



Mental Workload Influence of Drivers Reaction Time on Unexpected Events: A Driving Simulation Study

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objective

- investigation of the effect of increased Mental Workload (MWL) on driver behavior and specifically the changes in driver's RT while driving under increased MWL

methodology

- driving simulator experiment
- statistical analysis, for the analysis of the driving performance based on relevant parameters (RT, maneuver performance, accident occurrence).

context

- doctoral dissertation concerning the study of out-of-the-vehicle factors that influence driving behavior.
- The approach focuses on Greek drivers, emphasizing driver's reactions to visual stimuli.

The concept of Mental Workload (MWL)

MWL reflects “the level of attentional resources required to meet both objective and subjective performance criteria, which may be mediated by task demands, external support, and past experience” (Young et al., 2015)

Multidimensional concept, determined by

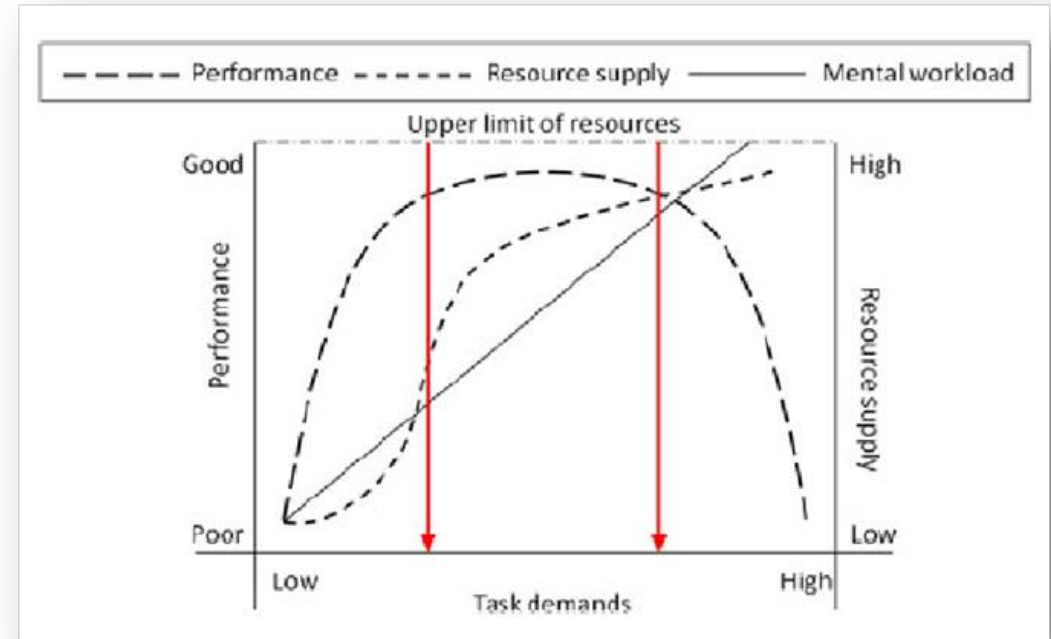
- the requirements of the task,
- the prevailing conditions,
- the driver.



The concept of Mental Workload (MWL)

