STUDY OF THE AUTONOMOUS VEHICLE USERS' BEHAVIOR IN DRIVING SIMULATION

Jean-Rémy CHARDONNET (Arts et Métiers)

Evolution of driving mode

- Traffic fluidity
- Other possible activities

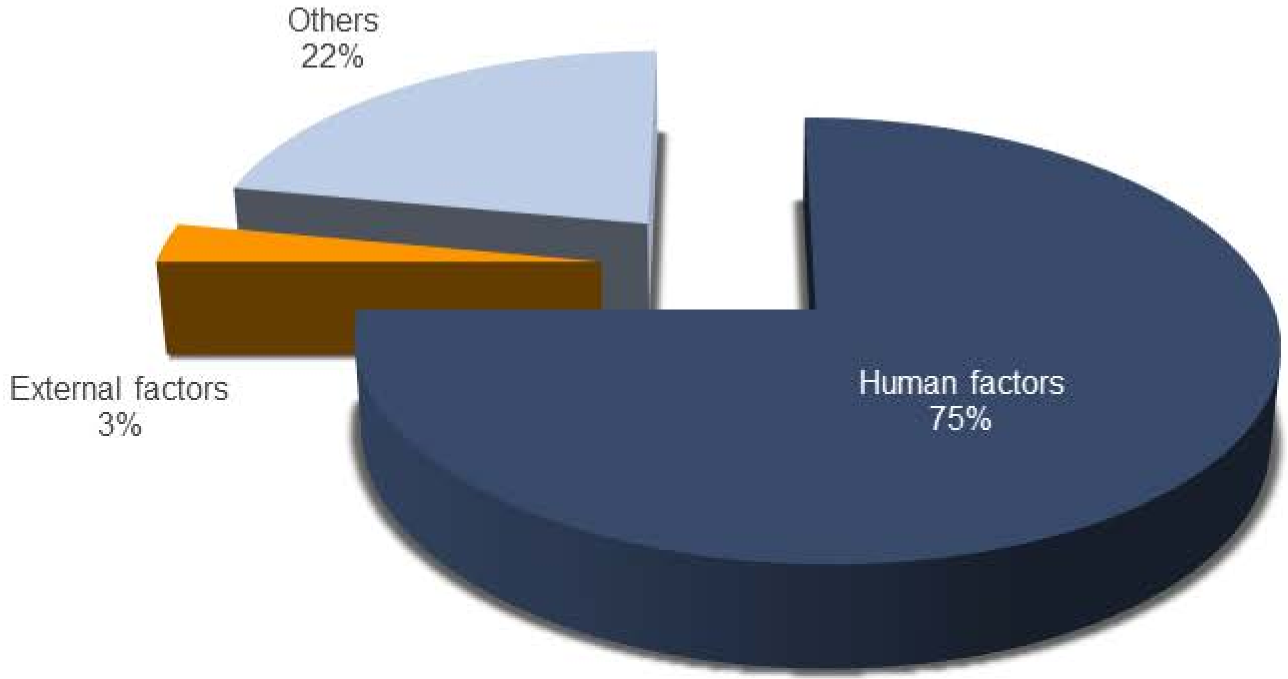
BUT change in human-vehicle interaction and accident conditions (Subit et al., 2017)

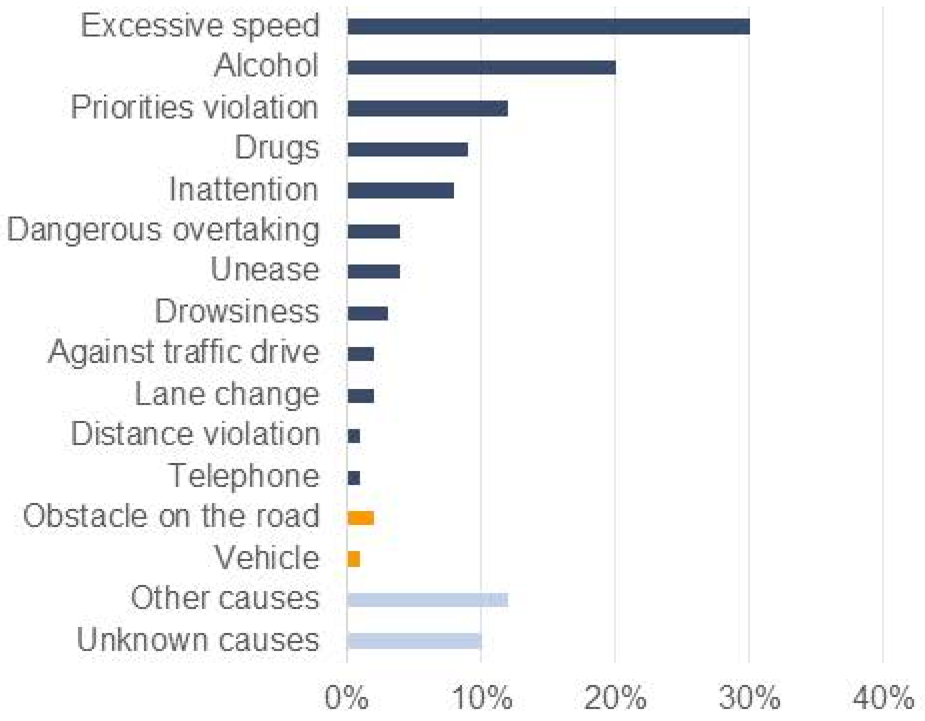
- New patterns
- Absence of driver
- More reactivity
- Out Of Position

