Recharging Future Mobility: Understanding Digital Anticipatory UX through Car Ethnographies

Thomas Lindgren
"An intense anticipation itself transforms possibility into reality; our desires being often but precursors of the things which we are capable of performing.”
Samuel Smiles, *Self-Help*
Abstract

Cars have created many positive experiences for people by providing them freedom of mobility, exciting driving thrills and status in society. However, cars are also known to create problems such as pollution, traffic congestion and accidents. To shift towards a more sustainable way of mobility for the future, we need to understand car users' experiences of today and how these shape their anticipation of future mobility.

Today users of new cars create their future car using immersive online car configurators, share their anticipation and experiences about the functionality of recent software updates on social media or consider how their future electric car could be charged in a ‘smart’-way through available charging ecosystems. These examples show how digitalisation through new digital technologies extend the ways users anticipate and experience cars as they evolve. These experiences go beyond the moment of in-car interactions, which so far has been the focus for user experience (UX) research and development within academia and industry.

UX of digitalised cars is no longer mainly about the experiences of in-car driving and entertainment. Instead, digital technologies expand the possibilities for peoples' anticipation and UX of cars to emerge anywhere and anytime, making human anticipation an important aspect of UX to understand. The forward-oriented decision process, which occurs when people's hopes and fears about the future become part of their present actions and decisions, becomes a strong driver for people's decision making. Therefore, it becomes important to understand anticipation in relation to UX of digitalised cars and for how people shape their futures with cars.

Digitalisation of traditional physical products enables a mix of the digital and physical representations of the product, which adds new challenges in how we can understand and research UX of digitalised cars to include more aspects than in the individual moment of physical use, such as people's experiences of anticipating cars. Consequently, my thesis intends to answer the question: How can experiences of anticipating digitalised cars be understood?

I have approached the question by studying how digitalisation extends possibilities for UX and anticipation of cars to emerge in everyday life. To investigate the phenomena in everyday settings and follow change over time, a qualitative Design Ethnography (DE) approach was chosen and further developed throughout three different studies. The first study showed experiences of antic-
ipation to be anticipatory, socially constructed, evolving and creating emotional experiences at an online car discussion forum. The second study demonstrated experiences of anticipating autonomous driving (AD) cars to be situated in the social and environmental context, influencing the instant, near and far time spans of people’s anticipation of AD. The third study revealed how electric cars as digital platforms enable people’s anticipation of cars to be related to the surrounding ecosystems. Thus, overall, the thesis consists of five papers that investigate people’s experiences of anticipating digitalised cars from different perspectives.

This thesis’s main contribution is directed to UX research in the academic field of Human Computer Interaction (HCI) and the automotive industry. It aims to provide an understanding of how people’s anticipatory experiences of emerging digital technologies related to cars shape new problems and possibilities for future mobility. It concludes that UX research and design needs to be extended to also include aspects of digital representations, evolving functionality and extensions into other ecosystems, which enable the user’s anticipation to emerge and evolve. I have defined this as Digital Anticipatory UX (DAUX), which exposes how people’s anticipation continuously evolves through digital-physical use in the everyday context and creates experience before “use”. By showing a methodological approach to investigate these anticipatory experiences, this thesis also offers a starting point for understanding how people’s evolving hopes and fears can provide insights that implicate the creation of innovative future sustainable mobility solutions with people.
Acknowledgements

Writing this thesis has been a five-year journey with a lot of unanticipated opportunities and challenges. Someone told me in the beginning of my journey that doing a PhD is a lot of lonely work. This is true, in the sense that you do much of the work yourself and you get your name on the cover paper. However, the statement is also very wrong. Doing a PhD is very entangled in everyday life, especially since so much in recent years have been done from home. There are many people who have been part of this PhD, helping me out in going forward and finding new routes when obstacles occurred. I will not be able to mention you all, but you are not forgotten, even if your name is not found below.

I will start by thanking my family for their support of this thesis. To my wife Jennie and my daughters Olivia, Alicia and Emilia, who give meaning to my life, without having you all as the foundation, completing this thesis would not have been possible. I know you all have been missing me a lot when life has sometimes been tough, and I’m grateful that you have given me the chance to do this thesis.

There are some people that have had a very close and active part in my whole PhD journey, for which I am very grateful. First, to my main supervisor, Vaike Fors, you have not only taught me to view things from different perspectives and how to do a PhD, you also have been so pedagogic at listening, preparing and guiding my PhD in the direction to which I aspired. I also want to thank the rest of my supervisors, Magnus Bergquist, Martin Berg and Robert Broström. You have all contributed with a huge amount of valuable feedback and support when needed. A very special thank you to Sarah Pink who has been my mentor and guru in ethnography and anthropology. I have learned so much writing with you. However, the best part about having all of you as supervisors were all the fun and laughs we had during our meetings, travels, workshops, writing sessions and chats.

To my fellow researchers and colleagues in the DriveMe and RELEVANT projects, Katalin Osz, Patrik Palo, Jan Nilsson, Emma Rubin, Robert Eriksson and Jonas Andersson, a huge thanks for being part of making my studies and these projects fun and inspiring. I send an extra star to my colleague Lingxi Yuan who helped me designing the front book cover, great work on the picture and all the fun subtle details in it. An extra thank you to my former manager at UX Vision, Volvo Cars, Mikael Gordh, for having anticipation and faith in my
research topic. I will miss you and our discussions on Tesla experiences and strategies a lot. I really wish you luck with your new assignment.

I would also like to thank all participants in my three research projects. Thank you all for letting me into a part of your everyday life and sharing that with me. I will bring your engagement with me in the future.

A special thanks to my closest research colleague, Kaspar Raats. You really know how to make people feel happy and chilled. You have provided me with a lot of feedback, great ideas, energy and fun throughout these sometimes tough times. You also have been great in providing me with access to things I wouldn’t have dared to do myself…

To everyone at E4, it has been great getting to know you and you have all contributed in different ways to my thesis and introduction into the academic world. Thank you to Maria, for your sharp and clear feedback and being my support person; Susanne, for inspiring me in how a good PhD should be done; Esbjörn, for your well thought out reflections and questions; and Jesper, for providing feedback and making me feel good even when it’s a critique.

I will miss this period in my life—maybe not the writing anxiety—but I will miss all the people who I have met and who have contributed in some way. Thank you. You have made me to level up and anticipate more for the future!
Anticipation is the red thread in this thesis; it has both been the topic to understand and my own force to craft this thesis. How does anticipation make people shape their futures and how can we understand the complexity of people’s experience of anticipation? The theme of anticipation in this thesis also reflects my own personal perspective on life and how it evolves. My anticipation of understanding how people create relations and experiences with new emerging technologies has been my main driver throughout my long career in the automotive industry.

My interest in people-car relations started even before my career as Interaction Designer at SAAB Automobile in 1999. Relying on studies in Human Factors and my exam in M.Sc. in Technical Design, I was well equipped in the early 2000s to make the interfaces between human and technology as easy to understand and as efficient to perform as possible. However, I discovered during these early years at Saab Automobile that people’s experiences of cars seemed to be more complex than interacting through perfectly-sized buttons and easy-to-understand labels and text. For example, designing the interface for an automatic climate control system, by following a quantitative driven development process and using ergonomic design guidelines metrics for button sizes, standardised labels and number of presses to perform a task, did not successfully deliver positive experiences to the end-users. “Ugly, complex and cluttered” was their response.

Further, the technical development of new advanced in-car infotainment systems, so-called Information Technology Systems (ITS), with navigation and communication capabilities opened up new challenges for interaction design during the early 2000s. As I was curious to explore these new challenges, I had the opportunity to develop and explore new innovative interaction concepts for these new ITSs in different advanced engineering car projects at SAAB. As the function growth for these ITSs increased rapidly, it became increasingly obvious that it was not possible to create optimal user interfaces by designing separated functions and dedicated buttons or screens for each function. This was the starting point of the era when multifunctional controls, and large screens with deep menu system structures were developed and introduced to car users. This new era of ITSs enabled people to experience cars in new ways, and more importantly, to discuss qualitative aspects of the look and feel of interaction. However, these new qualitative aspects were difficult to bring into a quantita-
tive driven automotive product development process. It was much easier to define and incorporate an ergonomic target of minimum readable text sizes, contrast or maximum number of steps to perform tasks than to try to subjectively judge the overall experience. At this time, there were no standardised methods of measurements used in the car industry to evaluate car user’s experiences.

When I later switched jobs from Saab to Volvo Cars during 2004, I was on the beginning of a radical transformation of interaction design towards User Experience (UX) in industry and academic research. The notion of UX changed the focus to design for user’s experiences and the hedonic aspects rather than designing interfaces purely based on the pragmatic usability aspects. However, I still found the automotive industry to struggle in how to understand and use UX in the development process. The car development process at the time was heavily based on requirements and measurable targets to track project process and goals. UX was gradually seen as important from a company perspective, however UX was still not so easily reduced to numbers and scales that could be tracked along the development process. As UX is individual and everyone has their own view of it, individuals in development processes often challenged the process, forcing quick decisions, not based on the target group, but rather on their own worldview of UX.

During this time, I discovered a way to understand users’ first reactions to new car technologies through self-generated online car discussion forums. Insights from people discussing UX of cars with others online was revelatory as it provided faster and more detailed descriptions in capturing emerging UX issues. This compared to the formal internal company process of sending out questionnaires with predefined questions and scales to users after three months of car use. However, even though the insights from the online forums could be very detailed and contextualised, it was difficult for these kind of insights to make an impact in the quantitative driven automotive development processes. The findings were seen as not statistically relevant given they were based on only a handful of people’s opinions and therefore were difficult to incorporate into requirement specifications.

During the 2010s, UX became even more important, which can be reflected in the fact that the number of people working within UX design in industry increased steadily. The focus on UX led to new perspectives on people’s interaction with cars. Instead of only focusing on the in-car interactions, the context for UX of the car extended the view through different kinds of user journeys and touch points to identify users’ ups and downs. Despite the increasing interest and importance of UX in the automotive industry, it was still difficult to bring user-centred design processes into the technical development processes. While decisions about hardware development need to be made in the early phases to be ready in time for production, and thus follows a waterfall development process, software development is an agile, iterative and incremental
way of working, meaning rather large decisions can be made at later stages. This created a tension between an older and a newer way of working, and the challenge for UX design became how to understand the user value and anticipation before the definition of the hardware is set.

As the relation between people and new technologies always seems to evolve, it continuously creates needs for new methodologies and processes to understand people’s experience with technology. This has been my driver in working within UX research and design in the automotive industry and sparked my aspiration to complete this thesis. Two major insights from my career have shaped the writing of this thesis. First, the development of UX at Volvo Cars provided three insights: that UX is an important quality aspect of the car from a user perspective and methods for understanding UX are needed but can’t reduce people into numbers. Second, as the pace at which new digital automotive-related technologies are introduced to users (such as connectivity, electrification, over-the-air updates, automated systems, etc.) is rapidly increasing, there is a need to be fast and look forward in understanding users’ anticipation of new digital technologies and how people share and shape their futures. This drives an ever-shifting need for new ways to understand people’s experiences of anticipating digitalised cars, as the digitalisation enables cars to become open-ended and experienced as a never-finalised product ready to be part of new, unknown future digital ecosystems.

I have learned over the years that the extension in ways people experience cars has grown far beyond driving, so it cannot be fully understood in a lab setting of driving simulators, static mock-ups or focus groups discussions. Therefore, the context of this thesis plays out in people’s everyday lives with cars. My interest in reading online discussions about cars and new digital technologies where people are engaged in sharing experiences and ideas has also strengthened my belief in people’s great potential to collaborate and co-create solutions for a better future. People might not know exactly what they want if asked, but they are the best at understanding their everyday life and how to adapt technology for their use and anticipated futures.

Also, during the period in which this thesis was developed, topics of sustainability, circularity and ethics have surfaced, questioning if humans should always be at the centre of design or if companies should mainly strive for rapid technology developments to make profit. I believe the digitalisation of cars enables many opportunities for automotive-related companies to provide future sustainable mobility solutions, without necessarily measuring their success in producing increasing numbers of cars, and instead finding new ways to create businesses around mobility with circularity in mind. However, I fear that digitalisation of cars could enable the opposite direction if car companies look for short-term solutions and are not able to foresee probable or preferable directions. UX design not only provides the tools to develop a car that supports people’s lives in a better way, in the future it could also become a tool for design-
ing software functionalities that lead to better and longer relevance of a particular piece of hardware for transportation, and thus lead to a more sustainable way of providing mobility to people. However, I believe digitalisation is already changing the way we experience cars more than we might think. The increase of digitalisation in everyday life has also been reflected in how my studies evolved practically as the Covid-19 pandemic disrupted the way people socialise and share experience as well as how ethnographic research had to be performed.

In the later phase of writing this thesis, a friend of mine that recently purchased his first Electric Vehicle (EV) captured the current change in UX of cars by posing this question to me: ”What do all the current car enthusiasts think about the future cars when all the traditional experience of a car is gone?” He was referring to the experience of sounds, smell, performance and craftsmanship of a powerful fossil fuel car drivetrain. He continued, “I have never been interested in cars before, but now with sustainable and connected EVs focusing on entertainment and continuous updates, I have become interested and engaged in cars…” I didn’t have time to give him a full answer, but I hope this thesis will be able to explain how we anticipate and experience digitalised cars differently and how we could investigate these phenomena.
List of Papers

*Paper 01*

*Paper 02*

*Paper 03*

*Paper 04*

*Paper 05*
### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD</td>
<td>Autonomous Driving</td>
</tr>
<tr>
<td>AUX</td>
<td>Anticipated User Experience</td>
</tr>
<tr>
<td>DAUX</td>
<td>Digital Anticipatory User Experience</td>
</tr>
<tr>
<td>DE</td>
<td>Design Ethnography</td>
</tr>
<tr>
<td>EV</td>
<td>Electric Vehicle</td>
</tr>
<tr>
<td>HF</td>
<td>Human Factors</td>
</tr>
<tr>
<td>ITS</td>
<td>Information Technology Systems</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
</tbody>
</table>
1 Experiencing Cars in the Digital Age

Anna, the single mother of a one-year-old son, is living in the city centre in a flat, but she dreams of moving to a small house in the countryside where she can grow her own vegetables. She is trying to have a sustainable lifestyle and finds some of her inspiration from following a young female popular lifestyle Youtuber alias “Ecotechlifegirl”. One day in a videoblog, this YouTuber shows off her excitement about a new high-tech EV from an unknown car brand. Cars are not Anna’s biggest interest in life and currently she meets most of her mobility needs through public transport. However, she struggles to bring all the needed stuff for her son when going for shopping or visiting family and friends by train or bus. The YouTuber starts talking about the traditional, boring car stuff—how good this car looks, how well it handles and how fast it is—and Anna is about to choose another clip to watch. However, when “Ecotechlifegirl” explains the car’s digital capabilities—how it drives almost by itself; how silent and clean it drives; how easy it is to charge; how it is always connected to the smartphone; how the software will be updated with new capabilities over time with, e.g., car sharing capabilities or autonomous driving (AD)—Anna starts to become a bit more curious. It seems that the car has only been released to a few people in the world so far, but the news about it has been shared quickly world-wide through social media, and it is already available for pre-order.

Anna wants to know more about the car and looks up an international Facebook group related to this new car brand. Once Anna starts scrolling through the discussions around the new possibilities offered by this car, she starts to imagine how the car might fit into her future life and provide new opportunities for her to use it. Maybe she could share it easily with her best friend and split the ownership costs. She could also pay full attention to her son while the car autonomously drives to her parents for the weekend. Anna’s anticipation is fuelled by the other engaged people in the Facebook group. Of course, there are some very sceptical people there as well. They complain about and fear the non-proven quality of this new car brand; the high purchase price; the lack of features delivered at launch; and the struggles to charge if you are living in a flat without possibility for charging when parked. However, their scepticism is challenged by other engaged people who anticipate how easily the car will be updated with new features over-the-air and explain that living with an EV is not difficult compared to a traditional fossil fuel car, it’s just a bit different and much more sustainable. Some people are already sharing screen shots and specs of their recently configured and pre-ordered cars.
Meanwhile, Anna is imagining the car in her life; she has already downloaded an EV-charging service app and started to plan where she could charge it every day as well on her longer trips to visit her elderly parents. Suddenly, she finds herself in the process of configuring a car at the newly launched website. A few “clicks”, and she has signed up for a private leasing contract including all running costs except the charging. This is done without even seeing or driving the car in person. Now Anna must wait for two months before delivery, but it does not matter, as there are plenty of YouTube clips uploaded by other owners explaining the different features and future possibilities for her. Anna’s anticipation evolves for a new life with this new car. She starts searching for houses in the countryside, as now with a car she will not be dependent on public transport and can move outside the city. One thing leads to another and even before the car has arrived, she has become the owner of a small house with a garden outside the city. She calls an electrician to install a wallbox charger even before she has moved out of her apartment and received the car. Through the Facebook group, she has already learned some tips about apps that will work best in planning for longer trips as well how EV batteries works in cold climates, during charging and how to prolong the battery life-time.

The day comes when Anna finally picks up her new car. Behind the wheel, she feels like she already knows it. In fact, she seems to know more about it than the delivery service guy showing her the different features of the car! The car feels great to drive and so much more modern compared to her past experiences with cars. Even if some of the driving assistance functions are not fully working yet, she does not care much as she already knows from the Facebook group discussions there will be a new software over-the-air release within a month with added and improved features. Anna’s anticipation to explore all new upcoming features makes her tick the box in the car’s Infotainment system confirming that she wants to try out new Beta software releases in the near future. Anna feels like she will be part of the future development of the car. She already has an idea she wants to share. Maybe the parking cameras on the car could be used as surveillance cams in front of her new house.

However, the experience of the new car is not all positive and according to her anticipation. She noticed that the charging stations close to her flat are rarely available or functional. The car is annoyingly sending push notifications to her phone telling her about a lot of random problems that need attention by the workshop. Also, during her first long journey to visit her parents at Christmastime, the battery drains much faster than expected during the cold winter temperatures and the advanced driving assistance system give up supporting her driving due to the snowy conditions. Unfortunately happens when she needs support the most. She instantly posts her experiences and worries to the car Facebook group when she has to stop yet another time to charge her car to be able to reach her destination—a couple of hours later than expected. She reflects that maybe it would have been a more relaxing, safe and sustainable option to take the train instead. However, she anticipates soon most of these problems will be solved by software updates at the time she is able to move to her new house.
While she has been searching online for the right type of wallbox in some of the forums discussing smart energy home systems, she has noticed how many people share their great experiences of solar panels in combination with an EV. The feeling of producing your own fuel becomes very tempting to Anna and now she starts to think that it might be worth investing in expensive solar panels for her new home. In the end, was it Anna’s anticipation for a more sustainable lifestyle that drove her in this direction or was it the other way around? Did she actually get a more sustainable lifestyle or only the feeling of it? And how did the anticipation provide her with an evolving UX even before she had tried out the car in the physical world?

The fictional narrative above, based on different empirical data excerpts from my studies, shows how digitalisation of cars, mediated through different digital technologies and services, have changed the process of becoming a new car owner. This has taken the process far away from stereotyped methods of men kicking tires at car dealers, taking a car for a test drive and then buying the car mainly as a well-made piece of metal on wheels with status. In the story above, I tried to describe how these new emerging digital technologies enable people’s anticipation to become part of how their UXs of cars are created and evolve. The story exemplifies how digital technologies extend the UX of cars through the way people can now, e.g., experience the car through digital representations online and outside its physical context; remotely experience the car through their smartphone app; experience the car as an unfinished evolving product through software updates; or experience the car as a part of their household energy ecosystem. Digitalisation also enables people to be engaged in co-developing services and products through, for example, evaluating unfinished early versions of functions in their everyday lives, like Tesla’s Full Self Driving functionality (Dixon, 2020).

My ambition in this thesis is to contribute to the understanding of how people’s experience of anticipation shapes their choices for future mobility by scrutinising how digitalisation expands the possibilities for people’s UX and their anticipation of cars to emerge. It is apparent that the digitalisation of the transport industry has occurred and has created new possibilities for experiencing mobility; this thesis is concerned with what this means for how future mobility can be envisioned. To provide people with sustainable future mobility solutions that easily fit into their everyday lives, there is a need to first understand how people are anticipating future mobility and where digitalised cars shapes their experiences and actions. Then these insights could turn into possibilities for innovations when designing for future mobility.
This thesis approaches and studies how experiences of anticipating digitalised cars can be understood, through how people’s experiences evolve and arise; that is, how, when and where people anticipate how it will feel or how they want it to feel to have the car in their “hands” and homes. In this way, my aim with this thesis is to contribute to UX research with a new understanding of UX that also includes experiences of anticipation emerging from digi-physical materialities as an important extension to current perspectives. This thesis also provides a methodological approach to investigating experiences of anticipation and foresights regarding everyday life with digitalised cars. This becomes useful for further UX research and development in creating innovative sustainable future mobility.

