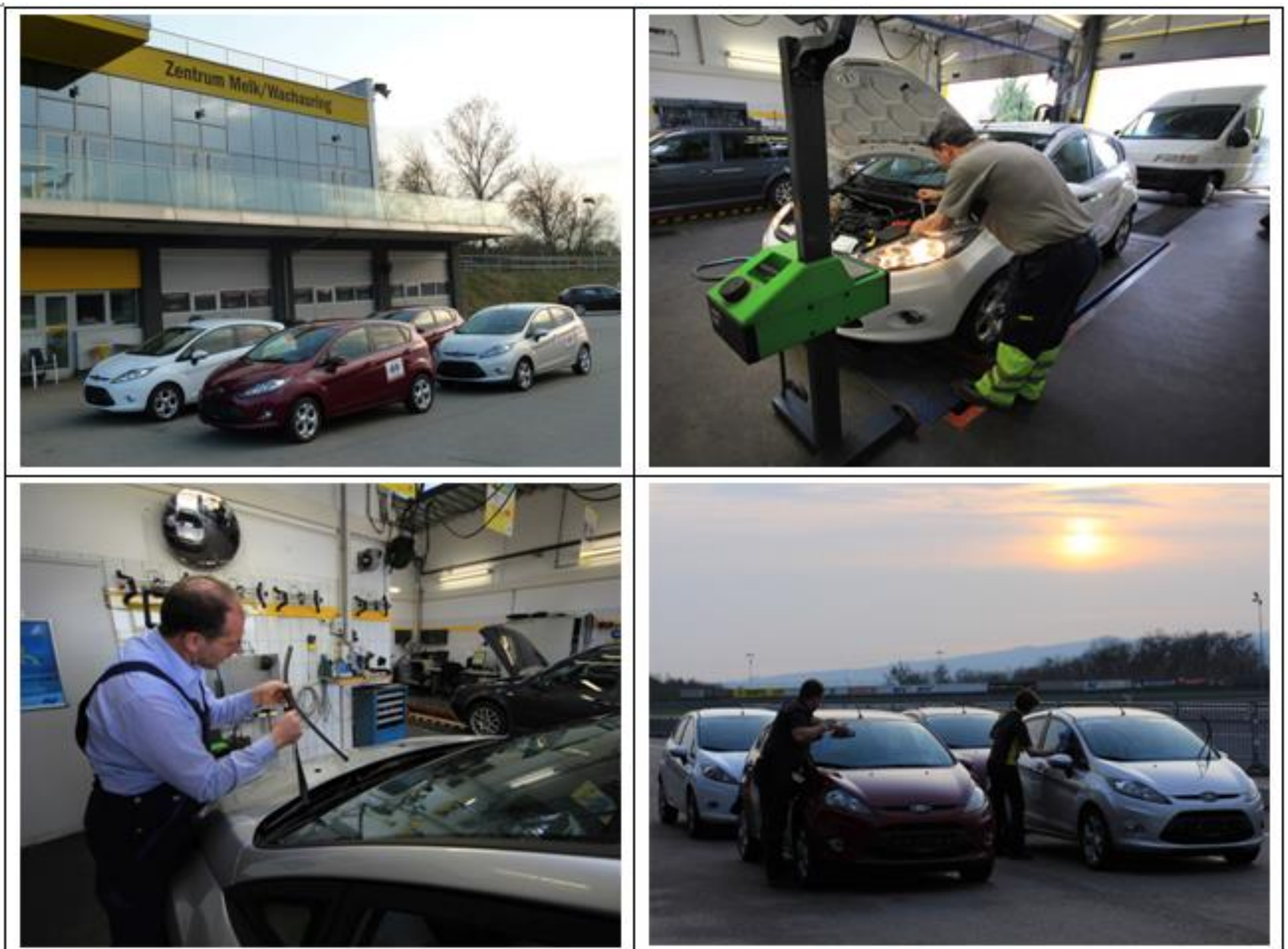




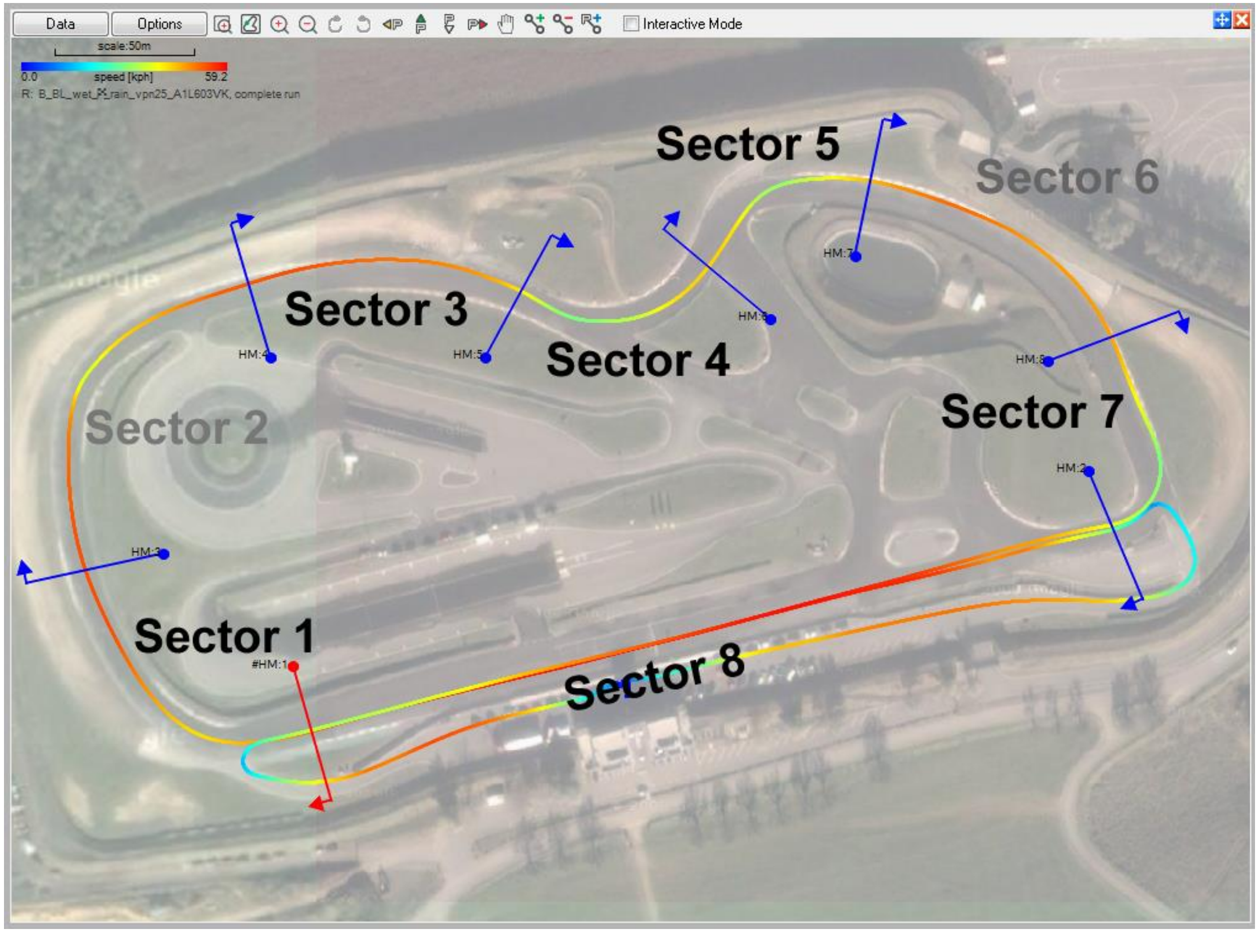
Finally, from 118 potential candidates, 90 have been selected to participate in the study, 88 took part



Test vehicles/preparations



Track Layout



Sector #	Lenght
sector 1	113 m
sector 2	**139 m**
sector 3	101 m
sector 4	76 m
sector 5	73 m
sector 6	**107 m**
sector 7	79 m
sector 8	296 m
whole lap	**984 m**

Race car causing headache

Due to damaged marking material in Sector 2 and 6, only 6 sections could be analysed. Driving in only one direction (clockwise).

