THESIS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Eliciting User Experience Information in Early Design Phases

The CARE Approach to In-Vehicle UX

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ABSTRACT

Experience-rich input in early phases of a design process can offer valuable information and inspiration to designers. However, there are methodological challenges linked with efforts to understand future user experiences. Experience encompasses multi-layered and tacit data, such as emotions and value, that are important for commercial success but are difficult to elicit from users for existing products, and even more so for concepts in early design phases. At early design phases, the inevitably incomplete representations of product and use context influences the outcomes. It is typically easier to elicit usability-related aspects, meaning that other aspects of experience may be insufficiently addressed. The contribution of this thesis is an approach for eliciting rich user experience (UX) data in early design phases, building on six studies. This thesis employs in-vehicle user experience as a study case, but results are however presented on a methodological level that can also be of use to other interactive products. The overall research questions are: *What signifies in-vehicle UX? How can UX data be elicited for input to novel in-vehicle concepts in early design phases?*

Firstly, the *analysis* phase of the design process was addressed, where a multi-method approach was employed to study current in-vehicle UX. UX is an umbrella term that has proven difficult to describe and conceptualise in studies. Therefore, the aim of the first study was to better understand what signifies the specific case of in-vehicle UX. Secondly, how to approach and understand user expectations on future autonomous cars was address in the two following studies, in order to address prospective research of novel systems. A method addressing research on user expectations was developed – Setting the Stage for Autonomous Cars. Thirdly, *ideation* was addressed in a series of workshops, containing generative and creative efforts for ideating future interactive in-vehicle systems. Methods such as enactment, small-scale scenarios, Wizard of Oz, a lo-fi driving simulator and the developed Setting the Stage for Autonomous Cars method were used. The final studies address concept *evaluation*, and comparatively explore the effects of choosing different product representations (storyboard and interactive prototype) and study contexts (Virtual Reality and in the field) in early UX evaluation.

Based on the outcomes of the studies, an approach is proposed – the CARE approach – for enabling richer and more in-depth UX data in early design phases. This approach suggests that there is a need to *Contextualise* the researched experience (conveying the intended use situation and sentisising the participants to experience), enabling the participant to *Act* (enabling interaction even at the stages of very lo-fi concepts), supporting *Reflection* on the experience (enhanced by generative elements in the methods, such as drawing concepts and enacting use) and enabling the participant to *Express* the experience (in more ways than by just relying on words). Furthermore, the thesis presents findings regarding what signifies in-vehicle UX, for example whole-body, multi-sensory interactions, the importance of the temporal stage of use, the social and multi-device context, and the changing relationship between user and car with increased automation. The results emphasise the importance of addressing the multisensory use situation in each design phase and for participants to express experiences, not only in words but also through enactment and generative techniques.

Keywords: *user experience, UX, design methods, interaction design, evaluation, in-vehicle systems, autonomous vehicles*

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APPENDED PUBLICATIONS

PAPER A

Pettersson, I., Lachner, F., Frison, A. K., Riener, A., & Butz, A. (2018, April). A Bermuda Triangle?: A Review of Method Application and Triangulation in User Experience Evaluation. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (p. 461). ACM.

Contribution: The first three authors contributed equally to the publication.

PAPER B

Gkouskos, D., Pettersson, I., Karlsson, M., & Chen, F. (2015, August). Exploring User Experience in the Wild: Facets of the Modern Car. In *International Conference of Design, User Experience, and Usability* (pp. 450-461). Springer.

Contribution: Pettersson and Gkouskos contributed equally to the publication, with support in planning and analysis from Karlsson and Chen.

PAPER C

Pettersson, I. & Karlsson M. (2015) Setting the stage for self-driving cars: Exploration of future autonomous driving experiences, *IET Intelligent Transport Systems*, 9 (7).

Contribution: Pettersson was principal author and planned, carried out and analysed the research, with writing input from Karlsson.

PAPER D

Pettersson, I. (2017) Travelling from Fascination to New Meanings: Understanding User Expectations Through a Case Study of Autonomous Cars, *International Journal of Design*, 11(2).

PAPER E

Strömberg, H., Pettersson, I., Andersson, J., Rydström, A., Dey, D., Klingegård, M., & Forlizzi, J. (2018). Designing for social experiences with and within autonomous vehicles – exploring methodological directions. *Design Science,* 4, E13.

Contribution: Strömberg and Pettersson contributed equally to the publication, with writing input from all authors.

PAPER F

Strömberg, H., Pettersson, I., , Ju, W., (2018) Horse, butler or elevator? Metaphors and enactment as a catalyst for exploring interaction with autonomous technology, *Proceedings of DRS2018,* Vol. 3, (pp. 1193-1207).

Contribution: Strömberg and Pettersson contributed equally to the publication, with input from Ju.

PAPER G

Pettersson, I., & Ju, W. (2017, June). Design Techniques for Exploring Automotive Interaction in the Drive towards Automation. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (pp. 147-160). ACM.

Contribution: The authors contributed equally to the publication.

PAPER H

Pettersson, I., Karlsson M., Gkouskos, D. (2018) System representations formats and their influence on user experience evaluations, *IADIS International Journal on Computer Science and Information Systems* Vol. 13, No. 1, pp. 96-109

Contribution: Pettersson, Gkouskos planned the research with support from Karlsson. The results were analysed by Pettersson and Gkouskos. Pettersson was principal author with contributions from Gkouskos and Karlsson.

PAPER I

Pettersson, I., Karlsson M., Ghiurau T. F., Carlsson, M., Sonesson, T. (submitted) Learning from user experience evaluation of in-vehicle systems in VR and in the field, *PRESENCE: Teleoperators and Virtual Environments,* MIT Press.

Contribution: Pettersson planned, carried out and analysed the main study with support from Karlsson. The pre-study was performed by Carlson and Sonesson with supervision from Pettersson. Pettersson was principal author with contributions from Karlsson and Ghiurau.

ADDITIONAL PUBLICATIONS

Publications that are related to the topic of this thesis but not appended:

Pettersson, I., & Hylving, L. (2017). The drive for new driving interfaces: transformationalchange in the era of digitalization. ACM *interactions*, 24(3), 54-59.

Strömberg, H., Pettersson, I., Nolhage, J., Ju, W., & Martelaro, N. (2017). Setting the Stage with Metaphors for Interaction--Researching Methodological Approaches for Interaction Design of Autonomous Vehicles. In *Proceedings of the 2017 ACM Conference Companion Publication on Designing Interactive Systems* (pp. 372-375). ACM.

Pettersson, I., Gkouskos, D., Karlsson, M. (2017) Investigating the influence of product representation formats in a user experience evaluation. In *Proceedings of the International Conference on Interfaces and Human Computer Interaction 2017 - Part of the Multi Conference on Computer Science and Information Systems 2017*, pp.177-184.

Pettersson, I., Rydström, A., Strömberg, H., Hylving, L., Andersson, J., Klingegård, M., & Karlsson, M. (2016). Living room on the move: autonomous vehicles and social experiences. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction* (p. 129). ACM.

Pettersson, I., Hylving, L., Rydström, A., & Gkouskos, D. (2016). The drive for new driving interfaces: Researching a driver interface from design intent to end-user Experience. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction* (p. 125). ACM.

Pettersson, I., Frison, A. K., Lachner, F., Riener, A., & Nolhage, J. (2017). Triangulation in UX Studies: Learning from Experience. In *Proceedings of the 2017 ACM Conference Companion Publication on Designing Interactive Systems* (pp. 341-344). ACM.

Pettersson, I. (2016). The temporality of in-vehicle user experience: exploring user experiences from past to future. *Chalmers University of Technology, Department of Product and Production Development,* (105).

Pettersson I., & Karlsson, M. (2016) The Temporality of User Experience – exploring past and future in two car case studies, In *Proceedings - D and E 2016: 10th International Conference on Design and Emotion - Celebration and Contemplation* (pp. 59-65).

Pettersson, I., (2014) Setting the stage for self-driving cars: Exploration of future autonomous driving experiences, In *Proceedings of the European Conference on Human Centered Design for Intelligent Transport Systems.*

FOREWORD

Before venturing into the thesis, a few words about the personal and project context are included. The research was conducted while employed in the automotive industry, with time and effort divided between academic and industrial undertakings. As the work is situated in a development context, this has consequences for both the underpinning epistemology of the work as well as the design examples employed. From a background of many years in industry, a pragmatic approach underpins the work, placing value in actionable outcomes in a design process but also curiosity in exploring new techniques outside the everyday tools. From experience, I value early explorations of concepts to minimise later, more cumbersome changes. Being aware of the many steps to take before products become real, and recognising the importance of early efforts, the thesis took a rather wide and exploratory approach to early UX design, rather than a narrow and comparative one. In terms of the specific choices of applied case studies, work has been devoted to currently developing topics such as designing for autonomous cars (providing input in the development of a concept car for autonomous driving), dealing with increasingly intelligent infotainment technology, and using Virtual Reality as a tool for UX exploration. The project started in 2013, when the interest on autonomous driving was still very novel and rapidly evolving. Performing UX studies in this field, during these years, has been challenging but also always fascinating. As the technology itself has developed enormously, the surrounding discussions and focus has also evolved, and will likely see many transformations again over the coming years.

As the work switched continuously between tasks at the university and at the company, it was able to connect between industry and academia. The duality of the research also meant that the research was conducted in four countries with a multitude of nationalities, as part of a global industry and research community. This means that the research is rich and exposed to many influencing factors, but also that it is close to the current real-life situation when developing products.

In a research context, the PhD was part of a larger research initiative named AUX (Automotive User Experience), which also contributed to the choice of study cases. The overall goal of the AUX project was to *"improve the competitiveness of the Swedish automotive industry by providing metrics and methods for User Experience (UX) development in infotainment and active safety. The focus is to enable a rewarding and pleasurable interaction with the vehicle."* (VINNOVA project 2012-03664). As well as an industrial, pragmatic outlook, the work is infused with concepts from User Centred Design as well as experience of Design Thinking (Brown, 2008) approaches, based on previous education at master's level and on industry experience. This means valuing input from users in order to shape products around real-life situations and needs. It requires venturing into their contexts, understanding the subjective experiences and transforming the insights into concepts. To me, UX relates to the everyday doings, often encompassing the tacit and fleeting, which are not readily addressed by means of scales and measurements in the early design phases covered by this PhD.

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photo by Linda Andersson

01 | INTRODUCTION

"It's not enough that we build products that function, that are understandable and usable, we also need to build products that bring joy and excitement, pleasure and fun, and yes, beauty to people's lives."
– Don Norman (2004)

The last couple of decades have been signified by enormous development within interactive consumer technologies and companies are typically intensly competing to provide users with pleasurable and valuable experiences. Knowing how users will react to a product once it is on the market is desirable for any company that develops products, and the user experience (UX) of interactive products has therefore been a growing research interest in academia and industry. Ensuring a positive experience for the user requires extensive focus on users' subjective perceptions, as user experience expands beyond the associated area of usability by including more multifaceted concepts such as emotions and value, as exemplified in the quote from Don Norman. Over the years, UX has become its own research field, where academic research has primarily been directed to accumulating knowledge of the phenomenon of UX. UX has been described as somewhat elusive, given that it is an umbrella term for a multitude of aspects connected to product use (e.g. Law et al., 2009; Roto, 2018). However, UX research typically agrees that UX is a dynamic and subjective phenomenon, influenced by the specific product, use context and user (Law et al., 2009; Kou & Gray, 2018).

It is easier to study a phenomena in retrospect than prospectively. Summarizing evaluations of existing, or close to finished, designs have thus for long been the typical focus of UX studies and methods (e.g. Bargas-Avila & Hornbæk, 2011; Law et al., 2009; Vermeeren et al., 2010). Not nearly as much attention has been directed towards experience-focused ideation and constructive feedback of *early design concepts* (Veeremeren et al. 2015, Roto et al., 2009), even though early insights into subjective experiences can help inspire designers, improve concepts and mitigate late changes (Forlizzi & Ford, 2000;

Özçelik Buskermolen et al., 2012; Sleeswijk Visser, 2009; Wright & McCarthy, 2010). Eliciting UX data in early design phases has been associated with a number of challenges, which will be outlined in this introduction and constitutes the research topic of this thesis. The aim is to explore and suggest ways of *eliciting user experience information at early design phases*, in order to provide practical support for the design process.

1.1 UX CHALLENGES IN EARLY DESIGN PHASES

Many design researchers have addressed the uniqueness of design processes as a means of solving problems and suggesting possible futures (e.g., Cross, 2007; Nelson & Stolterman, 2012; Brown, 2008). On a general level, early design phases can be described as encompassing an initial *analysis* of the problem scope, then *ideation* of design concepts, followed by the iterative *evaluation* and evolution of concepts (see for example Archer,1984; Jones,1992; Ulrich & Eppinger, 2015). These early design phases are then followed by a growing number of iterations, as the concepts move closer to finalisation and implementation (which are outside the scope of this thesis). Each of the initial phases of analysis, ideation and evaluation includes a number of challenges to designers, and decisions along the way are taken, influenced by the design team's skills, delimitations and preferences.

Starting with the analysis phase, a fundamental understanding of the design scope must be established, by for example understanding problems associated with current user experiences of existing products. This typically requires obtaining, understanding and making action plans based on rich and subjective experiential data (Özçelik Buskermolen et al., 2012; Sleeswijk Visser, 2009). By encompassing many facets of human experience, user experience data is typically complex, and obtaining and understandig this type of data is therefore not without difficulties. User experience design (UXD) may have been a developing field for over 20 years, but it is still *"a big challenge for design teams to make sense of the available information during the early phases of the UXD process"* (Roto et al., 2011). The multi-dimensional nature of UX, where data can be layered and tacit, encompassing not only judgements but also feelings and dreams related to products, has been described by for example Sanders (2002) as difficult to elicit from users by solely using traditional methods such as interviews; *". . . There are many reasons why people say what they say, and why they don't say other things. And there are many thoughts and feelings people are not able to put into words. These thoughts include tacit or inexpressible information which does not have a chance of being expressed when using research methods that rely solely on what people say."* Furthermore, some products under development are disruptive innovations, relying on highly interactive and intelligent functionality. As the use situation then fundamentally transforms with the increased ability of the products to act on their own, it is not enough to understand experiences of existing products; the design process must be able to explore the future experiences proactively (Gomes & Preto, 2018; Schmidt & Herrmann, 2017). In sum, the analysis phase of the user experience design process faces challenges in terms of effectively eliciting and making sense of UX data, especially so for novel, highly interactive products.

In the ideation phase, effective experimentation with focus on experience is needed (Sirkin & Ju; 2014; Odom et al., 2014; Davidoff et al. 2007). However, exploratory and innovative ideation before moving into high-fidelity concepts is often insufficiently addressed by designers, who have been described to often habitually fast-forward to deciding on a solution and making a tangible concept instead of challenging assumptions and exploring several directions of the design (Atasoy & Martens, 2011; Dubberly & Evenson, 2008;

Norman & Ortony, 2003). Many well-known ideation methods, such as brainstorming and future workshops, furthermore lack a strong connection to the future use situation (Biskjaer et al., 2010), which may affect results negatively given the importace of the use context for user experiences (Dray & Siegel, 2009). In addition, designers tend to focus on visual aesthetics over situational and experiential aspects (Norman & Ortony, 2003). There is thus a challenge in effectively exploring and focusing on experiential aspects in an ideation activity, including the important use situation.

Even though UX is described as clearly extending beyond usability, UX evaluations of interactive products both in industry and academia often elicit foremost usability information and not the more embedded aspects associated with user experience, such as emotions and value (Bargas-Avila & Hornbæk, 2011; Vermeeren et al.; 2010, Alves et al., 2012). Participants in user studies have been found to excessively concentrate on pragmatic qualities (i.e. usability-type values such as efficiency of use), even if it may be the more pleasure-related aspects such as stimulation and identification with the product that dominate in real life use, as for example studies by Yogasara report (2014, p. 150). A challenge for the evaluation phase (similar to the analysis phase) is thus to effectively elicit UX-specific data and not primarily usability data. At early concept evaluation, as opposed to the later stages of development, the often abstract nature of the early representation of the product may be difficult to overcome and shapes the outcomes of the evaluation (Lallemand, 2015). All product representations in UX studies (such as paper mock-ups, storyboards or lo-fidelity prototypes) are by definition incomplete, and an evolved understanding of how the product representation affects the outcomes of eliciting UX information constitutes an unresolved task for the research field.

Furthermore, the suitability of the study context is an important element for effective experimentation and also poses a challenge in UX research at ealy design phases, as the use study may not be accessible at early evaluations (Jambon & Meillon, 2009). Thus context representation is yet another challenge that needs to be addressed in order to effectively evaluate UX at early design phases (Lallemand, 2015; Roto et al. 2009). More needs to be known about how context can be conveyed in early design phases, as well as more of how the study context may affect the elicitation of UX data.

It has been claimed that UX must be further understood and described to fully understand the best methodological practices for eliciting UX information (Obrist et al., 2012; Roto, 2018). However, one problematic aspect in this quest is that UX may differ considerably depending on the product type. For example, aspects that influence the user experience of a kitchen appliance are typically not the same as those that impact a social media service, and an interactive game targets completely different experiences than that of a personal mobile banking application. This means that eliciting UX data must be approached in relation to the specific experience domain, which leads to the study case of this thesis: in-vehicle user experience.

1.2 IN-VEHICLE USER EXPERIENCE

It is clear that users of modern cars increasingly focus on, and expect, worthwhile in-vehicle UX (Owens et al., 2015) and that car manufacturers also are realizing the possibility of positioning their car brand by designing for positive in-vehicle user experiences (Kun et al., 2016). This is however a task that often proves difficult and concerns have been voiced of moderns cars as being too complex (Cunningham, 2015, Bubbers, 2018). In-vehicle user experience is an equally interesting as challenging area, shaped by the specific use context, personal preferences and the interactive systems present in the car. The experiences result not only from experiencing a product but also a place; the car is one of the few products that completely surrounds the user, and as the product/place is mobile, the use situation is constantly changing, making the user experience even more complicated to study and to design for.

In-vehicle UX is thus situated in a highly interactive environment (see Figure 1 for an example), with a growing multitude of in-vehicle interactive systems that affect experience, such as systems for infotainment, comfort, active safety and driver information. Interactions are typically multi-modal and engages the whole body - for example, feet are used for regulating speed, voice is used for commanding actions on the infotainment system, hands are used to control road position and instrumentation, and some modern cars are even equipped with gesture recognition. Users often form strong emotional attachments to their cars (Redshaw, 2012; Sheller, 2004) and bodily sensations such as sound, smell, vibrations shape the experiences: *"people respond to the thrum of the engine, the smell of the interior, the feel of the car seat, given that the kinaesthetic pleasures of the car ride are often experienced from infancy onwards"* (Featherstone, 2004, p. 13).

While there are many works that address user experiences of specific in-vehicle systems (e.g. Trösterer et al., 2014; Rödel et al., 2014) and context of the car (e.g. Meschtscherjakov et al., 2011), as well as summative assessment of in-vehicle experience (e.g., Körber & Bengler, 2013) and issues related to driver assessment, workload and distraction (e.g., Getty et al.; 2018; Kraft et al.; 2018), there is a wider gap in knowledge of holistic understandings of in-vehicle UX for formative, early input to in-vehicle UX design. A special challenge is posed by the current development of autonomous driving functionality, which means

Figure 1. The in-vehicle environment of a Volvo V90 (image by Volvo Cars).

that the relation between human and product fundamentally changes as the vehicle gains agency (Sandry, 2017). This development further warrants research connected to the in-vehicle user experience (Kun, 2018).

In conclusion, further knowledge of how to elicit UX data in the early design phases of analysis, ideation and evaluation is needed. As outlined in the previous section, there are specific difficulties linked with eliciting UX data at early design phases. Experience is layered and tacit, often challenging to elicit for existing products, and even more so at early design phases as use context and product representations are incomplete or inaccessible. To research what constitutes fruitful approaches for eliciting UX data, firstly an improved understanding of the study case of in-vehicle user experiences is required. This is researched in combination with exploration of methodological approaches useful for eliciting UX data in early design phases of novel systems.

1.3 AIM AND RESEARCH QUESTIONS

The aim of the thesis is to contribute with methodological insights for UX elicitation, supporting early UX design practice in early design phases. A specific challenge in relation to this is how to deal with future novel products, where there may be less to learn from existing designs, and where the use situation may not yet exist. The unspecific nature of the umbrella term of UX makes it difficult to base methodological approaches on the term alone. This thesis has therefore explored the specific nature of in-vehicle UX to add direction to the exploration of eliciting UX data. The initial research question (RQ1) is phenomenon-related, and serves as a stepping-stone to the main, approach-related research question of the thesis (RQ2).

RQ1: *What signifies in-vehicle user experience?*

RQ2: *How can UX data be elicited for input to novel in-vehicle concepts in early design phases?*

The phenomenon-related question - of what signifies in-vehicle UX - is researched co-jointly with the approach-related question - how to elicit UX data. This duality in research requires a careful approach and analysis, as the two questions are interdependent. Reflections on outcomes to one research question must thus be seen in the light of the other. The questions are posed with the specific study case of in-vehicle systems in focus but are expected to also lead to more generalisable insights of UX and its elicitation.

The research questions lead to two types of contributions:

- Empirical data of in-vehicle experiences, more specifically aimed at automotive interaction designers and researchers.
- Practical insights of methodological approaches useful for eliciting UX data in early design phases of novel systems, formulated as an approach for a UX study or ideation session.

The approach is aimed for practitioners, i.e. designers and UX researchers in academia and industry. Although the approach is based on findings from eliciting in-vehicle UX data, the approach may be of use to also other domains.

1.4 THESIS STRUCTURE

This thesis consists firstly of an overview of related research (partly based on the appended paper A) concerning the concept of UX, the design process and associated UX methods. Secondly, the thesis approach is presented, followed by a summary of eight publications from six studies (papers B-I, see an overview of studies and papers in Table 1). The first three studies addressed eliciting UX data during the analysis phase in the design process, the next study addressed UX data during the ideation phase, and the final two studies addressed how study context and product representation influences UX data elicitation during the evaluation phase. As well as information on eliciting UX, the studies explored apsects that signifies in-vehicle UX.

After the summary of studies, a proposal is made of an approach for eliciting UX data in early design phases, the CARE approach, based on the findings from the studies. Lastly there is a discussion of the research approach and results, as well as a summary of contributions. The nine publications are appended at the end of the thesis.

Table 1. Overview of studies and papers.

Studies	Contribution	Papers
Literature study	An overview of current UX empirical research.	– **A.** Pettersson, I., Lachner F., Friison A.K., Riener, A., Butz A. (2018). A Bermuda Triangle? - A Review of Method Application and Triangulation in User Experience Evaluation. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (p.461). ACM.
Analysis	Study 1, suggesting and exploring a methodological approach for understanding of in-vehicle UX as it is today.	– **B.** Gkouskos, D., Pettersson, I., Karlsson M., Chen, F. (2015). Exploring User Experience in the Wild: Facets of the Modern Car. In the *International Conference of Design, User Experience, and Usability* (pp. 450-461). Springer.
	Study 2, exploring different types of generative methods for user input to future technology, suggesting and employing a new method for this.	– **C.** Pettersson, I. & Karlsson M. (2015). Setting the stage for self-driving cars: Exploration of future autonomous driving experiences. *IET Intelligent Transport Systems*. 9 (7)
	Study 3, further evolving and exploring the developed method, employed to obtain more in-depth findings of user expectations of autonomous vehicles.	– **D.** Pettersson, I. (2017). Travelling from Fascination to New Meanings: Understanding User Expectations Through a Case Study of Autonomous Cars. *International Journal of Design.* 11(2)
Ideation	Study 4, suggesting and exploring UX ideation methods for generating concepts for interaction with autonomous vehicles, further evolving and exploring the method from Study 3, as well as other methods.	– **E.** Strömberg, H., Pettersson, I., Andersson, J., Rydström A., Klingegård M., Forlizzi, J., Dey, D., (2018). Designing for social experiences with and within autonomous vehicles – exploring methodological directions. *Design Science*, 4. – **F.** Strömberg, H., Pettersson, I., Ju, W., (2018). Horse, butler or elevator? Metaphors and enactment as a catalyst for exploring interaction with autonomous technology. *Proceedings of DRS2018,* Vol. 3, 1193-1207 – **G.** Pettersson, I. & Ju, W., (2017). Design Techniques for Exploring Automotive Interaction in the Drive towards Automation. In *Proceedings of the 2017 Conference on Designing Interactive Systems* (pp. 147-160). ACM.
Evaluation	Study 5, comparing different product representations' effects on UX evaluation of an intelligent in-vehicle infotainment system.	– **H.** Pettersson, I., Karlsson M., Gkouskos, D. (2018). System representations formats and their influence on user experience evaluations. *IADIS International Journal on Computer Science and Information Systems*, Vol.13, No 1, 96-109
	Study 6, comparing different evaluation contexts' effects on UX evaluation of a semi-autonomous driving system and infotainment system.	– **I.** Pettersson, I., Karlsson M., Ghiurau T. F., Carlsson, M., Sonesson, T. (submitted). Learning from user experience evaluation of in-vehicle systems in VR and in the field. *Presence: Teleoperators and Virtual Environments*, MIT Press

02 | RELATED THEORY

To further address the prerequisites for eliciting UX information in early design phases, there is a need to understand existing UX theory, including its origins and the implications for the design process in terms of approach and methods used. In this chapter, the multi-heritage theoretical background of UX is described, along with existing definitions and frameworks. Furthermore, research on the temporal stages of UX is described as this has been found to be highly influential on user experience (Karapanos et al., 2012; Karapanos et al., 2009; Kujala & Miron-Shatz, 2015). The related theory regarding the design process is then outlined, followed by an overview of UX methods connected to early design phases, pin-pointing where there are knowledge gaps in current research. This chapter will thus provide the definitions and analysis needed for further approaching the topic of eliciting user experience. The chapter is based on a literature study of important work in the UX field, stretching back to the 1990s, and on a literature review of the current state of research in academic papers (see Paper A in the thesis, Pettersson et al., 2018), where 100 papers concerning UX studies from 2010-2016 were selected for close analysis.

2.1. UX BACKGROUND AND DEFINITIONS

The constantly increasing interest in user experience has shifted attention in the research and design of interactive products. From primarily acknowledging the usability and performance aspects of products, now also the subjective, hedonic (in other words, pleasure-related) aspects and everyday use have become acknowledged topics that need to be addressed. The concept of UX has thus been described as the "third wave" of interaction design, complementing the earlier focus on ergonomics and usability with a wider acknowledgement of everyday life product use, including the pleasurableness and leisure of using systems (Bødker, 2006). In relation to interaction design, UX design thus adds not only a consideration of the nature of the specific interactions taking place between system and user, but the overall experience, as typically occurs in everyday life.

UX is recognised as a dynamic concept influenced by contextual aspects, such as place, social and temporal aspects of use, as well as the users' varying emotional states (see for example Hassenzahl & Tractinsky, 2006; Roto et al., 2011). Buchenau and Suri (2000) conclude that *"The experience with even simple artifacts doesn't happen in a vacuum but, rather, in dynamic relationship with other people, places and objects. Additionally, the quality of people's experience changes over time and it is influenced by variations in these multiple contextual factors"*. UX thus offers a much more holistic and dynamic take on interaction with products than usability.

As an academic discipline, the field of UX has a multi-disciplinary heritage, involving a variety of different perspectives that focus on studying human experiences with products, systems, and services. UX research can be found in the intersection of fields such as cognitive science, design, psychology, philosophy, sociology, marketing and engineering. All the different entrances to the field have their own epistemological assumptions and consequences, leading to a multitude of approaches. For example, inspiration has come from philosophy, such as phenomenology, where topics such as lived experience and how it unfolds and evolve have been studied. In particular, the pragmatist philosopher Dewey's writings of qualitative aspects of experience have been influential (Wilde et al., 2015). Another stream of research, design research, has added knowledge of the designers' and design processes' role in suggesting preferred futures and thus also experiences (for example Kaye, 2008). In this line of research, holistic and rich accounts of experience are covered, as well as the way the design practice can be used to with the intention to generate new knowledge, such as investigating speculative futures *"probing what the world could and should be"* (Zimmerman & Forlizzi, 2014). Influence from sociology has expanded UX research into contextual elements such as culture and social environments (see for example Forlizzi, 2008). In another vein of research, knowledge and methods from psychology research have been adopted to the UX field resulting in quantifying research, such as questionnaire-based inquiries of salient human needs, motivations, satisfactions and emotions (see for example Hassenzahl, 2004), as well as psychophysiological research that seeks to measure physiological responses to experience (Ganglbauer et al., 2009). From interaction design, awareness of the nature of the interactivity (for instance Janlert & Stolterman, 2017) is added to the research stemming from more direct responses to designed products (e.g. Desmet & Hekkert, 2007).

Kaye (2008) explored the epistemological foundations of UX, concluding that "experience-oriented" research requires open-ended approaches given the complexity of UX, whereas the "task-oriented" perspectives, to be found within measure-heavy, engineering-type research of interacting with systems, is typically closed-ended and inherently thus reduces the human experience, according to Kaye. The task-oriented perspective primarily addresses the measurable and predictable, which Kaye critiques for overlooking important dimensions of the human, subjective experience. Kaye claims that new and unanticipated knowledge serves an important role in the design of interactive products and he emphasises the need for open-ended UX research that can lead to a fuller understanding of *"the multiple, complex and situated experiences people have with technologies"* and furthermore "implies engagement with themes of affect, aesthetics, the body, human practices, and the role of the artifact in knowledge production" (Kaye, 2008, p.3). Sanders (1992) early highlighted the need for experience research that probes beyond the easily measured. She suggests that user needs and motivations consist of "layers", moving from the easily expressible to the tacit and latent knowledge containing *"knowing, feeling, dreaming"*. She concludes that tacit or inexpressible information (such as tacit knowledge,

dreams and feelings) may be difficult to elicit through traditional research methods, such as questionnaires or interviews (Sanders, 2002).

A wide collection of definitions of UX have emerged over the years, although none can be considered as the dominating one. Norman commented as follows: *"I invented the term because I thought human interface and usability were too narrow. I wanted to cover all aspects of the person's experience with the system including industrial design, graphics, the interface, the physical interaction, and the manual."* (in Merholz, 2007). In this line of thought, the Nielsen Norman Group (2012) defines UX as follows: *"User experience encompasses all aspects of the end-user's interaction with the company, its services, and its products"*. Alben (1996) defines UX as: *"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"*, which clearly places the focus on the holistic aspects of use, in contrast to the task-oriented approaches. Similarly, according to ISO (International Organization for Standardization, 2010), UX includes *"A person's perceptions and responses that result from the use or anticipated use of a product, system or service"*. By also bringing in expectations, the ISO definition thus further encompasses the temporal stages of use compared with the previous definitions. In a more narrow time-scope, Hassenzahl (2008) defines UX as *"… a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service"*. The emphasis of the subjective, such as feelings, in UX literature is a differentiator to for example the usability field. Emotional reactions are a central quality of human experience, also when interacting with a product. These emotions are typically of a mixed nature (Desmet, 2008) and researchers such as Desmet (2002) have contributed with clarifying research in understanding that products arouse emotions in users. The work builds on appraisal theory which describes the evaluative process that humans continuously make of their world (Lazarus, 1991). Desmet (2002) identifies five categories of emotional reactions based on product experience: surprise emotions, instrumental emotions, aesthetic emotions, social emotions and interest emotions, and has also developed the PrEmo tool for assessing these types of emotions (Desmet, 2003). However, the description of emotions alone may not explain experience, as emotions are fleeting and experience is typically understood as a much more multi-dimensional topic, limited not just to the momentary reactions. In longer time-frames, such as use over years, aspects such as product attachment has proven interrelated to UX (Kajiwara & Jin, 2012).

User value is another aspect of experience, relating to how the product-user relationship is valued by the user (Boztepe, 2007). For example, Sward and MacArthur introduce the concept of value into their UX definition; *"UX is the value derived from interaction(s) with a product or service and the supporting cast in the context of use (e.g. time, location, and user disposition)"* (Sward & Macarthur, 2007). They also note that user experience is heavily influenced by the use context, and for example Hassenzahl and Tactinsky (2006) highlights context and describe UX as *"a consequence of a user's internal state, the characteristics of the designed system and the context within which the interaction occurs"*. Similarly, Forlizzi and Ford (2000) acknowledge both the influence of context and the temporal dimensions of experience; *"experience is made up of an infinite amount of smaller experiences, relating to contexts, people, and products"*.

Comparing the different definitions, there is no consensus on an exact definition of UX. For example, while Hassenzahl (2008) and Desmet (2002) placed the focus on instantaneous emotions, the ISO definition and Forlizzi and Ford (2000) expands to much wider time

scopes. The definitions of Alben (1996), Forlizzi and Ford (2000) also emphasises the use context in a broader scope than the temporal. Reasons for the lack of a joint definition may be explained for example by the developing maturity of the field, the diversity of disciplines using the term and the divergence of products and thus the types of experiences studied. However, some common patterns can be found, as UX appears to be situated in the dynamics between the product, the use context and the user. It concerns topics such as emotion and value (cf. Alben, 1996; Hassenzahl, 2008; Sward & Macarthur, 2007). This understanding of UX is however too broad to efficiently provide methodological support for eliciting UX data, and the following section will address more detailed frameworks and models of UX.

