Analysis of a driver model sensitivity to various types of distraction

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An interdisciplinary collaboration

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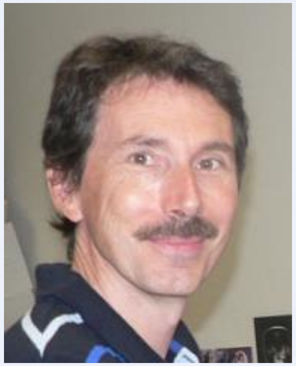

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The problem

Distraction as an increasing cause of accidents

- Less and less people die on the road
- 17% increase in accidents due to driver distraction (2011-2015)

Countermeasure: driver state monitoring

- direct observation of the driver (eye and head tracking,…)
- observation of the consequences of distraction on vehicular control

A key problem: to predict the driver behaviour

Our approach: to base driver monitoring on a driver model

Different types of distraction

Distraction as any situation where the driver is diverted from the driving task

It may be:

- Visual: eyes off the road
- Cognitive: mind off the road
- Motor: hands off the steering wheel
- Any combination of the three above

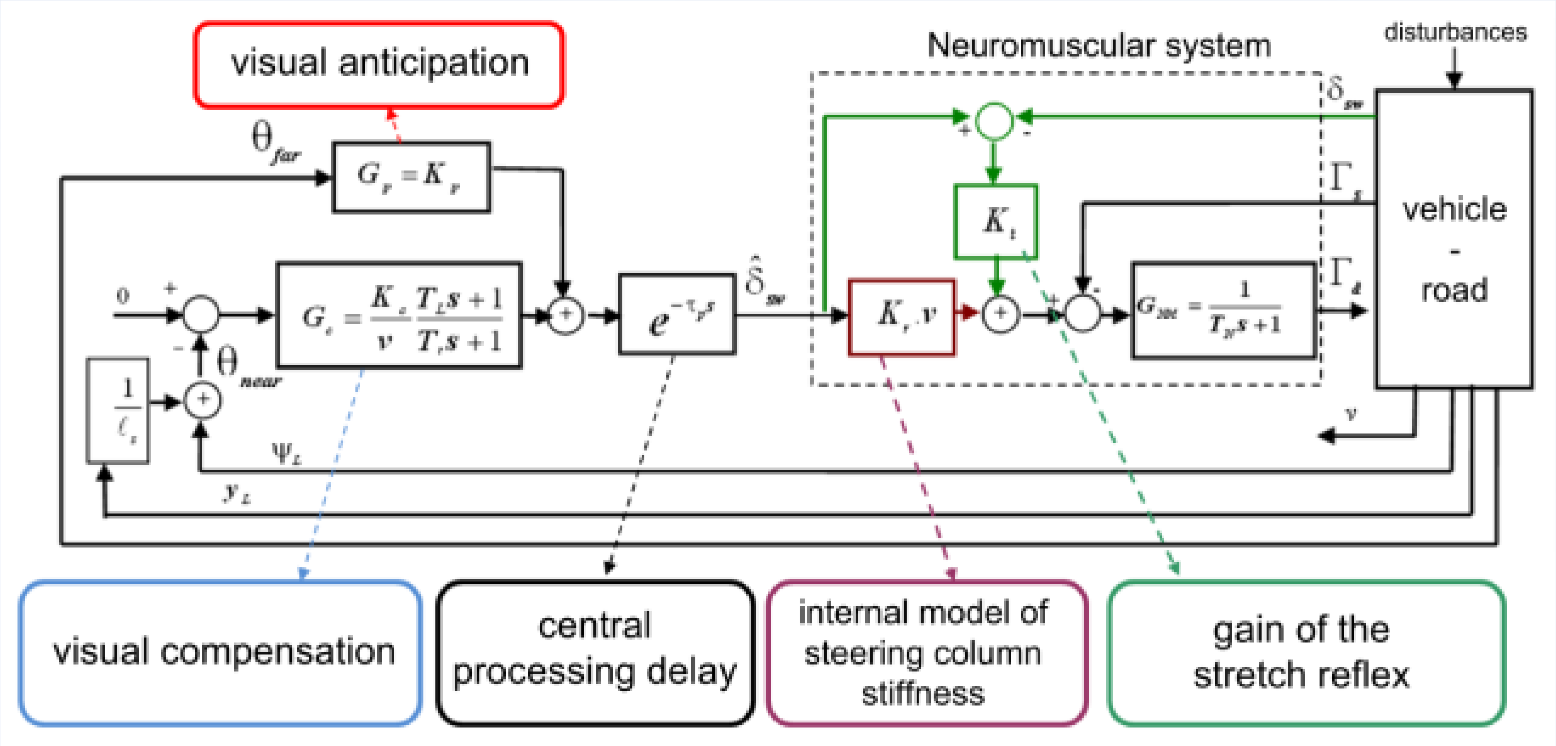
Different types of distraction, different processes impacted, different effects on steering behaviour