The digitalisation of cars will enable other possibilities for people to experience cars than merely in-car interactions. From the end-user perspective, there are many aspects of digitalisation to explore. However, in this thesis there are three different possibilities to experience cars that are of particular interest for understanding how experiences of anticipating digitalised cars can be understood: (1) experiencing cars through digital representations remotely and outside the car cabin, through social media, online car configurators or smart phone apps; (2) experiencing the evolvement of the digital materialities of cars, through software updates and intelligent algorithms; and (3) experiencing the car as a digital platform in connection and integration with other digital ecosystems and infrastructures outside the traditional road infrastructures, such as charging networks and home energy systems.

1.1 Need for More Sustainable Future Mobility

Cars have provided people with a feeling of freedom, thrilling driving experiences and status in society (D. Miller, 2001). However, car usage also generates huge world-wide problems of congestions, pollution of the environment, traffic accidents and an overuse of natural resources around the world. The current situation urgently calls for cars to become part of more sustainable mobility solutions for people. Mobility is needed to go to work, do shopping, meet friends and relatives, give children a ride to activities, go on vacation or sometimes just for fun. Cars are one of many means to provide mobility to people, while bicycling, ride sharing or using public transports are seen as more sustainable choices than personal car use. Even if people know about the problems associated with using cars, and authorities make it expensive and difficult to use cars, people justify of their need for personal car use and continue to use them (D. Miller, 2001). To change the direction towards a more sustainable way of mobility related to cars, there is
a need to understand the experience of cars in the settings of people’s social, cultural and experiential everyday lives.

The development of the digital economy and digital technologies is said to have changed the automotive industry after a century of primarily selling cars as physical products. In the past, the aim was to sell as many cars as possible and car manufacturers that produced the most affordable, luxurious, fastest or most flashy-looking cars were the ones that won the competition. Attracting new car customers was achieved through shiny adverts in papers and on TV, or by showing top results in car magazine tests. Whether people like or use cars in their everyday lives or not, cars have a long tradition as a symbol for freedom and status in society and are part of most people’s everyday lives (Urry, 2004). Many car users value the freedom and status cars provide and choose to buy into this dream, even if we realistically know the impact of cars is not all positive.

New mobility solutions involving cars are afforded by digital technologies such as AD, connectivity, electrification and shared mobility solutions. These emerging technologies are stated by both private and public actors to have a disruptive power on future mobility. For example, the McKinsey Center for Future Mobility (https://www.mckinsey.com/features/mckinsey-center-for-future-mobility/overview) states that a new paradigm is rising within transport that will “radically transform everything from power systems to the use of public space, while simultaneously introducing a new city dynamism”. Indeed, according to PitchBook (Hussain, 2019), between 2009-2019, venture investors have poured $197.3 billion into mobility technology in the US alone in the hope of identifying new business models while improving safety, reducing pollution, transforming power systems as well as changing the use of public space in urban areas from mainly being populated with privately owned cars to more socially, economically and environmentally viable cities. At the same time, it has been emphasised that to create this sustainable change, people’s attitudes, hopes, fears and values need to be taken seriously (Hesselgren, 2021; Mladenović, 2019) as part of the complexity involved in making sustainable systems (Nyström & Mustaquim, 2014). Thus, without a thorough understanding of people’s experiences and expectations of emerging digital transport technologies, the implementation of new sustainable and integrated transport systems risks being resisted by people and failing (König & Neumayr, 2017). Therefore, to understand how emerging mobility technologies can support a much-needed change in today’s transport and the choices people are able to make towards more sustainable solutions, we need to start by understanding the social, cultural and experiential context of people’s everyday logistics. Such a people-centric approach moves beyond simply taking people’s needs as a
starting point for designing new mobility solutions for sustainable futures to also include consideration of what people already know, value and feel.

1.2 Understanding Experience of Digitalised Cars

Research and development about experiences and design processes to create positive UXs are often referred to as UX theories and frameworks (Forlizzi & Battarbee, 2004; Hassenzahl & Tractinsky, 2006; Karapanos, Zimmerman, Forlizzi, & Martens, 2009; McCarthy & Wright, 2004b) and comprise a wide range of UX methodologies (Vermeeren et al., 2010). Within academic UX research, the Human Computer Interaction (HCI) field has been the main driver for developing the latter. However, even long before the term UX was introduced in the automotive industry during the 2000s, people’s experiences of cars have always received attention from the car industry and academia. The technology development and research methodologies used to understand human interaction with cars have been developed in relation to each other (Akamatsu, Green, & Bengler, 2013). Until today, the focus has been mostly related to the individual moment of in-car use through interaction (Akamatsu et al., 2013).

However, today, digitalisation (the enabling or improving processes leveraging on digital technologies and digitised data) in society has extended the possibilities for UX of cars today and in the future (Gao, Kaas, Mohr, & Wee, 2016). Stoltzerman and Fors (2004) highlight the effects of digital technologies in the everyday lives of human beings, stating, “This leads to a world that is increasingly experienced with, through, and by information technology”. The narrative in the introduction above demonstrates how digitalisation extends the UX of cars, temporally and spatially, beyond the traditional direct and individual interaction with a physical car as a product. The interaction interfaces between human and technology also becomes blurred when digital technologies extend the ways people interact with cars. Fast iterative software development with beta users and intelligent technologies such as Artificial Intelligence (AI) or Machine Learning (ML) adapt to our actions and habits, and people also adapt behaviours and routines accordingly (Applin & Fischer, 2015). The relation between human and technology becomes performative and fuzzy in terms of understanding who is in control and who shapes who. The complexity in how digitalisation enables a mix of digital and physical experiences of a product, referred to as digital materialities (Pink, Ardèvol, & Lanzeni, 2016), adds new challenges in how we understand the emergence of experiences in these settings.
The evolving, unfinished and indirect character of digital technologies also allows for people’s anticipation of products and services to form their UX of cars. As human anticipation plays an important role in how we direct our decisions and actions (Poli, 2019), it becomes a key theoretical foundation if we want to understand how people direct and evolve their experiences and relationship with cars. In current UX research, anticipation of UX is referred to as the so-called indirect experiences before use (Karapanos et al., 2009; Roto, Law, Vermeeren, & Hoonhout, 2011), also defined as Anticipated UX (AUX) (Yogasara, Popovic, Kraal, & Chamorro-Koc, 2011). AUX is defined as “the experiences and feelings that the user expects to occur when imagining an encounter with an interactive product or system” (Yogasara, Popovic, Kraal, & Chamorro-Koc, 2012) based on factors such as: intended use; anticipated emotions; desired product characteristics; dislikes; user characteristics; experiential knowledge; and favourable existing characteristics.

If the possibilities, time and place where the car can be experienced are expanded, the car also becomes more integrated into people’s everyday lives. As digitalisation provides an extension in the way people experience products, both temporally and spatially, evolving and making the borders unclear between the user and the product, there is a need to adopt an ontological (question of being) and epistemological (question of knowing) perspective of viewing humans and technology as inseparable entities with an always-evolving relationship between them. This has previously been referred to as Entanglement HCI (Frauenberger, 2019). This emerging phenomenological shift within HCI provides a guide for how understanding UX of digitalised cars could be approached. When there is no longer a well-defined interface between human and technology in time and space, and it is also ever evolving, there is a need for a different perspective and methodological approach to investigate the complexities of UX and the sociomaterial aspects of digitalisation.

This thesis goes beyond the individual interaction with a physical object as the unit of analysis to understand how digitalised cars are experienced. So far, the focus in UX research has been on the individual and direct use of a product studied through experimental lab settings, rarely including the context of everyday life (Alba & Williams, 2013; Diefenbach, Kolb, & Hassenzahl, 2014; Raats, Fors, & Pink, 2019). This calls for a need for methods to study UX of digitalised cars in the everyday context to investigate peoples interwove and evolving experiences. UX research regarding connected cars has also produced only a limited number of studies done in the context of everyday use (Ryghaug & Toftaker, 2014; Svangren, Skov, & Kjeldskov, 2017).
To provide implications for designing more sustainable future mobility solutions, the UX field in academia and the automotive industry could benefit from further understanding of how digitalisation enables anticipation, which provides an extension in how UX emerges and evolves.

1.3 Aim and Research Questions

This thesis mainly intends to answer the question:

Main RQ: How can experiences of anticipating digitalised cars be understood?

However, rising societal demands, such as designing for sustainable mobility or new digital technologies, such as connected, intelligent or autonomous systems, bring new challenges and opportunities to study and design for UX (Hassenzahl, Burmester, & Koller, 2021). The extension of UX and experiences of anticipation also comes with a need for other methodological approaches to study phenomena (Frauenberger, 2019). As digitalisation extends UX beyond the view of “interaction” between human and technology, it requires a methodological approach to investigate people’s experiences of the blurred boundaries and evolving relations between technology and humans (Frauenberger, 2019) and to turn these into implications for design of future mobility. As such, the sub RQ follows:

Sub RQ: How can experiences of anticipating digitalised cars be investigated to foresight problems and opportunities of future mobility?

In this thesis, I have chosen to take the end-user perspective and view digitalisation of cars in terms of the impact on people’s anticipation and UX of cars emerging from connectivity, automation, electrification, software updates or digital representations of the car. Given the complexity of how the phenomenon of UX appears, the main research question required an in situ and open-ended approach in ethnography (Kaye, 2008). To investigate experiences of anticipating digitalised cars in everyday settings and provide implications for design for future mobility solutions, a Design Ethnography (DE) approach (Crabtree, Rouncefield, & Tolmie, 2012; Müller, 2021; Salvador, Bell, & Anderson, 1999) was chosen and explored as it “focuses on the broad patterns of everyday life that are important and relevant specifically for the conception, design and development of new products and services” (Salvador et al., 1999). The two-dimensional contrasts in DE of
the prospective (design) and the descriptive (ethnography) account for a forward-looking and real-life perspective on experiences of anticipation.

To garner different views on digitalisation of cars and how it generates multiple and dynamic ways in which the social and the material are constitutively entangled in everyday life, the research questions were explored through three studies with different views on digitalisation of cars:

**Study #1 – UX of cars through digital representations**
Studying people experiencing cars digitally in a social media community and how this shaped their UX of the physical materialities of the car.

**Study #2 – UX of cars evolving by digital materialities**
Studying people experiencing cars physically shaped by the evolving digital materialities of the car in everyday driving by evolving semi-autonomous technologies.

**Study #3 – UX of cars as part of digital ecosystems**
Studying people experiencing cars as part of a digital ecosystem through EVs as a digital platform connected to smart charging and part of a home energy system.

The explorative DE approach in this thesis was chosen not only to answer the main research question for an extended theoretical understanding of anticipation and UX, but also to demonstrate a methodology to create knowledge about anticipation and UX as well as provide empirical implications for UX practitioners. In this thesis, the reason for a DE approach should not be interpreted as selection of a self-contained method, but rather as a starting point for encouraging new perspectives and thinking about novel methods that lead in iterative steps to the creation of implications for design. Study #1 used a generative ethnographic approach (Dourish, 2007) to explore experiences of anticipation as the participants themselves provided topics for speculative futures in their on-line discussions. In Studies #2 and #3, the DE was applied as a version of Anticipatory Ethnography (Lindley, Sharma, & Potts, 2014) by using speculative scenarios and designs to extend the temporal scope of practice for the participants to gain a forward-looking approach in studying anticipation.

The findings of the thesis lead to contributions within UX research in the HCI field and UX design within the automotive industry:
The main contribution of this thesis is to provide an understanding of how the problems and possibilities of the new digital technologies around future mobility are shaped by people’s experiences of anticipating the new digi-physical materialities of cars, called Digital Anticipatory UX (DAUX)

Secondly, the thesis contributes to UX research practice by demonstrating how DE as a methodological approach is used to investigate experiences of anticipation and turn these into foresights

Lastly, it provides empirical examples of DAUX that offer foresights as implications for design of future mobility products and services.

The contributions are aimed at UX researchers in academia, as well as designers and UX researchers in industry. Even if the findings are based on cars and the settings around cars, the theory and methods used may potentially be transferable to other domains as well.

1.4 Thesis Structure

This thesis consists of a cover paper and five individual papers (see an overview of the different thesis phases with related studies and papers in Table 1). The cover paper is structured as follows. The next chapter (2) will outline: the history in UX of cars both from a user and a research perspective; the state-of-the-art in human anticipation theory and current UX research; and the definition of entanglement theory and what its philosophical background means for the approach in this thesis. Chapter 3 will describe the research methodology of Design Ethnography and the adopted methods to investigate the experience of anticipation and how to generate Design Principles for UX design of future mobility technologies. Chapter 4 will describe the three empirical studies of this thesis. Chapter 5 will provide an overview of the different thesis phases, each paper’s contribution and how they jointly add to the evolving development of the findings of this thesis. Chapter 6 will discuss the findings and contribution for UX research and design in academia and industry, followed by a reflection on the limitations and transferability of the results. Finally, Chapter 7 will present the concluding remarks of the thesis. After the cover paper, the five individual papers will be attached.
### Table 1: Overview of Studies and Papers

<table>
<thead>
<tr>
<th>Thesis Phase</th>
<th>Contribution</th>
<th>Papers</th>
</tr>
</thead>
</table>

### 1.5 Key Concepts in Thesis

First, there are some basic concepts that need to be briefly explained to understand how they are applied. These are: *Digitalisation, User Experience (UX), Anticipation, Entanglement* and *Design Ethnography*. The contribution of this thesis will be to define a new form of *Digital Anticipatory User Experience (DAUX)*, which will be used throughout this thesis.
Digitalisation refers to the integration of digital technologies into traditional business/social processes to improve them. Digitalisation emerges when physical material turns into or also appears in a digital format, a process defined as digitisation (Brennen & Kreiss, 2016). In this thesis, the context of digitalisation refers to cars and specifically how examples of digitalisation are experienced from the end-user perspective. The selected situations of digitalisation in this thesis are based on digital technologies related to cars such as: digital representations of cars online (car-configuration tools, discussion forums and videos); connectivity (remote access, data sharing and traffic information); continuous software evolvement (over-the-air updates, intelligent machine learning); automated driving (driving support and AD); and electrification (charging and connection to household energy system).

User experience (UX) in this thesis refers to the ISO 9241-210 standard definition (ISO, 2010) widely used within academic research and industries related to cars and defined as “[a] person’s perceptions and responses that result from the use and/or anticipated use of a product, system or service” (ISO, 2010). In this thesis, the term is used to include car users’ experiences of cars that extend outside the context of physical in-car experiences (driving or riding experiences), related to the digital technologies of the car. Also, the temporality of UX is included in the definition and adopted as the digital representations of the car extends the moment in time when car experiences emerge.

Anticipation in this thesis refers to the act of humans looking to their future based on their hopes and fears and how it shapes their decision making in the present (Poli, 2019). In this thesis, anticipation is different to expectation, as the former includes people’s feelings of hope and fear of something about to happen. Expectation is more related to the probability of something happening, also sometimes referred to as the Expectation-Confirmation Theory, explaining causality for consumers’ expectation, confirmation and satisfaction (Bhattacherjee, 2001).

Entanglement (Frauenberger, 2019) is used to describe human relationships with digital technologies, such as virtual realities, intelligent technologies or cyber-physical systems where the interfaces of interaction between humans and digital technology become blurred and difficult to define and the relations are never static and become always evolving.
Design Ethnography (DE) (Müller, 2021) refers to the methodological approach to examine what people do in their everyday lives rather than what they say they do. The difference between traditional ethnography and DE is related to the timescales, where the former is more about understanding culture and the history, whereas DE in this thesis is used for the purpose of involving users in a process to examine, speculate and probe new technologies to gain foresights of future uses.
This thesis focuses on how people’s experiences of anticipating digitalised cars can be understood and how this could be investigated. In order to understand the future, there is a need to look back in history. This chapter aims to provide a theoretical background to the history of UX research related to cars, UX of cars, digitalisation of cars, human anticipation and entanglement. It will start with a rear-view look at the history of UX and cars from both the user and the academic research perspectives as well as an exploration of the importance of this topic. This will be followed by a discussion of the current understanding of human anticipation and the identified challenges in understanding anticipation in UX research before ending by outlining entanglement theories as a philosophical stance to understand UX of cars as an ever-evolving digitalised product and related services.

2.1 Experiencing the Car—a Brief Historical Overview

People's relations to and experience of cars are interesting, as cars are so integrated into our lives, regardless of whether we own, drive or ride in one regularly. Cars provide freedom and excitement to travel almost everywhere and solve many peoples everyday logistical puzzles. However, cars have also created a huge challenge for our future as they pollute the environment, create congestion and cause accidents. The question of why do people still like to drive their cars thus becomes an important question for research as:

Globally cars are the largest single item of consumer expenditure after housing, and the consequences of this are manifold and devastating. In this context it becomes pressingly important to understand why people drive as much as they do and, as part of this, how driving makes us feel. (Dawson, 2017)

To change the direction of the development and usage of cars for a more sustainable future, there is a need to better understand how people's anticipation of the experiences of cars emerges and evolves, especially in relation to those digital technologies that change the way cars are experienced. To
understand what the recent increase in digitalisation of cars means for car UX, we need to look back in the rear-view mirror to see their origins and to understand where the industry might be heading in the future. In his thesis, Martin (2020) provided a comprehensive historical narrative to describe how people have experienced cars from when they were first introduced in the early 20th century until today. Through different themes, Martin (2020) describes how the embodied relation between humans and cars has evolved, together constituting each other. Hence, people using cars found new uses and experiences with cars, which steered the development of cars, while new technologies introduced in turn changed people's use of cars.

Taking the academic and industry perspective on how UX of cars has been understood and measured, a long history follows the evolution of experience-related research and design around cars. This history comprises three eras, according to Akamatsu et al. (2013): Human Factor (HF) Engineering era—before World War 2 (WW2); Human Factors Research era—after WW2 until the 1990s; and UX Research era—from the 90s to the currently ongoing era of ITS integration in cars. If considering how the embodied experiences of cars have evolved according to Martin (2020) in relation to the research and development of car technologies (Akamatsu et al., 2013), it exposes that the constitutional relationship between humans and car technologies has evolved together with the understanding and research of the experience of cars.

The history commences with the first cars and the first era of Human Factors research, from the beginning of the century to WW2. Cars during this time transformed from open horse carriages with an engine instead of horses. These cars lacked protection against the weather elements and had very limited comfort to absorb the rough road surface of the underdeveloped infrastructure. The process to start, drive and control a car at this time required a lot of skill, physical effort and technological understanding of how a car worked. Imagining the experience of these cars to be quite uncomfortable in today's context—slow, bumpy, hot or cold, wet and physically very exhausting. However, it’s worth noting that the knowledge and physical force to drive a car was not needed by the car owner, as driving was typically a task performed by a blue-collar chauffeur. However, as the price of cars was dramatically reduced through mass production of cars during the 1910s (e.g., Ford Model T 1908-1927), the number of cars increased, enabling the middle class to also afford a car. To enable more people to drive a car more safely, effortlessly and with increased comfort, the technological developments refined the experience of cars to what Martin (2020) refers to as the theme of Insulating and floating:
For example, engineers of the 1910s were able to introduce the expectation that a car was not just meant to get you somewhere, it was meant to do so in a controlled and comfortable all-weather environment in which the car could permit desired and moderated sensations while keeping out the uncomfortable, enabling a feeling - or at least an idealized image of a feeling - of gliding across the road even when the weather or road itself may not be optimal.

The experience of cars became more insulated from the weather through the addition of a cabin around the passengers and driver as well as better suspension to enable a more comfortable feeling of floating above the rough road surface. According to Akamatsu et al. (2013), Human Factors (HF) research during this era focused on adapting the needed forces to start and drive cars according to human abilities. HF engineering also established requirements for cab size, seating position and control layouts to better fit the human body size as well as trying to standardise the large variety in how driving controls and instruments were designed into cars. This was to reduce the number of skills and amount of learning new drivers needed to incorporate before even being able to start and drive a car. The popularity of cars skyrocketed in the western world as more people could afford them. Only WW2 caused the expansion of cars to halt for some years as car manufacturing facilities were used to produce military equipment and vehicles instead.