2.2 UX FRAMEWORKS

The following section contains some of the most noticeable frameworks and models within UX. Patrick Jordan was a pioneer in the exploration of the concept of interactive products' qualities beyond usability and functionality, by deploying knowledge about what creates pleasurable experiences. Jordan (2000) constructed the 'Four Pleasures' framework based on the research of anthropologist Tiger (1992) who claimed that there are four types of pleasures that can be universally found in cultures. Relating to pleasures derived from products, Jordan translated the theory into four themes:

- Physio-pleasure: the ability of the product to evoke physical pleasure, derived from the five senses of hearing, seeing, smelling, touching and tasting.
- Psycho-pleasure: the ability to provide a psychologically rewarding experience, such as experiencing flow and achievement when using a product.
- Socio-pleasure: the ability to evoke pleasure from enabling social relatedness.
- Ideo-pleasure: the ability to connect to the user's values, beliefs and ideals.

Don Norman was also an early important contributor to the field in describing what he calls "emotional design" (Norman, 2004), as consisting of three interrelated levels of how users process and form experiences from product use, on different levels of abstraction and consciousness:

- Visceral Design: the product's appearance and appeal to the user's senses, for instance how the product's haptic and visual qualities give (or do not give) pleasure to the user. This shape the first impressions of the product and is not necessarily a conscious process.
- Behavioural Design: the product's pleasure of direct use, for instance usability-type qualities such as efficiency and ease of use. The behavioural design thus resides in the interaction with the product, and is also not necessarily a conscious process.
- Reflective Design: how the product appeals to the user's self-image, personal satisfaction, and meaning-making, for example how will the user think it fits into her/his life and the meaning it is ascribed. This typically takes place over a longer time span than the first two levels and requires active contemplation.

Similarly, Desmet and Hekkert (2007) claim that products can be experienced on three distinct components or levels, adding meaning and aesthetics to the basis of emotional responses in their framework for product experience:

- The aesthetic level: a product's capacity to delight one or more of the sensory modalities.

- The meaning level: assigned personality or other expressive characteristics, resulting in personal or symbolic significance.
- The emotional level: emotions that are evoked by a product.

However, where Norman address the interactive, cognitive elements such as effectiveness of use, the framework by Desmet and Hekkert does not emphasise or necessarily include interactivity of the product, as the framework's name of "product experience" also suggests (as compared to "user experience").

Psychology and interest in persistent human needs for satisfaction (Ryan & Deci, 2000; Sheldon, et al., 2001) have been a basis for the Hassenzahl et al. (2010) definition of the different needs on which to base designs for positive experiences: relatedness, meaning, stimulation, competence, security and popularity. Hassenzahl (2004) furthermore distinguishes between the "why, what and how" of the interaction with a product. The why addresses people's needs for using an artefact, such as establishing relatedness with another person through a telephone call, the what looks at what specifically can be achieved with the product (e.g. make a call), and the how addresses how the interaction is enabled by functionality and design. He divides product attributes into pragmatic (in other words, usability-related) and hedonic (in other words, pleasure-related) attributes. The pragmatic attributes of a product concern the 'do-goals' that a product can cater for, that is to say practical goals of interaction such as making phone calls or uploading documents on a web site. This connects to the usability and controllability of the product. The other category of goals, the 'be-goals' of a product, concerns the hedonic attributes that extend beyond usability. According to Hassenzahl, there are three main types of hedonic attributes: stimulation, identification (e.g. the user building identity with the help of the product), and evocation (e.g. provoking past memories and feelings). Numerous studies have since used this dual division of attributes into pragmatic and hedonic, in order to explore how the attributes interplay in use (for example Kujala et al., 2011; Yogasara & Popovic, 2011). Hassenzahl (2004) stresses that a designer's perspective of UX is not identical to that of the users (see Figure 2), implying that the designer must consider the future use situation.

In a similar vein to Hassenzahl's division of pragmatic and hedonic attributes, Mahlke and Thüring (2007) present a model of UX where the starting point is the product qualities, dividing the qualities into "instrumental" (corresponding to the pragmatic attributes in Hassenzahl's (2004) model) and non-instrumental (corresponding to the hedonic attributes), whilst also including affective reactions as a separated stream from the information processing of experience dimensions (see Figure 3).

Rooted in an interaction design and pragmatist perspective, Forlizzi and Battarbee (2004) described how experience can reside in unconsciousness, transcending into a cognitive state and finally into forming "an experience", that is to say a memorable event that the user is able to communicate to others. Three types of user-product interactions are described in their paper:

- Fluent: automatic and skilled interactions.
- Cognitive: interactions that focus on the product at hand, such as encountering a new product with an unknown interaction style.
- Expressive: interactions from which a relationship is built with the product.

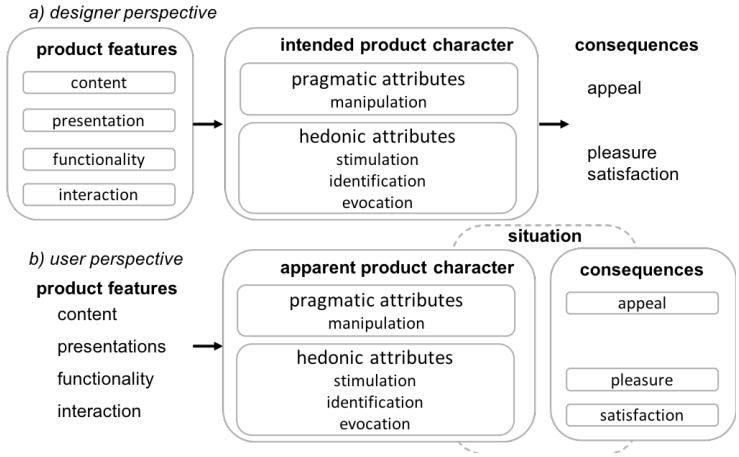


Figure 2. Hassenzahl's model of user experience (2004).

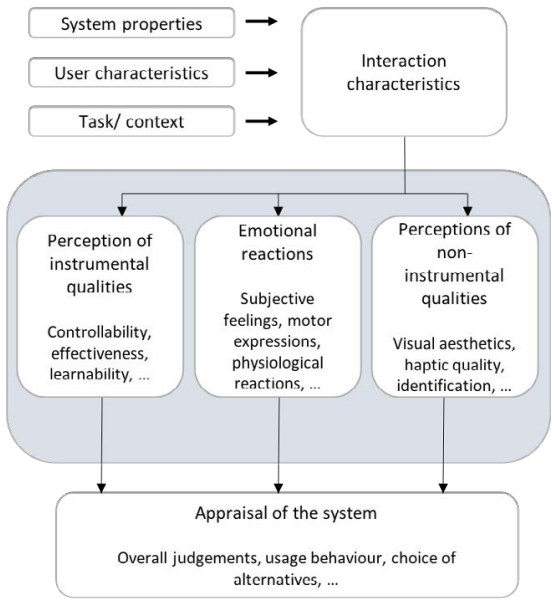


Figure 3. Mahlke's and Thüring's model of user experience (2007).

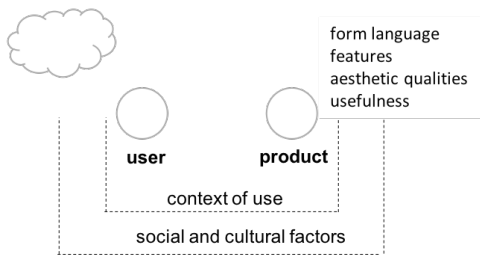


Figure 4. Forlizzi's and Ford's described influences on experience (2000).

Forlizzi and Battarbee describes that all these types of interactions may result in three types of experience:

- Experience: the "constant stream of self-talk that happens when we interact with products".
- An experience: a defined sequence which can be articulated or named.
- Co-experience: creating meaning and emotion together through product use.

The different types of experiences are gathered in the constant storytelling of interactive products in the user's life, i.e. stories that the user may retell to others, thus being an important aspect of how new technology is being adopted into everyday life use. The context of use and social and cultural factors are highlighted by Forlizzi and Ford (2000) who claim that user experiences are shaped by the individual user, the product, the context of use but also the social and cultural factors (see Figure 4).

Grounded in the earlier mentioned Dewey's pragmatist work on the formation of experience, Wright and McCarthy (2004) formulated four "threads of experience" in their book "Technology as experience". The threads encompass sensory aspects, emotions and the temporal composition of experience:

- The Sensual Thread: a user's experience connected to sensory engagement.
- The Emotional Thread: value judgements of the experience; whether positive or negative emotions are connected to the experience.
- The Compositional Thread: relationships between the parts and the whole of an experience.
- The Spatio-Temporal Thread: how the experience relates to the user's past and future and the place where the experience takes place.

The nature of the described frameworks differs in experience perspectives; the frameworks of Hassenzahl (2004) and Mahlke and Thüring (2007), for example, are deterministic in their nature, describing how specific attributes of products have a direct consequences on appeal, pleasure, satisfaction (Hassenzahl, 2004) or appraisal of a system (Mahlke & Thüring, 2007), where predictions of experience are assumed to be unambiguously linked to the product qualities (see for example also van Schaik et al., 2012). These types of frameworks have been described as reductionistic approaches (Karapanos, 2010, p. 15) as they assume experience to be possible to reduce into definite aspects, such as done in the AttrakDiff questionnaire (Hassenzahl et al., 2003). In contrast, the work of authors like Wright and McCarthy (2004) and Forlizzi and Ford (2000) have a much more holistic and open-ended approach, compared to more engineering-type and reductionistic research in the field. The differences between holistic and reductionist UX perspectives have been a clear divide in the field as described by several researchers (for instance Karapanos, 2010; Law et al., 2007; Roto et al., 2011). The frameworks also differ in terms of the interactivity addressed; most UX definitions has been claimed to require interaction with the product (Roto, 2006), where the user as well as the product states may be changed. Thus, UX may by nature be different from product experience, for example, where interaction with the product is not essentially part of the framework (see Desmet & Hekkert, 2007). However, one similarity between all the frameworks is the focus on users and their reactions, and the multi-layered nature of experience; ranging from direct responses (cf. Desmet & Hekkert; 2007, Desmet, 2002) to complex constructs, such as Hassenzahl's hedonic qualities of identification and evocation, Norman's reflective design and Desmet and Hekkert's

meaning level. Forlizzi and Battarbee (2004), Norman (2004) and Sanders (2002) also point to the layered nature of experience; some experiences take place unconsciously, some require much more cognitive effort and some relate to more emotion-related aspects. However, many of the frameworks (for example Norman 2004; Desmet and Hekkert, 2007) lack a particular emphasis of context, whereas the importance of context has been highlighted by for example Forlizzi and Ford (2000), who thus made a substantial contribution to the UX field.

In conclusion, a wide range of frameworks exists, from which can be learnt that user experience is multi-layered and affected by the use context, but a difference can be seen between more holistic and reductionist approaches. Hassenzahl's framework has been employed in numerous studies as a basis for empirical research, but may be critiqued for being too close-ended and pre-defined. For the research in this thesis, no framework on which to base further explorations for eliciting UX data can be singled out. As highlighted by Roto (2018), basing methodological approaches on the existing frameworks is difficult given the ambiguity of them. In this thesis, a more open-ended research of the specific case of in-vehicle UX is needed, in order to understand the important aspects of UX better.

2.3 TEMPORALITY OF UX

The temporal (time) dimension of UX has been gaining attention in recent years in UX research as especially important to study (for instance Karapanos et al., 2009; Kujala, et al., 2011; Varsaluoma & Sahar, 2014). The topic thus deserves its own addressing. Work in the area has often been inspired by Dewey's foundational work about the nature of human experience. In his work, experiences are described as highly dynamic and evolving (Dewey, 2005), and user experiences of products are no exception. Dewey describes how multiple experiences build upon each other and this may of course change expectations and attitudes to future experiences. In relation to user experience, the user may for example accumulate experiences of related products that change expectations on other products. The time dimension related to the experience of using products is for example described by Sanders (2001), who in this tradition highlights that experiences are linked to past memories and to the dreams and imagination of future use (see Figure 5).

Researchers have over time used different models to describe the temporality of UX. For example, extending beyond the four threads of experience described in section 2.2,

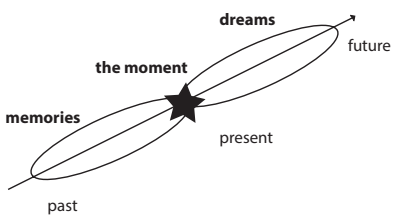


Figure 5. Experience is linked to past memories and imagination of future use, adapted from Sanders 2001.

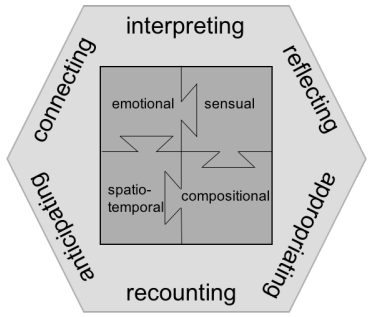


Figure 6. Technology as experience, adapted from McCarthy and Wright (2004).

Wright and McCarthy (2004) define six sense-making processes over time in relation to UX (Figure 6). The six steps of an experience are described as anticipating (for example expectations the user has from previous experiences), connecting (immediate responses with little cognitive effort), interpreting (making sense of an experience in a more conscious way), reflecting (reflections on experiences by retrospective evaluation and examination), appropriating (relating the experience to past and future), and recounting (telling the experience to oneself and others through storytelling).

Building on empirical research, Karapanos et al. (2009) described the experiences of new technology across a product adoption process. In each stage, different quality dimensions are valued: (1) early orientation to the product is largely influenced by stimulation and learnability qualities; (2) incorporation of the product in users' daily lives is characterised by long-term usability and usefulness; and (3) identification with the product is dominated by the product's abilities to partake in users' personal and social experiences.

Based on several sources, such as of Sanders (2002) and theories in psychology of how human-to-human relationships are formed over time, Van Gorp and Adams (2012) presented the "ACT model" of emotional design. The model has a temporal dimension and suggests that a product needs to attract (being desirable enough to the user to initiate use), converse (accommodating interaction) and transact (being useful and meaningful over time). If this is enabled, the user may bond with the product.

The "UX White Paper" by Roto et al. (2011) presents a series of time spans of user experience, and thus another way to describe the temporality of UX:

- Anticipated user experience: the period before use, where users form expectations and imagine experience.
- Momentary user experience: experiencing during usage, for example in terms of momentary feelings.
- Episodic user experience: appraisal of a specific usage episode.
- Cumulative user experience: views on a system as a whole, formed by reflections after having used it for a longer period of time.

This conceptualisation can be used to describe the varying time-frames of UX approaches in empirical studies. The majority of current UX research covers momentary and episodic UX (Bargas-Avila & Hornbæk, 2011; Pettersson et al., 2018). In the literature review performed as part of this thesis, 63% of 100 reviewed academic papers between 2010-

2016 evaluated a single session of use (see Paper A, Pettersson et al., 2018). The focus on momentary and episodic use is also evident in industry. In their overview of long-term UX studies in industry, Varsaluoma and Sahar (2014) found that while industrial practitioners value long-term UX studies, they often find them too cumbersome to address in practice. In theory, momentary UX should have effect on cumulative UX, but this has been for example contradicted by Luojos (2010), who found that the impact of episodic UX on cumulative UX was very little. Similarly, Kahneman (2011) studied the difference between moment-to-moment experience and episodic, cumulative user experiences, and found that what is seen as important in the moment scenario is not necessarily what the persons reflect on later. Furthermore, the work of Karapanos et al. (2010) and Roto et al. (2011) suggests that UX accumulates to more than the momentary or episodic interaction with a product; the formation of experience does not stop shortly after usage and also expectations on UX matter for the later outcomes. Anticipated user experience has thus been a minor, but growing, research interest. Expectations are filled with positive and negative emotions such as worry and hope; through them humans have the possibility to be surprised, delighted and provoked (Wright et al., 2008). The gap between the imaginations of use and actual use can thus be decisive for the following UX, as exemplified in several studies (for instance Kujala & Miron-Shatz, 2015; Michalco et al., 2015). For example, Yogasara (2014) performed studies of anticipated and real-life user experience, concluding that UX involves familiarisation and expectation disconfirmation factors which means that user expectations, and the way they compare to actual use, have a role in the formation of user experience over time.

In summary, the temporal aspects of UX are important, and different experiential aspects can be addressed by focusing on different stages of use, such as described by Karapanos et al. (2009) and Yogasara (2014). Studies require careful consideration and motivation of which temporal UX stage that is researched, in order to provide as much value as possible for the design process. It appears that it is highly significant to study anticipated as well as cumulative UX, as these reveal important information about the nature of the experiences that shape our daily lives with interactive artefacts.

2.4 IMPLICATIONS OF UX THEORY

Associated with all frameworks, models and definitions are the difficulties of balancing between over-simplification and the limitations of being too specific and detailed, as experience may be very different for different types of products, users and contexts. As many researchers have previously stated (see for example Law et al., 2009; Law et al., 2014; Obrist et al., 2012; Roto et al., 2011), UX remains a "fluffy" concept and therefore difficult to translate directly into methodological approaches.

The ISO definition of UX (i.e., *"A person's perceptions and responses that result from the use or anticipated use of a product, system or service"*) is used as a basis for the PhD research as the definition acknowledges the individual and the holistic perspectives, as pointed out as important by for example Kaye (2008). Furthermore, it highlights the temporal dimension of UX (cf. Karapanos, 2010; Kujala et al., 2011; McCarthy & Wright, 2004). In the thesis, the following further prerequisites for eliciting UX information are identified, based on the overview of theory:

- UX resides in the individual's experience; it is subjective.
- UX is multi-dimensional, made up of both pragmatic and hedonic aspects. UX includes facets such as emotions and value.

- UX is layered; from the easily accessible and expressible to the more tacit and latent.
- UX is influenced by the use context.
- UX requires attention to the dynamics of the interaction taking place between user and system.
- UX is influenced by temporal aspects of use (e.g. to what length of time the user has experienced the product). It is highly significant to study both anticipated and culmulative UX.

In the next chapter, the design process will be added to the overview of the UX theory, enabling a further understanding how theory may be translated into methodological approaches in a design process. The chapter ends with a concluding analysis of research gaps and considerations for the research conducted in the thesis.

2.5 THE DESIGN PROCESS

Design is a forward-looking process, striving to change a unsatisfactory current state into a preferred one. Design has been characterized as a unique approach to the world (e.g., Nelson & Stolterman, 2012) and Boess and Kanis (2008) conclude that *"many aspects of design problems cannot be resolved by prior reasoning or generalized guidelines. They can only be addressed in the course of a design process and through it"*. A user experience can never be "designed" itself, as a designer can never foresee actual use, but designers may have specific experiences in mind when creating the product, deliberately designing for a preferred future state of positive experiences. In this process, the designers need to deal with *"an unknown or only partially known situation, with demanding and stressed clients and users, with insufficient information, with new technology and new materials, with limited time and resources, with limited knowledge and skill, and with inappropriate tools…"* (Stolterman, 2008). This fuzzy situation has been described by numerous researchers over the years (for instance Archer, 1984; Fallman, 2008; Jones, 1992) and continue to constitutes a challenge to handle in practice, and in research.

Archer (1984) models the design process in an analytical phase (understanding the design problem and opportunities), a creative phase (ideating and exploring ideas) and an execute phase (transforming the ideas into final designs through an iterative process). In a similar manner, Jones (1992) describes the design process as consisting of the three phases of divergence, transformation and convergence: firstly by understanding a design problem and extending the boundary of a design situation so as to have a fruitful space in which to seek a solution, then convert that understanding of the situation to designs by ideation, resulting in prototypes which are then brought into the convergence phase where a final design is the result of iterative evaluation. Ulrich and Eppinger (2015) further introduce granularity into the product development by addressing the front-end development of concepts where the first step is to analyse customer needs, then establish target specification, generate product concepts, select product concepts, test and then set the final specification, and finally plan downstream development.

The UX design process is most often described with a similar outline to these design processes, and typically includes that a design team starts by observing the situation of interest for understanding the current state and constructing actionable insights, then ideating and creating new concepts as a reflection of how the current state might be improved (Karat, 1997; Hartson & Pyla, 2012). The core of UX work is the focus on the user, the use context and the nature of the interaction taking place, which can be compared for example with the experience of a non-interactive design object, where interaction and

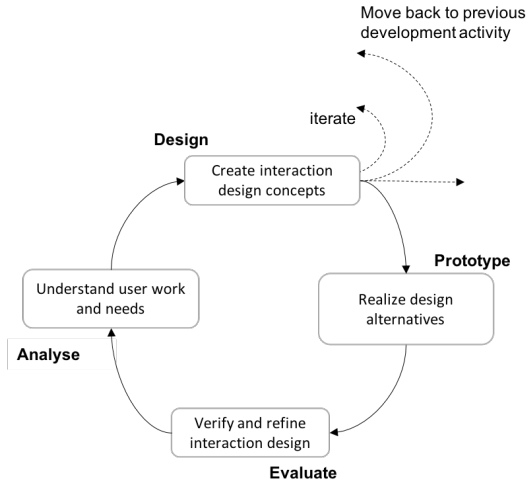


Figure 7. The UX design process, adapted from Hartson and Pyla (2012).

use context may matter less. In their book on UX design, Hartson and Pyla (2012) describe the UX design process as including an analyse phase, a design phase, prototyping and evaluation, where every phase is submitted to critical inspection and iterations (see Figure 7).

In sum, the UX design process can be generalised in the overall steps of analysis of studying the world and making models on which to base further work, ideation phases of suggesting and exploring future states, and finally concept evaluation (cf. Archer 1984; Jones 1992; Ulrich & Eppinger, 2015; Hartson & Pyla, 2012).

Building on their own and others' insights from design work, Dubberly and Evenson (2008) use a different representation of the process. Four quadrants are used to describe the process between analysis and design in a "bridge model" (Figure 8). The left column represents analysis (understanding current situations, needs, context, and so on) while the column on the right represents synthesis of solutions, preferred future states and other aspects. The bottom row represents the tangible world (for instance, we can interact and observe the world as it is, or with a prototype), and the top row the abstractions (i.e., what could be, what may be represented in models and ideas), which we may communicate to others.

In a design process, the task is typically to first collect concrete data about the world (lower left quadrant). The work then transitions to the upper left quadrant by analysing the data and producing models that connect the pieces of findings into comprehensible patterns and identified openings for innovation and/or improvement. This results in a description of the current state that may highlight both problems and design opportunities. The focus of the design process then transitions to the upper right quadrant, where solutions for an improved future state are proposed and explored. This work is generative (creative and productive) and divergent (multi-directional) rather than convergent, that is, contain more suggestions and explorations rather than exclusions and refinements of concepts. Finally, the work transitions to the lower-right quadrant by generating tangible concepts that seek

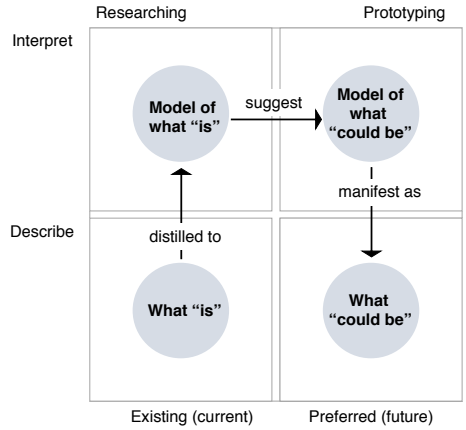


Figure 8. The bridge model of the early design process adapted from Dubberly & Evenson (2008).

to achieve this preferred future state, starting the convergence process. Here, designs are typically iteratively prototyped and tested with users. Dubberly and Evenson (2008) note that many designers neglect exploratory work in the upper-right quadrant and transition directly from models of the present into concrete design concepts which may result in that the work fails to question assumptions and may overlook novel design opportunities.

Furthermore, Cefkin in her foreword to Halse et al. (2010) critiques trends in the practice of Design Thinking, where the work may even stop short at *thinking*, not moving on to actually *doing* (designs). In a haltering design process, there might thus be extensive work put into observing and understanding users, but where very little of the findings are used in the ideation (cf. Cefkin, 2010), which instead becomes a separate activity that directly deep-dives into a solution based on the designers' own assumptions (cf. Dubberly & Evenson, 2008).

There are also implementation phases following the early design phases, but the focus of this thesis is on the early design phases and employs the model from Dubberly and Evenson (2008) to further address UX study approaches as the model emphasises the importance of carefully exploring "what could be". The quadrants of the early phases are described in detail in the following sections, where examples of UX approaches and methods are presented for each phase (*analysis*, *ideation* and *evaluation*, as summarized earlier in the chapter).

2.5.1 The analysis phase

The lower left quadrant of Dubberly and Evenson's (2008) quadrant deals with the task of understanding user needs and use context, where preconditions for the design are formulated. This phase resembles Hartson and Pyla's (2012) phase of analysis, as well as Jones' (1992) divergence phase. Having empathy with future users and considering their user experiences are central in this process (Buchenau & Suri, 2000; Wright et al., 2008). However, it is not enough to understand and empathise – the information must be analysed and framed to lead to action.

Özçelik Buskermolen et al. (2012) explored what type of information from end-users designers find useful during early design phases. Their conclusion is that designers value elaborate information from users, indicating clear attitudes and motivations, as well as the users' past, personal experiences. When interviewing designers, Sleeswijk Visser (2009) found that designers value what she calls "rich" subjective information, referring to "the diverse and muti-layered character of the information", where descriptions involve aspects of context of use and the user's feelings and aspirations. These aspects tend to be indivudual, diverse, fragmented and multi-layered (Sleeswijk Visser, 2009, p 22). Kaye and Taylor (2006) use a theoretical perspective to also conclude that rich, detailed descriptions of users' experiences are needed to understand the full complexity of the lived experience, including the use situation.

As stated in the overview of UX theory, UX is linked to understanding users' needs, use context and situations as they are today. As a consequence, approaches originating from ethnography have been picked up by UX researchers, such as observing daily life and practices. Important and ethnographically inspired examples of methods are cultural probes (where participants are given tools to record impressions from a situation, see Gaver et al., 1999; Mattelmäki, 2006), contextual inquiry (Beyer & Holtzblatt, 1997) and context mapping (Visser et al., 2005).

Methods outside the ethnographic outlook that deep-dive into the subjective have also been incorporated into the UX community, such as interpretative phenomenological analysis (IPA) (Smith, 1996) and analysis of users' narratives (Tuch et al., 2013). However, these techniques use interviews as the sole source of information, and criticism resides in that they run the risk of being too steered by the interviewer, insufficiently engaged in contextual aspects and unable to reach the layered aspects of experience due to limitations in expressing experiences in words (cf. Sanders, 2002). To mitigate this, measures such as the use of participant-generated photography for visual elicitation of experiences and for providing influence in the study have been suggested (Fors & Bäckström, 2015). Frameworks such as Participatory Design have gained attention over the years and highlighted the value of user participation and power in the design process (see for example Halskov & Hansen, 2014; Muller, 2003 for overviews). The user is here not only an informant and not only observed and analysed from "the outside", but becomes more of an actor in the knowledge production. In the UX field, participatory design approaches have been used to for example to study and design games for children (Gennari et al., 2017) and healthcare services (Andersen, et al., 2017).

When researching for future, yet non-existing products, it may not be enough to study current use. There is plenty of research that focuses on experiences as they are today, but much less research that explores future designs in prospective research (Dubberly & Evenson, 2008; Halse et al., 2010) and it has therefore been claimed that research is needed of how to better tackle UX at early design phases (Roto et al., 2009). With no functional prototype available during the early development phases, user study participants need to imagine how they will use the product concept in their daily lives. This calls for new user research methods that allow a transition from the current situation to the future possibilities of technology, which may enable designers to even *"learn something that we didn't know we needed to know"* (Sanders, 2002), meaning that prospective research must be open to the new and perhaps unexpected, and furthermore be able to question assumptions when needed.

Expectations have been claimed to be an important source of insights, on which

designs can be based (Kujala & Miron-Shatz, 2015; Olsson et al., 2009; Yogasara, 2014). However, the best ways of gaining access to more reflective material from expectations than pure opinions have been identified as a problem (Odom et al., 2012; Vermeeren et al., 2010). It has been suggested that by making the future situation more accessible for participants by applying open, generative research methods (such as engaging participants to themselves document the use context or part-take in prototyping activities), more reflective ideation can be built into the process (Brandt & Grunnet, 2000; Sanders & Strappers, 2012). A small number of specific methods has been developed to research expectations, such as the Anticipated Experience Evaluation (AXE) method which consists of three main steps: concept briefing of a future concept, concept evaluation based on interviews, and data analysis (Gegner & Runonen, 2012). However, given the sparse set of methods and empirical research at early design phase evaluations (as found in Bargas-Avila & Hornbæk, 2011; Pettersson et al., 2018) the topic still constitutes a challenge and further research is needed.

2.5.2 The ideation phase

Ideating the ultimate solution from an infinite set of possibilities is a challenging part of the design process. One step that is critical in this process is to constructively move from research findings to a conception of a preferred future state, by continuously ideating and exploring concepts. Davidoff et al. (2007) conclude that it is important not to steer too quickly into a selected design before the design space is properly researched and further that *"few tools or techniques help explore divergent design concepts, reflect on their merits, and come to a new understanding of design opportunities and ways to address them"*. They therefore call for more methods in the borderline between ideation and evaluative iteration. Biskjaer et al. (2010) reviewed nine design ideation and creativity methods, concluding that many lack a clear link to articulated sources of inspiration and insight. For example brainstorming (Osborn, 1953) is a well-established method originating from advertising, for imagining future designs in teams, but as a method itself holds weak links to the actual use situation or knowledge of users. Another well-established method is Future Workshops (Jungk & Müllert, 1987). The process is highly structured, consisting of three phases: critiquing the present, imagining the future and finally the adaptation phase where what is imagined is adapted to circumstances in reality. Yet another method is Interaction Relabelling and Extreme Characters, introduced by Djajadiningrat, Gaver and Frens (2000), intended to break free from limiting assumptions by designing for provocative fictional users, and by mapping interactions from one type of devices onto another type. The method Fictional inquiry (Dindler & Iversen, 2007) is another example, which includes creating a literary narrative on future use and situations. However, these methods do not include a strong focus on users' needs and characteristics, and the specific future use situations.

A well-known and more hands-on perspective is offered by Buchenau and Suri's (2000) "Experience Prototyping" approach to design, which propagates practical experimentation of future experiences for example by enacting future situated use, with support from objects that might mediate discussion (such as things that usually can be found in the intended use context) and simple prototypes of products. This highlights the experience dimension in the design process. Similar approaches can be found in Sanders and Strappers' (2012) Convivial Toolbook, describing user inclusion in the imagination of future design solutions, advocating generative efforts for providing informed foundation

for designs under development. As with Participatory Design, Sanders and Strappers perceive the users' role not only as passive experiencers, but also as possible active influencers in the design process. In this tradition, enactment of future technology can offer a rapid means of jointly improvising new ideas as well as critically probing future use in an evaluation-like setting (Arvola & Artman, 2007; Odom et al., 2014). A number of similarly founded techniques, based on enactment, have been developed over a period of almost 30 years, where aspects of drama and the use of the body in imagining new interactions with technology have been common themes, such as in body storming (Burns et al., 1994; Oulasvirta et al., 2003), speed-dating (Davidoff et al., 2007) and in embodied design ideation (Wilde et al., 2015). The roots come from phenomenology and the lived bodily experience, where bodily engagement is key to elicit the bodily type of information, not easily addressable by words. Compared to methods such as brainstorming, future workshops and extreme characters, which are more dissociated with the use situation and flow of interactions, methods such as body storming and experience prototypes are further tied to the context of use. However, several researchers (for instance Davidoff et al., 2007; Sirkin & Ju, 2014) point out that how to address novel technology in novel situations is still largely overlooked. UX specific approaches are needed that may specifically target prospective user experience of the non-existing, to the extent to which this may be possible.

2.5.3 The evaluation phase

In the final quadrant of Dubberly and Evenson's model, the new product/s have been represented in some form and can therefore be evaluated. Designers move from conceptual ideas into the real in an iterative process, where concept evaluation with users offers a possibility to inform designs of pitfalls and possibilities.

There are numerous ways representing interactive products, such as storyboarding, creating interactive prototypes, Wizard of Oz techniques, videos, etc. Kaye (2008) states that any representation of an experience is inherently incomplete, but is nonetheless key for communicating the concepts to other practitioners and users. Gegner and Runonen conclude that the format of the product representation influences the outcomes of an evaluation (Gegner & Runonen, 2012). Whereas work on how usability is influenced by the type of product representation exists (e.g. Boothe et al., 2013; Sauer & Sonderegger, 2009; Sellen et al., 2009), there is little research into how product representations influence user experience, constituting a challenge for UX design and research. Compared to usability evaluation, the holistic nature of UX, encompassing intangible, contextual and complex relations, makes UX evaluation much more complicated to assess than for example efficiency of use. Lallemand (2015) concludes that *"the highly contextual nature of UX thus challenges evaluation, as it ideally requires a holistic assessment of the interaction and questions the evaluation in artificial settings"*.

