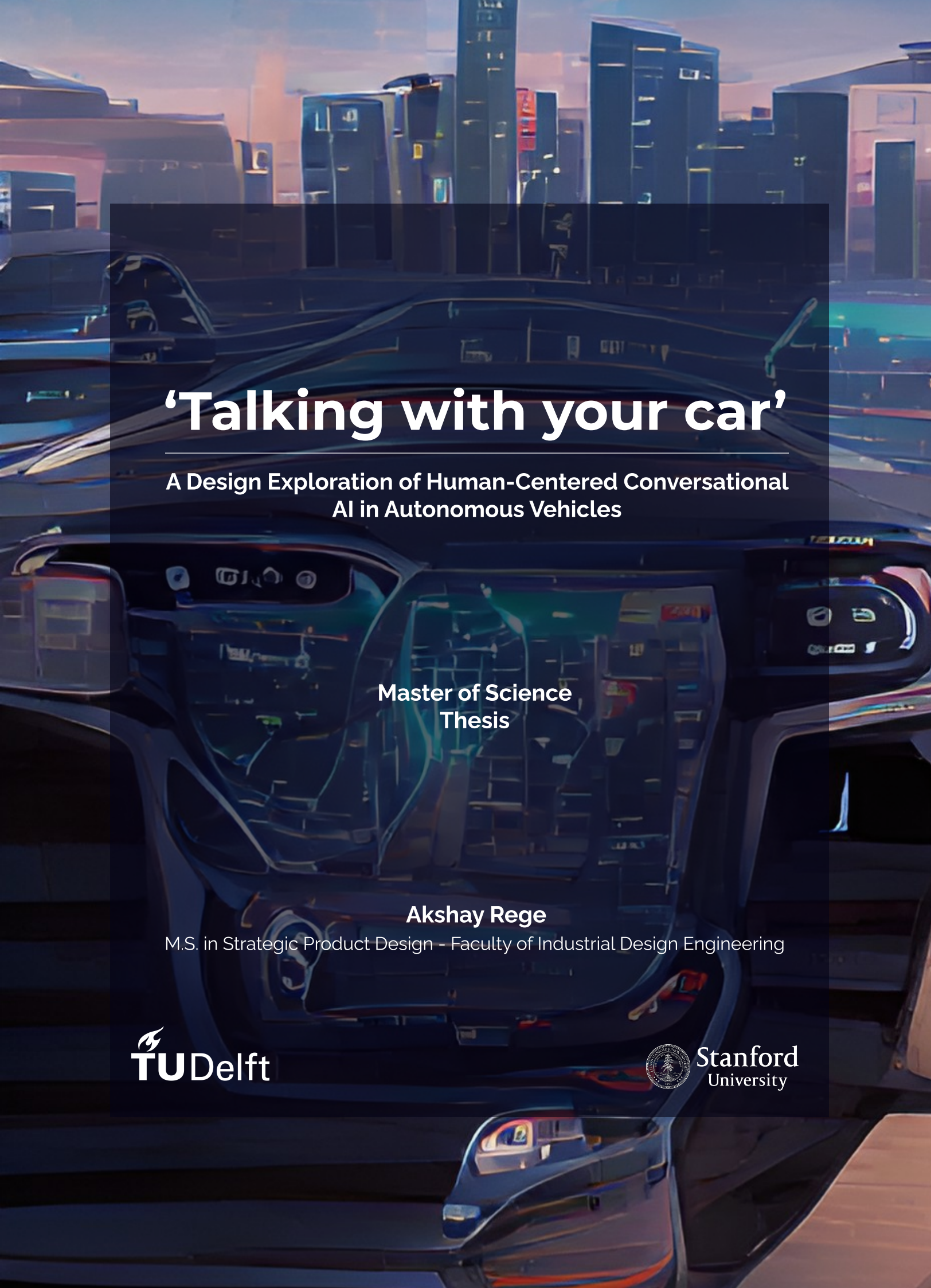


‘Talking with your car’

A Design Exploration of Human-Centered Conversational AI in Autonomous Vehicles

Master of Science Thesis

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M.S. in Strategic Product Design - Faculty of Industrial Design Engineering

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‘Talking with your car’

A Design Exploration of Human-Centered Conversational AI in Autonomous Vehicles

TU Delft X Stanford

Master of Science thesis

Akshay A. S. Rege

Acknowledgements

This section acknowledges the contribution of numerous people with whom I had the opportunity to associate with during the course of this project.

"You can design, create, and build the most wonderful places in the world. But it takes people to make the dream a reality."
- Walt Disney

While exploring the option of undertaking this ambitious collaborative project charting paths into still novel terrains of Artificial Intelligence and Autonomous Vehicles design research, and mentored by professors from TU Delft and Stanford University, I was filled with apprehension and uncertainty about my capabilities to successfully undertake this project. Six months later as I look back on this journey, I resonate with Walt Disney and I'm filled with immense gratitude towards all the people who supported me in the process of making this dream a reality.

First and foremost, I owe many thanks to my supervisory team of professors, for being generous with their knowledge and time. Dr. Peter Lloyd's thought-provoking conversations with a twinkle in his eyes always left me inspired for further research exploration in the project. Dr. Eui Young Kim's warm empathetic mentoring gave me the confidence and foresight to proceed through various difficulties I faced during the project. I am also grateful to Dr. Kim for his pivotal role in formulating this research collaboration between the two universities and having the faith in me to undertake this project. Dr. David Sirkin's insightful guidance and intelligent observations enabled me to navigate the world of Human-Autonomous Vehicle interaction design research with a renewed understanding and a deepened interest in the topic every time we spoke. Dr. Rebecca Currano's warm-hearted, ebullient, and erudite discussions during mentoring always left me highly motivated to pursue this project with great enthusiasm. Additionally, Dr. Sirkin and Dr. Currano despite being located in a different part of the world in California with a 9-hour time difference between us, were always generous and adjusting with time out of busy schedules, for which I am deeply grateful to them. Though this unique mentoring situation between 4 mentors located in multiple geographies of the world required me to proceed in a balanced manner taking into consideration each mentor's research interests and advice on the work to be done, my supervisory committee's open-mindedness to new ideas, acceptance of differing opinions, and willingness for mutual adjustments made proceeding with the thesis not only effortless but a very joyful and exciting experience.

Second, I want to deeply thank numerous experts and participants with whom I had the opportunity to work, for their contribution and participation in my research. Without their generous contribution of time and knowledge, this research would not have come to fruition.

Third, I want to thank the larger community at TU Delft and its Faculty of Industrial Design Engineering, including members of the faculty and my educational colleagues, for contributing to my overall educational experience, and making me capable of undertaking this project. I thoroughly enjoyed our discussions, lectures, and intellectual exchanges, some of which formed the bedrock of knowledge that propelled me to accomplish this project.

Fourth, I am immensely thankful to my dear friends here in Delft for their continuous emotional support throughout the Masters education, which gave me the fuel to persist and continue working even in times of adversity. I will always cherish our cooking rituals, festivities, long conversations, backpacking trips around Europe, and humorous exchanges that made life in Delft memorable.

Lastly, but most importantly, a big thank you goes out to my family for making all the necessary arrangements for me to study at TU Delft and supporting me throughout the journey of completing Masters education. Living in Delft made me realize how much I miss the little things that make the bond of family stronger.

In this short acknowledgment note, I am mindful of the fact that I may not have covered every person I feel thankful towards. However, I feel a deep sense of gratitude towards various situations and individuals that have shaped this journey to be a fulfilling one. To thank all of whom I couldn't mention in words, I quote *JFK* as an assurance to express it through my acts:

"As we express our gratitude, we must never forget that the highest appreciation is not to utter words, but to live by them."
– John F. Kennedy

Abstract

This section summarises the project in the form of a research abstract.

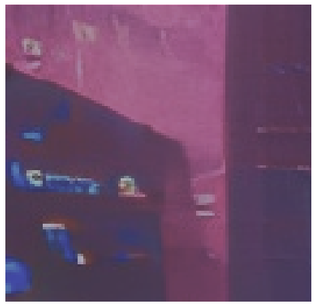
Abstract:
The development of Fully Autonomous Vehicles would fundamentally change the nature of user interactions, behaviors, needs, and activities within vehicles. Passengers who are free from driving would expect to undertake diverse in-vehicle Non-Driving-Related Tasks (NDRTs) to keep themselves occupied and free from boredom. Conversational Artificial Intelligence with its ability to have free-flowing conversations could offer a solution to improve in-vehicle user experience. To explore design innovation opportunities that Conversational AI may offer within Fully Autonomous Vehicles, this work first researches what roles and relationships can Conversational AI play towards users of fully Autonomous Vehicles. These are investigated by conducting qualitative interviews of end-users and subject matter experts, and analyzing these interviews using the Thematic Analysis method. Second, this work examines how end-users qualitatively assess the embodied user experience provided by Conversational AI roles and relationships designed for Fully Autonomous Vehicles through the means of user-technology interaction experiments. These are conducted by employing a combination of participant role enactment method and a Wizard of Oz experimental setup with a mock Conversational AI operated within a prototyped Autonomous Vehicle under laboratory conditions. Ensuing these interaction experiments, the qualitative assessment of these in-vehicle Conversational AI roles and relationships was done by conducting guided brainstorming sessions using the parameters outlined in the Subjective Assessment of Speech System Interfaces (SASSI) questionnaire along with two free-from questions. Results from both phases are presented in the form of user-desired in-vehicle Conversational AI roles, aspects that would enable the forming of Human-Autonomous Vehicle relationships mediated by Conversational AI, and user experience evaluation of the embodied idea. Based on these results, design guidelines are articulated that are aimed to inform design professionals as well as internal design strategies of Autonomous Mobility and Artificial Intelligence companies looking to innovate. Finally, we reflect on our methodological approach to indicate directions for future studies on similar lines and discuss our research's implications for professional practice.

Keywords:
Design guidelines, Human-Autonomous Vehicle interaction, Human-Artificial Intelligence interaction, Conversational AI roles and relationships, user experience

Reading guide

This section contains information to help the reader navigate this report.

This guide provides an overview of how to navigate through this report. It also provides a list of frequently used abbreviations and a statement on usage of AI tools in developing this report.



Covers for new chapters

"Text of the quote" – EP1

Research quote from anonymised participant

Abbreviations

AI = Artificial Intelligence

CAI = Conversational Artificial Intelligence

AV = Autonomous Vehicle

FAV = Fully Autonomous Vehicle

NLP = Natural Language Processing

ASR = Automatic Speech Recognition

RQ = Research Question

SASSI = Subjective Assessment of Speech System Interfaces

UX = User Experience

UI = User Interface

Statement on usage of AI tools in this thesis

In this thesis, artificial intelligence tools have been used for generating images only, in some cases. These are for:

1. For chapter covers
2. Visualising AV interiors
3. Illustrations for statement cards
4. Faces of Conversational AI roles
5. In some cases, for supporting graphics.

No text generators or other forms of AI have been used for writing this thesis.

Structure of the report

This section outlines the structure of the report and contents of various chapters.

Formulation

01 Project Introduction

This chapter introduces the initial assignment, approach and context of the project.

Literature review

02 Artificial Intelligence

This chapter introduces the basics of artificial intelligence at the outset and dives deeper into understanding the fundamentals of Conversational AI, through the review of literature in the form of research papers and book chapters.

03 Autonomous Vehicles UI / UX

This chapter explores the basics of Conversation AI's integration into Autonomous Vehicles at the outset and dives deeper into understanding the design of Conversational AI in Autonomous Vehicles.

Empirical research

04 Design research

The research methods, protocols and experimental set-up used in the project are described in this chapter.

05 Establishing roles and relationships

Results from phase 1 of research are presented here highlighting in-vehicle Conversational AI roles and relationships that were discovered.

06 Evaluating User Experience

This chapter presents results from guided brainstorming sessions conducted to evaluate user experience in phase 2 of the project, through interaction experiments using a prototyped set-up.

Synthesis

07 Design guidelines

Recommendations resulting out of our study are presented in the form of design guidelines in this chapter.

Prototyping

08 Toolkit ideation

Ideation for design strategy toolkit to involve users in the design process of Conversational AI for Autonomous Vehicles by companies is presented in this chapter.

Culmination

09 Project Conclusion

This final chapter consists of a discussion of our methodological approach as well as implications for professional practice, and sheds light on the limitations of this research with directions for future work.

Bibliography

Academic literature references in APA Format are listed and information about appendices are mentioned.

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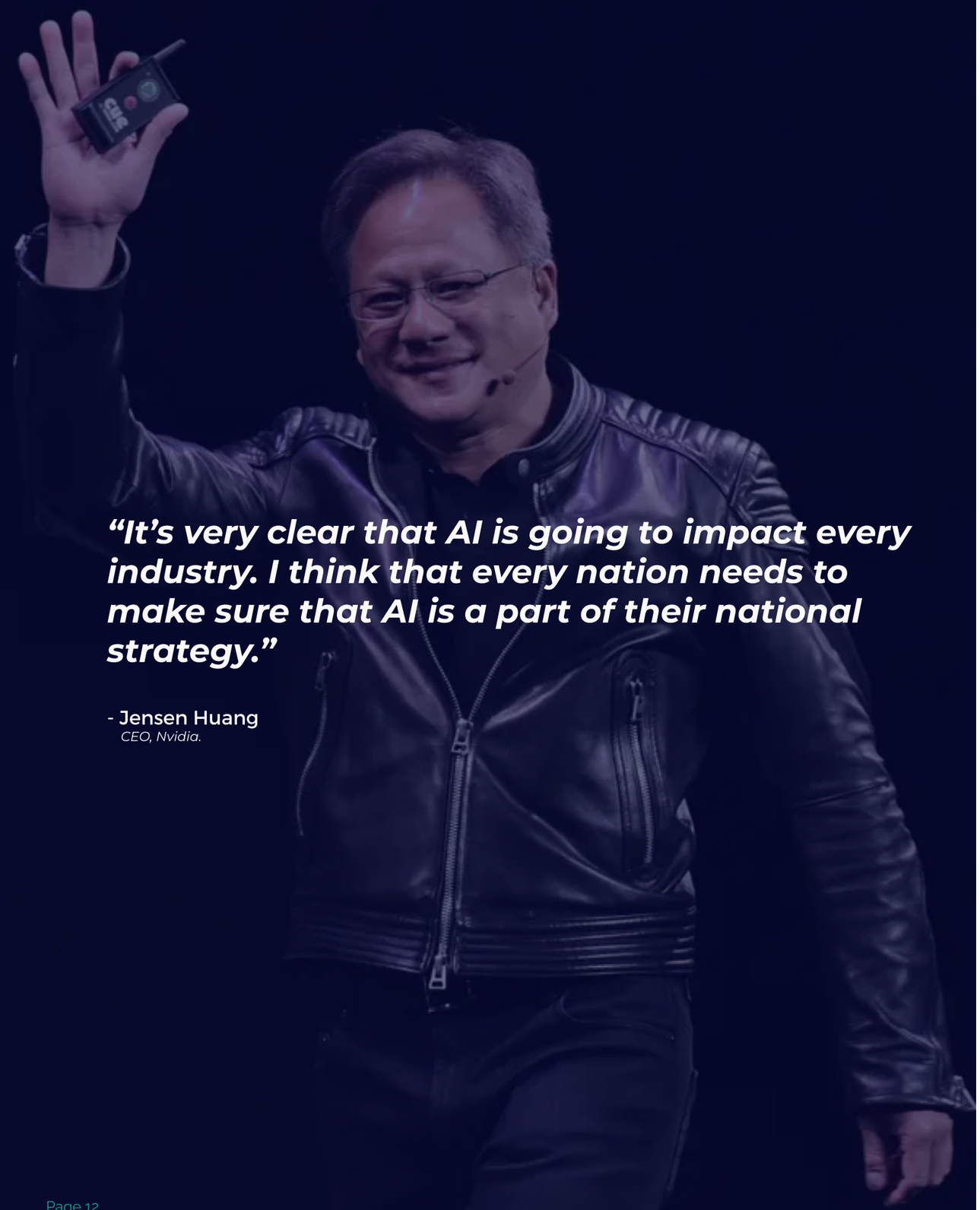
Appendix Confidential

Chapter 1

Project introduction

This chapter introduces the initial assignment, approach and context of the project.

In this chapter:
1.1 Initial assignment



"It's very clear that AI is going to impact every industry. I think that every nation needs to make sure that AI is a part of their national strategy."

- Jensen Huang
CEO, Nvidia.

1.1
Initial assignment

This section describes the initial assignment that the project started with. It lays out project context, problem definition, initial research questions, stakeholders involved, scope, project goal, deliverables, personal ambitions, project approach, research approach and perspectives.

