Losing a private sphere? A glance on the user perspective on privacy in connected cars

Jonas Walter, Dr.-Ing. Bettina Abendroth

Institut für Arbeitswissenschaft

Technische Universität Darmstadt

Otto-Berndt-Str. 2, D-64287 Darmstadt

Agenda

- Introduction: Connected car – a shift in privacy?

- Relevant privacy factors for adoption – a literature review

- A closer look – An user study on the connected car

- Conclusion and practical implications

CONNECTED CAR – A SHIFT IN PRIVACY?

IaD

Connected car – a shift in privacy?

- An increasing level of automation leads to high levels of safety and comfort in driving [1]

- High automation levels rely on so-called vehicular ad-hoc networks [2]
  - Data transfer between multiple entities like cars or infrastructure
  - A growing number of sensors targeting the environment as well as the interior

- Advent of these means of vehicular ambient intelligence fosters new functionalities [3]
  - But: perception of our car as private which has been persisting so far might change.

Connected car – a shift in privacy?

- So far, cars represent safety, enjoyment and autonomy,

  but also a private refuge [4]
    - Privacy is an important decision criterion for modal choice

- However, in the connected car, a multitude of sensors might compromise the driver's private sphere within a car
    - Multiple sensors to detect the driver's state [6] and the environment [5]

- How do drivers perceive the advent of connectivity within the car?
- Under which conditions do users accept connected vehicular services?

RELEVANT PRIVACY FACTORS FOR ADOPTION – A LITERATURE REVIEW

IaD

Relevant privacy factors for adoption – a literature review

- Systematic literature review on privacy-related user studies within the field of the connected vehicle
  - Key words applied on Web of Knowledge database [7]: "privacy vehicle", "privacy car", "connected car", "connected privacy" and "connected vehicle"
  - only user studies within the topic of privacy in the connected car

Key word combination	Hits (unselected)	Identified paper
"privacy vehicle"	500	[9] [19]
"privacy car"	89	[10] [11]
"connected car"	54	-
"connected privacy"	526	-
"connected vehicle user"	157	-
Additionally added (found at IEEE Xplore)	-	[8]

Relevant privacy factors for adoption – a literature review

- Connected services used in reviewed studies:
  - connected car (general), traffic safety measures like event data recorder, pay-as-you-drive insurances

- Core messages from the reviewed studies:
  - awareness: most users are unaware of connected cars [8]
  - concerns: 69 % of users report data privacy concerns [8]
  - benefits: connected safety features are most popular with users [8, 10]
  - social context matters: driving alone vs. co-driver [10]
  - usage context matters: professional vs. private usage [9]
  - data type: users are sensitive to the kind of data being shared [9, 10]
  - data receiver: data sharing with third parties is declined [10, 11]
  - compensation: financial compensation is effective for low intrusiveness [11]

Relevant privacy factors for adoption – a literature review

- Previous user studies show that…
  - privacy factors are relevant for usage adoption of connected services
  - transparency in data consumption and data procession & monetary incentives can compensate privacy concerns

- However, several questions remain…
  - How relevant is privacy in comparison to safety, efficiency or convenience benefits?
  - Which data in connected cars is sensitive to users?
  - To whom would users release their data?
  - Under which circumstances are users prepared to disclose their data?

A CLOSER LOOK – AN USER STUDY ON THE CONNECTED CAR

A closer look – An user study on the connected car

- Online-survey on connected vehicular services
  - 101 participants (33 women)
  - mean age: 36.74 years
  - 86 % of participants possessed an own car

1. Are the following data types personal to you? Please indicate your agreement.

	strongly agree	agree	undecided	disagree	strongly disagree
location data	○	○	○	○	○
fuel consumption	○	○	○	○	○
engine temperature	○	○	○	○	○