Over the years, UX evaluation has remained a challenging and strongly discussed area for researchers in academia as well as practitioners in industry (Bargas-Avila & Hornbæk, 2011; Law, 2011; Vermeeren et al., 2010). Given the vauge UX umbrella term, it may be difficult to understand what constitutes good UX prior to an evaluation, and a fundamental understanding what to evaluate may then easily be missing (Roto, 2018; Roto et al., 2009). For example, UX evaluation practice has been critiqued for the deficiencies in addressing early evaluation and handling the multidimensionality of UX (Bargas-Avila & Hornbæk, 2011;Vermeeren et al., 2010). Nethertheless, a wide range of methods has been

developed or adapted to address UX evaluation. Vermeeren et al. (2010) collected more than 90 methods developed or repositioned for UX evaluation and found that the methods have a high degree of variability as they rely on very divergent conceptualisations of UX. Much of the existing evaluation work was found to be largely based on questionnaires, largely stemming from usability (Bargas-Avila & Hornbæk, 2011; Roto et al., 2009). This trend was still persistent in the literature study performed in this thesis, where 100 academic papers including UX evaluation between 2010 and 2016 were closely analysed (see Paper A, Pettersson et al., 2018). It was found that there was a broad range of unique methods, but that specifically developed methods for UX are rarely reused. Self-developed questionnaires and interviews were used in almost half the papers reviewed. Possibilities for participants to express experience in other format than words or questionnaire ratings were rarely offered in UX evaluation; only 3 % applied some type of probing approach, such as participants making videos of their experiences.

The following sections will exemplify some of the formative methods (i.e., open-ended research to inspire and improve designs) and summative methods (i.e., close-ended for assessing and reporting status) that have emerged or been adapted for the evaluation of UX.

Formative evaluation methods

In order to elicit formative data for guiding the development of UX, there are a number of methods that have been developed or applied, with different epistemological origins. Many overlaps with methods for the analysis/ideation phase, as many of these methods can be used for both inspiration and evaluation of designs.

User narratives (i.e., the spoken stories) of user experiences have been a popular choice, employed to make sense of experiences (for example by McCarthy & Wright, 2004; Tuch et al., 2013). The narratives can be of a summarising nature, reflecting on the experience in retrospect, or take place during the interaction in so-called "think-alouds" (Jaspers et al., 2004) where an experience can be narrated as it unfolds. An additional technique is "laddering" (Reynolds & Gutman, 1988), originating from consumer research, where the question "why" is repeatedly asked in a user study, to uncover links between product attributes and consequences. The method has also been adapted to UX (for example Vanden et al., 2009; Zaman & Abeele, 2010). User experience diaries such as the day reconstruction method (Kahneman et al., 2004) are an alternate way of collecting user stories, in written instead of spoken form. However, given the multi-layered nature of UX, it has been claimed that the full experience cannot be expressed by words (cf. Forlizzi & Battarbee, 2004; Sanders, 1992). The ability to express visually as well as in words has therefore been suggested to aid in expressing experience (Kujala et al. 2011; Chamorro-Kocet et al., 2008). An example of a method that addresses this is the sensual evaluation instrument, where participants are asked to shape ceramic objects to express emotions (Isbister et al., 2006). This approach enables alternative ways of expressing experiences other than solely depending on words. On a similar note, drawing curves that represent the positive or negative development of experience over time have been used to visualise how experiences unfold, for example in the UX curve method (Kujala et al., 2011) and the i-scale method (Karapanos et al., 2012). Yet another alternative, presented by Gaver (2007), is to let a professional filmmaker skilled in portraying human experiences depict specific user experiences as they unfold in daily life (Gaver, 2007).

Summative evaluation methods

In contrast to formative method with qualitative, rich descriptions of experience (cf. Sleeswijk Visser, 2009), summative methods attempt to summarise an experience and heavily condense it. Questionnaires are by nature reductive and may not capture underlying reasons for the answers (Kaye, 2008). Still, questionnaires are commonly employed in UX research; 79 % used some type of questionnaire in the literature study of current UX evaluation (Pettersson et al., 2018).

There are a number of questionnaires developed to assess user experience specifically. The AttrakDiff (Hassenzahl et al., 2003) and UEQ (Laugwitz et al., 2008) questionnaires are two such examples, where both hedonic and pragmatic dimensions of UX are studied with semantic differentials. However, the literature study of current UX evaluation performed in Paper A (Pettersson et al., 2018) revealed that 26 % used a standardised questionnaire of some type (such as for example the NASA TLX, which assesses mental workload), and only 7 % used a UX-specific questionnaire, such as the AttrakDiff questionnaire (5 %).

Psychophysiological measures are also used to some extent for assessing UX. Measures such as electroencephalography (EEG), electromyography (EMG) and electrodermal activity (EDA) have been employed (Ganglbauer et al., 2009), but the field is still emerging. These types of measures may be found in for example game research (see for example Drachen, Nacke, Yannakakis, & Pedersen, 2010). In the literature study (Paper A, Pettersson et al., 2018), these types of measures were however very rare (only found in 2 of the 100 reviewed papers). There are also questionnaires to evalute emotions, such as the PrEmo Tool (Desmet, 2003) and the Geneva Emotion Wheel (Scherer, 2005), however not found within the literature study of current UX evaluation practice.

2.5.4 Triangulation

It has been suggested that employing multiple methods to further validate, explain or explore experience is important (Arhippainen et al., 2013; van Turnhout et al., 2014). This might imply using both qualitative and quantitative methods in so called mixed-methods studies or triangulation across several types of data or methods. Law (2011) writes that *"employing quantitative measures to the exclusion of qualitative accounts of user experiences, or vice versa, is too restrictive and may even lead to wrong implications"*.

Denzin (1978) outlined four types of triangulation that may be applied when studying a phenomenon: data triangulation, investigator triangulation, theory triangulation and methodological triangulation. Employing triangulation in research has been claimed to contribute to a more reliable, holistic and well-motivated understanding of phenomena, and to counteract inherent biases from data sources, investigators and especially methods (Johnson et al., 2007). Thus, triangulation can be claimed to lead to higher confidence in results and also to uncover unexpected, but important, results. Creswell (2014) furthermore defines two overarching types of mixed-methods research (that is, collecting and analysing both quantitative and qualitative data): either sequential (firstly either a quantitative or qualitative method is used, and the other type is used in a following study to explain, explore or validate the results) or concurrent (where two or more methods are employed within the same study scope to cross-validate findings).

All these approaches may be relevant in eliciting UX data, given the multi-dimensional and layered nature of UX. In a series of studies, Arhippainen et al. (2013) demonstrate how applying several methods in practice can help researchers to learn about users and their ways to express experiences, and to catch *"user experience information*

piece by piece by utilizing different methods". However, the authors conclude that there is a general lack of knowledge generation in the area of UX in relation to using multiple methods. Furthermore, numerous UX literature reviews have identified the poor use of complementary methods to study UX (Bargas-Avila & Hornbæk, 2011; Roto et al., 2009; Vermeeren et al., 2015). The litterature study of Paper A found several postivie examples of sequential explorations of UX, but very few examples of concurrent triangulation that matches quantitative with qualitative data to derive a joint analysis, where results can be questioned or strength- ened based on correlations or the lack thereof in the data. In many papers reviewed that applied triangulation, different types of data are gathered, but rarely cross-analyzed. There appears to development needed of practices for triangulation and multi-method approaches in relation to UX.

2.6 UX IN RELATION TO INDUSTRY AND TECHNOLOGICAL DEVELOPMENT

Studies have shown that there are certain differences in how academia and industry approach design processes (Stolterman, 2008) and UX evaluation (Alves et al., 2014; Ardito et al., 2014; Lallemand et al., 2015; Roto, et al., 2009). For example, a survey by Roto et al. (2009) of academic and industrial approaches to UX evaluation found that while in industry it was more common to perform UX evaluation to improve designs through rapid, small-scale evaluations, more extensive evaluations were found in academia. From another two industry surveys (Alves et al., 2014 and Lallemand et al., 2015), the common conclusion is that UX is still a fuzzy concept also for industry, with many interpretations of the term, depending on the widely diverse backgrounds of its practitioners.

Novel and specific academic UX evaluation methods are often slow in transferring to industry, for example due to the relevance, cost and efforts associated with the methods (Roto et al., 2009). There may often be a lack of understanding of and relevance to design practice when developing methods in academia (Stolterman, 2008). Stolterman (2008) writes that given the ever-changing situations of industry design processes, academia may need to become better at providing research that can aid in *preparing* for action (providing a mind-set for the design activities) rather than offering inflexible and overly specific guidance in action.

Giving precise guidance in action may be very difficult when the technological developments in industry are very rapid, such as within industrial development in machine learning (ML) and artificial intelligence (AI). These are areas that have seen rapid growth in recent years but can be challenging for designers to address (Yang, et al., 2018). Novel technologies like these are however of interest to the UX community also in academia, given the possibilities both of providing novel research and design tools (Dove et al., 2017) and of providing novel user experiences of technology with increasing intelligence (Yang et al., 2018). The development of intelligent technology (for example, intelligence residing in the abilities of adapting to needs of different users, learning new concepts, make own initiatives and providing explanations of its actions, Lieberman & Selker, 2003), creates a challenge for designers, who must proactively suggest ways for people to understand and engage with these new systems. The interaction with highly intelligent future systems may be difficult to imagine at an early stage in the development process and places novel demands on the processes and methods used (Taylor, 2009). Höök (2000) suggests that slowly emerging designs through iterative work by evaluating products in retrospect, may be unsuitable for

approaching novel intelligent technology, and also emphasises that the technology needs to address the increasing fluidity in use situations to which the intelligence.

The increasing attention to products' ability to initiate own learning and actions, has led to non-anthropocentric understandings of the human machine interactions, considering not only the user's need for information as central, but also the system's. Cila et al. (2017) use the metaphor of agency to describe the abilities and characteristics of networked, intelligent products. Janlert and Stolterman (2017) describe that agency *"has to do with the idea that the actions of both parties (human and artifact/system) are guided by some internal design to achieve certain goals"*; the system may act on its own to achieve these goals. In sum, when designing for the user experience of highly interactive and intelligent products, it has been suggested that new approaches may be needed to address the specific form and function of ML solutions (Yang, et al., 2018).

2.6.1 Automotive UX research

In terms of this thesis focus on automotive research connected to in-vehicle system use, the research has so far been heavily dominated by safety, distraction and usability research (see Kun, 2018 for an overview). However, in-vehicle systems also play a role in the more everyday experiences of car users, filling an important part in the logistic life-puzzle. The experiences are situated in the car, an object that tends to evoke strong attachment and emotions (Featherstone, 2004; Redshaw, 2012; Sheller, 2004). Commuters may also spend a substantial part of their day in cars, in Western Europe the average car commuting time is 38 minutes and in the US it is 25 minutes (Rodrigue, 2016), meaning that it is a significant place/product in which experiences can take place.

As described in the introduction of the thesis, in-vehicle systems are developed within an increasingly complex environment, to meet increasingly complex technological and customer-driven demands. Well-established car manufacturers today find themselves facing challenges related to digitalisation (Kun et al., 2016; Pettersson & Hylving, 2017); they have to compete with newcomers as well as new online transportation business models, keep up with the rapid movements in consumer electronics that nowadays also set customer expectations (Owens et al., 2015), and deal with heavily institutionalised development processes and structures, making competitive development times a challenge (Hylving 2015).

Autonomous driving has been described as a disruptive technology for the automotive industry (Kun et al., 2016). However, the idea of autonomous cars is in no way novel; self-driving cars have been present in fiction since the 1930s (see for example Keller, 1935), fascinating the public but not yet a reality for consumers. In 2004, the DARPA challenge introduced the first operational vehicles without drivers, although they were a long way from being driveable on public roads (Ozguner et al., 2007). Since then, the progress made in autonomous driving technology has increasingly become a hot topic in research and well as in media. Described as a paradigm shift in everyday transportation, there has been claimed gains of lower emissions (Brenner & Herrmann, 2018), more time for leisure and work (Mertens, 2018), and improved safety (Davila & Nombela, 2012; Rupp & King, 2010). Most premium car brands as well as examples from other technology developers are in the process of developing and testing autonomous cars. Research has been dedicated to several aspects that may influence user experience, such as mode confusion (Endsley,

2017), mistrust (Verberne, Ham, & Midden, 2012) and loss of situation awareness (Miller et al., 2014). A specifically dedicated UX approach to autonomous cars is yet however to be seen.

Although the traditional focus in automotive user research is directed to topics concerning safety, for example ethnographic-type work of understanding specific human situations in relation to cars has however been carried out, such as the studies by Lyons and Chatterjee (2008) into commuting experiences, Cycil's (2016) explorations of the role of in-car technology in family life and the investigation by Pink et al. (2018) of the role of the phone in relation to the modern car. Brown and Laurier (2017) addressed social interaction on the road in relation to autonomous and assisted driving by observing online videos.

There are also examples of studies that explicitly address in-vehicle UX, although these are based on addressing the UX of a specific system rather than a holistic outlook, such as parking assistance (Trösterer et al., 2014), assisted driving (Eckoldt et al., 2012; Rödel et al., 2014; Strand et al., 2011) or novel infotainment functionality (Inbar & Tractinsky, 2011; Krome et al., 2017, Terken et al., 2013). Very little work has so far addressed what overall signifies in-vehicle UX, how to elicit in-vehicle UX data and ideation of novel systems with experience in focus. Having said that, Gkouskos (2016) addressed in-vehicle experience as a study case for providing UX insights into a design process, and proposes that UX requires *"special attention to the UX aspects of time, emotions, and context"*. He emphasises the need to base ideations and evaluations on results from initial user research.

In a work more specifically targeting automotive UX design processes, Knobel (2013) relies on the work by Ryan and Deci (2000) and Sheldon et al. (2001) on psychological needs in general to understand in-vehicle user experiences. He proposes use of Hassenzhal's experience design process (Hassenzahl, 2010) for satisfying these needs in the automotive design context. The process consists of the sequential steps of identifying a basic human need to design for, composing an experience story around using technology to satisfy the human need, then translating the story into a concept to finally be evaluated in situ. Knobel then uses a number of case studies to exemplify this design process in the automotive realm, for example in the study "Clique Trip" (Knobel et al., 2012) describing the design process of an in-car navigation system designed to support relatedness between drivers in different cars. However, formative feedback of early concepts is not in focus. In contrast to this highly structured and linear approach, Hendrie et al. (2015) describe the vehicle UX design process as less directional (that is to say, moving towards a clear target in consistently higher fidelity) and more *dimensional*, i.e., addressing different aspects through generative/iterative design. The authors suggest an exploratory and playful approach to design, although they do not address this in great detail in the short paper. A third approach is described by Alvarez et al. in Meixner and Müller (2017, p. 377-400), where a more elaborate process is outlined for in-vehicle experiences grounded in ethnographic explorations using interviews, ride-alongs and GPS data, and employing a driving simulator as site for concept ideation and testing.

As for in-vehicle UX evaluation, some methods have been developed specifically with in-vehicle UX in focus, for instance a method by Niforatos et al. (2015) that elicits UX data by showing the study participant captured video clips from a previous car ride, helping the participants to recall and verbalize in-car experiences and summative UX evaluations based on psychological need fulfilment (see for example, Körber & Bengler, 2013; Körber

et al., 2013). A method that help interaction designers to better understand the existing context of the car have also been developed (Meschtscherjakov et al., 2011). Recently, the UX of autonomous driving has also become a focus of interest for academic research, with the new experiential challenges it imposes, such as no longer being in the loop of driving and having to trust the autonomous car (Choi & Ji, 2015; Haspiel et al., 2018; Verberne, Ham, & Midden, 2012) or develop concepts for other positive experiences than driving (Eckoldt et al., 2013; Krome, 2016). Much more research is needed, however, before highly automated driving is on the market, and in the stages leading towards automation, the experience and interaction taking place between driver and user is still a complex topic to address (Kun, 2018; Schmidt & Herrmann, 2017).

In conclusion, there is a need to further explore insights on in-vehicle UX and the way ideation may be done with experience in focus. Furthermore, more research is needed into how very early prototyping and tools to represent context can be applied for in-vehicle UX and how this may affect results.

2.7 SUMMARY

The literature study showed, similarly to other meta-studies in the UX area (Bargas-Avila & Hornbæk, 2011; Roto, et al., 2009; Vermeeren et al., 2010), that there is a methodological shortage in the early phases of the design process. In the academic field there has been a historic tendency to not address early design stages, including ideation, as much as summative evaluation (Cockton, 2012). Furthermore, as with design practice there is a tendency to move (too) fast from analysis of the current situation to a solution (Dubberly & Evenson, 2008), or simply stop short before designs in more ethnographically oriented studies (Cefkin in Halse et al., 2010). This implies risks of vast gaps between analysis and synthesis; a well-executed, rich exploration of experiences may run the risk of having little connection and traceability to the design that is created. Furthermore, as stated in the introduction, methodological obstacles for addressing future use also relate to that experiential data, such as emotions, value and contextual information may be difficult to elicit from users. Concepts of future designs are difficult to fully communicate to others at early stages of a design process and product representation as well as evaluation context have an effect on results (cf. Gegner & Runonen, 2012; Lallemand, 2015; Vermeeren et al., 2010).

Methods that address UX are rarely re-used in academia, as the literature review in Paper A revealed, as well as in industry (cf. Stolterman, 2008). It has been stated that eliciting UX data requires new methods (Vermeeren et al., 2010), but there appears to be a need to not only ideate new methods, but also to understand how to best combine existing methods and how to offer more strategic knowledge rather than exact guidance (cf. Stolterman, 2008). More knowledge is also needed on how the methodological choices affect the outcomes; how does the provided study context, the format of product representation, the data type selected for assessing experience, and so on, affect the outcome of a study? This has been more comprehensively addressed in usability research (for example Boothe et al., 2013; Sauer & Sonderegger, 2009; Sellen et al., 2009), but not to any deeper extent in UX studies. In particular for the case of in-vehicle UX research, more effort is needed in how to understand what signifies in-vehicle UX, and how to progress at early stages of designing for novel systems, with experience in focus.

Based on the review of related theory, lessons on *how to elicit UX in early design phases* can be

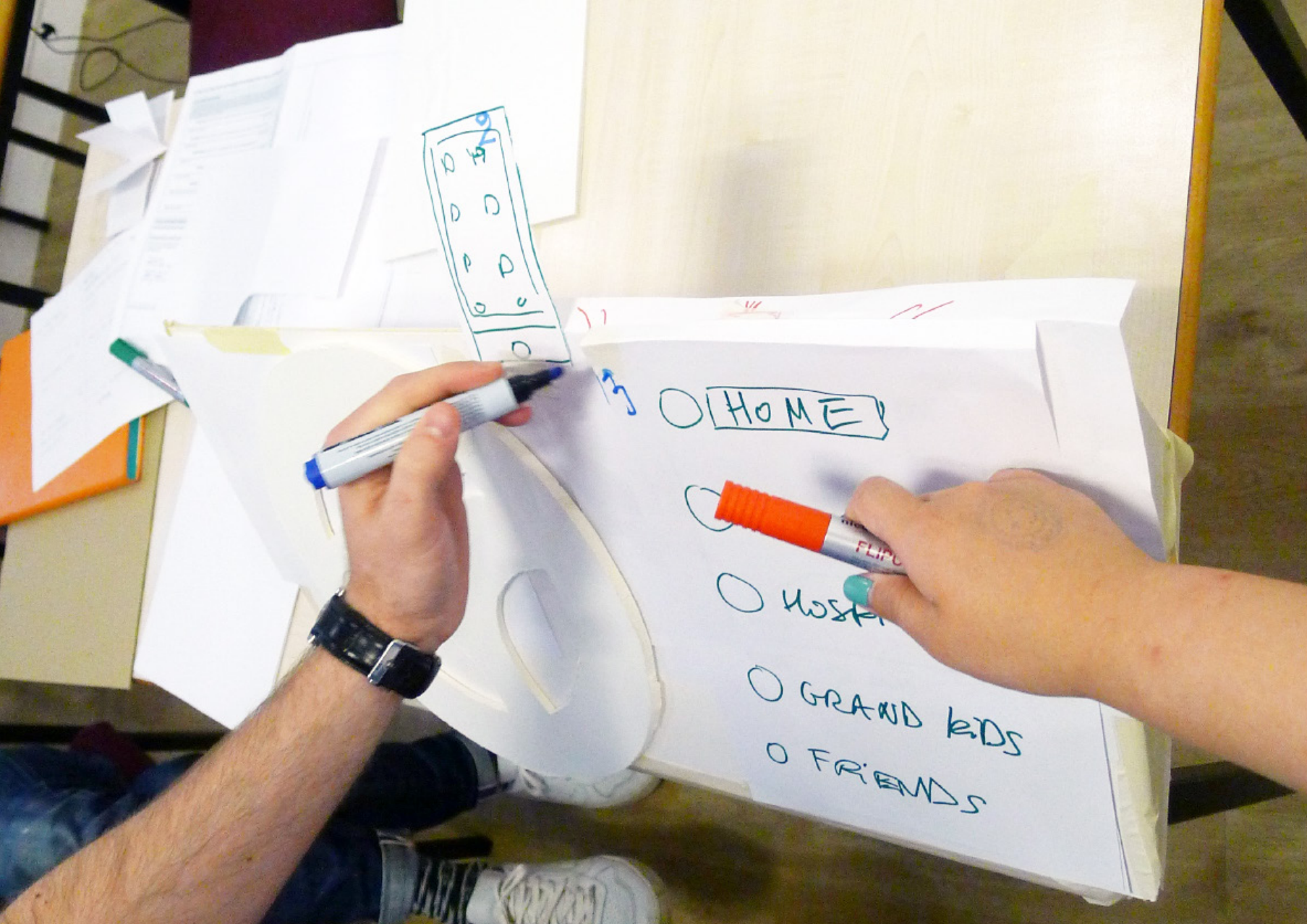
summarised as follows:

- For *analysis*, it appears useful to apply "open-ended" methods, considering the layered, multi-faceted aspects of experience (Sanders, 2002; Kaye, 2008). There is a gap in not only uncovering more of the experiences that exist today, but also in providing an empirical foundation to ideate for future experiences, based on user input and not only the designers' own speculation. One way of doing so appears to be in exploring possible futures with users, allowing more creativity by the participants in the process. Triangulation approaches also appear useful for offering complementing lenses when eliciting UX data. One way of doing so appears to not only rely on the narratives, when a complex experience such as the in-vehicle UX is analysed, but also include other ways of expressing and ideating. However, these types of approaches need to be articulated and crafted for the specific case of user experience for novel products.
- For *ideation*, there is a gap in methods that can flexibly ideate and explore concepts but with consideration of the future context and user experience (Biskjaer et al., 2010; Davidoff et al., 2007). Ideation of the products that do not yet exist on the market especially require an openness to novel ideas and early exploration of user experience.
- For *evaluation* there are similar needs as for inspiration/analysis, but also to explore aspects that influence the study coming from the "artificial" situation of evaluation, for example system representations and study context, and how they influence the ability to elicit UX.

Table 2 presents a number of prerequisites for the methodological approach in this thesis. In summary, the thesis needs to address UX as holistic, multi-dimensional, made up of both pragmatic and hedonic aspects, layered and influenced by the use context, especially temporal aspects of use (cf. ISO, 2010). There is a special challenge in addressing future user experience of novel technology (such as of autonomous vehicles), as opposed to solely understanding past experiences; novel designs need to be suggested, where it is not possible to rely on understanding existing use contexts and use. As industry may be reluctant to adopt overly specific methods, the thesis need to suggest a descriptive approach, tuned to specifically to user experience. The approaches used in the studies need to be able to flexibly allow for adaptation to the specific research/design case. This leads to the next chapter of this thesis: approach and studies.

Table 2: Prerequisites for eliciting UX data.

Prerequisite	Source	Implication on thesis
There is a need to evolve approaches for eliciting UX data in the early design phase.	Bargas-Avila & Hornbæk, 2011; Law et al., 2009; Vermeeren et al., 2010	The research of the thesis addresses the early phases of design. In specific, how the product is represented and how the study context influences the outcomes is addressed, as well as approaches for ideation.
There is a need for especially addressing the elicitation of UX for future experiences of novel products.	Brandt & Grunnet, 2000; Davidoff et al., 2007; Halse et al., 2010; Odom et al., 2012	The research of the thesis suggests and explores ways of addressing future user experience, not only relying on past experience of existing products, but also addressing novel situations through ideation and studies of expectations.
UX is holistic and multi-dimensional.	Kaye (2008); Sanders (2002); Wright & McCarthy (2004)	Holistic and multi-dimensional research requires open-ended research which will be the basis of the studies in the thesis. This may require triangulation of methods.
Designers value rich, formative data from users.	Kaye (2008); Sanders (2002); Özçelik Buskermolen et al., 2012; Sleeswijk Visser, 2009	Obtaining rich, formative data requires participants to be highly interactive in the studies performed in the thesis. There is a need for multiple data sources and the studies are required to elicit the personal and specific of experiences, over general opinions.
UX is dependent on the use situation.	Beyer & Holtzblatt, 1997; Dray & Siegel, 2009; Lallemand, 2015; Sanders & Stappers, 2012; Sleeswijk Visser, 2009	Addressing context is important in the studies of the thesis and the research needs to find ways of representing/understanding context at an appropriate level.
The nature of UX varies.	Florlizzi and Battarbee (2004)	The research of the thesis needs to uncover the specifics of the study case of in-vehicle experience.
Product representation influences outcomes of UX studies.	Gegner & Runonen, 2012; Sellen et al., 2009; Kaye 2008	The research of the thesis needs to explore what different product representations imply for the elicitation of UX data, as more in-depth understanding of this is lacking.
In industry, mind-sets may be more readily employed than specific methods.	Roto et al 2010; Stolterman 2008	The thesis need to support a holistic understanding and approach for eliciting UX data.
In industry, the activity must be able to be undertaken in a small-scale, flexible manner.	Roto et al 2010; Alves et al. 2014; Ardito et al., 2014	The results of the research of the thesis should be able to adapt flexibly and nimbly.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03 | APPROACH

3.1 EPISTEMOLOGY

Using the framework from Crotty (1998), the approach of the thesis is here described in terms of its ontology, epistemology, theoretical perspective, methodology and the specific methods applied.

Starting with *ontology*, the work is based on the understanding that the world is influenced by subjective constructions, in other words that humans construct individual meanings as they engage with the world (Crotty, 1998), where one cannot expect complete predictability and verifiability of a topic such as eliciting user experience data. Even so, research has a place in attempting to understand as much as possible of other people's experiences, making sense of them and suggesting an actionable way forward in a design process based on understanding of the world instead of assumptions based on one's own horizon.

Rather than inductive or deductive processes, design has been described as an abductive process (Sanders & Stappers, 2012), suggesting what a likely solution would be to the problem at hand, and exploring this solution. This pragmatic outlook is reflected in this thesis, where methods and designs are explored simultaneously. The activities of the thesis were all set in ongoing design processes, which each posed their own specific challenges, such as the design of an interior concept for an autonomous vehicle or the re-design of an infotainment system. Generalising knowledge from design research is a challenge as researchers have to deal with this uncertainty and uniqueness (Cross, 2007), but nonetheless learning through design practice is needed, so that sharing knowledge in the domain is made possible.

In this thesis, knowledge is pursued in what Brandt and Binder (2007) describe as a circular practice of learning from design experiments, where insights from previous research and each study in the thesis are brought into a line of experiments. As the input from academic research is fed into a design process, the reader may establish an

understanding of the approaches in practice. The work in this thesis addresses two separate lines of research questions co-jointly, where both the phenomenon-related question of what signifies in-vehicle UX, as well as the approach-related question of how to elicit UX data, are addressed. The evolving understanding of in-vehicle UX is used to evaluate and structure the approaches of eliciting UX data, as work progress. Based on the ontology that the world is influenced by subjective constructions, the studies search to address the personal and specific of user experience. Being positioned with a pragmatic outlook in a design process, outcomes that supported idea generation and may readily feed into a design process were valued, such as data relating to the direct interaction with artefacts within the in-vehicle space and being detailed enough to interpret and to spark design inspiration. The result of the thesis is a proposed suggestion/argument of what appears to work for eliciting UX data, as well as an understanding of the domain-specific example (in-vehicle system designs) itself.

As experience appears to be subjective, contextual and layered, the *epistemology* thus requires an openness in the investigation, with an accommodation to the personal and subjective (cf. Kaye, 2008), enabling empathy for the prospective users and tangible explorations of product concepts (cf. Buchenau & Suri, 2000). An experience may be unique to a user, but patterns typically emerge from several observations covering many users, providing more solid understandings that can be employed in a design process that not only relies on the designers' own experiences or an extremely small or homogenous sample of users. This aggregated knowledge of experiences helps to avoid what Pucillo and Cascini (2014) call "the experience paradox", where the net of experiences across several users is lost in the focus on the individual and specific.

There is no hypothesis to be validated in this thesis, instead the work is an exploration of eliciting early UX data. The work seeks to elicit, understand and tell the story of the experience, rather than define and measure. It is open-ended, opening up for novel experiences, requiring a willingness to welcome surprising study outcomes. The research is what Mattelmäki (2006) calls "innovative", by encompassing creative elements as for example photography, collages and drawings, where patterns and themes are identified from the material. Also more traditional user-centred research approaches are used, such as observations, think-alouds and interviews. The *theoretical perspective* applied can thus be best described as a pragmatic understanding (as described in Creswell, 2014) of how UX can be addressed in a design process – that is to say, drawing conclusions from the practical applications of the explored approaches.

As the aim is to uncover methodological aspects that support focusing on and understanding UX, the *methodology* applied is exploratory and iterative; trying out and inventing methods that fit the pre-requisites and learning during the process by presenting and iterating with industry and academia. To a large extent, the methodology relies on eliciting qualitative research data, thus requiring attention to the specifics of the participants' own, lived experience (over generalised statements), a sensitivity in the study situation to follow up on emerging themes and ensuring a positive experience for the participant, as described by Kvale (2001). The data analysis performed is foremost based on a bottom-up approach, akin to that of grounded theory (Glaser & Strauss, 1968), where themes are identified directly from the transcripts of the participants' voiced reflections, as well as of observations and of the participant-created material in the process (such as photos and drawings).

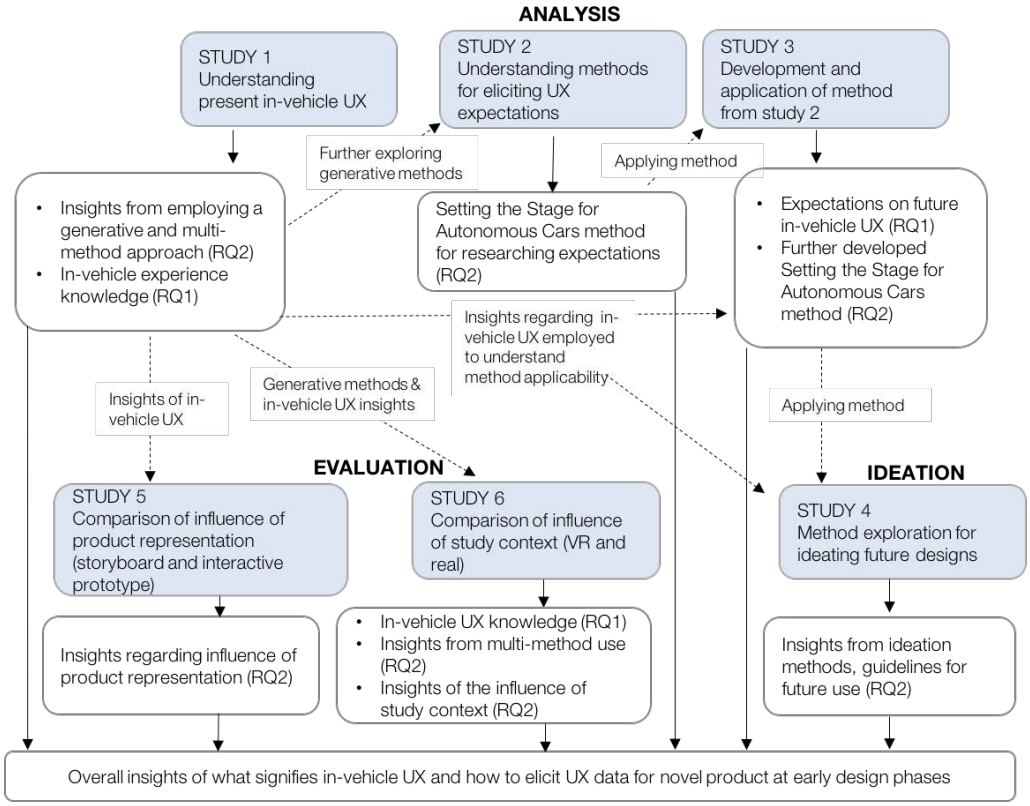


Figure 9. Overview of studies and insights, covering the design phases of analysis, ideation and evaluation.

3.2 STUDIES

In total six studies were undertaken, addressing the early design phases of analysis, ideation and evaluation respectively. The studies extracted a pattern of what appeared useful for eliciting UX data and of what signifies in-vehicle UX. Insights regarding methodological aspects and the nature of in-vehicle UX fed into the next study performed, as well as into the final, combined analysis of outcomes. Figure 9 describes the flow of the research, moving from the first design phase of analysis, into ideation and then evaluation.

