Impact of mobile phone use and music on driver behaviour and safety by the use of a driving simulator

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Research Objectives

Analysis of impacts of **mobile phone use and music** to drivers' behaviour and safety through a driving simulator experiment.

Quantification of the impact of contributory factors which affect drivers' speed and safety:

- Mobile phone use;
- Music;
- Drivers' characteristics (age, gender, etc.);
- Driving style;
- Driving environment.

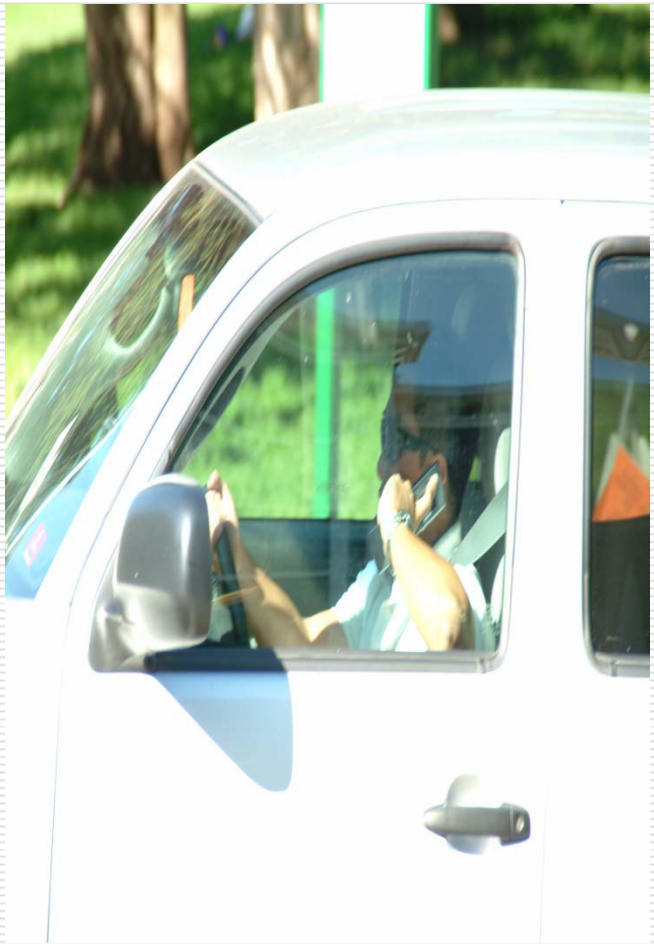
Study hypotheses – Mobile phone

Behaviour

Drivers decrease speed and increase headways in order to compensate the increased mental and physical requirements from the mobile phone use.

Safety

- Reaction time increased;
- Variation of drivers' behaviour;
- Higher risk of accident involvement.

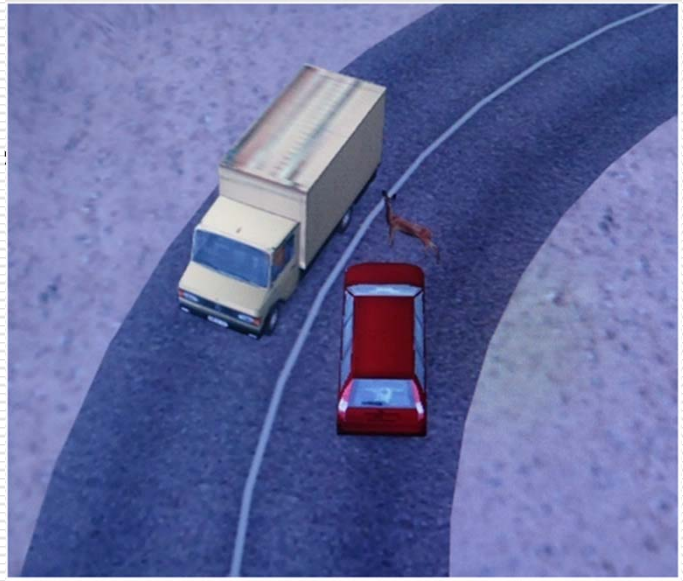


Study hypotheses – Music

- Few studies have specifically studied the distracting effects of listening to the music during driving.
- Turning on or simply listening to the radio while driving may distract a driver and degrade driving performance.
- Research results are not always converging.

Driving Simulator Experiment (1/3)

- 48 participants (age: 19 – 27),
- Route with mountainous characteristics,
- Manual unexpected event,
- 3 distractors [mobile phone (difficult/easy discussion), music],
- 2 assistants with different roles,
- 2 parts of the experiment.



