JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

Drive-In Lab:

A method for the measurement and rating of OEM in-car infotainment system's distraction potential

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Tuomo Kujala, Hilkka Grahn, Toni Hautaoja, Abhishek Sarkar

- ”The system should not visually entertain the driver.” [1]
- ”Graphics and symbols should conform to stereotypical norms.” [2]
- ”Controls and displays should function the way people expect them to function (test if not obvious).” [2, 3, 4]

[1] Commission of the European Communities (2007). *Commission Recommendation on Safe and Efficient In-Vehicle Information and Communication Systems: Update of the European Statement of Principles on Human Machine Interface*. Brussels, Belgium: European Union.

[2] Stevens, A., Quimby, A., Board, A., Kersloot, T. & Burns, P. (2004). Design Guidelines for Safety of In-Vehicle Information Systems. Crowthorne, UK: Transport Research Laboratory.

[3] Battelle Guidelines (1998). U.S. Department of Transportation - Federal Highway Administration. Human Factors Design Guidelines for Advanced Traveler Information Systems (ATIS)and Commercial Vehicle Operations (CVO) [report FHWA-RD-98-057].

[4] ISO 15005 (2002). Dialogue Management Principles and Compliance Procedures.

WHY?

- In-car UIs are a Wild West
- Lack of best practices for modern in-car UIs
- Lack of reliable and valid data of in-car tasks' distraction effects
- Existing state-of-the-art focus on the measurement of cognitive and/or visual demands of in-car tasks

- Drive-In Lab established at University of Jyväskylä in 2024

Goals

1. To measure and rate the latest in-car infotainment systems' distraction effects
2. To find the best and worst practices in in-car UI design
3. To provide design guidelines and recommendations
4. To publish all the observations and (reusable and non-personal) data open access

Premises

- Worst-case scenario
  - Car following: rear-end crashes [1]
  - Drivers should not have experience of the in-car UIs and tasks under testing

- At the same time:
  - a test of in-car UIs' intuitiveness

[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.

Method

- *N*=32
  - 8 x 18–24, 8 x 25–39, 8 x 40–54, and 8 x 55+ drivers (age groups per NHTSA, 2013)
- Car-following scenario on a highway (no overtaking)
- Goal: to get from A to B as efficiently as possible, but safely
- Drives:
  - Brake response time (BRT) drive
  - Baseline drive (without in-car tasks)
  - 10 in-car tasks while driving (no task instructions)
- Ca. 3 min drive time
- Ca. 1.5h / participant

Operationalization of inattention

Driver is inattentive if distance headway (DHW) is smaller than or equal to critical distance headway (<= $DHW^{(t)}_{critical}$).

$$DHW^{(t)}_{critical} = BD^{(t)}_{F} + S^{(t)}_{F} \cdot BRT^{(t)}_{F} - BD^{(t)}_{L} \quad \text{(Eq.1)}$$