What we need

A model of steering control

- A model that processes information from the visual scene
- A motor system that converts steering intention into actions

Our driver model



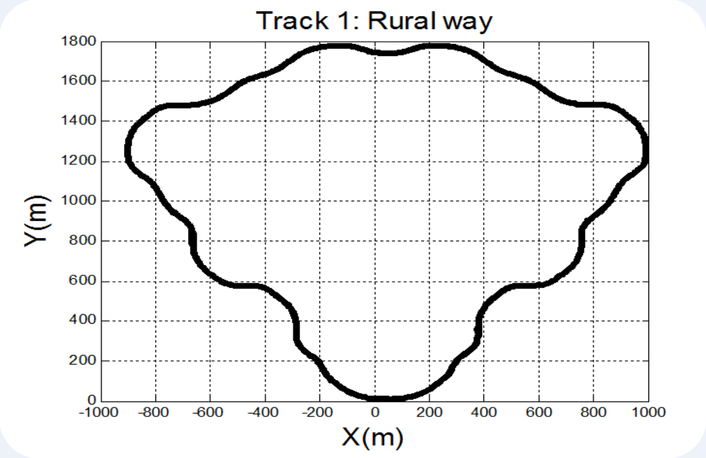
Saleh et al. (2011) IFAC World ; Mars et al (2011), HFES

A cybernetic model:

- designed as a function of current knowledge on perceptual and motor processes
- that can be identified in various driving situations

When the driver model drives

Setup and procedure



35 participants

- 25 men and 10 women
- 21 to 60 years old (mean: 32)

Fixed-based simulator using SCANeR Studio

15 km of driving on a winding track

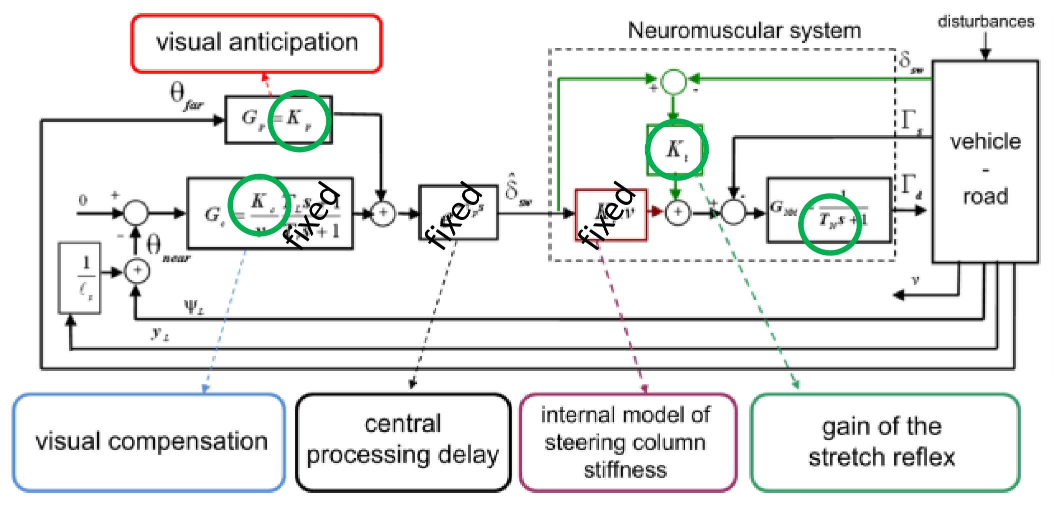
Succession of undistracted and distracted driving periods (1,15 min each)

