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Possibility over probability: A worst-case approach to driver distraction and inattention assessment

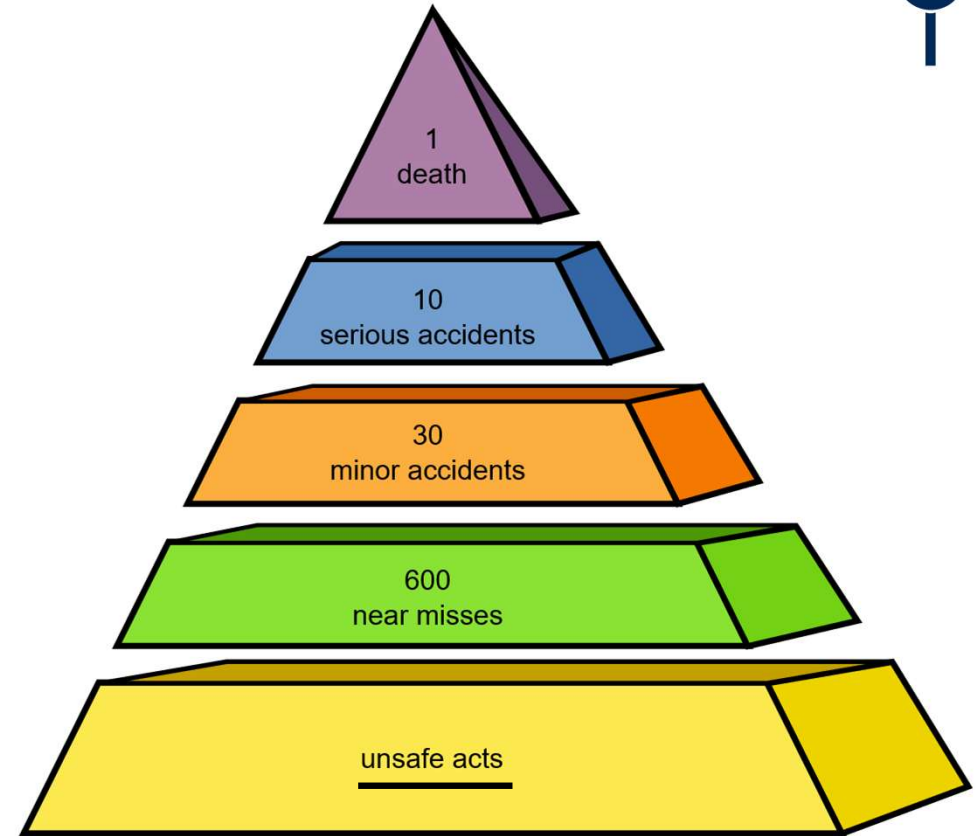
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Odds vs. Possibility?



- In safety impact analyses of technology, we often focus on aggregated probabilities.
 - E.g., number of crashes with and without
 - E.g., probability of over-2-s off-road glances
- However:
 - Unlikely but possible events matter for safety too, and
 - There are a lot of unsafe acts until one realizes into an incident.



Heinrich's triangle, as expanded by Bird (1966)
By Psychoslave - <https://commons.wikimedia.org/w/index.php?curid=75799632>

Drive-In Lab established at University of Jyväskylä in 2024



Premise

- Worst-case scenario:
 - Car following: rear-end crashes ¹
 - No experience or training for the in-car tasks
- “What-if?” scenario:
 - Driver is inattentive when cannot stop the car, IF the lead car braked suddenly at -6 m/s^2 .
 - Measures increase in crash possibility, not in the magnitude of crash likelihood or severity

¹ Bálint, A., Flannagan, C. A., Leslie, A., Klauer, S., Guo, F., & Dozza, M. (2020). Multitasking additional-to-driving: Prevalence, structure, and associated risk in SHRP2 naturalistic driving data. *Accident Analysis & Prevention*, 137, 105455.