After WW2, the car industry took off again and the car technology development and experiences of cars shifted towards what Martin (2020) defined as the theme of Push-button Rocketing. This was where the car of the future was seen to be as frictionless as possible, and the aesthetics of cars became more important to differentiate each model from the competition as well as express how car users should feel in it:

The explosion in the number of new automobiles being put on the road led to a period in which aesthetics became a crucial concern for automotive manufacturers. Driving a car could, at least in some sense, be said to be just as much about how one felt in a car as how the car physically operated and the mobility it permitted (Martin, 2020).

In line with the technological development for a more frictionless and faster experience of cars aimed at the rapidly increasing group of car users, the HF research entered the era of occupant accommodation and safety Akamatsu et al. (2013). The introduction of anthropometry in automotive HF research made the cars fit better with different body sizes even as the shapes of cars became more rounded for better aerodynamics and styling. Various standards for how controls and indicators should work and be labelled were also
established. As the road infrastructure was built with an increased focus on special-purpose and high-speed roads to cater for the rising number of cars on the road, crash safety and driver fatigue became concerns. Studies to measure mental workload, introducing methods from physiology and the cognitive sciences, began in the 1960s and driving simulators were developed to study driving behaviour.

Regarding the anticipation of cars in the early eras of automobility, people valued investing in brands with a solid reputation regarding quality and reliability. For many years, people's anticipation about cars was to a large extent related to their reliability and build quality based on the brand’s reputation (see figure 1) and stories about how many miles people had managed to drive without any issues.

Figure 1: Example of ads emphasising the reliability and build quality of the car

However, even if reliability is still a basic need for car users today, it was not the only aspect that made people anticipate their next experience of cars. After WW2, more irrational and emotional attributes of the car became increasing factors in people's choice of cars, such as the driving performance, craftsmanship and the design of the car. Also, what the car and the brand would tell others about you (see figure 2) became key. These attributes of the car and the brand took time to achieve and were built on many years of the brand’s reputation. Even if mass market brands were able to build cars as fast as Porsches or Lamborghiniis, the customers would not suddenly anticipate that buying a fast Ford would provide them with the same experience as buying a Porsche.
Car technologies continued to develop in line with HF research, refining the requirements for physical comfort and safety in cars, until the 1980s and the introduction of the computer. Computers entered HF research first via digital human models, thermal manikins to measure thermal comfort and video systems for gauging drowsiness. The first wave or paradigm for HCI research (Bødker, 2006; Harrison, Tatar, & Sengers, 2007) also occurred at this point, where the focus was on the individual cognition behaviour between human and machine (computer). Humans were modelled as computers and the aim was to optimise the interaction between these entities.

For a long time, experience-related research of cars was centred around the car and the driving experience of the car. In-car entertainment systems was for many years evaluated and designed as a separate experience from the car usage. The car stereo was bought as a separate product that you attached to the car through the so-called DIN slot (see figure 3). However, when the first cars with integrated Information Technologies Systems (ITS) were introduced around the 1990s, research on people’s experiences of cars extended to also include entertainment and infotainment features in cars. This was the start of the third era of experience-related research in automotive, called the era of Intelligent and Connected Vehicles (Akamatsu et al., 2013). Cars were no longer only about driving experiences, aesthetics or showing social status; now cars also made it possible for drivers to communicate through built-in mobile phone systems, navigate assisted by GPS map guidance and receive traffic information or avoid accidents with help from active safety systems that could warn or assist the driver to handle difficult or unsafe traffic situations (see figure 3).
At the same time, HCI research entered the second wave or paradigm, where the contextual aspects, social behaviours, and agency within groups of humans and machines become important for research. However, as HCI research during the second wave focused mainly on the workplace as context, research related to the experience of cars still focused on optimising the individual interaction between driver and car to reduce driver distraction and increase safety as the number of ITS and related controls increased at a rapid pace. It was not until the beginning of the 21st century that HCI research entered the third wave, which “...to some extent, seems to be defined in terms of what the second wave is not: non-work, non-purposeful, non-rational” (Bødker, 2006). The cultural and emotional aspects of interaction became more central in experience research of people with technology and the term UX became the hot topic in both HCI research and the automotive industry.

However, cars were still seen as ready-made products to fulfil user’s needs for mobility, leisure or status. Unfortunately, the fast pace in development of these built-in ITS made cars age faster than before. When people were comparing the UX of their latest smartphone to their car’s integrated ITS, the latter of which did not improve over time or was impossible to exchange, the overall UX of cars quickly deteriorated as technology became obsolete.

Today, software is taking over the automotive industry and UX of cars has become more dependent on software rather than the physical aspects as digitalisation. Software connects cars to other and new ecosystems more rapidly than before and allows them to evolve over time. The digitalisation-related trends of electrification, artificial intelligence, connectivity, over-the-air software downloads, etc., all enable cars to become a never-finalised product even beyond the point of delivery, as well as becoming part of new ecosystems such as electric energy, real-time traffic information systems or
big tech company platforms (Google, Apple, Amazon, etc.). The car is no longer only related to driving or showing off. It has become a “smart” piece of technology that aims to fit into people’s everyday lives (see figure 4). People’s anticipation of cars has shifted from reliability built on the physical attributes and past reputation towards the anticipated digital capabilities of the car to evolve and adapt to the fast-changing world of the users.

![Introducing the Smarter XC60](image)

*Figure 4: Examples of ads about the “intelligent” car, Volvo (top) and Audi (below)*

If summarising the history of understanding UX of cars and the research and development related to UX of cars, it become apparent how it started from an experience of cars as very physical and uncomfortable, requiring muscle power, skill and knowledge about how the machine worked to even start it.
At this time, HF research focused on the physical interactions between humans and machines. As the car technology developed to enable the experience of cars to become faster and more comfortable for longer journeys, the HF research extended to include the cognitive and psychological aspects of the interaction between human and car to increase safety and reduce driver fatigue and workload. When computers entered cars through built-in ITS, the field of HCI became interested in automotive research. The car ITS provided car users with entertainment, communication and navigation capabilities and extended the experience of cars further. As a result, HCI research has been actively investigating experiences of cars, often referred to as UX research. However, the perspective has often been from the individual user behind the wheel (Tan, Sun, Wenjia, & Zhu, 2021).

This historical overview of the experience of cars exposes three important points for this thesis. First, new technology developments within the automotive industry change the way people experience cars and viewing the introduction of digital technologies in cars as the new shift in technology, it becomes clear that it will cause a change in how people experience cars. Second, technology developments and research approaches have always evolved and influenced each other. New technologies entering the car industry need new approaches to understand the experiences that these technologies evoke. The increasing digitalisation of cars, enabling an ever-evolving product, possible to experience through your phone in your pocket, or connected to the energy system of your house, drives a need to understand the UX of cars as they become more integrated into people’s everyday lives through these new digi-physical materialities. At the same time, the development of new research approaches and topics of interest also inform the new technology developments. This highlights the need for new research approaches to understand the experience of the car when it becomes more and more digitalised, which will also provide insights for digital technology developments. Third, cars have changed how society works and societal changes have changed how cars are developed and used. The recent need in society for more sustainable mobility solutions to address climate change will also affect how people will experience cars as well as how the future technical developments of cars will set directions for how our society will be shaped. To aim for more sustainable mobility solutions, developing cars and related services towards that aim is a perfect tool to make an impact on society. However, without understanding how people anticipate and experience this change, it will be difficult to co-creatively and iteratively shape the new cars and services for a more sustainable future.
2.2 Digitalisation

Digitalisation has changed the way people experience the world (Tunn, van den Hende, Bocken, & Schoormans, 2020; Yoo, 2010). Since the introduction of smartphones, people now use mobile applications that combine mobility, social networking and multimedia, through mobile phones and the Internet, which has fundamentally changed how people experience, interact and socialise with the world. The developments have come so far that digital technologies even shapes people’s experiences of the physical rather than the opposite (Baskerville, Myers, & Yoo, 2020). From traditionally representing the physical world by digital technologies such as creating digital maps of the real world or making digital images to commemorate our holidays, people now commence their travel plans by first exploring and experiencing our points of interest through online services (e.g., Google Maps, Trip Advisor or Booking.com), then book and pay through digital services before they experience the trip physically in real life.

As summarised by (Trischler & Westman Trischler, 2021) digitalisation has consequences for experience and value creation, where digital technology can have different capabilities (referring to work by Aceto, Persico, and Pescapé (2018) and Lember, Brandsen, and Tõnurist (2019)): (a) sensing to access new forms of data through, for example, smart devices; (b) communication with new ways of information exchange; (c) processing with new means of data collection, analysis and decision making using intelligent data algorithms informed by big data; and (d) actuation with the replacement of human-to-human interaction with human-to-machine or machine-to-machine interaction. According to Trischler and Westman Trischler (2021), referring to the same work, digitalisation also affects co-production and co-creation activities in various ways. An important aspect of digitalisation has also been identified in terms of capabilities to enable a circular economy for more sustainable mobility solutions (e.g., Antikainen, Uusitalo, and Kivikytö-Reponen (2018); Centobelli, Cerchione, Chiaroni, Del Vecchio, and Urbinati (2020) and Ingemarsdotter, Jamsin, Kortuem, and Balkenende (2019)).

The digitalisation will change future mobility and therefore also change how people experience cars (Goehlich, Fournier, & Richter, 2020). Viewing the digitalisation of cars from the end-user perspective, there are some interesting aspects to investigate in this thesis. As seen above, there are many new capabilities and aspects of digitalisation impacting the experience of the car that could be explored. However, in this thesis, there are three of particular interest for understanding how UX of cars changes through: (1) the possibilities to experience cars through digital representations outside
the physical car via new methods of communication and information ex-
change on social media, via car configurators or smart phone apps; (2) the
continuous evolvement of the car by the capabilities of processing huge
amounts of data to improve functionality through software updates and intel-
ligent algorithms; and (3) the car as a digital platform with new sensing,
communication and actuation capabilities through connection and integra-
tion with other digital ecosystems and infrastructures outside the traditional
road infrastructures, such as charging networks and home energy systems.

All these emerging digital car technologies require a different context
and viewpoint when researching UX than previous research that mainly
focused on the in-car experiences. As digitalisation provides a temporal
extension, UX will emerge before the physical use and the evolving aspects
of a never ready-made product will extend the perspective towards users’
anticipation of future use.

2.3 Human Anticipation

In today’s society, the experience of anticipation plays a role in how people
consume products and services (Vichiengior, Ackermann, & Palmer, 2019).
The pace of release of new products and services is increasing, which
seems to drive people towards being more interested in longing for what is
coming next rather than what is experienced today or reflective memories of
past experiences. The phenomena of people showing excitement about what
is next is easy to find online, for example, in people sharing “unboxing”
videos of recently released tech gadgets on YouTube or people discussing
the next major software functionality update of a product or service in an
online community. People read others’ reviews about restaurants and hotels
and visit their next destination for vacation through Google Street view to
anticipate the upcoming experience. People buy the latest expensive
AirPods for their iPhone without even trying them out first—and not neces-
sarily because they are rated as the best headphones from the specifications
or from the design, but rather because of the anticipation that they will
seamlessly connect and work with the rest of their Apple product ecosystem
at home. Exchanging gadgets, restaurants or hotels in the examples above
with cars, will reveal similar phenomena of human anticipation.

The theory of *Anticipation* has been developed and used by many schol-
ars from different disciplines and fields. One of the most well-known gen-
eral definitions that applies on a higher level across several disciplines is
Rosen’s: “An anticipatory system is a system containing a predictive model
of itself and/or its environment, which allows it to change state at an instant
in accord with the model’s predictions pertaining to a later instant” (Rosen, 1985, p. 341). This means for human anticipation, people predict things to happen depending on their past experience and context, and they make decisions in line with their predictions, which also includes what they hope, or fear, will happen. People's hopes or fears of what they think or aim to happen is what differentiates anticipation to expectation, where the latter is about the probability of something happening.

In psychology, studies of human anticipation show that behaviour is more goal oriented than stimulus driven (Poli, 2010). In the social sciences, the Austrian philosopher and social phenomenologist Alfred Schutz bridged sociological and phenomenological traditions and argued that we simultaneously live in different contexts of meaning, with different temporal dimensions at different levels of familiarity. He distinguished three main systems: thematic, interpretative and motivational. The latter is of interest for UX research in understanding users' affect and motivation towards products (Hassenzahl & Tractinsky, 2006), and how it enables UX to emerge and evolve.

According to Schutz (1972), motivational systems are framed by two types of oppositions: first, the opposition between my actions and your actions; and second, the opposition between future and past actions. Future actions are referred to as in-order-to structures and past actions are referred to as a because structure. The in-order-to motives are components of the action and shape the action within. So, if you play around to configure a new car online, it might be in-order-to understand if you could afford the cost, justify yourself or convince the family that this car will fit into your life. It is not because you really need to do it, as you already might have a car in the household that works fine.

In contrast to the in-order to motives, the because-motives involve reflective acts upon already-taken decisions. This means, for example, that you need to order a new car as your old car is broken and must be replaced, and this is already decided by the rest of the family. These structures explain why people perceive actions as freely related to in-order-to motives compared to determined according to because-motives (Poli, 2017). This highlights not only the temporal aspect in past and future, but also the relation between users’ actions in a social context.

Anticipation exists in two different types, explicit and implicit anticipation (Riegler, 2003). Explicit anticipation is that which the system is aware of, also sometimes called predictions or expectations, like in the case of configuring a car online. You think if you build it and can show the cost and appearance to the rest of the family, you hope that they will agree to go ahead and order it. Implicit anticipation is the unconscious and intrinsic
mechanisms that a system has without knowing about them. You might not be aware of why you click and order that specific new high-tech electric car. Your decision to push the order button could be based on your “emotional feeling in the moment” and then the rational reason for it could be made up and justified later when someone else asks you why you bought it.

Anticipation stretches through different temporal patterns, from micro anticipation embedded in perception to longer forms of social anticipation, from seconds to years or decades. According to Poli (2017), explicit anticipation is an advantage because it enables more goal-directed processing. The negative effects are, however, that focused goal-oriented behaviour leads to inattentional blindness, e.g., to perceive things in plain sight (Simons & Chabris, 1999). The more efficiently the goal-direction process provides a behavioural pattern for our future actions, the more likely is the outcome of over-restricted focus of attention.

The complexity of human anticipation is described by Poli (2017) as temporal patterns of different multidimensional types of anticipation, such as the biological, psychological and social. These types work contemporaneously, and could be simultaneously active, work together or may interfere, but this has not yet been established in research. Poli (2017) claims that none of the best-known theories have yet explicitly addressed the problem that systemic behaviour may be the result of processes unfolding at different levels of reality, including the biological level (perception, brain processes), the psychological level (cognitive processes) and the social level (social interactions). People might decide to buy something online based on all these levels of reality simultaneously, i.e., the immersive possibility to experience the product online and easiness of the buying process, in combination with how people anticipate how it would feel to experience the product or what it might provide them on a social level.

This abstract structure of anticipation depends on hierarchical loops, also called self-referential or impredicative loops. This puts constraints on the modelling of anticipation systems, because, almost by definition, mechanical or algorithmic procedures cannot be self-referential and separate the phenomenon of anticipation vs. anticipatory systems (R. Miller, Poli, & Rossel, 2018; Poli, 2017). Mechanical or algorithmic formulas are mandatory for artificial intelligence applications, and these develop a type of anticipation that is very different from the anticipation characterising organisms. According to Tavory and Eliasoph (2013), the concept of human anticipation is defined by three modes of anticipation; protentions—which are our instant action or next move, e.g., when you instantly react by braking or steering to avoid an upcoming dangerous traffic situation; trajectories—which adds meaning to our protentions through a narrative with a beginning,
middle and end, e.g., the different steps you have to take to order a car online or all the actions needed for you to drive and visit your friend; and plans/temporal landscapes—that coordinate our actions in relation to the less intentional plans we think are inevitable, e.g., you use the car every day to commute to work or for the long drive to visit your family every Christmas. Although these modes of anticipation are not mutually interdependent, several modes might be ongoing in parallel and are easily shared between people who affect each other's anticipation. Thus, it is difficult to model a human as a rational being because individual behaviour or experiences cannot be predicted. In anticipating the future, several protentions, trajectories and plans are active, and people can shift easily between modes and adapt to others' anticipation or new conditions.

Although the field and theories within human anticipation are far from fully discovered, research about anticipation has relevant implications for our understanding of how users direct their actions and form their experiences of products and services. The way I will use the theory of human anticipation in this thesis is to emphasise the focus on the social interactions that play an important role in how people anticipate their futures. I also bring with me the understanding that human anticipation has different temporal modes (Tavory & Eliasoph, 2013), which means it is important to use a methodology that enable me to zoom in and out on these different modes. Hence, in my thesis, I take a longitudinal methodological approach to cover the different timeframes.

In the following section, the current understandings of anticipation, temporality and social aspects in UX research will be reviewed and how this has shaped this thesis’s view on anticipation and temporality.

2.4 Anticipation and UX Theory

To further understand the relation between anticipation and UX in the field of Human Computer Interaction (HCI), there is a need to investigate how existing UX theory and frameworks relate to the temporal and situational aspects of anticipation and experience. The HCI academia and automotive industry has dedicated extensive effort towards UX research and development since the early 1990s to better understand how to design interactive technologies. This has ranged from primarily being focused on the usability aspects (pragmatic) (Hassenzahl, 2007) of products and to now also including the subjective, pleasure-related (hedonic) aspects of everyday use (Hassenzahl, 2007). Although extensive research has been conducted to bring clarity to the theory of UX, several definitions still exist across differ-
ent cultural HCI communities around the world (Rajanen et al., 2017). An early well-cited UX definition is:

All the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they’re using it, how well it serves their purposes, and how well it fits into the entire context in which they are using it (Alben, 1996).

However, for the automotive industry and HCI academia, the ISO 9241-210 standard definition has been established and has formulated UX as:

[a] person’s perceptions and responses that result from the use and/or anticipated use of a product, system, or service (ISO, 2010).

The latter definition is widely shared within the industry and in UX research, even though there are some differences in the interpretation (Law, Roto, Hassenzahl, Vermeeren, & Kort, 2009). I have chosen to use the ISO UX definition as the departure point for my thesis as it reflects the common usage within the automotive industry.

The notion of UX is recognised as a dynamic concept influenced by different contextual aspects, such as place, social and temporal aspects of use, or the user’s emotional state (Hassenzahl & Tractinsky, 2006; Roto et al., 2011). Although, the general view of UX includes aspects of anticipation (Forlizzi & Battarbee, 2004; Hassenzahl & Tractinsky, 2006; Karapanos et al., 2009; Law et al., 2009; McCarthy & Wright, 2004b), these UX definitions do not provide a well-defined description that fully explains the relation between anticipation and UX to guide UX research and design.

Comparing the well-known UX frameworks to identify a methodological approach to research anticipation exposes a divide in approaches based on different epistemological and ontological foundations (Karapanos, 2010; Roto et al., 2011). There is a difference between the deterministic and reductionist UX frameworks by Hassenzahl (2005) and Thüring and Mahlke (2007), compared to the holistic open-ended approaches of the frameworks of Forlizzi and Ford (2000) and McCarthy and Wright (2004a). The deterministic UX frameworks describe through a cause-and-effect relation how specific attributes of products have consequences for the appeal, pleasure and satisfaction or appraisal of a system. The holistic and open-ended UX frameworks are rooted in pragmatist philosophy and phenomenology. This means understanding UX in a sensible way that suits the conditions that really exist, rather than following fixed theories, ideas, or rules. In phenomenology the focus is the study of “phenomena”: appearances of things, or things as they appear in our experience, or the ways we experience things,
thus the meanings things have in our experience. The theory foundation in this thesis is based on the pragmatist and phenomenology UX frameworks to account for exploration and the entanglement perspective on ‘interaction’ becoming more digi-physical. Also, to account for the extension in situatedness and temporality of experiences due to digitalisation, the more holistic and open-ended approach in pragmatist philosophy is chosen for this thesis.

The experience framework by Forlizzi and Ford (2000) from the pragmatist approach defines three different ways to talk about experience. First, experience in its purest form is a constant stream that happens during moments of consciousness. Second, we talk about having an experience, with a beginning and an end, and change the user and sometimes the context of the experience as a result. The third way is to talk about experience as a story, also called co-experience (Battarbee & Koskinen, 2008), where the stories are the vehicles to condense and remember experiences and communicate them in different situations to specific audiences. Due to the naturally communicative aspects of storytelling, Forlizzi and Ford (2000) emphasise why storytelling has relevance for sharing user findings with, for example, the design team of various disciplines. This has implications for how experiences can emerge and quickly be shared to many people through digital formats, e.g., social media, video, digital data, etc.