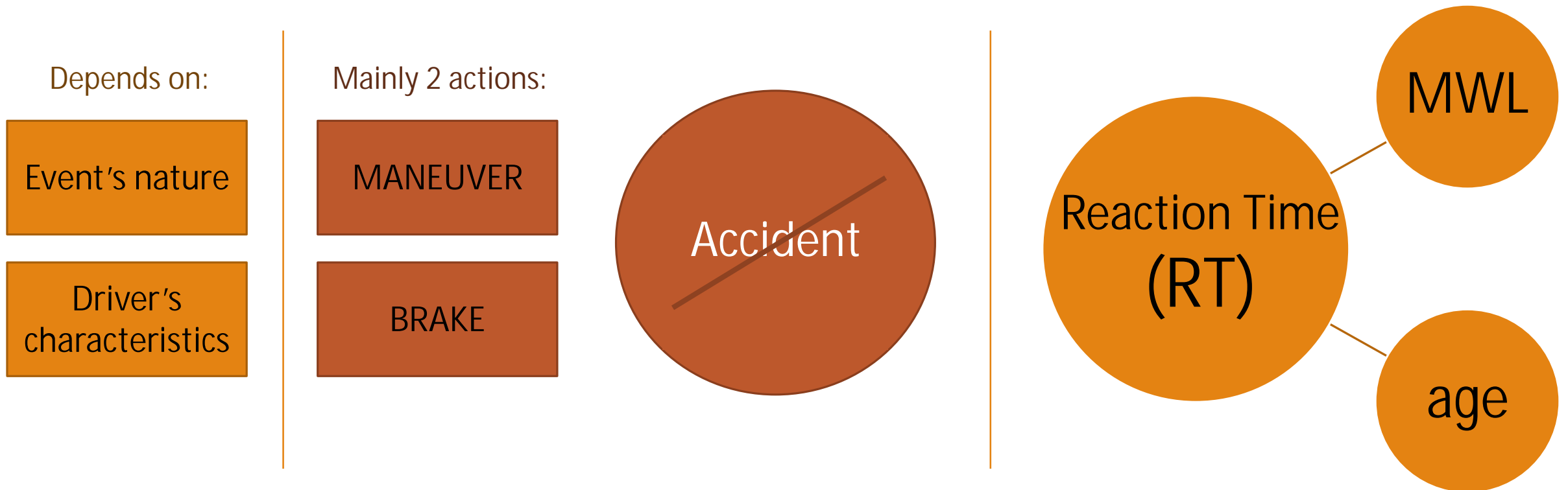
Crucial role in road safety:

- too low MWL (underload): causes boredom that reduces driver's alertness and attention (lack of vigilance), resulting in increased errors,
- too high MWL (overload): reduces driver's concentration, ability to process information and make decisions, leading to high levels of stress and often increased errors.



The driving task and the unexpected events

An unexpected situation demands priority, activating a compensation process to ensure safety.



Methodology

| | |
|------------------|--|
| Environment | Driving Simulator of the Hellenic Institute of Transport / Centre for Research and Technology Hellas |
| Vehicle | Mercedes Benz Smart Dynamic platform - feedback Automatic gearbox |
| Driving scenario | 6km drive in a rural road environment |



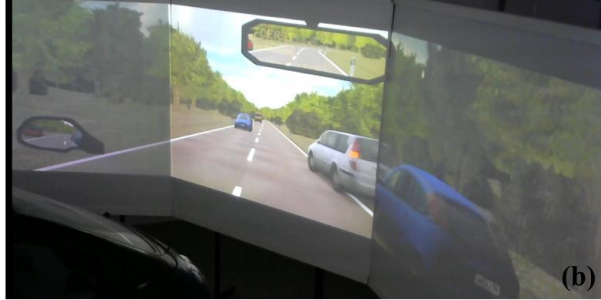
Research environment: driving simulator

The laboratory environment:

- ensures safety of the participants,
- allows complete control of the studied conditions,
- permits repeatability of the studied conditions, and
- facilitates the use of measurement equipment.

- High cost of a driving simulator experiment.
- The actual driving conditions can be simulated only approximately.
- Challenge to ensure the realistic response of the driver.
- Simulator sickness.