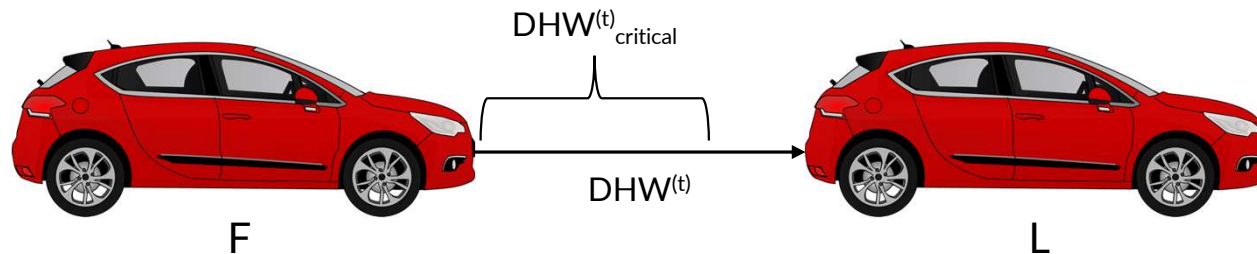


Operationalization of inattention

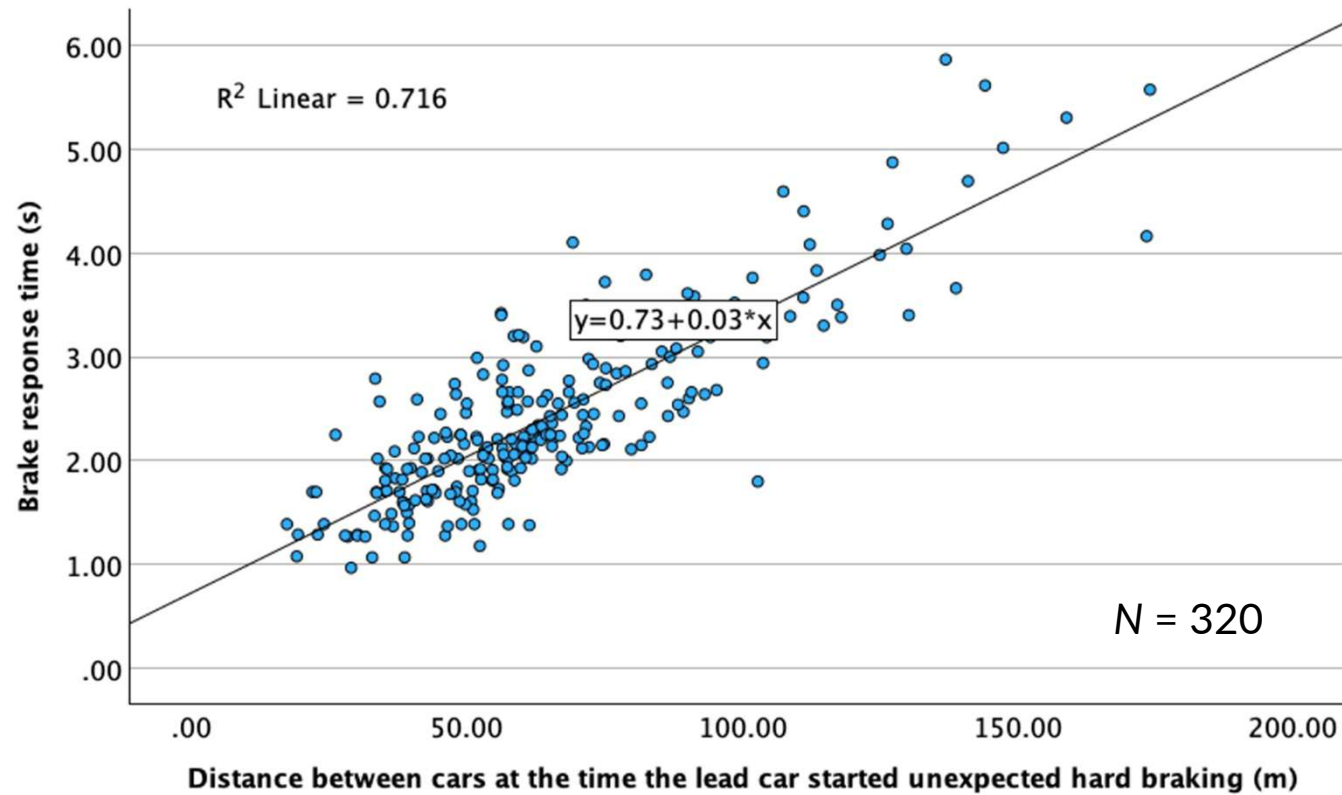


Driver is inattentive if distance headway $DHW^{(t)} \leq DHW^{(t)}_{critical}$

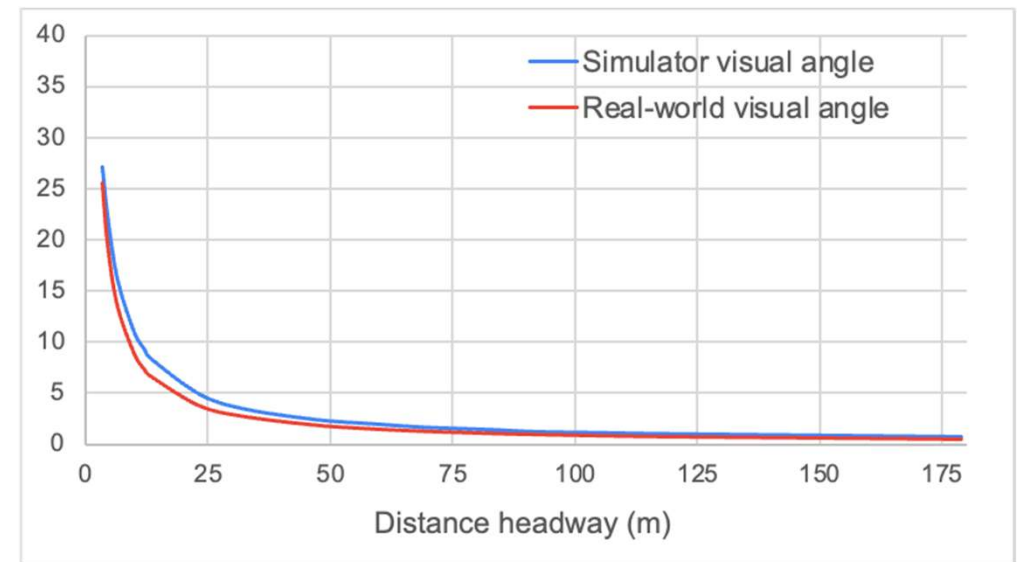
$$DHW^{(t)}_{critical} = \overbrace{BD^{(t)}_F + S^{(t)}_F \cdot BRT^{(t)}_F}^{\text{Following car's braking distance}} - \overbrace{BD^{(t)}_L}^{\text{Lead car's braking distance}} \quad (\text{Eq.1})$$



Kujala, T., & Sarkar, A. (2024). Spare visual capacity and driver inattention in dynamic car following scenarios. *Transportation Research Part F: Traffic Psychology and Behaviour*, 104, 506-521.