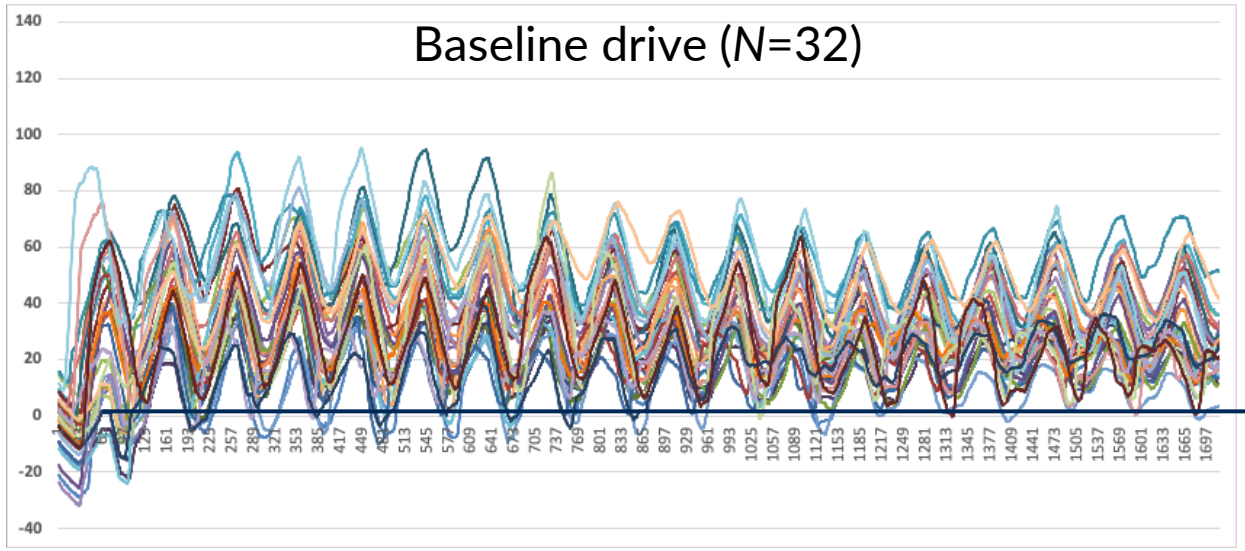
Kujala, T., & Sarkar, A. (2024). Spare visual capacity and driver inattention in dynamic car following scenarios. *Transportation Research Part F: Traffic Psychology and Behaviour*, *104*, 506-521.

In-car task's distraction effect

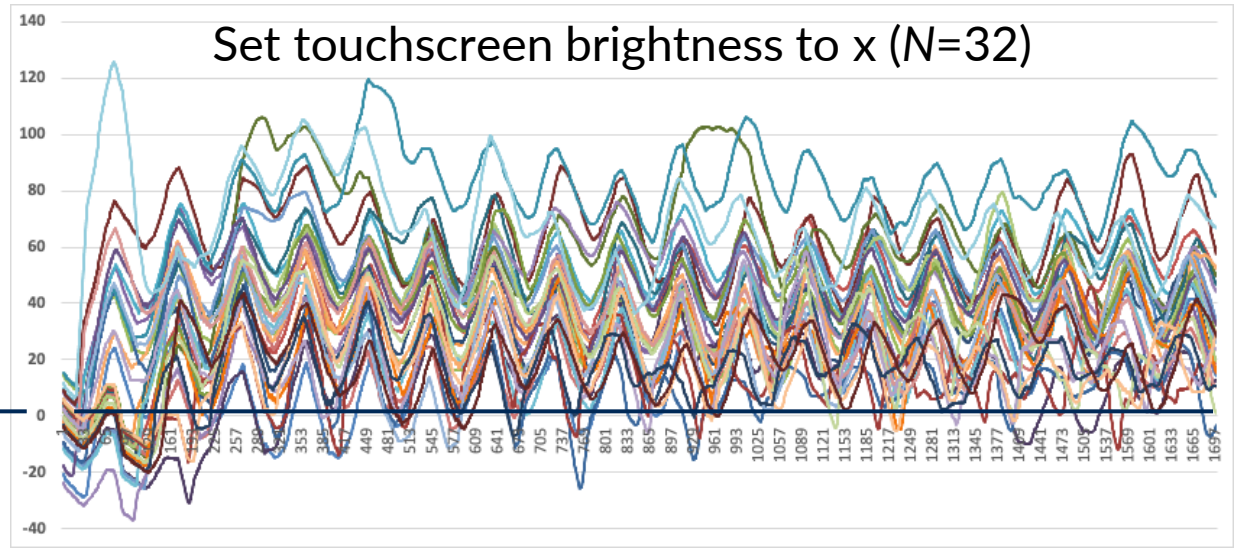
1. Inattentiveness (%) in the baseline drive (without secondary tasks)
2. Inattentiveness (%) in the in-car task drive
3. Pairwise comparison in inattentiveness: in-car task drive (%) – baseline drive (%)
4. Definition of effect size for the difference