Table 3 provides a more detailed overview of approach and method for all studies, which are further described in the following sections of the chapter. Methods often included generative elements, such as drawing, collages and photography of experience, and were partly re-used across several studies. A method called "Setting the Stage for Autonomous Cars" was constructed during the research in Study 2, and further developed and re-used across the studies.

The study cases were all positioned in the realm of highly automated and connected systems, either existing modern cars (with a high level of connectivity, advanced infotainment, safety and comfort systems, such as in Studies 1 and 6), or prospective research of autonomous cars (Studies 2, 3, 4) or an artificially intelligent infotainment

system (Study 5). The scope for the cases were all connected to users' direct interactions with systems, and thus not addressing for example future systems where no interaction with the car is included. Aspects on a societal level, such as (autonomous) cars as part of a mobility service and sustainable transport challenges, were also not part of the focus of this thesis, although as such very important.

Given the subjective nature of UX, all user research is dependent on the selection of participants for the empirical studies. Foremost participants with a solid experience of modern vehicles were selected, to make the concept of highly autonomous and intelligent vehicles more readily approachable for the participants. A range of modern vehicles were owned or driven by the participants regularly. Study 1, as well as Study 5, particularly targeted regular Swedish commuters with hi-tech, connected modern cars, in order to understand the use of current solutions at the forefront of the market, and where the level of connectivity is high. In Study 3, a similar selection of users was made, but the study was set in the USA (Los Angeles) to further understand expectations from autonomous cars in a much more intense traffic situation. A larger number of participants was included in Study 6 than the other studies, to increase the degree of significance for the questionnaire data included in the study. Study 4 consisted of a series of workshops with professionals, all with experience and interest in upcoming autonomous vehicles. In this study, participants came both from industry and academia, from a number of fields such as ethnography, engineering and interaction design.

Table 3. Overview of studies.

Study	Approach	Methods	Participants
Study 1, to suggest and explore a methodological approach for understanding of in-vehicle UX as it is today.	Open, qualitative, in-context, with generative elements. *Study case:* modern high-tech vehicles. *Analysis:* open qualitative content analysis of transcribed interview data and photos. The UX curves were analysed in terms development trends.	Contextual interview, reflexive photography, UX curve.	16 Swedish users of modern vehicles.
Study 2, to explore different types of generative methods for exploring and analysing user input to future technology.	Open, qualitative, with generative elements. *Study case:* autonomous cars *Analysis:* open qualitative content analysis of notes, concurrent with images from the participants' drawings.	Collages and sketching in combination with interviewing, Enactment in combination with sketching and interviews ("Setting the Stage for Autonomous Cars").	8 Danish and 8 Swedish participants.
Study 3, to further validate the method and to use it for more in-depth findings (of expectations in relation to autonomous vehicles).	Open, qualitative, enactment, with generative elements. *Study case:* autonomous cars. *Analysis:* affinity diagramming with professional designers/marketing experts, and a detailed, open content analysis.	"Setting the Stage for Autonomous Cars" method.	11 US users of modern vehicles.
Study 4, an array of 4 workshops for professionals to explore ideation methods.	Open, exploratory approach. *Study case:* autonomous cars. *Analysis:* qualitative content analysis of notes, observations/video recording, worksheets filled in by participants and the closing evaluative discussions from each workshop with the participants.	"Setting the Stage for Autonomous Cars" method, WoZ, Lo-fi driving simulator, small-scale scenario, design metaphors, etc.	45 professionals (academic and industrial), in the US, Sweden and UK.
Study 5, a comparison of different product representations' effect on UX evaluation (storyboard vs interactive prototype).	Qualitative comparison of outcomes of interview data after concept exploration of a highly intelligent infotainment system. *Study case:* infotainment system with predictive and personalisation possibilities *Analysis:* qualitative content analysis of transcribed interviews and quantitative analysis of questionnaire data.	Semi-structured interview and a self-defined UX questionnaire.	24 Swedish participants.
Study 6, a comparison of different evaluation contexts' effect on UX evaluation (VR vs real).	Interview, questionnaire and observation data were used to compare the two study contexts. *Study case:* infotainment system and semi-autonomous driving system *Analysis:* qualitative content analysis of transcribed interviews and think-aloud, quantitative analysis of questionnaire data (correlation analysis, etc.).	Semi-structured interview, UE-q, ICT-P questionnaires, emojis, think-alouds, observation.	43 participants, from Denmark and Sweden.
6 studies	Mainly qualitative, open-ended approaches applied to the study case of intelligent in-vehicle technology	15 methods explored	155 participants

3.3 ELICITATION METHODS

As the research covers examples from all the three initial stages of design, the methodology changes slightly from one phase to another. The analysis phase was approached through exploratory methods, typically to be found in ethnographic and participatory design practices. The ideation phase continued this approach but also encompassed methods from the field of interaction design, such as employing design metaphors. More structured comparisons of approaches were made in the final stage of evaluation, where questionnaires were also used to collect UX data.

Almost all studies encompassed generative elements of some form, in other words the participants had to create their own material to express experience. Each study contained triangulation of data, both concurrent triangulation of data such as using insights from observation, questionnaires and interviews to understand findings, as well as sequential, such as following up one method (for example user-generated photographs) by another (for example a following interview). Through the use of generative techniques, not only verbalized reports of experiences were addressed but also behaviours (such as of tacit and bodily information) and understandings what was of particular importance to the participants, surfacing in the generated material such as photos and drawings.

3.3.1 The analysis phase

Stemming from the need to understand the subjective aspects of experience and the use context, methods used fot the analysis phase were founded in ethnography and human computer interaction research, with a special focus on understanding subjective experiences in context and in retrospect. Three methods were used in the first study:

- Contextual inquiry (Beyer & Holtzblatt, 1997), for example, being in the context (of the car) to interview and observe use. This method is rooted in an ethnographic and participatory outlook on user research, where addressing contextual aspects is key.
- Reflexive photography (Harrington & Lindy, 1998), where participants take self-generated photographs depicting important experience. This method is also rooted in an ethnographic tradition.
- UX curves (Kujala et al., 2011), where participants draw and retell how their experiences have unfolded over time. The curve drawing area consists of a vertical timeline and a horizontal line that divides positive and negative experiences, where the participants mark out highs and lows of the experiences over time. The UX curve method is one of the few methods that specifically address experience, including both generative and narrative features.

To sufficiently address novel technology too, there is a need to employ and create methods so as to explore future experiences. Since it is a challenge to research novel interactions with non-existing technology, this was the focus in the second part of the research in the analysis phase. The research connects to bodily and multi-modal efforts of understanding future interactions, such as body storming (Oulasvirta et al., 2003) and embodied design improvisations (Sirkin & Ju, 2014). With inspiration from the work by researchers such as Sanders (2003) and Visser et al. (2005), the studies included participant-generated material, to understand what constitutes important experience aspects to the participants. The research firstly explored drawing, collages and interviews as compared to enactment, drawing and interview (combined in a method named "Setting the Stage for Autonomous Cars") to explore expectations on future user experience. The Setting the Stage method was then revised and reused in both Studies 3 and 4.

3.3.2 The ideation phase

In the research of the ideation phases, the aim was to explore methods with a set of promising approaches (for instance, to be able to address the interactions between user/product, the use context and support for rapid idea generation and evolvement of ideas) for addressing novel, intelligent products such as an autonomous car. There was an examination of how the methods could (or could not) support divergence and evolvement of the ideas. A series of four workshops were performed with academic and industry professionals. All methods combined generative and evaluative elements. The following methods were employed for exploration:

- Wizard of Oz (Landauer, 1987; Wilson & Rosenberg, 1988). The Wizard of Oz (WoZ) methodology is a well-established interaction design approach for prototyping and evaluating user interfaces. A human "Wizard" simulates the system's intelligence and interacts with the user through a real or mock interface, so that intended interaction between system and users is allowed although the technology needed is not yet ready to use in real life. The method is rooted in a pragmatic interaction design approach of lo-fi prototyping of what does not yet exist in digital form. In the automotive field, it has been applied in driving simulator explorations of autonomous vehicle interactions (Baltodano et al., 2015; Mok et al., 2015) as well as on-road explorations of pedestrian reactions (Rothenbücher et al., 2016) and interaction (Habibovic et al., 2016).
- Design metaphors, where the design ideations were founded on a guiding metaphor of choice. Metaphors have previously been used to frame design problems and to base novel product experiences (Cila, 2013; Hey et al., 2008). By mapping characteristics of novel interactions, abstract ideas can make designs more accessible (Bruemmer et al., 2007). Design metaphors have been used to reason about the communication and interaction taking place between the users and autonomous vehicles (Flemisch et al., 2003; Ju, 2015; Davidsson & Alm; 2009) but so far scarcely applied in design concepts.
- Enactment in small-scale scenarios. Small-scale scenarios such as table-top scenarios (Broberg et al., 2011) have been employed in participatory simulation of complex scenarios, for example to overview physical layouts and spatial conditions to be examined in design (Broberg et al., 2011; Österman et al., 2016).
- Enactment and rapid prototyping of future designs in a low-fidelity driving simulator. Rapid ideation of in-vehicle systems has previously been done for example in driving simulators (Alvarez et al., 2015), but in this session a more lo-fi set up was used.
- The Setting the Stage of Autonomous Cars. The method developed in Study 2 was employed, used with further props for interaction, such as a cardboard steering wheel, personal belongings for enacting social scenarios and so on.

3.3.3 The evaluation phase

As stated in the introduction, there are methodological challenges connected to UX evaluation in early design phases, given the inevitably incomplete study situation. Two studies explored the effects of methodological choices in early evaluations regarding product representations and evaluation context. Given the more tangible concept to evaluate compared with earlier studies, the methods employed were more formalised and less exploratory, and encompassed think-alouds (cf. Jaspers et al., 2004, where participants voice the experiences as they take place during interaction), semi-structured interviews,

questionnaires (self-defined, and the UEQ by Laugwitz et al., 2008), observations, and again generative tools such as reflexive photography (Harrington & Lindy, 1998).

3.4 ANALYSIS

The bulk of the elicited data was in form of verbalized experiences. The detailed approaches for the data analysis of each study differed slightly (as described in the summary of each study in Chapter 3.1), but all the data required interpretation by identifying important themes, following the outline of Denzin and Lincoln (1998) for qualitative research. The understanding of experience as described in section 2.4 was used as guidance to identify themes, meaning that attention was directed to the *individual and specific*, the *multi-dimensional* (i.e. including both pragamatic and hedonic aspects, such as emotions and identification), the *interaction* taking place, the *temporal* and *layered* (cf. Sanders, 2002), as well as the *contextual*. These general aspects were searched for in the data from each study, in order to understand how well the approach worked (or did not) for eliciting UX data.

However, themes for describing the specifics of in-vehicle UX were not pre-identified, but only guided by previous literature, and themes were constructed bottom-up from coding the data. By being open-ended, the approach was akin to that of Grounded Theory (Glaser & Strauss, 1968) that construct theories 'grounded' in the data itself. The analysis work typically followed a process, where firstly, after each activity (such as an evaluation or ideation session), a brief summary and analysis were done as directly as possible, based on impressions of the session by the research(ers) involved in the session. At a later stage, the voiced reflections of the participant were transcribed. Based on these transcriptions, each participant's responses were structured into themes and summarised, typically into a mind map. The themes were then compared to those of the other participants in the same study. The construction of themes was an iterative process, where themes were open to restructuring and relabelling as the work progressed. Typical quotes, images or video clips were selected for the themes to represent the data. As the thesis explored two research questions at a time, the identified themes were both directed to the nature of in-vehicle experience (such as primarily addressed in Studies 1 and 3) but also methodological aspects (such as primarily addressed in Studies 2, 5 and 6).

The collected data was not only in spoken form, it also included observations of behaviours, generative material from participants and questionnaire data. Videos recorded during the sessions (such as in Studies 3 and 6) were viewed to search for reoccurring behaviours that appeared to be linked to experience. For example, participants behaviour in the virtual reality context of Study 6 that reflected (or failed to reflect) real-life use was noted, and the enactments of participants in Study 3 provided information of the bodily aspects of user experience of the in-vehicle systems (enactments for example stressed the importance of having easy access to brought-in objects in the car, or used to explain emotions and feelings in the car). Generative material from study participants was analysed, such as participant-generated photographs, concepts and drawings. This material was also coded into themes, and used as complements to the analysis of narratives to deepen the understanding of the narratives and exemplify themes in presentation of the data. Questionnaire data was collected in Studies 5 and 6, which were analysed separately with appropriate statistical methods such as the Friedman test (e.g., Siegel & Castellan, 1988) to identify possible significant differences between UX ratings across different study contexts, and then in relation to the narrative data to check for similarities and differences between the types of

data.

In his book on qualitative interview-based research, Kvale (2001) emphasises the importance of supporting validity of qualitative data by practices such as engaging more than one researchers in the coding and thematization, and to clearly describe the steps of the analysis process. Where possible (for example in Studies 1, 3 and 4), analysis was made with other researchers or designers, to ensure a more thorough process. At all times, the data analysis process was defined and discussed with the other researchers involved in the research or the thesis supervisor. Part of the ongoing analysis, and contributing to what Kvale defines as the pragmatic validity (2001, p 224) that enable progress in the task at hand, was to conduct and employ work in an industrial setting. The work of presentations, workshops and communication in industry, as well as academia, helped in understanding the material itself and the impact of the material. These understandings were consequently used in planning the next study in the research project. Videos and photographs were especially important, for showing others the material and in turn gain from their perspectives and understandings of the data. The essence of the thesis outcomes is to guide design work. This was explored by continuously being part of research and industrial projects.

In order to answer the research questions, it was necessary to build understandings across data from all studies to identify larger patterns of how to elicit user experience data and of what signifies in-vehicle UX. Useful UX data was understood as being individual, specific, detailed and connected to interaction. Rather than referring to topics such as what others' might think or general statements, narratives that were peronal, reflective, and evolved were valued.

Analysis between studies was conducted in two streams: one stream of continuous learning from one study to the next, such as between Studies 2, 3 and 4, or Study 1 that provided inspiration to the concepts in Study 5, and one stream of structured cross-case analysis after the completion of all studies. In this manner, the series of studies continued to build up a repertoire of what appeared to work in design practice (as described by Brandt and Binder, 2007). The cross-analysis moved the centre of analysis from the parts (case studies) to the whole, and posed the question of whether common patterns emerged, in line with the approach of "strawberry analysis" (Presthus & Bygstad, 2014); in other words, the most meaningful conclusions ("the strawberries") from each study are combined into a larger understanding of eliciting UX data and of in-vehicle UX. These identified themes across studies are used to structure the detailed descriptions of findings in Chapter 5 and then used to propose an approach for how to elicit UX data in Chapter 6.

04 | STUDIES

This chapter presents summaries of background, aim, method and findings for each study. Included findings connects both to the first research question of what signifies in-vehicle UX and to the second research question of how UX data can be elicited. The full papers based on the studies can be found at the end of the thesis and provide further details.

4.1 STUDY 1: ANALYSING CURRENT IN-VEHICLE EXPERIENCE (PAPER B)

The first study addressed elicitation of the in-vehicle user experiences of existing modern solutions on the market. The study takes a holistic stance on the empirical study of experience and collect personal and situated data that can help designers better understand and empathise with users. The results were needed to feed into the later studies of eliciting UX data (Studies 2-6) with a holistic understanding of in-vehicle UX. What influences the UX of hi-tech vehicles (e.g. including functionality for connectivity, navigation and active safety systems)? What defines positive and negative experiences?

In terms of selecting and developing methodology for the task, the research aimed at proposing and employing a multi-method exploration of user experiences in order to capture as much of the experience as possible. Thus, methods where the users could be supported in reflecting on experiences and expressing them were selected, then combined and after the study reflected on.

4.1.1 Method

In order to access the individual experiences of the participants in the study through multiple entry points, and to stimulate a more in-depth conversation on lived experiences in cars, three methods were combined; contextual inquiry (Beyer & Holtzblatt, 1997), reflexive photography (Harrington & Lindy, 1998), and a simplified version of the UX curve (Kujala et al., 2011). Sixteen car users with modern, high-tech vehicles participated in the study. Each session lasted approximately 1.5 hours. Before the contextual inquiry,

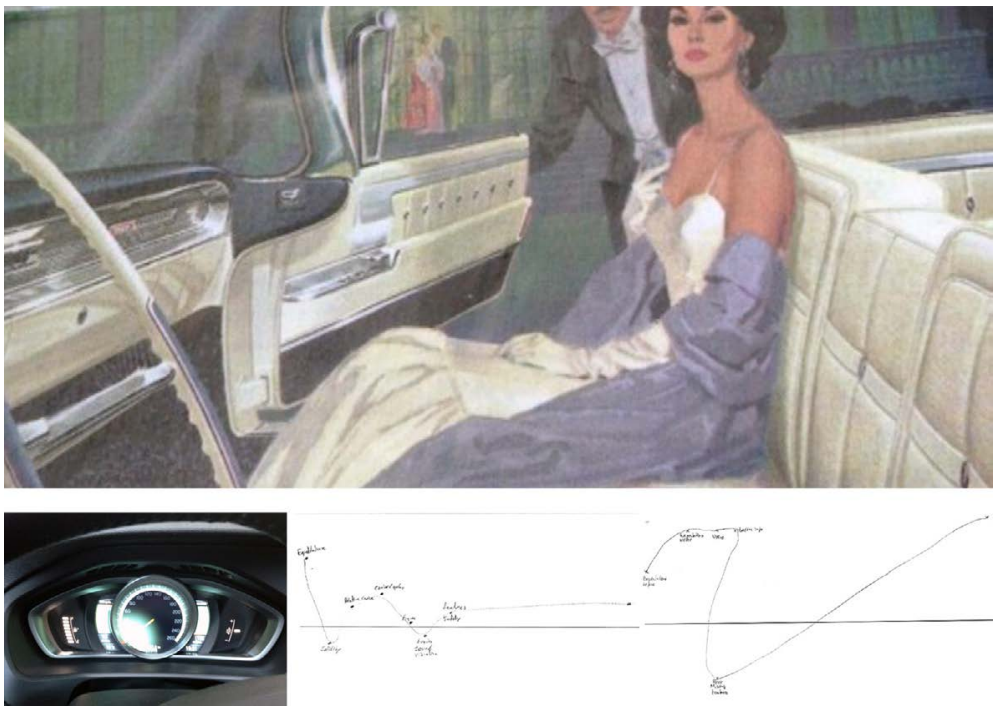


Figure 10. Examples of participants' photos and UX curves.

the participants were asked to photograph what they perceived as significant for them about their car. During the contextual inquiry, which took place in their cars and in their home, the photographs were presented and explained. The participants were also asked to draw a UX curve to describe how their experience of a product has changed over time. In this study, the UX curve method was employed for two reasons: firstly, to gain insights of experience as it changed over time and secondly, as a conversation mediator. Examples of photographs and curves are included in Figure 10.

Data was analysed using a qualitative content analysis, a method for characterizing and comparing content in text (Hsieh & Shannon, 2005). The interviews were transcribed and themes were established by coding the material. The coding software Nvivo was used, where the themes were evolved after additional insights stemming from further exploring the material in detail. As the UX curve and the photos highlighted experiences that were significant for the participants, data connected to the photos and UX curves were incorporated into the analysis and contributed to the categorisation of UX data. The UX curves were analysed by structuring the curves into three distinct trends of negative/positive/neutral development over time, interpreted together with the interview data to understand reasons behind the development trends. The curves were also analysed in terms of where across the ownership the curves fluctuated the most. The summary for each of the participants included themes in the narratives as well as photographs and curves. The summaries were used to identify experience patterns across several participants.

4.1.2 Findings

Of method

The combination of semi-structured interviews, reflexive photography and the UX curve method produced a wealth of stories from the everyday lives of participants and their cars. The photography provided an entry point for the participants to reflect on what is significant to them when it comes to their cars and served as a point of departure for experience discussions in the interviews. For example, a participant's photo of the car's phone list led to longer discussions about what it meant to be social in the car and how new routines had been established in his car during the daily commute. The UX curves served a similar purpose, and also infused an over-time perspective into the participants' narratives. Not all photographs and events on the UX curves were connected to the hedonic and multi-layered nature of UX – many were about usability and comfort, for example, but others resulted in expanding the discussions from usability to include more experiential aspects also connected to feelings and meaning-making. An example was a participant's description of his photograph depicting a dressed-up couple in a 1960s Cadillac (Figure 11), that gave information of the meaning he connected to the car: *"This feeling of luxury and happiness, of taking your date out to dinner at a restaurant on the Riviera … my car has a little of that feeling"*. Another participant photographed the eco-meter in her car (see Figure 11), a feature she appreciated as it helped her be more conscious about eco-driving, and furthermore: *"I think that unconsciously it was a big factor, the way it (the in-vehicle system) feels and appears. Small things, but they make a difference. They might not be important things but for the overall experience, I think it (the aesthetics) matters more than I'd like to say.* (…) *I'm more emotionally connected to the car than the phone. I see the phone more as a tool and the car is more a part of me. It's something I spend so much time with"*.

Furthermore, being in the use context made it possible to observe behaviours connected to everyday use, such as creating long phone call lists in the infotainment system before starting the drive to work, so as to be able to work down a list of phone meetings without causing too much distraction from driving. All in all, the findings suggest the methodological approach including multiple methods and generative data exemplified the use of these types of methods when eliciting experiential data. The photography assignment had a sensitising effect towards the experiential aspects of using the car, triggering experience stories such as of aesthetic experiences described by the ealier participant quote. This sensitising effect towards experience was also supported by the UX curve method and by taking place in the car context where the participants could show and recall typical use and experiences. This proved fruitful for uncovering rich, personal stories of experience such as of meaning, emotions, routines and identification (in other words, not only usability).

Of in-vehicle UX

The study led to a number of insights regarding what signifies in-vehicle UX. It clearly demonstrated the importance of the addressing context, not only as being physically placed in the car, but also that UX is depending on factors such as time of day, driving purpose and social context. For example there were different types of experiences connected to the daily drive home from work which typically differed from the experiences connected to driving to work, when experiences were more tuned into starting the work day with work-related phone calls and so on. The experiences were highly affected by the car being a

personal space, having different meanings for each individual user. Four distinct key areas of experiences were deducted when using the in-vehicle systems, for experiencing:

- Mental) transition, e.g. using the in-vehicle system to transition into work-mode by placing work calls during the morning commute, relaxing with music on the way home.
- Relatedness to others, e.g. using the systems to connect to others by routine calls to family members, or jointly making music playlists on holiday driving.
- Stimulation, e.g. discovering and enjoying new functionality in the vehicle.
- Caretaking, e.g. enjoying and finding security in the fact that the car looks out for one's best, for example by active safety and comfort systems.
- The research found that the participants' experiences were heavily influenced by temporal factors; the experience typically fluctuated from the initial positive expectations, a period of discovery with fluctuating experiences, to a stabilising level, where however the excitement and thrill of new discoveries are no longer present. The strong influence of the multi-device and social ecosystem on usage was also noted. Three principal aspects of the findings were found to be formative for the long-term user experience of in-vehicle systems:
- Influence of other products. All participants had in-vehicle systems that were connected to smartphones, and these units became intertwined from the users' viewpoint and the user experiences were profoundly affected by expectations originating from other products. It was evident already from the start of the interview sessions that it was impossible to distinguish experience stories of the in-vehicle system from those that also concerned the participants' phones and other connected technology. An example was the expectation to seamlessly listen to the same music or podcast when transitioning from home, to the car, to work, or that the car would have a similar updating rationale as their phone, adding new functionality and refreshing visual aesthetics over time.
- Influence of new behaviours. New behaviours emerged from prolonged use and considerably altered the experience over time, for example experiences of efficiency, relatedness and control. Examples of such behaviours were the use of hands-free phone (for example establishing routines of calling one's mother or child on the way home), working in the car and using apps for monitoring the car from home.
- Influence of social settings. A striking number of experience stories concerned social aspects of using in-vehicle systems, that is to say how they were experienced when in contact with other people. For example, one participant described experiencing socially awkward situations when mixing her private and professional persona in the car by incoming phone calls to a very different context, and another participant related the emotional stress of experiencing poor connection during his phone calls home to his young daughter.

Negative experiences related primarily to usability, but also to failures of the in-vehicle systems to cater for the multi-device and social ecosystems present.

The results were used as a basis for subsequent design activities with designers from industry, further described in Gkouskos (2016), and the resulting concept was addressed in Study 5. The findings for in-vehicle UX were re-used to understand the findings in Studies 2-6.

Summary of insights, Study 1

User-generated photographs served as a means to elicit personal stories of experience. For understanding experiences in retrospect, the UX curves worked well to both inspire stories and discern temporal patterns of experience from the curves. Being in the use context allowed behaviours to be observed and served as an opportunity to ask follow-up questions. The multi-method approach thus proved fruitful for obtaining rich, multi-layered, individual and holistic UX insights.

As well as of functionality, the in-vehicle UX was heavily influenced by the context of use (for example the period of time that the car has been used, social settings and the multi-device context). Furthermore, aspects such as sensory, comfort, usability, aesthetic and other qualities of the in-vehice environment gave rise to user emotions, assigned meanings, behaviours and habits. The research identified four patterns of in-vehicle experience that were facilitated by the in-car systems, depending on the type of journey that undertaken; for instance mental transitions (for example from work/to home), relatedness to others, stimulation and being cared for (for example through comfort and safety systems).

4.2 STUDY 2: EXPLORING METHODS FOR ELICITING EXPECTATIONS OF AUTONOMOUS CARS (PAPER C)

4.2.1 Background

The second study addressed a situation where the no or limited preceding products from which to start the analysis; the research for providing inspiration and analysis must then come from prospective studies of "what could be" instead of findings based on the existing (cf. Dubberly & Evenson, 2008). The study case was autonomous vehicles which are under development, but which face a number of challenges in user experience design. This could potentially include aspects such as mode confusion (Endsley, 2017), mistrust (Verberne et al., 2012) and loss of situation awareness (Miller et al., 2014). Preferably, the in-vehicle systems should be designed with knowledge of the users' needs, perceptions, motivations, and other such factors, and researching expectations and early reactions on concepts may offer insights on this. However, the methodological foundations for doing so have been sparsely explored, and this study aimed to suggest and explore methodological approaches for this and to learn more about what constitutes specific challenges and possibilities for the in-vehicle UX of autonomous cars. What do users expect of autonomous cars? How can methods be employed and developed to explore expectations, beyond the generalized, reaching the individual and specific?

Methods were based on generative approaches in user studies (cf. Sanders, 2003; Visser et al., 2005), encompassing two sets of creative tools for depicting expectations on experience, and comparing them.

4.2.2 Method

In total 18 participants were engaged in a between-subject study design, conducted in a shopping mall and at a parking lot, where participants were engaged spontaneously (but where all but two participants held a driver's license). The sessions typically lasted 15-20 minutes each. Semi-structured interviews were held in all sessions, structured around expected activities in autonomous cars, emotions in the car, worries, values and how they expected the car space to change with the introduction of autonomous cars. Notes and photographs were used to document the outcomes.

The research explored and qualitatively compared two possible generative approaches for researching user expectations, that complemented the interviews:

- User-generated collages, as used in numerous user studies (Sanders, 2003; Visser et al., 2005). The users were asked to depict their future autonomous vehicle designs and describe their activities, emotions and so on in such a vehicle.
- Enactment of future use in combination with user-generated drawings of future functionality. Enactment has been used in several studies of future technology (Brandt & Grunnet, 2000; Odom et al., 2014; Schleicher et al., 2010). The method employed in this study used a combination of enactment and drawing in a basic representation of a car (see Figure 11) was named the "Setting the Stage for Autonomous Cars" method. The participants were asked to take a seat in one of four chairs inside a drawn outline of a car. They were encouraged to use the available chairs and chalks to re-design the "car".

  The general outline of the analysis was based on qualitative data analysis with coding

Figure 11. "Setting the Stage for Autonomous Cars" method, interview and collages.

of themes (cf. Hsieh & Shannon, 2005). The drawings of the participants and photographs taken during the study were part of the analysis, as a complement to the predominant focus on analysing the narratives from the studies.

4.2.3 Findings

Of method

Differences in the qualitative nature of the data elicited by the two generative approaches were noted; the enactment in the Setting the Stage method was more effective in evoking reflections on tacit and physical interactions than when relying on collages and interviews. The Setting the Stage method elicited reflections on the flow of interaction, at a more detailed interaction level than the collages, as the collages mainly concerned dimensions such as owning/sharing vehicles, how the cityscape would change, the types of benefits of autonomous driving and what the exterior of the car would look like. The collages also contained more abstract, "sci-fi" expectations, such as flying cars. In contrast, the

Setting the Stage method resulted in more elaborate reflections on trust and interaction, and on interior car designs. The simple representation of a car in the Setting the Stage method supported the participants to relate the physical space of the car, while still being free to ideate new solutions. The drawings generated by the participants worked as a means of encouraging reflection, imagination and engagement. It triggered the evolution of arguments and caused new reflections to arise, such as what activities the participant expected to be comfortable to engage in while in an autonomous car, how they expected the car to present (or not present) information and behave in specific situations. However, as the time spent with each participant was rather short given the spontaneous engagement and much more aspects could have been covered given that extended time could have been allocated to each session, such as spending more time on connecting the future use to their current everyday life. Also, the drawing with chalks was at times perceived as messy.

Of in-vehicle UX

The differences between the two methods showcased how different approaches result in covering different aspects, especially regarding the interactions taking place between user and car for understanding mental models of use. The Setting the Stage method appeared more useful in addressing this than the collages did. The study gave insights into emotions connected to autonomous cars, such as curiosity, fear of mode-confusion, delight in novelty and so on. The study elicited expected values of autonomous cars, such as being efficient or being able to relax during transportation, and also expectations on interactions, such as ease-of-use and stimulation through novel interaction. The responses ranged from the trusting and relaxed, such as: *"I'd use my phone when the car is driving itself. (…) There would still be a speedometer so that I can see that everything is normal"*, to participants who voiced concerns for using the technology, for example: *"This is scary! I'd feel horrified if I suddenly had to regain control after falling asleep in the car. I hope the car would warn me in good time, with powerful and clear indications"*.

As the focus of the study related primarily to exploration of method, and not outcomes, a decision was taken to make a follow-up study, using the developed Setting the Stage of Autonomous Cars method, for deepened insights of expectations on future autonomous car experiences.

Summary of insights, Study 2

The study served as a first exploration of activities, emotions, attraction and uncertainties in relation to autonomous cars, and especially understanding expectations on interactions.

Methodological approaches to elicit UX were tried out and the “Setting the Stage for Autonomous Cars” method was developed. The “Setting the Stage for Autonomous Cars” method’s simple elements of contextualisation by the “stage” were useful for providing a context, tapping into the future situation, but open enough to transcend the car use of today and address future use. Where no context was given (that is, the collages + interview) less interaction aspects were reflected on (for example mental models of use, flow of interactions and sensory aspects) and the responses were less personal and less connected to the use situation.

4.3 STUDY 3: REFINEMENT OF METHOD AND FURTHER INSIGHTS OF EXPECTATIONS OF AUTONOMOUS CARS (PAPER D)

4.3.1 Background

The research continued to pursue the domain-specific question of understanding users' expectations of autonomous vehicles. As Study 2 was based on brief meetings with possible future users, and mostly focused on understanding the methodological aspects of researching expectations, another study was needed to further understand what these expectations consist of, as well as improving the method developed. Thus, Study 3 researched the following questions: How can the method employed in Study 2 be evolved as to better target the individual, specific expectations of autonomous vehicles? And what do these expectations consist of?

In this third study a more deliberate choice of study participants was made, in terms of income and interest. The "Setting the Stage for Autonomous Cars" method from Study 2 was slightly evolved with the aim of improving the ability to derive in-depth information. The research was conducted at an automotive design office in the US during the process of developing a concept car for autonomous vehicles.

4.3.2 Method

The "Setting the Stage for Autonomous Cars" method was employed and expanded by incorporating a pre-interview where participants described their daily commutes today, to further ground their reflections in their own personal experiences (see Figure 12). They were also subjected to a more thorough interview/enactment guide, depicting a morning commute, where they described the steps from leaving their house in the morning, until arriving at work. Expectations on interactions with the autonomous cars were described and enacted by the participants, such as handing over control to the car.

Eleven study participants were selected as they were considered potential early adopters in an environment that requires a substantial amount of commuting (Los Angeles). The participants were firstly interviewed about their daily commutes, and then asked to imagine the same route in a partly autonomous vehicle and were encouraged to act out interactions and draw future interactive systems in the car. The study involved designers and market experts as note-takers in the sessions as well as in the analysis work. All sessions were videotaped, the audio was transcribed in full, and all drawings and rearrangements

Figure 12. "Setting the Stage" method in the second study.