UNEXPECTED EVENTS



| | | | |
|---|----------|-----------|--|
| 1 | 2,170 km | Donkey: | A donkey stands behind a bush and crosses the road when the driver approaches (Figure a). |
| 2 | 3,010 km | Vehicle1: | A parked vehicle behind another parked vehicle at the side of the road, leaves its parking slot, drives in front of driver and parks again later at the side of the road (Figure b). |
| 3 | 4,760 km | Child: | Opposite a farmhouse, behind a parked vehicle, a red ball runs in the road and a child follows crossing the road (Figure c). |
| 4 | 5,000 km | Vehicle2: | Beside a parking, there are a lot of parked vehicles, the last one -in the row- leaves its parking slot, drives in front of driver and parks again later at the side of the road (Figure d). |

UNEXPECTED EVENTS

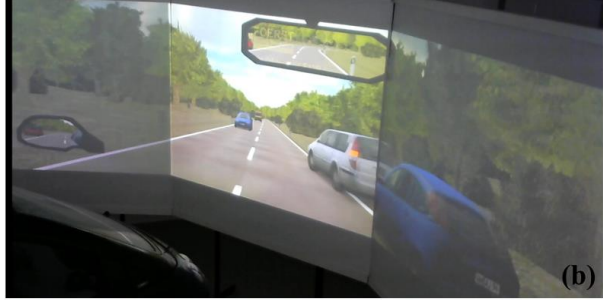
relevant to the driving task sources



| | | | |
|---|----------|-----------|--|
| | | | |
| 2 | 3,010 km | Vehicle1: | A parked vehicle behind another parked vehicle at the side of the road, leaves its parking slot, drives in front of driver and parks again later at the side of the road (Figure b). |
| | | | |
| 4 | 5,000 km | Vehicle2: | Beside a parking, there are a lot of parked vehicles, the last one -in the row- leaves its parking slot, drives in front of driver and parks again later at the side of the road (Figure d). |

UNEXPECTED EVENTS

irrelevant to the driving task sources



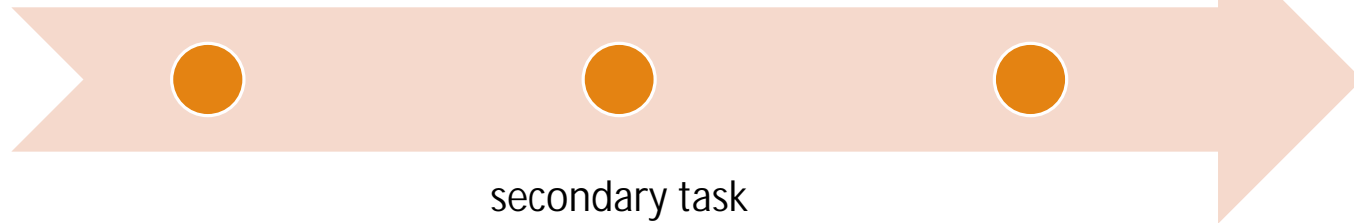
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DDRT secondary task