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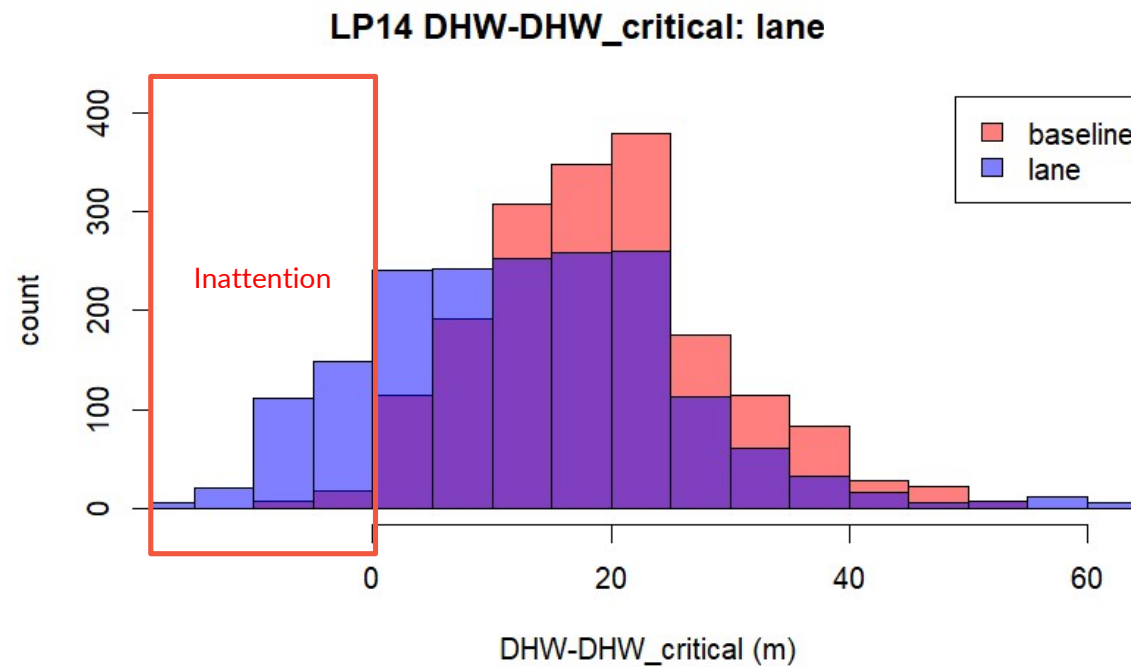
Kujala, T., & Sarkar, A. (2025, April). Evaluating In-Car Tasks' Distraction Effects with Drive-In Lab. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems* (pp. 1-24). (Best Paper Award, 1% of submissions)

In-car task's distraction effect

1. Inattentiveness (%) in a baseline drive
(without secondary tasks)
2. Inattentiveness (%) in a in-car task drive
3. Pairwise comparison in inattentiveness:
in-car task drive (%) – baseline drive (%)
4. Definition of effect size for the difference



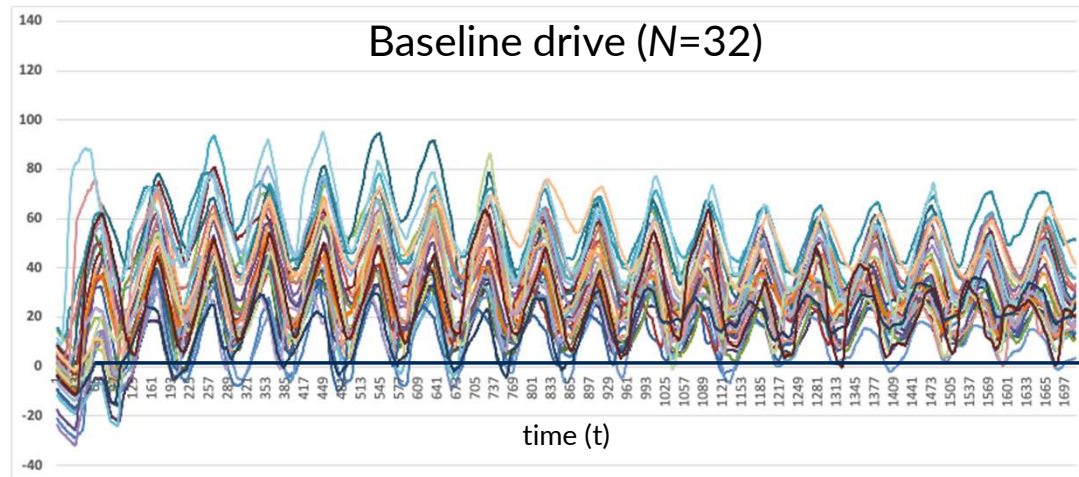
Example: Effects of in-car task on headway control