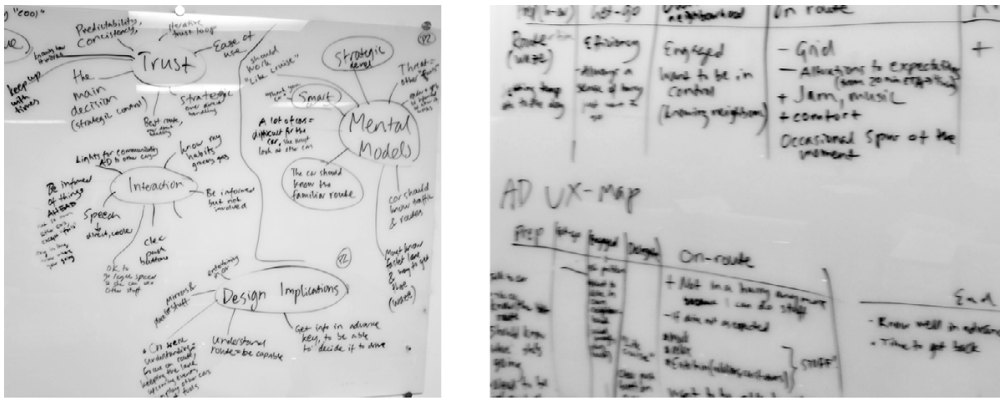


Figure 13. Summary example extract from one of the participants.

of seating were photographed for later analysis.
As the first step in the analysis procedure, the researcher and the note-taker (a designer, project leader or market intelligence expert) constructed a summary mind map on a whiteboard after each session. The summary board identified and summarised main themes in the session, such as values, emotions, expectations of use and trust (see Figure 13 for an example). Secondly, a detailed summary was later made from the transcripts, video observations and the photographs. The combination of the impromptu summary of the session and the detailed summary gave insights both from immediate impressions as well as more layered findings of spoken and observed data (this could for example be of how a participant described the physical actions of leaving over control to the car). Finally, the summaries from all participants were combined and the themes were reworked. There was a strict focus on experiential values, whereas findings regarding detailed expected activities and so on were not included in the final analysis. To make the findings regarding expectations more addressable in a design process, the themes were combined into a temporal structure, as it was found during the analysis that the themes could be related to different stages of experiencing autonomous cars.

4.3.3 Findings

Of in-vehicle UX

Through enactment of future interactions, the research elicited information about aspects such as the physicality of interaction; for example one of the participants described the physical sensation of handing over control to the car: *"When you hit cruise control you kind of feel the car jerk and start to go on its own* (…) *and I'm thinking when you do that (presses an imaginary button to activate autonomous driving) you need to feel it, a slow process so you can take your hands off the wheel…You probably want to wait a minute to see if it's doing what it's supposed to do. And once it earns your trust, you're in business!"* The car was expected to give cues of its state and intentions. Topics such as emotions connected to autonomous cars, mental models of interactions and values of autonomous cars were addressed. For example, nine main themes of value of autonomous cars were found, such as having more energy over for other aspects of life after the drive (see Figure 14).

Figure 14. Expected values of autonomous vehicles.

The daily multi-device environment was also addressed in this study, where in a typical narrative one participant showed how he used his laptop on the passenger seat during driving: *"I have my laptop with me so I can also pull off the road and do some quick heavy work like editing or big files that I can't do on the phone. And then I can get back on the road afterwards"* and further explained the difference autonomous driving would make in this busy scenario. The emotions during the transition between locations in Los Angeles were expected to become much more positive, as the driver would be left out of the loop and thus be spared the negative emotions that at times were connected with driving in the city: *"I think it* (autonomous driving) *is a boost, from a safety and nervous perspective, regarding emotions that are directly related to driving, anger due to somebody annoying you or cutting in front of you. If I'm doing my thing and somebody cuts me off, the car is programmed to do anything from stopping to slowing down. So in a sense as a "passenger" you're not concentrating, and the driver can become a passenger. You're not concentrating so you're actually more comfortable, it's the driver who usually becomes frustrated, but the car has no emotions and reacts exactly as it has to, while you as a passenger avoided that set of emotions"*. The participants expected an autonomous car to bring relief from this unwanted emotional engagement in the driving task, such as involvement in bumper-to-bumper traffic, to in the long run creating a better bridge between work and home life.

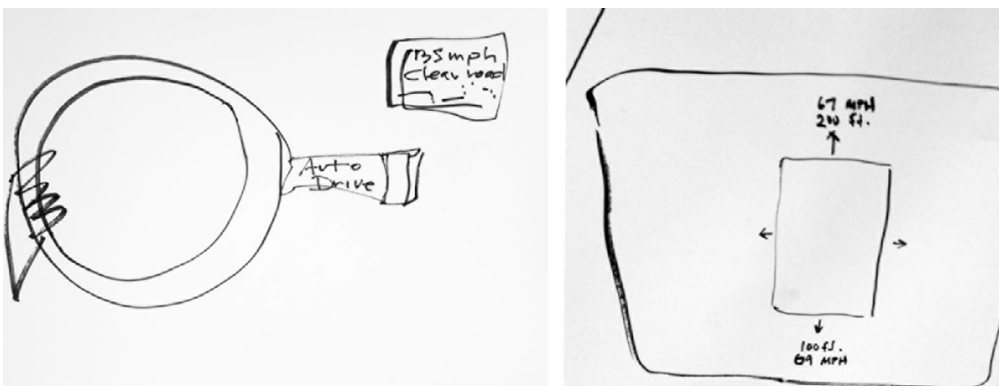


Figure 15. Driving information expectations differed between users, as exemplified by two participants drawings, one only wanted estimated time to arrival and one the exact distance to cars around her.

The research found that different participants had different levels of trust in the novel technology, as exemplified in narratives as well as in the drawings; two examples of participants' drawings are presented in Figure 15, where the left image describes a very trustful relationship with the car, primarily requesting information about estimated time of arrival, while the right image is drawn by a participant with lower levels of trust, wanting detailed information from the car regarding safe distances to other cars.

Based on the participants' narratives regarding expectations of the autonomous car, temporal themes of expectations were formed as a synthesis (Figure 16). In each sequence, differing experience attributes are predominant. In summary, the tentative model of expectations consists of three sequences:

1. The first sequence of the model includes reflections on getting to know the artefact, acquaintancing. In general, for autonomous cars this was expected to imply a novel (but not too futuristic) clean design as a clean slate on which to imagine tomorrow's more simple life. Acquaintancing was heavily influenced by social factors, such as friends talking about the technology or reading about it in social media. If the design was found to be attractive enough to make the user trust and want the artefact, this "want" would be the lever that would enable the next phase: becoming engaged in use.

2. Reflections of situated usage in an everyday-life context contained the expectations of ease-of-use, stimulation and building of trust in the artefact during use. This sequence included many reflections concerning the interaction with the vehicle. For autonomous cars the expectations concerned flawless, clear interaction, allowing the user to disengage in the vehicle and allocate time to other activities. Many described how they wanted very clear signals for being in autonomous mode, such as tilting of the steering wheel (see Figure 16). A successful use situation would then be the next lever into the final sequence – where the car result in long-term effects on the user's daily life.

3. The final sequence of practice and meaning transformations states how the artefact might make a difference to the user, in a longer time perspective. This is the sequence where the technology finds its final fit into everyday life if the value, identification and interactions with the product are perceived as satisfactory.

In short, it is suggested that the new car needs to successfully attract the user, fulfil expectations of usage situations, and finally make a difference in the user's life. The results were later used in a series of workshops with industry designers and engineers, to ideate concepts for autonomous vehicle interactions and interiors.

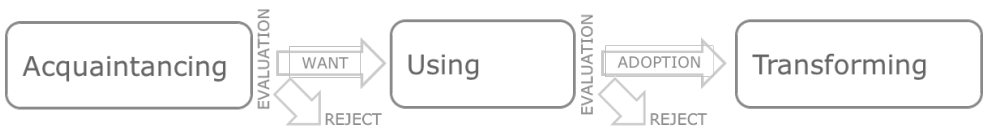


Figure 16. A model of UX expectations.

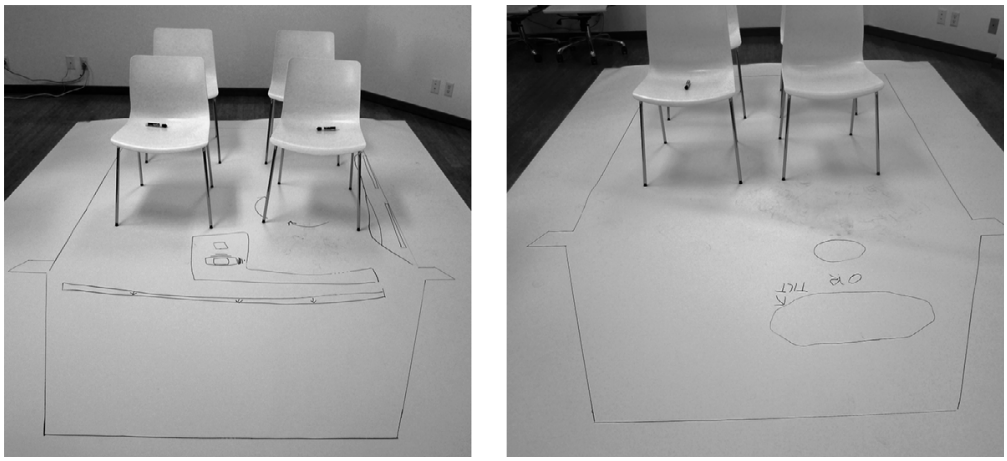


Figure 17. Drawings of a transforming vehicle interior when in autonomous mode.

Of method

The methodological approach was effective in eliciting reflections on future use, forming more than opinions or reflections detached from the personal (cf. Davidoff et al., 2007; Buskermolen & Terken, 2012). However, some of the participants found drawing more challenging than others, and further development of methodology where participants are additionally supported in the creative elements would be a possible development of the method. Future projections of experiences were narrated and enacted by the participants while still maintaining a tangible link to their personal situations and needs, for example how they expected to use the functionality in their neighbourhood and in their life/family situation. Starting the session with an enactment and interview of their current in-vehicle experiences was useful for anchoring responses in the participants' individual perspectives and sensitising the participants to talking about their own personal experiences (rather than opinions or what others might think). The stage for enactment was static (and not simulating driving as in a driving simulator), which may have influenced results, although many participants mentioned aspects such as expectations on the future cars' driving styles.

Though not specifically part of the research analysis, being in the industrial context as part of the early phases of a design project exemplified how important it is to both be rich in collected data, especially encompassing videos of expected enactments, and to make models, such as the temporal model, to inspire and inform design solutions.

Summary of insights, Study 3

The “Setting the Stage for Autonomous Cars” method was evolved and used to investigate users’ expectations on autonomous cars. The importance of situating the research in the participant’s own lived experiences was highlighted; sensitising the participants to their own personal data by pre-interviews was found to be important. Encompassing the full journey of a commute allowed for detailed experiences to be imagined and re-enacted. Enactment served as way to address multi-sensory aspects of in-vehicle experience, and drawings worked as a means of reflection during the research and offered an additional data source to make sense of the experiences.

In terms of in-vehicle UX, insights were made of the temporal nature of UX and formulated in a tentative model. Furthermore, insights of the expectations of value, emotions, meaning, multi-modal and physical aspects of the in-vehicle UX of autonomous cars were elicited.

4.4 STUDY 4: IDEATING INTERACTION DESIGN CONCEPTS FOR AUTONOMOUS CARS (PAPERS E-G)

4.4.1 Background

Study 4 addressed UX in the ideation design phase which takes place after the initial analysis, but before moving into detailed concepts. The aim of the research in study 4 was to suggest and explore ideation methods focusing on UX. This study also employed autonomous vehicles as a study case; as the relationship is changing between user and car with the increasing automation, designers are challenged to imagine novel interactions with the increasingly autonomous and intelligent technology. This imposes demands on methods to encompass the increasing agency of the system, where a much more mutual and dynamic relationship is forged. How users will react and behave in novel situations, such as handing over and receiving back control of the car, or pedestrians' interactions with the autonomous vehicles, need to be researched. Researchers such as Höök (2000), Dove et al. (2017) and Schmidt and Herrmann (2017) have called for new design methods for addressing products with an increasing agency. The question posed was thus: what constitutes fruitful and experience-focused ideation approaches in the early design phases of future, intelligent technology?

The methods were required to function in very early design processes, intended to bridge the wide gap between analysis and synthesis (cf. Dubberly & Evenson, 2008) by providing support in suggesting and exploring future experiences with novel, increasingly intelligent products.

Table 4. Overview of the three workshops.

	Workshop 1	**Workshop 2**	**Workshop 3**	**Workshop 4**
Context	Sweden, at an interaction design conference (NordiCHI16)	Sweden, at an automotive research and industry collaboration arena	US, at an university design research centre	UK, at an interaction design conference (DIS17)
Particpants	3 groups, in total 18 participants from industry and academia	2 groups, 6 participants from industry and academia	3 groups, 10 participants, from academia	3 groups, 11 participants, from academia and industry
Method	Enactment in mock-up of car, WoZ and small-scale scenario, design metaphors	Enactment in mock-up of car (setting the stage method) in combination with design metaphors	Enactment in mock-up of car (setting the stage method) in combination with design metaphors	1) Enactment in mock-up of car 2)Enactment and lo-fi prototyping in a lo-fi driving simulator 3)Small-scale scenario 4)Design metaphors

4.4.2 Method

The study approach was open and exploratory, and a number of early design methods were chosen and applied for exploring the ideation of future experiences. The methods During a series of four workshops (see Table 4) successive learning and adaption of the methods was enabled. The methods were selected and evaluated by their ability to address possible future experiences and to disrupt the current assumptions where needed. Since the study focused on understanding whether the methods help the design team to imagine and conceptualise designs of autonomous systems, the study participants were all designers and researchers with experience related to user experience of in-vehicle systems, for instance interaction design or ethnographic studies of vehicle use. In all the workshops, the participants worked in groups to develop an interaction design concept for an autonomous vehicle. There were minor differences between the workshops as the setup had to be adapted to the preconditions, but the structure remained similar throughout Study 4. The provided methods and tools for the design session are described below.

Metaphor cards: a set of ideation cards were given to the participants (see Figure 18), as well as blank cards to encourage new metaphor creation. The design metaphor cards each described a metaphor for potential vehicle-human relationship, such as previously employed metaphors in the field; for instance husband (Ju, 2015), horse (Flemisch et al., 2003) and team-player (Davidsson & Alm, 2009). In order to focus the activity, the metaphors were all describing the human-system interaction paradigm (and thus not for example addressing the system at higher level, such as sharing cars). The included metaphors were orchestra/conductor, horse/rider, team player, husband/wife, relay racer, driving teacher/student, supervisor/student, machine/operator and chauffeur/client. For workshops 3 and 4, the following were added: elevator/occupant, butler/master, dog/owner, autopilot/pilot and seeing-eye dog/owner.

Enactment techniques: In all the workshops, the "Setting the Stage of Autonomous Cars" method was used. The mock-up consisted of four chairs and the outline of the car drawn on paper covering the floor or using lines made of sticky tape (see first image in Figure 19). The workshops continued to develop the method, for example also including multiple users and including more props for envisioning use of the vehicle. In the fourth workshop, two further enactments were available: a small-scale road scene constructed using a play-mat with a map and toys representing cars and pedestrians (see second image in Figure 19), and a lo-fi driving simulator, constructed of a projected film of driving scenarios, and a simple foam board mock-up of a cockpit (see the third image in Figure 19). The lo-fi simulator and playmat overview were included in order to understand if contexts that encompass more of dynamics of the driving context would be a useful complement or alternative to the less contextual enactment scene.

Wizard of OZ: A Wizard of Oz set-up was employed in workshop 1 as a way to explore future situations with autonomous vehicles and pedestrians. The actual driver and steering wheel in a right-hand drive car were covered by an costume that resembled a car seat, making the car seem driverless (see Figure 20). The vehicle was driven around a block, and the participants, acting in the role of pedestrians, were asked to interpret the intentions of the vehicle and make decisions accordingly to cross the road in its presence. This was purposefully set up to trigger the participants with practical experiences and aid the creation of new models of what could be (cf. Dubberly & Evenson, 2008).

Prototyping material: In addition, paper, cardboard, and pens were provided for all, in order to make simple mock-ups for interface elements.

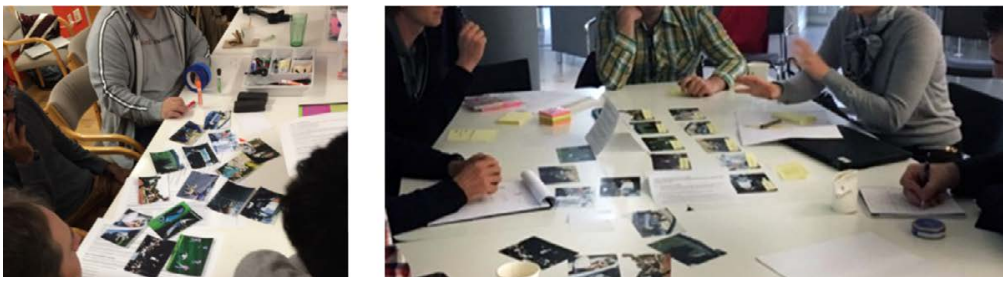


Figure 18. Metaphor cards in workshops 3 and 1.

Figure 19. Setting the stage in workshops 3 and 4, small-scale scenario in workshop 1, lo-fi driving simulator in workshop 4.

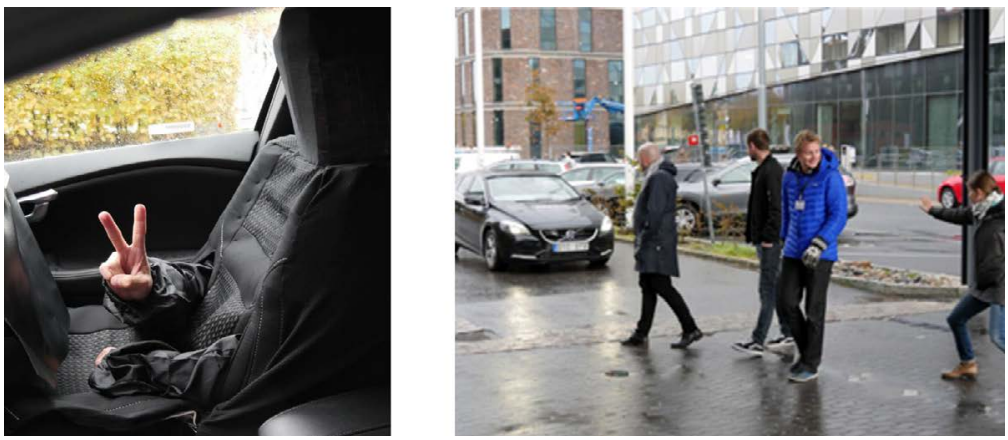


Figure 20. WoZ method in workshop 1, where a hidden driver perfromed the "autonomous driving" (courtesy of RISE Viktoria).

The first workshop divided the participants into three groups, where one team used WoZ and small-scale scenarios, one team the "Setting the Stage for Autonomous Cars" method, and one team used design metaphors. In the following three workshops the scheme was slightly adapted, allowing the teams to use two or more techniques (see Figure 21), but leaving out the WoZ set-up for practical reasons. After all sessions, groups discussions were held with all participants, with the aim to reflect on the suggested concept and value the respective methods.

For the analysis, notes from the workshops and video recordings were gathered in a spreadsheet, where information from the individual groups and general discussions were structured according to metaphor choices, evoked discussions, created interaction designs and so on. A thematic analysis was performed by several researchers, utilising affinity diagrams (see Beyer & Holzblatt, 1999; Hanington & Martin, 2012), to map out and group the general outcomes and insights from the methods. The methods were evaluated, both based on the participants' own reflections on positive and negative aspects, and based on the methods interpreted ability to derive and evolve concepts that addressed user experience of novel, intelligent technology as encompassing context, bodily reactions, emotions, value, the perceived relationship with the technology, addressing communication between user and car.

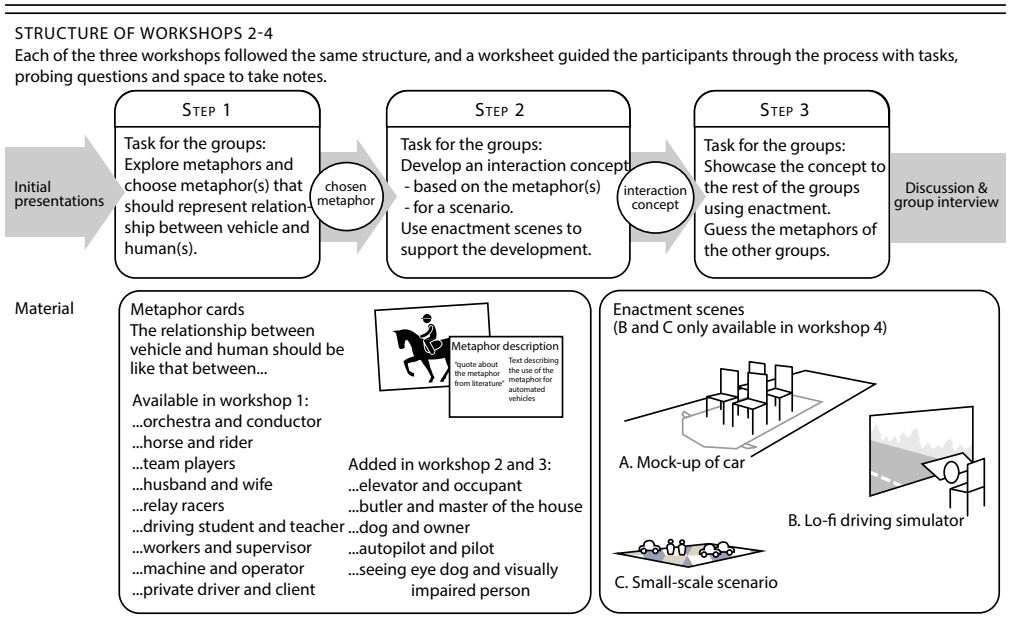


Figure 21. The structure, material and participants of workshops 2-4. Illustration by Strömberg.

4.4.3 FINDINGS

Of in-vehicle UX

The concepts that emerged were of different types and qualities, representing different aspects of in-vehicle experience. Many of the concepts held qualities that deserve to be explored further, for example a haptic seat for communicating the car's intentions, and a haptic steering wheel that responded to unsafe use to avoid mode confusion (see Figure 22 for a summary of concepts from workshops 2-4). The imagined relationship with the car surfaced, which was perceived differently by different teams. For example, one group in workshop 4 expressed their concept as *"the butler* (metaphor) *has a very clear hierarchy, but the car is also your friend. So, we made a talkative machine, this whole idea of a friendly machine, a friend in the car"*. In contrast to the vehicle inviting involvement and "small talk", another group in the same workshop proposed a different approach, where the "Snarky Car" instead denied involvement through very decisive interactions, like the steering wheel spinning away from the user *"it would kind of be like snatching your hand, like - don't touch me!"*. Through enactments, these experiential aspects were very precisely communicated. The workshops directed attention to experience aspects such as multi-modal interaction, emotions, ease-of-use and also topics such as hierarchy and trust surfaced. Several concepts addressed how to support trust by providing a sense of the car looking after the passengers in tricky/unexpected driving situations, and simplifying the interaction between car and user.

Of method

In all four workshops, the methods supported the teams (in varying degrees) to evolve from the conceptual to the more concrete. However, there were discernible differences in the way the methods worked. In particular, the enactment and the small-scale scenario provided a space for a group of developers to improvise and establish a common focus and shared ownership of a future design, used to rapidly move from the conceptual/high level to designing the concrete interactions. The results resonated with previously concluded strengths with such methods (cf. Davidoff et al., 2007; Odom et al., 2012; Buchenau & Suri 2000), where the contingent interaction between user and system could be dealt with, as well as the ability to introduce and reflect on contextual factors affecting the use of the system. The enactment as well as the WoZ method appear useful in supporting collaboration across disciplines, for instance by creating common goals and understandings of concepts and scenarios. However, when exploring scenarios that encompassed larger time frames of interactions (such as scenarios that condensed learning to use the system over several weeks), the methods were less adequate for effectively addressing UX, as discussions and concepts became imprecise. Also, when no contextualisation was offered (such as for design metaphors used alone), ideas became less evolved. For the design metaphors used alone, the discussion was marked by strong opinions regarding safety and cognitive ergonomics, and did not succeed in securing as much collaboration between team members. As for the lo-fi simulator, it was perceived as too inflexible compared to the simple car mock-up; *"it's more imaginative and less restricted by technology"* one of the participants explained. The simplicity and flexibility of the simpler enactment scene was appreciated by the participants. The moving context did not considerably contribute to further elicit in-vehicle UX, other than it probed participants to consider interactions and experiences that covered more of the journey than the more isolated instances of interactions in the static scenes.

	CHOSEN METAPHOR	FOCUS OF IDEATION	FINAL CONCEPT		
GROUP 1	Horse	Relationship dimensions - Level of involvement - Companionship and trust - Physical interaction Chosen scenario Every day commute to work		Car invites involvement and communicates certainty through driving behaviour (mimicking horse calling for attention, or resisting command). User uses steering wheel to give haptic input and pats car to communicate approval, developing companionship.	WORKSHOP 2
GROUP 2	Shape-shifter	Relationship dimensions - Learning & mutual adaptation - Trust Chosen scenario Early adopter getting to know new car, over weeks		Car welcomes user and gives voice-based instructions on its use before first take-off. During trips, car offers assistance and asks for preferences re interactions and modalities though voice and head-up display, learning over time.	
GROUP 3	Trust fall	Relationship dimensions - Trust through mutual understanding of situation - Physical interaction Chosen scenario Themselves in snapshot situations: steep hills, roadworks		An experience of a car "ready to catch" user through car seat physically "hugging" user in sensitive situations, and signalling sensed obstacles through haptic feedback in the seat.	WORKSHOP 3
GROUP 4	Snarky robot	Relationship dimensions - Trust through clear hierarchy - Physical interaction Chosen scenario Snapshot: Waking up from sleep, car denying user control		Car is more capable than human and stands up for itself through strong or weak haptic force feedback of steering wheel when driver is unfit to drive.	
GROUP 5	Repairer (of relationships)	Relationship dimensions - Trust - Efficiency versus safety - Personalization Chosen scenario Snapshot: After take-over situations		Car invites user feedback after take overs for the car to learn its user's preference between efficiency and safety margins (the user taps a green, orange or red field on a an audio-visual interface to "rate" a take over).	
GROUP 6	Guide dog + Kit from Knightrider	Relationship dimensions - Negotiation through physical interaction Chosen scenario Two scenarios: Take-over situation and pedestrians close to road		Using a haptic pedal, car signals to user when actions (e.g. overtaking) are unsafe by resisting. User can override car's decisions in some situations by pushing more forcefully on pedal or steering wheel.	WORKSHOP 4
GROUP 7	Elevator	Relationship dimensions - Trust - Ease of use Chosen scenario Hospital trip using a service for the elderly		Car adapts to user via phone-connection, visually presenting simplified choices on a touch screen, like the buttons of the elevator, and audio signals to give feedback.	
GROUP 8	Butler	Relationship dimensions - Friendliness - Hierarchy - Negotiation Chosen scenario Family trip, going to the airport		Car anticipates needs of users, listens in to the conversation and is there for you. Friendly atmosphere created though social seat placement and friendly voice-based communication, car also takes input via gestures, e.g. "go that way".	

Figure 22. Overview of concepts in workshop 2-4. Illustration by Strömberg.

The methods furthermore had different abilities for addressing the context and for triggering ideas about the relationship dimensions between car/user. By experiencing the WoZ car in a real-life traffic situation, the participants acquired an understanding of the social interplay and of reactions to autonomous cars. Continuing to the small-scale scenarios, the helicopter view of the encountered scenario also helped to map out the different stakeholders' perspectives of the scene, as found in previous research (such as Broberg et al., 2011). This was lacking in the case of the design metaphors, where a more one-sided discussion prevailed, mainly focusing on the driver and safety aspects.

In the cases where multiple methods were used (such as the combination of WoZ and small-scale scenarios), this further helped to support developments of concepts. The different methods triggered different modalities used for interaction in the concepts. *"It was good to have the metaphor and also all these* (enactment scenes) *because it helps you to discuss the different levels, you go from the details to the more abstract...and the metaphors helps you to take on the scenario in different levels. It expands the design space* (…). *It was like the diamond model, you go back and forth..."*, one participant verbalised the use of several methods. The free form of enactment in a simple car mock-up, in combination with simple props, helped the participants to exemplify and communicate the aspects of interaction designs that are difficult to put into words, such as the bodily and emotional response to haptic feedback in a seat, steering wheel or pedal (see Figure 19). The design metaphors used on their own did not have this effect.

Based on our experiences from the workshops, where techniques were combined to create concepts that were lo-fi but yet often very experientially precise, nine concluding guidelines were formulated for the use of metaphors and enactment together in the design of intelligent systems:

1. Set a reasonable scope for the scenario in terms of time scope of the interactions explored, futurism, and evolving relationships.
2. Explore a number of metaphors before selecting one to help find your assumptions and draw the design space.
3. Chose a metaphor that is known and easy to relate to.
4. Include potential for drama in the metaphor and/or scenario, as this is when the new relationship dimensions surface.
5. Use enactments early in the activity, to become concrete when designing the interactions.
6. Consider the dialogue/flow between the user and system. Designing for autonomous technology requires focus on the communication, i.e. not singular patches of information transfer.
7. Use "props" in the enactment to elicit physical interactions; in other words, introduce objects that may be part of the interaction itself and/or the environment.
8. Keep it tangible and consider the full palette of modalities that are available for interaction.
9. Invite others try to out the concept ideas in the evaluation enactment – not enacting only for yourselves means even more pressure to become clear, challenge ideas and find the most agreeable path of interactions.

The research contributed to understanding how approach experience-focused ideation. By making use of the resulting insights and guidelines from the workshops, attention may be directed to the highly contextual and multi-sensory aspects of future designs.

Summary of insights, Study 4

The study explored experience-focused ideation. The ability of the methods to offer contextualisation, for example by enacting scenarios and bringing in tangible props was important in order to effectively elicit UX. When no contextualisation was offered (such as for design metaphors used alone), ideas became less evolved. Elicitation of experience require focus on multi-sensory aspects and the communication between car and user and this was especially present in the activities including enactment (i.e. the “Setting the Stage for Autonomous Cars” method), together with props for creating a sense of context. It was also found that using multiple methods in iteration was effective for making design ideas more concrete and evolved. Having said that, careful balancing is needed between excessively open-ended approaches and too specific and directed ones, in order to effectively probe into user responses and interactions with the technology. The research suggested a combination of enactment and design metaphors to address the design of intelligent systems.

The importance of multi-sensory aspects of in-vehicle UX was once again highlighted, as well as the importance of supporting trust and the ability of both the system and the user to adapt to each other’s capabilities.

4.5 STUDY 5: INVESTIGATING HOW PRODUCT REPRESENTATION AFFECTS UX EVALUATION OUTCOMES (PAPER H)

4.5.1 Background

The fifth study addresses the evaluation of UX during early design phases and in specific the consequences of product (or system) representation type in the evaluation session. Whereas a number of studies have investigated how the choice of product or system representations impacts the outcome of usability trials (such as Kim et al., 2006; Sauer et al., 2010; Sefelin et al., 2003; Virzi et al., 1996), systematic comparisons of the influence of representations used in evaluations with a UX focus are scarce. A novel, connected, intelligent automotive infotainment system concept (containing entertainment functionality, navigation and vehicle settings) was employed as a case study. The concept was developed in a joint research project between industry and academia, building on research into what constitutes valuable, positive experiences in cars (Gkouskos et al., 2015), and a series of ideation workshops between interaction designers, software developers and researchers. More specifically, the system aimed to help the user stay socially connected to others during the drive, with simplified interactions for the ability to automate or suggest infotainment and scheduling activities. The user study investigated the users' perceived UX of the concept, as well as the influence of representation format. The question posed was: how do elicited UX data differ when employing a storyboard depicting the product in a user study, to when employing an interactive prototype of the same system?

4.5.2 Method

Two types of representations, a storyboard and an interactive prototype, (see Figure 23) of the same system were employed in a user experience evaluation to investigate how different representation formats influence participants' responses to interactive systems. The representation formats were chosen as both storyboards and interactive prototypes are two commonly used formats for early stages of the design process. The study encompassed a total of 24 participants in a between-subject study design. In order to form a common basis for all participants, the basic functions of the system and how it could be manipulated were first explained. The participants were then instructed to independently read the storyboard (Group A) or explore the interactive prototype (Group B) for as long as they desired. Directly after experiencing the product representation format, a questionnaire was handed to each participant. The questionnaire contained eight Likert-statements to which the participants had to indicate their level of agreement. Three of the items were adopted from the UX curve method (Kujala et al., 2011), with the intent to cover generic elements of user experience, namely attractiveness, ease of use and utility. An additional five items were added to capture the intended specific user experiences: the process of preparing activities next in life, simplifying daily routines, being socially connected, identification with the system and perceived stimulation from using the system.

In the structured interview following the exploration, the same questions were posed in the same order to each participant. These questions concerned valence, i.e. the participants' impressions (positive and negative) of the concept, how the participant imagined it would be to use the system, if it would support them in daily activities, and if it would fit their self-image. In addition, the participants were asked if there was anything they would like

Figure 23. The interactive prototype and the storyboard.

to change about the system and its design. The qualitative analysis included the coding and sorting of narrative data, in a combined top-down and bottom-up approach; that is both constructing novel themes where needed and checking for previously used experience themes in literature concerning formative UX evaluation (cf. Buskermolen et al., 2015; Özçelik Buskermolen et al., 2012); that is to say contextual aspects, emotions, reflections on personal aspects and design proposals.