As a UX framework with a holistic approach to experience—wherein the intellectual, sensual and emotional stand as equal partners—the framework by McCarthy and Wright (2004a), based on pragmatist philosophy, became a foundation for my perspective on UX. They include the emotional, subjective and transformational aspects of experiences (see figure 5).
McCarthy and Wright define four interconnected threads of experience in their effort to present a foundation for considering and evaluating technology as experience:

- The compositional thread—the relationship between the parts and the holistic view of an experience
- The emotional thread—the value judgements of the positive or negative emotions connected to the experience
- The spatio-temporal thread—how the experience relates to the user’s past, future and where the experience takes place
- The sensual thread—the user’s experience connected to the sensory engagement.

In their work, McCarthy and Wright also define six sense-making processes to be used to discuss experiences through a temporal lens. The authors note that the six distinct processes interrelate in a non-linear way. The first process is described as anticipating (e.g., user expectations of a new car based on previous experiences of cars); second is connecting (e.g., the direct response to how a new car looks without thinking); third is interpreting (e.g., make sense of the experience of an unfinished software in a conscious way and understand the future capabilities); fourth is reflecting (e.g., reflections...
on the recent experience driving a semi-AD car); and fifth is appropriating (e.g., relating the evolving experience of a semi-AD system to the past versions and potential future evolvement). The sixth process is recounting (e.g., telling others about your latest experience of your semi-AD).

McCarthy and Wright do not see experience as an instant phenomenon but rather as a constructed actively through the reflexive and recursive process of sense-making. Their focus is the individual, subjective and contextual experience. Their work acknowledges that a part of the holistic experiences is related to both the place where the experience takes place and the temporal aspects of an experience; however, how the processes are experienced by users are not so clearly exemplified in their work. Most of the empirical examples are provided through user narratives. McCarthy and Wright view experience as a continuous engagement and sense making process where the self is the centre of experience and brings to a situation a history of meanings and anticipated futures. This sets the perspective on sensemaking and UX as a dialogical process—in which the meaning of an artefact is not finalised by the designer but actively constructed through experience as multiple centres of value (McCarthy & Wright, 2004a). However, choosing one framework among the large variety of UX frameworks that exist and contain a pragmatic approach relevant to this thesis, does not guide or provide understandings on how to study or investigate the continuous engagement and sensemaking in UX through a single methodological approach. Generally, links between UX theory and practises are vague (Law, Hassenzahl, Karapanos, Obrist, & Roto, 2014).

Reviewing the core of UX research studies, the major part was found to be focused on the actual experience of usage or the reflections after usage (Bargas-Avila & Hornbæk, 2011; Pettersson, Lachner, Frison, Riener, & Butz, 2018), and most of these UX studies seem not to cover all temporal phases of UX. According to Roto et al. (2011), it is important to identify which of the temporal phases of UX is the focus of the research (see figure 6): anticipated UX, defined as the indirect experience before use formed from existing experience of similar products, brand, advertisement, presentations, demonstrations or other’s opinions; momentary UX, the responses to direct use; episodic UX, reflecting on an experience over a whole episode of use; or the cumulative UX, the recollecting of system experiences over multiple periods of use. Crucially, the AUX may not only relate to the phase before use, but also before any of the other time spans of use (Roto et al., 2011).
Karapanos et al. (2009) tries to shed light on the temporal aspects of UX and proposes an initial framework for UX over time, inspired by theories of product adoption from Silverstone and Haddon (1996) (see figure 7). Karapanos et al. (2009) describe the user’s process of adopting new technology as going through the stages of orientation (the user’s initial positive and negative experiences with the product functions), incorporation (the stage when the product become meaningful in the user’s everyday life) and identification (the phase when the product is connected to the user’s self-identity). Before these phases is the anticipation, the act of anticipating an experience resulting in a formation of expectations before any actual experience of use. They conclude that product qualities that make initial experiences valuable do not motivate sustainable use and suggest three directions for UX design practice: designing for meaningful mediation (products to become useful in people's lives); designing for daily rituals (products to become part of daily routines); and designing for the self (products that provide self-expression and differentiation from others).
The lack of theoretical frameworks and methodologies to fully understand human anticipation in relation to how UX evolves over a longer time could be explained by the time-consuming limitations of high cost and effort in research (Huang & Stolterman, 2014). The more cost-effective alternative, which is studying experiences in retrospect, has limitations as it relies on making users recollect their experiences (Kujala, Roto, Väänänen-Vainio-Mattila, Karapanos, & Sinnelä, 2011).

To understand and identify the general characteristics of the anticipated UX (AUX) of interactive products (Yogasara et al., 2011) conducted a qualitative study of people’s anticipation of a digital camera product. They found that positive AUX was almost exclusively related to an imagined product and negative AUX was mainly associated with existing products. Also, the hedonic quality of the product received more focus in positive AUX than negative AUX. The results also indicated that context, user profile, experiential knowledge and anticipated emotion characterised AUX.

In his extensive work, Yogasara (2014) presented a detailed AUX framework with relations between the characteristics of AUX (see figure 8). The main findings from Yogasara’s thesis (2014) showed that pragmatic
quality is perceived as the main factor that determines both positive and negative future experiences with a product and that hedonic quality appears to have a greater potential in engendering positive rather than negative anticipated experiences.

Figure 8: Anticipated UX (Yogasara, 2014)

Yogasara (2014) also presented the differences between AUX and the Real UX. For designers to better predict product characters that fulfil user’s pragmatic and hedonic goals, he recommended exploring the user’s positive anticipated experiences. Also, to avoid undesirable product attributes, the negative anticipated experiences often associated with existing products should also be considered. The key point is that AUX is beneficial for the early stages of product design to provide rich design ideas and understanding of user’s concerns and expectations of their experiences. However, when using the framework of AUX to understand the digitalisation aspects of car UX, there is a risk of narrowing down on the physical product as the unit of analysis and missing out on the surrounding and integrated digital technologies that might contribute significantly to the UX of cars.

A review of anticipation and UX research within HCI exposes that little work has been done on this from the early 2000s until 2015 (Bargas-Avila & Hornbæk, 2011; Pettersson et al., 2018). However, as digitalisation extends the borders for experiences to emerge beyond the moment of physical use, there appears to be a need for a revival in UX research by including the digi-physical aspects.

My take on temporality and how UX builds on human anticipation and UX theory could be viewed through figure 9, which provides a perspective on temporality of experiences that guides this thesis UX research. By building on the framework “Technology as an experience” by McCarthy and
Wright (2004a), AUX theory by Yogasara et al. (2011) and anticipation theory by Poli (2017), I view the moment of (user) experience as not only depending on past experiences but also on what people anticipate regarding the far, near and instant moments of the future. This way, people’s moment of experiences does not only rely on what they had previously experienced but also what they hope, or fear, might happen in the future. Here, hopes and fears direct their experience towards their anticipation. Building on the theory of different temporal modes of anticipation by Tavory and Eliasoph (2013), I have also chosen to view anticipation as having different time horizons that all have an impact on how we perceive the moment. As people hope for something to happen, this not only has implications for how the moment of experience emerges, but also how it directs the experience towards what they hope or fear. Each action becomes a step towards what they hope or fear in the future.

For example, if someone anticipates the UX of rebuilding and driving a classic old car in the far future, the person might try to coordinate their actions to come closer to that dream step by step. Even if their past experience of owning old cars reminds them that it will be a lot of hard work and struggle to make an old car run, the moment of experiencing the purchase of the undrivable old car wreck will still feel great, as the person anticipates what might come out of it in the future. Standing there with a recently purchased car wreck, parallel modes of anticipation emerge. First, it needs to be possible to get the car wreck on a trailer to get it home to the garage. The steps to make that happen need to be figured out and executed. There must be enough space in the garage and, therefore, actions will be taken to make that possible. Even if the moment of experience might be challenging, anticipation of the future makes each step worth it or even rewarding. This view on temporality emphasises how both the experience of the past and future impacts the moment of experience and directs the actions towards the hopes or away from the fears of the future.
Building on figure 9, digitalisation increases the possibilities to visualise and anticipate the futures as well as speeding up the process and feeding past experiences. As such, it becomes apparent that anticipation plays an important role in how UX emerges and evolves when digitalisation becomes a natural part of the everyday. My view on temporality and UX also provides a need for the methodological approach in this thesis to explore both people’s past experiences as well as their anticipation of the future in order to understand people’s experience of anticipating digital technologies.

2.5 Challenges of Understanding Anticipation in UX Research

Considering how digitalisation changes the UX of cars, there is an extension in time, space and relation between people and cars in the everyday context. Digitalisation enables a shift and extension from the momentary physical
direct use towards experiences of indirect before use, the so-called AUX (Yogasara et al., 2011). However, if trying to understand how digitalisation extends people's experiences of anticipation through using the available UX frameworks mentioned in Chapter 2.4, at least three challenges arise.

First, if dividing temporality of UX into different phases (Roto et al., 2011), where AUX is the indirect before use phase impacting the UX of the following moment of use, it becomes difficult to define what is a before or after interaction and experience with digitalised cars. When configuring a future car online or planning the charging stops for a long-distance trip in the smartphone app, are these before or moment of experiences of a car? Applying a UX framework with different phases means it becomes static and difficult to investigate the evolving and socio-technical context of digitalisation. Further, applying a framework with separation into different and defined phases raises some questions. If digitalised products are experienced in both digital and physical representations, is there a clear boundary between what is the before or actual use? Is the interaction with the physical materialities enough for understanding the UX of digitalised products?

AUX and the different phases of UX (Roto et al., 2011) are grounded in the same ontology and epistemology in defining and separating the use into different phases as the popular cluster of research based on the Technology Acceptance Model (Davis, 1985), which aims to identify and quantify the factors required for people to accept use of new technologies. Within this approach, some of the recent work by Distler, Lallemand, and Bellet (2018) defines differences between acceptability (before use) and acceptance (after first use). There are also examples of work showing the relation between technology acceptance models and UX frameworks such as, for example, the optimised model for car use, the Car Technology Acceptance Model CTAM (Osswald, Wurhofer, Trösterer, Beck, & Tscheligi, 2012). Based on the same area of acceptance research, Dupont, Hubert, Guidat, and Camargo (2019) exemplified the user journey for an EV owner with different phases from Representation, when the user imagines the experience in a process of acceptability, followed by the Use phase of the concrete experience shifting to the acceptance phase and ending up in the reflective Instrumentation phase, where the user finds meaning and appropriation of the car.

The adapted figure 10 shows how the phases of UX and TAM align and share the same separation into different distinct phases. However, these models put emphasis on the physical object, viewing the car from a physical experience perspective where the phases make a clear-cut distinction between use before and after. This way, UX of the digital representations of the car and their relation to its context become unknown or suppressed, as
the model does not involve the digital representations of the car and the experiences these created.

Figure 10: Example of contemporary view on anticipated UX overlaid on acceptance phases (TAM) adapted from Dupont et al. (2019)

The second challenge is the limited amount of AUX-related research and methodology frameworks available to apply to a study of AUX. The term expected UX is also used in UX research instead of AUX (Olsson, Lagerstam, Kärkkäinen, & Väänänen-Vainio-Mattila, 2013) or is framed as an understanding of user expectations (Pettersson, 2017). More recent work has attempted to define an AUX evaluation tool (Sánchez-Adame, Mendoza, González-Beltrán, Meneses Viveros, & Rodríguez, 2018). Their conclusion was that gathering the expectations, hopes and idealisations of the participants will allow the developers to know the underlying needs, the possible contexts of use and what participants consider essential to obtain a pleasant experience. Most UX research is aimed towards understanding the direct and individual product use, not capturing the extension of experiences that digitalisation provides (Bargas-Avila & Hornbæk, 2011; Pettersson et al., 2018). This exposes a gap in the HCI field in understanding AUX or user expectations within UX research.
The third challenge is the fact that the ontology and epistemology that has been driving UX research within HCI has stemmed from computer science, cognitive science and human factors engineering (Frauenberger, 2019). This means an ontology in separating human and technology in distinct entities connected through an interface with the aim to improve rational efficiency and the hedonic emotionality of the interface. This leads to methods in isolating and studying the factors that impact the relation between human and technology, which often puts research into lab settings to ensure they are quantifiable and objective. A search of UX research in relation to cars reveals that most UX research is done in experimental lab settings, not in the context of everyday lives (Ryghaug & Toftaker, 2014; Svangren et al., 2017). However, if the digitalisation of a physical product extends the UX of the product, how can we understand how UX emerges, if we do not study it in its natural context? To sum up, the challenges in understanding UX of digi-physical materialities lead to a need for a different ontology and epistemology that can shed new light on digitalised cars and how digitisation impacts people's experience of anticipation. This leads us to entanglement theories, which will be addressed in the next section.

2.6 Entanglement in HCI

As digitalisation provides dynamic and shifting human-machine interactions, it changes the conditions for how to understand UX. In the search for an ontology and epistemology that embrace the complexities of blurred boundaries and evolving relations between human and digital technologies, Entanglement HCI (Frauenberger, 2019) emerged as a proposed new fourth wave within HCI research to handle these new challenges. Referring to Bødker (2006), the different waves in HCI could be referred to as follows. The first wave was the idea that interaction is a form of human-technology connection (interface) that needs to be optimised in a human-factors way (usability aspects) aimed at work settings. The second built on the metaphor of humans and technology being information processors of similar workings that need to be connected and optimised, considering their weaknesses and strengths, and still in terms of work settings. Finally, the third wave is focused on interaction that is situated in the social and bodily complexities of a messy, real world in the everyday.

However, according to Frauenberger (2019), the third wave seems to lack the ability to address the new challenges of understanding entanglement of digital technologies in people's everyday lives—for example, natural language processing, social robotics, artificial intelligence, cyber physical sys-
tems, virtual reality, augmented reality or neuro-implants—that are all making the boundaries between human and technology very fuzzy. The interfaces become blurred and dynamic when, for example, an intelligent algorithm not only tracks where, when and how a person uses a smartphone but also continuously changes the content in the smartphone according to what that person might prefer. In this example, there is no well-defined interface between the technology and the user, and the technology will change according to the user’s behaviours while the user will change behaviour according to the technology.

Frauenberger (2019) proposes that the aim of entanglement theories is to deal with those new challenges of ontological (question of being) uncertainties, epistemological (knowledge creation) diffusion and ethical questions in HCI. Entanglement HCI is based on the Phenomenological philosophy (Heidegger, 1977) and builds on theories of entanglement (Orlikowski, 2010), which make the radical proposition that humans and things are “ontologically inseparable from the start” (Introna, 2014). Entanglement theories mostly originate from the field of Science and Technology Studies (STS), which view science and technological innovation through a sociological lens. Frauenberger (2019) explains entanglement theories as re-framing the problem by making things social actors, e.g., they are not denying the social construction of our knowledge about the world but seek to emphasise that the world is not a passive object in this process and rather is intimately entangled in the production of knowledge. Also, the relationships between human and technology create a performative process where they constitute each other in an ever-evolving action.

The entanglement HCI has inspired the ontological and epistemological direction for this thesis regarding how to view and study changes in experiences that are created in the intertwined and evolving relation between people and digital technologies. This has provided three main implications for the methodological approach of this thesis. First, the phenomenon of experience becomes the centre of study rather than the physical product and the experiences it might generate. Second, viewing people and digital technologies as inseparable implies that people and technologies need to be studied together, with a focus on the relations between different entities rather than interfaces between them. Third, to account for the performative and evolving relations between people and technology, there is a need to study phenomena over time to understand the change. This has guided me towards a methodology that is explorative, longitudinal and conducted in everyday life settings rather than aiming for isolating a phenomenon, studying each of its components and testing a hypothesis at a specific moment in time.
By taking the lens of entanglement to view anticipation experiences of the blurred digi-physical materialities of cars, there are some possibilities to evolve the current understanding of the experience of anticipation and the relation to UX. This involves expanding on: (1) the temporal view of UX beyond the “physical” moment of use; (2) the situation of UX beyond the individual’s direct and physical use of a product; and (3) the research settings into everyday lives beyond empirical experimental settings. However, as described above, the digitalisation of cars changes the conditions for UX of cars and challenges our ideas of how people experience cars and anticipate their use.

The explorative and open-ended approach to digitalisation of cars people’s anticipation could generate many different perspectives. Therefore, the scope of this thesis has been narrowed down to take three angles to study UX of cars and entanglement of the inseparable digi-physical materialities: (1) how experiencing cars through digital media shapes the experience of the physical materialities; (2) how experiencing cars physically is shaped by the evolving digital materialities; and (3) how experiencing digital ecosystems connected to cars shapes the experience of the car. These three angles were also chosen to simplify the analysis given the constraints on the studies. Despite the limitation in perspective of digitalisation, these approaches aimed to account for at least three different views on entanglement of people and digitalised cars, by including a longitudinal and contextual parameter in each of these angles, which will be explained in Chapter 3.
This chapter presents the Design Ethnography (DE) approach in this thesis and explains why it was chosen as the main research approach and its relation to phenomenology. This will be followed by a subchapter explaining how DE was used throughout the explorative and evolving phases of the three different studies of digitalised cars (see figure 12, Chapter 3.2). A subsection describing the different methods used to collect, analyse and represent data will follow, including why they are relevant given the RQs, and how I ensured the data can answer the RQ. This chapter will be concluded in the two last sections where I first reflect on the ethical considerations of the approach and then consider the quality aspects of the chosen methodology and the transferability of the results.

3.1 Design Ethnography Approach

The methodology in this thesis is a combination of two different dimensions: the prospective (design) and the descriptive (ethnography). Design is striving to create something new, not yet existing, and is therefore speculative—in contrast to the tradition of ethnography in social science, which aims to be descriptive. DE is a qualitative open-ended approach to deeply study phenomena of people and technology relations in everyday lives to provide insights for design (Müller, 2021). DE is forward looking and aimed at understanding the future users of a design. This is done through a structured process to deeply engage with users in their everyday lives to gain a holistic view of their experiences that provides an empathic understanding of their anticipation and future needs. In design practice, “The intention is to enable the design team to identify with these people, to build up an empathic understanding of their practices and routines and what they care about” (Van Dijk, 2010). DE is used to gain insights into the user’s environment and eliminate the designers’ worldview. This aims to garner a better understanding of the context of use of the technology and a more holistic view of what the technology actually means for the user. Therefore, by including the outside influences on the users, this approach enables the discovery of possibilities to optimise new technologies, even if there are
uncertainties regarding how users might use the technology (Blomberg, Giacomi, Mosher, & Swenton-Wall, 1993).

DE shares a lot of similarities with Participatory Design (PD) (Muller & Kuhn, 1993) and Co-Design (Steen, Manschot, & De Koning, 2011) in that these approaches involve people in research and design processes. PD is rooted in the Scandinavian cooperative design tradition and has a strong political emphasis (Kensing & Blomberg, 1998) as the first "experiments" in participatory design were collaborations between labour movements and academia in supporting stakeholder participation in the design of work environments. PD is commonly referred to as a democratic process for design (social and technological) of systems involving human work, based on the argument that users should be involved in designs they will be using, and that all stakeholders, including and especially users, should have equal input into interaction design (Muller & Kuhn, 1993). Co-Design, conversely, does not need to have a political starting point. The basic aim with Co-Design is to support collaboration in the design process between stakeholders.

In contrast to PD and Co-Design—and to avoid any uncertainties of political aspects or too much focus on a design process—I have chosen DE as the main methodological approach. DE set this thesis’s agenda somewhere close to the centre of the landscape of human-centered design research according to Sanders and Stappers (2008) (figure 11). My interpretation of DE has a slight direction towards user as partners and led by research, which would put my use of DE in the lower right quadrant, intersecting lead-user innovation, applied ethnography and Scandinavian PD research.
In my use of DE in this thesis, ethnography is the foundation to understand people's everyday life. The design adds a speculative component to trigger anticipatory experiences and to invite the participants into the design process. This opens up the potential for innovations rather than narrowing down to a final design solution.

DE is used to question the certainties of the everyday world, deconstruct the reality into singular aesthetic and semantic phenomena, and reconfigure them into new contexts of signification (Müller, 2021). However, while DE could be seen as a critique of a positivist research approach, it should be viewed as a complementary way of understanding the world for designers as, “The goal of design ethnography is not to colonize the discipline of design with a positivist and objectivist scientific ethos, but rather to reinforce and reflect upon the explorative and searching methods that are inherent to it” (Müller, 2021). While the traditional way of doing ethnography in social science is for researchers to avoid interfering in the contextual settings, in DE, the aim is to provoke the settings by the researcher being actively involved in the research process and bringing in design as a trigger for reactions and to generate experiences (Müller, 2021).
The common theme in the different methods used within DE is to generate new information, questions or understandings; it is not about testing hypotheses or measuring and rating user responses to technology experiences. There are commonly used methods to document user’s behaviours in everyday contexts, from a wide range of sources, preferably in parallel. Examples of methods of data collection are participant observations recorded through audio or video. Activity-based methods, such as having the participant draw, demonstrate routines, take pictures or write diaries, enable the participant to recollect routines, habits and experiences and increase the researchers’ ability to gain a more holistic understanding (O’Reilly, 2012). Online communities can also be used as a data source for DE to include the digital parts of everyday lives; however, there are limitations in fully understanding the user behind the keyboard. The analysis of the data involves interpretation of the meanings and functions of the participants’ actions and turning them into verbal descriptions that could be further analysed. The results could be turned into, e.g., themes, quotes, provocative questions, insights, foresights or design principles to be used in design processes.