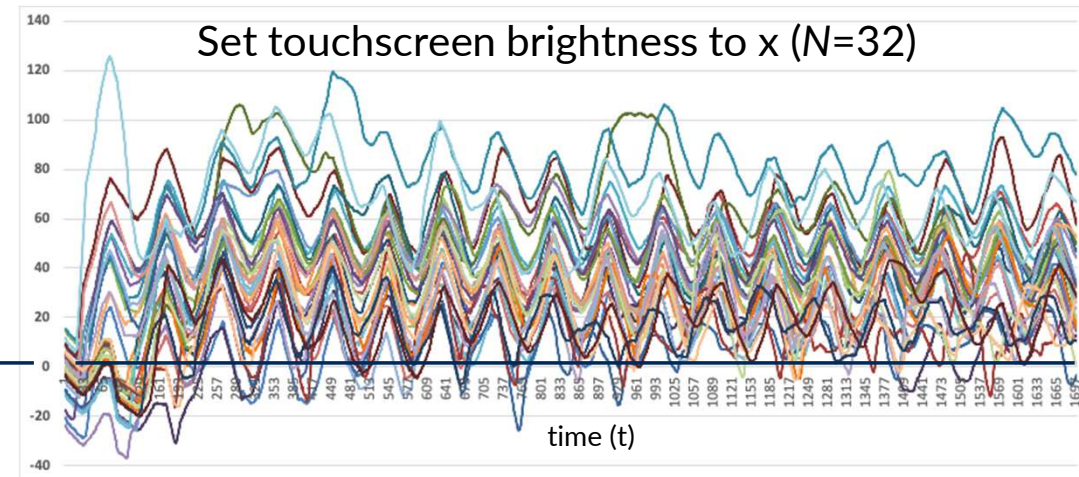
Nissan Leaf MY 2023, lane task: "Set lane-keeping assist to position x."



Example: VW ID.7 MY 2024, 3 min drives



(<=0 is risky: crash is inevitable IF the lead car brakes hard)



(<=0 is risky: crash is inevitable IF the lead car brakes hard)