1.1.1. Project Context

While Autonomous Vehicles (AV) based on Artificial Intelligence (AI) technology are being looked upon as a new normal concept of mobility in human society, what would be the future of human activities within vehicles remains a major topic of contemplation for people. The development of autonomous vehicles would fundamentally change the nature of user interaction with vehicles as non driving users have expectations of undertaking diverse activities when seated inside the AV (Jorlöv et al., 2017). This will in turn inspire new forms of automobile and Human-AV interaction design that Tang et al. (2020) ascribe to two main factors - firstly, the fact that the automation will relieve drivers from the task of driving and secondly, drivers free of driving tasks would would then require a redesign of in-vehicle information and functions leading to new interaction mechanisms. However, the introduction of autonomy in vehicles doesn't completely free the non-driving users of decisions to be made and responsibility for vehicle behavior.

Firstly, in the event of an accident, Siebert et al. (2022) note that it can be unclear who is responsible and determine who was really in control of the vehicle - the driver, the designer, the policy makers, other road users? In these cases, it's not enough for the driver to have optional control without situational awareness or inability to maneuver the vehicle without skill loss, thereby requiring AV designs that actively influence human drivers through mutual interaction and mixed autonomy (Di & Shi, 2021). Secondly, without understanding how an AI system works and makes decisions, humans find it hard to trust autonomous systems based on them. Building Human-AI trust would require the AI system operating the AV to have transparency and explainability of the decisions made while in operation, as this improves trustability and decision making of users when using AI systems (Balasubramaniam et al., 2022). Thirdly, users would be enthusiastic to interact and undertake different kinds of activities with the AV, Human-AV interaction raises data privacy concerns in the minds of users regarding the amount of personal information they can share with the AV (Alekszejenkó & Dobrowiecki, 2022). Fourthly, the main focus of work surrounding autonomous systems is centered around the technology itself. One of the main criticisms advanced by the user automation research community toward technology-centered taxonomies is their limited consideration for the human element involved in automation (Biondi et al., 2019).

Adopting a human-centered design approach has found to be of utmost importance for developing a conducive ecosystem wherein AI and HCI based systems can collaborate seamlessly (Vishwarupe et al., 2022) to build user-friendliness and trust in its application. Additionally, Human-AV interaction has found to have explicit communication methods such as eye contact ("I see you, did you see me?") and gestures ("please go ahead") as well as implicit communication methods such as gait or driving behavior (Dey & Terken, 2017).

Dialogue in vehicles often takes place through implicit and explicit forms of communication. Accordingly, this concept of shared autonomy necessitates a dialogue between non-driving humans and autonomously driving vehicles for a Human-AV collaborative driving experience. William Isaacs in his book 'Dialogue and Art of Thinking Together' states that 'a dialogue is a conversation with a center, not sides that lifts us out of polarization into a greater common sense thereby becoming a means of accessing the intelligence and coordinated power of groups of people.' How would it be if humans and autonomous vehicles could have a dialogue with each other to maintain situational awareness, critique driving decisions, have friendly banter and enable other such forms of collaboration?

1.1.2. Problem Definition

Considering the human-centred perspective is critical in achieving successful integration of autonomous vehicles within our cities and lives of people. The need for this approach is bolstered by studies on behaviour of humans around autonomous vehicles, which show people like to get some form of communication from AVs (Rothenbucher et al., 2016). Humans seek intelligent 'things' to be collaborative, responsive and personalized towards them in order to function seamlessly for which a socio-technical approach would be essential (Valentine et. al., 2021; Fridman, 2018). Herein lies the opportunity for designers to contribute towards building these Human- AI collaborations, which would require the discernment and integration of different capabilities, uniquely human and uniquely artificial, into appropriate co-performances (Giaccardi & Redström, 2020). A research gap exists in the articulation of the nature of dialogues that could occur between these co-performances. Dialogues are different types of encounters that occur during the process of design which could be verbal, visual, physical, interactive, or even tacit (Lloyd et. al., 2022) and are a site of a complex interplay of ideas, structures, meanings, and explorations (Arzberger et. al., 2022). To design for dialogue within Human-AV collaboration, the human-machines interaction design will have to be re-imagined to enable innovation within AV companies, which will have to be soundly grounded in research to understand customers', users' and other stakeholders' current experiences, expectations and aspirations for future experiences (Kim et al., 2022).

Herein lies the opportunity to research the following initial research questions:

Q2: What could be the opportunities for conversational dialogue in the context of Human-AV collaboration?

Q3: What interaction design concepts and solutions could be designed to foster a dialogue between Humans and AVs?

Q4: What design guidelines & innovation strategies could be developed to design for dialogue between Human & AV?

1.1.3. Stakeholders

This master graduation project will be completed under the aegis of TU Delft - Stanford University research collaboration. The project stake holders will be my graduation committee consisting of internal mentors from TU Delft and external mentors from Stanford. Secondly, the research is conducted by involving industry and academic experts to get a better perspective. Thirdly, the research process involves people who would be the future users of this technology. The user studies are conducted at the Delft University of Technology on a driving simulator named DAVSi with Yaris cockpit as part of the Intelligent Vehicles Group.

1.1.4. Scope

This master thesis looks at opportunities that Conversational AI offers to engage users in Fully Autonomous Vehicles. As Fully Autonomous Vehicles free users from any form of driving task, this would leave users without any specific task to be accomplished in a car leading to a boring user experience. Conversational AI technology could offer solutions to engage users in various activities using conversations that they enjoy and present an opportunity for novel enjoyable user experience.

The scope of this master project is to understand what opportunities does Conversational AI offer, what activities and behaviours would users undertake in a Fully Autonomous Vehicles, and how can Conversational AI offer innovative opportunities for enjoyable user experience in AVs. The outcome of the research would be design guidelines and design innovation strategies to inform internal thinking in mobility companies to design their user experiences.

The research will seek to address autonomous mobility companies that want to design autonomous vehicles for Human-AI collaboration. The secondly, the research will inform the academic research community, where in this research could add a leaf to the tree of knowledge surrounding Human-centered design strategy of conversational AI design in autonomous vehicles.

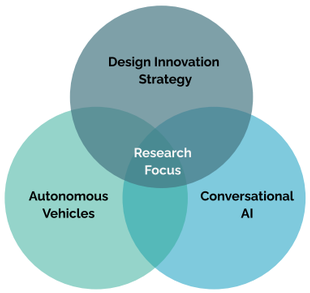


Figure 1: Research domains of the thesis

1.1.5 Project Goal

The goal of this project is understand the opportunities that exist and develop design innovation strategies for the integration of Conversational AI in Fully Autonomous Vehicles.

1.1.6 Deliverables

The deliverables of this project based on the research conducted would be:

1) Interaction concepts and future vision.
2) Interaction design guidelines.
3) Innovation strategy framework / toolkit.
4) Research paper

1.1.7 Personal Ambitions

Through this project, I intend to achieve the following personal ambitions to develop as a design strategist:

Firstly, I seek to develop the following hard skills:
Academic research : During my master's, I discovered that I had a passion for undertaking research. Setting up experiments to understand various phenomena, interactions, strategies, and design features in order to innovate fascinates me. Through this project, I want to further strengthen my process of undertaking academic research and become more confident in communicating research outcomes.

Interviewing and facilitating skills: I enjoy having conversations and learning from people with deep knowledge in their fields. However, integrating this into my professional work is something I want to be good at. Through my thesis, I want to strengthen my learnings of conducting professional stakeholder interviews and creative sessions with subject experts, users and designers.

Innovation mindset: I have always been fascinated with the process of innovation and creating an impact in society through it. Learning to develop innovation strategies by applying the skills and knowledge I have learnt in design, innovation, artificial intelligence and mobility during my master is something that I want to develop an aptitude for.

Secoundly, I seek to develop the following soft skills:
Time Management: I have a habit of diving too deep into a subject and not being able to come to a resolution to make choices. This leads to procrastination on my work to make the best possible choice which causes an imbalance in time management of the project. I want to learn the art of time management while undertaking research work.

Work-Life balance: Sometimes, while working I neglect exercising which ultimately decreases my productivity. During the course of the project I want to undertake lap swimming to maintain good health and work-life balance.

1.1.8 Research approach and perspectives.

This thesis employs three design approaches to accomplish the thesis while dealing with the chosen topic, mentioned below.

Strategic Design
Strategic Design refers to a professional field in which designers use their design practices to co-determine strategy formulation and implementation toward innovative outcomes that benefit people and organizations alike (Calabretta & Gemser, 2017). This thesis will research how design innovation strategies can be articulated concerning the topic of investigation for autonomous vehicle organisations.

Human-Centred Design
Human-centred design (HCD) is a group of methods and principles aimed at supporting the design of useful, usable, pleasurable and meaningful products or services for people, where the main principle of these methods is that they describe how to gain and apply knowledge about human beings and their interaction with the environment, to design products or services that meet their needs and aspirations (Van Der Bijl-Brouwer & Dorst, 2017). This project makes use of HCD principles by involving users at every step of the process and understanding their perspective thoroughly .

Interaction Design
In research Interaction Design is an umbrella term used to refer to a collection of research areas having a common interest in understanding and supporting the interaction between people—individuals or small groups—and digital technology (Kaptelinin & Bannon, 2011). Further, Interaction Design is defined as the design of interactive products to support the way people communicate and interact in their everyday and working lives (Rogers et al., (2007). This thesis researches how people will interact with Conversational AI technology and Autonomous Vehicles while articulating design strategies.

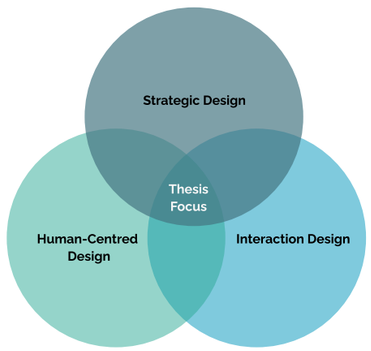


Figure 2: Design perspectives of the thesis

1.1.9 Project approach

The following 7 phase project approach is taken to accomplish this research thesis.:

Phase 1 - Define: Define the appropriate research questions, context of enquiry, project deliverable and form a graduation committee. Finalize the brief by developing a common research direction.

Phase 2 - Collect and analyze: Identify literature review domains, experts and users for qualitative interview, design simulator studies and quantitative forms. Design and set up experiments to study interactions in simulators. Analyze the results of interviews, simulator studies and literature research. Use the results to inform the design process.

Phase 3 - Design and Develop: Ideate on design concepts of opportunities for Conversational AI in Fully Autonomous Vehicles. Prototype design guidelines innovation strategies/ framework and toolkit.

Phase 4 - Test and validate: Test the developed deliverables to validate their performance.

Phase 5 - Revise and Reflect: Reflecting on the learnings, achievements and shortcomings of the project in order to incorporate whatever needs to be updated.

Phase 6 - Deliver: Deliver the results of research and present the project in front of an audience.

Phase 7 - Publish: Put in the efforts to develop and publish the work as a research paper in an academic journal.



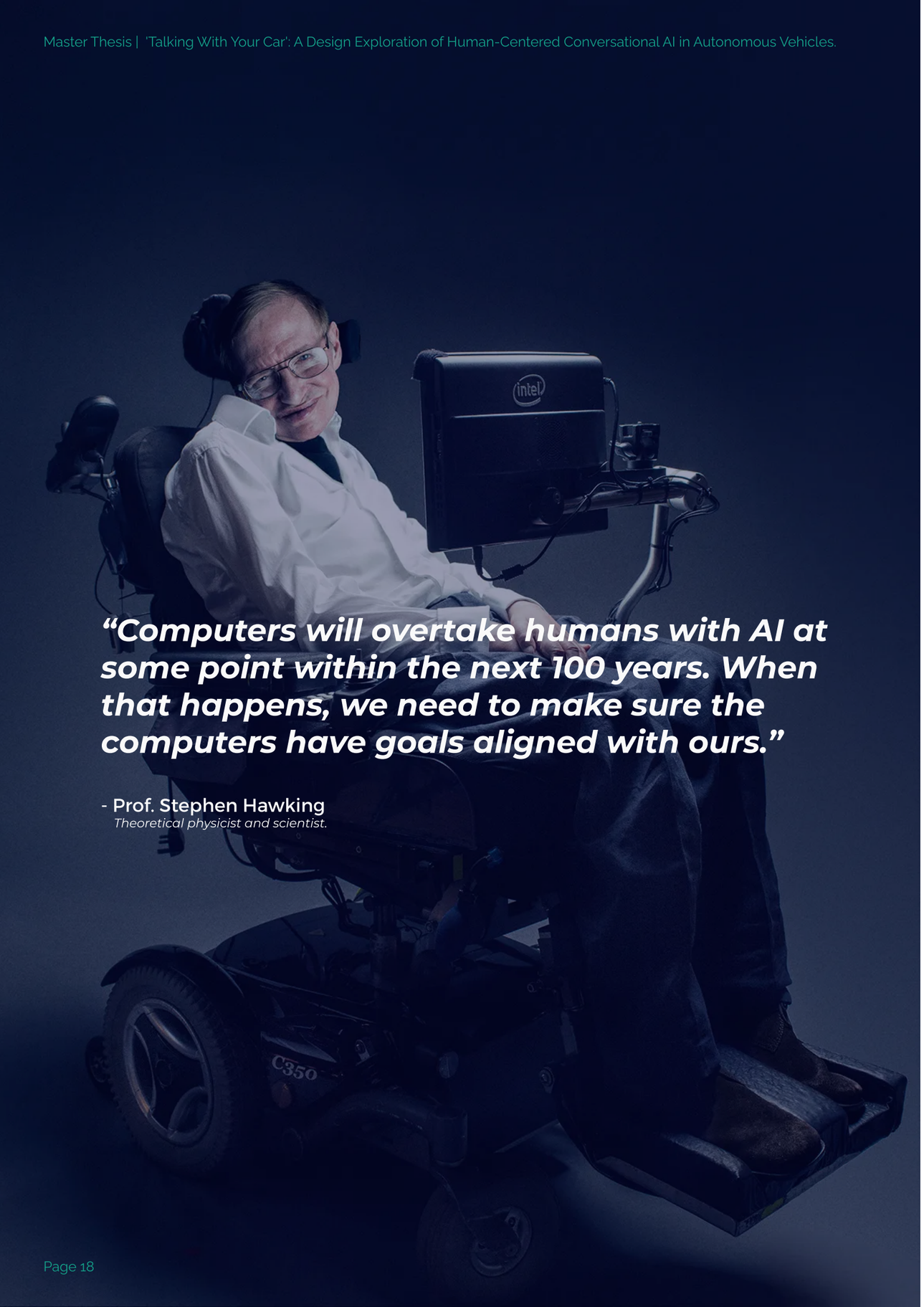
Chapter 2

Artificial Intelligence

This chapter introduces the basics of artificial intelligence at the outset and dives deeper into understanding the fundamentals of Conversational AI, through the review of literature in the form of research papers and book chapters. Though the AI discipline is vast, this chapter scopes the extent of understanding to the relevance of this thesis which is Conversational AI.

In this chapter:

2.1 Introduction to AI
2.2 Fundamentals of Conversational AI
2.3 Design of Conversational AI



2.1
Introduction to Artificial Intelligence

Artificial Intelligence (AI) has become a very popular term and has created much buzz around itself in today's times. But what are the elements that constitute Artificial Intelligence? This chapter explores AI fundamentals to develop a basic understanding.

2.1.1 Background of AI discipline.

Artificial intelligence (AI) in its simplistic view is an idea of creating machines that would have intelligence capabilities equivalent to humans. Though AI is in buzz in recent times, one of the first publications alluding to AI was work published by McCulloch and Pitts in 1943 who describe a computer model used to learn based on a process comparable with neurons in the human brain (Muthukrishnan et al., 2020). Over time, scientists felt a need for a systematic method to evaluate various computer models in order to determine level of computer capability. Alan Turing in his work "Computing Machinery and Intelligence" in 1950 presented the 'Turing Test' to test if machines can human intelligence. The test involved a human investigator asking the same questions to humans and machines, and if the investigator couldn't discern the difference between the answers, the machine would be considered intelligent. This has been considered the goal of AI for the longest time. However the understanding of AI technology in today's time is much broader than the aforementioned, some of which we discuss in th following sections.