Baseline condition

Non-reflective priming material

Marking material I

Standard non-reflective marking material

RL (dry) 570 - 685mcd/m² lx (exceeding Class R5 in EN 1436)

RL(wet) 3 -12mcd/m² lx (RW0 = no wet reflectivity performance according to EN 1436)

Marking material II

Retro-reflective marking material

R_L (dry) 407 - 572mcd/m² lx (exceeding Class R5 in EN 1436)
R_L (wet) 43 - 112mcd/m² lx (Class RW2 – RW4 in wet reflectivity performance according to EN 1436, the performance range was measured in different locations and is a result of the varying rain and drainage conditions throughout the track)

Equipment & Analysis

Driver comfort measurement

Driving comfort safety impact is measured lane keeping behaviour (lateral and longitudinal g-forces), speed choice and subjective stress levels (by using a post-test questionnaire) of drivers.

Measuring driving performance

Additional to the driving speed, longitudinal forces (acceleration, deceleration) and lateral forces (steering manoeuvres) are measured. Furthermore, the system records date, time, video and audio data simultaneously and stores all data on a commercial compact flash (CF) card.

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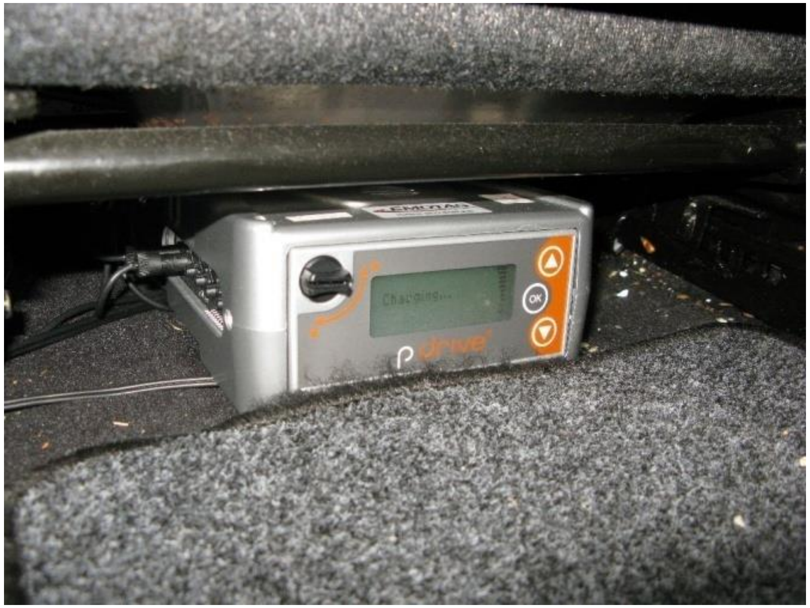
Equipment & Analysis

Cameras – e.g. behind rear mirror



Data logger (pdrive) - under seat

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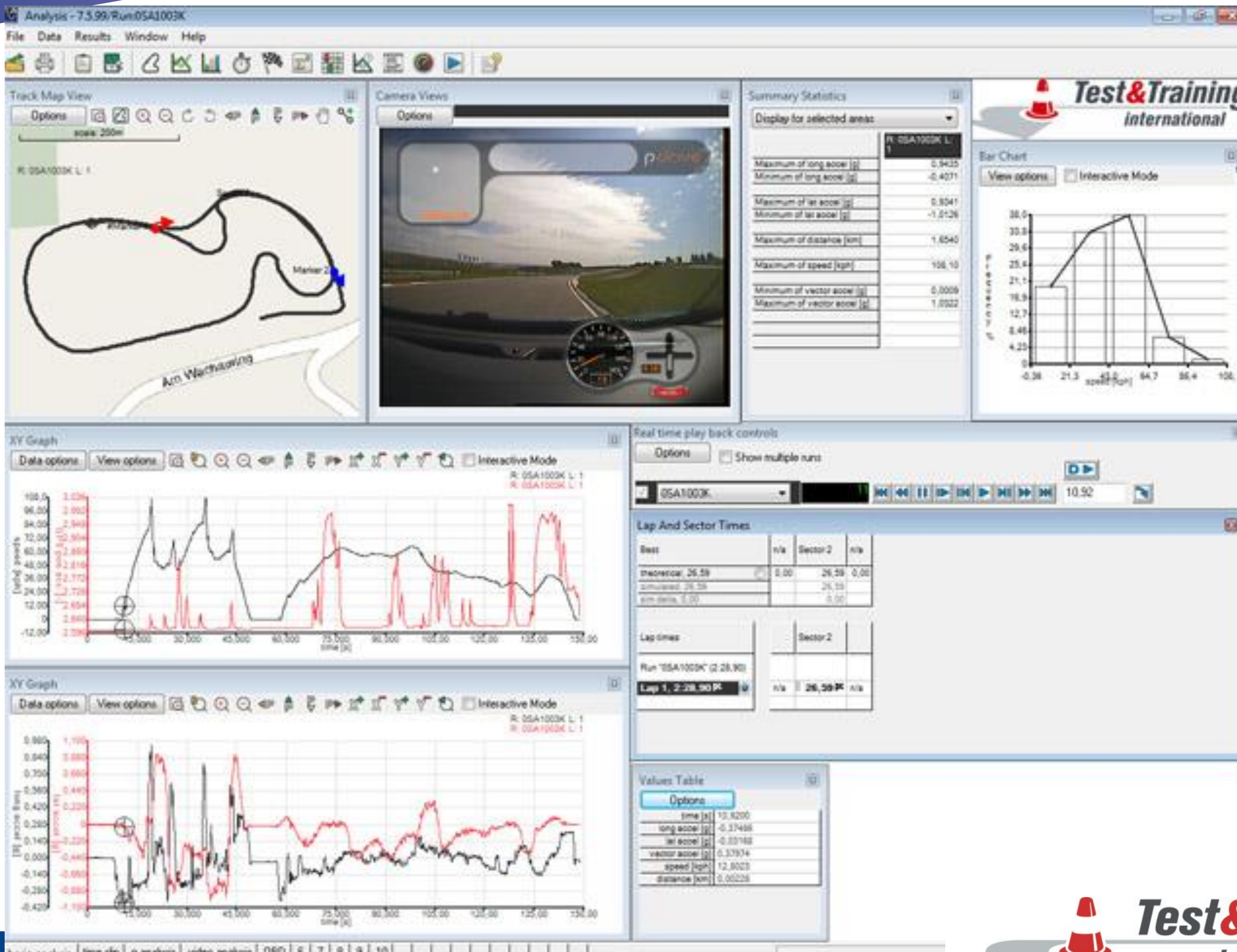


Test&Training international

Equipment & Analysis

Comparison of marking materials from inside the test vehicle
(left: baseline, existing marking, middle: marking material type I, right: marking material type II)

