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Background: Problematic

Road safety problematic:
- Nearly 1.3 million people are killed on the world’s roads each year
- 90% of casualties from road deaths occur in developing countries
- Road traffic injuries are the number one cause of death for young people worldwide
- Unless immediate and effective action is taken, road traffic injuries are predicted to become the fifth leading cause of death in the world

Background: Actions

According to the UN, the solution must start from the acceptance of human error and design a harmonized road transport system on the basis of these limitations ensuring that accidents do not result in serious human injury.

Thus, a first step would be to analyze those human factors and test and assess compliance policies in order to reduce crash risk in a systematic way.

Driving behavior - Human Factors

- Workload
- Speed motivation
- Decision, awareness, apprehension
- Risk perception - perception, judgment and acceptance of risk
- Drowsiness

Driving behavior – Researching tools

- Statistical analysis
- Observational study
- Test track
- Naturalistic driving study
- Driving simulation study
Driving simulators: Pros & Cons

- Safety environment
- Experimental controllability and reproducibility
- Ease data collection
- Increased potential of virtual reality

Through a reliable validation, results of research studies using driving simulators are as relevant and applicable to real-world safety policies as results based on on-road studies.

Driving simulators: Workflow

- Research scope
- US selection
- Variables
- Practical scenarios
- Sample
- Scenario authoring
- Experiment
- Analysis
- Validation

Driving simulator validity

- How to validate a driving simulator study?
  - On-road comparison
  - Construct validity
  - Ecological validity
- Physical validity: Physical correspondence between the simulated and the real-world driving environments
- Psychological validity: The extent to which the simulator elicits the same driving behaviors that occur on-road.
  - Absolute validity
  - Relative validity: This is the most important validity in terms of human factors researches.
- Well-designed experiments must create constrained situations through clear instructions and incentives which elicit the expected behavior/performance.
  - Instruction
  - Incentives

Fidelity or sophistication degrees

- Low-level
- Mid-level
- High-level

- Which the differences about the visual system?
- Which the differences about the motion system?
- Which one should be used?

Simulator sickness

- Although no theory has yet explained simulator sickness completely, it is well-known that can result in headache, sweating, disorientation and nausea which must affect the outcomes and the validity of a driving simulator study.
- To overcome this feeling of sickness and its effects the following proceedings are suggested:
  - Screen participants
  - A narrow field of view.
  - A frame rate higher than 30 Hz
  - Avoid tight curves
  - Use a practice scenario
  - Monitor the subject

The practice session

- Adaptation is an important precondition for validity of experiments carried out using a driving simulator. Without learning how to control a simulated vehicle the participants would be distracted from performing the main task.
- A review of the literature in driving simulation shows that there is not a single method used for the practice scenario and adaptation and that adaptation to a driving simulator is task-independent.
- It is highly recommended to do a practice scenario with demanding task using several times the steering wheel and pedals in order to familiarize the subject with this controls and its feedback. Finally, according to the literature, it is recommended a practice session of 15 minutes in order to guarantee a completely adaptation with the driving simulator without producing fatigue.
Surrogate measures

<table>
<thead>
<tr>
<th>Human factor/OS Variable</th>
<th>Speed estimation</th>
<th>Attention</th>
<th>Risk perception</th>
<th>Fatigue</th>
<th>Workload</th>
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**Literature review: Driving behavior**

- Some researches have assessed how the driver allocates its attention in the environment features, which is a key element in order to understand risk perception. In general, it was found that the majority of the driver’s glances were indeed directly ahead, however some researches have found that under “safer” environments about 3 of 10 glances were out of view and just 1 was on-road signs (Zwahlen, 2003).

- Regarding differences between driver characteristics, a lot of studies have been assessing the differences in risk perceptions according to the driver age. In general, there were found significant age-related differences in driver scanning behavior, consistent with the hypothesis that the more information contents on the traffic sign, the higher the risky driving behavior (Shinar & Ronen, 2007).

- On the other hand, there are a lot of researches that have assessed the attention management between multiple tasks, in general, the studies found that the driving task performance decreased (speed and travel control) by the presence of a second task, and that the road safety became non-compliant as a result of the same perception (Card, 2007; Stryker, 2007; Reid, 1999).

**Literature review: Environmental improvement**

- In terms of environment improvements and risky behavior, e.g. Riemersma et al. (1990) assessed the effects of speed reduction methods on the driver behavior using a driving simulator. The study found both a reduction of the risky behavior and a relative validity of the results with the outcomes of a similar on-road study.

- On the other hand, Sun et al. (2011) concluded that the more information contents on the traffic sign, the higher the risky driving behavior. The simulation outcomes showed a highly correlation between complex traffic signs and a less control of the vehicle, higher speed variance and longer glances out of the vehicle path.

- Finally, regarding the development of technologies in order to improve drivers’ behavior, Nagi et al. (2004) developed, tested, and modified a Personally Adaptive Driving Support System according to the outcomes of a driving simulator study. The system advice the driver of a non-normal braking according to his own braking patterns.

**Conclusions**

- Driving simulation is a powerful research tool which guarantee a safety environment, a high experimental controllability and ease data collection in order to study driving behaviors. However, its acceptance always depends on its validity.

- The evidence reviewed indicates that simulator driving behavior approximates but does not exactly replicate on road driving behavior. Thus, exists a relative validity which ensure the acceptance about the use of driving simulators in driving behavior studies.

- About behavioral researches, the psychological validity is more important than the sophistication degree of the driving simulator. To achieve that validity, the use of instructions and incentives is highly recommended.

- In general, regarding behavioral researches a low-level or mid-level driving simulator would be enough in order to produce reliable results once the psychological validity is guaranteed.

- Even there is not a unique and certain proceeding about driving simulator researches, some methodological comments were drawn according to well designed researches founded in the literature reviewed.

**References**

Thank you!