2.1.2 Definition of AI

Dr. John McCarthy, one of the founding fathers of the Artificial Intelligence discipline describes AI as the science and engineering of making intelligent machines, intelligent computer programs and using computers to understand human intelligence (McCarthy, 2020). Prof. McCarthy further writes that though a substantial portion of artificial intelligence emulates human intelligence, this is not a necessary criteria for machines to be considered intelligent. The term 'Artificial Intelligence' as a scientific discipline was coined in the "Dartmouth Conference" of 1956 organized by Marvin Minsky, John McCarthy, and Shannon and Nathan Rochester. This conference inspired a series of developments in artificial intelligence over the coming years which in recent times have seen a rapid growth in influence of AI technology into our human lives. Ergen (2019) describes that this increase in AI omnipresence has been due to three technological developments that have reached enough maturity and convergence, which are due to the (1) advancement in algorithms, (2) the availability of massive amounts of data and (3) increasing computational power along with storage available at low cost.

2.1.3 Science behind AI

There are two classifications of Artificial intelligence available through the perspective of which AI developments can be better understood.

Firstly, AI can be classified into Super AI, Strong AI and Weak AI (Wang & Siau, 2019), based on their level of task performance and capabilities.

Super AI
This is a distant vision for artificial intelligence when it would surpass human intelligence by leaps and bounds. This is a conceptual long term vision and the science hasn't been articulated yet due to which it's difficult to define what exactly the term implies and outline how humans will experience this technology.

Strong AI
This is a vision for AI technology when human beings and machines would have a comparable level intelligence. Machines will have the ability to reason, think and do all functions that a human is capable of doing (Kumar & Thakur, 2012). They would have consciousness, self awareness and intelligence to autonomously carry out day to day activities. The current level of technological development in computer science and engineering is far from this level of intelligence, but it is the current goal of the computer science field that it is heading towards.

Weak AI
This is the technology that we have currently and it is termed so because it excels at undertaking specific tasks with a high level of proficiency. Weak AI represents a collection of specialized algorithms that can perform a given task with high accuracy, provided we can feed them with a large set of training data (Tizhoosh & Pantanowitz, 2018). The development of weak AI takes a practical approach of developing the technology to first undertake specific specialised tasks as then it requires a relatively limited amount of data, specific algorithms and specific set of queries that it can be asked to execute. Few examples of this kind of AI are ChatGPT, conversational task delegation agents, email autocomplete functions, object detection and other such applications of such lines. Developing weak AI well would potentially lead to developing strong AI.

The second classification is based on functionality into 4 types of AI (Kolte et al., 2020):

Reactive machines
These are the most basic type of AI machines that react the same way every time and are good at accomplishing repetitive tasks. Such AI systems do not store memories or past experiences due to which they are good at accomplishing ephemeral tasks. Chess software game is a good example of such types of AI.

Limited memory
These machines have a limited amount of memory and can store data for a limited amount of time. These machines are built on models that absorb data and learn over time. Some examples are self driving cars.

Theory of the Mind
These machines are conceptualized as forms of AI that are close to human intelligence. This type of AI would understand human emotion, people, beliefs and be able to interact socially. This AI would form a part of social robots that could interact with and work with humans.

Self awareness
This is a type of AI machines will be super intelligent, and will have their own sentiments and self-awareness. The capabilities of such type of AI are theorized to would extend beyond Human intelligence.

2.1.4 Applications of AI

Artificial intelligence technology has a great potential to influence human life through various applications that can be developed. Artificial Intelligence can be employed in any field that requires a systematic (human like) thinking such as learning, reasoning, problem solving, etc and has data resources available or are procurable for this intelligent processing. Every discipline having the aforementioned potentials can be thought of for artificial intelligence application. In concern to the topic of enquiry of this thesis, AI is the driving force of conversational agents and chatbots which are designed to undertake conversations with humans through the use of natural language (Svenningsson & Faraon, 2019). Further, autonomous vehicles make use of deep learning and artificial intelligence to make informed decisions as well as detect the surrounding environment to undertake positioning, sensing, planning, and control (Gao & Bian, 2021). Each of these products use different sub technologies of the umbrella term of artificial intelligence. In the coming chapters, we will explore these topics in greater detail.

AI classification based on capabilities		
Weak AI	**Strong AI**	**Super AI**
Qualities	Qualities	Qualities
1. Can do specialised tasks well. 2. Can access past data to suggest future actions. 3. Responses generated have to be designed by humans.	1. Learn from their experiences & environment. 2. Plan future course of action by being conscious. 3. Develop independent reasoning for actions.	1. This type of AI is conceptualised to surpass human intelligence in the future. 2. It's qualities are yet unknown

Figure 3. Table showing classification of AI based on capabilities

AI classification based on functionality		
Reactive Machines	Qualities	
	Good at repetitive tasks	No memory
Limited memory	Qualities	
	Less memory	Learns from data
Theory of Mind	Qualities	
	Close to human intelligence	Social interaction
Self awareness	Qualities	
	Aware about existence	Beyond human capabilities

Figure 4. Table showing classification of AI based on functionality

2.2
Fundamentals of Conversational AI

This section transitions from discussing AI in general sense to focus of the thesis which is Conversational AI (CAI). This section discusses Conversational AI in greater details outlining the underlying technologies of CAI and how conversational AI functions.

2.2.1 Introduction to Conversational AI (CAI)

Conversational AI (CAI) is a sub domain of Artificial Intelligence that deals with the possibility of humans having a conversation with computers, thereby improving human-computer interaction. This technology pushes forward the idea of enabling humans to "talk" with machines, in order to give commands, delegate tasks, have informal conversations and articulate other possibilities that could exist or occur through human-machine voice based conversations. CAI typically make use of speech-based or text-based AI agents and have the capability to simulate and automate conversations and verbal interactions (Kulkarni et al., 2019). The underlying key technology push that bolstered the development of CAI was due to the advancements in Natural Language Processing (NLP) which has been revolutionizing the way humans relate with computers (Saka et al., 2023). In addition to NLP, three major technologies have contributed to the current level of development of commercial conversational agents which are Machine Learning (ML), Automatic Speech Recognition (ASR), and Advanced Dialogue Management (ADM). These technologies are elaborated upon for a gaining an in depth understanding in the following chapters.

Components of Conversational AI Technology	
Natural Language Processing	Definition Natural language processing (NLP), is the subfield of computer science concerned with using computational techniques to learn, understand, and produce human language content (Hirschberg & Manning, 2015b).
Machine Learning	Definition Machine learning uses large amounts of data to continuously optimize models and to make reasonable predictions under the guidance of algorithms, by using processes of data processing, modelling, and validation (Wei et al., 2019)
Automatic Speech Recognition (ASR)	Definition ASR is the process of automatically identifying patterns in a speech waveform, including the speaker's identity, language, emotion and the textual transcription of the spoken utterance (Aldarmaki et al., 2022).
Advanced Dialogue Management	Definition The dialogue manager in a spoken language system determines the system's response to the user's utterances, by performing a combination of confirming, validating and requesting a single dialogue turn (O'Neill et al., 2005).

Figure 5. Table showing Components of conversational AI technology

2.2.2 Machine Learning

Machines learning is the study and computer modelling of learning processes in their multiple manifestations (Carbonell et al., 1983). Machine learning discipline works towards developing the science and technology to create machines that can learn from the environment and act independently to accomplish tasks. Machine learning can be further classified into 3 types of categories based on the process machine learning algorithms follow to learn, which are supervised learning, unsupervised learning and reinforced learning (Maleki et al., 2020). Supervised learning is a technique in which each observation made in the input data has to be labelled with variables. A supervised model's performance is heavily influenced by the quality of the training set in a phenomenon known as "garbage in, garbage out" where the model's performance can be heavily influenced by the size, sample bias, and data labelling/annotation of the training dataset (Lim et al., 2023). On the contrary, unsupervised ML uses the concept that a ML model can compress information to a lower dimensionality and reconstruct the information back to the higher dimensionality (Strohmann et al., 2023). Unsupervised learning technique is used to find associations and patterns in a data set that may not have been extensively processed or annotated. Lastly, reinforcement Learning is a branch of machine learning in which an agent learns from interacting with an environment through trial and error (Mousavi et al., 2018). In reinforced learning the machines undertakes trial and error to study optimum decisions that have worked in the environment to apply them to accomplishing tasks. Either of these three techniques are employed to undertake machine learning tasks based on the type of job to be done and capability of machine learning technology that can best achieve the results.

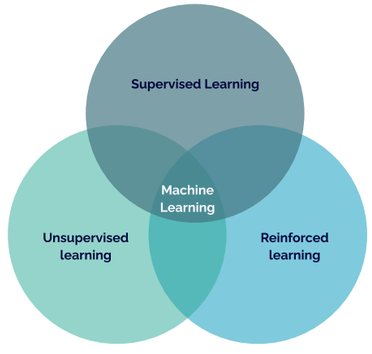


Figure 6. Diagram showing components of machine learning technology

2.2.3. Natural Language Processing

Natural Language Processing (NLP), also known as computational linguistics, involves the engineering of computational models and processes to solve practical problems in understanding human languages (Otter et al., 2021). NLP is a scientific discipline that works in converting human language and the information conveyed through it into an understandable format for computers to process and act upon. NLP is employed in analysis of the linguistic structure of language and developing technologies such as machine translation, speech recognition and speech synthesis, creating spoken dialogue systems and speech-to-speech translation engines, mining social media for information and sentiment or emotional analysis (Hirschberg & Manning, 2015). The developments in the NLP discipline have had multiple ramifications. Firstly, the ability to translate between languages is enabled by natural language processing. Secondly, conversational agents which are an interface between humans and machines run on NLP technology, using NLP to understand human language and formulate a response. Over time, with the development in NLP technology many more applications would arise . The Sub-technologies that NLP technology employs to function in Conversational AI is that it uses Natural Language Understanding (NLU) to categorize the user's intent, followed by Dialogue Management (DM) to determine user's intent, after which Natural Language Generation (NLG) is employed to generate a response in a natural language. The process flow of NLP can be mentioned as input generation, input analysis, output generation, and reinforcement learning to generate a conversation with users (Suta et al., 2020). This process is seamlessly integrated into products that have the option of integrating conversational agents as an interface with the user.

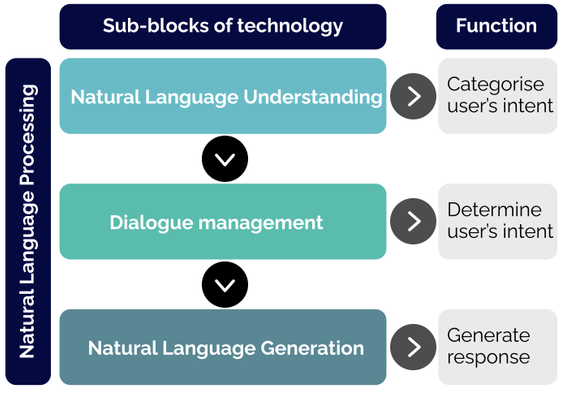


Figure 7. Natural Language Processing Process in Conversational AI

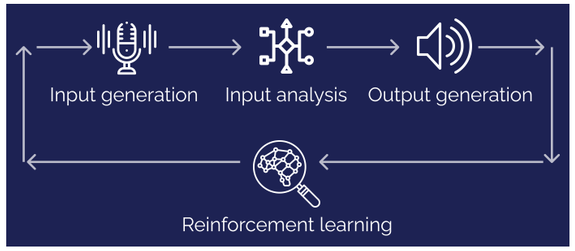


Figure 8. Process flow of Natural Language Processing in Conversational AI

2.2.4 Automatic Speech Recognition (ASR)

Automatic speech recognition (ASR) systems help digital machines interpret spoken speech and automate human tasks, such as typing text and web searches (Schultz et al., 2021). The manner in which ASR works is that a human speaks to the conversation agent via audio feed which is then converted into a wave file of words, which is further cleaned by removing background noise and normalizing volume. The words are broken into phenoms, which are basic sounds in english. These phenoms are chains which are analyzed using statistical probability to deduce whole words and produce sentences (Catania et al., 2019). The availability of large sets of training data is key for a smooth transcription of speech. Further improvement in efficiency of ASR technology will enable having accuracy and efficiency of ASR (Wald et al., 2007).

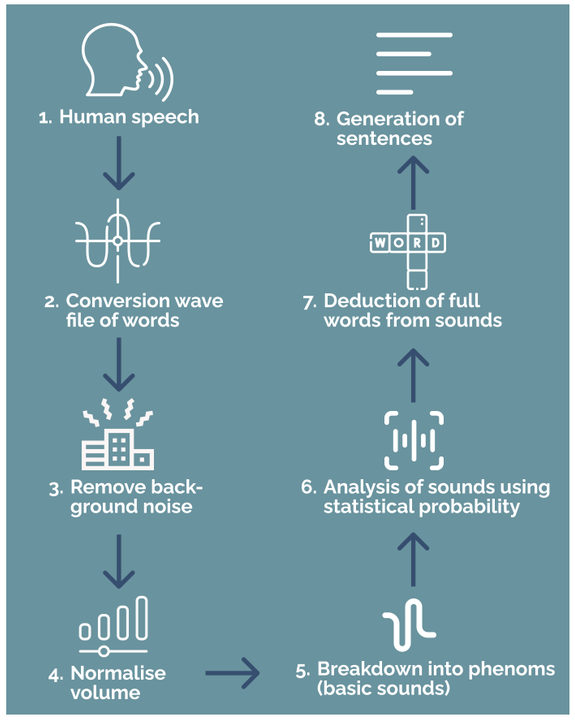


Figure 9. Functioning of Automatic Speech Recognition Technology

2.2.5 Advanced Dialogue Management.

Dialogue Management Systems (DMS) are important in conversational AI agents as they play a crucial role in determining what conversations to display to users and how to keep them engaged. Dialogue management coordinates the activity of all components, controls dialogue flow, and communicates with external applications (Lee et al., 2010). The Dialogue Manager (DM) keeps tracking the current dialogue state and determines the next action to be taken (Quan et al., 2021). Further, Brabra et al. (2021) articulate that DMSs play a crucial role in (i) tracking of information that is entered implicitly or explicitly by users, (ii) understanding conversation context and resolving ambiguity, (iii) controlling the conversation flow between users and system, (iv) communicating with external services/databases and finally (v) identifying system actions to fulfill the ultimate user goal. Hence, being the facilitators of an efficient conversation flow, ensuring having a well functioned DMS plays a paramount role in the design of conversational agents.

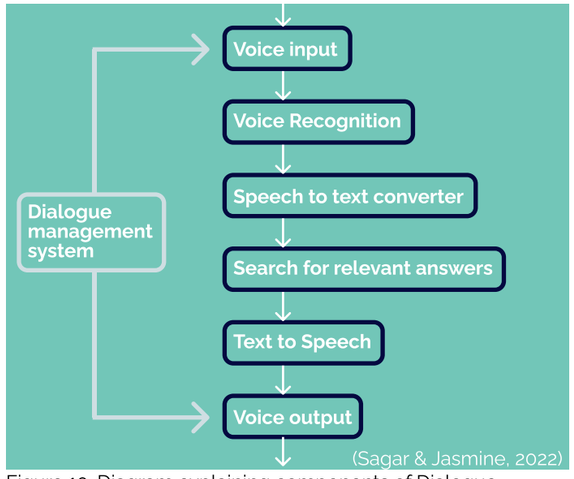


Figure 10. Diagram explaining components of Dialogue Management System.

2.2.5 Challenges of designing CAI

Though the basic technology is available and improving over time for creating chatbots and conversational agents, there are challenges that designers of CAI have to consider which are associated with building conversational agents that Ram et al. (2017) outline, some of which are Conversational Automatic Speech Recognition (ASR) for free-form speech, Natural Language Understanding (NLU) for multi-turn dialogs, Conversational Datasets and Knowledge Ingestion, Common sense Reasoning, Context Modelling, Dialogue Planning, Response Generation, Natural Language Generation (NLG), Sentiment Detection, Inappropriate Response Filtering (e.g. profanity, inflammatory opinions, inappropriate jokes, hate speech), Personalization, Conversation Evaluation, and Conversational Experience Design.

2.2.6 The AI Landscape of related disciplines

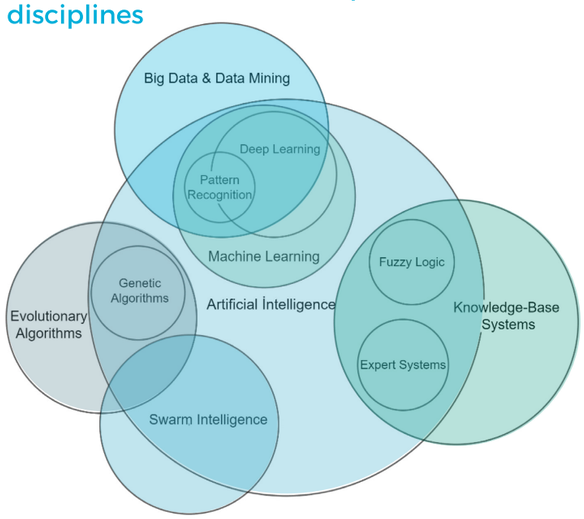


Figure 11. AI landscape & relationships between AI disciplines (Yüksel et al., 2023)

2.2.7 Challenges of Human-AI (H-AI) Interaction

Machine behaviour
As AI systems can lead to unique machine behaviours, potentially displaying biased and unexpected outcomes. Therefore, AI should be designed for responsible behaviour while interacting with Humans.

