

Framing the opportunities of robotics in meaningful autonomous vehicle experiences

An exploration of fundamental needs, AI-systems, and user interfaces

Vehicle automation will increasingly release car drivers from driving tasks, allowing them to engage in previously inconceivable activities. Experiential components are therefore expected to become central in human automotive mobility. In this context, the design of future in-vehicle experiences is a research gap to still discover, that concerns both academia and industry alike. This graduation project explored the opportunities of using robotics and AI technology for the provision of meaningful autonomous in-vehicle experiences. In that aim, different user interfaces (UIs) were analyzed, to study different user-technology interactions. The outcomes of the research comprise recommendations about promising scenarios that could be included in autonomous vehicles as well as insights into how different UIs shape user experiences differently.

Theoretical ground and research questions

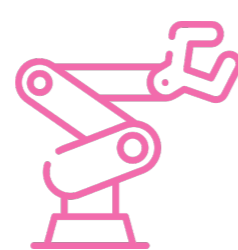
MEANINGFUL AV EXPERIENCES

- As the automation level increases in automated driving, the primary driving tasks will become obsolete, meaning that extra time will emerge for other activities. The focus of the current research is on non-driving-related tasks (SAE levels 3 to 5).
- Meaningful experiences can be provided if fundamental needs are addressed (Typology of 13 fundamental needs [Desmet and Fokkinga, 2020]).
- Prior work identifies new user needs and activities that will emerge in future autonomous vehicles; we have compiled them and connected them to the 13 fundamental needs.



TECHNOLOGICAL ENABLERS: ROBOTICS AND AI

- The robotics field is currently experiencing a shift towards service robotics.
- Robotics and AI would bring the following capabilities to the user experience in autonomous vehicles: deep personalization, context awareness, simulated presence, intelligent interfaces, autonomous action, managing big data, and advanced automation.



USER INTERFACES (UIs)

- UIs will shape how users experience the technologies and also how they ultimately fulfill their needs.
- Many classifications and types of user interfaces can currently be found in the user interaction field, most of them combinable with each other.
- Since we could not cover all and every user interface in the current research, three interfaces are selected, that represented three different manifestations of the technology: ambient, graphical and tangible user interfaces.



RESEARCH QUESTIONS:

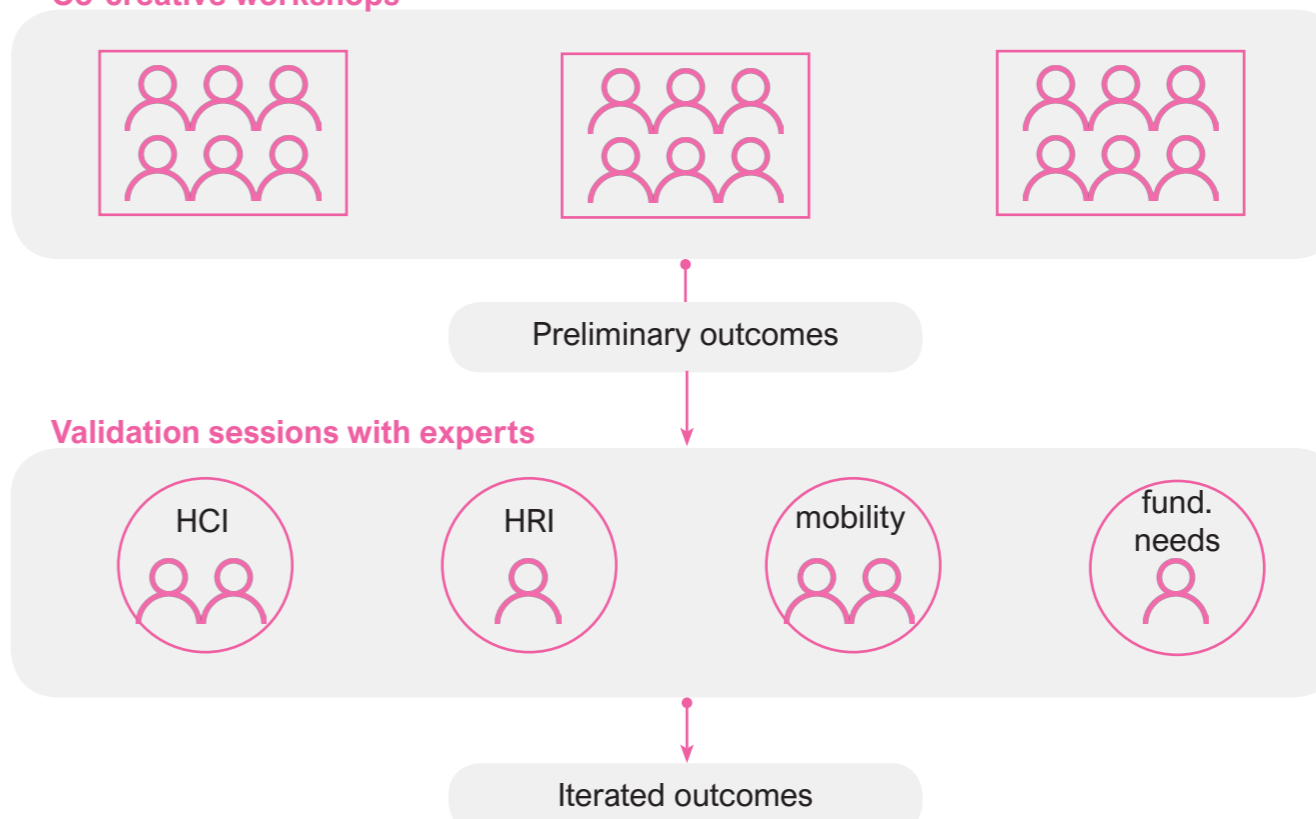
- What in-vehicle scenarios can be designed to support fundamental needs?
 - How do different user interfaces enable those use cases?
 - How do different types of user interfaces affect the in-vehicle user experiences?
- What are the most promising scenario and user interface combinations?

Method

To address the aim of this study, a qualitative **co-creative workshop** was designed. The participants were asked to envision future needs in AVs, based on the typology of 13 fundamental needs, as well as to design meaningful scenarios that would use UIs to fulfill them. Through a questionnaire, they voted for the most promising scenarios (i.e., most attractive and most innovative scenarios). After three iterations with 18 participants, and by theorizing from the data collected, preliminary insights were gathered.

Those outcomes were shared with six experts in **validation sessions** (experts in Human-Computer Interaction (HCI) (n=2); Human-Robot Interaction (n=1); future mobility (n=2) and fundamental needs (n=1)). The sessions were aimed at contrasting the outcomes with academic-level knowledge and adding new perspectives to the gathered results. Feedback was collected on how to improve the proposed results.

Co-creative workshops



Results

MEANINGFUL USE CASES & MOST PROMISING SCENARIO and UI COMBINATIONS

Fundamental need	Scenario	ATTRACTIVE			INNOVATIVE		
		A. UI	GUI	TUI	A. UI	GUI	TUI
Autonomy	The car will change its shape and configuration, considering where it is or where it is going.	1		3			6
Beauty	Users will be provided with new and exciting virtual views in situations in which outside landscapes are dull and boring.	2	2		1		1
Comfort	A very easy, hassle-free and simple food delivery service will be created to receive food when traveling in an autonomous car.	1	1	1			1
Community	Users will cook in the autonomous vehicles, to later share their dishes and ingredients with people in other cars.	3	2		1		3
Competence	The car will train users in their driving skills, through a simulator-like environment.			2			3
Fitness	The car will be a personal fitness tracker, that will be able to track users' bio-metrics and will provide them with different stimuli to contribute to their health.	2		1	3	2	
Impact	The car will be a space where to spend quality time with your kid while traveling.	1	1	1	1		
Morality	The car will be a space where you can pray.		1	2		1	
Purpose	The car will be a therapeutic space that will help users envision their future objectives.		2			1	1
Recognition	A very advanced and modern in-vehicle video-calling system that will allow users to connect with people that appreciate them.	2	1	1		1	
Relatedness	Users will be allowed to attend meetings virtually when they are not able to attend them in person as a way to support human relations.	3					
Security	The vehicle will make users feel safe, welcome and under control inside of the vehicle in situations in which the outside environment is hostile.		2				
Stimulation	a) The car will be a party room, where users can have fun by singing and dancing.	2	1		1		
	b) The car will be a meditation room, where users will be mentally stimulated.	1				1	