Driving Simulator Experiment (2/3)

NTUA Driving Simulator was used. A medium-fidelity, quarter-cab simulator with a motion base (Foerst).

Assistant 1:

- Recording observations;
- Activation of unexpected events;
- Activation of music passage.

  (music volume at 75 dBA, song: “Sleep Now in the Fire” by Rage Against The Machine, a rap metal genre song of fast tempo (127 BPM))

Assistant 2:

- Recording route with camera;
- Make phone calls;
- Recording observations for phone calls.

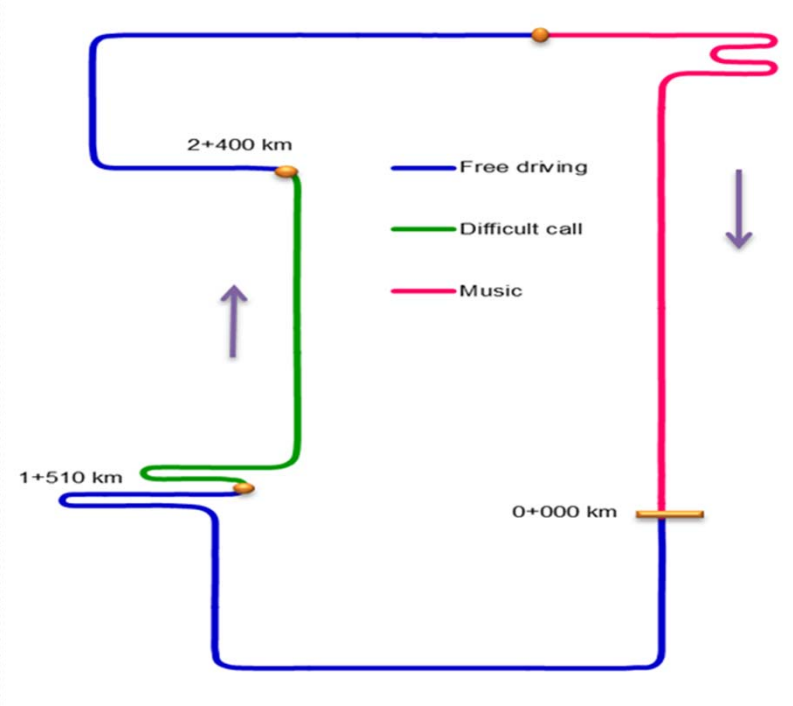
Driving Simulator Experiment (3/3)

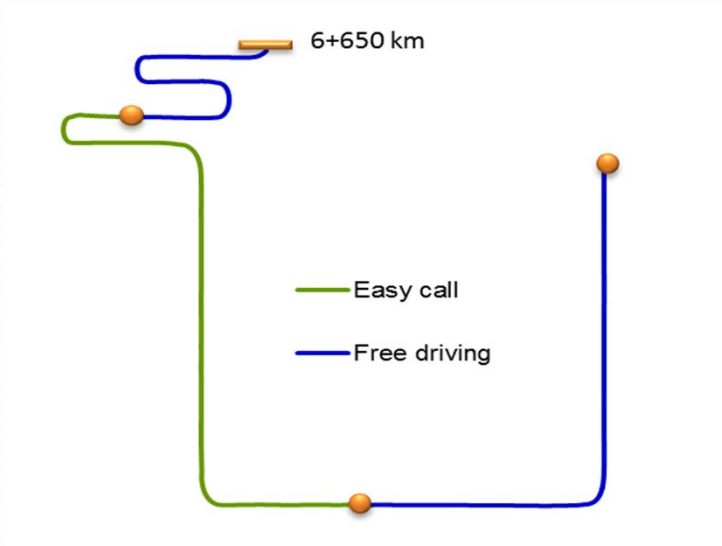
Part A:

- Completion of questionnaires;
- Briefing participants.

Part B:

- Trial route;
- Main route 6,650m
  - 2 phone calls;
  - 1 musical passage;
  - 6 unexpected events.