There are several reasons for using DE in this thesis. The synthesis of the theoretical review in the previous chapter provided a direction for the ontological and epistemological foundation for the chosen research methodology of DE. Mainly, DE is phenomenologically situated (Harrison et al., 2007) as it focuses on the meaning and meaning creation, is based on human experience with technology, aims to be performed through multiple perspectives and uses a perspective to see the relationship between human and technologies. To understand how the digitalisation of cars extends the experience of anticipation, a methodology that investigates the complexity, multitudes of interaction and the situatedness in everyday life is required. A DE approach accounts for the entanglement, performativity and digital materiality of the studied phenomena in data generation, analysis and re-presentation (Frauenberger, 2019; Schultze, van den Heuvel, & Niemimaa, 2020).

Secondly, DE is open ended, meaning it does not seek to give a true or false answer. It aims to find the unexpected (Müller, 2021). As the RQ is open ended, an open-ended research approach for the studies is also required. This thesis is about exploring how people are experiencing anticipation of digitalised cars, which necessitates an approach that is open to new, unexpected and unknown relations and ongoing transformations. DE, as an explorative approach, eludes inductive and deductive methods (Müller, 2021). Proceeding inductively may lead to generalising to the researcher’s own observations, making the research findings only valid for the specific case without any possibility of generalisation. Proceeding deductively means starting with constructing a hypothesis to test, which is problematic.
when exploring an unknown area and if there is little known to build the hypothesis. Going into an unknown area with a very specific question might lead to missing out on other relevant phenomena outside the scope of the narrowed-down question.

Thirdly, DE is forward looking as it uses a speculative dimension. It aims to find out the new, unexpected and evolving relations between humans and technology. To account for *performativity*, the phenomena need to be studied over time. This thesis is about understanding people’s evolving experiences of anticipation and is therefore forward looking by default. People's past experiences and reflections always play a role in their decisions for the future; however, when we want to study anticipatory experiences, we need forward-looking approaches that can investigate people’s hopes and fears of the future (Poli, 2017).

Fourthly, DE acknowledges the researchers to be involved and active. As Müller (2021) describes, “The design ethnographer observes actions—and acts. They generate knowledge—through praxis. Design ethnography not only investigates designed realities—it also brings them forth”. As digital technologies are so immersed in everyday life and evolve at a fast pace, the research approach requires the researcher to be “entangled” in the settings to observe the complexities (Walsham, 1995). To trigger the participants’ anticipation of the future, this could be done by introducing speculative designs or scenarios. This also means that the researchers are active and involved in forming the participants' anticipation. This will raise some ethical concerns; further reflections on this are provided in section 3.3 of this chapter.

Fifth, DE explores relationships between people, physical and digital materialities. This thesis does not aim to understand a specific interaction between a user and a technology but rather their relations. To account for *Entanglement*, the relations and meanings rather than the interfaces need to be studied. As Salvador et al. (1999) explain:

> Design ethnography offers a powerful way to examine the circulations of meanings, objects, and identities in diffuse time-space and bring these to fruition, not in new description of localities, but in new objects and services that will make sense to these localities (p. 41).

Sixth, DE aims to explore a real-life setting to investigate the meanings and relations between human and technology in everyday life. From the researcher’s perspective, investigating everyday life provides the possibility to study not only what people say but also what they do and know; this is based on the notion that people know more than they can articulate (Schon,
In the ethnographically investigated research by Pink (2013), she demonstrates how everyday practices are carried out and what specific knowledge the participants possessed. As this thesis needs to account for digital materiality, it explores the digi-physical experiences between human and digital car technologies. Therefore, the study setting must be in an everyday setting, e.g., online, at home, on the road and outside the car.

Lastly, DE can use speculative design or scenarios to trigger the conversations and challenge the status quo. To understand how people use their anticipation of the future to form their decisions, some types of speculative enactments or triggers are required to trigger anticipation and to enable participants to enact and imagine their future everyday lives.

3.2 Research Process and Methods

This thesis is based on three different research projects/studies aimed at understanding people’s experience of anticipating digitalised cars (figure 12). The focus on anticipation emerged from the first research project and evolved through iterations in the subsequent projects. The research process started from a generative ethnographic approach (Dourish, 2007) followed by a DE approach in iteratively and continuously evaluating and refining the findings. Each iteration increased my understanding of how anticipation plays a role in how UX of cars evolves. My role in each research project was to be an involved researcher to identify aspects that are not easily articulated and to explore new understandings rather than testing hypotheses. I was an involved researcher and triggered responses and reactions from the participants by bringing in speculative designs, scenarios or enactments. Being heavily involved in the research projects enabled me as a researcher to acquire a deeper first-hand understanding of the participants' everyday lives regarding their digi-physical relation with their cars.
Figure 12: Three different research projects/studies aimed at understanding people’s experience of anticipating digitalised cars

The study of how experiences of anticipating digitalised cars can be understood was achieved through different approaches to garner at least three transformations with digi-physical entanglements:

3.2.1 Study #1 Methods for Studying UX of Cars through Digital Representations

This study investigates the experience of anticipating cars through digital representations in a social media community and how that shaped and evolved the experience of the later physical materialities. Study #1 did not fully use DE as an approach as it was the first explorative study to identify anticipatory experiences without any use of speculative design as triggers. In this study, the ethnography was the foundation in order to study the phenomena of anticipation through netnographic methods (Kozinets, 2015). This was performed in a Swedish Tesla online discussion forum, to explore how anticipation of a highly digitalised car was expressed before and during ownership. The setting of a Tesla forum community was selected as it was expected that the phenomenon of anticipation would be more readily expressed and easier to identify there rather than in other traditional car discussion forums.

The participants in the Tesla forum did not need any designs or probes as triggers for anticipation as many of the forum members contributed with a huge variety of future speculative scenarios and technologies shared in the discussion threads. The ability to refer to past posts in discussion threads
enabled evolvement of such conversations over time to be studied. In this study, my role was mainly to observe what was discussed and shared within the forum. At the end of the project, six selected active forum members were invited to take part in individual phone interviews to reflect on their journey of becoming Tesla owners, how their experience of the Tesla cars started in the online forum, how they shared experiences and knowledge within the forum, how they prepared before becoming Tesla owners and after becoming owners of a Tesla car. However, their journey did not stop there, as the Tesla cars evolved over time through frequent software updates. In this study, I took a more observational role as a researcher and did not actively engage in the online discussions. As other members of the forum shared recent news, rumours or experiences, this naturally triggered others’ anticipation to emerge.

3.2.2 Study #2 Methods for Studying UX of Evolving Digital Materialities of the Car

Study #2 investigates people experiencing cars physically as shaped by the digital materialities in everyday driving created by evolving semi-AD technologies. It comprised Drive-along and In-home interviews with participants from families with access to highly automated cars to study how anticipation was expressed in everyday driving situations around automated driving. The settings of the DriveMe project enable a long-term ethnography approach to build relations with the participants to better understand the phenomenon of anticipation in relation to AD. Providing the participants with evolving levels of automated driving functions to try out in their own everyday context enabled them to enact and imagine future experiences and created new anticipation about AD technologies in their own social and environmental context.

3.2.3 Study #3 Methods for Studying UX of Cars as Digital Platforms

Study #3 investigates people’s experiences of anticipating digitalised cars as part of digital ecosystems around the car. The study was done by following participants from ten selected privately owned households with EVs connected to smart charging technologies as part of their home energy system. This study was intended to involve in-home interviews of families with EVs in private households and iterative co-design activities for a smart EV charging application. However, as the Covid-19 pandemic limited the possibilities for on-site meetings in real-life settings, video call interviews with
members of the households were instead adopted to understand how their anticipation of EVs and energy ecosystems evolved. The settings of the RELEVANT project enabled a long-term DE approach to build relations with the participants to understand the phenomenon of anticipation in relation to EVs connected to smart home energy systems. The continuation of the project outside the scope and time of this thesis aimed to enable the participants to co-create and take part in the iterative design process of future technical smart charging solutions.

Using DE as the main thesis approach in the studies, except in Study #1 which used a generative ethnographic approach (Dourish, 2007), enabled me to conduct the research through a selection of various qualitative data collection methods such as: In-home activity interviews, Drive-along interviews with different levels of automation (AD level 2-4) according to the Society of Automotive Engineers (SAE) standard (SAE, 2018), Wizard of Oz (WOz) techniques, Speculative workshops with Virtual Reality (VR) mock-ups, Video call interviews, etc. (see Table 2).
Table 2: Summary of data collection methods

<table>
<thead>
<tr>
<th>Year</th>
<th>Study</th>
<th>Methods</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>Study #1: Tesla Forum</td>
<td>Netnography</td>
<td>3 active Tesla forum members and Tesla owners</td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td>Phone Interviews</td>
<td>6 voluntary Tesla forum members</td>
</tr>
<tr>
<td></td>
<td>Study #2: DriveMe AD</td>
<td>In-home activity interviews</td>
<td>5 (+2 pilot) families that are part of the DriveMe project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DriveMe experience blog</td>
<td>5 families that are part of the DriveMe project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drive-along AD level 2 interviews and observations</td>
<td>5 families that are part of the DriveMe project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Speculative WS AD level 5 (VR) interviews and observations</td>
<td>5 families that are part of the DriveMe project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Drive-along AD level 3 (Prototype) interviews and observations</td>
<td>5 families that are part of the DriveMe project</td>
</tr>
<tr>
<td>2019</td>
<td>Study #3: RELEVANT Smart Charging</td>
<td>Drive-along AD level 4 (WOz) interviews and observations</td>
<td>5 families that are part of the DriveMe project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video Call interviews</td>
<td>14 RELEVANT households with EVs and planned to be part of project</td>
</tr>
<tr>
<td>2020</td>
<td>Study #2: DriveMe AD</td>
<td>Design Guidelines Workshops</td>
<td>3 UX designers AD</td>
</tr>
<tr>
<td></td>
<td>Study #3: RELEVANT Smart Charging</td>
<td>Video Call interviews</td>
<td>10 RELEVANT households with EVs equipped with wallbox charger</td>
</tr>
</tbody>
</table>
As human anticipation has different temporal modes (Tavory & Eliasoph, 2013), such as the instant, near and far future anticipation, a large variety of methods were needed to investigate the different modes. For example, drive-alongs exposed the very instant forms of anticipation to take back control of driving; near future anticipation was seen when Tesla owners discussed in the forum threads their anticipation of the next software upgrade; and far future anticipation was triggered by VR mock-ups in the fully AD workshops.

The iterative research process started at a very explorative level around the digitalisation of cars. Through the netnographic Tesla forum study (#1), the identification of anticipation informed the following research in the DriveMe AD study (#2). Anticipation became the theme to further investigate within the DriveMe study, but the direction of how digitalisation transformed the physical car to evolve became the second approach to digitalisation. Being closer to the physical car and real driving situations required the use of drive-along interviews and observations. The DriveMe project was ongoing for more than two years, which meant that I as a researcher got to know the participants in the families very well. The findings from the DriveMe project provided a deeper understanding of anticipation and UX and how to utilise different tools for speculation to trigger the participants' anticipation of their future. Ultimately, some of the findings from the DriveMe AD study were also included in a Design Principles Workshop with AD UX designers at Volvo. The final study within the RELEVANT Smart charging study (#3) was designed based on the findings of both theoretical and methodological findings from the other studies. In the RELEVANT study, the focus on digitalisation was shifted towards the connection to surrounding ecosystems enabled through digitalisation. The plan was to do in-home and drive-along interviews; however, the Covid-19 pandemic set restrictions on physical meetings and the interviews had to be conducted through digital media, such as video meeting interviews, email conversations and intranet chats (Microsoft Teams).

3.3 Ethical Considerations

The basic ethical principles for research are based on questions of: *autonomy*—an individual's right to decide for themselves; *beneficence*—the duty to do good; *non-maleficence*—the duty to avoid harm; and *justice*—fairness and the duty to protect human dignity (Mingers & Walsham, 2010). Ethnographic research explores deep into the participants' everyday lives, and therefore calls for a greater personal commitment to the field and its mem-
bers than virtually any other mode of research (Atkinson, 2009). This section will reflect upon the ethics of this research based on these foundational ethical principles.

**Autonomy**

Being a deeply involved researcher comes with responsibility to the individual participants' right to decide for themselves and to have respect for the autonomy of the people involved. The participants agreed to provide informed consent in all of the studies. In the Tesla netnography study, the quotes used in Paper 01 were anonymised and translated into English and interviewees were contacted to give informed consent afterwards. In the DriveMe and RELEVANT study, the participants gave informed consent to take part in the studies according to standards produced by The Swedish Research Council and principles articulated through standardised forms and data protection policies produced by Halmstad University.

**Beneficence**

The research needs to follow the ethical obligation to maximise benefits and minimise harms in the duty to do good. This means that the risks and benefits need to weighed up, and therefore, it was important to follow up the two first studies with phone interviews (Tesla study) and a final workshop (DriveMe study) to present findings from the studies and provide the participants with an opportunity to reflect on the experience of being part of the research studies. The last study (RELEVANT study) was still ongoing at the time of this thesis publication. However, the participants had the opportunity to share their feedback at any time during the research through a discussion forum and in each interview, the focus was not only on their experience of the technology but also being part of the research. Given the design ethnographic approach and focus, the participants’ anticipation benefits their positive possibilities to provide direct input to future technical development. Even if the benefit to science and society is great, however, we should never forgo participant protection. Yet the participants often expressed positive experiences with providing insights for development. While the primary purpose of this thesis research is to generate new knowledge, this goal can never take precedence over the rights and interests of individual research subjects according to the World Medical Association Declaration of Helsinki 2013 (WMA, 2013).

**Non-maleficence**

It is important for research to serve the duty to avoid harm to persons. That means to avoid any physical, social, psychological, juridical, economical or
risk to personal integrity. All the studies have been carefully performed, data has been stored safely according to General Data Protection Regulation (GDPR) requirements in EU and informed consent has been given. Being an empathic and involved ethnographic researcher also means being sensitive to the participants' concerns about taking part in the research and, as such, empirical data has either been anonymised or acknowledged through informed consent.

Justice
In research, justice means fairness and the duty to protect human dignity. To provide a primarily distributive justice for the participants in the studies, the participants in the DriveMe and RELEVANT studies were provided with some compensation for their time through economic incentives and a preferential company lease car contract (DriveMe participants) or smart charging technology (RELEVANT participants). To align with the principle of justice, the selection process was undertaken in such a way as to prioritise groups that are likely to be among the beneficiaries of the future applications of the research. The selected participants in the studies were selected as they are among the first to be affected by the digitalisation of cars. However, this also becomes an issue as people that might be affected negatively by the effects of digitalised cars will not have a chance to be heard in this thesis research. As the digitalisation of cars is mainly experienced by people with the economical ability to pay for these new products and services, it leaves out inclusion of diverse populations that may benefit from the research findings. However, the scope of these studies meant such populations were somewhat set outside my ability to include. Taking a family perspective and interviewing both adults and some of the children in the families of the DriveMe and RELEVANT studies enabled a broader inclusion of gender and age.

3.4 Quality Criteria for Research
To judge and define the quality of the thesis research, the theory foundation has been categorised according to Gregor (2006) taxonomy of five theory types of information systems research: Analysis, Explanation, Prediction, Explanation and Prediction and Design and Action. This thesis foundation is based on the theory type of explanation, characterised by the aim to provide explanations but not to predict with any precision. In other words, it will say “what is”, “how”, “why”, “when” or “where”. Therefore, this thesis will not provide any testable propositions. This thesis's compilation of design ethnographic studies is also in line with
the theory type of Explanation, as the aim was to explain and explore the digitalisation of cars and people's experiences of anticipation. Further, to evaluate the quality of the thesis work, Guba and Lincoln's (Guba, 1981; Lincoln, 1995; Lincoln & Guba, 1985; Lincoln, Lynham, & Guba, 2011) five key concepts of credibility, transferability, dependability, confirmability and authenticity have been adopted:

**Credibility**
The participants or members of the community taking part in the research need to feel that the findings represent their experience. As the empirical data from qualitative research and the research is dependent on the involved researcher, there is a risk that the findings might not have been interpreted in line with the participants’ actual views. To secure credibility from the participants, several precautions were taken. In the Tesla forum study, which was observational in the netnographic study, the forum members contributing to the empirical data were later interviewed over the phone regarding themes identified in their postings online. In the DriveMe study, the participants were involved in a prolonged engagement over 18 months to really get to know them through various activities (in-home, drive-along, blogs, workshops, etc.). In the RELEVANT study, the same approach of a prolonged engagement was taken. All the papers (except Paper 05) have been completed with the involvement of several researchers in the data collection and analysis phases; however, as the main researcher, I have been the most deeply involved and the leader of the research process. By viewing digitalisation from three different approaches in the studies, it also increased the probability that the research would generate credible findings.

**Transferability**
It is important that the findings are applicable to other contexts. To evaluate for transferability, qualitative research needs rich descriptions of the participant’s responses and the researcher’s interpretations. In all the included papers, the ethnographic empirical data has been provided at length, as well as my interpretations. This will help the reader of this thesis and the included papers to see the possibilities for transferability into other contexts beyond cars. The results of the qualitative research approach could not be generalised but may be implemented to study the phenomenon of anticipation and identified aspects that could be transferred and used for further research and design.

**Dependability**
A challenge with qualitative research is the question: Would similar findings be produced if someone else also undertook the research? As this thesis
is based on the phenomenological foundation that each situation is unique and cannot be re-created, this also means that it would not be possible for another researcher to reproduce the same results. However, the aim of this thesis is not to prove a hypothesis or show a correlation; rather, it is about exploring the phenomena of digitalised cars and people’s anticipation to provide a new theoretical view and methodology for further research.

**Confirmability**
In qualitative research, it is important that the findings are a product of the participants’ responses and actions and not biased by the researcher's motivations, interests or perspectives (Lincoln & Guba, 1985, p. 290). Being a researcher affiliated and employed by an automotive manufacturer, I had significant responsibility to distance myself from my employers’ interest, to take a critical perspective and to treat the findings reflectively. Being involved in the work with other academic researchers assisted me to distance myself from business opportunities and to avoid leaving out company critical perspectives.

**Authenticity**
The research needs to represent a range of differing viewpoints on the topic to show Authenticity. This is also a challenge in qualitative research as findings could be based on a very narrowed-down perspective and settings that limit the possibilities for the intended receiver community to find the results useful and apply them for further actions in research or design (Lincoln et al., 2011, p. 116). This has been mitigated by the peer review process and publishing the included articles in journals and conferences relevant to the field. Also, the findings of the DriveMe study were shared with both AD technical and UX design teams within the automotive company.
4 Empirical Studies

This thesis is based on the findings from three studies (Study #1—Swedish Tesla forum; Study #2—DriveMe AD families; and Study #3—RELEVANT Smart Charging households). In this chapter, the different studies, context and empirical content for each study will be explained in more detail.

4.1 Study #1: Tesla Forum Netnography

Background
The Swedish Tesla forum study was initiated at the beginning of my PhD studies in 2017. The starting point for this study was to learn more about peoples' anticipation of digitalised cars while the start of the main project (DriveMe) for my PhD studies was delayed. The Swedish Tesla forum was chosen as it was at the time a very fast-growing (with around 4,000 member accounts and an unknown number of readers at the time), open for anyone, self-organised and active forum where the Tesla as the car was not always at the centre of the discussions. Many discussions included members adding interesting perspectives on digitalised cars and sustainable futures in general. The Tesla brand was also seen at the time of the study to provide the most highly digitalised cars and services to car users in the market, being among the very first to provide over-the-air software updates and functionality add-ons, intelligent software for charging and driving support systems, remote functionality through smartphone apps, online sales, etc. The possibility to investigate and study the phenomena of people's anticipation was also judged at the time to be better within the social and contextual setting of the Tesla forum as compared to others.

Aim
The aim of the study was to understand how people's anticipation of becoming car owners was expressed and shared digitally within a self-organised online car forum.
Duration
The study was undertaken over ten months during 2017-2018.