Human - Machine Collaboration
With the possibility of machines having an independent process of working, they can act as teammates to function in collaboration with humans. This framework for collaboration through Human driven decision making has to be designed well.

User Interface
AI provides possibilities to design new forms of interfaces such as:
a) Intelligent user interface with voice/ facial recognition
b) The UI in the case of AI may be invisible & implicit.
c) Humans and AI adapt to each other's capabilities to undertake collaborative tasks.
d) Natural and usable design of AI - Human interfaces and creating HCI design standards for AI systems.

Autonomous characteristics of machines
AI systems need to be designed to have unique autonomous characteristics such as learning, self-adaption and self-execution.

Figure 12. Challenges in Human-AI interaction (Xu et al., 2022)



"Some people call this artificial intelligence, but the reality is this technology will enhance us. So instead of artificial intelligence, I think we'll augment our intelligence."

-Ginni Rometty
Former CEO & President, IBM

2.3
Design of Conversational AI

This section discusses the design of Conversational AI, what the desired user experience and what are the challenges of designing CAI.

2.3.1. User Experience Design of CAI.

Conversational AI agents are designed based on Input-Intent-Action-Response model (Baez et al., 2019) in which the user provides input consisting of the intent. The CAI processes and understands the intent to translate into an action using NLP. The execution of the action results into a response that can be conveyed to the user. Hence, creating a decision tree plays can important role the design of conversations. The design of a chatbot typically has to deal with the front end consisting of input/output of speech and text, and the back end consisting of either no-coding platforms or programming languages (Singh & Beniwal, 2021). To design the front end, designers have to understand from users what their expectations, behaviours, desires and needs are. By understanding nature of desired speech and text from CAI, designers need to think of decision trees of conversation flows. After this stage the design has to be materialised through working on the backend engineering by encoding these conversation decision trees into the system consisting of a programming based environment.

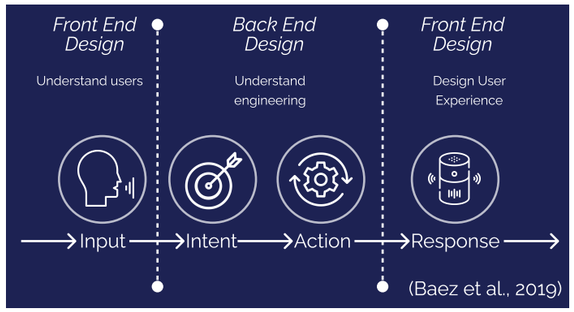


Figure 13. Model of Conversational AI Technology.

2.3.2. CAI-User interaction and behaviour.

Further, it is important to understand how user behave while interacting with CAI to design CAI in a human-centred manner. Studies have found that people apply their social and interpersonal skills to conversations with computers as people have found to be treating different voices as distinct social actors and treating the same voice as the same social actor (Nass et al., 1994). Further, it has been found that people send twice as many messages to CAI than to other people, though they prefer that these conversations are short having fewer words (Hill et al., 2015).

Furthermore, studies point out that a computer is cherished by individuals because they have become emotionally attached to it, which is related to the evocation of memories and emotion management, rather than a direct response to the object itself (Nass & Moon, 2000). How these behaviours materialise into product experience needs to be understood and translated into design strategies for innovating. Liebrecht and Van Hooijdonk (2020) present three strategies to design conversational Human Voices for more engaging conversations, which are (1) Message Personalization (degree to which a specific stakeholder can be addressed in a message), (2) Informal Speech (casual, everyday language that differs from formal, corporate language such as the adoption of non-verbal cues and interjections) and (3) Invitational Rhetoric (to what extent the organization's communication style stimulates stakeholders).



Figure 14. Design Strategies for Conversational AI (Liebrecht and Van Hooijdonk, 2020)

Furthermore, the current usage of CAI is towards task delegation. Human interact with conversational AI to ask them to play music, call a person, search the internet for information and get the CAI to accomplish tasks based on commands given to them by humans. CAI design has to transition from being a task-delegation based system to a system that has a mind of its own designed on the 'theory of mind'. CAI should not only have the capability of understanding what the user wants, but have the social characteristics to converse with the user as if it were completely autonomous (Heyselaar & Bosse, 2019). Chaves and Gerosa (2021) point out that social intelligence parameters of proactivity, consciousness and communicability as well as personification parameters of damage control, thoroughness, manners, moral agency, emotional intelligence and personalisation are the aspects that most literature suggest are key components of CAI design.

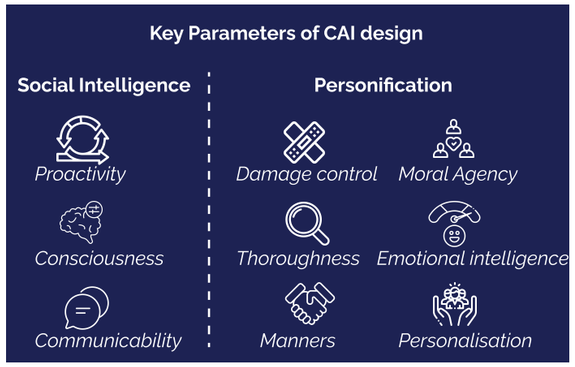


Figure 15. Key Parameters of CAI design (Chaves & Gerosa., 2021)

Kvale et al. (2019) find in their research that customer behaviour and chatbot characteristics play an important role wherein the customers always have a specific need that they can convey at the right level of abstraction to the chatbot. The chatbot has to be designed to make use of the right vocabulary to match with that of the customers, along with a forgiving interpretation of customers language and have a good customer journey to reach the goal of the conversation.

To design CAI having the characteristics of human, Svenningsson and Faraon (2019b) advice producing designs that avoid small talk while maintain a formal tone, identify itself as a bot and asking how it can help, providing specific information while using sophisticated choices of words, ask follow-up questions in decision-making processes and providing an apology when the context is not comprehensible followed by a question or a statement to dynamically move a conversation forward.

2.3.3. CAI Interaction Design

Diederich et al. (2022a) propose a framework for CAI design adapted form HCI research that encompasses context, human, agent, and perceptions and outcomes.

An important consideration while designing CAI is an understanding of the topics of conversations that people would be interested in having with it. The research by Ng and Lin (2022) presents six themes of conversation topics between users and CAI, which are functional gratification (function, use, control, and automation features), hedonic gratification (use of media apps and voice shopping), social gratification (interactions between users and conversational AI), settings (account and sound adjustments and settings), problems encountered (problems and program errors), and connections between devices (smart devices and smart speaker connections).

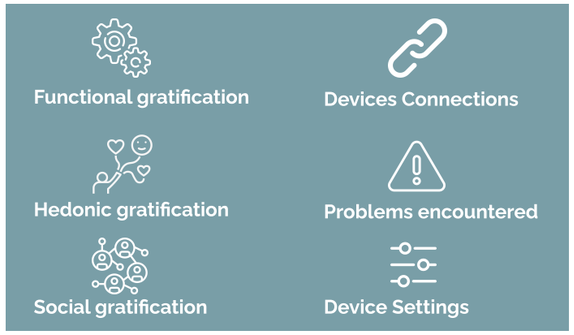


Figure 17. People's preferred topics of conversations with AI (Ng and Lin., 2022)

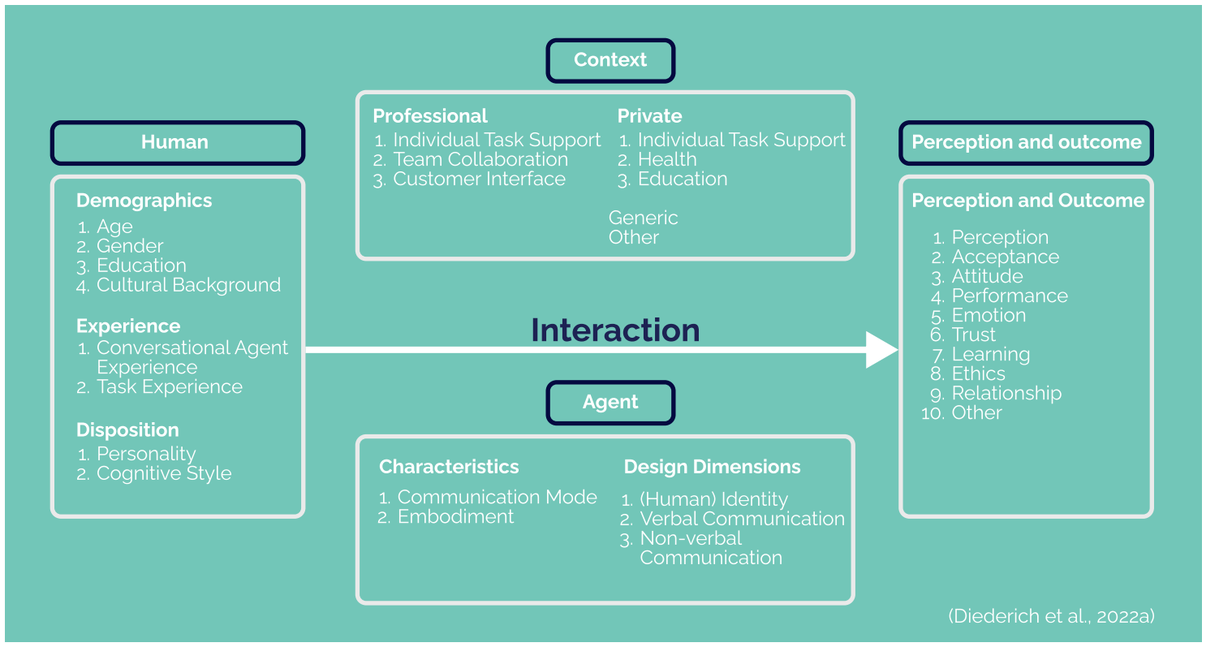


Figure 16. Framework for Human-Computer Interaction via Natural Language adapted from Diederich et al. (2022a) .



Chapter 3

Autonomous Vehicles UI/UX

This chapter explores the basics of Conversation AI's integration into Autonomous Vehicles at the outset and dives deeper into understanding the design of Conversational AI in Autonomous Vehicles, through the review of literature in the form of research papers and book chapters. The chapter also explore User Experience design of CAI in AVs by understanding user needs, behaviours and activity within AVs.

In this chapter:
3.1 AV Voice Interfaces
3.2 AV CAI User Experiences



3.1
Voice Interfaces in Autonomous Vehicles

This chapter explores the voices interfaces that have already been deployed within autonomous vehicles to in order to understand unrealised aspects and issues being faced in the integration of Conversation AI into Autonomous Vehicles.

3.1.1 Introduction to AV and levels of Automation.

The development of autonomous vehicles has been segregated into 6 levels of automation (0 to 5) by the Society of Automotive Engineers that has been adopted by the US Department of Transport (See figure X). These levels define which tasks vehicles will undertake and which tasks humans will undertake as levels of automation clearly progress. These levels of automation make it very clear to comprehend how human-autonomous vehicle interaction will be shaped in future and is a good point of reference for this thesis.

3.1.2 Preference of Voice Assistants in AVs

Numerous research studies have indicated that voice assistants are desired and preferred within AVs and self-driving cars. Studies have found that voice assistants are highly attractive for drivers who prefer the system instead of driving without any assistance, and personalization was not only noticeable in the results but enhanced driving by monitoring of traffic situation compared to driving with a non personalized system (Orth et al., 2017). The voice assistants were found useful in aiding drivers in self-driving cars where the level of automation was not very high. In these cars, personalisation of the CAI was also looked upon favourably.

Studies with usage of sound as a medium of communication have identified that the use of less intrusive continuous sonic interaction can be a more successful strategy to facilitate a positive user experience, as with a proper user interaction design user can be provided with a level of information, which could help to build more appropriate mental models and foresee the system's behavior and the user can perceive the information given by the user interface even with eyes closed as well as allows the user to keep his/her eyes on the road/ traffic during the time of the actual handover (Larsson et al., 2019). These learnings can be extended to Conversational AI, where some aspects of the conversation can only be indicated with sounds. Generating mental models and conveying information without the requirement of eye gaze is crucial aspect of Conversational AIs.

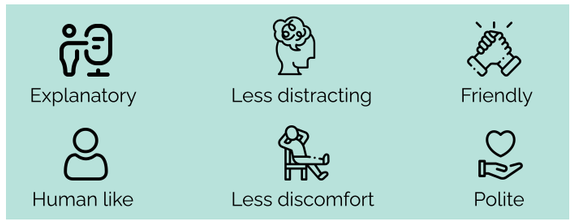


Figure 18. Preferred qualities of voice-only agents

Numerous studies also looked at different robot agents for assistive driving in lower levels of autonomy while looking at potential for Human-AV collaboration in higher levels of autonomy. It was found in most studies that voice agents were preferred for being least intrusive in terms of eye gaze distraction and mental workload. Although participants rated robot agents higher in amount and quality of driver-agent interaction, they preferred voice-only agents the most due to their qualities of being explanatory or instructive consisting of essential information, less distracting, friendly and polite, and human-like causing less distraction and discomfort. (M. Wang et al., 2022). There is a clear potential of Conversational AI to contribute meaningfully to Non-Driving Related Tasks and Driving Related Tasks during handover of control in Self Driving Cars.

3.1.3 Design of Conversational AI in AV

The design of Conversational AI in Autonomous Vehicles has to be sensitive to multiple aspects related to human desires, needs, and behaviours. Karlsson et al. (2020) present a conceptual exploration through co-creation in which voice agents are used for cars anticipating the needs of the users, listens in conversations amongst the users and is there for you watching your back through a friendly voice based communication. The parameters they identify that could play a role in communication within Human - Conversational agent in AV are (1) level of involvement, (2) Hierarchy in the relationship, (3) Negotiated willingness in making decisions, (4) Distinctive interactions, (5) Range of modalities of AI. Voice characteristics or factors of vHAI experience identified are Gender, Anthropomorphism, Humanlikeness, Natural vs. Synthetic Voices, Vocal Fillers, Affect and Emotion, Accent and Dialect, Paralinguistic Cues, Prosody, and Speech Style, Personality, Morphology and Medium, (Seaborn et al., 2021)

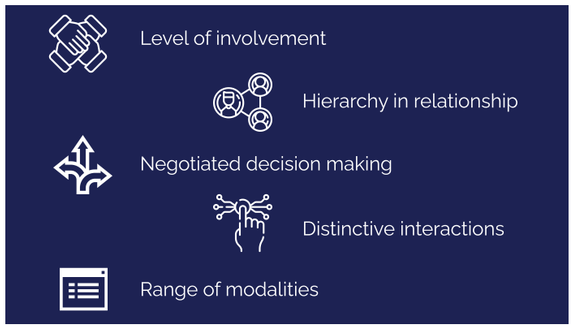


Figure 19. Parameters of communication between Human & Conversational agents in AV (Karlsson et al., 2020)

Further, the role of gender has also shown an effect on the communication styles desired by users. In case of sedans, super reasonable communication style and female voices were favorable whereas in the case of SUVs, congruent communication style and male voices were preferred (Park & Lee, 2022).

Designers have to also be sensitive towards the tone of vocabulary employed by CAI. The findings on wording in conversational AI suggest due to the safety-critical nature of driving, commanding/formal prompts are preferred most of the time for handover and handback scenarios, but some of the time an informal wording can have a delightful effect on drivers (Jestin et al., 2022).

Conversational AI has the potential of having social memory that can remember connections and relationships that track regularity of pattern of interaction and perhaps even establish a trust network for information exchange, reciprocal (favour exchange) interactions, and to perform problem-solving over such networks (Loke, 2017).