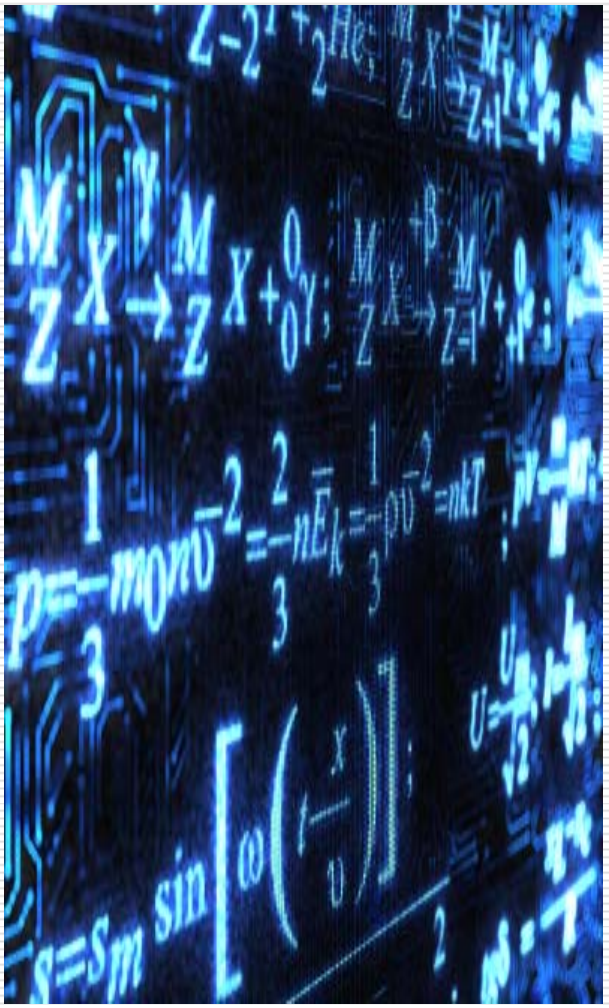


Model Development

Lognormal regression models
- speed (4 models),
- mean distance from central axis (2 models),
- reaction time (1 model).

Binary logistic regression model
Accident probability (1 model).

Elasticity was used to compare the influence of the independent variables.
Pseudoelasticity was used for nominal variables (accident probability model).