$$DHW^{(t)} - DHW^{(t)}_{\text{critical}}$$

Worst-case parameters

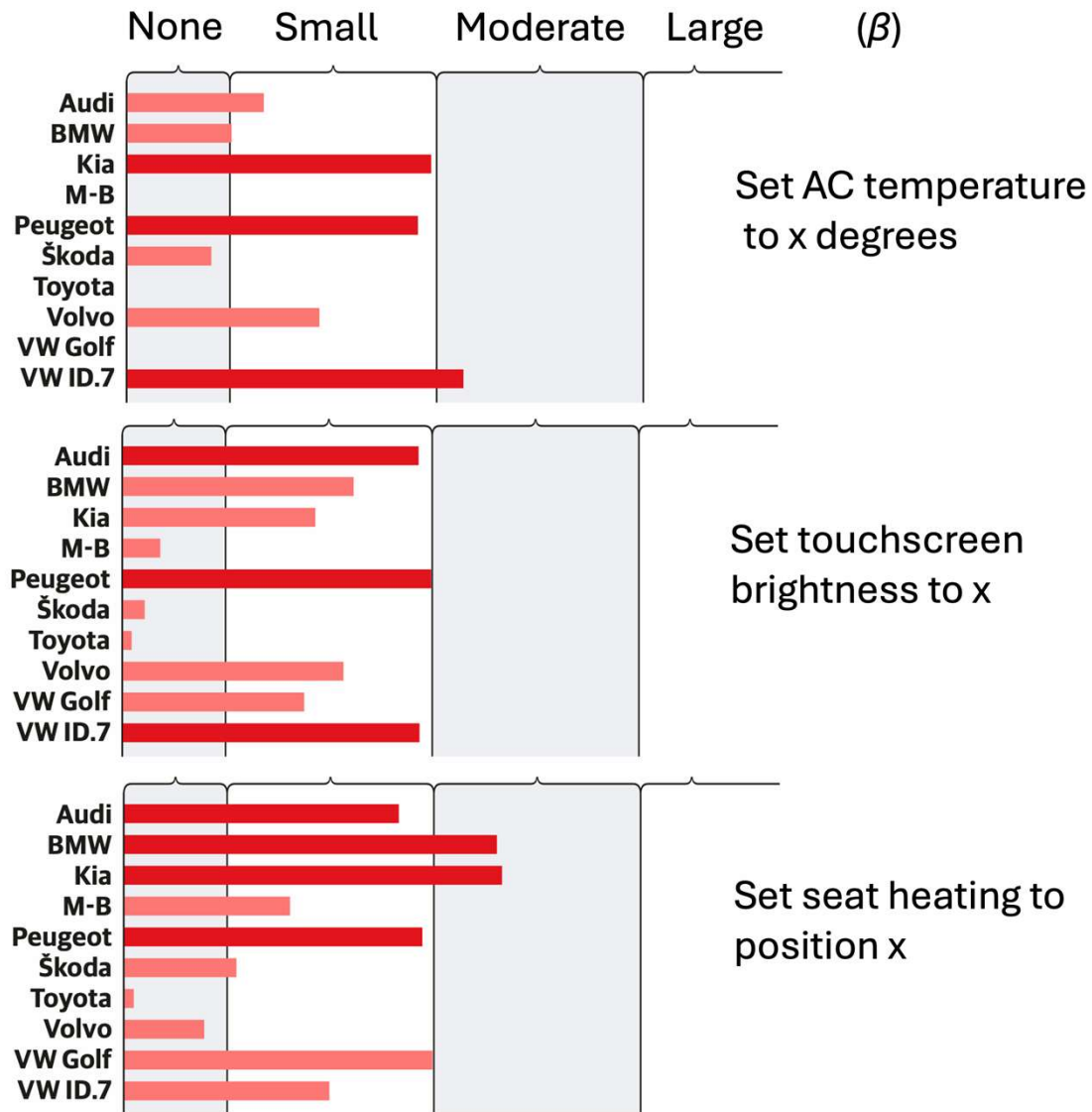


- Car-following scenario with no possibility to swerve
- The lead car could brake hard at any time (-6 m/s^2)
- Brake reaction time estimation for an unexpected event
- New car and infotainment system for the participant
- No training for the in-car tasks