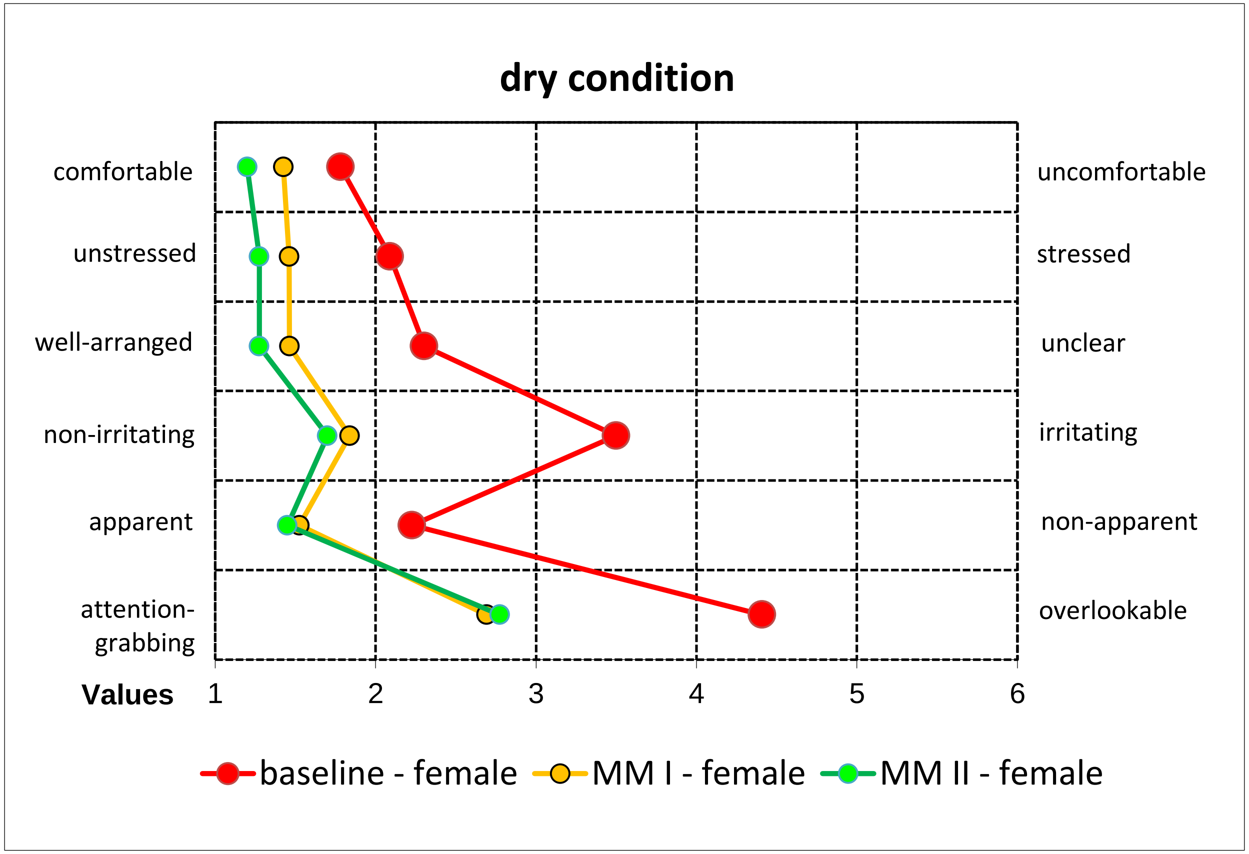
Results

Driver comfort measurement by Questionnaire

Significant differences between materials was measured WITHIN test subjects (by means of GLM testing for repeated measures) for the following parameters:

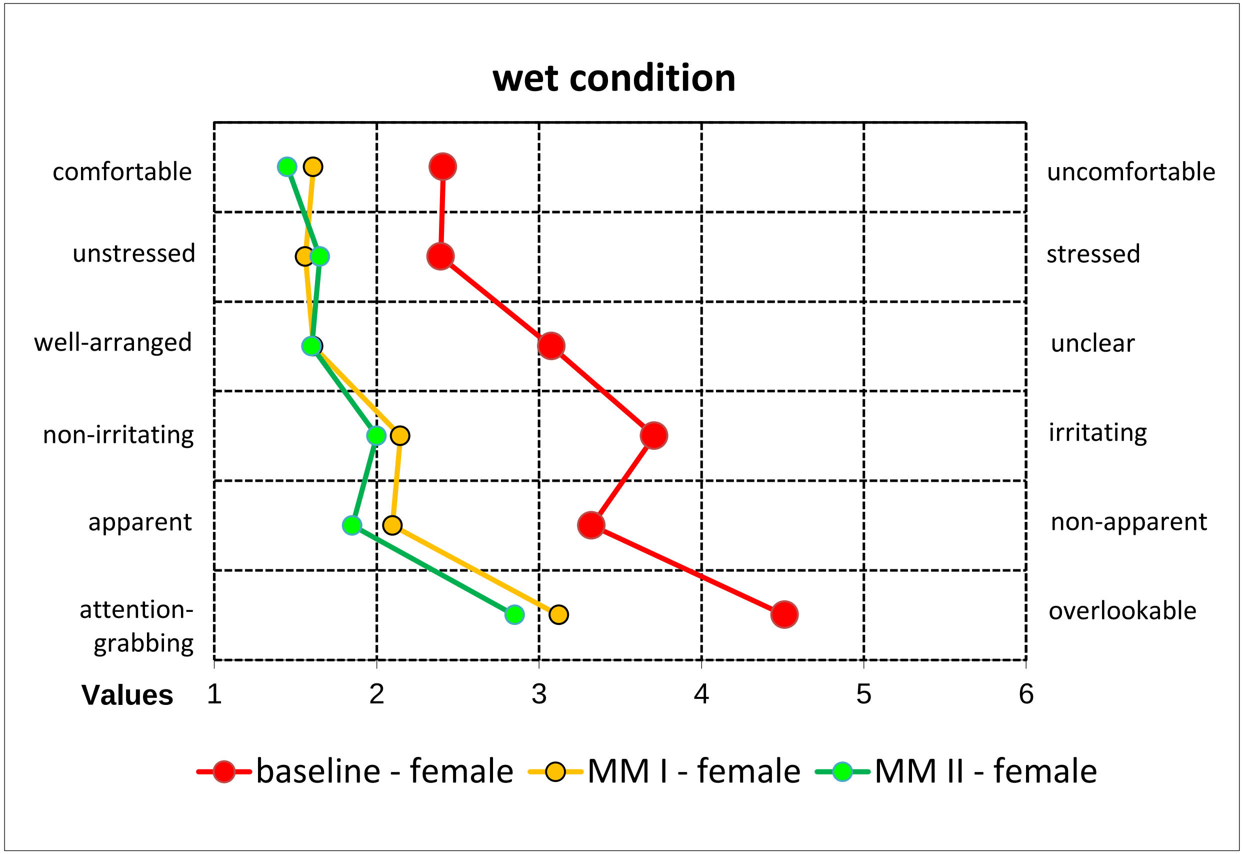
- Comfort
- Stress
- Clearness
- Confusion
- Perceptibility
- Attention