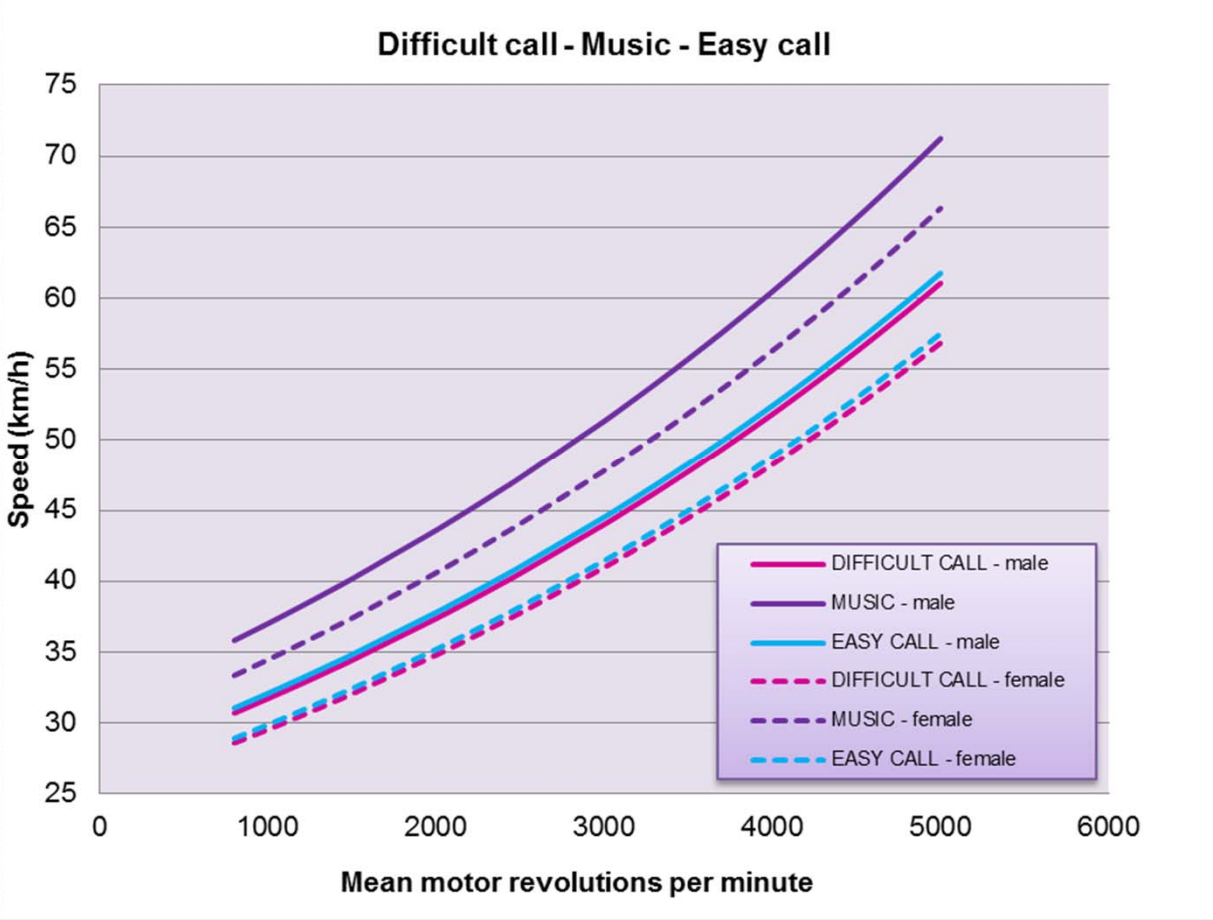


Mean speed

Explanatory variables	Difficult call			Music			Easy call			Combination of distraction factors		
	β_i	t-test value	Elasticity e_i	β_i	t-test value	Elasticity e_i	β_i	t-test value	Elasticity e_i	β_i	t-test value	Elasticity e_i
Scale variables												
Motor revolutions per minute	5.09E-05	13.842	0.097	4.97E-05	12.189	0.092	3.59E-05	9.883	0.068	7.11E-05	17.222	0.135
Mean distance from the right border	-	-	-	-0.025	-4.255	-0.024	-1.70E-02	-3.142	-0.016	-0.013	-2.235	-0.013
Mean time to collision	6.40E-06	4.955	0.032	7.77E-06	4.964	0.039	7.64E-06	5.963	0.038	-	-	-
Mean time to line crossing	-	-	-	-	-	-	-	-	-	-3.20E-05	-8.712	-0.007
Nominal variables												
Difficult call	-0.010	-1.808	-0.002	-	-	-	-	-	-	-0.027	-3.491	-0.004
Music	-	-	-	0.036	4.406	0.004	-	-	-	0.040	4.130	0.003
Easy call	-	-	-	-	-	-	-0.018	-2.970	-0.003	-0.022	-2.626	-0.002
Straight line road sections	0.138	25.615	0.032	0.169	24.959	0.037	0.149	25.729	0.038	-	-	-
Uphill road sections	-0.059	-10.776	-0.012	-0.052	-6.695	-0.008	-0.062	-9.654	-0.014	-	-	-
Gender	-0.027	-5.101	-0.007	-0.040	-6.871	-0.010	-0.033	-5.980	-0.008	-0.031	-4.925	-0.008
Weekly milage above the average	0.017	3.403	0.004	-	-	-	-	-	-	-	-	-
Mobile phone use while driving more than once a day	-	-	-	-	-	-	-0.020	-3.702	-0.004	-	-	-
Driver considers talking in the mobile phone as a high risk activity	-0.045	-6.176	-0.004	-	-	-	-0.023	-2.942	-0.002	-	-	-
Trouble answering the easy phone call question	-	-	-	-	-	-	-0.020	-3.595	-0.004	-0.028	-4.274	-0.006
R^2	0.581			0.617			0.621			0.234		

- Mobile phone use while driving reduced speed regardless of the difficulty level of call as opposed to music which tend to increase.

Mean speed and mean motor revolutions per minute



- Higher speed with music passage while driving, whereas lower speed for difficult calls while driving.

Mean distance from central axis

Explanatory variables	Difficult call					
	β_i	t-test value	Elasticity e_i		t-test value	Elasticity
Scale variables						
Headway	-4.70E-06	-5.519	-0.158	-	-	-
Wheel revolution to the left	-0.002	-13.679	-0.104	-	-	-
Wheel revolution to the right	-	-	-	0.001	10.194	0.05585653
Mean time to line crossing	-3.80E-05	-9.438	-0.080	0.000	-8.89E+00	-0.0417013
Nominal variables						
Difficult call	0.013	1.949	0.015	-	-	-
Easy call	-	-	-	0.015	2.157	0.01402283
Uphill road section	-	-	-	-0.052	-8.628	-0.0803329
Closed curves	-0.032	-4.007	-0.023	-	-	-
Gender	0.017	2.767	0.025	0.018	2.904	0.02591474
Driver is accustomed to use a bluetooth device	0.050	3.599	0.008	0.051	3.43	0.007
Previous involvement in a mobile phone related accident	-0.079	-5.247	-0.016	-0.047	-3.114	-0.0094698
Trouble answering the easy phone call question	-	-	-	0.016	2.546	0.02007066
Weekly milage above the average	-0.016	-2.664	-0.025	-0.016	-2.642	-0.0244914
R^2	0.244					

- Mean distance from central axis increased using mobile phone regardless of the difficulty level of the conversation.