4.5.3 Findings

Of method

The study emphasised that product representation needs to be chosen as regards which aspects of experience are intended to be investigated, as the two studies resulted in very different elicited UX data.

For the questionnaires, the concept as described by the storyboard was given consistently lower ratings than the concept represented by the interactive prototype in all aspects except ease of use. However, no statistically significant difference could be found except for one item: "I feel that this concept would make me feel more in contact with those people who are important in my life", which was rated higher for the interactive prototype. In the qualitative data, there were however more striking differences to be discerned. First, there were different UX factors that surfaced in the participants' narratives in response to the respective representation; the storyboard narratives addressed mostly temporal, contextualised issues, while the interactive prototype narratives focused mostly on personal, visual and interaction issues. Second, the overall impression of the system differed in the respective verbalised judgements of the system; the system represented in the interactive prototype was received much more positively than that in the storyboard. The participants' own acts when trying out the interactive prototype appeared to more effectively elicit their personal reflections; the participants were able picture themselves as the user interacting with the system, and this had a direct effect on the richness of elicited user experience data as they were able to draw upon, and share, previous personal experiences that they deemed relevant. For example, one participant said *"I would like it very much. For me, I'm a salesman and I use my cell phone, my computer, my tablet all the time so it would suit me very well. It would fit my image"*. However, the participants were not sufficiently able to address contextualised use

over time in order to envision a whole experience with the (future) system. The storyboard provided participants with a complete story that included context, assumed benefits, and a specified user. As a consequence, the participants focused their comments on these factors – but they did not appear to be able to identify themselves as an intended user. Negative responses concerned perceived distraction and loss of integrity due to the system design, aspects that were virtually not addressed at all for the interactive prototype. For example, one participant voiced concerns wen commenting the storyboard; *"The brain of this CEO is not focused. Maybe the system is so smart it knows what's safe... but what does it do to her? Is she able to make wise, informed decisions?"*. For the interactive prototype, the underlying use of personal data to inform the system was less clear to the participants, and thus had less negative responses regarding privacy and control.

Of in-vehicle UX

In the study, neither representation provided responses corresponding to what could be expected from the experience of a finished product, for example including more detailed information concerning emotions, value and behaviours, as this is difficult to reproduce before the experience is actually lived by the final users.

Related to the research question of in-vehicle UX, the study highlights UX aspects such as the influence of context (especially in relation to distraction while driving), aesthetics, multi-modality and level of identification with the product. Privacy of shared data and the possible unsettling aspects of intelligent technology was also highlighted in this study, to a higher extent than the previous studies.

Summary of insights, Study 5

The study emphasises how UX elicitation practice will affect results and that representation of product in the study matters. When the participant could identify as the intended user and acquire a hands-on experience with the system, i.e. not only receiving information but being able to act, more reflections were narrated. A second-person perspective as in the storyboard appeared to make the participants distance themselves from the system and fewer personal reflections on experience were verbalised. However, the context was made more explicit to the participants that experienced the storyboard, and more elaborate feedback on the use of personal data and user control was gained.

The study highlights in-vehicle UX aspects such as the influence of context, pragmatic aspects such as ease-of-use, modality of use and distraction, but also aesthetics, identification, privacy and user control. The study emphasises that product representation needs to be chosen as regards which aspects of experience are intended to be investigated.

4.6 STUDY 6: INVESTIGATING HOW STUDY CONTEXT AFFECTS UX EVALUATION OUTCOMES (PAPER I)

4.6.1 Background

Context is an important part of UX. Roto et al. (2009) point out that early input will aid designers in improving concepts, but that the available methodology most often lacks the important contextual elements. Rebelo et al. (2012) propose that *"VR, because of its characteristics, and when framed in adequate methodologies, can be useful in creating and controlling contexts of use that can represent real-life situations while assuring ecological validity, which is a key aspect in the evaluation of UX"*. The final study deals with the effects of virtual contextualisation in the evaluation of in-vehicle system user experience. UX evaluation may be supported by access to virtual context when the real may be unavailable, and this study addresses how UX data was influenced by employing a virtual context. Is there a difference in how participants experience the in-vehicle systems? If so, how? And why? This study explored the consequences of employing a virtual evaluation in relation to a real-life UX evaluation, by comparing results from user experience (UX) evaluations of the same in-vehicle systems studied in the field and in VR. In addition, the study employed a multi-method approach and further tried out techniques for eliciting stories of experiences.

The study case was yet again intelligent functionality in the car, this time a semi-autonomous adaptive cruise and lane keeping system and an infotainment system. Semi-autonomous systems may be subject to mode confusion (Lee et al., 2014) and steep learning curves (Wu & Boyle, 2015) and this study contributes knowledge of the experiences connected to these systems.

4.6.2 Method

In order to investigate if there is a difference in how participants experience in-vehicle systems depending upon context, the study was undertaken in several steps (see Figure 24). Firstly, a pre-study investigated eleven participants' UX responses to the same in-car system across different study contexts, leading to an improvement in the VR system as well as modifications to the study methodology for a main study. In the main study, the same in-vehicle systems were evaluated in the field and in the improved VR environment, in a between-subject study with 32 participants.

The in-vehicle systems evaluated consisted of a touch-based infotainment system, a digital driver information display, a head-up display (HUD) and a system for semi-autonomous driving, activated from steering wheel buttons (see Figure 25). The VR system enabled experience of interaction both with the in-vehicle systems, as well as a driving environment (to a certain degree). A lightweight and interactive desktop setup

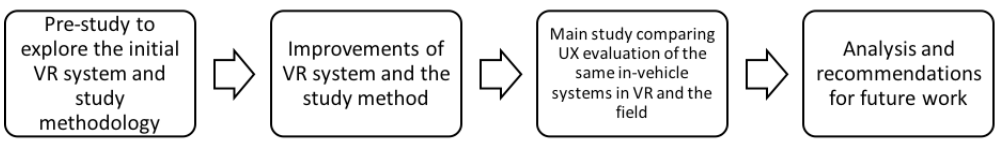


Figure 24. Overall study approach in Study 6.

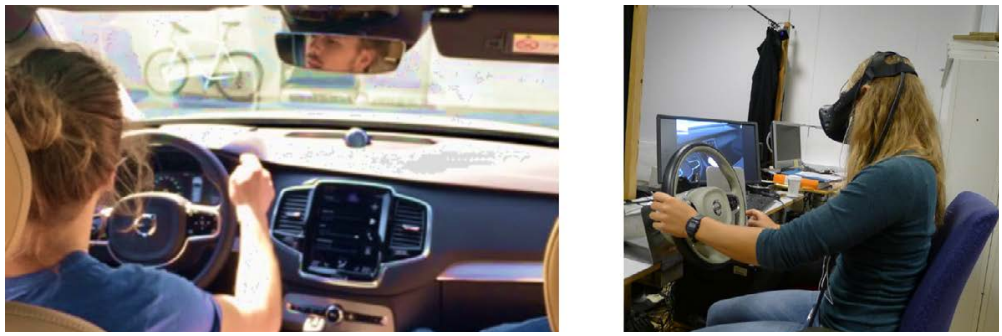


Figure 25. The field study context and VR study context.

was developed for tactile feedback in the VR environment (see Figure 25). The steering wheel buttons used to interact with assisted driving functionality were connected to the 3D environment with visual feedback for the functions. The user could apply steering to enter and exit traffic, as well as give input to the semi-autonomous driving system from the steering wheel. An inductance steel plate was used to represent the touch-operated infotainment screen and could detect touch events and manipulate the contents of the display in virtual reality.

In order to collect data in the main study, a mixed method approach was applied, with methods for quantitative and qualitative data. Just as in Study 1, reflexive photography (Harrington & Lindy, 1998) was used before the interview, where participants were asked to take photographs reflecting their current in-vehicle experiences, and a pre-interview concerning their daily experiences was held. Think-aloud methodology (Jaspers et al., 2004) was employed during the session and video recordings were used to collect data on user behaviour that could further aid in understanding the participants' experiences. Behaviours such as difficulties in interaction with the in-vehicle systems, and behaviours in the VR context, such as trying to touch elements of the cockpit that were not physically represented, were noted. After the interactions, emojis were used to elicit the initial emotive reaction to the in-vehicle systems; the participants were asked to select two emojis (using an iPhone 5, SW 5.2) to represent their emotions when experiencing the in-vehicle systems. Quantitative data was collected by means of two different types of questionnaires. First, data on the participants' experience of the in-vehicle systems was collected by the UEQ questionnaire (Laugwitz, 2008). Secondly, to assess the participants' experienced presence in the VR context, an 11-question excerpt of the ITC-Sense of Presence Inventory (ICT-SOPI, in full 38 questions) (Lessiter et al., 2001) was presented to investigate the level of immersion in the VR. The qualitative data was once again analysed in terms of content analysis, and the quantitative with descriptive statistics, significance test (Mann-Whitney U-test, Siegel & Castellan, 1988) and a correlation analysis of the experienced presence and UX ratings (Spearman rank correlation coefficient, Siegel & Castellan, 1988).

4.6.3 FINDINGS

Of method

The study indicates how much the study context impacts the results. As previously addressed in other research (for example Jambon & Meillon, 2009; Lallemand, 2015; Meschtscherjakov et al., 2011), the context of a user study matters, and the findings of the study indicated that VR is clearly no simple, all-embracing solution to the problem of lacking use context early in a design process, but it may offer one way of approaching user responses to early concepts.

Compared to the VR environment employed in the pre-study, in the main study more elements of actual driving were incorporated, which appeared to work better for eliciting more experiential data concerning the user experience of the in-vehicle systems. Although improved, the VR system continued to have a poor resolution capacity for the more detailed interactions, which negatively affected the experiences also in the main study. The most commonly selected emojis for representing the user experience in the field were the smiling face with heart shaped eyes (5), smiling face with sunglasses (6) and the heart emoji (3). For the VR, the emojis were more neutral; the slightly smiling face (7), the face with open mouth (4) and the thinking face (4). This was mirrored by the much more strongly verbally expressed emotions (mostly positive) in the field, as compared to the more neutral judgements on hedonic qualities in the interview data from the participants experiencing the in-vehicle systems in VR. The differences were mainly due to the physical experience of driving the vehicle with the semi-autonomous driving system for the first time in real life; participants were awed, and the think-aloud revealed many emotions, for example one participant said: *"…I'm in heaven right now. It is a phenomenal car* (…) *it's gorgeous"*. In VR, few such strong expressions were used. The experience of the semi-autonomous system in the real car was very tactile and dependent on aspects such as lane positioning and contrasted to the linear experience in VR: *"The movement is too linear to feel real, you don't get the dynamic car experience. I felt like I was being pushed on a trolley"*. Furthermore, in VR there were fewer re-design proposals for the UI. One participant expressed the reason as follows: *"I was so distracted by being inside the virtual reality, I couldn't think about that* (design proposals)". It was clear that it was required to allocate enough time in the context to overcome novelty effects. There was furthermore a strong tendency to communicate less overall during the sessions in VR compared to in the field.

The work also highlighted difficulties with employing generic UX questionnaires; the UEQ questionnaire was experienced as difficult to understand and answer by many participants, and questions arose concerning wordings and their meanings. No significant differences were found between questionnaire data in VR and the field.

Of in-vehicle experience

The study did not only feed into the continuous work of improving the VR study context, it also contributed to understanding experiences of in-vehicle systems. The many comments of the real car's lane keeping and decision making, or the trolley-like movements in VR, showcase how much the movement patterns of the car matters for the user experience. Also, the accumulated use time was found to be very influential for the resulting experience.

Summary of insights, Study 6

The elicited UX data differed between the same in-vehicle system, experienced in two study contexts (VR and in the field). VR gave more comments on a general level, whereas in the real context, more narratives of emotions and reflections on aesthetics, emotion and design proposals were made. The research highlighted the importance of the sensory, multi-modal aspects of in-vehicle user experience. Think-aloud and efficient communication with the UX study participants are important in order to understand their experiences, and there is a need to evolve this in VR.

Introducing more interaction in the VR context in the main study compared to the pre-study contributed to a more effective environment of eliciting UX data and the results once again point to the importance of being able to act in the evaluation situation to elicit UX data.


VIVE

05 | FINDINGS

A number of recurring methodological approaches that was considered to support the elicitation of UX data were identified in the cross-study analysis, as well as an aggregated understanding of in-vehicle UX. In this chapter, firstly the findings concerning in-vehicle UX will be reported, followed by the methodological findings. A summary of findings will be provided last, in table 5, section 5.3.

5.1 UNDERSTANDING IN-VEHICLE UX

As a basis for understanding what signifies in-vehicle experience, UX is interpreted as a holistic and multi-layered concept (see the conclusions in 2.4). The narratives in all studies stretched from overarching, large concepts, such as the perceived general value of the in-vehicle systems (for example as how the car did or did not correspond to expectations of quality and functionality), to more personal and specific stories (such as of how the tightening of a seatbelt in steep curves could result in positive emotions and attachment to the car). Learning from the studies, some experiential factors were in particular found to be very determinant to the in-vehicle experience, extending beyond pragmatic usability.

Firstly, the *multi-device and social context* was imperial in shaping the in-vehicle experiences. How the ecology of in-car technology enabled or obstructed social interactions largely influenced the user experience, as well as how the in-vehicle technology was compatible with and able to fulfil expectations transferred from other devices. In Study 1 and in the initial interviews in Study 6, there were many narratives as well as photographs taken addressing the multi-device experiences (see Figure 26), for example the fluid movement between different places and devices while listening to music. One participant phrased it as follows: *"It is almost easier to say when I do not use Spotify. When I wake up, I connect to the Apple TV, when I leave the house it automatically connects to the car and the same music is now in the car* (…) *When I arrive at the office I put on my headphones and continue."*

Figure 26. Photo by a participant in the Study 6, depicting UX in his car, influenced both negatively and positively by the multi-device environment.

Figure 27: An image selected by a participant in the Study 1 of Yuri Gagarin, representing his in-vehicle experience, and the personalised driver information for another participant in the same study, to fit the sportiness she felt represented the car as well as herself.

Driving with company in the car included different types of strategies for using and experiencing the in-vehicle space, such as avoiding disrupting sounds in the car or keeping children busy by giving them tasks in the infotainment system (such as selecting tracks for a playlist). Connecting to others through in-vehicle systems was generally felt to be very important and formed strong habits for the daily commute, such as calling family members on the way home from work. The in-car experience was found to also expand into the home and work-life of the participants, as they often used the car app on their phone to check on the car's status, or simply to show friends and family the functionality.

The time spent in cars was for many people also a time to be private and in their "own bubble". Participants retold experiences of inhabiting the *personal space* of the car, for example singing wildly along to the radio or using the time alone to silently think and reflect on the day. Other examples of inhabiting the space, making it one's own, were changing the graphic interface of the digital driver information system so that different

family members could use their chosen design, or to emphasise their personal meaning of the car (such as representing exploration, adventure or sportiness, see Figure 27). Thus, the in-vehicle experience was often connected to the car as being a highly personal space.

Connected to the personal space aspect was the notion that in-vehicle UX contained different types of experiences depending on goal and context. In Study 1, four main themes were identified:

- Mental) transition, e.g. using the in-vehicle system to transition into work-mode by placing work calls in the car during the morning commute, relaxing with music on the commute home.
- Relatedness to others, e.g. using the systems to connect to others by routine calls to family members, or jointly making music playlists on holiday driving.
- Stimulation, e.g. discovering and enjoying new functionality in the vehicle.
- Caretaking, e.g. enjoying and finding security in the car looking out for one's best.

There was thus no single, overall "experience" as the nature of the experiences changes depending on the overall goal for the time spent (such as being social, effective or adapting one's mind-set from work to home). *Emotions* were often highly present in the participants' stories, such as the joy of singing along or enjoying music by oneself, or the stress and anger that traffic might induce: *"Every time I get into the car it's a hurried feeling. It's like - everybody in South California - move out of my way!"* Emotions like theese were fleeting and interchangeable, depending on context and the mood of the user. Connected to emotions and types of experiences are also the perieved *values* of the in-vehicle systems. In Study 2, the values of an autonomous car were collected (see Figure 28). These values also resonate with the findings in Study 1, although provided to a different degree, by less autonomous systems.

It is important to point out that as autonomous technology is introduced, the changing *relationship* between car and user needs to be acknowledged for in-vehicle UX. The increased intelligence and agency of the car drastically transform the in-vehicle UX and need careful research. This changed situation was addressed by many of the study participants in Studies 2 and 3 (of high levels of vehicle automation) as well as in Study 6 (of a semi-autonomous car). Results showed that important needs included being aware of the car's mode (in other words, if it is the user, or the car, that is control of driving), intentions and capacity. Using the full palette of the car's modalities should not be overlooked in a design process.

Figure 28: Expected values of autonomous vehicles.

Figure 29. A participant in Study 3, explaining her UX expectations on handing over control to an autonomous vehicle as highly dependent on physical sensations of feeling the car taking control by a change in movement pattern.

The in-vehicle experience was also heavily dependent on the *sensory aspects and multi-modality* of car use. For example, in the case of experiencing use of in-vehicle infotainment systems, the need for several interaction points was mentioned (such as interactions from steering wheel, from centre stack displays and through voice operations). The study participants often mentioned the physicality in-vehicle experience, such as experiencing a tightening seatbelt in sharp corners, the jerk that the car can make when transitioning into semi-autonomous driving (see Figure 29), lane positioning, and so on. These cues were felt to influence experiences in negative or positive ways.

Since it is set in a driving context, the in-vehicle experience was further signified by the users' *trust and perceived safety.* Experiences of trust (or the lack of it) were influential parts of the in-vehicle experience, especially for the autonomous cars, and constitutes an important research topic. Several participants in Studies 2 and 3 expressed very high levels of trust for example regarding how autonomous systems would handle heavy rain and snow, which in reality may be difficult conditions for an autonomous car to function in (Van Brummelen et al., 2018), and is something that designers of the system must be aware of. Trust in in-vehicle systems tended to build up over time, where incidents could increase or decrease trust; such as one participant in Study 1's experience of the car's safety system helping him avoid an accident, increasing his trust and appreciation of the car. Trust and perceived safety were also common topics for the participant to address in Study 5, but there not of autonomous driving technology, but of the car obtaining and making decisions based on the user's personal data, such as family members, routines etc.

Rather than snapshots of specific stand-alone interactions, experience emerged in understanding the *flow of interactions*. For autonomous cars, enabling flexibility in the studies was important, to follow up on the interactions evolving between user and system. As the agency of the car increases, mutual ways of understanding each other's actions, abilities and intentions must be explored. For existing solutions, understanding the users' experiences of interaction with the car over longer time spans, as in Study 1, gave further understanding of the in-vehicle experience. The experiences evolve over time, in other words the *temporality* of experience matters, where routines connected to in-vehicle experience can make an improvement in daily life (such as being able to make work calls on the way to work when using a hands-free phone). In a general pattern, observed especially in Studies 1 and 3, the expectations varied from the first appeal (mainly dependent on novelty, aesthetics and social influence), through experience of direct use (where not only

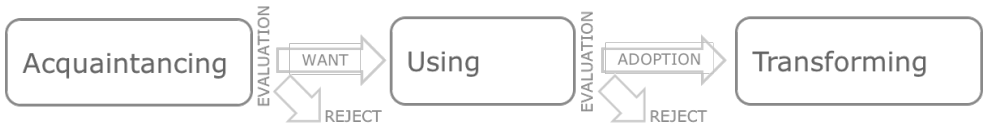


Figure 30. Temporal model of User Experience.

ease of use and efficiency were appreciated, but also stimulation from use and aesthetics), to forming habits and meaning over time that become important pieces of the puzzle of daily life, such as using the in-car systems to connect to family on the way home, or start the working day on the commute to work. Figure 30 presents a summary of the findings, describing themes of expressed in-vehicle technology over time, that were found both in the prospective (Study 3) and the retrospective (Study 1) studies. The model highlights the process of user experience; transition from one stage to another is achieved if the previous stage is satisfactory.

The first sequence of Figure 30, *Acquaintancing*, defines the stage where the user got/gets to know the car before actual use. In the studies, a number of aspects were found to be influential at this stage, such as perceived novelty, aesthetics and functionality. In both studies it was also noted that acquaintancing was heavily influenced by social factors, such as friends talking about the technology in the car, in person or in social media. The acquaintancing phase set the expectations for later in-vehicle UX.

The second sequence, *Using* the car in an everyday life context, contained elements such as ease-of-use and stimulation but also building trust in the car by interacting with it and its systems. An important aspect is that this sequence in itself contained temporal dimensions, in other words stimulation and trust had evolved/were expected to evolve over time. For existing in-vehicle systems, stimulation represented encountering new and sometimes unexpected features over time, such as updateable interfaces offering continuous stimulation. In Study 3, stimulation signified the initial confirmation of the novelty of the autonomous car, but also (over time) liberating the user to be entertained by non-car-related activities.

The final sequence of *Transforming* describes how the car made/will make a long-term difference to the user by enabling and mediating new behaviours and with the new assigned meaning of the car, where the car often transformed everyday life. In Study 1, this was exemplified by the changes in work, leisure and social routines that the existing in-car technology offered. The autonomous car, addressed in Studies 2-4, held more far-reaching expected possibilities of a less stressed and more efficient life in and with cars, including influencing where to live and work. In all the studies, the routines of the participants in relation to driving were very important, such as using a hands-free phone during the drive home to make phone calls. In the third sequence of transformation, these new routines are encompassed into daily life, providing value to the user.

The presented model has similarities to other temporal models of UX, such as ACT (van Gorp & Adams, 2012) and the model by Karapanos et al. (2009). However, the model in this thesis further describes the phase of getting to know the product, and the final process of forming habits over time. It also stresses the aquaintancing phase, heavily influenced by social factors, and the variety of influences on the experiences during active use, such as other devices and persons present. The temporal sequences in relation to some of the most important denominators of the context, the car and the user's experience are summarised in Figure 31.

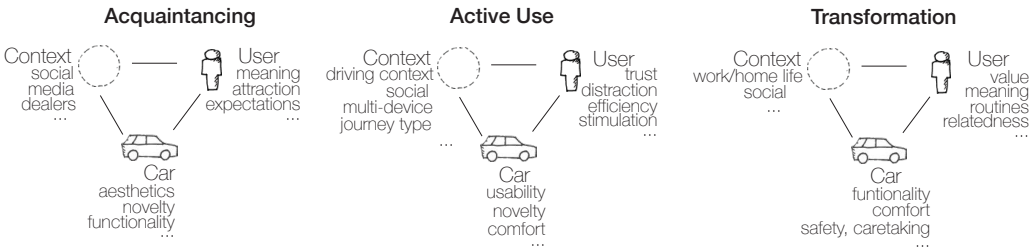


Figure 31. Temporal stages of XU in relation to examples of important factors in context, person and product at each stage.

5.2 ELICITING UX INFORMATION

As for the main research question regarding how to elicit UX data, there were clearly overlapping approaches between the studies that appeared to be positive for eliciting user experience information. These are described in the following sections and form the groundwork for a proposal of an overall approach to eliciting UX data for novel products. The outcomes were compared to both the basic understanding of UX as contextual, subjective and dynamic, (i.e. *"a person's perceptions and responses that result from the use or anticipated use of a product, system or service"*, International Organization for Standardization, 2010), as well as the understanding of in-vehicle UX that was built up over the studies. This meant understanding in-vehicle UX as influenced by temporal aspects, multi-device and social context, for instance.

The findings are presented along the time-line of performing a UX study; including a start (with *pre-study activities*), an active session where a product is ideated and/or evaluated (in some sort of *representation* of the finished product), in a *study context*, where the participants may (or may not) interact with the concept, *reflect* and *express* their experience.

5.2.1 Pre-study activities

Firstly, *sensitising* participants (in other words, to make aware of and create a sensativity towards a topic) to their experiences at the start, or even before, the study (such as in Studies 1,3 and 6), was helpful for starting up conversations about experiences. This expanded the converstations beyond usability, as overly focusing on usability is too often found in UX studies (cf. Arhippainen, 2009, Yogasara, 2014). In this thesis, sensitising was done for example by the photo homework in Studies 1 and 6 (see Figure 32 for examples). This had value as a conversational starter in the session but also sparked many stories about specific experiences, and thus understanding of personal meanings, emotions and routines. Stories connected to the photos were about positive experiences, such as enjoying experiences of regular phone calls to close family from the car, singing along to music, or discovering new functionality in the car, as well as negative, such as the hassle of bringing in a multitude of external devices for navigation and communication. The stories were the foundation for understanding the nature of in-vehicle UX, such as in Study 1.

In the case of UX activities concerning autonomous driving, which pose new challenges and involve new situations, it was useful to start the session by sensitising the participants to the topic of experiences with pre-interviews of their current daily situations and experiences connected to car use. This elicited reflections on personal taste, life situation and previous experiences, rather than the occasional flying cars and other such less personal and specific results as in the collages in Study 2.

Figure 32. Photos from pre-study task of photographs representing important experiences; the luxurious space and feeling that a participant wanted from his car and another participant's connected commute.

5.2.2 Providing context

The studies were all performed with different levels of context present; from none, to only chairs on the ground, to VR and to a real car (see Figure 33 for an overview of some of the study contexts). Infusing the *context* into the study session appeared to help in eliciting detailed and grounded reflections on experience. Much experiential data relied on that contextual data could be accessed, such as the sensory aspects in interactions, behaviours, stories of previous experiences and so on. For example, when studying experience in VR (Study 6), which lacked the full context, fewer emotions and personal reflections (such as of the physicality of experience, the personal space, trust, temporal and social context) were mentioned than for the same systems experienced in a real car. In Study 4, there was also a clear difference between designing for a design metaphor only, and when also including the contextualising enactment; only designing for a metaphor led to a narrower discussion with less room for idea exploration. In Study 2, there were fewer personal reflections and fewer reflections on interactions for the study set-up with collages + interviews, than for the staged outline of the car with seats that provided at least a basic form of context and where the space and enactment seemed to trigger reflections. The full, real, context may not be available at early stages of a design process and in Studies 2-4, it was clear that providing only some basic contextual references helped in grounding and eliciting experience information. The material for creating a sense of before-hand experience did not need to be elaborate and exact in order to trigger rich reflections on experience.

Figure 33. Overview of some of the study contexts; simple mock-up of car, VR, on road, and a small-scale scenario.

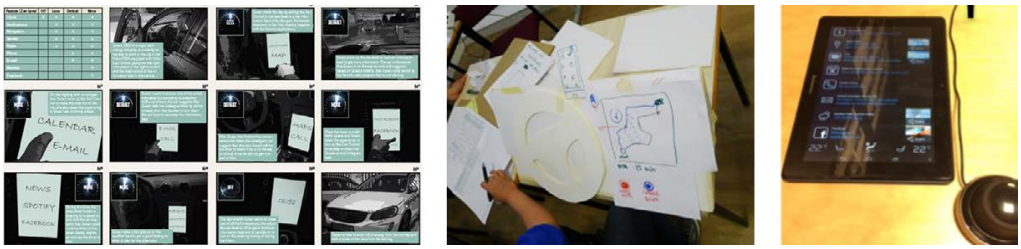


Figure 34. Overview of some of the product representations used in the research: story board (Study 5), lo-fi prototype (Study 4) and an interactive prototype (Study 5).

5.2.3 Representing the product

Related to the contextual factors, it was clear that the *representation of the product* concept also mattered. The studies contained a range of representations, from a finished car in Studies 1 and 6, a basic storyline in Study 3, to the storyboard and interactive prototypes in Study 5 and the virtual mock-up in Study 6. The representations of products gave different levels of focus to the experience stories: for example, enactment evoked stories of physicality in use, flow of interactions and so on, whereas the more "finished" but fixed-path interactions of the storyboard and VR gave more overall, general responses to the core idea of the system (such as of the predictive and adaptive abilities of the system, based on user habits, calendar and so on). For these product representations, fewer personal reflections on use, detailed reflections on specific interactions, design proposals, and similar aspects were elicited.

The product representation can thus enhance and mute different parts of the experience; a storyboard or a fixed path of interactions in VR may evoke reactions on the main points of the interactions and may surface aspects such as control and the use of personal data in intelligent systems, but will give less holistic responses and less detailed reflections on the interactive experience, as it could unfold in real life.

5.2.4 Enabling interaction and agency

A sense of ownership and control of an evaluation situation was found to be an important factor for eliciting experience. The extent to which the study participant/designer felt like the main actor in the situation appeared to influence how elaborated and in-depth the resulting reflections were. When interacting, more of the physical and contingent aspects of experience surfaced, as well as more personal reflections on the participant's own previous use. For example, in Study 5 the evaluation of the storyboard was less successful in eliciting personal experience data, and reflections were on a more general level of what others might do and think, as compared to the interactive prototype in the same study where there was a possibility to directly act in the evaluation. The persona in the storyboard appeared to have worked as a distancing factor to the concept and stories often concerned how the persona in the storyboard would misuse the system. These aspects were definitely not prevalent to the same extent for the interactive prototype depicting the same concept.

In Study 3, the concept was more or less an outline of a story which the participants filled in with their own content. This worked well to initiate not only interaction design ideas and the uncovering of mental models of interactions, but also to spark conversations about trust and emotions at an early design phase. Approaches such as enactment appear

to help in enabling a sense of agency for the participant (see Figure 35 for examples from Study 4), directing attention to the interactive elements of user experience than the more static approaches of the storyboard or the fixed path of interaction in VR. More of the experience may surface when the flexibility to follow up on the flow of users' and systems' contingent actions is allowed, as well as more sensory aspects rather than predominately visual. In Study 6, this contingency and physicality were low in the VR product representation, for example, which limited the study outcomes of experienced emotions and design proposals. However, when the participants in Study 6 were allowed a little more interaction in the main study as compared to the pre-study (in the main study participants could steer the car in traffic to a limited extent, and the scenario was made more natural), this was experienced as much more immersive and gave more responses regarding the context in which the experiences unfolded.

In Studies 2-4, the *changing relationships* to be had with autonomous cars were addressed, eliciting UX aspects that might contribute to or endanger trust, attraction and aspects such as mode confusion. Here too, the experienced agency in the activity was a pre-requisite for researching/ideating experience. In the workshops for Study 4, the design metaphors offered no interaction with the concepts during the ideation sessions, and the results led to less evolved concepts. Un-contextualised situations with limited possibility to explore interaction (e.g. the collages and interview in Study 2) gave less experiential data (e.g. emotions, behaviours and meanings) compared to enactment in/with a simple representation of the car. Design metaphors without tangible interaction explorations resulted in less open discussion and less iteration. Interaction in the "Setting the Stage for Autonomous Cars" method in Study 4 was enabled by props (see Figure 35) able to give physical response, such as giving the cardboard steering wheel or pedals different haptic responses. Experiencing this feedback gave a more exact understanding of the intention of the concept, sparked discussions and evolved the concepts further.

Figure 35. Enactments were able to trigger reflections on and before-hand experiences of physical interactions, such as haptic interaction with pedals, seat and steering wheel.

5.2.5 Triggering reflection

It was deemed important to make time and tools available for participants to *reflect* and evolve their thoughts during the sessions. When employing tools such as the UX curve method (Kujala, et al., 2011) or reflexive photography (Harrington & Lindy, 1998), stories of experience emerged, such as experiences evolving over time or connected to social situations. This was evident in Studies 2 and 3, where the drawing of expected interactive elements in the car sparked new ideas and reflections, often changing or evolving the thought lines of the participants (see Figure 36). This could for example be in the form of evolving ideas on the car altering visual and physical layout between driving modes, as the drawing made the participant realise more of what he/she would be comfortable with. In Study 4, the ideation was evolved when subjected to rapid evaluation sessions in the "Setting the Stage for Autonomous Cars" method (see Figure 35). It was common to add visual and/or haptic details to the concept after the first enactment and the enactment provided an important tool and opportunity for reflection during the ideation sessions. Another such elicitation tool was to offer the possibility to express experiences with emojis, such as in Study 6, where this gave rise to reflections on emotions during use and the motivations behind them.

5.2.6 Expressing experience

As found in the literature study, eliciting multi-layered experiences is no easy task. In Study 5, the users' responses to the concepts were captured only by a questionnaire and a structured interview, resulting in considerably less dense material than the other studies. In the studies using more *expression* formats than words, additional qualitative data was elicited that could enhance the researchers understanding of experiences, as well as the participants' reflections. For example, in the enactment and drawings of future interaction, participants were able to both show and talk about the often very physical, multi-modal interaction with the car. Figure 37 contains two drawings made by two of the participants in Study 3, who had very different levels of willingness to trust the novel technology of autonomous cars (although both driving cars with advanced assistance systems); the participant drawing the first image had a high level of trust in the technology and only wanted to know if she would get to her destination in time, whereas the second drawing was made by a participant who expected that it would take time for her to trust the technology and wanted the car to display the safe distance and speed of surrounding cars.

Figure 36. Drawing and reflections in Studies 3 and 4.

The general UX scale (UE-Q, Laugwitz et al., 2008) in Study 6 proved difficult to use for obtaining information on experiences, and negative reactions to scale items were expressed by several participants where wording of the items were found to be confusing. Similar reactions were observed by Lallemand and Koenig (2017) when employing another standardised UX questionnaire (mCUE), and the authors question such academic tools' relevance to UX practice. No significant differences were found in the data pool of 32 participants in Study 6. In contrast, expressing the experience in the emojis gave a more vivid and explained view of the differences between UX in VR and the real car, and worked as an door opener to expressing the emotional aspects of the experience (see Figure 38 for the most used emoji to represent the in-vehicle system in each study context, out of all included in iPhone SW5.2).