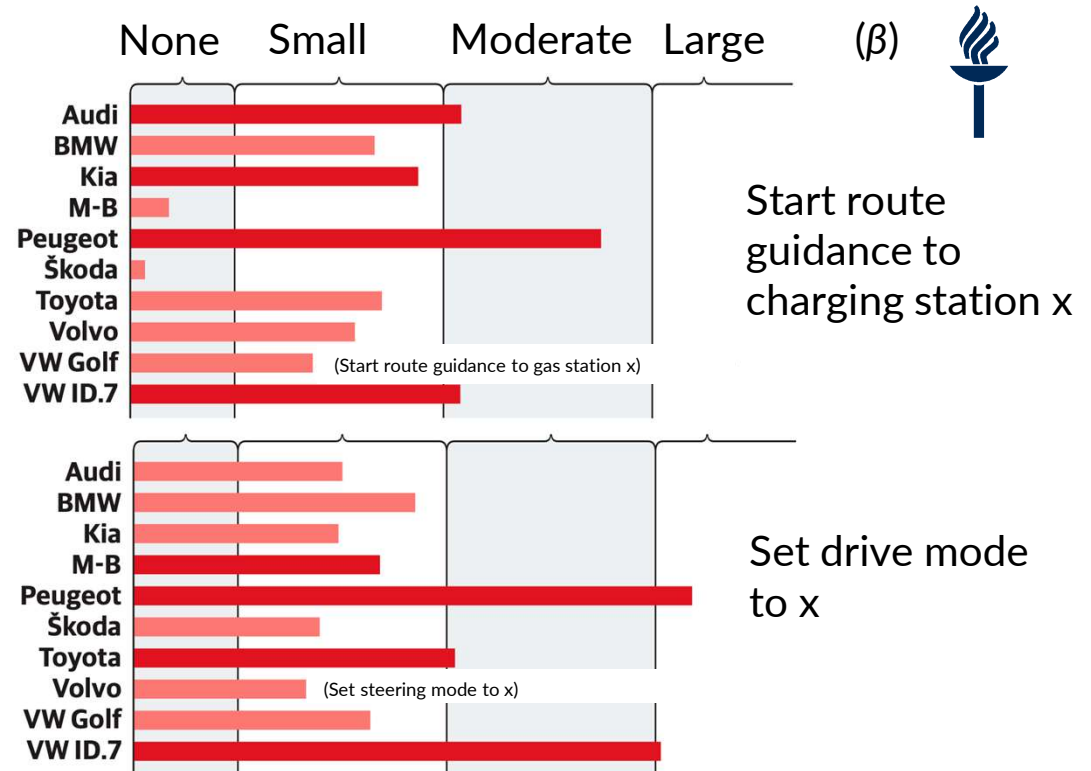
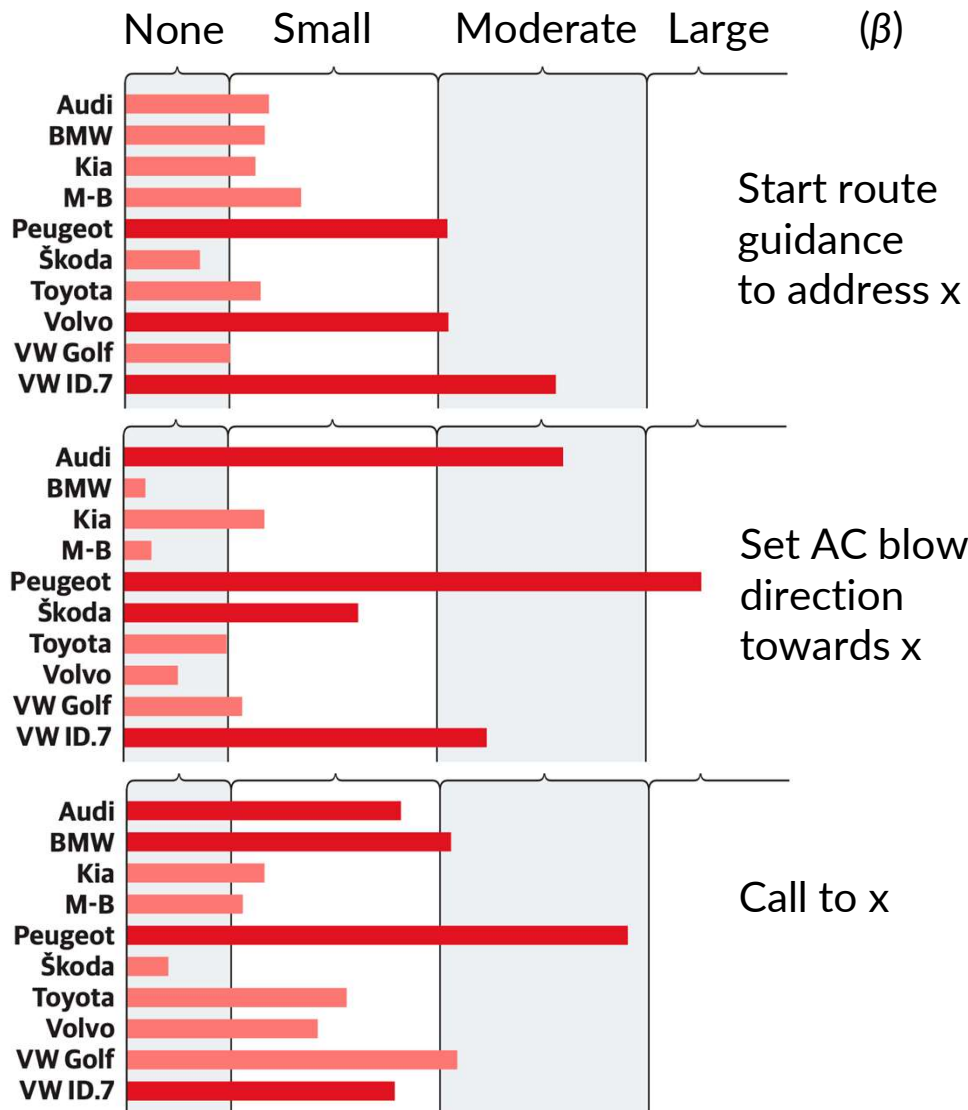
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**Results: 10 cars, 320 drivers
(from 4 different age groups)**

