Effects of Environmental, Vehicle and Individuals' Factors on Comfort in Partially Automated Driving: A Scenario-Based Study

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Introduction

Driving automation is usually classified in 5 levels (SAE International, 2016). Halfway between the absence of automation (level 0) and full automation (level 5), is **partial automation (level 3)**.

At this level, the driver can delegate the control of the vehicle to the automated system, without the need to supervise it, but while remaining able to take-over control if asked for.

The driving activity will thus be shared over time between the vehicle and the human behind the wheel, the latter alternating between the **driver** and the **passenger** status, becoming a "**driv**enger"

Driver status:
Flourishing litterature: take-over and post-take-over driving performances.

Passenger status:
Little to no literature. Core issue: improving passenger's comfort through automated driving styles (Hartwich et al., 2018).

→ **Very few studies investigating comfort in SAE levels 1-3.**

→ **Studies on comfort in automated cars do not consider many factors like weather conditions.**

→ **Little is known about the influence of individuals' profiles on the perception of comfort.**

Method

Scenario-based method.

202 participants were exposed to **24 written scenarios** describing situations in which a person is being driven by an SAE level 3 car.

The scenarios featured all possible combinations of four within-participants factors: **type of road** (highway, departmental road or downtown road), **vehicle speed** (prescribed speed, 20 km/h below), **weather conditions** (clear, very rainy), and **traffic congestion level** (low, high).

Participants were asked to **rate their comfort** if they were the protagonist in each scenario, on a scale ranging from 0 ("not at all") to 20 ("very much").

After the test, participants were asked to rate their **trust in automated cars** on a scale ranging from 1 ("low") to 5 ("high").

Scenario example:
*"Julien is on the **highway**. His vehicle is driving at the **prescribed speed**. The weather is **clear**. There are **few vehicles** on the road."*

Results

Statistical analysis were performed at 2 levels : whole sample level and cluster level.

Analysis conducted on the whole sample:

Comfort was negatively influenced ($p < .001$) by :

- Rainy weather ($\eta^2_p = .46$)
- High traffic congestion ($\eta^2_p = .45$)
- Downtown road ($\eta^2_p = .04$)

Results

Interaction analyses showed that the negative influence of unfavorable weather and traffic congestion was reduced ($p < .001$) by the lower vehicle speed ($\eta^2_p = .18$ and $\eta^2_p = .14$ respectively) (see Figure 1).

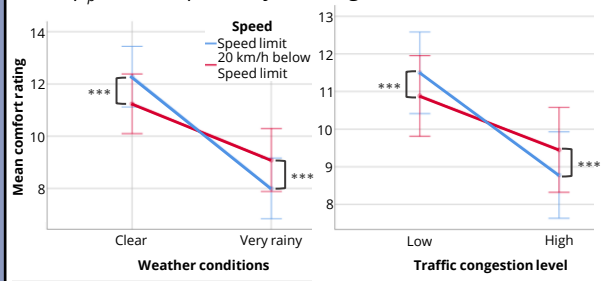

Figure 1. Interaction effects between weather conditions and vehicle speed (on the left), and between traffic congestion level and vehicle speed (on the right).
***: $p < .001$

Analysis conducted at cluster level (method: K-means clustering).

Four behavioral profiles identified:

1. ***Averse to risk*** ($n = 75$)
   - Medium level of trust in automated cars (ACs).
   - Overall prefer the reduced speed.
2. ***Trustful in automation*** ($n = 51$)
   - Highest level of trust in ACs.
   - Comfortable even in the least favorable conditions.
3. ***Mistrustful in automation*** ($n = 46$)
   - Lowest level of trust in ACs.
   - Uncomfortable even in the most favorable conditions.
4. ***Averse to speed reduction*** ($n = 29$)
   - Medium level of trust in ACs.
   - Very low comfort when the vehicle was driving below the prescribed speed.

Discussion

Comfort in SAE level 3 cars can be altered by driving conditions **leading to an increased risk of critical events** (e.g., reduced vision in rain).

Reducing the vehicle speed could help to moderate these effects.

The TCI model (Fuller, 2000) suggests that when following the prescribed speed without considering the driving conditions, automated systems do not take into account variations in task difficulty and drivers' capabilities. **This dissonance between task demands and driver's capabilities could lead to a feeling of discomfort and explain our results**.

Trust in ACs can be considered as a key factor when trying to improve comfort in ACs.

Finally, cluster analyses highlighted 4 respondents' profiles, suggesting that **in order to optimize comfort, a personalization approach should be favored over a one-for-all.**

References

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