Reaction time

Difficult talk:

Explanatory Variables	β_i	t-test value	Elasticity e_i
Scale variables			
% use of brake	-0.002	-2.000	-0.109
Wheel revolution to the right	3.87E-04	1.776	0.353
Nominal variables			
Difficult call	0.114	3.710	0.135
Gender	-0.044	-1.798	-0.218
Tangent road section	0.129	4.101	1.996
Trouble answering the difficult phone call question	0.071	2.581	0.457
R^2	0.149		

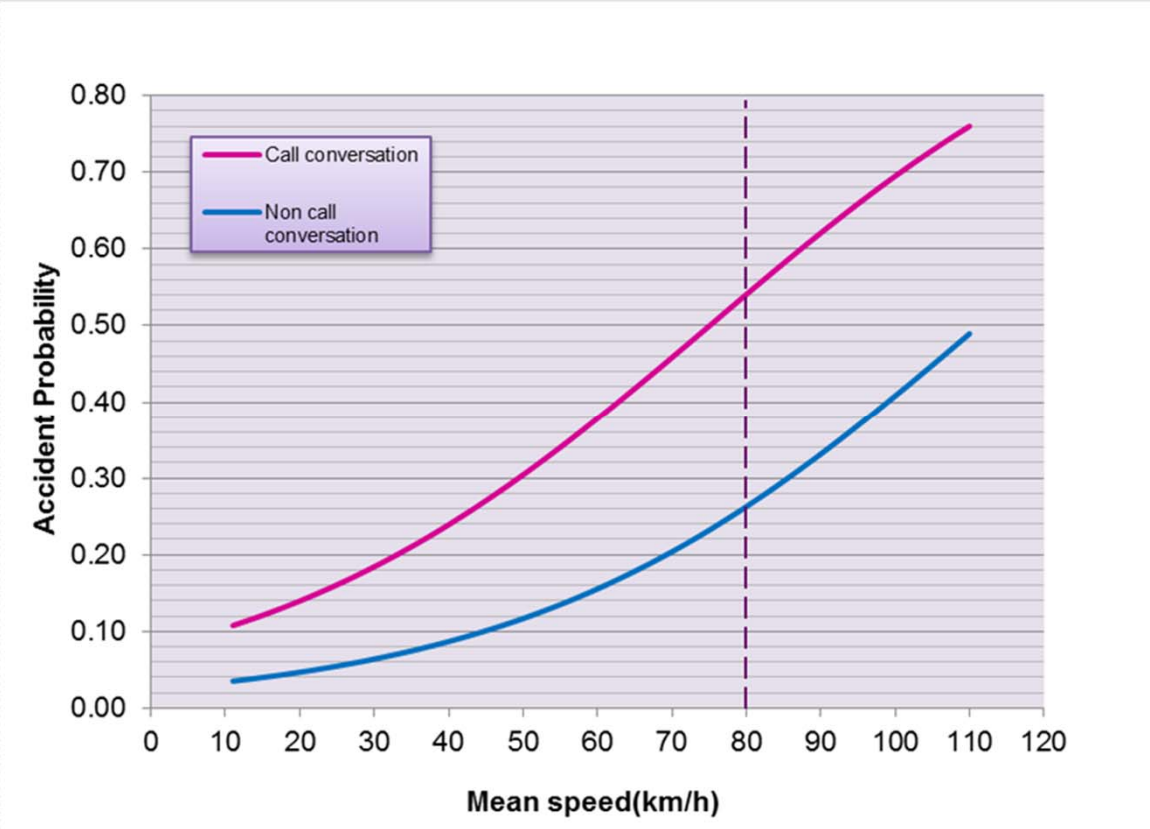
- Reaction time increased for mobile phone usage while driving.
- Reaction time increased for drivers who were troubled answering the difficult phone call question.