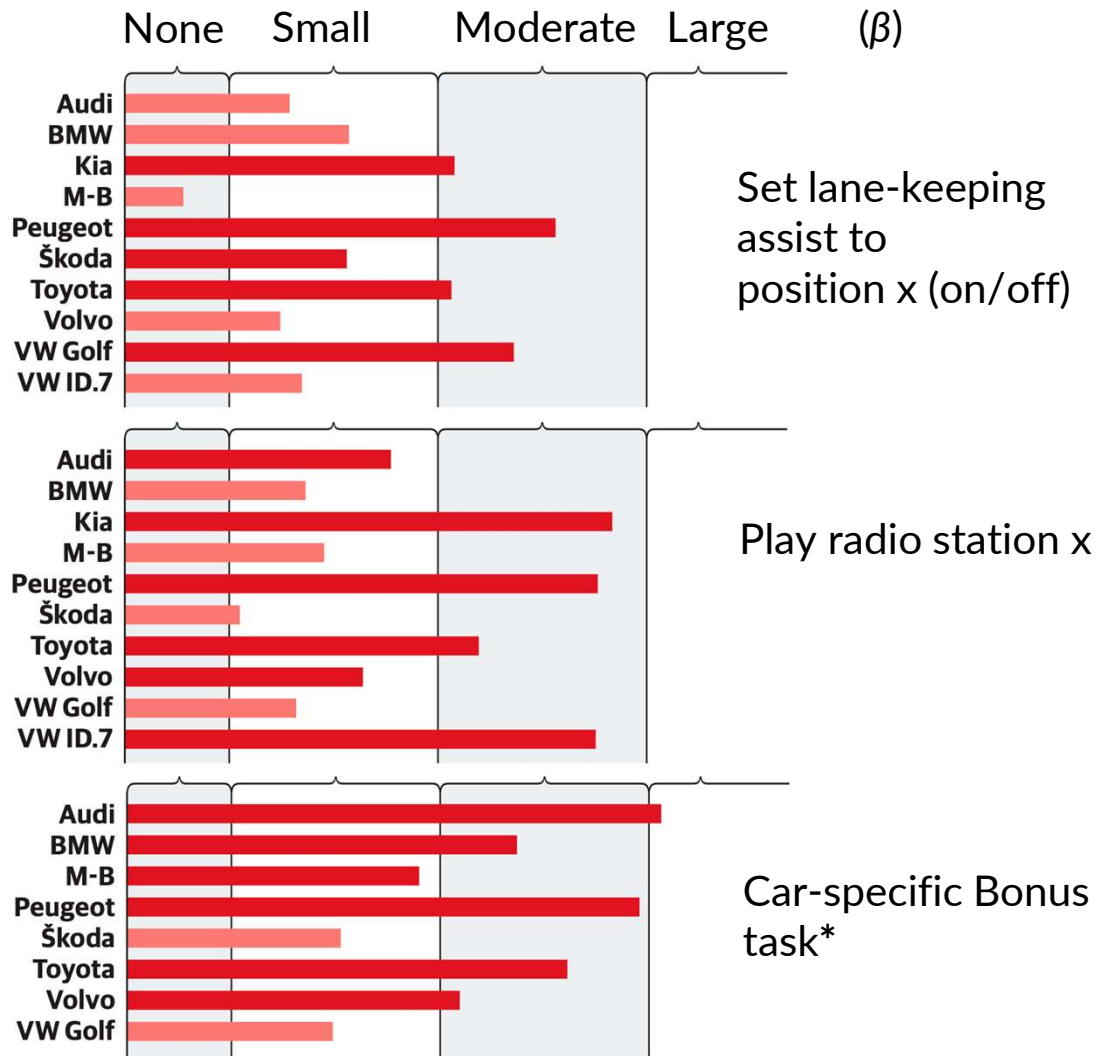


The least distracting tasks

(statistically significant distraction effects in dark red)



More distracting tasks



*Audi Q6 e-tron: Set Collision Avoidance Assistant to setting x (on/off)
BMW i5: Set cruise control to setting x
M-B E300e: Set bass level to x (audio)
Peugeot E-3008: Set mirror folding to setting x
Škoda Elroq: Set ESC to setting x (on/off)
Toyota bZ4X: Set speeding alert to setting x
Volvo EX30: Set audio pre-tune to setting x
VW Golf (2017): Set bass level to x (audio)

The most distracting tasks

Full Self-Driving (Supervised)?

- Safety evaluation of automated driving:
 - Odds vs. possibility?
 - E.g., machine vision only vs. machine vision + radars?
- **If there is a way to avoid even a single crash by design, we should do it.**





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Thank you for your Attention.

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