Driver comfort measurement: Questionnaire data, female



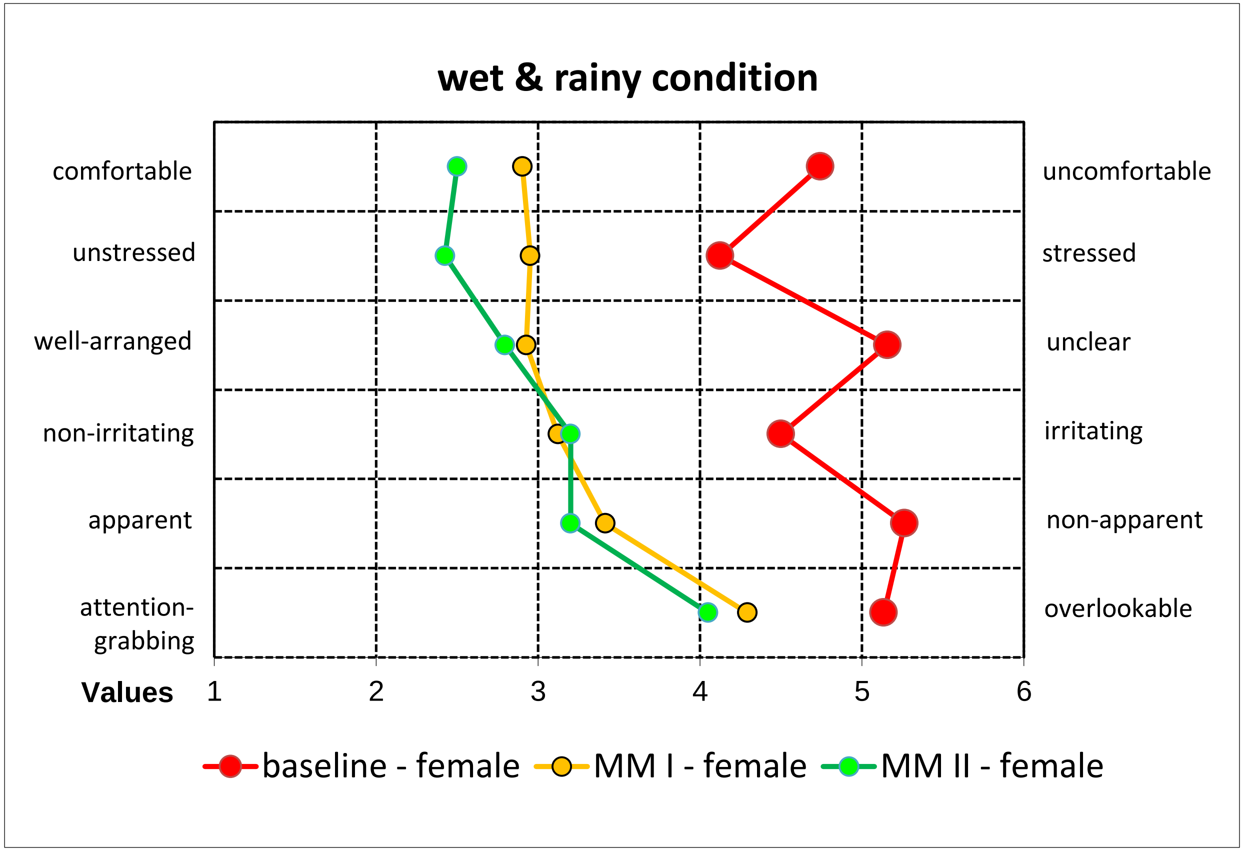
Mean values

Driver comfort measurement: Questionnaire data, female



Mean values

Driver comfort measurement: Questionnaire data, female



Mean values

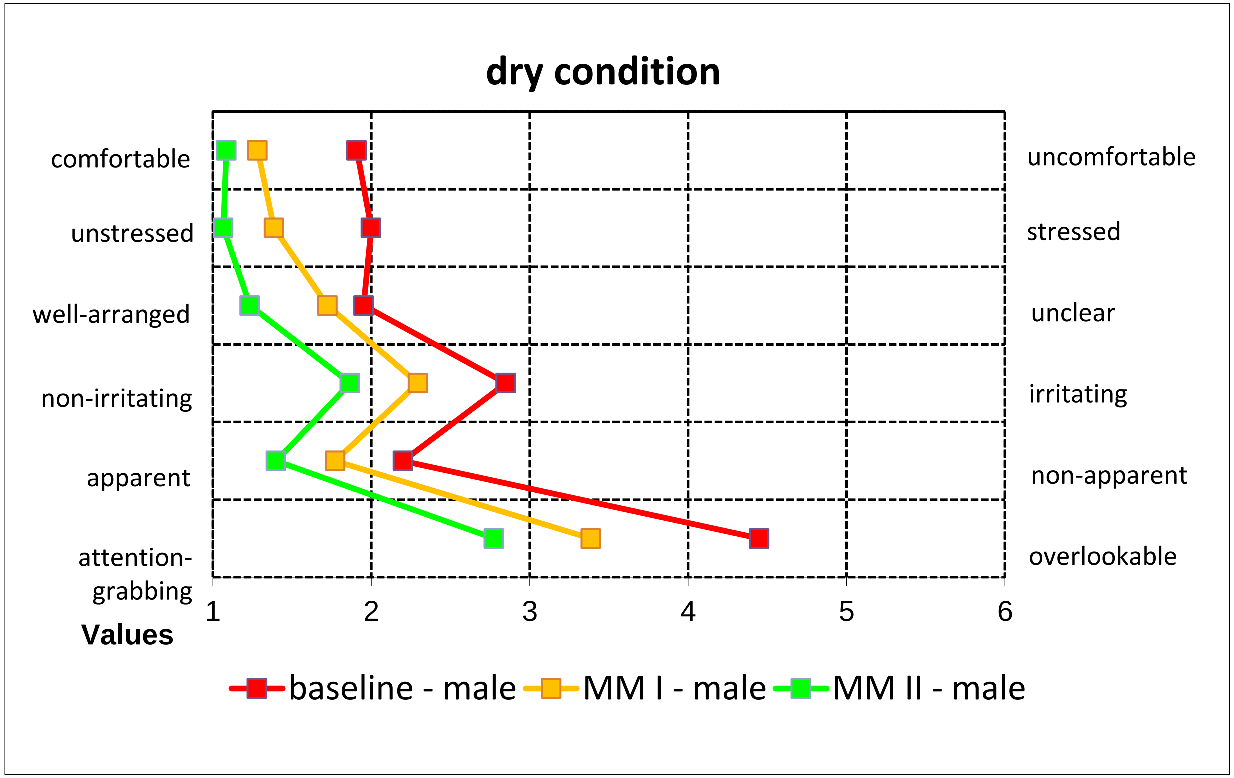
Driver comfort measurement: Questionnaire data, female

Significant differences between materials WITHIN test subjects: MM I & MM II (by means of GLM testing for repeated measures)

- Comfort (wet, wet &rainy)
- Stress (wet & rainy)
- Clearness (wet, wet &rainy)
- Confusion (wet)
- Perceptibility (wet, wet &rainy)
- Attention (wet)

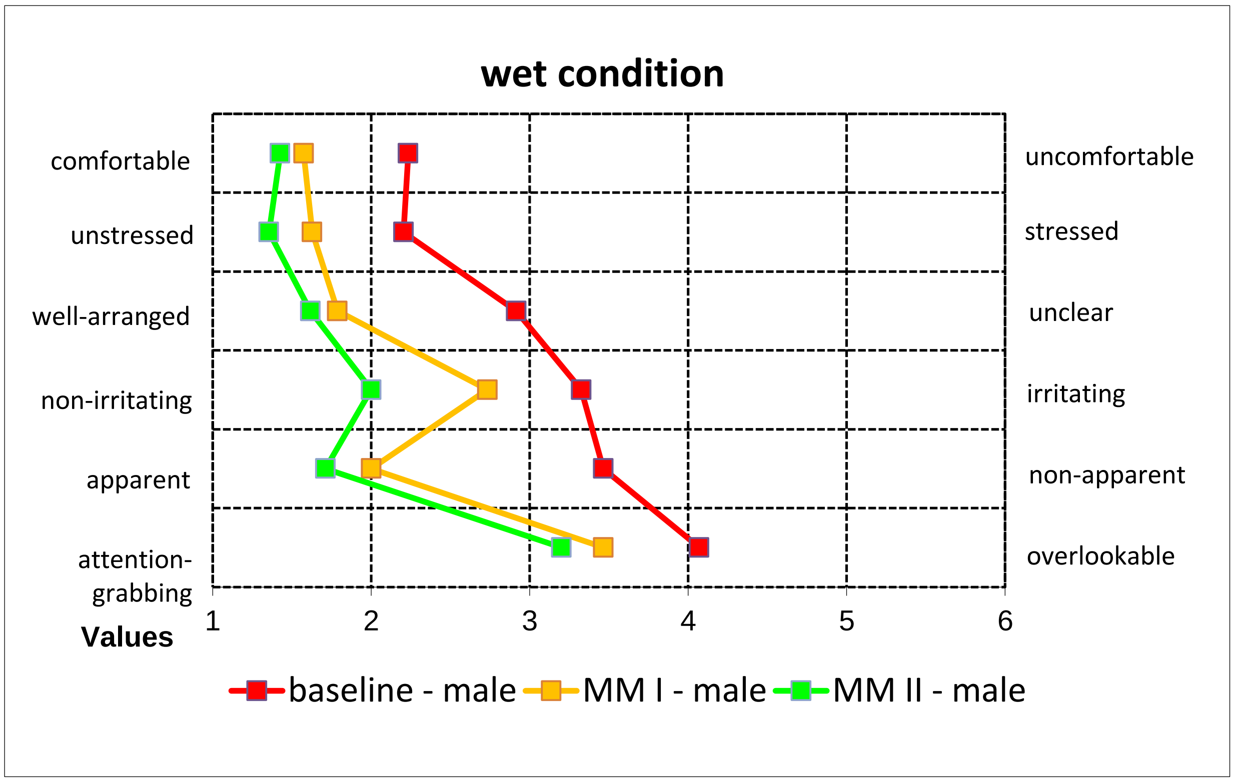
Under condition MM II, the test drives were assessed more comfortable, less stressful, more clear, less confusing, better perceivable and more attention-grabbing than MMI.