Accident Probability

Explanatory variables	β_i	Wald	Elasticity
Scale variables			
Reaction time in case of an unexpected event	3.066	29.534	2.198
Mean speed	0.033	2.921	0.774
Nominal variables			
Difficult call	1.195	5.663	0.890
Driver enjoys driving	-1.063	3.342	-0.421
Driver considers talking on the mobile phone as a non risk activity	-1.465	1.930	-0.586
Likelihood Ratio = 53.762 (6 degrees of freedom)			

- From scale variables, reaction time leads to statistically significant increase of accident probability.
- From nominal variables, difficult call increase the accident probability to a greater extent.

Accident probability and mean speed



- Accident probability increased when drivers used mobile phone.
- Higher increase was observed in speed 80km/h, where the accident probability almost doubled when drivers used mobile phones.

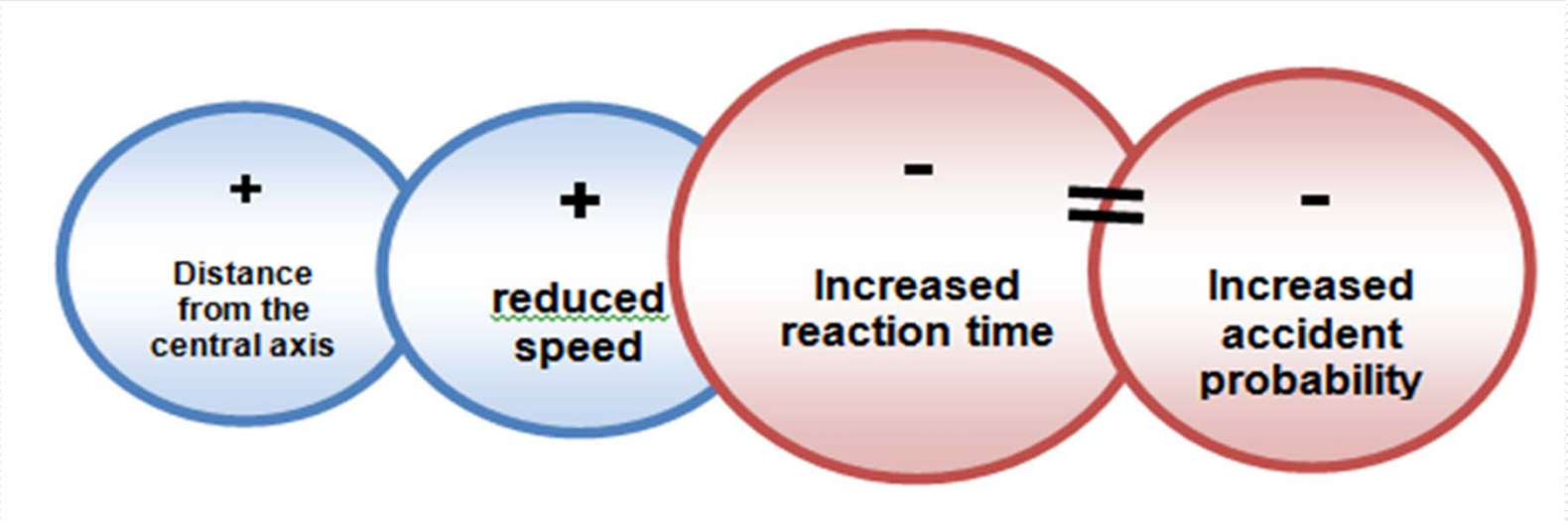
Conclusions (1/2)

- Mobile phone use (easy and difficult call) leads to decrease of drivers' speed, whereas music leads to increasing it.
- Comparing the three driving distraction factors, showed that difficult call has the greater impact, on mean speed, followed by music and easy call
- Drivers who find it very difficult to use mobile phone while driving, drive at slower speed than the others even when they are not using mobile phone.

Conclusions (2/2)

- Using mobile phone (easy and difficult call) leads to statistically significant increase of the distance from the central axis.
- Difficult call increased reaction time in case of unexpected events.
- Difficult call leads to increase of accident probability in case of unexpected events.
- There was no statistically significant increase of reaction time and of accident probability due to easy call or music.

Distracted driving accident risk – The Mechanism



The decrease in speed
and the increase in the distance from the central axis,
during distracted driving might be considered beneficial for road safety,
however, they cannot always counter-balance
the related increased reaction times,
and eventually increased accident probability,
especially at unexpected incidents.

Recommendations – Further Research

- Further explore functions behind distraction activities
- Separate impact from the various distraction factors
- Examine the combined effect of the various distraction factors
- **Link distraction-associated driver behaviour with accident risk**
- Cross validation through experiments (driving simulator, naturalistic driving) and epidemiological studies

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