- cognitive distraction (backward counting)
- visual distraction (peripheral reading)
- motor distraction (dialing)
- visuomotor distraction (dialing + eyes-off-road)
- one-hand driving (without distraction)

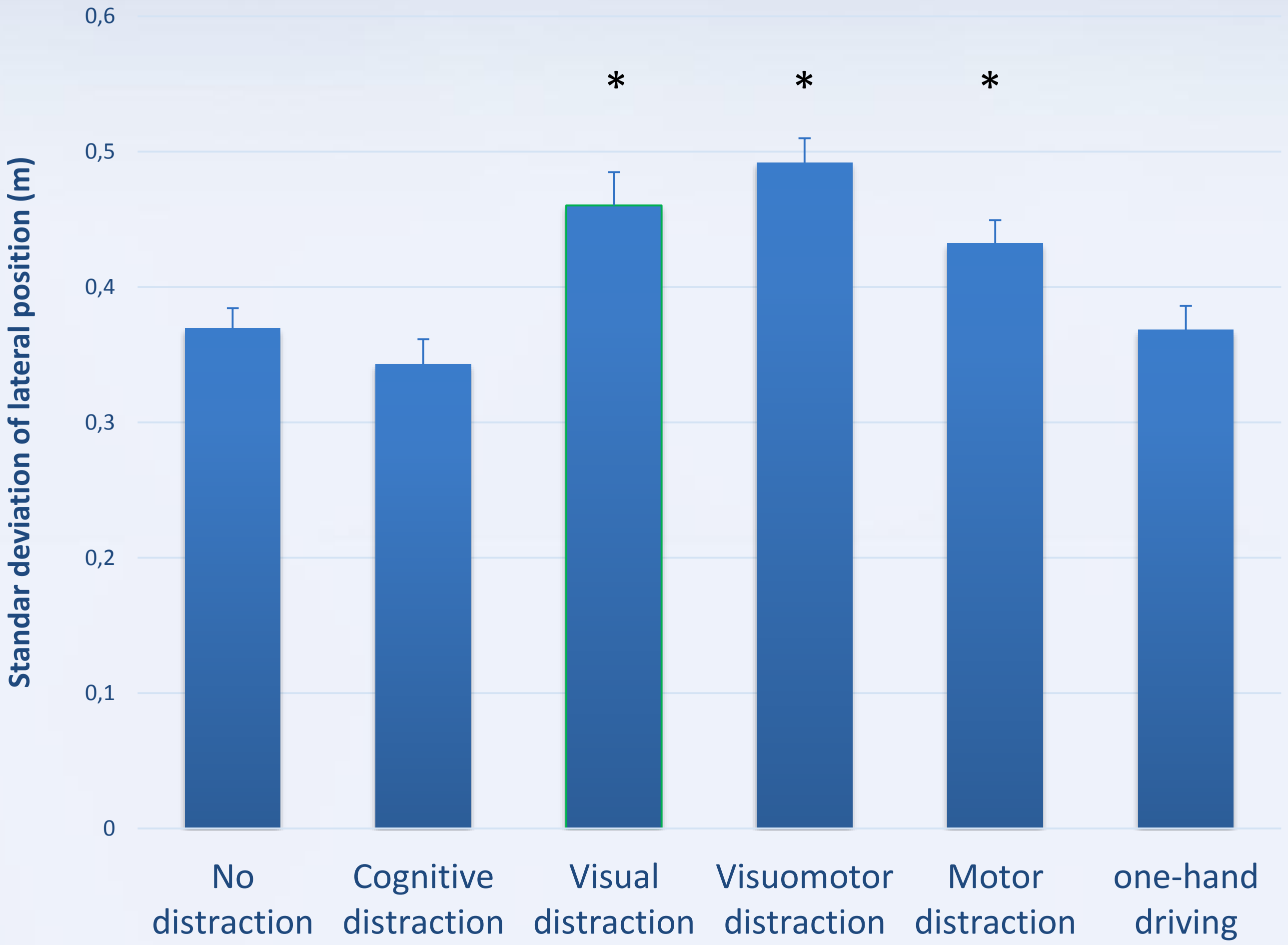
Data analysis

Analyses of variance + Dunnet tests were performed on:

- two indicators of steering behavior
  - Standard deviation of lateral position (SDLP)
  - Steering wheel reversal rates (SWRR)
- 4 parameter values obtained after identification by the prediction error method
  - Kp : visual anticipation gain
  - Kc : visual compensation gain
  - Kt : motor correction gain
  - Tn : time constant of muscular dynamics

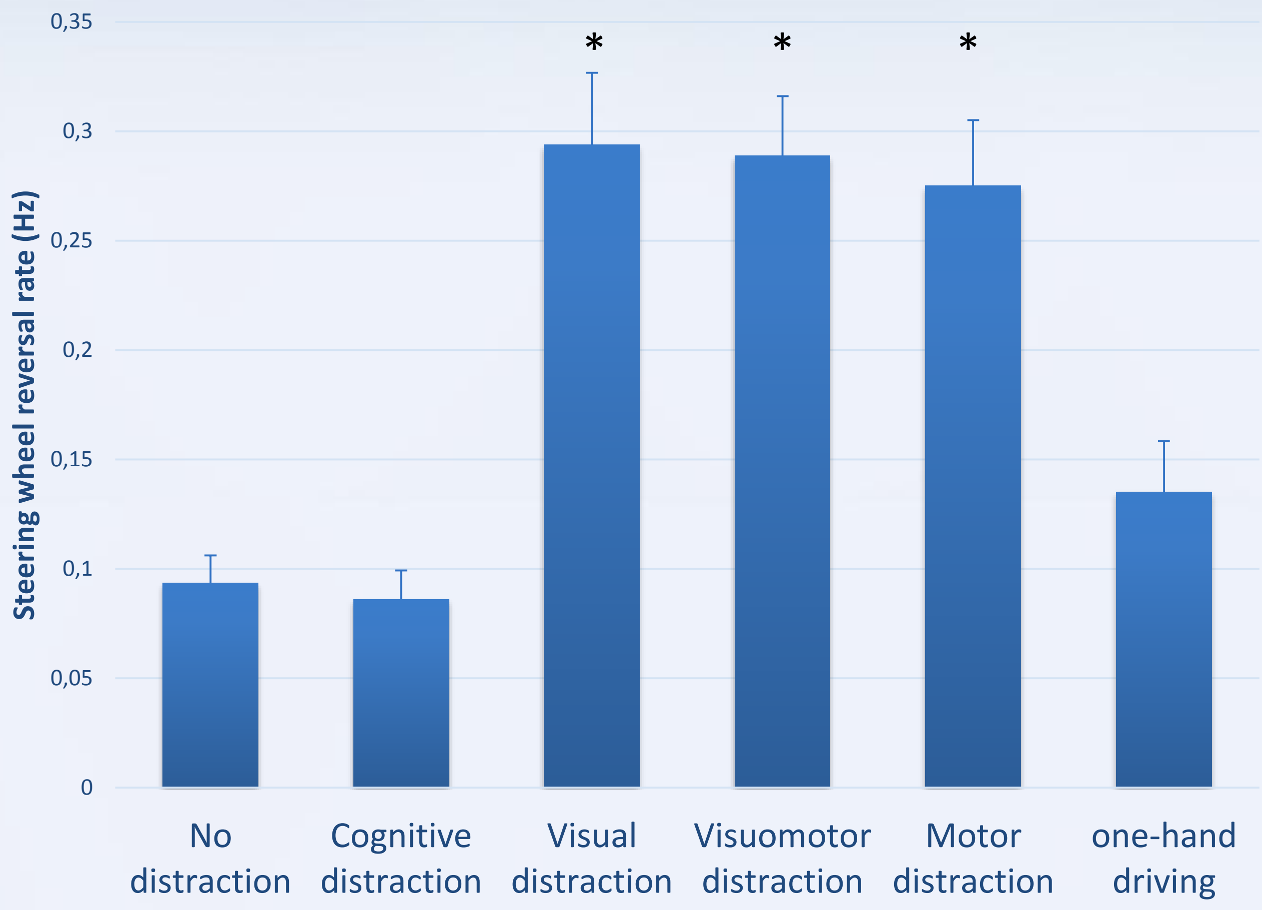


Lateral position variability



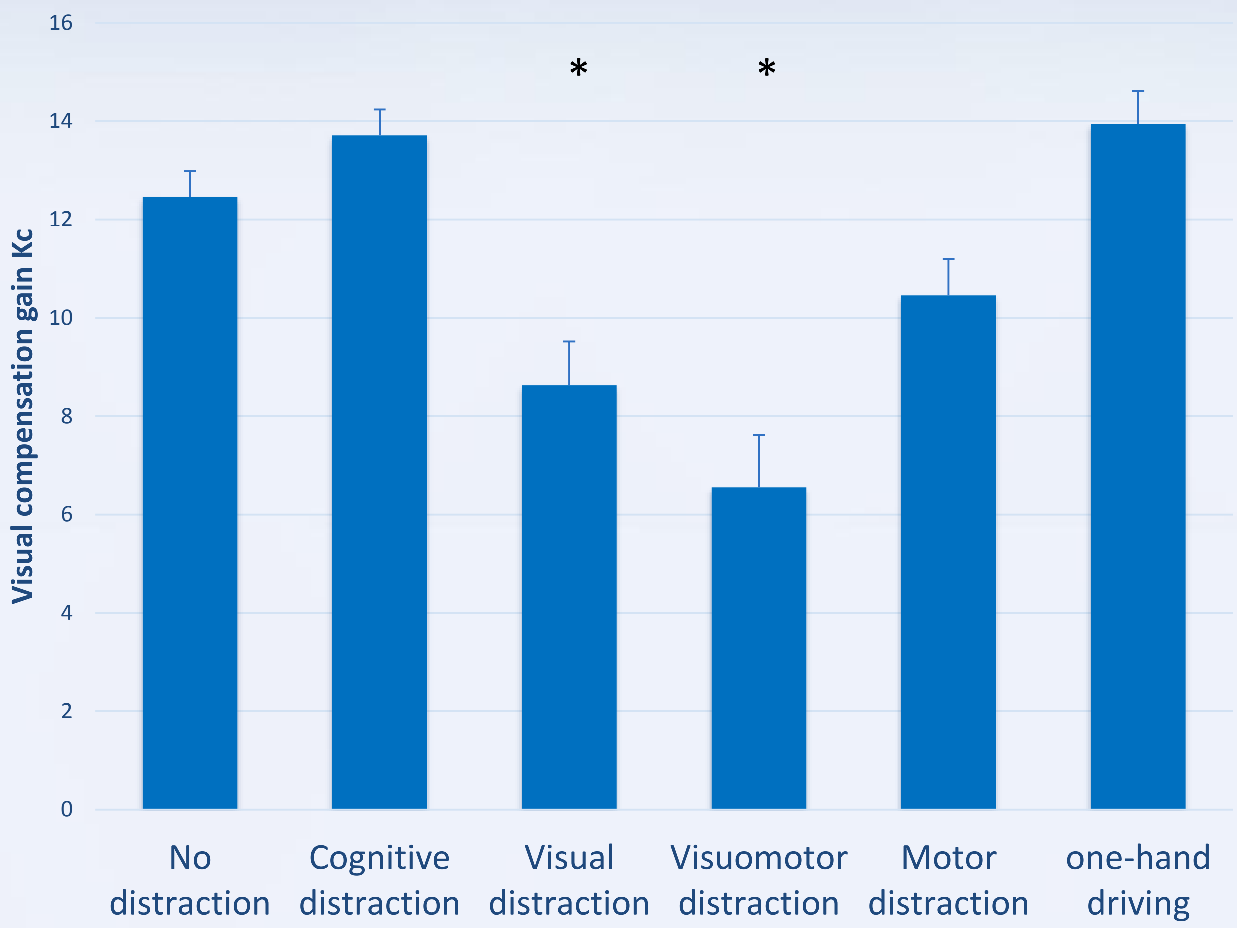
Lateral position variability increases with V, M and VM distraction