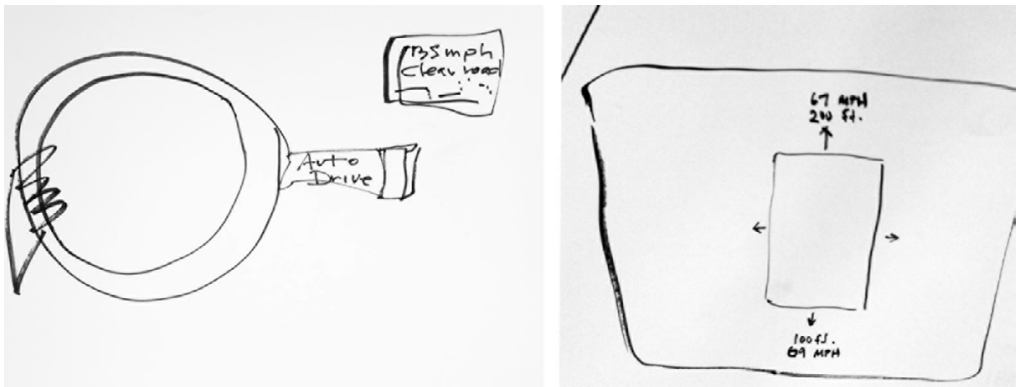


Figure 37. Two study participants' drawings of in-car information during autonomous driving in Study 3, representing two different trust levels in the technology.

Figure 38. The three most commonly used emojis selected for representing the experience of the same in-vehicle systems in the real car and in VR.

5.2.7 Addressing future experiences

Studies 2-5 addressed ideation of and expectations for future products. It was found to be important to ground the experiences in today, but allow a transition into the future situation; allowing a balance between the overly abstract and the overly defined was crucial. The future situations must be made tangible and in this, enactment together with simple props appeared promising. The simpler set-ups of the small-scale scenario and the Setting the Stage for Autonomous Cars method were experienced by the workshop participants as more apt for generation of design ideas, than the more elaborate lo-fi driving simulator. Furthermore, using multiple methods in iteration was very useful to make design ideas more concrete and evolved. Addressing future novel experiences requires an investigation into different dimensions that may not all be readily captured at once through one technique, requiring instead the transition between different experience dimensions in different experimental settings, to build up an evolved understanding through these encounters.

For future technology with increasingly intelligent abilities for sensing the world and the user, a focus on *communication* between technology and user is indispensable. In the studies, the fluid and exploratory methods such as enactment or WoZ approaches worked well for this. Through these explorations, topics such as trust and mental models of interaction could be approached.

In the explorations of future technology, it was found to be important to not detach from the very physical interaction with in-vehicle technology, such as the bodily sensation of the autonomous driving style and information cues. Although the representation of a car was very simple in Study 3, stories of physical and multi-modal interaction still emerged, as opposed no non-existing in Study 2's collages and interviews of future autonomous driving experiences. Adding more props but also more users to the enactment, such as in Study 4 (see Figure 39), gave further access to the social aspects of future in-vehicle interactions. Many of the representations were very lo-fi, yet experientially very accurate, as for example simulating the haptics of a chair providing the user reassurance that the car is sensing and handling a difficult traffic scene, or providing a clear response to misuse by the haptic response of the steering wheel (see Figure 35).

5.2.8 Triangulating experience

Finally, by *triangulation* of methods (such as in Studies 1, 6 and two of the workshops in Study 4), richer understandings of the experiences can be obtained. For example, concurrent triangulation was employed in Study 6, where observations of use complemented the interview and questionnaire data and the data was cross-analysed to understand the immersion of the virtual reality and the UX of the in-vehicle systems. Observed behaviours such as participants trying to adjust elements not physically present (see Figure 40) helped with understanding the participants' immersion in the virtual environment.

Drawings and photographs such as in Studies 1, 2, 3, and 6 gave a complementary understanding of the narratives. Interviews gave important information of the in-vehicle experiences that the questionnaires were unable to reveal; in Study 6 for example, there were very minor differences in questionnaire data, and when asking the participants about the questionnaire (UE-Q, Laugwitz et al., 2008) many participants expressed difficulties in understanding the items in the questionnaire. This points to the importance of careful cross-checking of results.

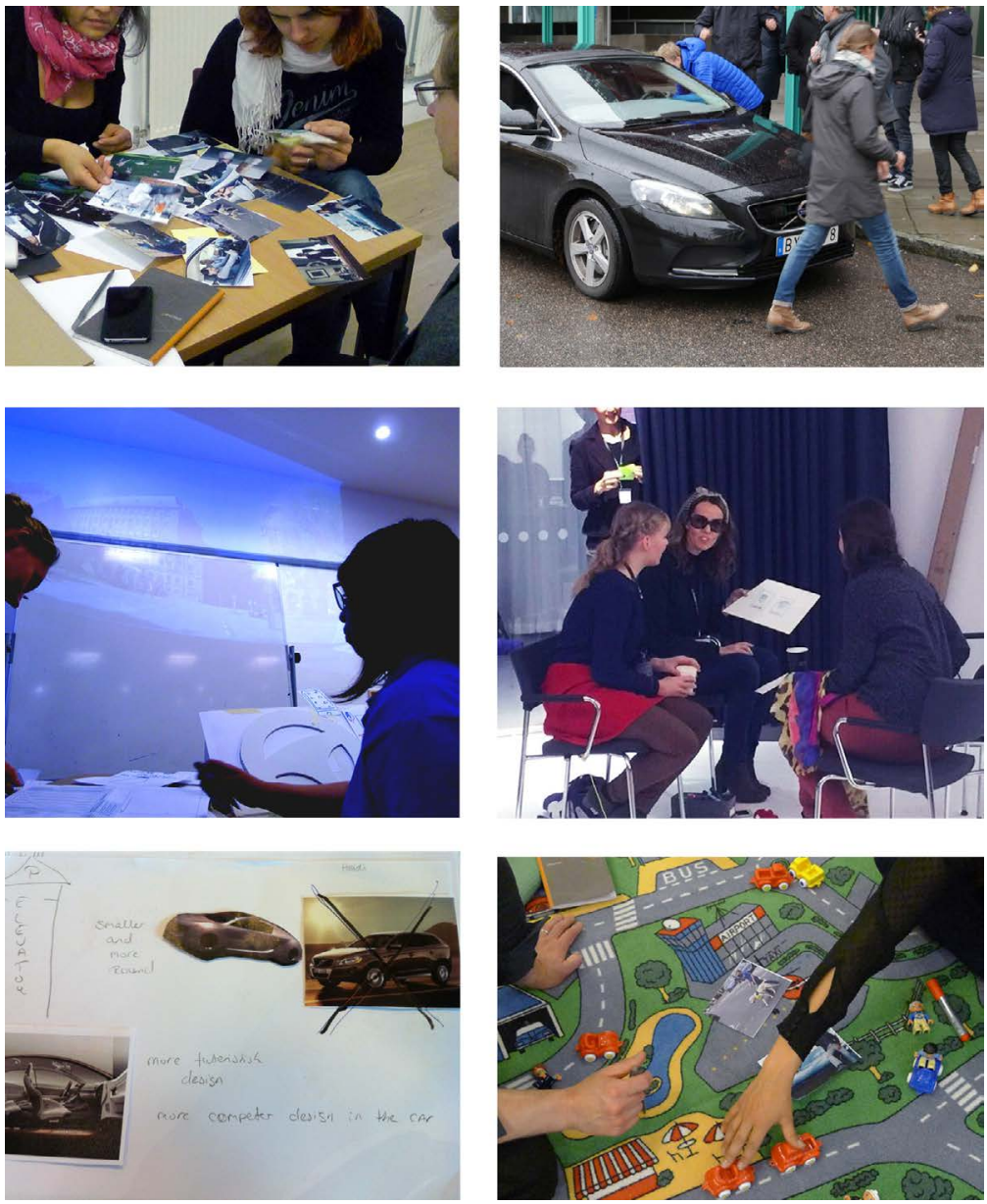


Figure 39. Different ways of approaching the future experience: design metaphors, WoZ car, lo-fi simulator, setting the stage method, collages, small-scale scenario.

By applying multiple methods, more evolved ideas also emerged in the ideation sessions of Study 4; it was found to be beneficial to move between different abstraction levels of the scenario at hand, for example experiencing the WoZ car and then obtaining a helicopter view of the scene in a small-scale scenario generated more ideas. For example, when ideating for interactions with an autonomous vehicle employing the elevator metaphor, the group firstly started in a small-scale scenario where a whole journey was addressed (from summoning the car, setting the address and so on, until arrival) and then transitioned to the lo-fi driving simulator, where ideas about visual and audio interface were added to the outline of the concept.

5.3 SUMMARY OF FINDINGS

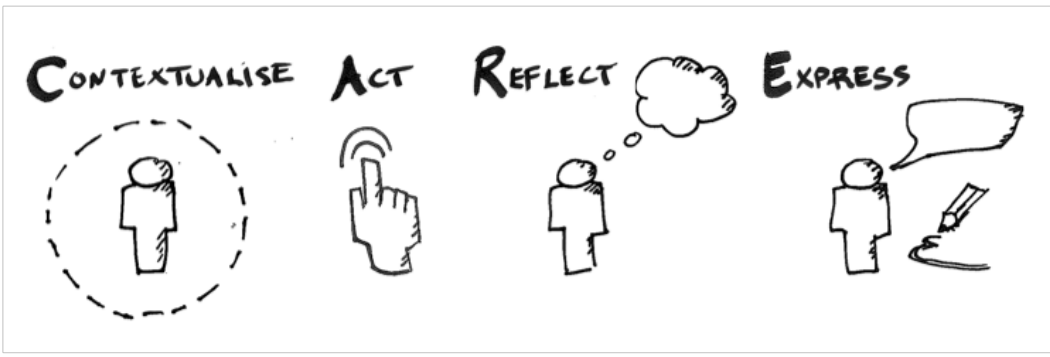
Table 5 provides an overview of findings from the six studies, which are used as the basis for the next chapter, suggesting an approach for eliciting UX. Insights about what appeared valuable in eliciting UX data were gathered in a proposed approach for eliciting UX information, presented in the following chapter.

Figure 40. Participant trying to adjust non-existent rear-view mirror in VR.

Table 5: Overview of findings from studies.

	Methodological learnings	**In-vehicle UX learnings**	**Contribution**
Study 1 (Paper B)	– User-generated photography worked as a means to sensitise the participants to experiences in their daily lives and as a conversation stimulus – Drawing of UX curves uncovered temporal aspects of experiences – Being in the use context enabled observations of use and made it possible to pose follow-up questions of behaviours – The triangulation of methods worked in synergy to provide several openings for eliciting UX data	– UX is highly influenced by contextual factors, such as social context, device ecology, temporal context and journey goal – In-vehicle UX is of different type. Dependent on the above factors, four UX themes were identified	– An outline of in-vehicle UX themes – An approach for combining research methods into a triangulated and holistic research of experiences
Study 2 (Paper C)	– Compared to collages and interviews, the enactment in the simple representation of a car (the Setting the Stage for Autonomous Cars method) elicited more reflections on the use context and more concrete reflections on interactions, also incorporating the flow and physicality of interactions	– UX data was elicited of the emotions, values, activities mental models of use, expectations, etc., connected to autonomous vehicles	– A qualitative exploration of user expectations on autonomous cars – Understanding how methodological choice affects outcomes
Study 3 (Paper D)	– Starting in personal reflections on current UX elicited more personal and specific reflections on future UX – Reflection on use was triggered by the simple car representation – Drawing triggered reflections and expressions – Employing the research in an industry design	– Mental models of future interaction, values and concerns were uncovered – Expectations over temporal stages connected to autonomous driving were elicited	– A more detailed understanding of user expectations from autonomous cars including a tentative model of these – Refinement of the method and employing it in practice
Study 4 (Paper E-G)	– When addressing future UX of novel products, contextualising the study is important. Simple set-ups worked better than more detailed ones when ideating concepts (but better than no contextualisation) – Addressing the physicality of the interactions is important for evolving in-car UX design concepts and addressing multi-modal use – Mutual understandings in multi-disciplinary teams is supported for example by including tangible objects and scenes in the idea generation – Multi-method approaches were found useful to evolve concepts	– The changing relationship between user and car (as autonomous driving is introduced) was addressed as well as eliciting expectations and concerns connected to this (e.g. mode confusion, need for the car to convey its intentions and ability to the user, adaptiveness to personal preferences)	– Suggested guidelines for ideation of intelligent technology using enactment and design metaphors – Presentation of techniques for exploring automotive interactions

Study 5 (Paper H)	– Interaction in the evaluation session triggered richer UX data reflections than the storyboard – Questionnaires gave dissimilar results compared to the interview data – The context in the storyboard provided more contextual data, but less personal data – The interactive prototype gave more reflections on the interaction, but less on the overall concept	– The importance of the influence of context (e.g. distraction during demanding driving, social contexts) and previous, personal experiences were exemplified – Privacy and the importance of the possibility to influence automatised actions of the system was highlighted as important UX aspects of the intelligent in-vehicle system	– Understanding of differences that may occur when employing story boards and interactive prototypes – Further contributing to understanding in-vehicle UX aspects of importance, such as of data privacy and of distraction
Study 6 (Paper I)	–The given study context shapes the nature of elicited UX data, i.e. in the VR context some aspects (e.g. aesthetics, ease of use) were scarcely mentioned and other aspects were given more attention (e.g. attitude to the technology in general) – Think-aloud data helped to understand experiences and were limited by the VR context –Asking or emojis representing the in-vehicle UX served as a way to talk about and motivate emotions defined by using the systems	– The importance of the multi-sensory nature of in-car experience as highly influenced by full-body interaction was highlighted. For example, the semi-autonomous cars' lane and speed positioning highly influenced the users' experience of the system	– Contributing to understanding in vehicle-UX of semi-autonomous driving, where the cars' lane and speed positioning influenced the user experience – Contributing to understanding potentials and limitations of using VR as a study context – Contributing with an exploration of using multiple methods, including sensitising to UX and tools to elicit UX stories
Summary	In order to elicit UX data also for novel products in early design stages, the following aspects appeared beneficial for gaining insights: – Sensitise to experiences before the main activity and introduce context to the activity – Offer possibilities to act and interact also at very early stages support reflection on experience – Offer triggers for reflection, such as generative techniques and employing multiple methods – Offer possibilities of expressing experience (not only in spoken format)	In-vehicle UX was found to be dependent on: – Multi-modal aspects and physical interactions – Multi-device and social ecology – Temporality – The personal space – UX includes the values, meanings, emotions, attachment, usability etc. connected to the in-vehicle systems – Journey type – Level of automation	– Contributing to a fuller understanding of in-vehicle UX, including a model of UX over time – A proposed approach to eliciting UX data, especially emphasising the context and the experienced agency of the user in the situation, and sensitising to experiential data


CONTEXTUALISE
ACT
REFLECT
EXPRESS

06 | SYNTHESIS: THE CARE APPROACH

This chapter presents a suggestion for an approach to elicit UX data. The approach is derived from the exploration of in-vehicle UX, but is aimed at being usable across other UX domains as well.

6.1 MOTIVATION

The literature study performed in Paper A revealed that the vast majority of academic UX research is conducted during late development stages, and often relies on summative methods such as self-defined questionnaires. This is a contrast to formative insights that provide qualitative data that can help to shape the product at early design phases, in order to mitigate late and costly changes.

The findings from the studies in this thesis emphasises the importance of carefully crafting the UX activity (such as a user study or ideation session) to tune the participants (designer or user) into experience. Understanding a topic like user experience is not only a matter of employing suitable methods since the usefulness of a method may largely depend on *how* it is used, rather than *that* it used. For example, an interview can be deep or shallow, depending on the interviewer and the context. The approach proposed here is intended to support the craftmanship of UX studies, bringing focus to the physicality and context of designs, and not predominately focus only visual aspects, as is often done by designers (cf. Dubberly & Evenson, 2008; Norman & Ortony, 2003). The shared understandings and focus on experience across team members in a design project are important, especially as technology is becoming more and more advanced and working in a multi-disciplinary environment is increasingly common. This require effective communication and sharing ideas and visions focused on experience.

Furthermore, the approach is based on the understanding that UX activities are not only retrospective, looking back at finished or close to finished products, but also prospective - able to probe into future situations. The path towards a testable interface is immensely important for crafting a successful design and the ideation or user study should enable an early focus on experience and be sensitive to parameters such as human capabilities and cultural prerequisites. A novel technology system like the future autonomous cars studied in this thesis, is an opportunity to rethink interactions, while tuning the system to user needs, abilities and motivations. This requires exploratory ideation, trying out of novel ideas, and understanding users. However, ideation also requires focus – not all future possibilities of different time horizons and of different business models can be explored effectively at once.

6.1 THE APPROACH

The studies presented in this thesis found that eliciting UX data may be supported by:

- A tangible study context
- Enabling ownership in the study/ideation by including the possibility of acting and interacting in the session
- Offering triggers to effectively reflect on experience in the session
- Offering multiple and generative tools for expressing experience

Based on this, the approach presented in the thesis contains the steps of ***C****ontextualise*, ***A****ct and interact*, ***R****eflect* and ***E****xpress* (CARE, see Figure 41 for a summary). The framework is intended to be used in iteration, in any of the early design phases of analysis, ideation and evaluation. To begin a design process with many, flexible and exploratory studies at the start (using multiple methods, product representations and also contexts) may shed light on more aspects of the future experiences and progress the designs to a greater extent than the single, large effort typically to be found in academic publications (Pettersson et al., 2018; Roto, et al., 2009).

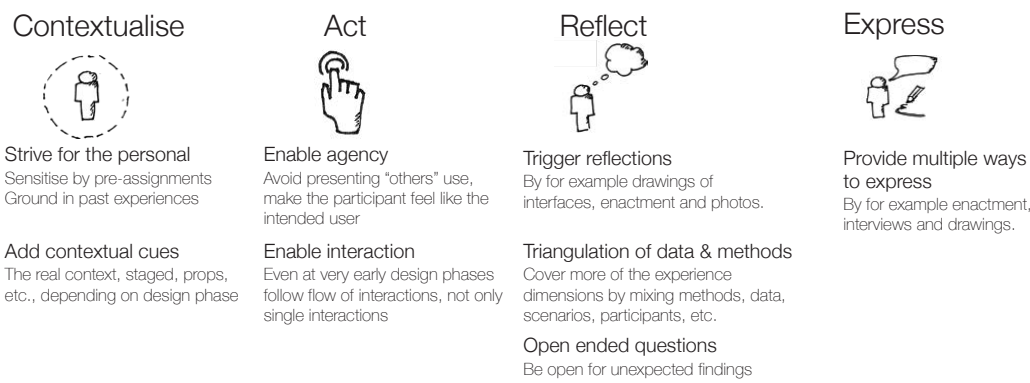


Figure 41. Triggers in the CARE approach. At each stage of the UX activity, experiential focus can be triggered: by triggering contextualisation, the subjective and personal, by enabling and encouraging participants' agency and interaction, by triggering reflections and by supporting expression.

Step 1: Contextualise

The first aspect is how to "tune" the UX activity (e.g., a user study or design ideation) into user experience, that is to say the subjective and contextual nature specific to UX, as opposed to for example usability reflections on ease of use and efficiency. As Arhippainen (2009) concludes, it is all too easy to focus on usability and not experience. This might be mitigated by making the participants aware of the topic, in other words to *sensitise* participants (users or designers) into the *"UX mind-set"* by introducing them to the topic of UX and start the process of relating to their own experiences. Focus in the discussions can then be pushed towards personal experience stories and emotions, rather than only usability. This can for example be achieved by steps that take place before the main session, such as employing reflexive photography (see Figure 42 for examples of photos from Studies 1 and 6) or other triggers to surface participant's reflections on experience well before the study session. In an evaluation session, it may be suitable to bring up previous experiences in an introductory interview. For future technologies, it is beneficial to ground imagination in relation to today's experiences (cf. Sanders, 2001, who links experience to past memories and imaginations of future use). This helps sensitise participants to the topic and to become accustomed to the study. In the ideation sessions, focusing on the future experience may be supported for example by an initial discussion on present daily experiences and by defining a future, specific, situation to address in the session.

A user experience focus is also promoted by making the use context accessible in the session. Addressing the context, even before it may be possible to do so in the field under realistic conditions, is vital. Specific contextualised aspects that are of particular importance to the product under development can be probed for, such as user experience in social situations (see Figure 43 from Study 4, addressing social experience of autonomous cars) or a specific multi-device context. For in-vehicle user experience, it is necessary to address the driving context at some point, although not all situations can be explored at once.

Figure 42. Photos representing the in-vehicle UX to two particiapants; the first from a participant in Study 1 where the participant explained that she emotionally connected to the eco-mode of the driver information module and to the aesthetics of the interface. The second image is from a participant in Study 6, where in-vehicle UX was connected to positive experiences of discovery on holiday trips.

Figure 43. Exploring social situations in one of Study 4's workshops.

Contextualisation is an important part of experience prototyping (Buchenau & Suri, 2000) and Suchman (1987) describes how observations in real-life situations are crucial for understanding technology use. For addressing future situations, studying the present context of use is however not enough – also the future must be explored. For future situations, making the context come to life even though it does not exist is challenging but essential for the results (cf. Sirkin & Ju, 2014, Halse et al., 2010). Grounding the sessions in the participant's current life, values and practice may extend participants' responses beyond pure opinions and on-the-fly statements (cf. Davidoff et al., 2007). When researching non-existing solutions, the context needs to be created or represented, to enable a *transfer to the future situations*. This can be achieved for example by using commonly found objects in the context and simple mock-ups of systems, where there is a possibility to act and interact in the situation. It can also be useful to move between contextualising scenes, such as from the field to a small-scale scenario. The aim is to move the participant or designer to a future, but not into too far-fletched versions of the future. Offering tangibility in ideation is an important aspect for technology such as the study case of in-vehicle systems, where there are important experiences dependent on physical and tacit interactions and information.

Sensitising study participants to the session has been employed for example in interpretative phenomenological analysis (Smith, 1996), and context mapping (Visser et al., 2005), where the researchers describe the importance of setting up a conversational tone and feeling of ease before a session. The CARE approach further suggests that the arm-up can take place even before the active session, and that the awareness of experience is supported by introducing the study topics before the session's main activities take place. Very few UX-specific methodologies, such as AttrakDiff (Hassenzahl et al., 2003), UEQ

Figure 44. Adding context in an ideation session in Study 4.

(Laugwitz et al., 2008), MAX (Cavalcante, Rivero, & Conte, 2015), include a sensitising component but the research in this thesis suggests that by providing sensitisation, more grounded results may be obtained.

In summary, the UX activity can strive to reach deeper into the experiences, in the past, the present and the future (avoiding going into the "sci-fi" scenarios, see Figure 45), when establishing a foundation/reflection of context and personal data. Designers can never predict the future and what the user experience actually will be like, but there is value in suggesting futures with solid information from potential users, and a thorough ideation process that contain information clearly linked to the future use situation. The link to future situations in ideation methods is often lacking (Biskjaer et al., 2010) and the CARE approach and the examples provided in the thesis suggests ways of improving awareness of the contextual. By including a thorough analysis of the existing situation, and for example enacting the future situation, or creating it through WoZ-experiments (that is, simulating the system for the user), the situation can be made more relevant in the ideation session.

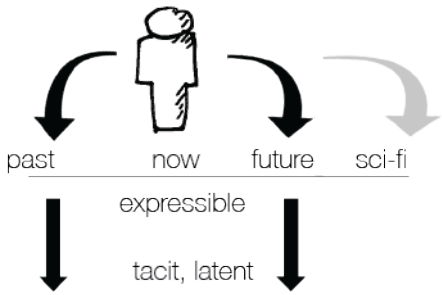


Figure 45. The approach aims to avoid the sci-fi but explore the past, present and future as deeply as possible, from the easily expressible to the more tacit and latent (cf. Sanders 2001).

For enabling contextualisation, consider...

Pre-activity approaches. For example, probes or tasks can be handed out before the study to sensitise the participants to the study topic and to the experiential aspects of using technology. Consider a pre-interview for example of previous experiences of other products, to further lay out the ground for approaching experience.

The scenario. Is it one specific or many scenarios that are to be addressed in the UX activity (such as ideation session or user study)? What stage of use is addressed? Who are involved in the experience, are there several actors to be included in the contextualisation (e.g. a family drive)? Is it a multi-device context?

Staging. How can the sensory environment, for example in terms of spatial layout, and props, be designed to give the participant a basic sense of the future scenario?

Step 2: Act & Interact

The interaction between user and system is what separates user experience from "product experience" from non-digital products (cf. Desmet & Hekkert, 2007) or from life experiences in general (Roto, 2006). Acknowledgement of this interaction must also be enabled in the design work leading up to the final products, even at the early stages when no working prototypes may exist. The second aspect of the CARE approach is thus to provide an ability to act and interact in the situation, carrying out (or acting/imagining to carry out) direct interactions, although no hi-fi prototypes exist yet. If the participant has an ability to interact in the UX activity, he/she is likely to have more accessible personal reflections, covering more of the interactive aspects of user experience. The participant needs to be the *main actor of the session*, in an as tangible a way as possible, making room for *flexibility* and contingency in ideating the interactions. With the introduction of increasing intelligence and agency in products, the research in this thesis proposes that there is a need for approaches where both the machine's needs and the human's needs of information and feedback, intentions and actions can be explored.

In the interaction, aspects such as the *physicality* of use can be addressed among other topics deemed important for the specific product under development (see Figure 46 for examples of product representations offering interaction). Rather than a snapshot of use, the *flow of interaction* may also be researched with increased possibilities of interaction and flexibility in the UX activity (cf. as contrast to the more task-oriented approaches, measuring specific aspects of interaction, described by Kaye, 2008).

Even in a simple representation such as combining a basic narrative of a concept with four chairs on the floor such as in Studies 2-4, the participants could still be invited to interact and "own" the story, for example by asking them what they would do next or solve problems at hand. In this way, more personal and embodied information is uncovered by expanding the focus from mainly visuals representations of systems to more interactive formats. Employing more interaction throughout the design process, such as in the ideation activity and in concept exploration, is an integral part of UX design. One aspect that appeared to help concretisation in the ideation sessions was the provocativeness of the metaphors used – a strong metaphor with potential "drama" offered a more accessible "problem" to solve. An example was the "Snarky" car's authoritative behaviour hindering

Figure 46. Left: the interactive prototype in Study 5. Right: ideating and exploring haptic feedback in Study 4.

the user from driving when unfit to do so, where perceived agency and interaction were in focus of the design activity. The study set-up of the car's behaviour using simple props was experientially very precise.

The research in this thesis suggests that even at very early stages when no hi-fi prototype may exist, access to interactivity (enabled for example by enactment) helps elicit experiential data. Atasoy and Martens (2011) as well as Hassenzahl (2010) for example, point out the lack of a clear understanding of how to put experiences in the foreground during design processes, where Atasoy and Martens attribute this to designers' tendencies to be overly focused on visual product representations in the design process, instead of being experience-focused (including also the multi-sensory and contextual aspects of product use). The use of physical objects to relate to and modify has earlier been exemplified primarily in participatory design approaches as useful for understanding use and users (cf. Sanders et al., 2010; Brandt and Grunnet, 2000; Broberg et al., 2011), and was also found to be important in the studies performed in this thesis, as a way to enable agency (see Figure 46 for two examples) and elicit more in-depth and personal UX data.

For enabling the participant to act and interact, consider...

Fidelity of interaction. Consider in what way the product representation can offer response in the activity. Even if it is only a basic story of a concept, the participant may still interact with the concept through enactment. Letting the session be incomplete in some aspects of system and context representations does not prevent it from being experientially precise in other aspects.

Dimensions of experience addressed. Different experience dimensions may require different approaches, depending if there are for example haptic interactions, co-experiences, etc., that are addressed. Consider the modalities that are used for interaction and include these in the activity (do not only rely on visual representations).

Drama of interaction. Create a certain degree of uncertainty, to enable room for the unexpected and to allow the participant to experience agency in the situation. Consider how the session is able to follow the flow of interactions and how to be flexible in the scenario. What can the participant influence and what can he/she not influence? What does the system need to know and how may it respond? Be prepared to improvise for unexpected turns in the activity.

Own or users' interaction? Consider how to address experts' roles in the activity: is it one's own or other people's interactions that are addressed? If it is others', use material to concretise the selected user groups situations and behaviours.

Step 3: Reflect

Richer UX information may emerge when participants/designers have the ability to reflect during the activity; through reflections, connections are made between several experiences and meaning is constructed of what the product may represent to the user and what it enables in the user's life (cf. Wright & McCarthy 2004). Experiential data, such as of emotions, temporal and social use, can be elicited by *triggers for reflection*. These can encompass probing interview questions, but preferably also other tools that do not rely solely on the spoken word, such as drawing and photography, before, during and after the activity. Using additional experience triggers, such as asking the participant to draw the expected interface or express the experience in an emoji (as in Study 6), or other techniques of choice, may work as a trigger for continued discussions which might offer new perspectives on the experiences. Applying multiple methods can also be beneficial by providing several reflective angles to the topic, as well as employing "laddering" questions for encouraging reflections on own behaviours and judgements.

In all stages of the early design process, the design team needs to enable time and tools for reflection. At ideation, it may be useful to incorporate elements from evaluation even at the ideation stage, not to "kill" ideas but to evolve them in an exploratory way. Moving from an intangible idea to an enactment situation may be one way to further push the ideas and tune into the specifics of experience (such as the flow or interactions, the multi-modal interaction or emotions during specific situations).

Figure 47. Exploring and reflecting on experiences of autonomous vehicles in Study 4 in sequential settings (WoZ and small-scale scenario, small-scale scenario and lo-fi driving simulator).

The different product representation used in the studies helped the participants to reflect on different aspects of experience. For example, in Study 5, the product representation of a storyboard made it clear to the participant how the system was using their personal data and gave rise to many critical reflections on this, and the interactive prototype of the same system gave elicited UX data concerning other aspects, such as aesthetic and ease-of-use. Kaye (p.153, 2008) concludes that product representations are all different and in some way incomplete, but not necessarily therefore flawed, as they may fit their purpose in the process. Lim et al. (2007) similarly describe prototypes as manifestations and filters of specific (usability) design aspects during the development process. The representation format of the product and the context will steer the reflections, as found in this thesis too; for example, VR allows designers to filter away stray elements that might detract from the interaction at hand, and also to introduce novel or fantastic elements that suit the exploration. Being mindful in applying the representation of product and context is important for directing reflections towards specific aspects of experience. Also, the openness of the method is important; UX evaluation methods such as AttrakDiff (Hassenzahl et al., 2003) or UE-Q (Laugwitz et al., 2008) allow little understanding of the qualitative, holistic aspects of experience, if used stand-alone at early design phases.

For enabling reflection, consider...

Spaces for reflection. Make sure to have pauses and room for the participants to form their own reflections in the activity, as well as more direct communication in think-alouds etc.

Approaching experience from multiple angles. Multiple methods may provide different angles or dimensions of the future experience to be considered. Examples can be of probing into social experiences or multi-modal experiences by using complementing approaches.

Connecting to past experiences. Relating to past experiences may help in addressing future experience on a personal level rather than a general. For example, using user-generated photographs of past experiences may help to reflect on anticipated experiences.

Allow for the unexpected. Include open questions and allow time to deflect from the intended path.

Step 4: Express

Being able to communicate the user experience is the basis for extracting information that can shape the design in a preferred direction. This means including combinations for example of *narrative, visual and acted* information, to encompass more of an experience, such as the physicality of interacting with a system. In this way, a *triangulation approach* (cf. Creswell 2014) is preferably employed for making connections between the sources of expression.

There are aspects of user experience that may require more ways to address than just the spoken or written word (Sanders 2002; Isbister et al., 2006). Outcomes of such activities are much more ambiguous than for example interview data, but can serve as a way for designers to understand more of the experience, the user and the context. These expressions can be incorporated into the deeper understanding of what shapes and signifies the experience (see Figure 49, which contributed to understanding expectations about autonomous cars in Study 3). Through enactment, it was found that more of the tacit aspects of experience can be uncovered, as also described in previous research (Sirkin & Ju, 2014; Oulasvirta et al., 2003). Sketching elements of the experience has been employed in previous research as a tool for expressing experience as users accumulate visual references for their experiences (Chamorro-Koc et al., 2008).

However, gathering too large amounts of data runs the risk of derailing insights and data sources should be chosen wisely and to avoid over-loading the study participant and the researcher/designer. Another aspect to be aware of is that not all study participants may be comfortable about participating in generative techniques; for example, in Study 3, some participants were much more apt at drawings and enactment than others were. Also, not all competences in industry and academia may be comfortable with generating ideas in ideation sessions, but may still contribute and derive value. Reluctance to engage in creative work has to be respected and planned for in the work, as to not put the participant in awkward situations, hindering personal reflection and sharing.

Figure 48. Expressing emotions and activities in enactment.