→ **Influence on human behavior?**

From le moniteur automobile

CONTEXT





Source: File of alleged perpetrators of fatal accidents, 2014-2017, ONISR (France)

Simulation: ideal tool

- Safety – controlled environments
- Repeatability
- Reliability
- Portability

- Used by all car manufacturers and many labs

ISSUES

Simulation: not as simple

Motion restitution

Interaction

Validity

Latency

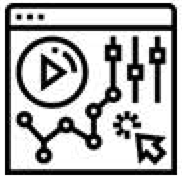
Environment rendering

Perception

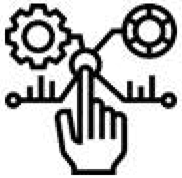
Simulator sickness

ISSUES

Simulation: not as simple



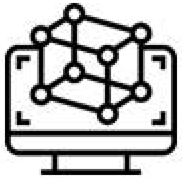
Motion restitution



Interaction

Validity

Latency



Environment rendering

Perception

Simulator sickness

Work on the simulator itself

- Development of motion cueing algorithms (e.g., (adaptive) MPC-based, using NN) (Rengifo et al., 2019)
- Compensation of the latency
- Development of appropriate human-vehicle interaction modalities (Guo et al. 2019)
- Appropriate environment rendering (Mestre et al., 2016)

Take into account the driver/occupant

- Ensure distance/speed perception (Kemeny & Panerai, 2001)
- Alleviate simulator sickness (Chardonnet et al., 2017)
- Integrate drivers'/occupants' characteristics

Validity (Yannis et al., 2016)

- Absolute validity
- Relative validity

ISSUES

Simulation: measuring driving behavior

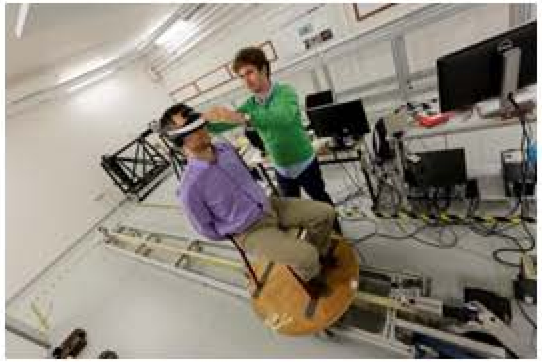
- Performance measurements: reaction time, break response time, longitudinal and lateral controls (e.g., steering control)
- Physiological measurements: eye movements, heart rate, skin conductance, respiration
- Subjective measurements: NASA-TLX, Driving Activity Load Index, SSQ, presence

Can be intrusive

Online/offline measurements

ILLUSTRATION

Sandoz et al., 2018



Personalized cognitive assessment of autonomous vehicles occupants' safety, study of the interactions between virtual reality and real dynamic events

Collaboration between a VR lab (LISPEN) and a biomechanics lab (IBHGC)