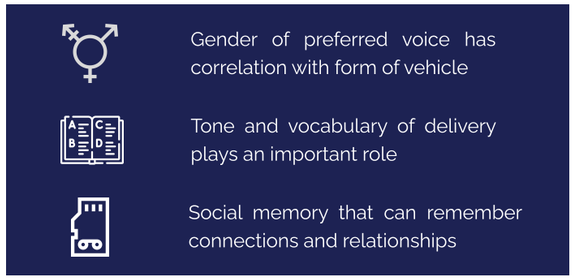


Figure 20. Considerations in design of Conversational AI for AVs

3.2.3. Qualities of acceptable parameters of voice agents from satellite navigation

There Satellite navigation was a task delegation based software that helped people navigate using satellite maps. Though Conversational AI is fundamentally a different technology, satellite navigation user studies can provide guidance regarding the desired quality of conversation expected by people. The implication for design based on satellite navigation based voices was that people are likely to choose an authoritative voice that is clear, trustworthy and assertive but does not distract or annoy for everyday use, and choose a more entertaining voice for one-off use where in the perceived acceptability parameters of voice agents in a self-driving car were “Appropriate”, “Artificial”, “Acceptable”, “Annoying”, “Assertive”, “Effective”, “Entertaining”, “Friendly”, “Human-Like”, “Raising Alertness”, “Undesirable”, “Helpful”, “Trustworthy”, “Distracting”, “Useful” and “Understandable” (Large & Burnett, 2013). These are qualities are preferred in different nature of situations of driving which could inspire the design of tone of voice in CAIs.

3.2.6 Opportunities for CAI in AVs

The development of technology behind Conversation AI presents new opportunities for their integration within Autonomous Vehicles to benefit users. At the outset, Lugano (2017) discusses that the state of commercial strategy of car manufacturers is more conservative than it may appear, current state-of-the-art in-car virtual assistants are closer to the notion of "virtual butler" (reacting to the user) than to that of a "virtual companion" (self-aware and autonomously acting), hinting that there is a need to think beyond what's currently possible to develop a long term vision.

The topics of interest in automated driving of researchers over the years have been limited to takeover, trust and acceptance, interacting with road users, UIs, and methodology, with Wizard of Oz technique being a suitable methodology to undertake user tests in absence of possibility of using AVs while mitigate the ecological validity effect of simulators (Ayoub et al., 2019).

However, there are areas of research in concern with CAI in AV which hold potential for further research. Beyond simple voice commands, conversational natural language interaction with an ADS is still an unrealized concept with many unsolved challenges and future research should focus on delivering better methods to inform/prepare the driver for easing the transition (Yurtsever et al., 2020). Transition from non-driving situation to driving situation in lower level of automation is critical for design and research about in-car voice assistants is important as they can act as mediators to aid a smoother transition between driving and non-driving tasks (Wong et al., 2019). Further, while designing for cooperative behavior between humans and AVs, it is not so clear which cooperative behaviors should be best implemented at the reactive control level only and which requires higher-level situation-aware reasoning. (Loke, 2017). Empirical research needs to be conducted to investigate how many opportunities there are for shared control, whether shared control is indeed desirable, and if so, how it should be implemented concretely (Terken & Pfleging, 2020). There are indications that If scenario-based tasks or situations were considered in the experimental design, a more clear picture could be defined (Park & Lee, 2022).

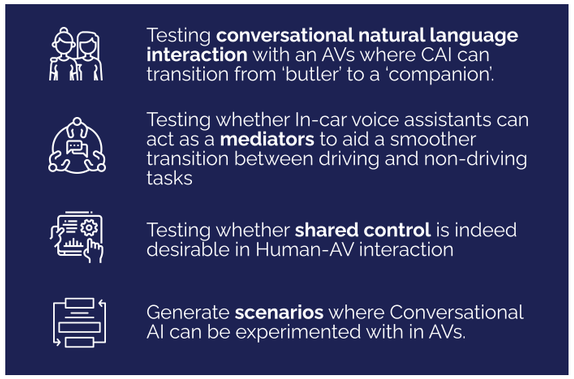


Figure 21. Future opportunities for research

There is also a question about who is responsible for various actions of AVs and the decision it takes. In that context, how can conversational AI function and behave responsibly while interacting with users. Responsible Artificial Intelligence is concerned with the fact that decisions and actions taken by intelligent autonomous systems have consequences that can be seen as being of an ethical nature and it provides directions for actions which can be best be seen as a code of behaviour — for AI systems, but, most importantly, for us (Dignum, 2019). The discipline of Responsible AI takes a holistic picture on AI Responsibility and makes all stakeholders a part of the discourse. Designing Responsible AI conversations are key towards ensuring AI interactions are of higher quality and have a positive social impact of technology.

3.2.6 Disadvantages of VUI in AVs

There are a few disadvantages of VUI in AVs that need to be catered towards and taken into stride while designing. VUI lacks flexibility to control interfaces, no shortcuts to perform which causes a reduction in efficiency, it doesn't help people recover from errors, lack support to reduce the cognitive load required to retain the critical information in voice outputs, lack of flexibility, to aid people to recognize and recover from errors, difficult to review edit, speech is transient and therefore difficult to review or edit (Cui et al., 2021). The speech also has an effect on cognitive load of the driver, though voice is considered to be least distracting. Concluding that speech input is not affected by additional demands of specific situations would be wrong, since there is a significant effect on subjective ratings that reflects the specific influence of additional auditory demand on speech input (Roider et al., 2017). Further, transparency and explanability of automated driving operation will be critical to construct a cooperative human–system environment (Biondi et al., 2019b) which also applies to the functioning of conversational agents in Autonomous Driving. These aspects pose a challenge for designers to think about and mitigate before implementing VUIs.

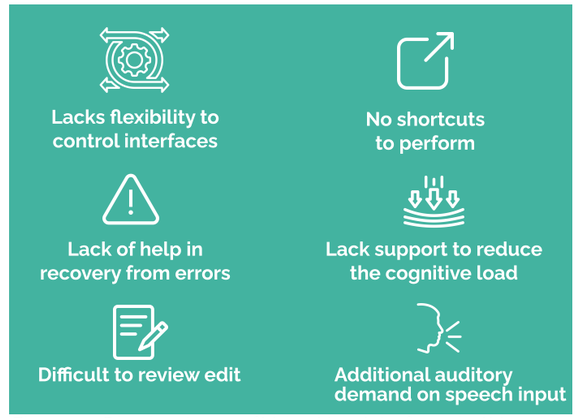


Figure 22. Disadvantages of Voice User Interfaces in AVs



Figure 23. Levels of automation in autonomous vehicles sourced from Mutzenich et al., (2021).



"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."

- Dr. Donald Norman
Professor and Research Scientist - UX Design.

3.2
User Experience of Conversational AI in AVs

This chapter explores aspects of User Experience (UX) of Conversational AI that are desired in Autonomous Vehicles (AVs) based on User Behaviour, Need and Activity as observed in academic literature.

3.1.1 User activity and behaviour within AVs

Implementation of Conversational AI for Non-Driving Related Tasks as well as Driving Related Tasks will require an understanding of what activities are users engaged in while in autonomous vehicles. Large et al. (2019) point out clear benefits of HMI designs to keep drivers in-the-loop and take over control of the vehicles while identifying that people's Non-Driving Related tasks in an AV were (1) using their mobile phone, (2) reading a book/magazine or printed papers, (3) some form of physical movements, (4) using a laptop, (5) sleeping, (6) effect on drivers' state and physical surroundings with participants repurposing their cabin or relaxing their seating position or posture to accommodate secondary task execution, (7) On occasion, returning visual attention to the road-scene through occasional glances which reduces over time as they get comfortable with AV. The study by Jeon et al. (2018) also identify sleeping, eating, undertaking office work, monitoring vehicle operation, making a phone call, watching TV, social networking as the main activities that users want to undertake in an AV as non-driving tasks

Further, Kim et al. (2015) identify leisure, eating, rest, communication, self cleaning task, working were identified as main intended user activities in AVs wherein the main requirements for user experience design considerations were that (1) AV's should seamlessly transition between a private space that require the privacy of personal data into a public living room where communication and intimacy, (2) unexpected transitions should occur smoothly, and (3) people should no longer be concerned with driving tasks.

Furthermore, studies that while studying user activities have also looked in what activities can CAI contribute to human activity. Assist, Bond, Control, Educate, Entertain, Guide, Inform were the tasks that were undertaken in autonomous vehicles for which three design strategies for integrating VAs in automobiles developed were 1) personification, 2) individualization, and 3) contextualization (Schmitt, 2021). User behaviour study with CAI using content analysis revealed the following six themes, which define the key aspects of participants' linguistic behaviour which are during the analysis formulating responses; turn-taking; back-channelling, fillers and hesitation; vague language; mitigating requests and politeness and praise (Large et al., 2017).

Perterer et al. (2018) talk about user behavior while collaborating with other vehicles about route instructions where in the discussion were centered around localization of the other vehicle, arrangement of meeting places or intermediate stops while driving in direct sight, informing each other about the planned coping strategies, expectations, assumptions, and unexpected driving behavior of the drivers.

These observations of user activity within AV provide a clarity about the context within which human conversations and interactions could occur with AVs. These situations would influence the nature of conversations that could occur in Human-AV interaction.

3.2.4 User needs in AV

It is important to determine what user needs occur within AVs, as they influence the specifications that product design should have. S. Lee et al. (2020b) identify 12 user needs that occur within fully automated vehicles which are (1) Personalization & Customization, (2) Connectivity Needs, (3) Social Needs, (4) Maintenance Needs, (5) Accessibility Needs, (6) Information Needs, (7) Space Needs, (8) User Interface, (9) Privacy, (10) Trust, (11) Health Needs, and (12) Safety & Security. They further identify four categories of design requirements to fulfill the aforementioned user needs which are 1) System functionality, 2) Input control, 3) Information display, and 4) In-vehicle space. These needs have to be fulfilled while designing CAI in AVs.

Further, Moore (2019) identifies that people would like to converse with robots regarding 3 topics which are (1) the physical world of stuff and things such as coordinating actions and for managing joint attention, (2) the social world of people, agents and relations such as provision of emotional and/or motivational support for the human being through companionship and the exhibition of empathy or even dominance, and (3) the abstract world of ideas, information, data and thought such as the provision of mental support, more intuitive method of communication and a very high information exchange rate.



Figure 24. Aspects to consider for User Experience Research.

Chapter 4

Design research

The research methods, protocols and experimental set-up used are described in this chapter

In this chapter:

4.1.1 Identified research opportunities and questions
4.1.2 Research method for Phase 1
4.1.3 Research method and protocol for Phase 2

4.1 Research methodology

This section contains identified research opportunities and formulation of research questions. Further, research methods and protocols followed during two phases of the research are described. The experimental set-up employed during the phase 2 is explained and documented in images.

4.1.1 Identified research opportunities and questions

We undertook a literature review encompassing the topic of Conversational AI (CAI) in Autonomous vehicles (AV) to explore research opportunities. We were able to locate 30 articles that were relevant to our direction of inquiry. This literature review pointed to a research gap wherein what nature of conversations would passengers want to have with Conversational AI in fully Autonomous Vehicles (level 5) when involved in Non-Driving Related Tasks (NDRTs) or are free from driving activity had not been studied. The scenarios of usage also hadn't been established in these. Future opportunities for innovation would lie in understanding these finer points. As a result, the following research questions evolved to be explored further.

RQ1: What roles and relationships can Conversational AI play towards users in Fully Autonomous Vehicles?

RQ2: How do users qualitatively assess the embodied user experience provided by Conversational AI roles and relationships designed for Fully Autonomous Vehicles?

Accordingly, this project was divided into two phases with each phase dedicated to investigating one research question each.

4.1.2 Research method for Phase 1

In the first phase, we decided to research RQ1 to establish the roles and relationships the users of fully autonomous vehicles would want to have conversational AI. We decided to employ a qualitative approach to research the first question following a semi-structured interview technique (Patton, 2002). This approach allowed for flexibility in words, forming questions during the process of interviews and inquiring deeper into particular areas of interest. However, interview guides were formed beforehand to guide the session.

4.1.2.1 End-user research

The aim of the end user research was to understand and establish what kinds of Conversational AI roles and relationships would users desire in Fully Autonomous Vehicles. To research this participants were provided with a sensitizing booklet developed based on the path of expression line of inquiry (Sanders & Stappers, 2012) encompassing past, present, and future experiences. Contextmapping as a design research method was selected as it enables the investigation of contexts of user-product relations in which tacit knowledge is gained about the context and the interaction with the product therein (Sleeswijk Visser et al., 2005).

Semi-structured interviews (Patton, 2002) were then conducted based on the contents of the sensitizing booklet. The participants were asked to reflect and fill in the booklet over 5 days using themes established through the literature review.

The first day activity page asked participants to reflect on and fill in experiences of a past journey experience in a car based on activities, behaviors, purposes of journeys, needs, and values. The second day activity page asked participants to reflect on the conversations that they have in their leisure time encompassing parameters such as companions of conversations, roles they play, purpose of conversations, and memories they have created. Next, they were asked to analyze the component of the conversation that made them engaging and which of these conversations would they have with their cars. On the third day, they were asked to watch a video of Zoox Autonomous Vehicle and asked to think about why they think the experience of traveling in autonomous vehicles would be boring including what activities they would undertake to make the experience less boring. Day four was about the future where participants were asked to envision a role /companion, list desired characteristics of the AI companion, and mention the desired nature of conversations with the chosen companion. They were given a supporting sketch to ideate as well. The fifth day was about envisioning a future journey using the created AI companion for the autonomous vehicle basing it on parameters of activities, behaviors, purposes of journeys, needs, and values. This format enabled the users to transition from the past to the future through the present to research the question.

A semi-structured guide was formed based on this sensitizing booklet where questions were asked on the content of each day with the flexibility to dig in deeper and go on tangents when interesting thoughts were brought up.

4.1.2.2 Expert research

The Expert research aimed to gain an in-depth understanding of three topics which were the expert's work related to the topic of investigation, the expert's thoughts on the design of Conversational AI for Fully Autonomous Vehicles, and design guidelines for Conversational AI in Autonomous Vehicles. Within these topics, we specifically looked to gain knowledge on potential Conversational AI roles and relationships they could play towards users, strategic opportunities for the design of Conversational AI in Autonomous Vehicles, design strategies employed by their organizations for the design of Conversational AI and Autonomous Cars, and barriers of innovation they face.

To research this, semi-structured interviews (Patton, 2002) were found to be the best method following the path of expression line of inquiry (Sanders & Stappers, 2012).

4.1.2.3 Data Collection

The data from each of the interviews was recorded with video and audio for analysis. Most of the interviews were conducted online using video meeting software with recording capabilities. The audio from the interview was transcribed for further analysis.

4.1.2.4 Data Analysis

The interviews were transcribed to be analyzed using the Thematic analysis method (Braun & Clarke, 2006) wherein all recommended phases were followed. Firstly, initial ideas were noted down in the process of familiarizing with the transcribed data. Secondly, the first round of in-vivo coding was done to search for patterns and collate similar data points. This was followed by a second round of coding in which these codes were categorized into themes. Upon reviewing themes, overarching aggregate dimensions of themes emerged (Gioia et al., 2012). This coding process was reviewed by the 4 member supervisory team to achieve an intercoder triangulation and various interpretations of single codes and categories have been peer-debriefed.

4.1.2.5 Participant characteristics

Table 1: Expert research participant characteristics

Label	Field	Area of Expertise	Years of experience	Duration
EP1	Practice	Automotive UX design, Conversational AI & Product Management.	24 Years	41 mins
EP2	Practice	Automotive UX Design.	5 Years	1 hour & 1 min.
EP3	Practice	Design strategy, UX, product manager & Conversational AI design.	4 Years	52 Mins
EP4	Practice	UX Designer & Conversational AI design.	17 Years	45 Mins
EP5	Practice	Conversational AI Design, UX Design & Voice interfaces.	11 Years	
ER1	Research	Smart Mobility, Human-Centered Design, Autonomous Mobility, Automotive UX Research & Human-Machine Interaction.	28 Years	42 Mins
ER2	Research	Conversational AI, UX Research, Perception & Cognition.	3 Years	54 Mins
ER3	Research	Automotive Design, Mobility Strategy, & Autonomous Mobility.	40 Years	
			16.5 Years Average	

Table 2: User research participant characteristics

Label	Gender	Age	Education	Duration
U1	Male	25	Bachelors	1 hour & 21 mins.
U2	Female	26	Bachelors	56 mins.
U3	Male	19	Bachelors	1 hour & 10 mins.
U4	Female	24	Bachelors	1 hour & 7 mins.
U5	Male	27	Masters	1 hour & 2 mins.
U6	Female	23	Bachelors	1 hour & 3 mins.
U7	Male	24	Masters	1 hour & 1 min.
U8	Female	25	Masters	1 hour & 6 mins.
U9	Male	27	Masters	1 hour & 21 mins

Generation Z, people born between 1995 to 2010 between the ages of 18 to 30 (Ganguli et al., 2022) who would be the future adopters of this technology were chosen as the end-user group. Another criteria was that these people should hold a driving license and have experienced driving a car, along with siting in passenger position. Lastly, those participants were invited who enjoy expression through speech and are comfortable with talking to Conversational AI.