Participants
Three long-term (over two years) actively posting Tesla forum members were consciously selected due to their well-documented and particularly interesting narratives of becoming Tesla owners. Two of these main participants were later part of an individual follow up phone interview. Four other additional voluntary forum members were also interviewed. These additional participants were recruited through an open invite in the forum. All the participants gave consent to be part of the study before any publications.

Approach
To investigate the development of social car-ownership anticipation, this study used a generative ethnographic approach (Dourish, 2007) mainly through covert netnographic methods (Kozinets, 2015). Netnography was chosen as it has been acknowledged as having potential to investigate the increasing online sphere of everyday life and generate understandings of customers’ experiences (Heinonen & Medberg, 2018) and supported the research design in several ways. First, it extended the ability to follow changes over time and to track the evolution of anticipation. Second, it enabled the possibility to track narratives backwards in time through the ability to access existing data before the start of the study. Third, it was an unobtrusive method of observing how anticipation was expressed in social interactions online. Fourth, it enabled the possibility to identify a set of key participants to be easily contacted for subsequent interviews. Finally, it provided a tool for uncovering unexpected data and studying how experiences were digitally shared and expressed on-line. At the end of the study, phone interviews were used to validate some of the findings from the netnography.

Methods
The methods used in this study were mainly covert netnographic methods (Kozinets, 2015) and open-ended and semi-structured phone interviews. The empirical data from the netnography and phone interviews were coded into group themes and categories by three researchers using thematic analysis (Braun & Clarke, 2006) and paper, whiteboards and Atlas.ti as tools. The interviews were undertaken in Swedish, and all quotes are translated into English.

Process
The netnographic process was undertaken in several steps to identify themes of the forum members' anticipation of car ownership. The first step of the
Netnographic analysis provided a basic overview of the forum structure, member activities, biographies and culture, and in doing so, disrupted some of our preconceptions of a typical “Tesla owner”. This first step was based on 28 of the recently updated discussion threads in the member presentation section and 25 of the most recent and popular forum discussions, mostly in the sections of “General topics” and “Model S”. This generated a series of themes, which included: *Different reasons for becoming Tesla owners; If Tesla owners like to drive or not; Expectations of fully AD; and If a continuously evolving (beta software testing) product is a premium experience.*

The most significant quotations were transcribed for the second step in the analysis, which focused on the process of becoming a Tesla owner and how this process evolved over time.

In the second step, three engaged forum members with particularly interesting narratives of becoming Tesla owners were consciously selected and their posts from when they first entered the forum until they became Tesla owners were collected. The data was drawn mainly from their personal presentation threads and additional threads about anticipation and experiences in which they had been actively participating. These were analysed through thematic analysis. How their anticipation evolved over time was analysed, which enabled a broad understanding of how anticipation and ownership were articulated.

In the third step, the findings from the two previous steps were partly validated through in-depth, open-ended and semi-structured phone interviews (between 30-60 min each) with six Tesla forum participants—two of whom we had analysed in the second step, and four members (also Tesla owners) who were recruited through a post in the Tesla forum. The questions in the interview guide included topics to understand the process of becoming a Tesla owner in more detail, and to identify how anticipation and UX were created and evolved within the community. Although these forum members had different backgrounds and levels of interest in cars or sustainable technologies, they shared a similar process in their anticipatory journey of becoming Tesla owners. Through this process we created a deeper understanding of how different modes of anticipatory UX could be exemplified.

**Outcome**

The findings from this study generated Paper 01, where more details of the Tesla study are provided. This paper became the starting point for my understanding of how anticipation not only forms the subsequent UX of physical materialities but also provides an experience in itself.
4.2 Study #2: DriveMe/HEAD project—AD families

Background
Study #2 was part of an AD research project, Human Expectation and Experience of Autonomous Driving (HEAD), a Swedish government-funded (by VINNOVA) Autonomous Drive research project. The HEAD research project was performed within the umbrella of the DriveMe program, a large collaboration involving stakeholders from industry, municipality, road governance and academia, including Volvo Cars, the Swedish Transport Administration, the Swedish Transport Agency, Autoliv, the City of Gothenburg, Chalmers and Halmstad University. The DriveMe program was a collection of different research projects with the aim to investigate concerns about AD cars for safer and more efficient driving.

Aim
The aim of Study #2 was to understand how people experience and anticipate evolving AD features in their everyday life. Initiated by the findings from Study #1, the focus of Study #2 centred around how people’s UX of AD systems in cars as an anticipatory experience can be understood, both from a theoretical and methodologic perspective.

Duration
Study #2 was undertaken during the 24-month period between December 2017 and December 2019.

Participants
The empirical materials from Study #2 involved a total of 18 participants from five families (nine parents and nine children). The families were consciously selected from more than 1,000 volunteers who had signed up to an open application process. The sample of families was not intended to be statically representative but was instead a purpose sample to recruit families with an interest in AD technologies and who were also dependent on their car for their everyday routine.

Approach
The settings of the DriveMe project enable a long-term DE approach to build relations with the participants and to provide them with speculative AD situations and technologies to enable their experience of anticipating AD technologies to evolve. Throughout Study #2, the participants experienced different AD SAE levels 2 to 5 (SAE, 2018) through speculative materials and enactments in the context of their everyday life.
Methods
The empirical material from the study was extracted by using several types of ethnographic methods of longitudinal engagement with the participants such as: In-home activity interviews (Mitchell et al., 2014); Drive-along interviews (Pink, Fors, & Glöss, 2017) with evolving AD design prototypes (Paper 03) and a WOz AD car (Osz, Rydström, Pink, Fors, & Broström, 2018) in real-life situations; Speculative AD future workshops (Paper 03); and AD experience blogs (Paper 03). At the end of the study, the results were presented to the participants through a workshop where they had the opportunity to reflect on their participation in the project.

Process
Study #2 had to be done through an iterative and creative process as it was dependent on several project-related factors such as: AD prototype development, public relations policies, legislation for AD testing on public roads and other people working within the DriveMe program but not directly involved in the research project. The families were selected to be part of the DriveMe program, which enabled them to try out and live with different levels of AD technologies in everyday life.

The first connection with the families was made through in-home interviews (approx. one to three hours each) including a series of group activities with as many family members taking part as possible. The semi-structured in-home interviews were done to get to know the families and understand the role of the car(s) in the family, their everyday routines with their car(s), their experiences of driving and how they anticipated their AD futures. The interviews were done during a “fika” or dinner session with the families as they did different enactment exercises, e.g., to draw their everyday trips on a map or document their in-car routines and items taken in the car. At the time of this event, the families had recently received their leased DriveMe (AD level 2) project cars provided by Volvo in the DriveMe program. For all of the families, these AD level 2 (SAE, 2018) cars were their first car with this level of semi-AD technologies, enabling driving assistance with longitudinal and lateral driving support. However, they were obliged to have their hands on the wheel and eyes on the road at all times.

The next ethnographic event took place two months after the first interview at an AD level 3 (SAE, 2018) Driver Education course at a test track provided by the DriveMe program. The education was done in order for the family participants to familiarise with higher levels of automation in real traffic situations. The AD SAE level 3 prototype cars provided by Volvo enabled partly unsupervised driving where the driver did not need to have their hands on the wheel during certain conditions. The intention was to
later upgrade the participants' own AD level 2 prototypes to level 3 through software updates; however, the Swedish road administration did not allow that during the time of the DriveMe program.

A first set of drive-along interview sessions (with AD Level 2) was done after the families had become familiar with their DriveMe project car for their everyday use. Four in-car drive-along interviews and observations with selected family participants were performed. Each drive-along lasted between 30–90 minutes depending on the distance covered by the family’s usual trip. The AD level 2 drive-alongs were aimed at understanding how everyday life was affected by this level of automation and were designed to investigate the families’ experiences and aspects of AD more deeply. To achieve this, the family members were accompanied during their daily commute from or to work. A semi-structured interview guide was used, which engaged all the participating family members' experience of the drive. Driving along their ordinary commute routes at their usual times enabled the family participants to reflect on their experiences and to relate their feelings of anticipation of AD in relation to their own social context and upcoming traffic situations as they appeared. The traffic situations themselves often inspired participants to talk about AD experiences and what they anticipated the car would do or what it should do for the next iteration of AD development.

Halfway through Study #2, the families were invited to experience an AD prototype/VR event about the future with a fully autonomous car (AD SAE level 5) based on a concept car from Volvo (Volvo 360c Concept car). Nine participants from four of the families participated. A physical interior mock-up of the concept car was available, and the participants could jointly immerse themselves in the experience of riding along in a speculative AD SAE level 5 future scenario by using VR headsets and hand controls. The participants also experienced AD from an outside perspective by watching a VR-movie of different scenarios with the AD concept car driving around in a fictional city. Throughout the demonstrations, the participants could ask questions and interact with the mock-ups. Part of the discussions were audio recorded.

One year into Study #2, a second set of 16 drive-along observations and interviews were conducted with eight of the family participants during their morning and afternoon commutes. This set of drive-alongs was undertaken to observe partly unsupervised driving with AD SAE level 3 prototype cars in real traffic. These cars were the same model as their own AD level 2 project cars and the differences were mostly related to software updates of the AD system capabilities. Through this set-up, the family participants were
able to experience an increased and evolving level of automation in their own environmental context.

One-and-a-half years into the Study #2, a third set of drive-along interviews and observations was conducted with eight of the participants from the five families on their daily commute route. In this activity, a type of WOz research car (Osz et al., 2018) was used. The WOz car enabled the possibility to experience an AD technical system according to AD SAE level 4 in real traffic. The WOz cars were also based on the same car model as the participants’ own AD SAE level 2 project cars. The WOz research car enabled the family participants to experience almost full autonomy along their whole commute route, without the need for them to have their hands on the wheel or eyes on the road. These cars had a “WOz driver” in the rear seat that was able to fully drive the cars by steering, accelerating or braking without exposing the control set-up to the participants.

At the end of Study #2, the families were invited to a follow up meeting to summarise all events and their experiences of being part of the DriveMe project. In this meeting, they had the opportunity to share positive or negative experiences of the DriveMe/HEAD project in general as well as their learnings, experiences and anticipations of the future of AD. Participants from four out of five families joined the event. In total, 25 hours of drive-along and ten hours of in-home interviews were video recorded by the researchers involved in Study #2. The other research events were audio recorded to a total of six hours.

Outcome

The DriveMe AD family study generated empirical material for papers 02-04 included in this thesis. The papers provided new knowledge around the phenomena, through deeper understandings of anticipatory experiences around evolving AD technologies (Paper 02), the methodological approach to study the phenomena (Paper 03) and finally a reflection on how entanglement theories enable new perspectives to view human-technology relations (Paper 04). This study generated several themes of anticipatory experiences, to serve as foresights for AD design practitioners, whereby three themes were tried out with AD UX designers in a workshop to generate Design Principles (Cronholm & Göbel, 2018; Fuchs & Obrist, 2010; Tan et al., 2021).
4.3 Study #3: RELEVANT—Smart Charging Households

Background
Study #3 is based on an ongoing (at the time of this thesis publication) academic-industry collaborative research project about smart charging of EVs in private households, called RELEVANT. The project was founded by the Swedish strategic innovation program for future sustainable mobility solutions, and incorporates the car manufacturing industry, energy providers, research institutes and academia. The project was founded to better understand both the new technical and end-user issues of charging EVs in a cost efficient, easy and sustainable way.

Aim
The aim of Study #3 was to understand how people anticipate EV futures and learn to live with digitalised EV cars as digital platforms connected to energy ecosystems. Part of the project outcome is to develop a smart charging algorithm to power the digital platform to optimise the time for charging depending on various sources such as momentary household peak load, energy cost, vehicle usage, weather or user preferences.

Duration
The RELEVANT project started at the end of 2019 and Study #3 commenced in June 2020 with the first initial interviews with participants from the selected households, who would be part of the project for at least a two-year duration. The RELEVANT project and following studies were still ongoing at the time of this thesis publication.

Participants
The participants were from ten selected private households with EVs (including both plug-in hybrids and full EVs), and four of the households also produced energy through solar panels. They were selected to represent families living in privately owned households with an active lifestyle that made them use their cars for both planned and unplanned use on a daily basis.

Approach
Study #3 used a DE approach to trigger the participants' experiences of anticipation of future electromobility. By providing the households with EVs, hardware for charging and measuring energy consumption, the settings of the RELEVANT project enabled the participants in the households to experience the journey of increasing levels of electrification of their mobility and connection of their car to their households' energy system management.
Methods
The empirical material was extracted from video call interviews with family participants using the EV in the households. Due to the Covid-19 pandemic, the interviews with the families had to be conducted through video calls instead of the planned set-up in-home activities and drive-alongs. As the technological development of the smart charging algorithm in the project took longer than planned, the interviews had to focus on the participants' anticipation of how to learn to live with electrified cars in their everyday lives rather than experiences of the smart charging algorithm and functionality.

Process
The households were provided with a wallbox to charge their cars and an energy contract for a variable (per hour) energy price. The participants were informed about the project deliverables to connect the EV battery status, driving data and measuring the household energy consumption (and solar production) in real time, to a cloud-based charging algorithm controlling the charging of the car. The participants were also informed that a smartphone user interface to the charging algorithm was going to be iteratively developed alongside the project by involving the participants in the process. However, the findings included in this thesis are only based on the initial interviews.

Outcome
The first results from Study #3 generated empirical material for Paper 05 included in this thesis. Study #3 presents a first set of findings on how people experience and learn to live with EVs in their everyday life, when cars become a digital platform and part of other ecosystems. Paper 05 argues that ethnographic understandings of EVs as evolving digi-physical phenomena provide opportunities to foresight how to implement EVs from a people-centric perspective. The findings from Study #3 will also provide insights to iteratively develop a smart charging function of the EVs to better understand what smart charging means for people in everyday life.
5 Presentations of the Main Findings

This thesis is based on a collection of five individual papers that have been peer reviewed and published in international journals or conferences. Chapter 5.1 gives an overview of the iterative process that resulted in the contribution of this thesis and its relation to the papers. At the end of this chapter, the contribution of each of the papers will be summarised.

5.1 Phases of the Thesis and Research Papers

This thesis takes an explorative journey to study people's experiences anticipating digitalised cars through the phases of Exploration, Analysis, Practice, Reflection and Implications. Anticipatory experiences of digitalised cars where through this process identified, studied and evolved into a contribution of this thesis defined as Digital Anticipatory UX (DAUX), see chapter 6. Each phase is represented by a paper included in this thesis (see figure 13).

Figure 13: Phases and studies of the research papers

5.1.1 Exploration Phase

This phase defines the first explorative steps of the thesis in studying and understanding human anticipation in relation to UX. The exploration phase generated Paper 01, based on Study #1, which was this thesis’s first exploration of how anticipation around the car ownership journey was expressed in
an online car community (Swedish Tesla forum). It started from the viewpoint of how the experience of high-tech cars shared digitally on an online forum evolved into experiencing the car physically by becoming a user of it. Paper 01 contributed the basic characteristics of Anticipatory UX (in this thesis, later developed into DAUX) and set the foundation for the following phases to zoom in on AUX and the methods to study the phenomena.

5.1.2 Analysis Phase

The Analysis phase comprised a deeper analysis of Anticipatory UX to understand its components and relations, as the Exploration phase exposed anticipation to have an impact on UX, especially for digital materialities. Paper 02, based on Study #2, analysed Anticipatory UX (the foundation for DAUX in this thesis) by building on the empirical data based on the Drive-Me families’ evolving anticipation of AD. The starting point was from the experience of the car physically while driving and how it evolved digitally through increasing levels of automation capabilities. Paper 02 contributed with a theoretical framework for Anticipatory UX (defined as DAUX in the thesis) showing the situational sources of anticipation, how anticipation has an impact on different time spans and how it iterates back through learnings.

5.1.3 Practice Phase

After the phase of analysing Anticipatory UX in detail and understanding its complexity and entanglement with everyday life, the Practice phase of the thesis was needed to apply and demonstrate a methodological approach to explore and investigate Anticipatory UX. Paper 03 was also based on Study #2 but with the aim of demonstrating how a long-term DE approach with related methods can generate and investigate Anticipatory UX and turn findings into user foresights. Paper 03 contributed several methods for practice as well as empirical examples of Anticipatory UX themes that could be used in AD design practice.

5.1.4 Reflection Phase

The Reflection phase provided a deeper reflection on the philosophical foundations regarding how to view and research Anticipatory UX. Paper 04, based on Study #2, provided a reflection into the philosophical foundations for Anticipatory UX theory and methods and connected it with Entanglement HCI (Frauenberger, 2019). Paper 04 contributed to both Anticipatory UX theory and methods by referencing Entanglement HCI and providing the Anticipatory UX themes for the AD design practice.
5.1.5 Implications Phase

The Implications phase describes the final iteration of how to apply the Anticipatory UX theory and methodology and provide user foresights. Paper 05, based on Study #3, was the final step in identifying the implications of Anticipatory UX and how to provide user foresights for innovation. The study is based on the RELEVANT project, which aims to co-develop a smart EV charging function together with participants from families in private households. The paper contributes both methods for practice as well as Anticipatory UX implications for design.

All the papers will jointly contribute to this thesis, foremost by offering a theoretical contribution to a new view about how anticipatory experiences of digitalised cars emerge and evolve, as described by the DAUX characteristics and definition in chapter 6. Secondly, the papers will demonstrate a methodological approach in using DE to investigate anticipatory UX and provide user foresights for UX design innovation. Lastly, the papers will present some empirical examples of Anticipatory UX themes for UX design of AD systems and services related to the electrification of cars.

5.2 Paper 01: Experiencing the Future Car: Anticipatory UX as a Social and Digital Phenomenon


Background and Aim

The starting point for Paper 01 was to address the gap in how UX research commonly provides insights through investigating specific situated moments during use, or users’ reflections after use, yet does not provide much knowledge about UX of pre-product use. Hence, Paper 01 aims at filling the gap of UX research in understanding how users will engage with not yet physically existing products.

Research Question

To explore how a focus on anticipatory experiences can extend UX research to account for users’ experiences and expectations through digital format before the physical use, the paper’s research question was framed as: How
can we understand anticipation as a socially shared dimension of the user experience of the digitalised car?

Theory
This paper reviews the current understanding of how temporality of UX (Karapanos et al., 2009; Roto et al., 2011) and AUX (Yogasara et al., 2011) are related in contemporary research and industry (ISO, 2010). The paper identifies a lack of empirical UX research about anticipation (Bargas-Avila & Hornbæk, 2011). This is followed by a theoretical analysis of human anticipation as explained in interdisciplinary research (Poli, 2017; Tavory & Eliasoph, 2013), the social context of digital media (D. Miller et al., 2016) and how this shed new light on socially shared anticipatory experiences.

Research Design and Empirical Data
The paper takes a generative ethnographic approach to analyse the activities of members of a self-organised web-based discussion forum for Tesla car enthusiasts, to understand how product anticipation emerges in a digital-material setting. It demonstrates the role of pre-product UX in product design through a netnographic study (Study #1) of three people’s experiences of anticipating and owning a Tesla car. Most of the empirical data and analysis were based on these three selected active and long-term forum members. Their posts in the forum were analysed from their first post as non-Tesla owners to their most recent as Tesla owners. By using this ethnographic approach throughout the duration of a ten-month netnography of the online forum, the study managed to investigate how anticipation evolved over time.

Findings
The study identified how modes of anticipation evolve before using the actual car, through online social interaction, creating experience of pre-product use through digital representations of the car. These results provide implications for product development, as the study identified no clear boundaries between people’s imaginations, expectations and desires of future products, and the ongoing socially shaped and emergent experiences of the product, in its physical or digital form. Paper 01 concludes that the shift towards digitalisation of cars and subscription services creates a need for more interdisciplinary research into spatial and temporal aspects, where socially shared anticipatory experiences are increasingly important for the overall UX.
Contribution
The paper offers a foundation for theorising UX of pre-product use as socially-generated AUX, as well as insights for UX design of cars. These anticipatory experiences were shown to be important for how goals are formed and decisions made, and how these are ongoing in the pre-product phase, thus making anticipation important for UX design of products. Paper 01 contributes to this thesis theoretically by providing foundations for Anticipatory UX characteristics by referring to the theory of human modes of anticipation (Tavory & Eliasoph, 2013). It represents the first Exploration phase of this thesis. Study #1 in this paper provides the first of three approaches in this thesis by viewing digitalisation starting with cars as digital (through a Tesla online community) and evolving into UX of the physical car (becoming Tesla owners). Paper 01 identifies AUX as always evolving; the temporal and social perspectives therefore become important to understanding how it emerges and evolves. AUX was also shown to create an experience in itself. The conclusion was that the “Anticipated” in AUX should rather be described as “Anticipatory”, in order to capture these evolving and emotional aspects.