Steering wheel reversals



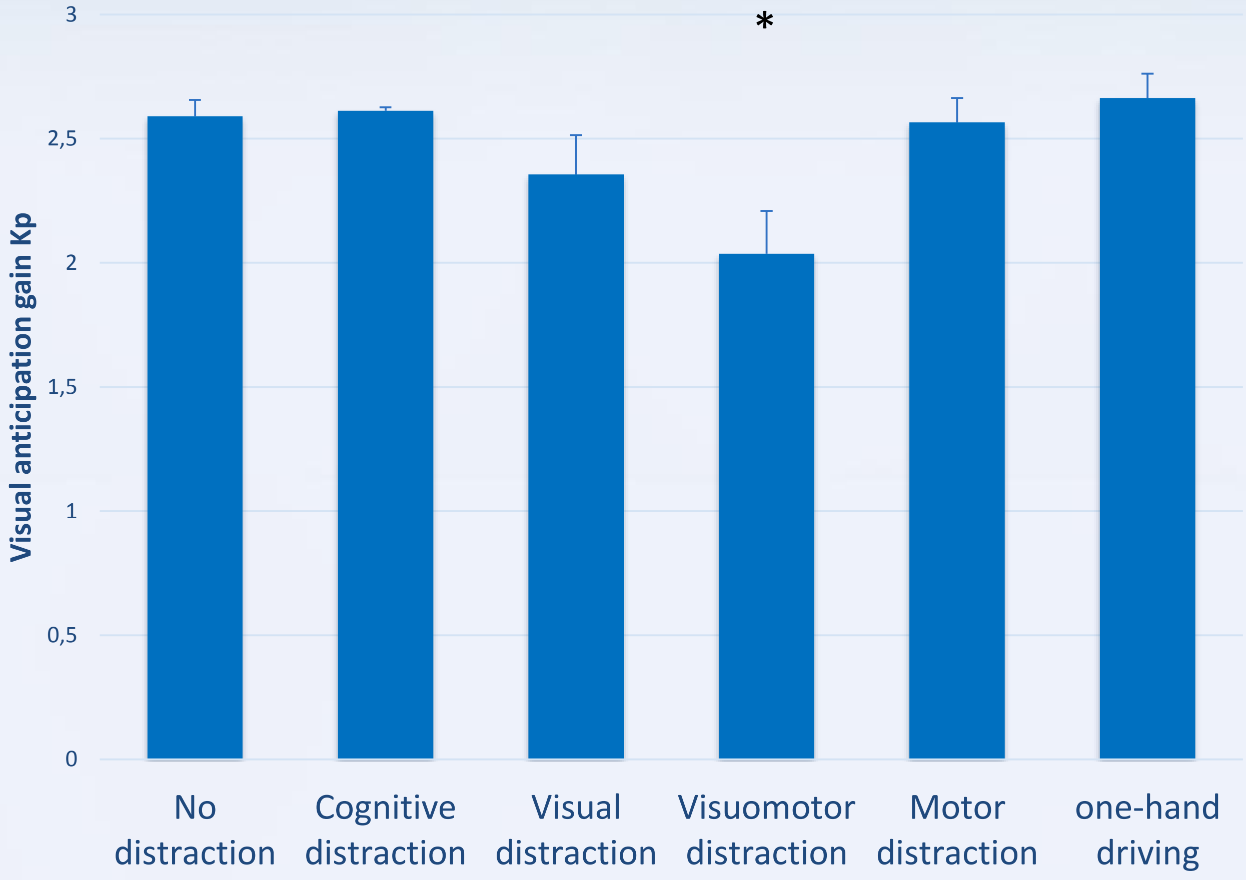
Steering wheel reversal rate increases with V, M and VM distraction