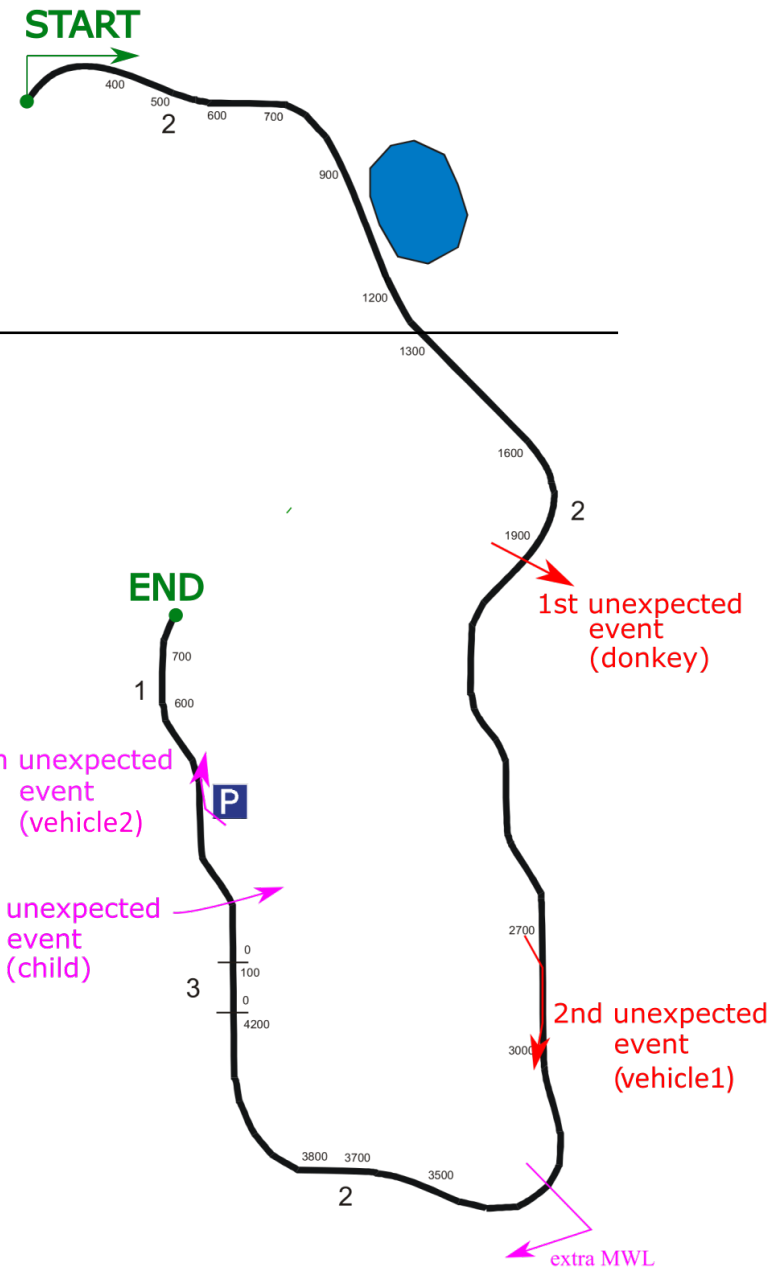
MIT AgeLab
Delayed Digit Recall
Task (n-back)
(DDRT) (1-back
version)