5.3 Paper 02: Anticipatory Experience in Everyday Autonomous Driving

Background and Aim
Paper 02 addresses the need for research in understanding how AD cars and related services are anticipated and integrated into people’s everyday lives. This paper aims to demonstrate how people’s UX of AD cars can be understood as a shifting anticipatory experience when people learn to use and integrate degrees of AD in their everyday context, through digitally evolving Advanced Driver Assistance Systems (ADAS).

Research Question
As per the aim to better understand the social and situational aspects of anticipation and UX in everyday life circumstances, the research question in the paper was framed as: *How can we understand people’s user experience of autonomous driving cars as an anticipatory experience?*
Theory
Paper 02 identifies the contemporary UX research into AD to be mainly focused on understanding the acceptance of AD based on technology acceptance models such as the TAM (Davis, 1985). These AD UX studies were found to be either mostly done through evaluations in experimental settings or through collecting data about attitudes and willingness to adopt through pre-defined questionnaires. To understand how people anticipate AD, Paper 02 builds on previous findings from Paper 01 on anticipatory UX and the different modes of human anticipation (Poli, 2017; Tavory & Eliasoph, 2013). Paper 02 takes a broader approach in understanding anticipation of AD UX by bringing together the concept of anticipatory UX in everyday life (from Paper 01) with McCarthy and Wright’s (2004a) UX framework, Technology as Experience (figure 5 in Chapter 2.4).

Research Design and Empirical Data
The paper used a design ethnographic research approach to achieve an in-depth understanding of how participants’ everyday lives with ADAS technologies unfolded in natural settings, with a focus on Anticipatory UX. The empirical data was drawn from a long-term ethnographic study from the DriveMe AD families project (Study #2) that comprised five families who had access to AD research cars with evolving AD features in their everyday lives for a duration of one-and-a-half years. The study was based on design ethnographic methods such as: In-home Activity Interviews, Drive-along commutes and a Speculative Scenarios Futures workshop. Participants were provided with semi-AD cars during the study period as triggers for making them anticipate their autonomous futures. Also, an advanced highly semi-AD prototype car as well as a WOz car (simulating fully AD) was used to allow the experiences of the AD technologies to evolve.

Findings
Paper 02 showed that the participants gradually adopted AD cars, through a process that involves anticipating if they can trust them, what the ADAS features will do and what the longer-term technological possibilities will be. The paper identified four situational sources to the participants anticipatory experiences: Social, Technology, Environment and Individual. All the situational sources of anticipation noted above were found to generate anticipatory experiences and actions related to three different time spans of: Instant, near and far future anticipations, which all are part of creating the evolving UX of AD. Paper 02 also indicates how the socio-technical elements and the situatedness of AD are part of a temporal process in which anticipatory modes and actions are key.
**Contribution**

Paper 02 expanded on the theory from Paper 01 and concluded that anticipatory UX occurs within specific socio-technical and environmental circumstances. The paper also showed that these circumstances could not be investigated easily in experimental settings. The implication is that studying anticipation offers new insights into how people adopt AD in their everyday commute. Paper 02 contributes to this thesis with a theoretical framework for investigating how anticipatory experiences of AD technologies occurred and changed over time within specific socio-technical and environmental circumstances. The situational sources of the participants’ anticipation were identified as stemming from **Social**, **Technology**, **Environment** and **Individual** sources, which generate anticipatory experiences and actions related to different temporal time spans of instant, near and far futures. Paper 02 represents the second **Analysis phase** of this thesis research process as it went deeper into the analysis of anticipatory experiences. Study #2 in this paper provides the second perspective of digitalisation, starting from the driving experiences of the physical car evolving digitally through evolving levels of automation mainly via software updates. Anticipatory UX was found to be iteratively evolving through learnings of experiencing automation in real life settings.

---

**5.4 Paper 03: Foresighting Autonomous Driving—an Ethnographic Approach**

**Lindgren, T., Pink, S., & Fors, V. (2021).** Fore-sighting autonomous driving - An Ethnographic approach. *Technological Forecasting and Social Change, 173*

**Background and Aim**

Paper 03 addresses the need within HCI research and industry to better understand upcoming user needs to enable new innovations beyond acceptability forecasts and UX lab tests for emerging technologies. The paper aims to investigate how people gradually anticipate AD in their everyday commuting contexts while engaging with already existing and evolving AD technologies as well as demonstrating how user foresights can be created through an ethnographic approach to anticipatory UX of AD.

**Research Questions**

To address the need to go beyond acceptability forecasts and UX lab tests of AD, the following two-stage question is formulated in the paper: **How can anticipatory user experiences be identified, analysed and understood conceptually through ethnographic research?** and **How can the con-**
cepts associated with anticipatory user experiences be mobilised to create user foresights?

Theory
This paper reviews the existing research into people’s expectations and experiences of AD and found current AD research related to UX was commonly undertaken to provide user insights by studying the individual-technology experiences in lab settings or by forecasting attitudes and acceptability through large surveys (see table 1 in Paper 03). The review found the common approaches based their knowledge on people’s past or present expectations and a very limited amount of research involving real life experiences of AD. The paper also reviews UX methodologies to understand user behaviour and attitudes to new emerging technologies, which expose most methods to be quantitative and using a deductive approach (see table 1 in Paper 03). These types of approaches based on historical data were found to limit the possibilities to create user foresights. The paper explores theoretically how to move from forecasting (predicting future needs) and user insights (incremental ideas based on current needs) to creating user foresights (exploring future possibilities) (Bas & Guillo, 2015; Gabrielli & Zoels, 2003; Sakellariou, Karantinou, & Goffin, 2020) by combining ethnography and speculative scenarios (Elsden et al., 2017).

Research Design and Empirical Data
In this paper, a DE approach was used with iterative speculative scenarios of AD. This is demonstrated through a study undertaken with participants from five families who were introduced to evolving levels of AD, in real-life situations (Study #2). This was done through a long-term ethnography approach of 18 months, comprising In-home activity Interviews, Drive-along commutes interviews, AD blogs and a speculative AD futures workshop. Through these activities, they explored how participants might interact with future ecosystems within their daily routines.

Findings
Using a DE approach, the paper generates user foresights based on participants’ evolving anticipation of AD in their everyday lives. The paper findings provide three examples of anticipatory experiences, which were abstracted through the concepts of confidence, hope and being-in-the-moment. The concept Confidence was described as having three facets: the first involves how people reflect on the probability of how a technology will perform, based on their past experience; the second involves how they judge their self confidence in using the technology; and the third involves how this reflection impacts on how they anticipate their future confidence in current
use and development of the technology. *Hope* was identified as a theme to describe the participants’ feelings that their future AD experiences will turn out for the best. Finally, the concept of *being-in-the-moment* was defined as participants’ both positive and negative emotions regarding the future reflecting being-in-the-moment of actively or passively driving. These examples were then used to generate user foresights for innovation processes in AD design.

**Contribution**
Paper 03’s contributions are twofold and both directed towards the UX research field of AD as well as the AD industry. The main contribution of the paper is the methodological approach to include the contextual and temporal perspectives on how people learn to trust, use and live with AD technologies. This was done by demonstrating how a DE methodological approach was applied to AD research and how the concepts associated with anticipatory UX can be mobilised to create user foresights. The second is the theoretical contribution, which was exemplified in how the findings of anticipatory concepts of *confidence, hope* and *being-in-the moment* generate user foresights that can be elicited to implications for innovation in AD design. Paper 03 contributes to this thesis with a methodological approach to investigate anticipatory experiences using a DE, by demonstrating how it enabled the intertwined anticipatory experiences to emerge from everyday lives. Combining ethnography and speculative scenarios and designs enabled a forward-looking approach that allowed the participants’ hopes and fears about new technology in the context of their everyday lives to emerge. Paper 03 represents the *Practice* phase in this thesis as it focused on the methodology to investigate and trigger anticipatory UX in research practice. The empirical material was extracted from the DriveMe study (Study #2) with the second perspective of digitalisation, starting from the physical car and evolving through digital experiences.

5.5 Paper 04: Entangled Intelligent Driving: Relations with Automated Cars


**Background and Aim**
Paper 04 addresses the new challenges in HCI research methods to understand UX as the machines become more entangled in our everyday lives. In the case of AD, this involves new scenarios where humans and intelligent
vehicles need to act together in real life traffic situations with other road users. As machines become more intelligent and the interfaces become more invisible, there is a need for new approaches to study the fuzzy and entangled relations between humans and machines.

Research Question
To address the emerging need for new understandings and perspectives on how humans and intelligent technology mutually learns and adapts to each other accordingly, the paper’s research question is framed in the context of AD vehicles to find out how people and machines learn together through how people anticipate the AD technologies will make the car behave, and in turn, how that will make the driver feel and behave.

Theory
The paper illustrates how these complexities could be analysed by engaging with theories of sociomateriality (Schultze et al., 2020) and entanglement in HCI (Frauenberger, 2019). These theories rely on a philosophical direction that proposes methodological approaches that accommodate people’s fuzzy relations with intelligent technologies and how they continuously evolve. Hence, the paper proposes researching entanglements of human-technology relationships in everyday life of AD cars, through ethnography combined with theories on anticipation as a fundamental aspect of human experience in our relationship with technology.

Research Design and Empirical Data
This paper adopted a longitudinal design ethnographic approach to investigate human-machine relations in a study of people from five families (in total 18 people) driving semi-AD cars in their everyday environments over a duration of 18 months (based on Study #2). The methods used to elicit ethnographic material were mainly based on drive-along interviews and observations in real life traffic situations with speculative levels of automation. The empirical material was extracted from the same DriveMe study as in Papers 02 and 03 (Study #2).

Findings
This paper shows how current in-depth knowledge about how UX evolves through relations and interactions between people and AD technologies in everyday contexts is limited and requires further research. This paper contends that users' trust and acceptance of AD cars are more complex than only being determined through the interface of the car or the general public’s attitude towards AD cars. In the case of AD, this involves new scenarios where humans and intelligent vehicles need to act together in real-life
traffic situations with other road users. In our drive-along studies, we identified four different anticipatory experiences that emerged from the AD network: *Embodied Knowledge, Embarrassment, Empathy* and *Uncertainty*.

**Contribution**

Paper 04 has a two-fold contribution. The first is aimed at HCI research by demonstrating how an ethnographic approach, developed in line with theories that view technologies as formed by socio-material relations (Schultze et al., 2020), can be useful for uncovering how AD cars become part of people’s everyday life through entangled human-technology relations (Frauenberger, 2019). Second, the paper demonstrates how the findings from our approach provide new perspectives that can forge new insights for UX design of AD by decentralising the human as the centre of interaction in favour of a relational approach (Schultze et al., 2020). This highlights how anticipatory experiences emerge in the entangled relationship between humans and AD technology in everyday life. Paper 04 contributes to this thesis by offering an ontological and epistemological foundation that reveals the entangled nature of human-machine relationships of emerging digital and intelligent technologies. The findings provided principles for theoretical understandings and methodological approaches to view anticipatory UX and how *relations* rather than *interfaces* are key for future UX research of digital-physical technologies. This paper also provided examples of anticipatory UX such as *Embodied Knowledge, Embarrassment, Empathy* and *Uncertainty*, which are aimed to be used in AD UX design processes.

5.6 Paper 05: Experiencing Electric Vehicles: The Car as a Digital Platform


**Background and Aim**

Paper 05 addresses the need to understand the impact of digital platforms related to EVs on everyday life and their implications for digital transformation of the car industry. Digitalised EVs are shifting from being simply machines that provide a means for transport to becoming a digital platform to serve as a power source or sensor platform with computing capacity powered with AI driven technologies. As this occurs, new ways are needed to understand UX.
Research Question
To identify new challenges and opportunities EVs and related digital platforms could bring from an end-user perspective, this paper proposes a DE approach to study people's anticipatory experiences and expectations of EVs. As such, the paper asks, How can the impact digital platforms have on everyday life be understood through insights into people's everyday experiences and anticipations of EVs? and What implications does these insights contribute to understandings of the digital transformation of car industries?

Theory
The paper briefly reviews digital platforms research and identifies the lack of a human-centred perspective on digital platforms in everyday lives, which has been identified as one of six key focus areas on digital platforms within Information Systems research (de Reuver, Sørensen, & Basole, 2018). A large amount of digital platform research has tried to understand the impact on customers' purchase intention based on customer experience (Saberian, Amirshahi, Ebrahimi, & Nazemi, 2020); however, critical determinants of success are still difficult to understand and remain unclear (McIntyre & Srinivasan, 2017; Pagani, 2013). As the introduction of digital platforms and resultant changes to traditional manufacturing industries has received heightened attention within Information Systems research (Jovanovic, Sjödin, & Parida, 2021), this becomes relevant for the automotive industry when EVs, filled with energy, enable possibilities for a car to be used as a digital platform that is mobile, always connected and equipped with a wide variety of sensors and powerful computing processing power. This provides new opportunities for EVs to be integrated into people's wider everyday lives (Nicley, Lazaros, Truell, Zhao, & Davison, 2020).

Research Design and Empirical Data
The paper presented ethnographic findings from an ongoing empirical study of ten households with privately-owned EVs (Study #3) and explored the experience of the EVs as digital platforms connected to their homes via smart charging. The empirical data was collected through video call interviews with the households. The interviews included both parents who used the car (and sometimes teenagers with a driver’s licence) to garner different perspectives from the discussions.

Findings
The paper shows that the global transition towards EVs and the electrification of cars is not only about hardware but also implies a digitalisation of cars. The literature review in the paper exposed that little was known about how digitalisation of cars affects people’s everyday lives. The paper's three
main findings were as follows. First, that life with Digital EVs was more complex, abstract, and always evolving compared to the more static, analogue and tangible experience with fossil fuel cars. Second, the understanding that integrating EVs into everyday life is to appropriate the digital technologies, maintenance and care that the EV brings with it. Finally, participants' anticipation of EVs are shifting the focus from the traditional driving performance aspects to become a piece of a puzzle in terms of a future energy ecosystem and to work seamlessly with future digital services.

**Contribution**

This paper responds to the identified research gap by presenting findings on how people experience and learn to live with EVs daily. The paper contributes to digital platform research by offering three main conclusions. First, that EVs become a digital platform connecting with new digital infrastructures creating both possibilities and problems for the end-users. Second, an ethnographic approach enables understanding experiences of EVs and surrounding digital infrastructures from an end-user perspective, which also allows foresighting into how EV futures might evolve from a human-centric perspective. Finally, it shows how automotive industries need to develop their understanding of how electrification of cars causes changes, including how EVs become part of wider digital infrastructures and how to implement EVs to better fit these new surrounding ecosystems with a human-centric perspective.

This paper represents the last and final Implication phase of this thesis. It contributes by showing implications for design when novel digital infrastructures around EVs enable new future possibilities for the users beyond traditional means of transport. In this paper, the ecosystem energy around digitalised cars formed the UX. This paper represented the third perspective on digitalisation by starting from a new ecosystem around cars shaping people’s experience of anticipation and UX of cars. The paper also showed how an ethnographic forward-looking approach generates foresights for UX design. Capturing people’s hopes and fears of emerging technologies in everyday life allows us to foresee opportunities and risks for technology and service development.

**5.7 Summary of the Paper’s Contribution**

The main contribution of this thesis is a new expanded view on experiences of anticipation, labelled Digital Anticipatory UX (DAUX), which will be discussed in depth in chapter 6. This is based upon the five different papers’
contributions, through the process of five steps, one for each paper (see figure 14).

Figure 14: Contribution from each of the research papers

Papers 01, 02 and 04 provide the foundation to frame the characteristics of DAUX. These three papers contribute to the theoretical foundation of DAUX as temporal, situational and social. DAUX is a development of what was called AUX in the various papers. The “D” in digital is added to emphasise the digital materialities’ relation to UX and to also differentiate form the acronym and definition of AUX (Anticipated UX) by Roto et al. (2011) and Yogasara et al. (2011). Paper 03 demonstrates the methodological approach to research DAUX in everyday settings through DE, but also to inform UX design innovation processes through foresighting. Paper 03 also provides three empirical examples of DAUX themes to explain the methodological approach and provide implications for UX design of AD. Paper 04 represents the reflective phase and contributes with a philosophical view of ontological (question of being) and epistemological (question of knowing) perspectives for DAUX research. Papers 03, 04 and 05 provide this thesis with empirical examples of DAUX themes to show what it could be and how it could be used as foresighting for UX design processes. Paper 05 finally connected all learnings from previous papers to demonstrate how the theoretical understandings and methodological approaches to DAUX are used to provide implications for innovation UX design processes. Therefore, this thesis follows an iterative process where learnings from the previous phase were used in the following phase, which enabled the understanding of DAUX to evolve over time.
This thesis's starting point was to address an increasing need for new future sustainable mobility possibilities that engage with end-user anticipation in the design process. As digitalisation in the automotive industry is expected to disrupt future mobility, it becomes crucial to understand how people anticipate and shape their futures with digitalised cars as they are part of making the change. This chapter is divided into five sections: the first section will present and discuss the justifications for the extension in how to view UX of digi-physical materialities and which these different ways are; the second will outline the contribution of how to view the emerging and evolving anticipatory experiences explained through Digital Anticipatory User Experience (DAUX); the third will describe the contribution of the methodological approach to research DAUX; and the fourth will offer the contributions of implications for designing for DAUX. The last section in this chapter will reflect on the limitations and transferability of the DAUX contributions. All together, these five sections summarise this thesis’s contribution towards understanding people's experiences of anticipating digitalised cars and its implications for designing future mobility.

### 6.1 Experiencing Digitalised Cars

The justifications for the proposed view of UX through DAUX originate from Papers 01 and 02 in the first two explorative and analytical phases of this thesis. In the explorative Study #1 about the people on a Tesla forum becoming Tesla owners, their anticipation was found to play a major role in how they experienced, shared and formed their everyday life with their Tesla car. In Paper 02 based on Study #2 and the DriveMe families, the characteristics of anticipatory experiences related to AD were further explored and analysed. These two papers revealed a difference from the current understandings of anticipation and UX, referred to as AUX (Roto et al., 2011; Yogasara et al., 2011). When peoples’ experiences of cars are extended through digital materialities, peoples’ anticipatory experience of cars alter in three apparent ways:
Digital representations
First, when cars become possible to experience digitally through, for example, immersive digital representations in narratives of cars in future or present contexts created and shared by other people and companies, it enables people to easily anticipate what their future might look like. The impact on UX of cars through digital representations should not be underestimated. However, the entangled character of digital representations makes it difficult clearly separate it’s part of UX. What is experienced through physical or digital representations of the car does not matter to people, as their everyday life is already naturally digi-physical, which was seen in all the studies. As such, it becomes difficult to define a clear before use, moment of use and reflection of use as in the definitions of AUX and in TAM. To emphasise the digital-physical character in DAUX, the word “Digital” is part of the term. However, the “D” should not be interpreted as excluding or purely focusing on the experiences of the digital, but rather to denote the inseparable digi-physical ways to experience a product.

Software updates
Second, the unfinished character of digitalisation where products such as the car are never ready-made, but continuously evolving through intelligent algorithms and software updates, allows for people to anticipate their future experience rather than reflecting on their current state. However, this can also create friction as not everything is continuously changing or is changing at a slower than anticipated rate, e.g., physical objects like road infrastructures, home infrastructures or hardware in the car. Still, people's hope and fears of the future, in combination with their view on digital technologies as open-ended and unfinished, make a strong impact on their present experience of cars and the anticipation of what will come. For instance, if a driving assistance system is not currently working perfectly today, it does not matter so much for people who hope it will become better via a software update or by the system learning to become better by itself. As this transition is taking time, people will learn, and technology will be updated accordingly. Therefore, I propose to define the always-evolving situation is anticipatory rather than anticipated in DAUX.

Digital sharing
Third, digitalisation enables digital data and representations to be easily shared, which provides people with increasing possibilities to share their experiences, anticipation or even to become an active part of the future technology development. In the studies, the participants' anticipation was shown not only to shape their own experience but also those of others and the technology. Anticipation not only refers to one individual's anticipation
of a piece of technology; it is also a part of the social network around people. These three main arguments are the basis for my proposal for a new term and definition of DAUX to better understand how digitalisation of cars impacts people's everyday lives. As this thesis’s findings are based on studies in the context of people's everyday lives with cars and their anticipation of the future use of cars, the view of DAUX is formed by the context of this specific phenomena. However, I have tried to make the definition of DAUX somewhat generic to be more easily transferable to other products or services that are experienced through continuously evolving digi-physical representations.