Distraction measurement

- Dependent variable:
  - DHW – critical DHW* (m)
- Distraction effect:
  - in-car task drive (%<=0) vs. baseline drive (%<=0)

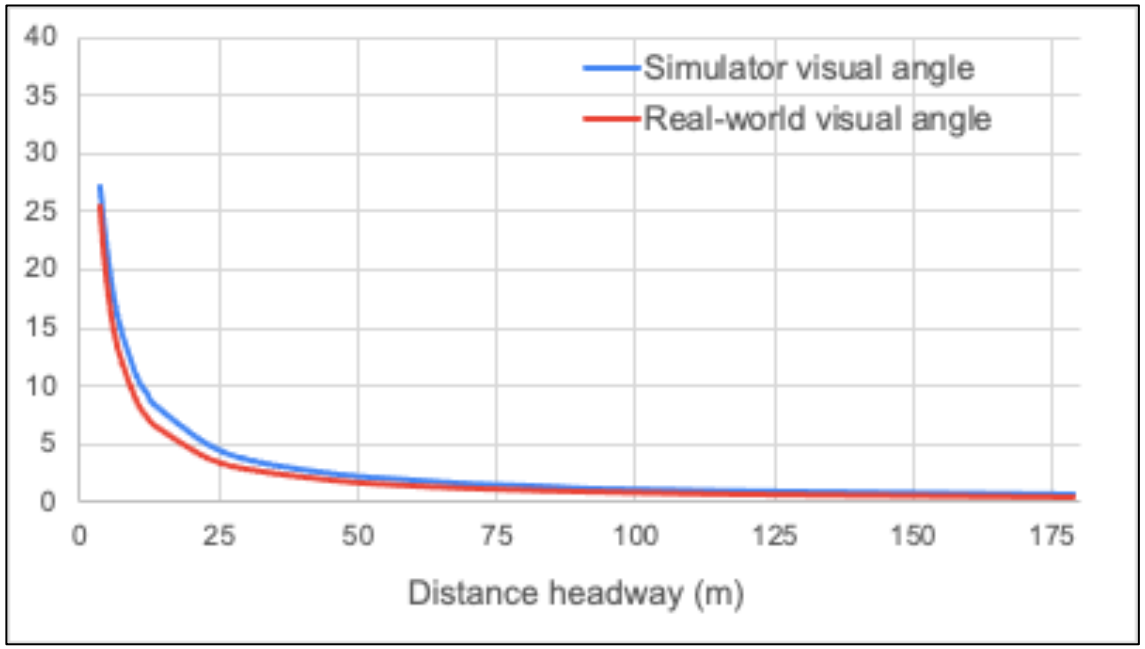


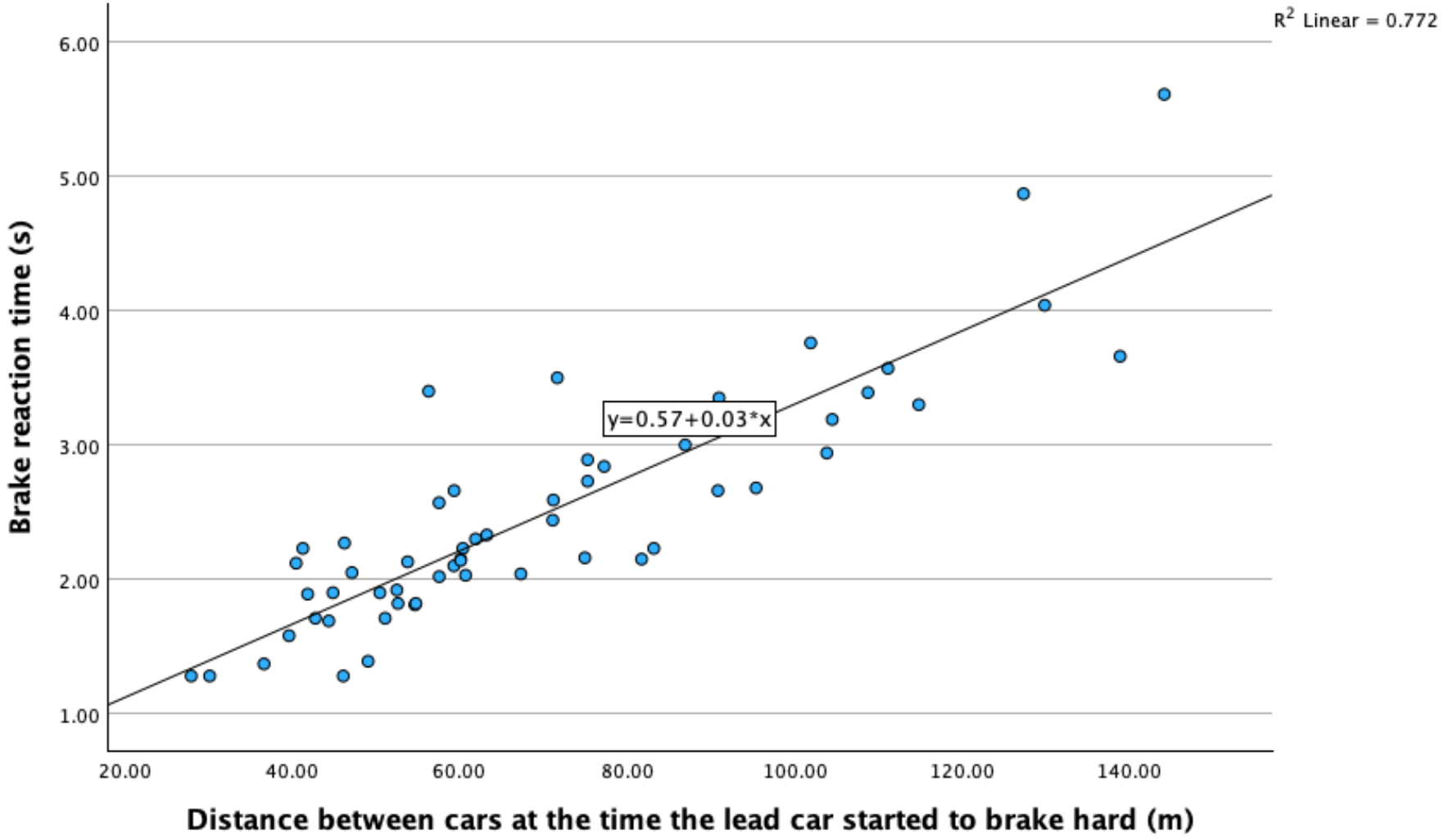
(<=0 is risky)



(<=0 is risky)

* 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.


40
35
30
25
20
15
10
5
0
0
25
50
75
100
125
150
175
Distance headway (m)
Simulator visual angle
Real-world visual angle



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.

In-car tasks

Task	Instruction	Target (x) examples
AC direction	Set AC blow direction towards x.	Feet, Windshield, Driver, Feet and Driver
AC temperature	Set AC temperature to x degrees.	20, 18, 22, 24, 19, 23, 21, 25
Drive mode	Set drive mode to x.	Eco, Normal, Sport
Touchscreen brightness	Set touchscreen brightness to position x.	Max, Min, Middle
Lane-keeping assist	Set lane-keeping assist to position x.	Off, On
Navi to charge	Start navigation to charging station x.	Fortum Recharge Vapaudenkatu
Navi to address	Start navigation to address x.	Keskikatu 24, Jyväskylä
Call	Call to x.	Spider-man, Ant-man, Iron man, Star-Lord, Wasp
Radio	Play radio station x.	Rock, Classic, Nova
Seat heating	Set seat heating to position x.	1, 2, 3, Off