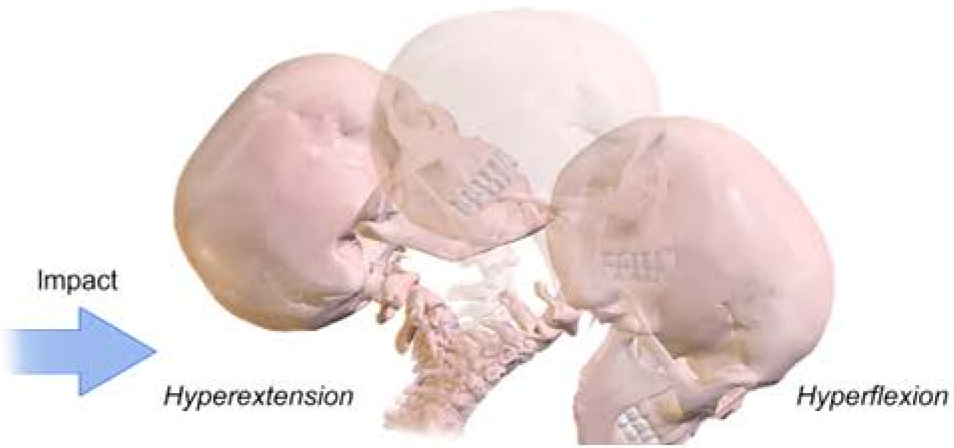
C. Di Loreto, J-R. Chardonnet, B. Sandoz, F. Merienne
Arts et Métiers LISPEN/IBHGC

PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

75.000 whiplashes/year in France

- 20 billion €/year in EU *European Transport Safety Council 2017*
- 25% of long term injuries *Bella et al. 1982,1988*
- Skull hyper flexion/extension
- Still not fully understood *Chen et al. 2009*

Whiplash



Blausen Medical Communications

Prevalence likely to increase *Subit et al. 2017*

- ADAS and autonomous car
- Out Of Position (OOP)
- Less energy involved

→ **How to better understand head stabilization strategies and prevent injuries?**

In vivo tests
Dynamic solicitation
Virtual reality

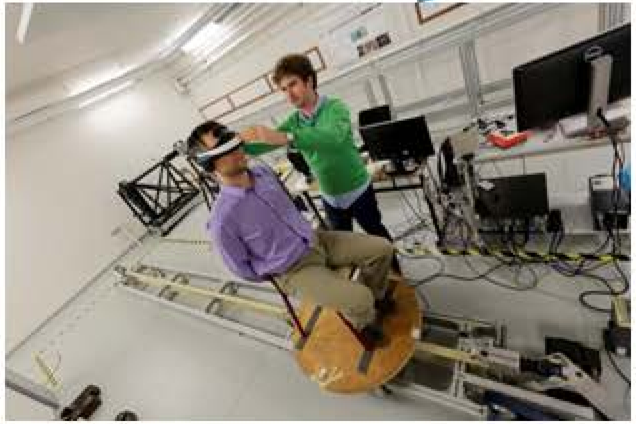
Cognition

PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

In progress

Real situation

Simulated situation



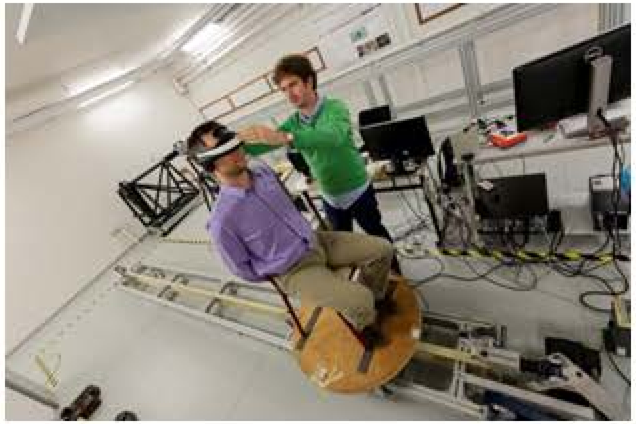
SLED (IBHGC)

SAAM (LISPEN)

PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

In progress

1



Influence of the emotional state on the dynamic response using VR

2

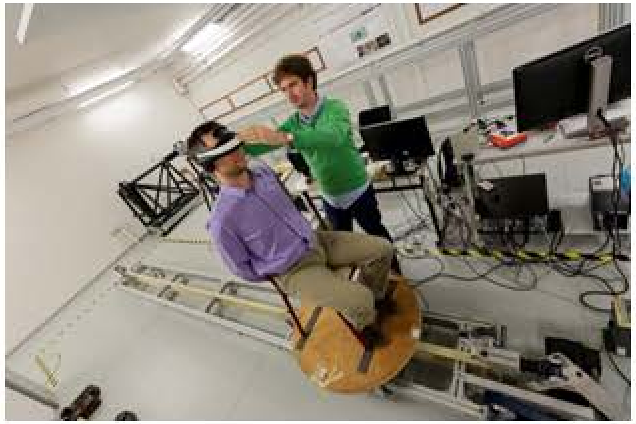
Comparison real-simulated

DSA

OPAL-RT TECHNOLOGIES

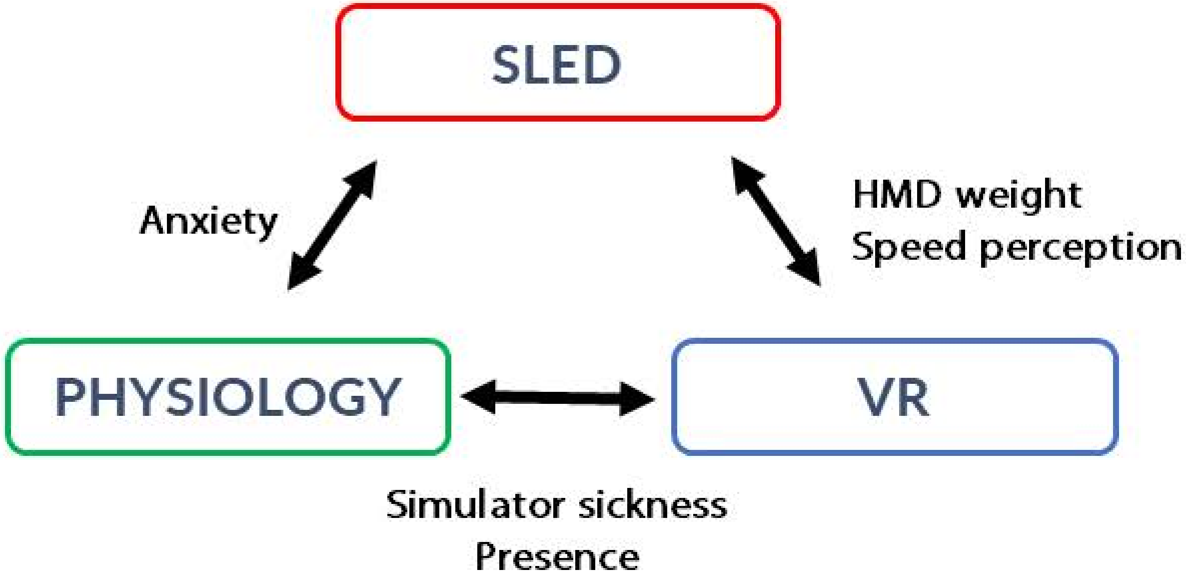
PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

1



Influence of the emotional state on the dynamic response using VR

Influence of cognitive parameters on head movements studied in in vivo tests (Blouin et al., 2006; Vibert et al., 2001; Kumar et al., 2003; Siegmund et al., 2003)



PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

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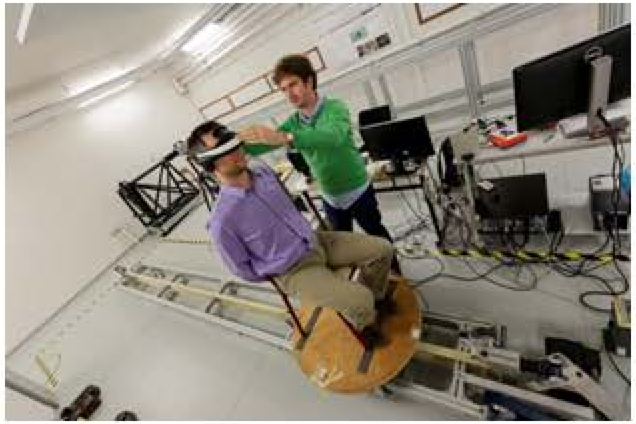
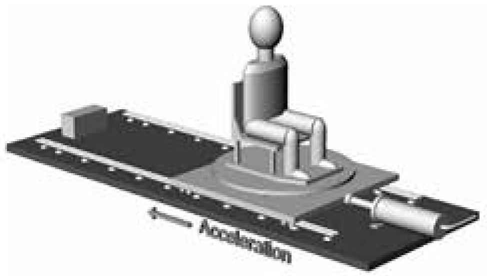