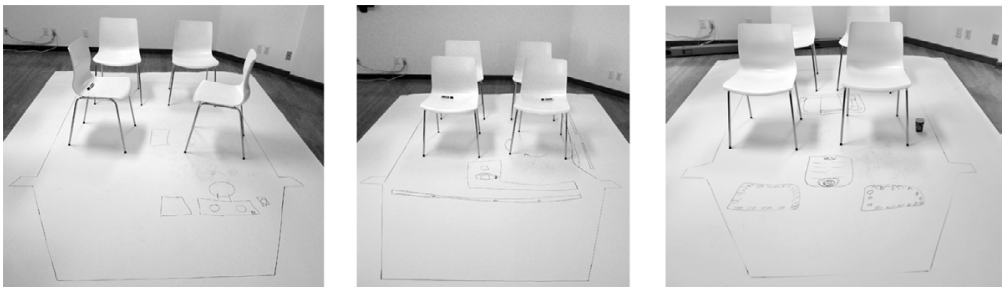


Figure 49. Examples of drawings in Study 3.

For enabling expression, consider...

Expressing in drawing, pictograms, enactment etc. Techniques such as drawing and enactment may help in uncovering more tacit information of emotions, for example. Let the participants engage in these techniques at their level of comfort, by for example offer several possible levels of engagement in the creative efforts.

Observations of behaviours. Consider if, and how, to make sense of observations of behaviours. Look for behaviours not necessarily expressed in words, such as where there appear to be difficulties, positive feelings, surprises, and so on. Visual materials such as video recordings are of considerable use when understanding the data after the study.

Triangulation. Consider if, and how, to triangulate data and plan the data analysis to anticipate what may constitute important learning opportunities from the expressed experiences, and how to make the results stronger by (possibly) finding confirmation of expressed experience from multiple data sources.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07 | DISCUSSION

Firstly, the findings of what signifies in-vehicle UX (RQ1) are summarized and discussed in relation to previous research. Secondly, eliciting UX information (RQ2) is discussed, including reflections on the research approach and methods used. Lastly, the contribution of the CARE approach is discussed and personal reflections on the thesis are made.

7.1 USER EXPERIENCE

In answer to the first research question of what signifies the study case of in-vehicle UX, the work pinpointed a number of aspects such as the influence of whole-body, multi-sensory interactions, the importance of the temporal stage of use, the social and multi-device context, and the changing relationship between user and car with increased automation. These aspects expand beyond the usability and distraction themes that tend to dominate in-vehicle research (see Kun, 2018 for an overview of the field). Avoiding potentially dangerous distraction is imperial for the safe use of in-vehicle systems, but distraction and usability were found to often be ubiquitous in the users' everyday in-vehicle experiences.

The in-vehicle experience was found to be highly personal and contextual. For example, the research of Study 1 identified a number of specific in-vehicle UX themes, such as stimulation, caretaking, relatedness and mental transitioning. Many exampels of situations and experiences on which to base novel or improved designs were identified in the studies. An example mentioned by some of the participants in Study 1 was the awkward social situations when private and work context were mixed in incoming phone calls. This was solved in some of the later car models on the market by allowing privacy options for incoming phone calls. Attention to issues like these should preferably be made early in the development process, to mitigate late changes or dissatisfied users.

In the studies, the analysis of the interview data were conducted with a bottom-up approach. This bottom-up approach differs to the approach of for example Knobel (2013), where themes are pre-existing and based on satisfying basic human needs (Hassenzahl et al., 2010). Some of the aspects are found to be the same between these two approaches, such as the need for stimulation and relatedness in a car, but as starting point for design concepts, these types of general approaches may lack the specificity and the type of personal perspectives claimed as important in design processes (Özçelik Buskermolen et al., 2012). The insights gathered of in-vehicle user experience continuously informed the design processes that were part of the research project (see Gkouskos, 2016).

Furthermore, the research of this thesis contributes to highlighting the temporal nature of in-vehicle UX as the experiences were found to transform over time. The temporality of UX is however often overlooked in current UX research (the literature study of Paper A revealed that 63 % of the reviewed UX studies explored only a single session of use, 34 % over days or weeks, and very few over months or longer). As other researchers have pointed out (e.g. Karapanos et al., 2009; McCarthy & Wright, 2004), there is a need for research that further addresses the temporality of UX. The tentative temporal model of UX, presented in the previous chapter, contains a stage of "transforming" everyday life. This expands the attention from the typical focus on direct interaction in task-oriented UX research, to how the product may impact daily life and habits over longer periods of use. The model highlights how the meaning(fullness) of the product may change over time, contributing to the overall user experience. What Hassenzahl et al. (2008) describe as "be-goals" of a product can thus not be seen as set and stable. In the studies reported here they were instead found to transform. There is thus a evolving relationship between product and user, extending beyond the direct experiences of product-user interactions. By breaking down the temporality of user experience into a sequence, such as in the proposed model in this thesis, designers and researchers may approach this transformation of experience over time in design concepts. For example, with a novel product such as an autonomous car, the interfaces must be designed to cater for the need of initial stimulation and novelty, as well as being allowed to fade into the background as alternative activities and priorities emerge, as discussed in Paper D (Pettersson, 2017), where the initial focus on aesthetics and novelty was expected to be complemented by focus on also values such as being able to relax in the car.

The model presented in Chapter 5.1 (Figure 30) also includes expectations as an important part of experience to address in user studies, as highlighted by for example Olsson et al. (2011) and Yogasara (2014). It is not possible to fully evaluate an interface before it fully exists in its intended context, but researchers and designers can still learn from early efforts and continuously evolve their assumptions of future user experiences. Studying expectations may provide valuable insights to mitigate gaps in the user expectations as compared to the real outcomes. Being aware of underlying motivations, mental models of use, needs and wants can form the basis for product visions and working hypotheses (Özçelik Buskermolen et al., 2012; Atasoy & Martens, 2011; Buchanan, 1992) and thus serve as a vehicle for design progress. In the case of the studies of autonomous cars (Studies 2-4), information of the communication between user and car was elicited, such as the mental models connected to future interfaces and the changing relationship between user and car. Hypotheses of user reactions and behaviours can be constructed and reshaped in the ongoing process, with input from further UX activities. In practice however, early

UX data of for example user expectations are still often overlooked in empirical studies in the UX field (Bargas-Avlia & Hornbæk, 2011; Pettersson et al., 2018). More research could beneficially be addressed to expectations, for example in order to understand how expectations can inform designs over a completed design process (and not stopping short after early stage evaluation, as in this thesis), exploring how designers' working hypotheses may evolve over time with input from early user studies. Further employing the approach and the design concepts from the studies in design processes would be a valuable next step of research.

Although all of the studies in the thesis contributed to the understanding of in-vehicle UX, there is further work to be addressed to the topic. The findings of what signifies in-vehicle UX were likely steered by the methods used. In Study 6, the movements of the vehicle in semi-autonomous driving mode were found to be very important for the in-vehicle user experience. Studies 2, 3 and 5 took place only in static scenes, and thus not for example fully addressing these dynamic aspects of in-vehicle user experience. However, aspects related to topics such as sensory experiences of movement and distraction during drive still surfaced in these studies, such as narratives of the expected driving styles of the autonomous car in Study 2 or worries of distraction in Study 5. Many concepts developed in the workshops of Study 4 explored physical, multi-modal interfaces, such as haptics for avoiding mode confusion and conveying system performance, likely also steered by the format of the method that included a simple but physical mock-up of a car.

Another delimiting study choice was to focus only on personal vehicles. Furthermore, Studies 2,3 and 4 that primarly addressed autonomous cars, focused on the future scenarios where some interaction with the car would still be required or possible. The studies thus did not for example encompass research of fully autonomous vehicles with no interactive aspects, or of shared vehicles or other types of novel mobility systems, etc. These are imporant topics for further research, and if included in the thesis, other metaphors for interaction would (for example) have been needed than the ones now explored in Study 4.

The research of the thesis contributes to a holistic understanding of in-vehicle UX. Outside the vehicle domain, user experience and configuration of multi-device environments have received increased recognition over the years (Crabtree & Tolmie, 2016; Dong et al., 2016) and were also found to be important in the studies of this thesis, especially in Study 1. In order to shift attention from a single-product, single-user and single-context perspective, to embracing the complexity of interactive products, there has been a quest for an "ecological turn" (Kaptelinin & Bannon, 2012) to understand experiences related to the co-existence of multiple products and people. The terms "product ecology" and "ecosystem" have been used by a number of researchers (see for example Bødker & Klokmose, 2012; Forlizzi, 2008; Jung et al., 2008; Nardi & O'Day, 1999) to signify the importance of interrelated products and users in a contextualised product usage situation. The success of an individual product does not only depend on the single product's attributes and interactions as a standalone, but on the product's ability to improve and add value to the ecologies of which it is and/or will be a part of. This was found to be important for in-vehicle UX and is also relevant for other products of today, but still not typically studied in current UX research (Pettersson et al., 2018). This warrants further attention in future research to address the compositional and connected aspects of in-vehicle (and other) UX.

7.2 ELICITING UX DATA

The second research question addressed eliciting UX information, and research approach, specific methods and the suggested CARE approach are discussed next.

7.2.1 Research approach

Approaching research for formative, early exploration of a complex topic such as in-vehicle UX requires a large number of decisions along the way, and many of these decisions are important to discuss. As stated in the initial chapters of this thesis, practical examples of UX studies in early phases of design are scarce (Bargas-Avila & Hornbæk 2011, Pettersson et al., 2018) and thus the approach of the thesis was exploratory, trying out methods for early UX elicitation in an ongoing learning process where insights into what worked in practice were gained continuously. Another approach could have been to be more directed in the selection of methods, with more structured comparisons between methods, following a pre-defined scheme. However, this would likely have limited the learning process from the domain-specific experiments, where insights are digested and used in the next set of experiments (cf. the description from Brandt and Binder, 2007, of approaches to experiments in design research). A more directed approach would have required a less open-ended process, but important decisions would likely have been taken without sufficient initial understanding of in-vehicle UX and of UX elicitation methodology.

The simultaneous approach of exploring ways of eliciting UX, while at the same time forming an understanding what constitutes it, created a specific challenge for the research, as also found in other research dealing with experience (see for example Boehner et al., 2008). Further increasing this complexity, the research addressed not only one of the early design phases but three; analysis, ideation and evaluation. In hindsight, focusing on one phase would have been sufficient for a thesis project. Due to the project context and ongoing activities, the research expanded and along the way common patterns were discerned for all three phases. In the end, this likely provided a better understanding of UX than what might otherwise have been the case. The dual focus of the thesis was time-taking, but also helped to understand effective ways of eliciting UX.

The research also encompassed a multitude of in-vehicle systems, such as (semi-) autonomous driving systems and infotainment systems. It may have been productive to have employed one single design case in all the studies of the thesis, to close the loop from analysis to evaluation in one coherent effort. However, as the work partly unfolded in an industrial setting and as part of a joint academic and industrial research project, this was not possible in practice. It can be argued that the most interesting findings surfaced from Studies 2-4, which included a high level of participant creativity and involvement in ideation and exploration. The studies helped fill in the ideation gap between "what is" and "what could be" in an explorative and iterative manner (cf. Dubberly & Evenson, 2008). Given this divide between identifying the problem and providing a solution (cf. Cefkin, in the foreword to Halse et al., 2010), there is a need for these articulations and examples of practical ways for addressing UX elicitation during early design phases. The suggested approach in the thesis may support the designers and researchers to probe into tacit experiences and behaviours. These types of findings from the studies were however also the most difficult to assess and compare.

As the ambition of the research was to tell the stories of experience, rather than to measure and predict, the data was approached in an open-ended manner. Handling reliability for these types of data-rich, qualitative studies is difficult; the results depend heavily on the selection of participants and the researcher. My own background in industry, my education and my interests, attitudes and so on all have implications on method selection, questions asked as well as analysis and interpretation. Through the description of methods, data analysis and conclusions, I hope to have added transparency to the process (cf. Kvale, 2001). My ambition has been to approach the data from multiple viewpoints, such as of using multiple methods, triangulation of data and where possible other academic researchers or industry UX researchers and designers have been involved in planning, carrying out and analysing the studies. The methods, such as the set of methods explored in Study 4, served as a way of incorporating the viewpoints of many stakeholders, such as researchers, designers, engineers and users. This is important when designing complex systems as (semi- to highly) autonomous cars.

As well as validity of data, the relevance of the research to (automotive) industry is important. This was inadvertently addressed throughout the studies to a certain extent, where results fed into projects and continued research. In Studies 4 and 6, this feedback was more structured than otherwise, as the participants were explicitly asked to reflect on the relevance of the research approach. Further valuable insights could have been enabled by also giving the participants access to the full analysis of results and conclusions, which could have added to the representativeness of the data. In retrospect, more research could have been applied regarding the communication and use of the results in the industrial setting, and this constitutes a topic for further research. The principles for evaluating the methods used, such as enabling personal, contextual, and detailed narratives of experiences, as well as the concepts created in the studies, could beneficially be refined and further discussed in future research. An example would be to include expert evaluation groups for reviewing the material in terms of relevance and validity.

Another aspect that was linked to the industrial setting of the work, was that at least 10 different nationalities participated in the studies taking place in four different countries, including both users and professionals. The inclusion of multiple perspectives affected the results of the studies, as it widened the perspective on in-vehicle experience. For example, in Study 3, set at a design office in Los Angeles (US), the value of having a self-driving car was perceived as immensely high, given the amount of time and emotion invested in their daily driving. This contrasted to the relatively quiet traffic scene in Gothenburg, Sweden, where parts of Study 2 took place. Another example was differences in sharing one's car between family members and of having company in the car; driving was much more solitary for the American participants than for the Scandinavian. Many of the Scandinavian participants had strategies for adapting systems and use when having company in the car, or ways of personalizing the car interfaces to become more of their own when sharing the car with family members. According to previous studies by for example Wang et al. (2016) and Lindgren et al. (2008), users from different markets respond differently to in-vehicle systems. More research examples are needed to understand the influence of culture, on elicited UX in general but also the specific case of autonomous cars. Since the start of the research, the "Setting the Stage for Autonomous Cars" method has been used also in China (Jorlöv et al., 2017). Continued research would be recommended; for example, the

research in Study 4 could also have been carried out with users and not only professionals, and over longer periods than one day. This would further offer insights into in-vehicle UX as well as of the applicability of the method across different study set-ups.

The research process was also subjected to external factors related to the technological advances within the field. The focus of automotive interaction research transformed during the span of this PhD project as autonomous driving became a strong focus in research and in development. Topics such as trust in automation (e.g., Choi & Ji, 2015; Haspiel et al., 2018; Koo et al., 2015) became prominent interests. The design cases developed during the PhD project all featured highly interactive and (semi-) automated concepts, representing important challenges for the automotive industry today, such as how to enable an appropriate level of trust in the system. Given that design concepts could have had a more coherent focus, more insights would have been valuable to further understand the topic of intelligent products (for example, an autonomous car), such as how to define and explore the specifics of intelligent products more clearly. This could provide further contributions to the field, in order to understand how designers might approach designing for products that rely on tools such as machine learning. How to further approach intelligent products as a design material is a future research need, highlighted by for example Dove et al. (2017) and Yang et al. (2018). Shared insights across intelligent products of differing types can likely be made, and Paper F (Strömberg et al., 2018) presents insights for a general level of designing for intelligent systems. Technology may evolve rapidly, but this does not hinder designers to strive to address the development from a user-centred perspective, rather than technology-centred perspective. The CARE approach is intended to support the focus on user experience, over specific technological solutions.

7.2.2 Elicitation methods

In this thesis, 15 methods were used and at times combined, and several product representations and study contexts were addressed, to learn from similarities and differences. For example, the two product representation formats employed in Study 5 gave very different facets of experience data, as did the two methods for exploring expectations of autonomous cars in Study 2. This does not mean that the different results are contradictory, they may just provide different pieces of the experience puzzle. These puzzle-pieces need to be compared and combined wisely. For example, the collages in Study 2 gave insights from an everyday experience perspective of using autonomous cars extending beyond in-car use (such as how a cityscape might be made more attractive), which uncovers other important facets of the UX of autonomous cars, than the experiences firmly positioned inside the car that the "Setting the Stage for Autonomous Cars" method was more apt to address. These results, as well as the work by Hendrie et al. (2015), may be used to think critically about moving linearly from low-fidelity prototypes to higher fidelity, based on the assumption that this progressively captures "more" of the experience. The research into product representations in Study 5 suggests that there might just be other dimensions of the experience that are addressed, studies are likely always missing out on some facets of experience and capturing others. As stated by Kaye (2008), UX data elicited in early design phases is always a result of an incomplete representation of product and context. This incompleteness leads to that multiple methods and tools are needed to address UX throughout a design process. The "Setting the Stage for Autonomous Cars" method was

developed as one way of how to more flexibly address and explore in-vehicle UX at early design phases. By employing different representations and also study contexts (such as in Study 6), designers may be helped to critically reflect on their ideas and implications for the users. The driving context could have further been implemented in studies, but with the drawback of offering less flexibility for ideation and exploration. VR can be one way of early bringing in dynamic aspects to the design process, but need further development in terms of technical performance and study set-ups.

In this thesis, insights from applying several methods in several instances were gathered into practical guidelines for how to conduct a UX activity, presented in the CARE approach. The methods were selected both based on previous knowledge (for example Kujala et al., 2011; Sanders & Stappers, 2012; Visser et al., 2005) and by an ongoing evaluation of what appeared to work for eliciting UX. Other methods could have been used in the research than the ones selected, such as the Love- or Breakup Letter (Hanington & Martin, 2012), or the Repertory Grid Technique (e.g., Goffin et al., 2010; Hassenzahl & Wessler, 2000; Pope & Keen, 1981) that would be interesting to explore experiences, but which are not adapted to prospective research of future, novel products. It is typically less complicated to assess a product in retrospect and describe the problems, than it is to provide ideas to solve these problems (that several of the studies in the thesis attempts to do). Paper G (Pettersson & Ju, 2017) contributes an important entry point to possible ideation methods when designing for autonomous vehicles, as well as for other novel technology.

The research in this thesis did not only use existing methods but also suggested a new method, the "Setting the Stage for Autonomous Cars" method. At the time of the study, there was a need to complement the survey-based research predominately performed in the field of user expectations on autonomous vehicles (such as Kyriakidis, et al., 2015; Schoettle & Sivak, 2014) with more qualitative understandings, including user interactions and experiences. The method is oriented toward ideation, in contrast to the methods that foremost address evaluation of autonomous systems (see the overview from Kun, 2018). More of this type of research has been performed by for example Sirkin et al., (2016), but is otherwise largely lacking from the field of in-vehicle UX.

The methods used in the studies encompassed both qualitative and quantitative data, to explore different ways of addressing UX. Reflecting on this, one limiting aspect that surfaced was the difficulty in combining rich qualitative data with questionnaire data in the same study, as currently done in most UX evaluation (e.g., Bargas-Avila & Hornbæk, 2011; Pettersson et al., 2018). Establishing the possible significance of questionnaire data results while at the same time handling qualitative data insights is, to say the least, a challenge. Also, there must be time dedicated to uncovering the personal and specific experiences of a study participant which require efforts from both the researcher and the participant. This aim may suffer if numerous scales are used in addition to interviews and/or generative techniques, such as in Study 6. The questionnaire data in Studies 5 and 6 did not particularly add to the understanding of the user experiences addressed in the studies. A possible reason of this, aside the number of participants, is the questionnaire items. In Study 6, many participants expressed critique of the UEQ items, as they found them difficult to relate to. This difficulty has also been observed by Lallemand and Koenig (2017) for another general UX questionnaire. Effectively triangulation of UX data remains a challenge for the UX field, as concluded in Paper A of the thesis.

All elicitation methods employed in the studies resulted in large amounts of data. The focus of data analysis was first and foremost on transcribed narrative material from the studies, which was then complemented with observations, generated photos, drawings and concepts. Important findings came from the explanations given to a participant-produced artefact such as the photographs in Studies 1 and 6, but the photographs themselves also served an important role in feeding data into design processes that the studies were part of (see for example Carter & Mankoff, 2005; Mattelmäki, 2006 on visual material). Showing video snippets of behaviours was also central for presenting the work to others, and through this process helped to evolve the understanding of the study outcomes. Sharing material from rich, qualitative data is not always easy; for example, enactment of tactile interaction was difficult to transfer to written or visual reports from the study, yet extremely important for understanding the ideated experiences during the sessions.

The results from the studies suggest that narrative, visual, acted and behavioural data may be beneficially employed to enhance the understanding of and focus on experience in early design phases. The participatory nature of many of the methods, when employed with people from different places in the world, invited conversation about cultural norms and differences that are often invisible to designers working in their specific context. The methods employed, such as the "Setting the Stage for Autonomous Cars" method, encourage users to be active in imagining future designs and services, an important aspect of the future mobility systems that will shape the everyday lives of many. This type of generative and formative research contrasts with the summative results from questionnaires often used to evaluate in-vehicle UX, for example by Körber et al. (2013), Rödel et al. (2014) and Cho et al. (2017).

7.3 THE CARE APPROACH AND ITS APPLICATION

In answer to the second research question of how to elicit UX information, an approach was suggested. The choice of representing the findings in a general approach differs from other research in the UX field. Previous research has typically focused on specific methods, such as AttrakDiff (Hassenzahl et al., 2003), UEQ (Laugwitz et al., 2008), Experience Triggers (Lallemand, 2015), UX laddering (Abeele & Zaman, 2009), MAX (Cavalcante et al., 2015), and Sentence Completion (Kujala et al., 2013). Although many methods have been developed, the literature study of Paper A found that UX-specific methods are rarely reused. Industry tends to adopt less of specific methods, and more of general mind-sets in design work (Stolterman, 2008). The intent is that the CARE approach supports designers and researchers to focus on the holistic design process, including ideation. The CARE approach specifically addresses the case of *prospective* research for novel products and suggests approaches for transferring participants to future experiences, and this contrasts to primarily focusing on evaluation, which user-centred design has been criticised for (Cockton, 2012). The holistic focus enabled exploration of a broad range of experience aspects. For example, in the enactments of future systems (Studies 2-4), both the user actions as well as the system's actions were enacted and reflected on, in order to gain an empathetic understanding of their respective needs of information. The research in Study 4 also highlights important factors for incorporating viewpoints of the many stakeholders involved, such as engineers, designers, researchers and marketing expertise. The design process has increasingly become a team activity rather than an individual process, and methods need to be able to accommodate for this. The CARE approach is intended to

bring experience into the centre of the multi-disciplinary ideation taking place.

The CARE approach verbalises some of the mechanisms of eliciting UX data and offers practical guidance to designers and researchers. Previous research such as experience prototyping (Buchenau & Suri, 2000) also emphasises the importance of attention to use situations and empathy with future users, offering a series of inspiring examples, but with limited practical guidance in how to conduct the activities. In another vein of research, Hassenzahl (2010) offers an approach to UX design, but as previously discussed, the approach focuses on overall, basic, salient needs and is not focused on eliciting early, formative data of the personal, specific, contextual and interactive.

The research in Study 5, for example, contradicts summative efforts to compare the influence of product representation formats; where for example Diefenbach, et al. (2010) concluded that there is limited difference between interaction and no interaction with a product in a user experience evaluation, the research in this thesis suggests otherwise. More research could be undertaken to better understand the experience dimensions triggered by different product representations and study context. As Alves et al. (2014) and Lallemand et al. (2015) conclude, the lack of understanding the concept of UX in evaluations may contribute to poor study results; the CARE approach may be of help in obtaining a holistic understanding of UX in comparison for example with the close-ended results of employing a generic UX questionnaire at the end of the process, which may miss addressing the specific important experience aspects for that product/situation. This has been pointed out by Suri (2002) who suggests to "tune in" into experience by qualitive methods, over using potentially misleading measures.

A number of delimitations for the CARE approach were decided on. Firstly, the CARE approach does not include the subsequent data analysis to be conducted after an ideation session or user study. Data analysis is an essential part of any UX activity, but not an expressed part of the CARE approach as the data analysis needed does not greatly differ from the approaches of affinity diagramming (Hanington & Martin, 2012) or qualitative data analysis (Denzin & Lincoln, 1998). Secondly, the CARE approach also does not address the later phases of design, such as implementation. Thirdly, the research in this thesis does not evaluate the CARE approach, and to learn more about the approach's applicability, it would be necessary to employ the approach in practice and not only in the automotive context, from the start of a design process.

The CARE approach is intended to spark ideas, evolve assumptions and help to avoid some of the deficiencies of existing products. To achieve this, a meticulous decision must always be made regarding which UX factors are the priority in an early exploration, as some UX factors will be in the background and others in the foreground depending on the choice of product representation or evaluation context (cf. Kaye 2008, or Lim et al., 2008 on usability). The chosen format of the UX activity (study or ideation) will filter out some UX aspects and emphasise others. The analyses presented in the thesis exemplify the need for *iterative* studies, moving between what users say, do and feel, in ways that are difficult to do in a single session. All experiential dimensions are not possible to address in one single scenario or product representation, and with iterations, the CARE approach is intended to support a continuous focus on UX, although the exact scenarios, methods and questions asked may change along the way. In the development of in-vehicle technology, especially in relation to (semi- and fully) autonomous cars, effective early explorations of experience must be able to focus on interaction (rather than only interfaces, meaning

that the method can cater for flexibility and contingency between system and user, and mutual understandings), particularly regarding whole-body, multi-sensory interactions (using the fuller palette of modalities needed) and the changing role of the car as it is gaining intelligence (see appended Papers D-G). Understanding the future communication between user and product is key in the approach and this may especially be of use when approaching the evolving partnership between highly intelligent technology and users, such as between the autonomous car and the user. It is as important to prototype and suggest, as it is to understand user needs and use context. Designers cannot solely approach the future with knowledge of current user needs and behaviours; design needs to make propositions and carry out experiments to learn about future experiences. The CARE approach is devised as a general guideline to this process, with focus on experience and the elicitation of UX data.

7.4 PERSONAL REMARKS

My work in industry before and while I conducted the PhD have likely pushed this thesis into a practice-oriented text. I was keen to address users' everyday life with and in cars, and I had a curiosity to explore study approaches that could provide the kind of in-depth data I saw needed to shape concepts into user-friendly and desirable products. My ambition was to contribute to the value and pleasure that may be derived from interactions with the car and its systems. The exploration took me further into the ideation phase, and closer to the topic of autonomous cars, than originally planned. I also involved users in creative processes more than what I had anticipated, and I look forward to continuing to address these topics. The design possibilities and discussions surrounding autonomous cars will likely change substantially again over the coming years, just as it did over the years of the PhD project, and preferably the progress will be driven from a user-centred, sustainable perspective. The research in this thesis is situated close to the interaction within the (autonomous) car, but there are many more aspects to be approached from a UX perspective, such as autonomous cars as part of new mobility services, addressing sustainable transport challenges. The development can not only be driven by individual users' needs, but also on what is sustainable in a larger perspective.

My thesis research started in a desire to better understand the elusive concept of UX, and as stated in the beginning of the thesis and exemplified by the diversity of topics addressed in this chapter, UX is a broad term, encompassing many aspects. The literature study indicated that the number of papers addressing UX has slightly declined in recent years. The academic approach towards studying UX as an umbrella concept may have seen its peak. I am unsure there will be a more precise definition of UX than the ones that exist, such as the ISO definition. There may be other terms and fields that will replace UX in the future, but there is still a need to probe for the personal and contextual in user studies and in ideation sessions, and approaches such as CARE will still be of use to the field.

After employing more than 15 methods during my time as PhD, I do not expect that there is one perfect method or definition that can be used to address UX. I however do believe there is a set of skills and methods that the researcher and/or designer can use to understand how the specific user, situation and product may influence the experiences to be had. How to approach this must be a living, evolving practise, informed by academic knowledge, but also tuned into the specific product, users and context. Openness, curiosity

and leaning on best known practices must always be part of the process. By exploring new methods, tools and adaptations, new design directions may evolve, in contrast to repeating methods over and over with similar results for each repetition.

08 | CONCLUSIONS AND CONTRIBUTIONS

Eliciting tacit and multi-layered user experience data is a challenge, especially in early design phases of novel products when the product representation is incomplete. The aim of this thesis was to provide guidance to industry and academia on user research and ideation with user experience in focus. The research questions were: What signifies in-vehicle UX? How can UX data be elicited for input to novel in-vehicle concepts in early design phases? The first research question was answered by describing a number of aspects that signifies in-vehicle UX, identified throughout the studies. The second research question led explorations of methods and approaches, were the findings were used to suggest an approach for eliciting UX.

The thesis contributes to:

- *Identifying key factors of the study case of in-vehicle UX, which may help in approaching UX design of in-vehicle systems.* Especially important for understanding in-vehicle UX, and thus also for addressing the design of such systems, were for example the multi-modal and sensory aspects of experience, the influence of the multi-device and social context, and the importance of the temporal stage of use, such as the formation of habits and meaning creation over time.
- *Identifying important considerations for prospective research and ideation of concepts addressing future user experience with intelligent technology.* The "Setting the Stage for Autonomous Cars" method, containing enactment of future interactions and experience in a simple car mock-up, was suggested and employed in several studies as a means to address future experience. The method offered flexibility as well as contextualisation in the ideation session. In addition, several other methods were explored and used, adn may beneficially be used together to understand more of experience, in ways difficult to do all at once.

- *Evolving UX design practice in early design phases by suggesting key factors of formative UX elicitation (summarized in the CARE approach).* This approach serves as a springboard for infusing the design process with close attention to UX, with users and context at the forefront rather than designers' own assumptions. Furthermore, it may serve as a lightweight approach in industry, as many of the steps can be taken with relatively small, nimble efforts.

The CARE approach suggests that in order to elicit UX effectively in early design phases, there is a need to enable *Contextualisation*, *Action/Interaction*, *Reflection* and *Expression* in every UX activity (such as ideation and evaluation).

- In order to contextualise and surface experience, sensitising participants to experiences before the main activity can beneficially be carried out, for example through pre-study activities such as reflexive photography tasks and pre-interviews of experiences. Also, the activity needs to address the use context, which can be done even at early stages of design by using low-fidelity representations of context or Wizard of Oz representations of the product in the real context.
- As user experience is highly personal, often sensory, and dependent on interaction, the activity needs to offer possibilities to act and interact, also at very early design phases. This can for example be done by introducing the concept in narrative form, in combination with enactment of interactions, such as in the "Setting the Stage for Autonomous Cars" method.
- To elicit the type of open-ended subjective data that signifies UX, the activity needs to support personal reflection. This can be triggered, for example, by generative techniques (such as photography or drawing), connecting the explored experience to past experiences, physical representations of context and by using several methods to approach the experience from multiple viewpoints.
- There must also be tools provided to express experience efficiently, for example by using methods not only relying on words. Examples are observations of behaviour, drawing experiences and interactions, etc.

Comparing the approach to the prerequisites for the research derived from the literature review in Chapter 2, contributions were made to the area of in-vehicle UX and of eliciting UX (see Table 6). A subsequent research step would be to assess the CARE approach, also in other design contexts than the automotive.

Table 6: The contributions of the thesis.

Prerequisite	**Contribution of thesis and reflections**
There is a need to evolve approaches for eliciting UX data in early design phases.	A holistic approach to eliciting UX data was suggested (CARE).
There is a need for especially addressing the elicitation of UX data for future experiences of novel products.	The research highlighted the importance of grounding research into future experiences in personal reflections on previous experiences. It requires providing interaction and contextual clues, even at very early stages of development. The "Setting the Stage for Autonomous Cars" method was suggested and employed. Guidelines for how to employ enactment together with design metaphors were defined, as a support for the ideation of novel, intelligent products.
UX is holistic and multi-dimensional.	In addition to information sources such as interview data, the proposed approach suggests inclusion of interaction, context, and several ways to enable expression, with practical tips for doing so (see Chapter 6). The research contributed to a more specific understanding of what defines in-vehicle user experience, including aspects such as multi-modality, temporality of use, journey types, social and multi-device context.
Designers value rich, formative data from users.	The thesis suggests an approach for eliciting formative data, i.e., rich and personal reflections from participants, and highlights the need to provide interaction in user studies and to use generative techniques.
UX is dependent on the use situation.	The studies exemplified how study contexts (for example VR and real) affect the outcomes of UX studies. It was found that for novel products, a balance must be found between being too loosely connected to the use situation (e.g. using design metaphors only) and offering a too inflexible set-up which allows less open-ended explorations of future experiences at very early stages (such as the lo-fidelity driving simulator).
The nature of UX varies (e.g. depending on product type/users/use context).	The research exemplified what defines in-vehicle UX. Identified examples of experience themes can be used to guide and evaluate concepts against the specifics of the intended experience.
Product representation influences outcomes of UX studies.	The results of the studies indicate that perceived agency and interaction are important factors for bringing personal experience stories to the evaluation. To avoid the risk of only focusing on usability and aesthetics, the use situation must simultaneously be addressed as interaction.
In industry, mind-sets may be more readily employed than specific methods.	The thesis presents a general approach to eliciting UX information, that may likely be adapted to any interactive product, and not only in-vehicle UX. More research is however needed.
In industry, the activity must be applicable in small-scale, flexible manner.	The approach can/should be modified to suit the specific product, context and users. It is possible to obtain results in low-fidelity set-ups and the approach is intended to enable rapid explorations and many iterations.

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