MV1.EUR.ccNC.001.002.231027 (https://www.kiamedia.com/us/en/models/ev9/2024/gallery)

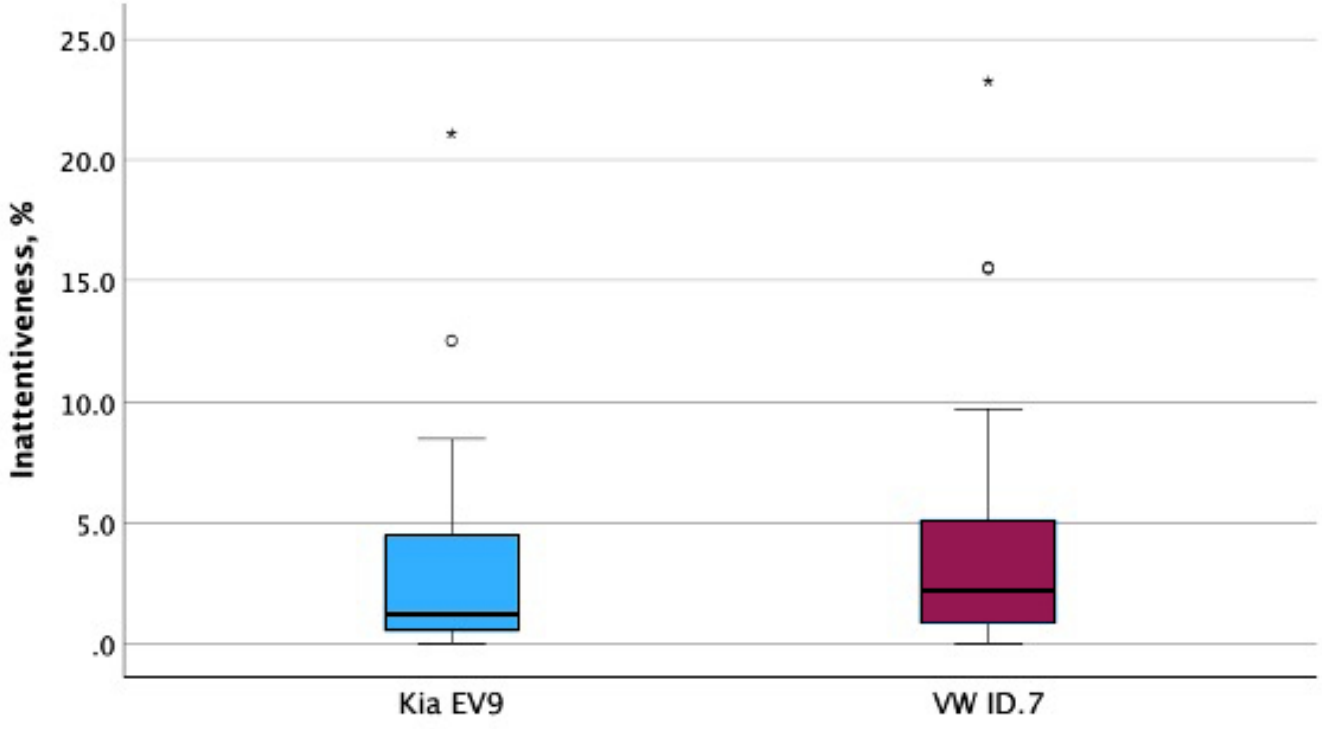
First test results

ID.Software 4.0 (https://www.volkswagen-newsroom.com/en/images/albums/id-7-6594)