4.1.3 Research method and protocol for Phase 2

4.1.3.1 Description of study

In the first phase, we undertook a qualitative study to establish which kinds of Conversational AI roles and relationships potential users of fully autonomous vehicles desire. The next step was to study how users qualitatively assess the embodied user experience provided by Conversational AI roles and relationships designed for Fully Autonomous Vehicles, to better understand how these roles can be implemented in a real-world scenario from a user experience point of view. Dourish (2001) defines embodiment in interaction design as the property of being manifest in and of the everyday world where embodiment constitutes the transition from the realm of ideas to the realm of everyday experience. Further, Duarte et al. (2022) describe embodiment as the property of human engagement with the world that makes it meaningful through engaged interaction with artifacts. This research understands the term embodiment as the manner in which the Conversational AI roles and relationships will manifest or take shape in terms of the user experience and physical forms. Furthermore, this study employs the Subjective Assessment of Speech System Interfaces [SASSI] (Hone & Graham, 2000) which is a toolkit to assess user experience provided by speech interfaces,

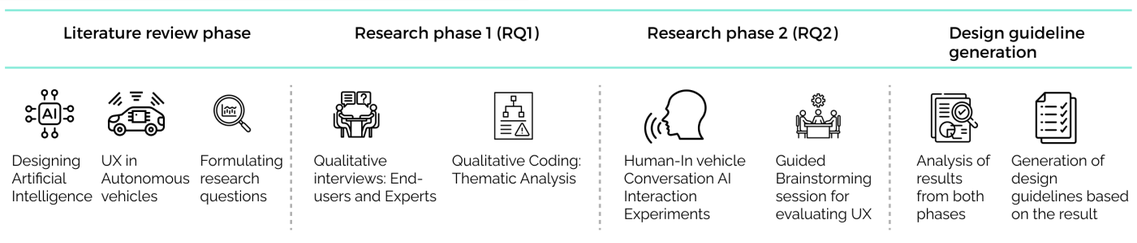


Fig 25: The design research process.

to develop qualitative questions for a guided brainstorming session with participants of the experiment. In addition, a few free-form questions will also be asked to get a broader picture. In order to conduct the experiment, we employed a mock experimental setup of conversational AI in autonomous vehicles by using participant enactment (Strömberg et al., 2020; Burns et al., 1994) and Wizard of Oz (DahlbäckN. et al., 1993) design research methods. Statement cards are developed based on qualitative research results that would be made use of by participants to support them to have free-flowing conversations in case they need support to continue with conversations and avoid the participants from going silent. Participants had to interact with the top 3 Conversational AI roles found in the phase 1 research and personally enact roles based on the top 3 purposes of travel. The Wizard of Oz controls an iPad running a combination of text-to-speech apps and the 'Genie' app which is a form of ChatGPT AI text generator connected to a voice-based readout application.

The experiment followed a process where users imagine a journey based on a specific purpose of the journey and they enact a role based on a scenario using speech or explicit form of human interaction. The 'Wizard of Oz' generates responses from the Conversational AI setup and reads them out using the voice-based readout application. To keep the conversations going, the participants had to make use of the statement cards that they can glance at whenever they desire or feel they are going blank in conversations. These cards were designed to inform the participants about (1) the content of conversations, (2) aspects of shared control over AVs, and (3) in-vehicle user activities. Each sub-session continued for 10 minutes and three of such sessions took place per participant pair.

Following this interaction phase, a guided brainstorming session was be conducted in which the participants will have to brainstorm on the following aspects, adapted from the SASSI questionnaire:

1. Likeability
   a. Give 1 reason each why you would like as well as dislike conversational AI interface in fully autonomous Vehicles. (Like here refers to a useful, pleasant, and friendly system).
2. System Response Accuracy
   a. Give 1 reason each about why you would think that Conversational AI interface in Autonomous Vehicles could improve as well as deteriorate the accuracy of conveying passengers' intentions that the autonomous vehicle should fulfill.
3. Cognitive Demand
   a. Give 1 reason each why Conversational AI in AVs could decrease as well as increase the perceived amount of effort needed to interact with the fully autonomous vehicle (cognitive demand) from passengers.
4. Annoyance
   a. Give 1 reason each why Conversational AI could be annoying as well as pleasant to have in a fully autonomous vehicle. (Annoying here refers to the extent to which you rate the system as repetitive, boring, irritating, and frustrating).
4. Intuitiveness
   a. Mention 1 reason as to why and why not you would intuitively understand what to do with the Conversational AI in the AV and consequently understand what the system is doing as well.
5. Speed
   a. Mention 1 instance each where you would expect a faster response and slower response than the perceived normal speed from the Conversational AI in the AV.
6. Open-ended questions
   a. In your opinion, is it a good idea or a bad idea to develop Conversational AI roles for AV? Justify your answer.
   b. What physical manifestation would you like the conversational AI roles to take?

4.1.3.2 Limitations that participants had to ignore.

There are two significant limitations of this experiment, that the participants were asked to ignore:
(1) The delay or occasional mistakes in Conversational AI responses from the setup would have to be ignored in evaluating the user experience, and
(2) The vehicle would be stationary and participants would have to imagine its movement.

4.1.3.3 Participants

The study featured 12 participants in pairs of 2 representing Generation Z as the chosen target segment of the study. They were split into pairs of two divided into 6 sessions spread over 3 days, with two sessions per day. The reason for conducting the experiment in groups of 2 is to increase the chatty-ness of conversations in the autonomous vehicle setup while users can enact a scenario together. Secondly, the study can test a shared vehicle scenario and interactions arising therein as the first phase results pointed out that people dominantly see AVs as shared forms of mobility in the future.

Table 3: End-user participant characteristics

Label	Pair no. / session	Gender	Age	Education
P1	1 / Session 1	Male	24	Masters
P2	1 / Session 1	Male	27	Masters
P3	2 / Session 2	Female	26	Masters
P4	2 / Session 2	Male	29	Masters
P5	3 / Session 3	Female	26	Masters
P6	3 / Session 3	Female	23	Masters
P7	4 / Session 4	Male	27	Masters
P8	4 / Session 4	Male	27	Masters
P9	5 / Session 5	Male	22	Masters
P10	5 / Session 5	Male	23	Masters
P11	6 / Session 6	Male	25	Masters
P12	6 / Session 6	Male	25	Masters

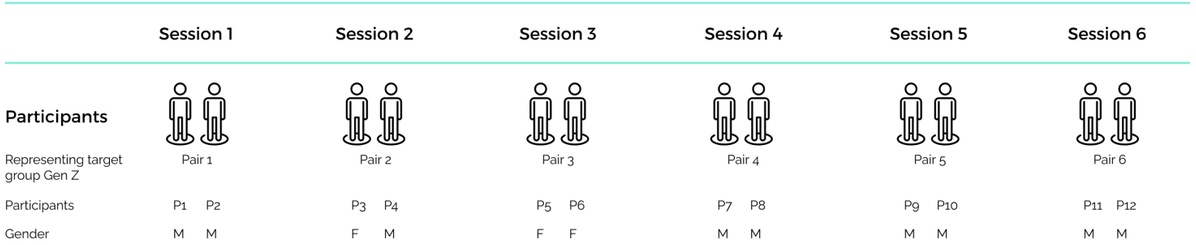


Fig 26: End user participant characteristics arranged as per experimental sessions

Table 4: Details of time and paring of Conversational AI roles with corresponding purposes of journeys for user's enactment

Sub-section (Changing order in each experimental session)	Conversational AI roles.	Purposes of journeys for enacting user's roles	Time for each pair (Total = 30 Minutes)
Subsection A	1. AI Tour Guide	1. Leisure	10 minutes
Subsection B	2. AI Mentor (Advisor)	2. Work	10 minutes
Subsection C	3. AI Storyteller	3. Shopping	10 minutes

Table 5: Randomised order of roles for each research session to avoid order effect

Session	Day & Date	Order of roles
Session 1	Monday 17/07/2023 Morning	Tour guide > Mentor > Storyteller
Session 2	Monday 17/07/2023 Afternoon	Mentor > Tour guide > Storyteller,
Session 3	Tuesday 18/07/2023 Morning	Storyteller > Tour guide > Mentor
Session 4	Tuesday 18/07/2023 Afternoon	Tour guide > Storyteller > Mentor
Session 5	Wednesday 19/07/2023 Afternoon	Mentor > Storyteller > Tour guide
Session 6	Wednesday 19/07/2023 Afternoon	Storyteller > Mentor > Tour guide

Table 6: Structure of each experiment session

Section of the session	Time (Total duration - 1 Hour 35 Minutes)
Introduction	10 minutes
Priming Session	5 Minutes
Experimental session	30 minutes (10 Minutes per role)
Short break	5 Minutes
Brainstorming Session	45 Minutes

4.1.3.4 Information given to participants at the start of the experiment

1. Welcome
2. Project Introduction
3. Consent form to be signed
4. Steps the experiment will follow.
5. Prime the people to have conversations with the conversational AI set-up, to get a feel of how the conversations will go and get used to having conversations. They would also get a feel of topics in the cards and enact a role based on the purpose of the journey.
6. Reminder to put phones on silent.

4.1.3.5. Experimental protocol for the participants/enactors to follow

Step 1: The participants were welcomed into the experimental setup and given a brief overview of the study. They were handed a consent form to be signed. The 2 limitations of the experimental setup were explained and asked to be ignored during the experiment which are, (1) The delay in responses from the Conversational AI mock setup would have to be ignored in evaluating the user experience, and (2) the vehicle would be stationary and participants will have to imagine it's movement. After this, they were handed the statement cards to be drawn whenever required during the experiment and asked to take a seat in the setup.

Step 2: The participants had a 5-minute priming session, to get used to speaking with the Conversational AI set-up, practice enactment, and get a feel of how the conversations will go. Once this phase was over, the recording was begun for the actual session.

Step 3: The conversational AI welcomed the participants into the AV setup. They were conveyed the Conversational AI role being played and the purpose of the journey. Based on this information, the conversational AI will be made to play the role of the wizard. The participants who were also enacting a role based on their purpose of the journey, had to imagine the movement of the car and have conversations accordingly. They had access to statement cards which were spread out on cardboard planks to be glanced at once in a while, that either hinted at a topic of conversation, type of activity, or aspects of shared control that they had to enact conversationally while interacting with the conversational AI. This process continued for 10 minutes per sub-section of the experiment. After this experiment, they were given new roles and purposes of journeys to continue with the 2nd and 3rd sub-sections of the experiment in a similar process. After three cycles of experiments were completed, the experiment proceeded to step 4.

Step 4: At this step, the participants had to brainstorm along with the researcher. The brainstorming session was guided by the questions on parameters defined in the SASSI questionnaire method. This brainstorming session was guided by a digital brainstorming canvas that was displayed on a large screen while brainstorming in a discussion room. The participants were provided snacks and juice to be had while brainstorming.

4.1.3.6 Technical setup to check before starting and after ending the experiment

1. Connect the laptop to a widescreen simulating a moving road scene.
2. Connect the external large speaker to Bluetooth on the computer for simulating the sound.
3. Play the looped video of the road.
4. Begin voice recording using the voice recorder kept inside the vehicle.
5. Set a 10 min alarm timer per role.
6. Connect the iPad to the smaller speaker kept inside the vehicle prototype.
7. Open apps on the iPad and keep them ready.
8. Arrange the statement cards.
9. Begin side camera recording.
10. Begin front camera recording.
11. After the experiment, recharge all digital devices.
12. Clean the memory and store everything as a backup.

4.1.3.7 Data Collection

The data from the interaction session of the experiment was recorded with video and audio for analysis. The data from the brainstorming session was recorded on a canvas and the discussion's voice recording was preserved for analysis.

4.1.3.8 Data Analysis

The data collected was analyzed to derive insights using the statements recorded on the canvas from the brainstorming session and qualitative statements mentioned during the experiment. These insights were tabulated and used to formulate design guidelines in combination with phase 1 of the project. The notes from the guided brainstorming session as well as voice and video recordings of the whole session were tabulated into a spreadsheet. A thematic analysis was performed using tree diagrams from the brainstorm graphic organizers method (Martin et al., 2012) to map out the brainstormed qualitative responses received under parameters from SASSI (Hone & Graham, 2000) and two free-form questions. The line of questioning specifically asked for positive aspects and negative aspects for participants to formulate clear responses. The findings from this analysis are presented below.

4.1.3.9 Photos of brainstorming and experimental set-up.



Fig 27: A brainstorming session in progress



Fig 28: Screen playing a looped video and speakers playing traffic sound to simulate a road scene experience



Fig 29: Division created between participants and the 'Wizard of Oz' to avoid visual contact