A closer look – An user study on the connected car

TECHNISCHE
UNIVERSITÄT
DARMSTADT

- Which data in connected cars is sensitive to users?
  - sensitive: user preferences, location, physiological data, driving behavior related data
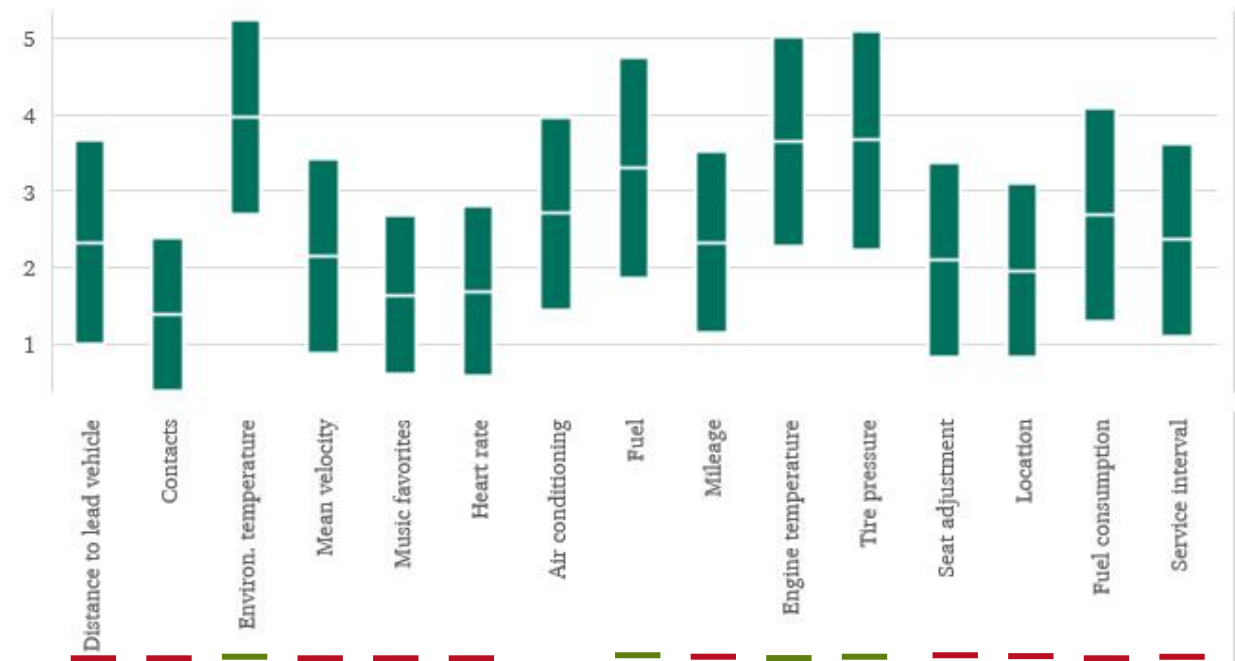 - uncritical: environmental data & operational characteristics

- sensitive categories:
  - user preferences
  - location
  - physiological data
  - driving behavior related data

- uncritical:
  - environmental data
  - operational characteristics

User rating of the privacy level of data in the connected vehicle

N = 101; y-Scale: Average of perceived data sensitivity (1: very sensitive; 5: not sensitive at all)

IaD

A closer look – An user study on the connected car

- To whom would users release their data?
  - strong trust in safety and care providing parties (e.g. ambulance and police)
  - general reluctance towards private market players (e.g. car manufactures)
  - least trust in providers of connected applications

Trust in data receiving parties
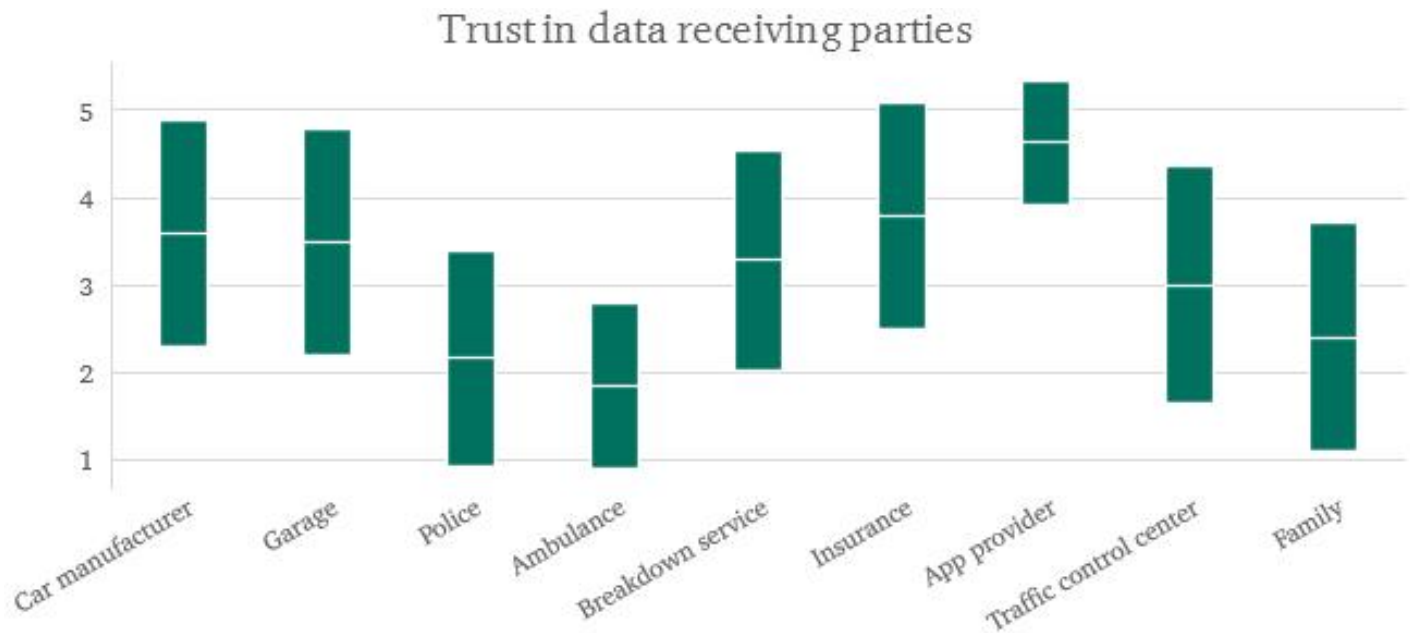
N=101; y-scale: Average trust in data receiving parties (1: very trustworthy; 5: not trustworthy at all)

IaD

A closer look – An user study on the connected car

- How relevant is privacy in comparison to safety, efficiency or convenience benefits? Under which circumstances are users ready to disclose their data?