Driver comfort measurement: Questionnaire data, male



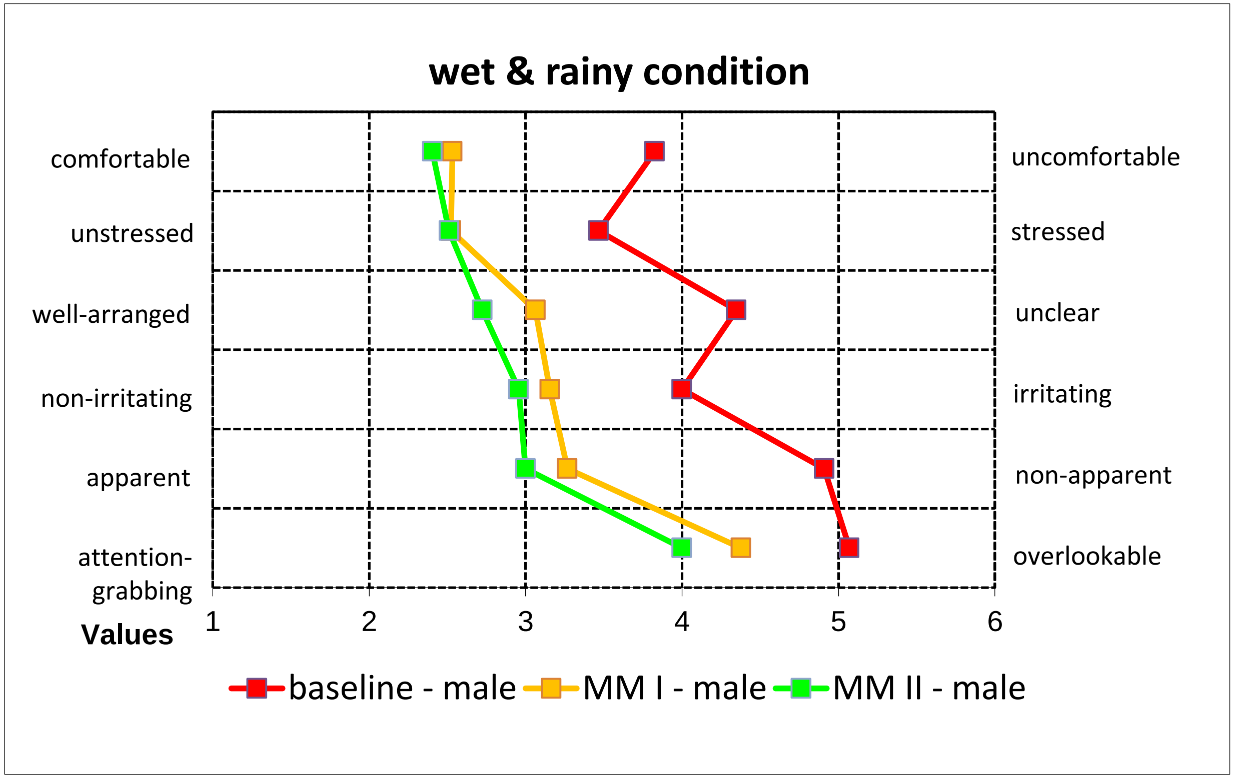
Mean values

Driver comfort measurement: Questionnaire data, male



Mean values

Driver comfort measurement: Questionnaire data, male



Mean values

Driver comfort measurement: Questionnaire data, male

Significant differences between materials WITHIN test subjects: MM I & MM II (by means of GLM testing for repeated measures)

- Comfort (dry, wet, wet &rainy)
- Stress (dry, wet)
- Clearness (dry, wet, wet &rainy)
- Confusion (wet)
- Perceptibility (dry, wet, wet &rainy)
- Attention (dry, wet, wet &rainy)

Under condition MM II, the test drives were assessed more comfortable, less stressful, more clear, less confusing, better perceivable and **less** attention-grabbing than MMI.

Driving performance

General remarks & used statistical methods

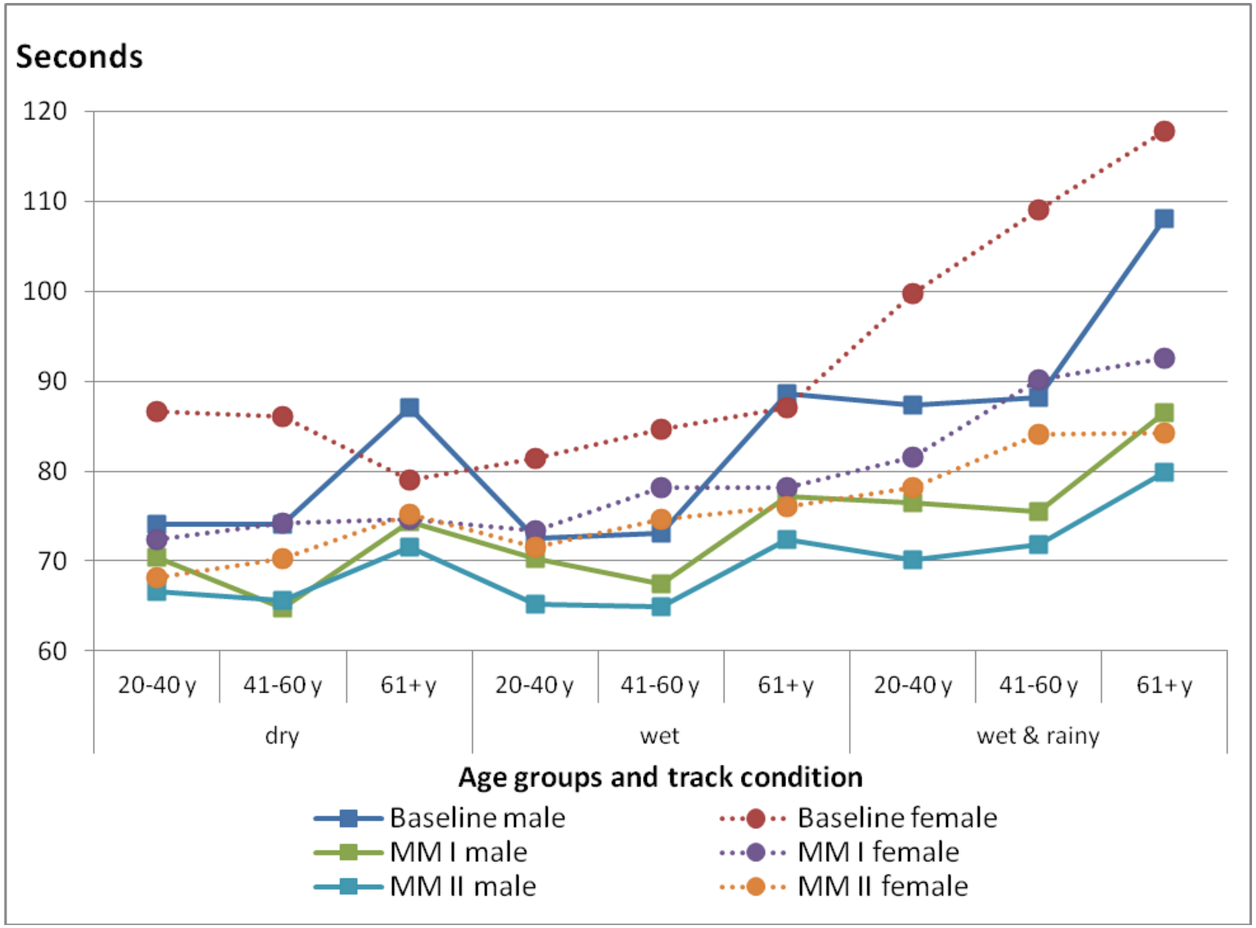
Driving performance was measured by lap times, lateral and longitudinal acceleration throughout all marking and track conditions.

For statistical comparisons as regards lap & sector times, GLM MANOVA procedures were used.

For statistical comparisons as regards acceleration behavior, MANOVA procedures for repeated measures were used which allowed for the inclusion of a covariate,
i.e. lap time.

Explanation:
Wikipedia: “A covariate is a variable that is possibly predictive of the outcome under study. A covariate may be of direct interest or it may be a confounding or interacting variable.”