6.2 Digital Anticipatory UX (DAUX)

The main contribution of this thesis is directed towards UX research by providing an elaborated view on how UX emerges and evolves with digi-physical products, such as the car. Reflecting on the narrative of Anna in the introduction to the thesis, exposes the entangled and improvised way she became a new car user, and how her anticipation of the future played a role in her decision making related to the car as well as how her experience of the car evolved over time. Subsequently, it becomes difficult to define when her UX of the car started and when it ended. Anna's experience of the car emerged gradually when she first experienced the car digitally and then as a physical object in her "hands". There was no clear before and after use, as is assumed in the AUX and TAM paradigm. Her UX also continues to evolve through software updates of the car or when it merges into energy ecosystems. Concluding the findings presented in the articles included in this thesis, the main research question will be discussed by bringing the concept of DAUX to life to visualise the change the findings prompted. As the research questions and the findings are based on studies of everyday life with cars, a definition of DAUX might be very related to this context; however, to extend a broader and wider use of DAUX, I have suggested defining DAUX more generically as:

A person’s continuously evolving anticipation of digi-physical use, situated in everyday life, socially contextualised and creating emotional experiences.

This proposed definition of UX of digitalised cars is exemplified through figure 15 based on the narrative of Anna’s EV user journey in the introduction section of the thesis (Chapter 1). This definition should be seen as an evolution of the current definitions of AUX and TAM in figure 10 (Chapter 2.5) to accommodate the entanglement of technology, due to digitalisation.
The proposed DAUX definition is based on the following propositions: DAUX is characterised by being digi-physical, evolving, future-oriented, socially co-created and emotional. The DAUX understanding is intended to help UX research and UX design to lift the perspective from interfaces, the physical moment of use and specific user needs to embrace a wider perspective of how people's anticipation plays a crucial role in forming their futures and experiences with digital technologies.

Figure 15: Digital Anticipatory UX exemplified through a journey of experiencing and becoming an EV user

Figure 15 shows in the centre the individual user and the object (an EV in this example) together with the social context of other people related to the individual (e.g., family, friends or online people). Around the person in the centre, the DAUX evolves without any specific starting or end point, shown as a pink circle. DAUXs are constructed through occasions or moments of experiences labelled *construction of use*, where these moments are shown as black dots. Within the DAUX circle, the blue arrow shows how people learn from the combined digi-physical use through the object examples inside the blue arrow. In the process of knowledge of use, the user’s imaginary, use and reflective processes work in parallel. The five identified specific characters of DAUX—*Digi-physicality, Evolvement, Future-orientation, Social Co-creation* and *Emotionality*—will be further explained below:
6.2.1 Digi-physicality

The ethnographic data from the three studies indicate that experience is physically and digitally intertwined (Baskerville et al., 2020; Dourish, 2001; Greenhill & Fletcher, 2009). My research demonstrated that UX cannot be easily referred to as emerging from either digital or physical representations and, therefore, as inseparable. People's experiences with technology can emerge from interacting with more or less digital or physical representations of the technology, but they are rarely purely based on one of them. Therefore, I suggest that the knowledge of use process between human and technology to be called Digi-Physical Use (DPU). In my view the anticipated use (Yogasara et al., 2011) or representation (Dupont et al., 2019) (imaginary use) becomes entangled and parallel to the Use, which blurs the definition of before and after use. Also, the phase after use, called the episodic, cumulative (Roto et al., 2011) or instrumentation phase (Dupont et al., 2019) (appropriation), becomes intertwined as the physical object of the car evolves through its digital capabilities, e.g., software updates or integration with external ecosystems. The ethnographic studies demonstrated that the digi-physical aspects enable the former linear process of different phases to come together in users’ Knowledge of use process (blue arrow) by their representation and instrumentation in parallel. This emphasises the materials experience (independent if they are digital or physical) and how materials shape how people do and form practises, and how this is rooted in the experience of those materials (Giaccardi & Karana, 2015).

6.2.2 Evolvement

What also defines DAUX is its continuously evolving character. Instead of viewing UX as a linear process (Dupont et al., 2019; Roto et al., 2011), DAUX should be perceived as a circular ever-evolving process. The studies indicated that there was no clear "before" use moment. The journey for an EV owner could appear to start from the digital representation of a cool car in an online forum and progress through an anticipatory process of learning about sustainable technologies, forming a vision for the user to aim for climate neutral sustainable living. Or, it could have emerged from a user anticipating a future of sustainable living by searching for a mobility solution (e.g., an EV) that fits into this vision. The digital materialities also enables the “product” to continuously to evolve and there are no steady state.
6.2.3 Future-orientation

Another aspect of DAUX is its forward-looking focus. As digitalisation extends the possibilities for users' hopes and fears of the future to become more visual, tangible and open ended, human anticipation plays a prominent role in the decisions taken by the user. However, I argue based on the empirical material from the studies and human anticipation theory (Tavory & Eliasoph, 2013) that people’s decisions are driven by anticipation on both short- and long-term timescales. People have plans and anticipate processes to reach certain goals or tasks, which justify the instant actions taken. In other words, it is not only our past learnings and experiences that form the decisions but also our hopes and fears of the future. This process is represented in figure 13 by the pink arrow. As anticipation on different timescales is ongoing in parallel, the empirical findings showed that there is not only one point of action that changes the construction of use but rather a mix of several smaller or prominent actions that make UX evolve. This is represented by the black bullets in different sizes (impact on the construction of use). The participants' anticipation was often mediated through digital technologies, such as representations of the car online. In the studies, it emerged that the participants' anticipation of future technology was so strong it shaped the actual experience, e.g., when the “soon to be” Tesla owners impatiently tracked their new cars’ boat trip across the ocean to the dealership for delivery. The empirical material also made evident the entangled relation between people and technology in everyday lives. This is represented in figure 13 through the examples of different digital technologies that are part of mediating UX of the car in the story (e.g., cars in an online forum, ordering cars through a smartphone, planning trips through a charging app, experiencing battery characteristics, trying out beta software, adapting households for charging, investing in solar panels for the roof, aiming for circular and sustainable living).

6.2.4 Social Co-creation

As experiences are sometimes shared (Battarbee & Koskinen, 2008) and digitalisation increases the possibility and speed of sharing experiences, it was no surprise that sharing experiences of anticipation became evident in the studies. People share and co-create experiences with others. This is also in line with the human anticipation theory (Tavory & Eliasoph, 2013), which explains how one person's anticipation influences another person's anticipation and actions. The studies reveal how people in the online forum or within the family or closest friends co-created UX of cars through sharing narratives of news, gossip, their own anticipation or experiences. All of this
is mediated by the digi-physical materiality. It becomes difficult to define who informs who or if technology changes the person or the other way around.

6.2.5 Emotionality

Anticipation was shown to create a strong emotional experience in itself in Paper 01, in line with what others have stated (Nicolás, Aurisicchio, & Desmet, 2013). This emphasises the role anticipation has in creating positive (or negative) emotions related to UX (Van Boven & Ashworth, 2007). If the borders are blurred between phases of before and after use, then it’s also needed to give more attention and value to what anticipation actually means for UX. The studies in this thesis show how people expressed the joy of anticipating the future. For instance, when participants performed actions like reading about or viewing others’ experiences of a new car technology, this provided them with a more positive and emotional experience than when they later had the “real” experience. The latter became more of a confirmation of the anticipated experience. Interestingly Study #1 and #2 also exposed that the participants seemed to accept or neglect the present poor or limited functionality of the car, as they were anticipating the next software release with more and improved functions. As also shown in psychological research (Van Boven & Ashworth, 2007), this would mean that when the possibilities with digitalisation extend the opportunities for anticipation to emerge, it also generates emotional experiences related to UX, which in some cases are stronger than the reflection after use. The DAUX process evolves through Imagining, Anticipating, Integrating, Experiencing, Sharing, Learning and Creating. These moments occur without any predefined order similar to the framework by McCarthy and Wright (2004a). These moments also often happen in parallel which was also shown empirically in my studies. The DAUX view therefore describes a highly integrated, always ongoing process. This leads into the following section, which aims to answer the secondary research question.

6.3 Contribution to Researching DAUX

The second contribution of this thesis is useful for both UX research in academia and industry by providing a methodological approach for researching DAUX. The DAUX view characterises the relations between human and technology as dynamic, fuzzy and evolving. For future UX research, this calls for a phenomenological epistemology to understand these kinds of entangled phenomena (Frauenberger, 2019). Relations between human and
technology, and combinations of human and technology, become the focus, rather than the interfaces between users and technology. As was shown in Chapter 2.1, new car technology developments and research methodologies go hand in hand and when digitalisation today enables new ways to experience cars, there is also a need for a change in how we study these phenomena. The fuzzy and evolving relations between the participants and digital car technologies became evident in the studies, which showed it is difficult to describe such relationships as being clearly separated into entities with well-defined boundaries connected through an “interface”. Three important aspects for studying DAUX were identified as *In situ*, *Anticipatory* and *Longitudinal*.

6.3.1 In Situ

The view of DAUX is important for UX research, as too much focus on interfaces between human and technology will miss out what actually matters; for people’s UX, for the society and the environment and for how things evolve over time. By applying *in situ* research approaches such as DE, it becomes possible to immerse into and understand these complex relations of humans and technology. To be able to discover unknown relations and experiences, there is a need for open-ended research approaches that can find the unexpected insights. Starting research by categorising or building hypotheses to test will risk missing out new phenomena of experiences with digital technologies in everyday lives. If UX research and design is too occupied with measuring and optimising the interfaces between humans and technology in cars, UX research loses the ability to provide implications for UX design processes of future mobility solutions.

6.3.2 Anticipatory

Anticipatory experiences range in their temporal modes, emerge from different contextual sources and continually evolve within the stream of lived experience. As anticipation appears both in explicit and implicit forms (Poli, 2019), by examining those more implicit anticipatory experiences through, for example, ethnography, it is possible to gain insight into much more than simply what people hope for, plan on, aspire to or fear. That is, “We catch a glimpse of how a given articulable experience of the future comes into being” (Stephan, 2019). However, to enable a forward-looking approach, the ethnography also needs something to trigger user's anticipation of the future. The speculative part in DE enables these possibilities for participants to anticipate, experience and reflect on possible futures related to their own everyday lives. Shown in Papers 03 and 04, anticipatory experiences were
triggered by speculative enactments based on In-home interviews, Drive-alongs with AD prototypes or Speculative workshops. In DE, the two different dimensions of the prospective (design) and the descriptive (ethnography) come together to allow DAUX to surface.

### 6.3.3 Longitudinal

The entangled and complex aspects of how DAUX emerges in everyday life settings, needs to be studied for longer durations to be able to investigate both the different temporal anticipatory modes ongoing as well as the different sources and relations required for anticipation to emerge. To investigate these evolving aspects, a longitudinal approach is also needed to understand where on the circular DAUX journey a participant is and the direction in which they are heading. Taking only a “snapshot” approach to research will limit our understanding of the relations before and after the research. Without, for example, getting to know participants’ cultural and social context as well their aspirations in life, it would be difficult to fully understand where their anticipatory experiences emerge from and where they want to go next. As anticipation is based on both our past experiences and what we hope or fear about the future, we need to study both people’s history as well as their anticipation of the future. This requires a study duration at least longer than a single occasion. However, as this kind of open-ended forward-looking approach expands the problem space rather than narrowing it down, this has implications for UX design processes, which will be explained in the next section.

### 6.4 Contribution to Designing for DAUX

The third contribution is directed mainly towards the UX design practice in industry by providing some guidelines to design for DAUX to evolve and provide opportunities for innovation. As the DE approach explores rather than evaluates design solutions, the outcomes and implications for UX design processes become different from the approach in providing design requirements. Papers 03 and 05 explored the possibility for the DE approach to provide foresights, instead of insights or forecasts. As digitalisation enabled participants’ anticipation to emerge and evolve in the studies, the opportunities and risks became the input for UX design processes. This opens up the problem space rather than narrowing it down. The possibility for ethnographic approaches to provide foresights has been discussed in for example EPIC: [https://www.epicpeople.org/best-laid-plans-an-ethnographic-approach-to-foresight/](https://www.epicpeople.org/best-laid-plans-an-ethnographic-approach-to-foresight/). However, there are three aspects for UX designers to...
remember if applying DE and foresighting; Beyond the physical, Co-create with people and Foresights for Innovation.

6.4.1 Beyond the Physical
UX design practitioners for future mobility products and services need to look beyond the physical and tangible interfaces to better include important aspects of DAUX in the design process. Study #1 demonstrates that the digital and physical materialities of a product or a service should not be viewed as separate elements of experience and therefore must be designed together. People’s everyday lives with digital technologies are so intertwined with the physical that being too focused on the traditional physical properties of a product will limit the possibilities for a holistic view of UX design. Thus, when the UX of a physical product extends and shifts towards also being experienced through digital materialities in a broader social context, the definitions and boundaries of where the UX starts and ends also need to correspondingly change for the design process.

6.4.2 Co-create with People
To successfully incorporate foresights into UX design processes, DAUX emphasises co-creation with users to include their anticipation in the design process. The process needs to be driven with the mindset of designing with people rather than for people to include and enable anticipation to evolve and be part of the process. The view of DAUX exposes an ongoing process where people learn and technology develops, and new habits and experiences are shaped. There are no static rules or requirements that are given. However, design processes need some directions and one method to generate Design Principles (Cronholm & Göbel, 2018) was tried out to provide tangible implications for design. The empirical examples of DAUX based on Paper 04’s findings were later used in a workshop with AD UX design team at Volvo to co-creatively for further AD UX design. However, evaluation of the process has not been part of this thesis.

6.4.3 Foresight for Innovation
Innovation is a hot topic within the automotive industry. Everyone wants to identify new opportunities and discover a unique solution, product or service that gives them advantages on the market. The problem is that innovation is difficult to uncover simply by following forecasts and trends. Taking such approach often directs the development into improving the current technology, business and markets. Asking people what they want will often
not expose new and innovative ideas. In this thesis, I argue for DE with an emphasis on speculative scenarios, designs or enactments that trigger user’s anticipation and allow for research foresights to describe possible opportunities and risks of the future. Foresights enable possibilities for innovations. The studies revealed that the participants' creativity brought up new ideas for innovation, e.g., one of the Tesla forum members developed and shared an Excel sheet to rethink the way the ownership cost of an EV should be calculated. Digitalisation provides ideas and solutions to be co-created in a rapid phase; therefore, the DE approach enables UX researchers and designers to come closer to the end-user’s experiences and anticipation of the future. To be innovative as a company, there is a need for close co-creation with users to avoid becoming too slow in adapting technology to changes in people's everyday life, society and environment.

By providing a starting point to create innovative and sustainable future mobility possibilities this thesis contribution sums up into three parts of the DAUX framework; People, Ethnography and Design, see figure 16.

![Figure 16: DAUX Framework how to view, research and design for DAUX to provide innovative and sustainable future mobility possibilities.](image)

By understanding people’s anticipatory experiences through the definition of DAUX, we could better understand how people shape their future with technology, plus how they share their experiences and evolving fears and hopes, which drive them in different possible directions, and also the importance of how DAUX in itself could provide positive (or negative) UX. To study DAUX, an ethnographic approach is needed to account for the
situatedness, anticipatory and longitudinal aspects of how DAUX emerges. These aspects of DAUX need to be investigated if we want to understand people's hopes and fears of future mobility possibilities. Finally, to design for DAUXs that engage people into future mobility solutions to become a meaningful part in people's lives. To provide opportunities for innovation, there is a need to bring in digi-physical designs as triggers, probes or speculations for people to let their anticipatory experiences emerge. Only by letting people experience things in their social and environmental context of routines and habits, will designers be able to co-create futures that not only mitigate problems but also provide foresights into new possibilities to create innovation.

6.5 Reflections on Limitations and Transferability

This thesis proposes a view of DAUX, characterised and exemplified by a narrative from a car user's perspective. This view and the recommended methodological approach of DE to view DAUX are aimed at UX researchers in the HCI field as well as UX design practitioners in the automotive industry. The thesis is based on three studies that provided unique possibilities to follow people over time as well as advanced digi-physical material as speculative scenarios or enactments. However, the research is based on a small sample of people, so it does not aim to generalise the DAUX view or use of the DE methodology approach to be fully applicable or replicable. The thesis contribution is not about generalising the results and reducing it to numbers; rather, it is about patterns that could be transferable. The examples are only offered to describe the theory, and the social and emotional context would be totally different for other people. Yet the effect of digitalisation on other products or services will be present in some way and the DAUX concept provides a foundation for explaining these entangled phenomena. The view of DAUX will hopefully assist UX researchers and designers to understand the digitalised products or services from a more holistic and temporal perspective.
7 Conclusions

This thesis answered the main research question: *How can experiences of anticipating digitalised cars be understood*, by defining Digital Anticipatory UX (DAUX) as a view to identify and visualises the consequences for UX of digitalised cars. This thesis also contributes to UX research by showing empirically how digitalisation extends and enables possibilities for people’s anticipation to emerge and evolve through digi-physical moments with technology in everyday lives. DAUX is a way to view UX of digi-physical materialities as anticipatory experiences. These anticipatory experiences are characterised as future oriented, continuously evolving, shaped through changing digi-physical representations and easily socially shared with other people. Specifically, this research contributes to AUX research by proposing that the view of AUX in a digi-physical environment needs to be refined into DAUX to account for the extended possibilities for UX emerge and evolve. By including the characteristics above, I suggest defining DAUX as:

a person’s continuously evolving anticipation of digi-material use, situated in everyday life, socially contextualised and creating emotional experiences.

The secondary question of the thesis, *How can experiences of anticipating digitalised cars be investigated to foresight problems and opportunities of future mobility?*, was answered by showing how DE, combined with speculative designs or scenarios, trigger people’s anticipation around digital technologies (DAUX) and make them look forward and share their hopes and fears about these technologies in relation to their own everyday lives. Empirical findings of DAUX could then be turned into foresights for UX design innovations.

This thesis suggests several contributions to UX research and UX design processes. Firstly, Papers 01, 02 and 04 provide a theoretical foundation for DAUX, which were refined into characteristics in this cover paper. Secondly, Papers 03, 04 and 05 demonstrate a methodological approach to research DAUX through DE and propose how this approach can be used to create
foresights for UX design processes. Thirdly, Papers 03, 04 and 05 also offer empirical examples and implications for design.

Last, but not least, my ambition with this thesis is to contribute to understandings of how people's anticipations of future mobility developments can enable implementation of sustainable future mobility solutions. This thesis demonstrates this by showing how people’s anticipatory experiences of digi-physical cars are shaping their actions and views of the future. Indeed, Appadurai (2013:5) has argued that anticipation will be an essential analytic lens for understanding “the ways in which humans construct their cultural futures”. In the same vein, my hope is that my proposed DAUX framework can become a useful tool to study and develop technologies and services for sustainable future mobility possibilities.

This thesis has also demonstrated how design ethnographic findings enable possibilities to foresight opportunities and risks with future mobility solutions from an end-user perspective. Without a deeper understanding of how people integrate digital technologies in everyday life, it has proven difficult to develop sustainable mobility solutions that can easily be appropriated into peoples’ everyday lives. I hope that my thesis can inspire stakeholders to study people and digital technologies, guided by the suggested DAUX framework, and subsequently to create ethnographic foresights that enable innovative and sustainable future mobility solutions. The context in this thesis is limited to people’s experiences of digitalised cars and does not aim to generalise the results; however, it is not far-fetched to believe that the contributions could be transferable to study how people relate to other emerging digital technologies and services for everyday use, such as smart mobile devices, ride-sharing services, entertainment systems, smart home appliances, health care equipment, etc.

My anticipation is that this thesis can become useful for further research and development in new ways of knowing and creating sustainable mobility solutions with people rather than for users. The digitalisation of products and services in society today offers a lot of opportunities but also risks—risks of people feeling left out, monitored, patronised or used. However, by engaging with people and their everyday lives in the research and development of these new digital technologies, I hope this will make a smoother and faster transition towards sustainable futures where all parties feel included.
8 References


Bas, E., & Guillo, M. (2015). Participatory foresight for social innovation. FLUX-3D method (Forward Looking User Experience), a tool for
evaluating innovations. Technological Forecasting and Social Change, 101, 275-290. doi:https://doi.org/10.1016/j.techfore.2015.06.016


A comparison between Turkey, Finland, Denmark, France and Malaysia. In: *Vol. 10516 LNCS. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (pp. 218-239).


Yogasara, T. (2014). *Anticipated user experience in the early stages of product development*. Queensland University of Technology,