  - Privacy decisions in the context of realistic scenarios
    - e.g. intelligent traffic assistant during a holiday trip

- advanced real-time traffic information
- automatic emergency call in case of a crash or breakdown
- automatic reservation of a hotel room at the destination

IaD

A closer look – An user study on the connected car

- Users are ready to release their location data in exchange for safety and efficiency benefits…

  ✔
  - real-time traffic information *(M = 1,73; SD = 1,06)*
  - automatic emergency call *(M = 1,56; SD = 0,98)*

- but are undecided in case of convenience benefits

  ━
  - automatic reservation of a hotel room ($M = 3,24$; $SD = 1,42$)

- Are users ready to release their data for monetary benefits?
  - pay-as-you-drive insurance: driving behavior vs. lower insurance rate ($M = 3.43$, $SD = 1.53$)
  - car purchase: operational data vs. discount on sales price ($M = 3.40$, $SD = 1.49$)

→ Participants are not ready to release neither their car's operational characteristics nor their driving profile for monetary incentives

IaD

CONCLUSION

Conclusion

- There has been only few user studies on connected vehicular services
  - most research has focused on a technical / IT perspective

- The connected car offers promising services such as safer driving

- However, the connectivity bears privacy risks to which users are at least partly sensitive.
  - Data type, identity of the data receiving party and purpose of data collection seem to be the most influential privacy factors
  - Manufactures and service providers can foster the adoption of connected vehicular services by providing transparency in data collection and data processing

IaD

Conclusion

Practical implications

- Collect your data parsimoniously.
  - data have become a new source of high economical value, but users view most data as being sensitive.

- Share it with as few as possible.
  - The more parties are granted access to the collected data, the lower user acceptance becomes.

- Differentiate between private versus professional contexts
  - Users tend to be more reluctant towards connected vehicular services in their private car than in professionally used cars.

- Communicate the extent and purpose of data collection transparently
  - Transparency builds trust between consumers and firms [12] and thus is a powerful tool to gain consumers.

References

[1]   De Winter, J C et al. Effects of adaptive cruise control and highly automated driving on workload and situation awareness: A review of the empirical evidence, Transportation research part F: traffic psychology and behaviour, 27, 196-217, 2014.

[2]   Chen, L, Englund, C. Cooperative intersection management: a survey. IEEE Transactions on Intelligent Transportation Systems, 17(2), 570-586, 2016.

[3]   Papadimitratos, P et al. Vehicular communication systems: Enabling technologies, applications, and future outlook on intelligent transportation, IEEE Communications Magazine, 47(11), 84, 2009.

[4]   Gardner, B, Abraham, C. What drives car use? A grounded theory analysis of commuters' reasons for driving, Transportation Research Part F: Traffic Psychology and Behaviour, 10(3), 187-200, 2007.

[5]   Pohl, J et al. A driver-distraction-based lane-keeping assistance system, Proceedings of the Institution of Mechanical Engineers, Part I: Journal of Systems and Control Engineering, 221(4), 541-552, 2007.

[6]   Rebolledo-Mendez, G et al. Developing a body sensor network to detect emotions during driving, IEEE transactions on intelligent transportation systems, 15(4), 1850-1854, 2014.

[7]   Thomson Reuters, ISI Web of Science. https://www.webofknowledge.com/2017, accessed on 5th of June 2017.

[8]   Schoettle, B, Sivak, M. A survey of public opinion about connected vehicles in the US, the UK, and Australia, ICCVE 2014, 687-692, 2014.

References

[9]   Eyssartier, C. Acceptability of driving an equipped vehicle with drive recorder: the impact of the context, IET intelligent transport systems, 9(7), 710-715, 2015.

[10]   Endo, T et al. Study on privacy setting acceptance of drivers for data utilization on connected cars, In: 14th Annual Conference on Privacy, Security and Trust (PST), 82-87, 2016.

[11]   Derikx, S et al. Can privacy concerns for insurance of connected cars be compensated?, Electronic Markets, 26(1), 73-81, 2016.

[12]   Kang, J, Hustvedt, G. Building trust between consumers and corporations: The role of consumer perceptions of transparency and social responsibility. Journal of Business Ethics, 125(2), 253-265, 2014.

Thank you for your attention!

M.Sc. Jonas Walter
Wissenschaftlicher Mitarbeiter
Research Associate

j.walter@iad.tu-darmstadt.de
Otto-Berndt-Straße 2
64287 Darmstadt/Germany
www.arbeitswissenschaft.de

Phone   +49 6151 16-23110
Fax   +49 6151 16-23101