Driving performance: Lap times



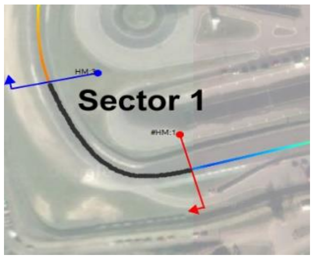
Driving performance: mean speeds

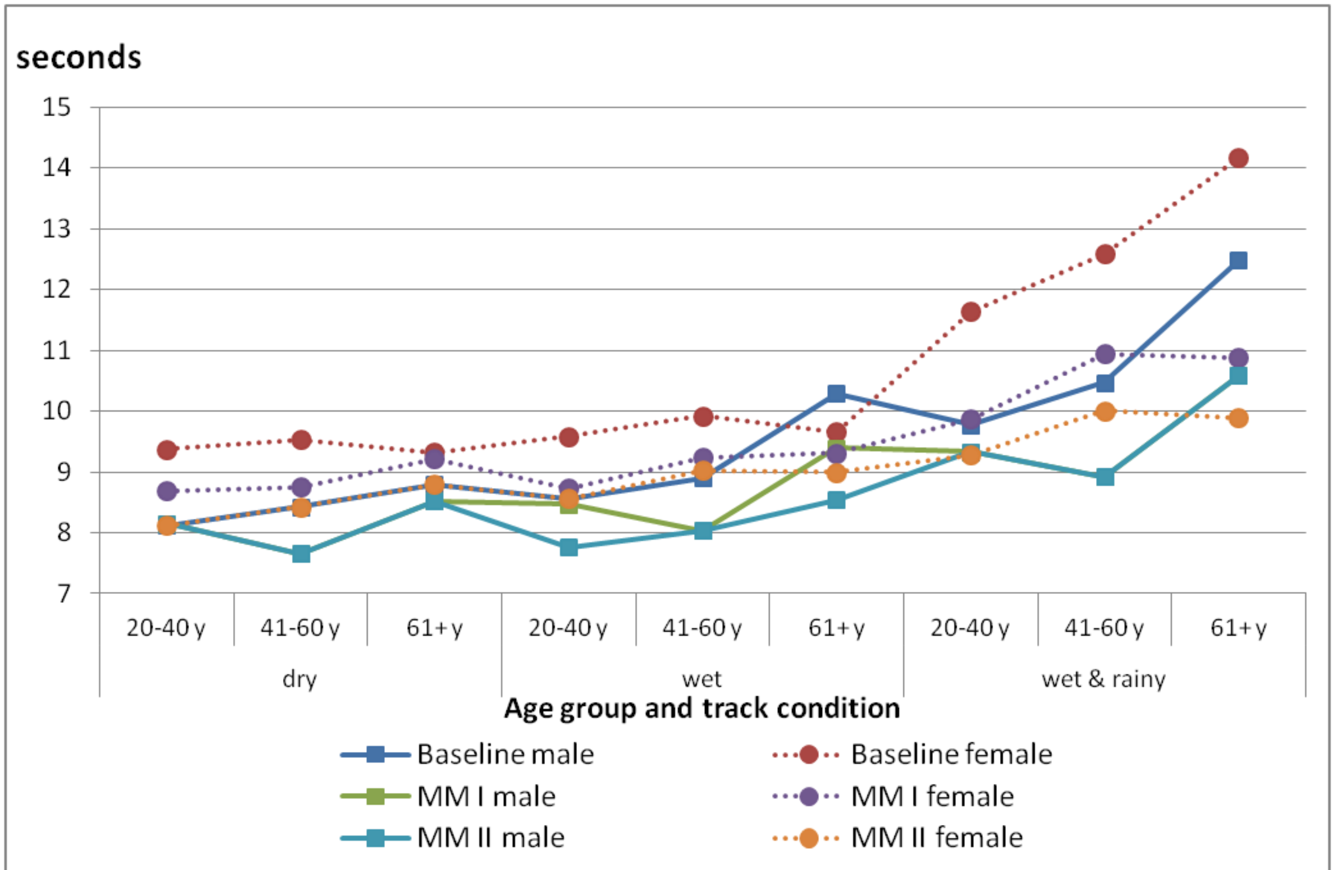
Looking at mean lap speeds, there are big differences comparing the baseline-condition with both marking conditions.

track condition	age group	Baseline female	MM I female	MM II female	Baseline male	MM I male	MM II male	
dry	20-40 y	40.86	48.92	52.00	47.804	50.26	53.15	half sample!
	41-60 y	41.17	47.74	50.43	47.816	**54.67**	54.00	
	61+ y	44.83	47.44	47.05	40.680	47.61	49.54	
wet	20-40 y	43.51	48.26	49.55	48.860	50.42	54.36	
	41-60 y	41.85	45.33	47.45	48.504	52.55	54.58	
	61+ y	40.71	45.33	46.55	39.965	45.90	48.96	
wet & rainy	20-40 y	35.49	43.42	45.33	40.535	46.32	50.50	
	41-60 y	32.47	39.29	42.12	40.184	46.89	49.35	
	61+ y	30.08	38.28	42.08	32.780	40.98	44.36	

On average the overall mean speed difference between e.g. MM I and MM II is between 2.06 km/h (female) and 2.58 km/h (male) for the whole lap (~1 km).

Driving performance: Sector times: Example Sector 1





This pattern is similar for all sectors!

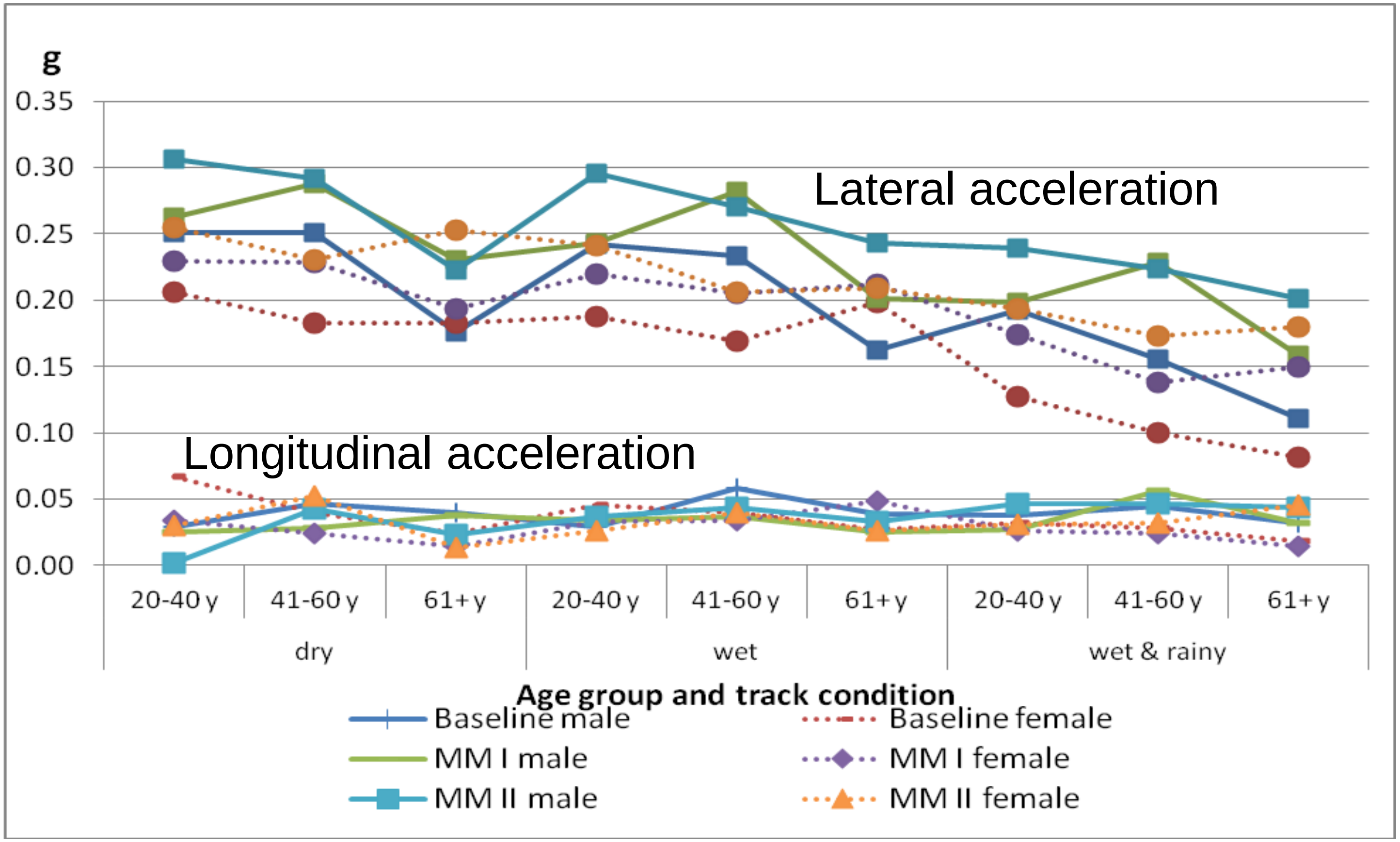
Driving performance: Lateral and longitudinal accelerations

When controlling lateral and longitudinal for time/speed (treated as covariate) no statistical differences occured (except one which can be regarded as caused by chance).