Visual compensation gain



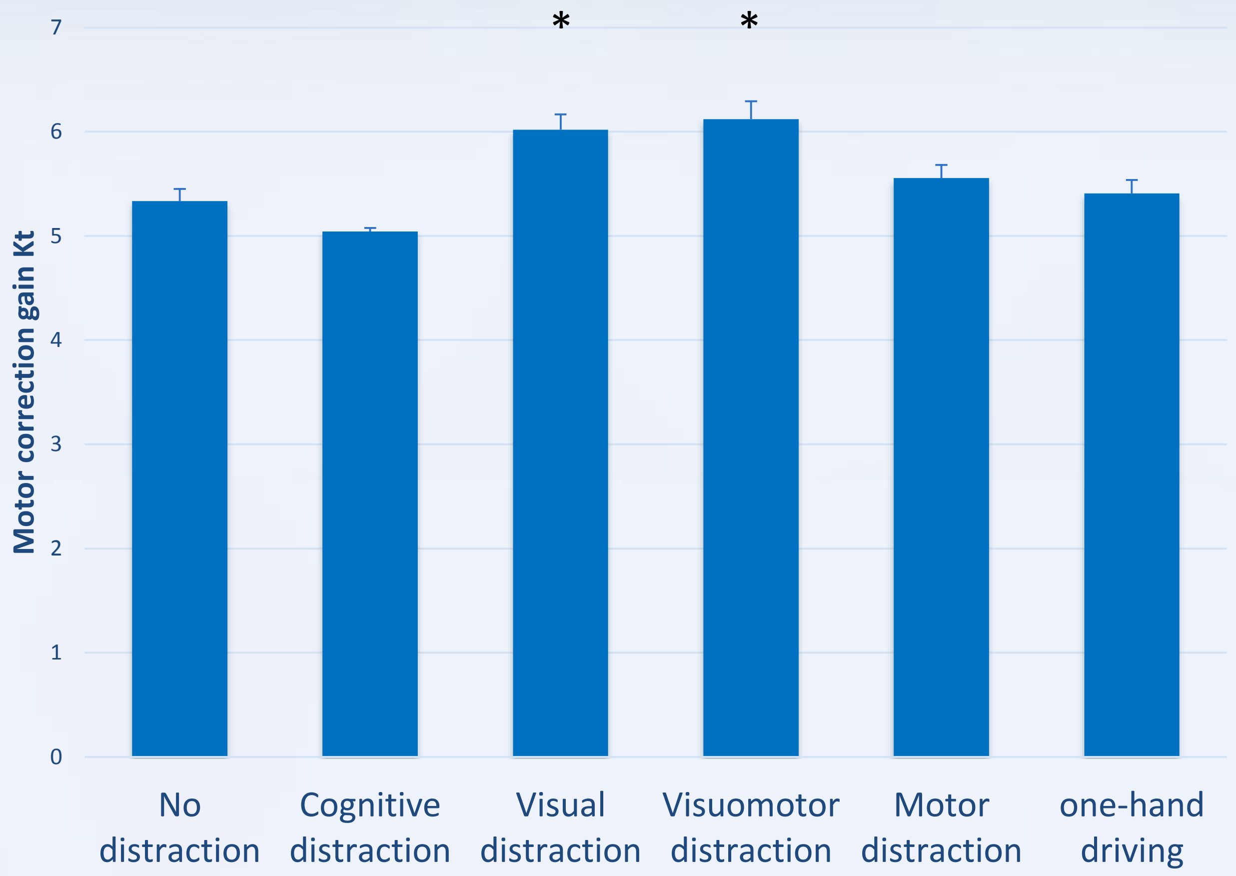
The visual compensation gain decreases for both types of visual distraction