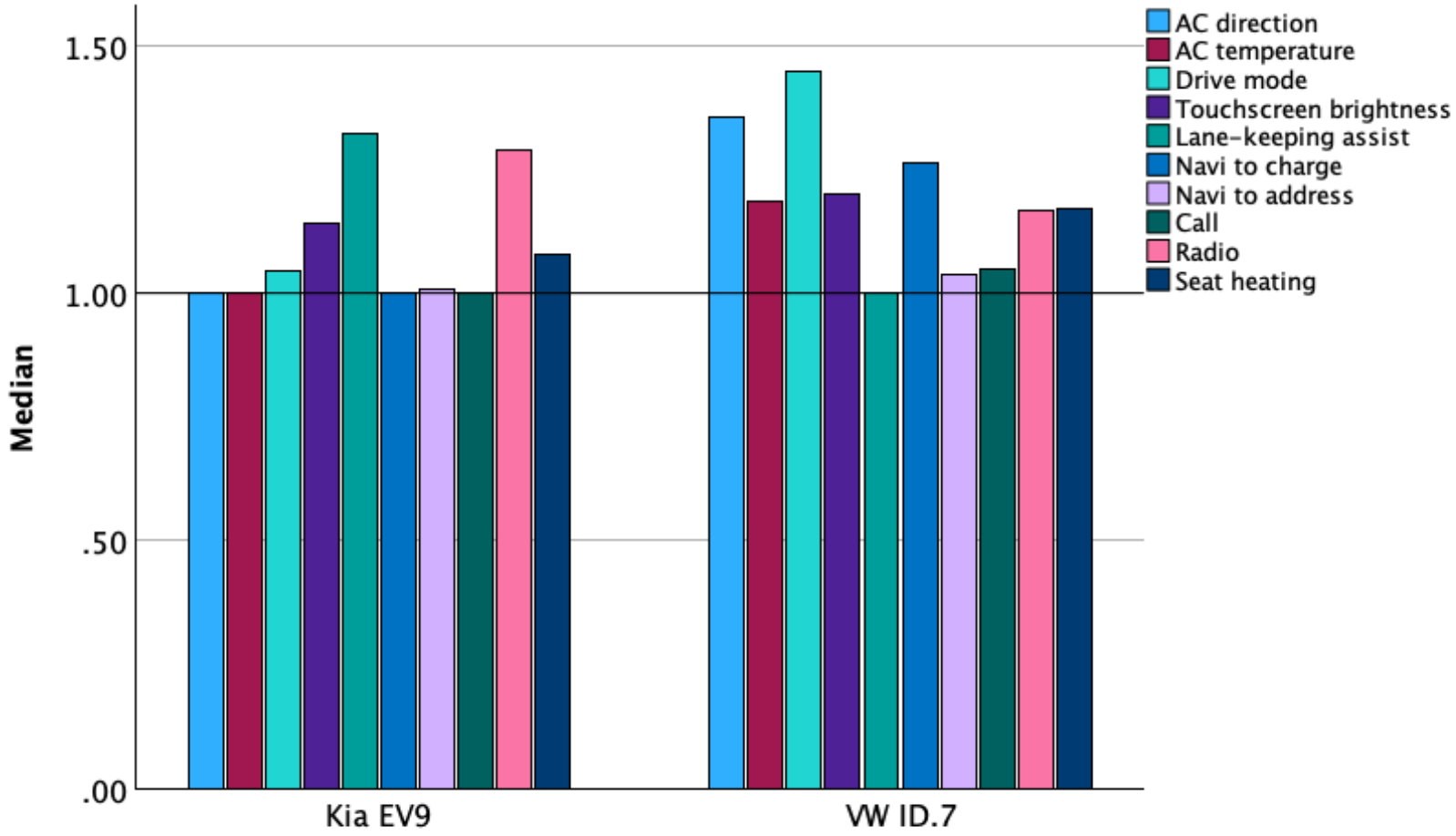
Inattention in the baseline drives (without secondary tasks)