For the simulation
of the increased
MWL conditions

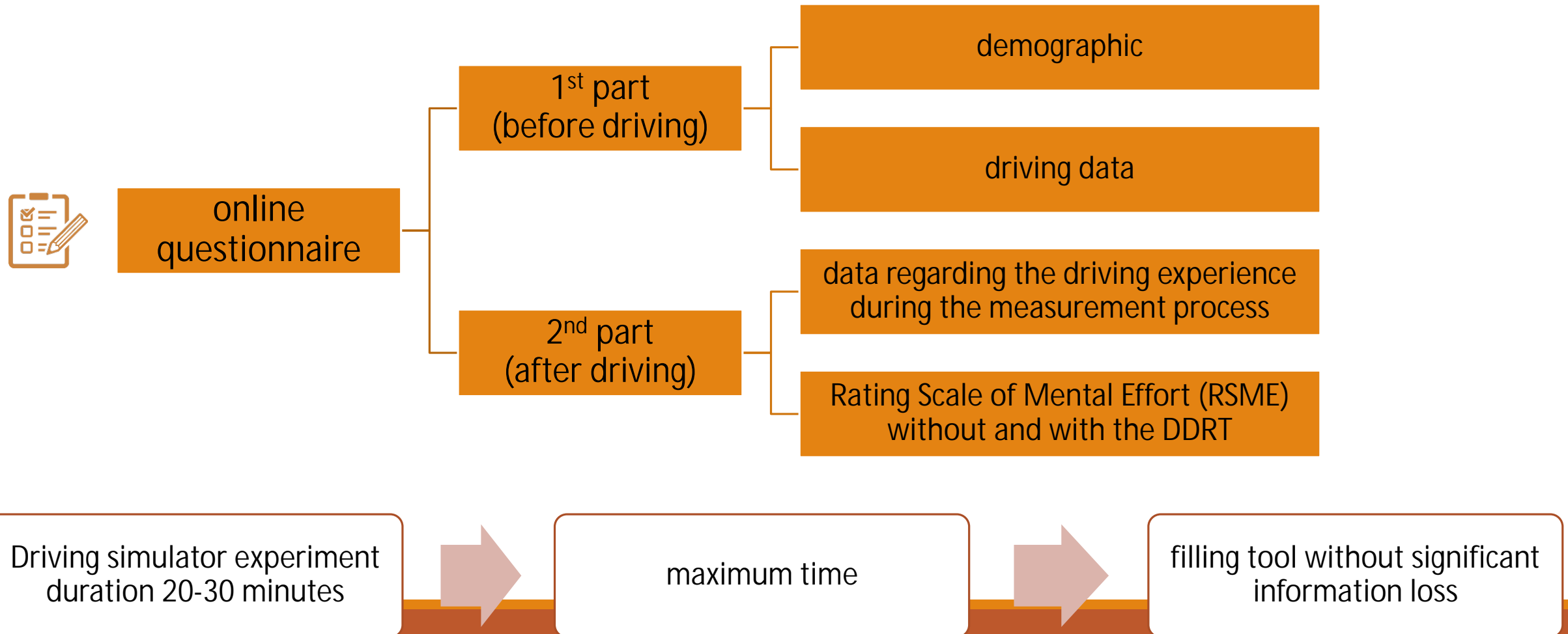


Listen:
Say:

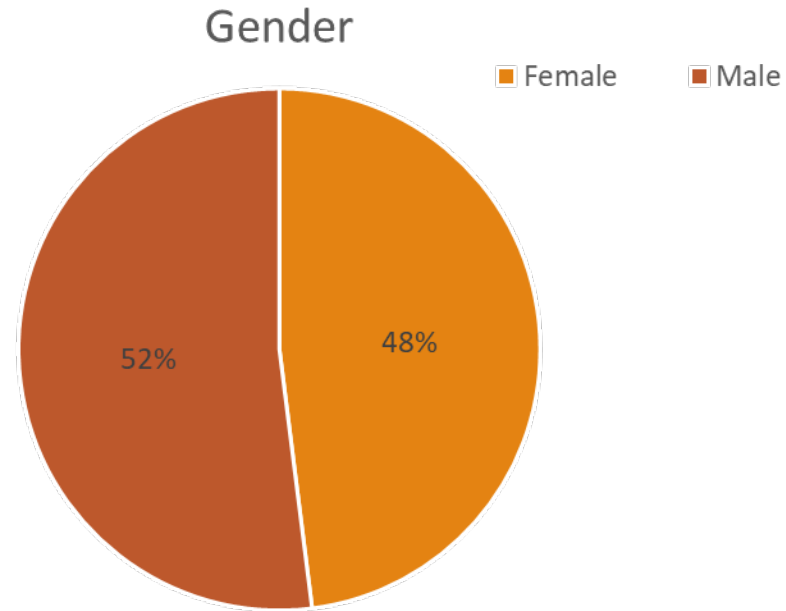
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 1 | 6 | 3 | 4 | 8 | 0 | 5 | 2 | 9 |
| - | 7 | 1 | 6 | 3 | 4 | 8 | 0 | 5 | 2 |