Visual anticipation gain



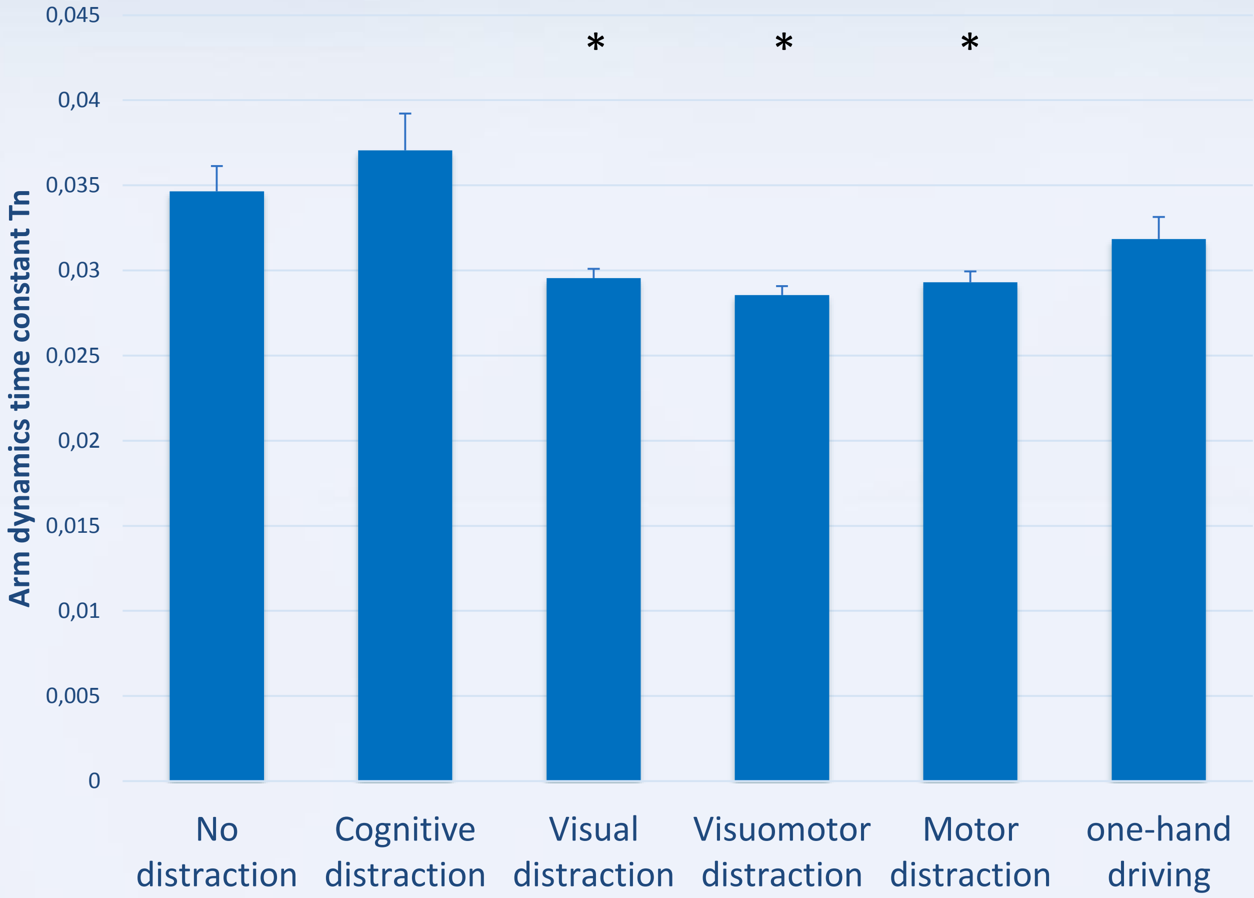
The visual anticipation gain decreases only for high visual distraction

Motor correction gain



Visual distraction propagates to the motor system parameters

Arm dynamics time constant



Motor distraction only influence the arm dynamics parameter

Conclusion

	steering performance		parameter analysis			
Distraction type	SDLP	SWRR	Kp	Kc	Kt	Tn
Cognitive	-	-	-	-	-	-
Motor	*	*	-	-	-	*
Visual	*	*	-	*	*	*
Visuomotor	*	*	*	*	*	*

- Steering behavior did not allow to discriminate between different types of distraction
- Taken together, the model parameters may be useful for detection and discrimination of distraction

More works needed to build a robust estimator of distraction

Contact information

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