MM I vs. MM II		dry				wet				wetrain			
		marking effect (within subjects)		age interaction (within subjects)		marking effect (within subjects)		age interaction (within subjects)		marking effect (within subjects)		age interaction (within subjects)	
sector	sex	mean lat acc	mean long acc	mean lat acc	mean long acc	mean lat acc	mean long acc	mean lat acc	mean long acc	mean lat acc	mean long acc	mean lat acc	mean long acc
1	female	.254	.324	.406	.459	.823	.752	.191	.501	.668	.118	.962	.419
	male	.602	.720	.723	.346	.344	.128	.093	.805	.947	.152	.304	.069
2	female	.694	.689	.451	.799	.830	.045	.418	.517	.947	.987	.737	.802
	male	.690	.586	.364	.230	.810	.097	.463	.826	.920	.994	.076	.383
3	female	.776	.960	.545	.644	.886	.251	.351	.723	.575	.199	.641	.750
	male	.540	.479	.234	.607	.773	.211	.420	.718	.990	.012	.263	.461
4	female	.476	.157	.084	.944	.488	.116	.873	.723	.512	.675	.372	.495
	male	.825	.527	.212	.521	.154	.722	.102	.891	.166	.070	.250	.306
5	female	.452	.526	.579	.967	.931	**.001****	.078	.290	.457	.015	.825	.790
	male	.140	.545	.661	.176	.654	.102	.702	.792	.382	.360	.140	.750
6	female	.566	.340	.666	.950	.984	.654	.060	.603	.430	.691	.880	.770
	male	.320	.497	.346	.421	.468	.430	.464	.766	.353	.290	.268	.545
7	female	.366	.045	.782	.388	.298	.488	.097	.874	.996	.832	.720	.514
	male	.098	.631	.334	.186	.682	.419	.167	.524	.234	.451	.332	.350
8	female	.416	.502	.362	.794	.642	.583	.623	.591	.812	.283	.543	.621
	male	.351	.749	.913	.500	.632	.389	.451	.936	.744	.940	.404	.610

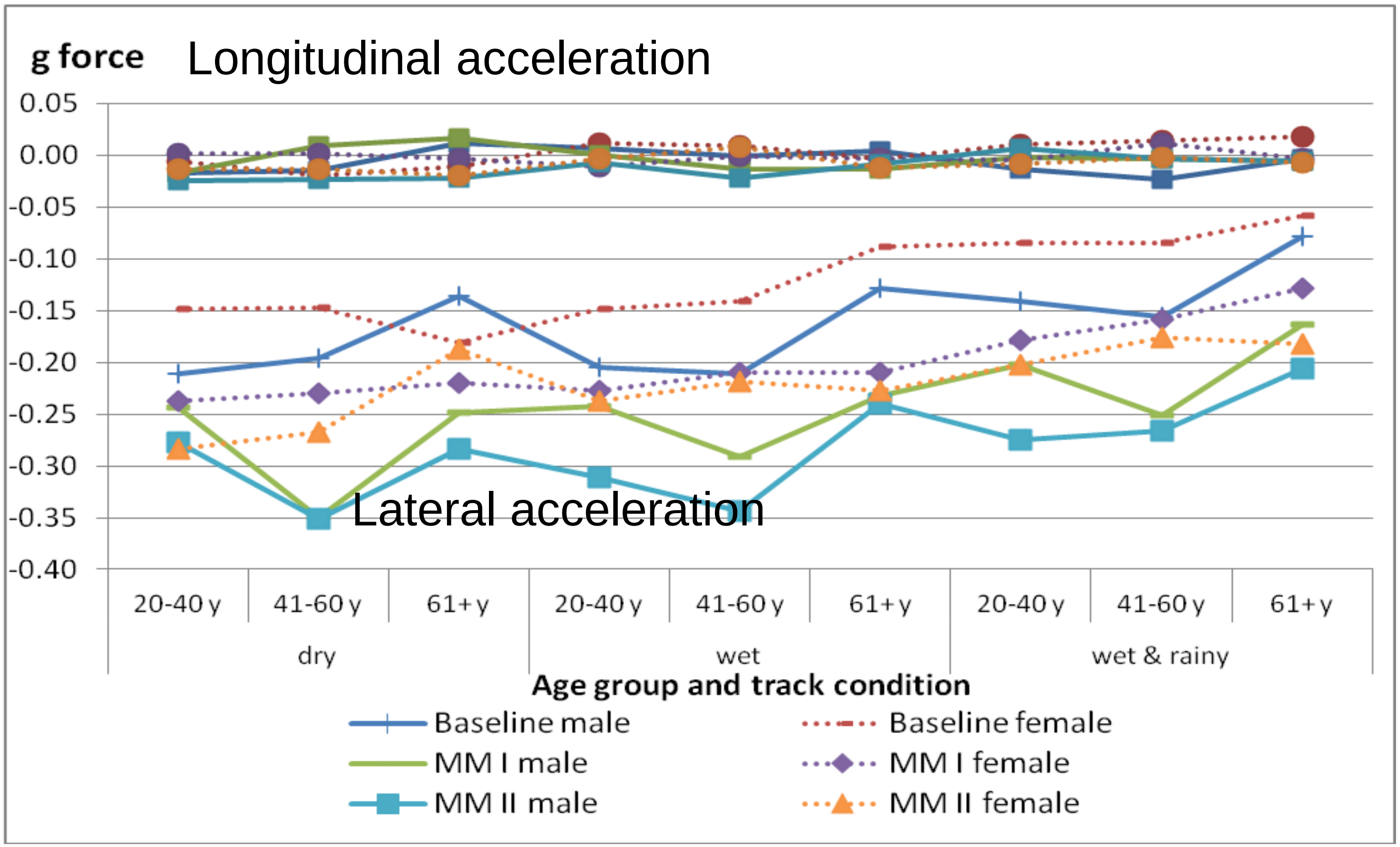
P-values from MANOVA procedures for single sectors comparing lateral and longitudinal accelerations in two different marking and track conditions, by sex

Driving performance: Lateral and longitudinal acceleration (absolute values) Example Sector 1:



This pattern is similar for all right-bend sectors!

Driving performance: Lateral and longitudinal acceleration (absolute values) Example Sector 4 (the only left-hand bend):