Questionnaire



Sample:
56 drivers



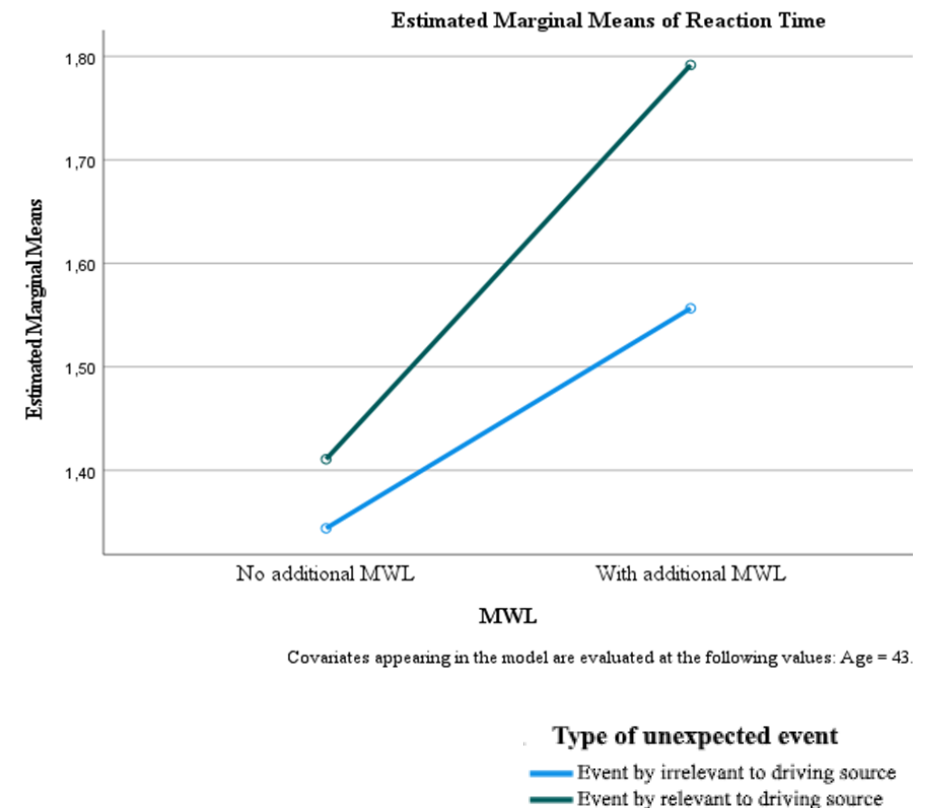
Gender

| Age group | N | Mean | SD | Male | | Female | |
|-----------|----|------|-------|------|------|--------|------|
| | | | | N | % | N | % |
| 18 - 25 | 6 | 0.50 | 0.548 | 3 | 10% | 3 | 11% |
| 26 - 40 | 19 | 0.47 | 0.513 | 10 | 34% | 9 | 33% |
| 41 - 55 | 17 | 0.47 | 0.514 | 9 | 31% | 8 | 30% |
| > 56 | 14 | 0.50 | 0.519 | 7 | 24% | 7 | 26% |
| Total | 56 | 0.48 | 0.504 | 29 | 100% | 27 | 100% |

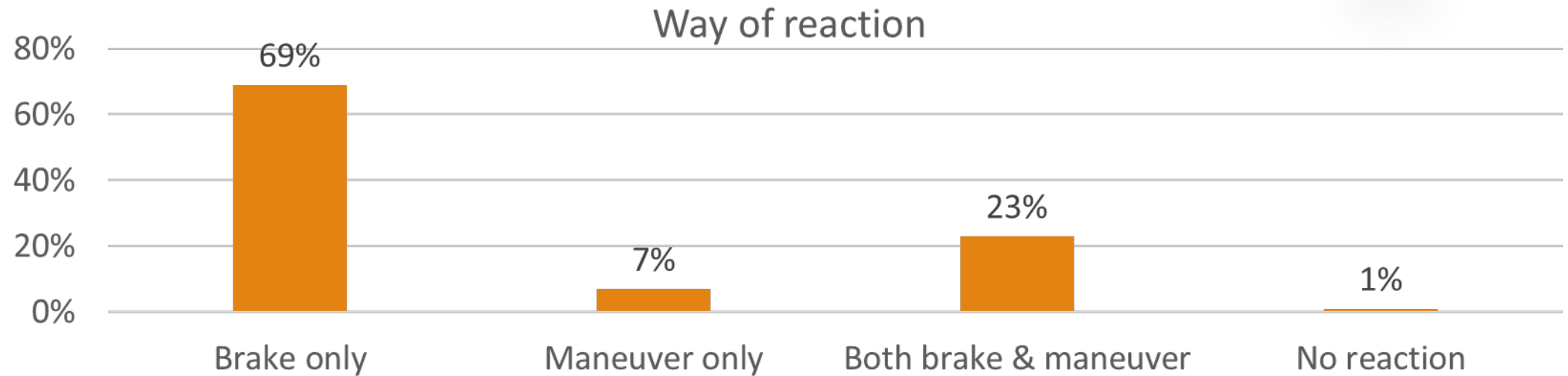
Analysis & Results: Effect of MWL and type of the unexpected event to the driving task, on RT