- One outlier removed from both samples

➔ *N* = 31 for both cars



Median inattention ratio per in-car task



1 = level of inattention in the baseline drive

Effect size and stars per task and car (max 3 stars)

	Kia EV9				VW ID.7			
AC direction	** [a]	r = .12	Z = 0.928	p = .353	*	r = .35	Z = 2.781	p = .005
AC temperature	**	r = .24	Z = 1.870	p = .061	*	r = .34	Z = 2.679	p = .007
Drive mode	**	r = .22	Z = 1.765	p = .078	*	r = .35	Z = 2.756	p = .006
Touchscreen brightness	*	r = .30	Z = 2.375	p = .018	*	r = .35	Z = 2.739	p = .006
Lane-keeping assist	*	r = .32	Z = 2.527	p = .012	**	r = .15	Z = 1.156	p = .248
Navi to charge	**	r = .21	Z = 1.628	p = .104	*	r = .37	Z = 2.883	p = .004
Navi to address	**	r = .12	Z = 0.952	p = .341	**	r = .27	Z = 2.146	p = .032
Call	**	r = .12	Z = 0.952	p = .341	**	r = .20	Z = 1.538	p = .124
Radio	*	r = .31	Z = 2.476	p = .013	*	r = .38	Z = 2.984	p = .003
Seat heating	**	r = .28	Z = 2.193	p = .028	**	r = .25	Z = 1.994	p = .046
Mean rating (car)	**	**r = .22**			*	**r = .30**		

a. Based on effect size $r = Z/\sqrt{62}$ (0-1): The stronger the effect, the more likely the task causes more inattention than in baseline driving. ***: r <.10 (no effect), **: r < .30 (weak effect), *: r <.50 (medium effect), -: r >=.50 (strong effect).

General observations

- Visual search and uncertainty on where to find/how to use lead to larger distraction effects
  ➔ Intuitiveness! (e.g., icons, locations, controls/functions)
- After learning ➔ Distraction effects decrease significantly
- Visual search may still be required (e.g., unordered lists of radio channels or nearby charging stations)
- Searching for targets in visually complex menus should not be allowed while driving – at least without assistance systems (AAC, in particular).

Research plan 2024-2025

- April-May: Nissan Leaf MY 2023 (pilots)
- June: VW ID.7, Kia EV9
- October: Volvo EX30
- November: Mercedes-Benz E series
- By summer 2025 at least 10 car models

- Comparisons:
  - OEM vs. Apple Carplay and Android Auto?
  - Voice vs. visual-manual UIs?
  - Instructions vs. no instructions
  - Older car: e.g., VW Golf 7 (pre-facelift)?
  - Test-retest reliability?

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Thank you for your attention.

tuomo.kujala@jyu.fi

Research material

- Demographics
- Stationary visual search performance
- Driving logs
- Eye-tracking data and videos
- Videos of participants' UI usage
- In-car task performance data (e.g., tasks/3 min)
- Questionnaires
  - NASA Task Load Index (NASA-TLX)
  - System Usability Scale (SUS)
  - User Experience Questionnaire (UEQ)

Challenges in distraction measurement

- Glance metrics (e.g., AAM, 2006; NHTSA, 2013), occlusion (ISO 16673, NHTSA, 2013), task duration (SAE J2365_201607), Lane change test (LCT: ISO 26022), Box task (Buchholz et al., 2023), lane crossings and headway variability (AAM, 2006), Detection response task (DRT: ISO 17488)

- Cognitive control hypothesis (Engström et al., 2017)
- Measurement's relationship to real-world crash risk?
- No reliable baseline
- Most of the metrics measure in-car task's visual and/or cognitive demand, not distraction effects
- Drivers' ability to adapt and time in-car tasks in relation to the variable driving task demands?
- Drivers inter-individual and situational differences in driving and in in-car task demands?
- Results may depend more on participant sample than the properties of the in-car UIs
- In general, participants are instructed on the use of the systems and in-car tasks

Contents

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