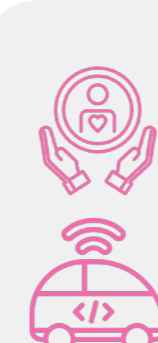
Highlights from table 1:

- Ambient user interfaces were considered more attractive than innovative, while the tangible user interfaces show a trend of having been considered innovative rather than attractive.
- Most prominent combinations for both categories: the tangible UI in the 'Autonomy' scenario received the highest vote percentage (i.e., 28.6% of the votes), followed by the competence-tangible and fitness-ambient combinations (each with 15.5% of the votes) and the community-ambient and community-tangible combinations (with 10.7% for each).
- The graphical UIs received fewer votes overall for both innovativeness and attractiveness.
- 'Autonomy', 'Community' and 'Fitness' were the top three fundamental needs (with 31.0%, 26.2%, and 25.0% of the votes each).

CONTRIBUTION OF THE UIs TO THE USER EXPERIENCE (overview of the themes)

ROLE OF THE USER	ROLE OF THE UI	DESIGN PROCESS
Passive user role	Nature of the interfaces and impact on the in-vehicle experience	Need to combine the UIs
Active user role	Nuances between UIs and relation with the car interior	Focusing on one interface as part of the design process
	Different sensory stimulation and engagement	

Discussion



FUNDAMENTAL NEEDS IN AVs

- We referred back to the literature, the validation sessions, and to the latest practices in the mobility sector to see if our fundamental need hierarchy could be generalized to further AV contexts.
- We concluded that some fundamental needs are often more prominent (for instance, 'Autonomy'), both in academia and real-life applications, which suggests that they are probably relevant to the context of autonomous vehicles. Additionally, by comparing the results from the literature with the traditional needs that are addressed in the mobility sector, we can see that manufacturers could take inspiration from academic work to open their scope of action to some relevant but still unattended needs (e.g., 'fitness' and 'community').



PROMISING SCENARIO and UI COMBINATIONS

- Regarding attractive scenario and UI combinations, it was raised that the ambient user interfaces might be preferred by the participants as they offer interactions that feel "more elemental, natural and human", similar to the "ambient nudges" that we experience in real life (E1). Our hypothesis is that, in this case, participants voted for the values that they would like to support in future AVs, being the means for experiencing those innovations things they can imagine, representing mainly incremental innovations.
- Innovativeness was overall perceived to be better represented by tangible user interfaces. Experts connected this to the fact that both technology (E4) and "futuristic" elements (E1, E5) (e.g., space transformations), which are usually linked to innovation, were among the proposed tangible UIs. Regarding innovation frameworks, when voting for the most innovative scenarios, participants chose the scenarios that generated new meanings in the in-vehicle environments.
- People often react with caution to new concepts and transformations, which may be the reason why the results for innovation and attraction are not coincident in our study.



CONTRIBUTIONS

- The results of this study may contribute both academic knowledge and industrial practice to frame the topic of in-vehicle experience design in the autonomous vehicle context: possible design directions are given and the project could also be seen as an example of how we can design for meaningfulness within autonomous vehicles or technology-driven settings. Finally, analyzing the concept of interface and comparing ambient, graphical and tangible UIs might help further define the implications of each interface in the interactions with the users.

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