Two-way ANOVA - Tests of Between-Subjects Effects

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---------------------|-------------------------|-----|-------------|---------|-------|---------------------|
| Corrected Model | 17.363a | 4 | 4.341 | 33.674 | .000 | .387 |
| Intercept | 13.416 | 1 | 13.416 | 104.077 | .000 | .328 |
| MWL | 10.781 | 1 | 10.781 | 83.635 | <.001 | .282 |
| Type of event | 4.791 | 1 | 4.791 | 37.167 | <.001 | .149 |
| MWL * Type of event | 1.240 | 1 | 1.240 | 9.617 | .002 | .043 |
| Error | .386 | 1 | .386 | | | |
| Total | 27.457 | 213 | .129 | | | |
| Corrected Total | 555.013 | 218 | | | | |



Analysis & Results: *Way of reaction*



33 accidents /
224 unexpected events

15%
of events

Analysis & Results: Effect of MWL and type of the unexpected event to the driving task, on maneuver execution

Binary logistic regression on maneuver execution - Variables in the equation: MWL, Type of event

| | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I. for EXP(B) | |
|---------------|--------|------|--------|----|------|--------|---------------------|-------|
| | | | | | | | Lower | Upper |
| MWL | 1.032 | .310 | 11.077 | 1 | .001 | 2.807 | 1.528 | 5.154 |
| Type of event | -.137 | .303 | .205 | 1 | .650 | .872 | .482 | 1.578 |
| Constant | -1.399 | .282 | 24.591 | 1 | .000 | .247 | | |



Analysis & Results: Effect of MWL and type of the unexpected event to the driving task, on accident occurrence

Binary logistic regression on accident occurrence - Variables in the equation: MWL, Type of event

| | B | S.E. | Wald | df | Sig. | Exp(B) | 95% C.I. for EXP(B) | |
|---------------|------|------|-------|----|------|--------|---------------------|-------|
| | | | | | | | Lower | Upper |
| MWL | .407 | .435 | .877 | 1 | .349 | 1.503 | .641 | 3.526 |
| Type of event | .340 | .417 | .664 | 1 | .415 | 1.405 | .620 | 3.181 |
| Constant | .644 | .478 | 1.815 | 1 | .178 | 1.904 | .746 | 4.857 |



Discussion & Conclusions



Higher MWL increases drivers' RT, deteriorating driving performance

- lower RT in the presence of high MWL could be attributed to adaptive control behaviours



The type of the unexpected event, affect driver's RT

- higher RT in relevant to the driving task sources events (vehicle1, vehicle2)



Way of reaction to the unexpected events:

- dominance of the brake use, alone or along with the execution of a maneuver
- MWL affects maneuver execution: drivers "forget" to maneuver in conditions of high MWL

Discussion & Conclusions

- Important role of MWL on driver performance: further research on
 - its consequences on driving performance, and
 - the factors that influence its variance during driving.
- Source creating the unexpected event: important influencing factor of driver's RT.
- Opt for braking or steering maneuver should be further investigated.

thank you

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