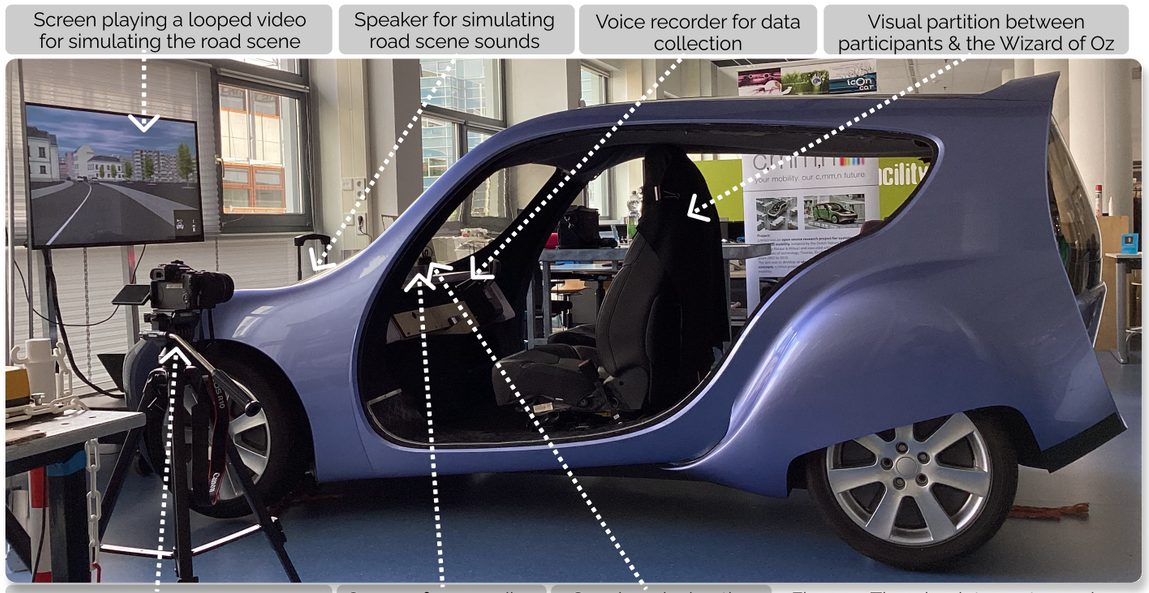


Fig 30: The simulator setup using prototype vehicle at TU Delft IDE

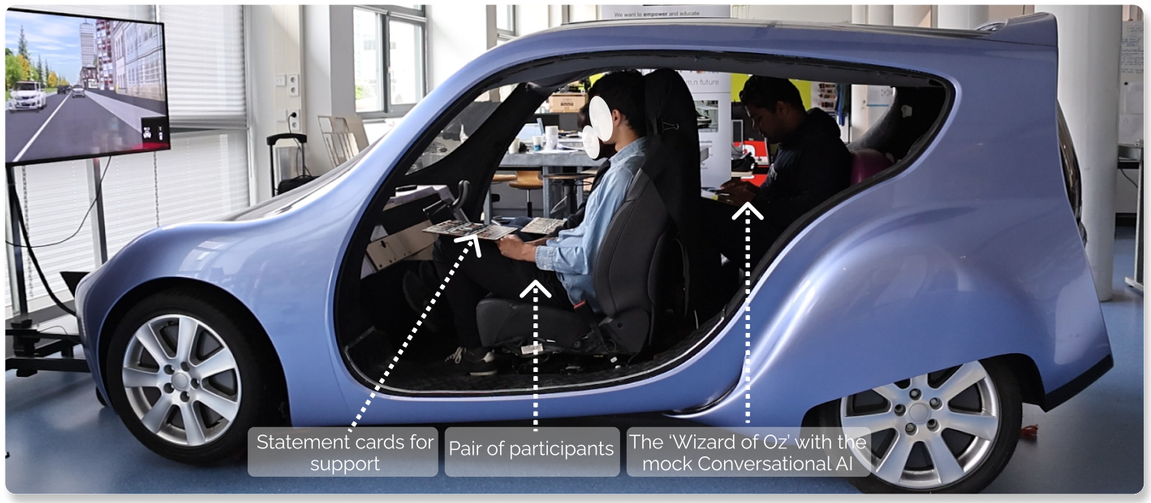


Fig 31: Image of the interaction experiment in progress

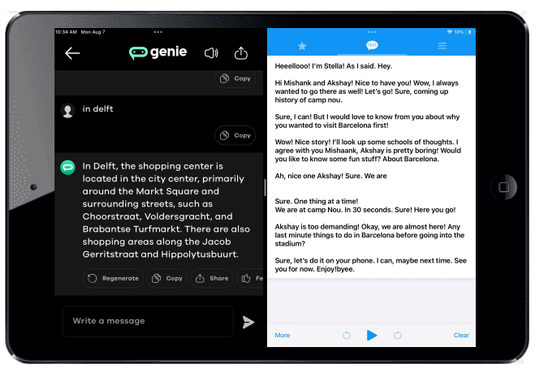
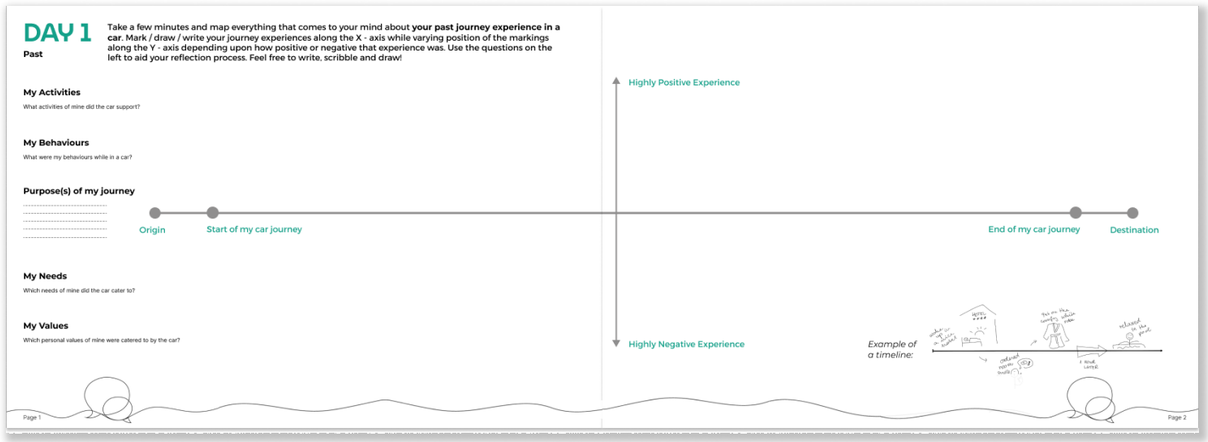


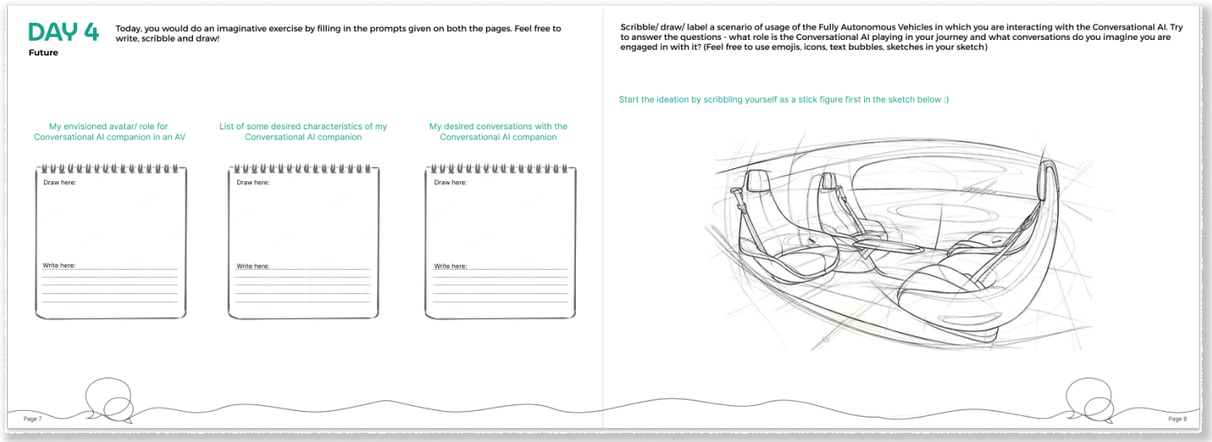
Fig 32: Conversational AI mock set-up operated by the 'Wizard of Oz': Genie App + Text to speech software

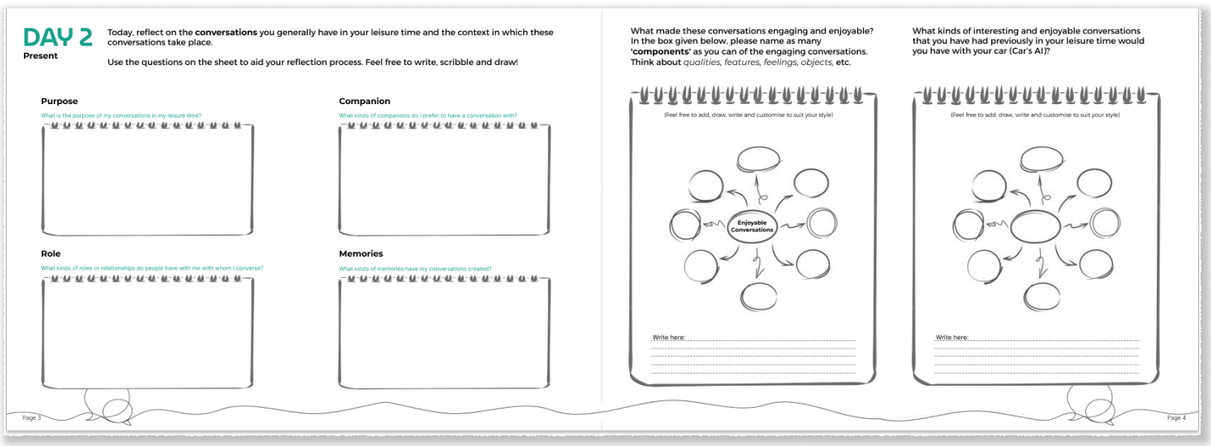


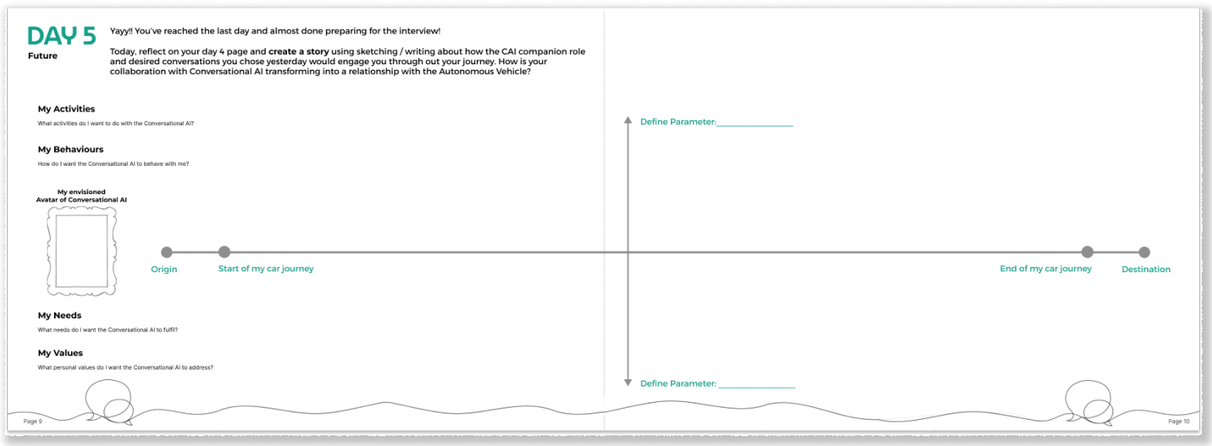
Fig 33: Participant's view of the simulated road scene

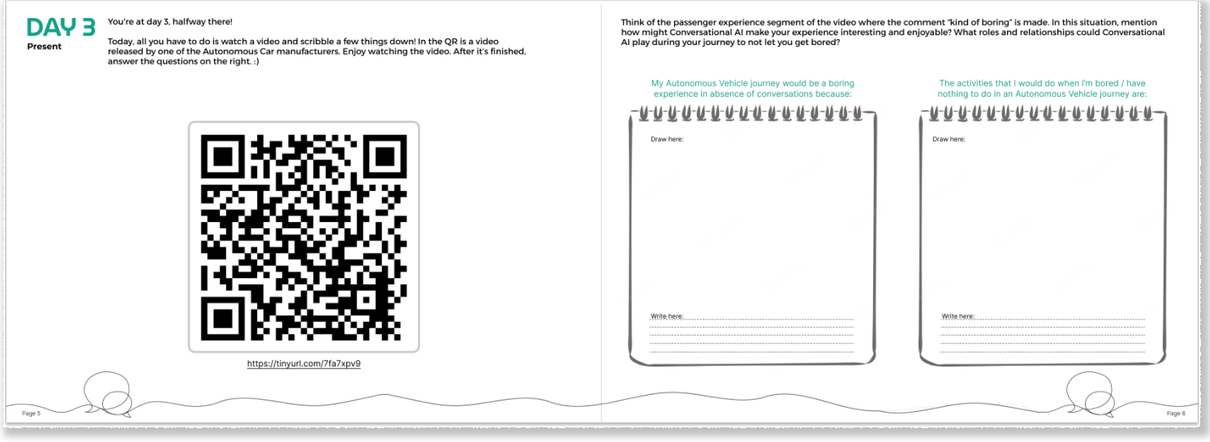
4.1.3.10 Images of sensitising activity booklet handed over to end-users for 5 day reflection activity leading up to qualitative interviews











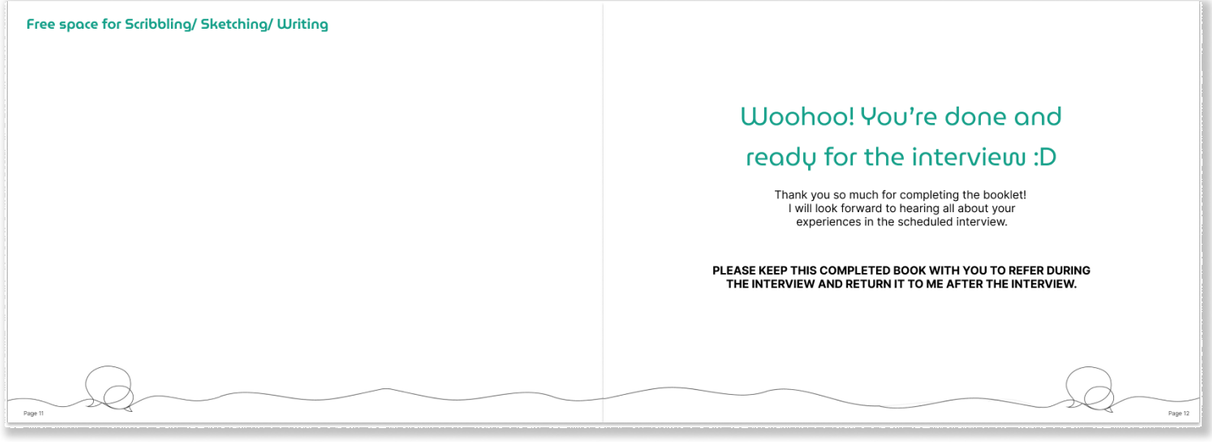


Fig 34: Images of sensitising activity booklet

Chapter 5

Establishing Roles and Relationships

Results from phase 1 of research are presented here highlighting in-vehicle Conversational AI roles and relationships that were discovered.

In this chapter:

5.1 Analysis of end-user interviews
5.2 Analysis of expert interviews

5.1
Analysis of end-user interviews

In this section, results of thematic analysis of end-user interviews are presented in the form of 10 aggregate dimensions and multiple themes.

The insights from participant interviews based on a 5-day sensitizing exercise representing the target user segment were derived using qualitative coding employing thematic analysis. These insights are presented as aggregate dimensions and themes that emerged from the analysis.

5.1.1 Aggregate Dimension 1: Elicited Conversational AI roles for Fully Autonomous Vehicles

This was the first aggregate dimension that arose from the analysis in which several roles and categorized themes of roles were established, as discussed below.

- **Roles for hospitality services** was the theme with the most number of codes (41 codes) within this aggregate dimension. Under this theme, the Conversational AI Role of a Tour Guide was most popularly suggested with (20 codes) as participants found a tour guide's role relevant and contextual to have in an autonomous vehicle to entertain them as they travel in the vehicle without any driving activity to undertake. This was followed by the role of a Conversational AI Party Host (1 Code), where the role could support the activity of partying in the car. People in general suggested that having food enhances the in-vehicle user experience (20 codes) and roles that are based on supporting the activity of eating food would be desirable to interact with while the activity of dining is undergoing in the vehicle.

- **Roles to provide mentorship and advice** was the next most coded theme (40 Codes) in this aggregate dimension, as participants felt that asking for advice and mentorship from an 'all-knowing' and 'non-judgemental' AI mentor would be an activity that they would like to undertake when traveling in the vehicle. The Conversational AI role of Advisor and Role of Mentor received an equal number of codes (18 codes each). A special theme of the Conversational role of financial advisor was mentioned multiple times by U1 (4 Codes). Participants discussed that they would love to take advice and mentorship on various walks of life such as those concerning professional pursuits, philosophical thoughts, health, and other deeper questions that come to their mind. In addition, the participants also would like to take advice from the vehicle to co-formulate aspects of the journey such as the route to choose, destinations to travel to, climatic information, and so on.

- **Roles to entertain users** was the next theme that evolved (30 codes) as participants desired various forms of entertainment during the journey. Participants enjoyed listening to stories when idle during the journey due to which the AI role of a storyteller was popularly suggested (14 codes). This was followed by the suggestion of the AI role of a podcaster (12 codes) as participants enjoy listening to podcasts and getting knowledge on various topics from subject matter experts. Lastly, people also enjoyed listening to music and would enjoy the AI to creatively engage users with music for which they felt the Conversational AI role of Disk Jockey or Radio Jockey (4 codes) would be a good addition.

- **Conversational AI role for inspiring and motivating** emerged as the subsequent theme (23 codes) where participants discussed that there are moments when participants feel emotionally down or uninspired in their personal lives to continue pursuing what they believe in. At such moments they would love to have an AI role that inspires and motivates them. The quiet time when traveling in the autonomous vehicle would serve as a good moment to discuss issues that are concerning them and seek motivation and inspiration to continue on the desired path. The roles that participants described to materialize this concept were the AI role of a Motivational Speaker (9 codes) and the Role of an Inspiring Public Icon (1 code). The participants desired to derive a sense of inspiration from these conversations and build confidence to accomplish the task that they were struggling with.

- **Conversational AI role of anime characters/cartoon characters** was the next most discussed theme (19 codes) where participants mentioned that they would enjoy having conversations with anime characters or cartoon characters that can entertain them and enable participants to pass the time. This would also be preferred by children who would enjoy talking to their favorite cartoon characters, enabling parents to manage children by keeping them engrossed in activities with cartoon characters.

- **Task-based Conversational AI roles** was the next theme that emerged (16 codes) as participants thought that having roles that can accomplish tasks would be the primary roles users would interact with, even in events where participants do not desire to have conversations with other roles or desire to remain silent during the journey. There will always be some tasks that users want to accomplish while traveling in the Autonomous Vehicle for which conversational AI could provide a platform. To accomplish this, the role of a butler was suggested.

- **Conversational AI role of news anchor** was another theme of roles suggested by participants (14 codes) as participants had a desire to know about the happenings in their localities as well as around the world. The role of a news anchor could serve this purpose in the vehicle when having time to listen to the recap and a discussion of news.

- **Conversational AI role of a therapist** was the next most popular theme (8 codes) that emerged as participants felt that this role could be a nice avenue to vent out frustrations and talk about psychological issues that participants may have. Being non-judgemental, the participants felt that the role could act as a person who listens to grievances and provides a therapeutic experience to participants during the journey.

- **Conversational AI role of a lover** was the next theme (7 codes) of roles that emerged, where participants felt that they could express their love for the vehicle and vice versa through this role. The conversational AI lover could also 'coach' participants to maintain romantic relations and help users meet their emotional need for love

- **Conversational AI role of digitalized humans** was the subsequent theme (6 Codes) that emerged where participant U4 felt that a digital version of the user like a digital twin or the user's preferred person could be played by the conversational AI. The participant discussed that the digital version of yourself could be a good avenue for self-criticism and improvement. The users could co-reflect about their lives with this form of a role. Secondly, digital versions of people whom the user misses could also be created as a way to interact with them. People who have changed locations have expired or other such reasons due to which the user doesn't have access to them, can be digitalised for users to interact with through conversational AI.