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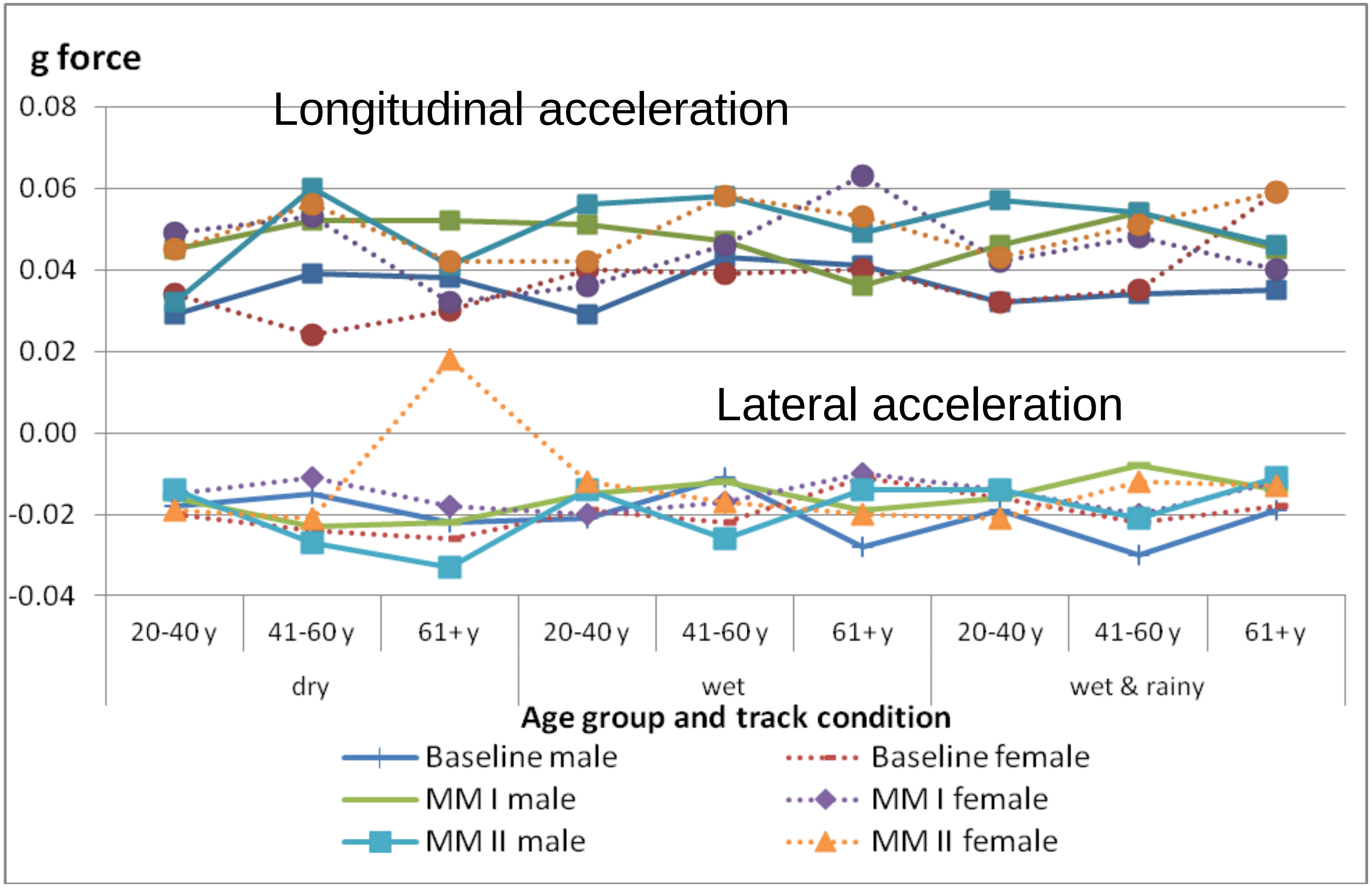
Driving performance: Lateral and longitudinal acceleration (absolute values) Example Sector 8 (straight):



Summary

The results from the track test show that:

1. Test subjects assess the test run with applied marking material II (type II folia) best compared in terms of comfort , clearness & perceptibility

2. Regarding lap times, test subjects drove slowest in the baseline condition, faster under condition with applied marking material I (type I), but fastest under condition with applied marking material II (type II)

3. When analyzing lateral and longitudinal acceleration behavior, no statistically significant differences occurred after controlling for lap time

Conclusions

No/bad road marking vs. marked road

In unknown driving circumstances, especially when there is no road marking, an application of marking material surely provides more driving comfort, decreasing the drivers uncertainty when following a route.

This holds especially true in adverse weather circumstances, e.g. at night and wet and/or rainy conditions. Surely, it can be expected that less unsafe/uncertain feeling regarding following a route has a positive impact on road safety in general. An age effect indicates that older drivers in particular benefit from road markings compared to non-equipped locations.

Hence, from a drivers point of view, type II folia seems to be a positive asset of road infrastructure compared to type I and/or no road marking.
This conclusion is suggested by questionnaire data results.

Conclusions

Marking material I vs. marking material II

Comparing both marking materials, there are less stronger effects than compared between no marking/marking conditions.

However, in terms of realized speed, there is a statistical significant difference, although differences seem small (approx. 2 km/h faster on the whole track on average).

From the track test, it finally can be concluded that marking material II (type II) does increase driving comfort and slightly increases driving speed compared to marking material I.

The higher speed should not be generally associated with a reduction in traffic safety. The speed increase was small and obviously well balanced with the increased visibility of the road marking material. In practice, one has to see if such differences occur in real driving environments (WP4, on-site tests) and if so, to which extent.

THANK YOU!

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Driving performance: Lap times – no positional effect

	Condition		
	baseline	**marking material I**	**marking material II**
Group A	**test day 1**	test day 2	test day 3
Group B	**test day 3**	test day 1	test day 2

Throughout the different marking conditions, test subjects went slowest in the baseline condition, quicker in condition MM I and quickest in condition MM II. This result is independent of a possible positional effect as e.g. group B was slowest in the baseline condition, just as group A:

	female				**male**			
track condition	Group A (n)	mean	Group B (n)	mean	Group A (n)	mean	Group B (n)	mean
BL wet	23	81.51	15	87.49	22	76.56	24	78.53
MM I wet	23	73.10	18	81.85	23	70.75	24	72.54
MM II wet	23	72.01	17	76.95	23	66.27	24	68.33
BL wet rain	23	103.32	16	115.02	23	94.80	24	94.91
MM I wet rain	23	81.68	17	94.35	23	78.23	23	80.18
MM II wet rain	23	79.31	16	84.81	23	74.69	24	74.07

Mean lap times of subjects of two groups (A,B) in different marking and track conditions by sex

Driving performance: mean speed differences

The table shows that on average the overall mean speed difference between e.g. MM I and MM II is between 2.06 km/h (female) and 2.58 km/h (male) for the whole lap (~1 km).

track condition	age group	female MM I - BL (km/h)	female MM II - BL (km/h)	female MM II vs. MM I (km/h)	male MM I - BL (km/h)	male MM II - BL (km/h)	male MM II vs. MM I (km/h)
dry	20-40 y	8.06	11.14	3.08	2.46	5.35	2.89
	41-60 y	6.57	9.26	2.69	6.85	6.19	-0.66
	61+ y	2.61	2.23	-0.38	6.93	8.86	1.93
wet	20-40 y	4.76	6.04	1.29	1.56	5.50	3.94
	41-60 y	3.48	5.59	2.11	4.04	6.08	2.04
	61+ y	4.62	5.84	1.22	5.94	8.99	3.06
wet & rainy	20-40 y	7.93	9.84	1.91	5.79	9.97	4.18
	41-60 y	6.82	9.65	2.83	6.71	9.16	2.46
	61+ y	8.20	12.01	3.81	8.20	11.58	3.38
	mean	**5.89**	**7.95**	**2.06**	**5.39**	**7.96**	**2.58**

Driving performance: Lap times

	Marking condition>>		Baseline		MM I	MM II	Sign.	Effect size	Sign.	Effect size	Sign.	
sex	track condition vv	age group	n	mean (s)	mean (s)	mean (s)	p (within, marking)	Eta²	p (within, age group)	Eta²	p (between, age group)	
female	dry	20-40 y	10	86.71	72.42	68.13	**.000****	.436	.321	.113	.939	half sample!
		41-60 y	10	86.04	74.20	70.25						
		61+ y	2	79.03	74.68	75.29						
	wet	20-40 y	15	81.42	73.40	71.49	**.000****	.659	.848	.019	.109	
		41-60 y	15	84.64	78.14	74.66						
		61+ y	8	87.01	78.15	76.11						
	wet & rainy	20-40 y	15	99.81	81.58	78.15	**.000****	.804	.100	.104	.165	
		41-60 y	15	109.09	90.16	84.10						
		61+ y	8	117.78	92.55	84.18						
male	dry	20-40 y	7	74.10	70.48	66.64	**.000****	.553	**0.006**	.32	**.006**	half sample!
		41-60 y	9	74.08	64.80	65.59						
		61+ y	4	87.08	74.41	71.51						
	wet	20-40 y	17	72.50	70.26	65.17	**.000****	.620	**.000****	.232	.229	
		41-60 y	15	73.03	67.41	64.90						
		61+ y	14	88.64	77.17	72.35						
	wet & rainy	20-40 y	17	87.39	76.48	70.14	**.000****	.622	**.040***	.109	.165	
		41-60 y	15	88.15	75.54	71.79						
		61+ y	14	108.07	86.45	79.86						

Significant differences among conditions and age interaction effect within male subjects!