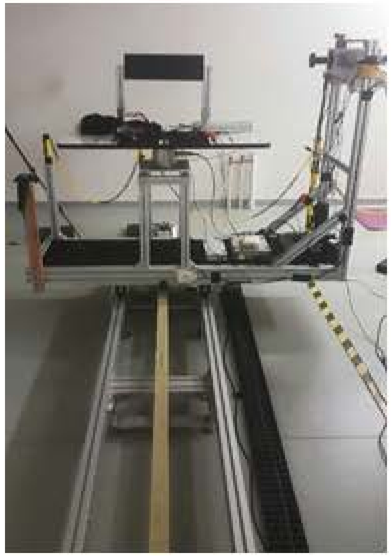
Influence of the emotional state on the dynamic response using VR

SLED

- ✓ Travel distance: 5 m
- ✓ Acceleration : 0.5 g (empty operation: max 10 g)
- ✓ Labview control



Kumar *et al.* 2003



PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

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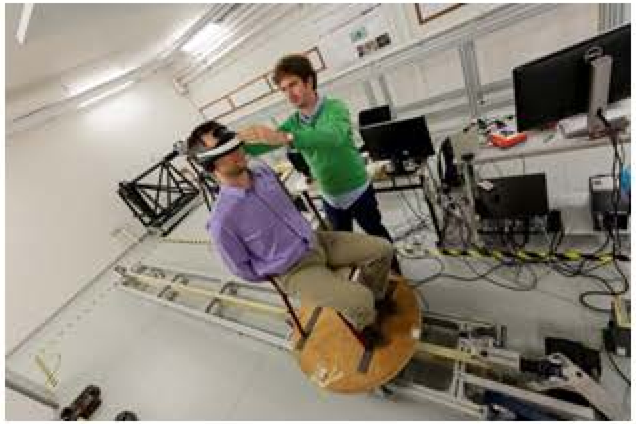


Influence of the emotional state on the dynamic response using VR

SLED

Anxiety

HMD weight
Speed perception

PHYSIOLOGY

VR

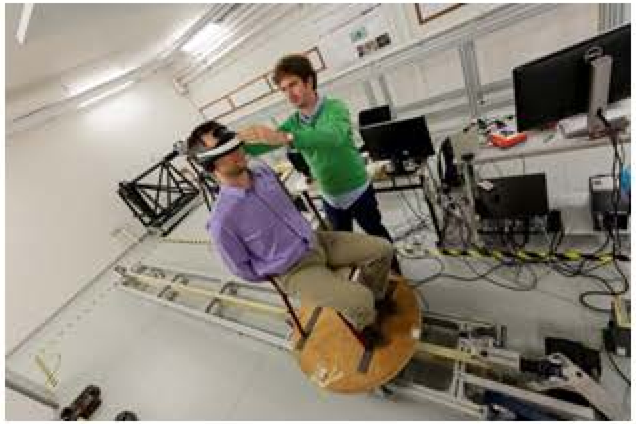
Simulator sickness
Presence

Gross & Levenson, 1995

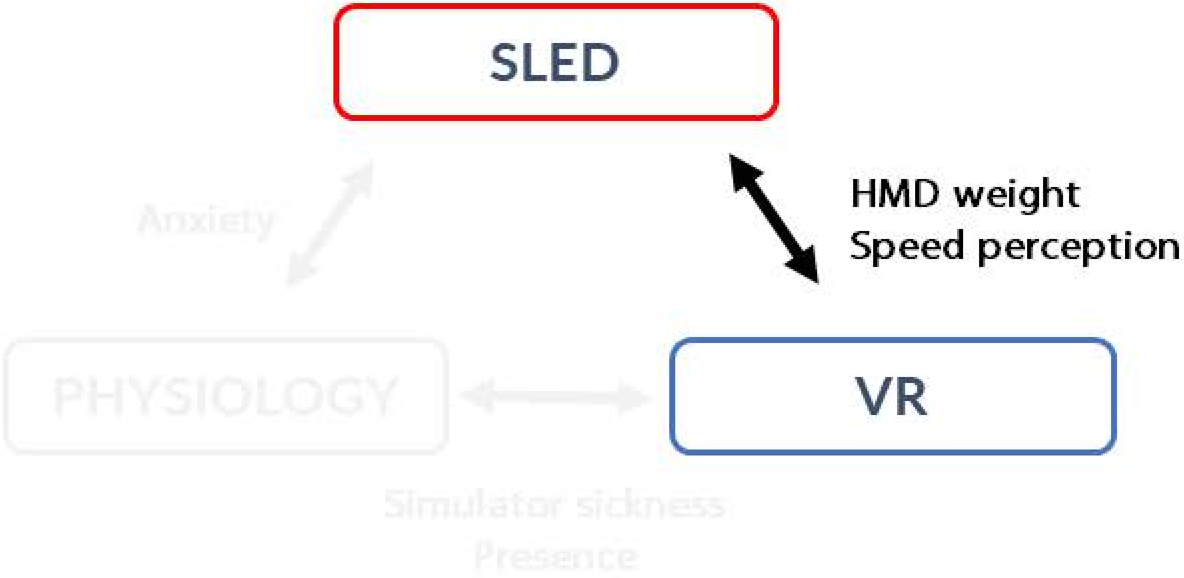
Observed significant differences on ROM

PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

1



Influence of the emotional state on the dynamic response using VR



HMD weight
- Subjects seem to compensate too much
- HMD may have a significant influence on behavior

Speed perception
- No significant difference but change in stabilization strategy
- Incorrectness of simulated environments rendering may have an influence on behavior

PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

2

Comparison real-simulated
Collaboration with CASR (Australia)

10 male subjects:

- Height: 179 ± 4 cm
- Weight: 77 ± 3 kg
- Age: 35 ± 13 yo

Physically comparable
Ethics committee

For each subject:

- ROM recording
- 36 trials, 12 conditions:
  - 8 or 15 km/h
  - 3 positions
  - AEB or « human » braking

Forward

Discussion

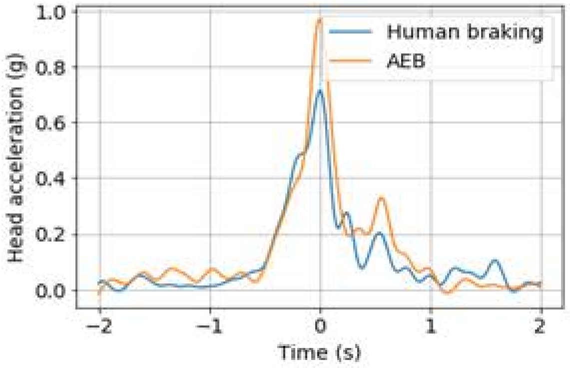
Phone

PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

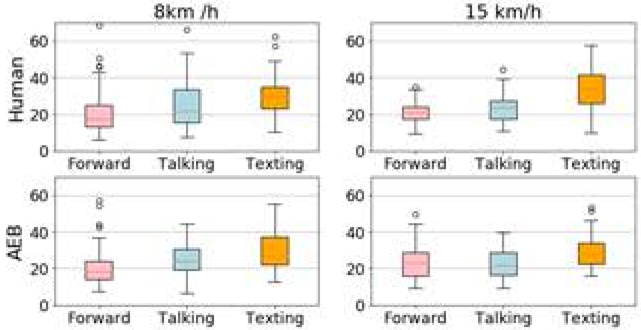
2

Comparison real-simulated
Collaboration with CASR (Australia)

- ✓ Head acceleration significantly affected by the breaking modality and not by the speed



- ✓ ROM significantly affected by the position



(Di Loreto et al., 2019)

PERSONALIZED COGNITIVE ASSESSMENT OF AUTONOMOUS VEHICLES OCCUPANTS' SAFETY

To be presented at DSC 2019

2

Comparison real-simulated
Collaboration with CASR (Australia)

Institut Image's SAAM driving simulator

Degree of Freedom	Displacement Comb. Motion	Displacement Single DOF	Velocity	Acceleration
Pitch	+25/-23 deg	±22 deg	±30 deg/s	±500 deg/s²
Roll	±22 deg	±21 deg	±30 deg/s	±500 deg/s²
Yaw	±23 deg	±22 deg	±40 deg/s	±400 deg/s²
Heave	±0.18 m (±7.0 in)	±0.18 m (±7.0 in)	±0.30 m/s (±11.8 in/s)	+0.5 g
Surge	±0.27 m (±11.1 in)	±0.25 m (+10.2/9.5in)	±0.50 m/s (±19.7 in/s)	±0.6 g
Sway	±0.26 m (±11.7in)	±0.25 m (±10.2 in)	±0.50 m/s (±19.7 in/s)	±0.6 g

OPAL-RT TECHNOLOGIES

Study of driver's behavior

- Complex to achieve (consider many parameters – hardware, software, psycho-physiology)
- Work on driving simulator (hardware): achieve real time (motion restitution, image), consider OOP situations (360°)
- Better integrate the driver in the loop (system customization – use of AI tools –, appropriate HMIs)

From le moniteur automobile

From Renault

STUDY OF THE AUTONOMOUS VEHICLE USERS’ BEHAVIOUR IN DRIVING SIMULATION

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