- **Conversational AI's role of providing security** was an interesting theme mentioned by U4 (4 codes) where the AI could play the role of providing security to the in-vehicle passengers. Upon detecting relevant dangers, the role could contact appropriate forums through internet connectivity to safeguard passengers. An out-of-the-box point mentioned by the participant was that the roles could also argue on behalf of the users in events of accidents with other vehicles on the road.

- **Conversational AI role of a shopping assistant** was mentioned by participant U3 (3 codes) where the participant felt that the time in the vehicle could be better used for shopping and a role that aids shopping activity would be very helpful. The users could co-determine items to shop and place an order online. The role could be a good interface between various online shopping avenues and passengers who want to make an informed choice in a user-friendly manner.

- **Roles to entertain users** was the next theme that evolved (30 codes) as participants desired various forms of entertainment during the journey. Participants enjoyed listening to stories when idle during the journey due to which the AI role of a storyteller was popularly suggested (14 codes). This was followed by the suggestion of the AI role of a podcaster (12 codes) as participants enjoy listening to podcasts and getting knowledge on various topics from subject matter experts. Lastly, people also enjoyed listening to music and would enjoy the AI to creatively engage users with music for which they felt the Conversational AI role of Disk Jockey or Radio Jockey (4 codes) would be a good addition.

- **Conversational AI role of an emergency service provider** was a theme suggested by participants U1 and U2 (3 codes) with the simple idea that in case the vehicle meets with an accident or there is a situation of emergency, then the role could play an important part in safeguarding the passengers. The AI role could be connected digitally with institutions that cater to emergencies and trained with data to guide in providing first aid to passengers.

- **Conversational AI role of a host and the role of a defender** were the last two themes of roles that were suggested by participants U4 and U8 (1 code each). In the first case, the conversational AI playing the role of a host that hosts people in the vehicle would cater to guests and provide a good user experience on behalf of the owners of the vehicle. Secondly, the role of a defender was suggested where the role could defend the passengers and owners of the car during arguments or fights. These two roles were interesting to note, though they were isolated ideas from participants.

Amongst all the aforementioned roles, the top three most preferred roles by the participants that emerged were (1) Conversational AI Tour Guide, (2) Conversational AI Mentor (Advisor), and (3) Conversational AI storyteller.

5.1.2 Aggregate Dimension 2: Information about the journey

The second aggregate dimension that emerged was information about the journey where participants discussed that the nature of the journey would influence the kind of role the users would desire to interact with during the journey. It would be important for the conversational AI to gauge the purpose of the journey, the travel time of the journey, whether the journey is shared or individual, and have access to information about the vehicle's journey status to play Conversational AI roles effectively. The following are the themes that emerged from the conversations:

- **Gauge the purpose of travel** was the first theme that emerged under this aggregate dimension (37 Codes) where participants discussed that the user's purpose of travel would influence the mindset and mood of the users which in turn would influence the nature of the role they would desire the conversational AI to play and the conversations they want to have with these roles. The majority of participants stated that professional work was the most common purpose for which they traveled by a vehicle, where conversations tended to revolve around either prepping for or evaluating aspects of work. Leisure was the next most popular purpose of journeys using vehicles where the mindset was more relaxed and conversations were those seeking a joyful time. This was followed by shopping as a reason for using vehicles, where the conversation's focus was on consumer activities. Subsequently, people found it convenient to use vehicles for trips concerning health and wellbeing, such as those to hospitals or going to a yoga center. Some of the lesser-mentioned purposes of trips but interesting ones to note were cultural and religious, adventure, and the transportation of luggage and good trips. The conversational AI would have to detect such purposes of trips and transition into playing suitable roles to create the desired atmosphere for users through conversations.

- **Information about the vehicle's journey** was the second theme that evolved from the analysis (33 Codes) where participants mentioned that they would desire information from the vehicle itself. The participants mentioned that the conversational AI should provide a status update on vehicle performance as they would like to know how the vehicle is performing. Performance indicators such as fuel efficiency, fuel level, energy need, air pressure, engine temperature, and so forth could be described by the Conversational AI. Users would also desire an estimation of the time for the vehicle's transit from point to point and the details of information about the trip itself for example localities while transiting, distance of travel, whether outside, and much more. Lastly, U2 mentioned that it would be a good idea to prepare the passengers with information about the destination to mentally prepare themselves.

- **AVs as shared mobility services** was the next theme that emerged from the analysis (18 Codes) in which participants thought that autonomous vehicles would most commonly be used in a shared scenario with multiple passengers. They would also be open to switching modes of transport between various autonomous vehicles. These are the reasons that users think that autonomous cars would be implemented as a shared mobility service that users could avail of.

- **Travel duration influences interaction** was the last theme derived in the aggregate dimension where participants noticed that the duration of in-vehicle presence due to the length of the journey would influence the nature of interactions with conversational AI roles. Participants would maintain shorter forms of relationships for specific activities when the duration of the journey is shorter. When the journey is longer, they would like to have deeper conversations where time is spent in mutually understanding each other between the Humans and AI. Participants would also maintain longer forms of relationships for recurring activities over multiple journeys.

5.1.3 Aggregate Dimension 3: desired content of conversations with Conversational AI in Autonomous Vehicles.

This aggregate dimension was about the types and content of conversations that users would desire to have with Conversational AI in Autonomous Vehicles. Designers and engineers would have to train Conversational AI on databases consisting of these topics to cater to providing a good user experience through conversations.

- **Conversations for knowledge and experience-based wisdom** was the first theme (74 Codes) that emerged from the analysis where participants mentioned that the conversations where they gained knowledge about topics they wanted to know about and wisdom from someone who has had experience in the area were the most memorable and desirable form them. Participants want to always gain new information about various topics through conversations and also desire to understand something bigger about happenings in the world. Participants mentioned that they would love to have conversations about the aforementioned topics with the Conversational AI. Lastly, the participants mentioned that they usually would read to gain this information to get knowledge and information, but it would be pleasurable if it could be learned from conversational AI through conversations.

- **Conversations for reflective thinking** was the next theme that emerged (72 Codes) where participants mentioned that they desire deep and healthy conversations as such conversations are the most memorable and satisfying conversations. Such conversations on philosophical topics fascinate people and result in an engrossing conversation people are interested in having. These topics of conversation also enable people to reflect back on various pursuits of life and articulate a possible course of life ahead. Therefore, participants expressed that this topic would be something they would desire to have conversations on.

- **Conversations to assuage boredom** was the subsequent theme that emerged (64 Codes) where participants wanted to have conversations for the sake of doing away with their boredom. Due to the lack of activities in autonomous vehicles, boredom could set in for which participants felt having random conversations with the AI would be effective to assuage boredom. People want to have conversations and undertake activities with the Conversational AI as they would be free from driving tasks. Overall, people desire to use their time efficiently and conversational AI provides an opportunity to do so in various ways.

- **Conversations for emotional bonding and memories** was the theme that evolved next in order (61 Codes) where participants discussed that they find conversations as a good medium for emotional bonding and creating memories. People enjoy having conversations about nostalgia and memories which increases their bonding with fellow companions. Participants discussed that they would desire to create a sense of bonding and good memories in the vehicle through conversations with the car. These should be enabled by empathetic conversational AI roles that people can resonate with and have conversations to understand the emotional response from the users.

- **Conversation about analyzing the future** was the next theme that arose (42 codes) where participants mentioned that they find themselves wanting to have conversations where they can analyze their future. Participants desired to have conversations on personal futures with an informed AI role which could allow the people to critically analyze themselves to chart a course for the future. Conversational AI would also enable users to discuss the future course of action of the vehicle itself and take a negotiated decision with the vehicle.

- **Conversations to learn information** was the theme that came next in order (38 Codes) where participants discussed that a sizable portion of the conversations they had was to learn information about various topics. An AI companion in this regard would work very well due to its access to large amounts of data. Participants would like to have conversations to learn general knowledge and verify information.

- **Humorous and playful conversations** were a theme (37 codes) in conversations that participants mentioned made conversations enjoyable and memorable. People in general enjoy humorous conversations and such humorous conversations create lasting memories. Therefore, Conversational AI should be playful and create happiness for users.

- **Conversations to increase professional productivity** was a theme (30 Codes) where participants described that they would desire various forms of conversations that would increase their professional productivity. People desire an efficient use of their time during the journey wherein journeys during weekdays for professional activities influence conversations as a means to increase work productivity. Work colleagues are often part of these journeys which result in work-related discussions. The conversational AI can serve as an informed companion to support these activities and conversations. Some services that conversational AI can provide to users were that of scheduling assistance, drafting emails, and sending messages.

- **Reassuring and mentally supportive conversations** was a theme (29 Codes) where the participants spoke about how conversations were a key part in providing mental and emotional support to them with an empathetic personality in their lives. Sensing good intentions behind these conversations was key for mental support and reassurance. Participants desired that the conversational AI was able to provide reassurance to help them build confidence when participants are facing a low time. Secondly, they also discussed that good intentions of the AI should be conveyed through transparent ethical design of Conversational AI's technology wherein an assurance of passenger's data security and privacy would be regularly provided.

- **Conversations to gain diverse perspectives** was the subsequent theme (27 Codes) that arose from the analysis wherein participants described conversations as a medium for gaining new open-minded perspectives which they were previously unfamiliar with. Autonomous vehicles with their experience of the road and passengers traveling in them can seek to be a medium to gain new perspectives on life. This would lead to a dialogic interaction between the passenger and the autonomous vehicles where each learns and exchanges perspectives.

- **Casual conversations** were a theme (24 Codes) wherein participants mentioned they would desire to have casual conversations with the AI to pass the time when boredom sets in. U7 mentioned that having conversations about day-to-day happenings in personal life is what sometimes is enjoyable to pass the time. Conversational AI should have the possibility to engage users in casual conversations as well.

- **Conversations about global welfare** was a theme (11 Codes) under which people wanted to talk about their concerns and gain information about widely discussed topics such as sustainability, politics, civic laws, societal welfare, and contributing positively to society. These conversations were from a point of deep concern for the larger good and the intention to contribute to society positively, thereby seeking opinions and information from the Conversational AI to guide them.

- **Conversations for healthcare assistance** was a theme (20 Codes) where participants mentioned that they would like to discuss issues related to their health and well-being with the car. It was stated that a bad user experience in the vehicle can affect their mental health, for which the conversational AI could provide therapy in some form. There was a fairly balanced amount of discussion about motion sickness affecting participant's health, wherein an equal number of people were not affected by it as opposed to those who were. However, designers should be mindful of the possibility that long exposure to AI may lead to health concerns or diseases.

- **Conversational AI for co-analysis of users to nurture themselves** was a theme that arose (20 Codes) where participants sought to co-analyze themselves with a non-judgemental yet intelligent Conversational AI companion. The atmosphere of the autonomous vehicle provides them with an opportunity to have the aforementioned nature of conversations that enable users to shape themselves. Conversations that help users understand themselves and help them grow were very much enjoyed by the people. These capabilities must be built into AI, for which a good idea was suggested by U8 where an option of integration of digital twins through Conversational AI can be provided to analyze yourself.

- **Acquainting with the AV through Conversational AI** was a theme (12 Codes) in which participants wanted to get to know their autonomous vehicle better. Just like humans want to get to know fellow humans better through conversations, participants believed that Autonomous Vehicles which metaphorically would represent intelligent beings should have the option of getting to know their personalities better through Conversational AI.

- **Conversations to debate various points of view** was the last theme (11 Codes) where participants enjoyed debating various points of view and through such conversational debate understanding the bigger worldview. Participants found these conversations very interesting and looked forward to having debates with Conversational AI.

5.1.4 Aggregate Dimension 4: User activities for interaction with Conversational AI.

In this aggregate dimension, participants discussed activities that they usually undertake in cars to assuage boredom or keep themselves engrossed during the journey. These activities they thought could be also mediated by Conversational AI by being a good digital companion that can act as an enabler or a host of these activities.

- **User activities for creative expression** was the most discussed theme in this aggregate dimension (76 Codes) where participants felt that the free time within the Autonomous Car would be best spent being engaged in creative activities. They discussed that pursuing artistic activities such as making paintings, singing, learning instruments and many more that they normally wouldn't have the time to pursue would be undertaken during the journey. Participants discussed that Conversational AI could play a role of a prompt suggestor who would inspire or push the participants to be creative if they chose this option. Conversational AI could also act as a facilitator of ideas or a co-ideator with the participants to undertake creative expressions. Lastly, the desire for artistic self-expression could be made possible through conversational AI.

- **User activities for entertainment** was the next theme (61 Codes) that participants discussed at length. Participants wanted to undertake activities to keep themselves entertained during this journey where the activity of watching movies and videos was most popularly mentioned. Participants also wanted to listen to music to improve the user experience and sing songs in collaboration with the AI. Further, participants desired to undertake gaming activities and thought it would be a good way to interact with fellow travelers in the vehicle. Apart from digital games with AI mediators, an interesting suggestion by U1 & U2 was role-playing games to engage with co-travelers. Lastly, participants enjoyed comedy as a form of entertainment and an AI comedian could be an option to provide this form of comedy. In conclusion, AI-generated music, videos, games, and comedy would be a plausible opportunity to explore user entertainment in autonomous vehicles.

- **User activities for rest and recuperation** was the last theme that emerged (43 Codes) wherein participants stated rather than doing activities they may also prefer to rest and remain silent during this journey. Participants found that this could be a great time to catch some sleep between the two points of travel while few others mentioned that there may be times where they may prefer to remain silent during the journey. People require timely breaks and rest during the day for which the autonomous vehicle could serve as a great medium unlike in manual cars where drivers have to remain attentive and focus on the active road scene. Autonomous vehicles generate a possibility for all passengers to remain fresh for activities at the destination by taking rest and falling asleep during the journey. Lastly, people also sometimes enjoy getting lost in thoughts and participants found that this could be an activity that they would undertake in silence for some time. These aforementioned activities could be supported by conversational AI not only by remaining silent but also by creating a conducive environment for rest and recuperation through various design features through Conversational AI.

5.1.5 Aggregate Dimension 5: User in-vehicle interaction with internal environment.

In this aggregate dimension, the participants discussed that several user interactions with autonomous vehicles could be mediated by Conversational AI. Conversational AI could provide the option of interacting with the internal environment using the voice-based interface as discussed below.

- **Desire for physically interacting with Conversational AI** was the first theme that evolved (23 codes) where participants expressed that they would prefer interacting with conversational AI through some form of physical Interaction with physical elements connected to the voice interface. Further, it's natural for humans to interact with fellow humans using body movements and expressions. The same would translate while interacting with Conversational AI as various forms of communication would take place through nonverbal means while interacting with vehicle systems which the conversational AI would have to detect through various sensing systems. U5 mentioned an interesting idea where interaction with conversational AI should be designed for incorporating gestures from users.

- **Visual technology support for Conversational AI** was a theme that evolved (20 codes) where participants discussed that some form of visual support would be required while interacting with the AI. Screen-based visualization to support conversational voice interface using either the face of roles or text and graphics to display what's being said would be desirable. U8 proposed an interesting idea of flexible and modular interfaces that can seamlessly appear and disappear while U3 proposed interaction with Conversational AI through projections. This visual aid will increase legibility and relatability of the voice interface, however will demand eye gaze and visual attention. Hence, the visual interface could be designed as a good supporting system for conversational AI but not one that will make the user dependent on it for interaction with the voice interface.

- **Open to voice-only interfaces** was a theme discussed equally as the previous theme (20 Codes) where participants mentioned that they would be just as comfortable if not more with a voice-only interface. People enjoy mental visualization generated from conversational interfaces and find it a convenient way of interaction that would free their eye gaze.

- **Conversational AI synchronized with auditory and visual cues** was a theme that participants spoke about wherein participants observed that receiving auditory and visual cues from the conversational AI would improve the quality of interaction with the Conversational AI. Notifications of various kinds would be effectively conveyed through such cues including a signal of whose turn it is to speak. U9 mentioned an interesting idea where Conversational AI paired with lights on the roof to give various visual cues.

- **Centrally accessible in-vehicle location of the Conversational AI** was the next theme that came to the forefront wherein participants mentioned that the location of speakers and the voice detection system should be located at a well-accessible location. Various locations were suggested including the center of the car's seat, the opposite side of the seating and besides the seat were some ideas that were floated. In all, a visual and auditory connection with the passengers must be established.

- **Interconnected ecosystem of in-vehicle technologies** was the last theme that emerged in which participants stated that conversational AI must be developed as an ecosystem of technologies interconnected for a better user experience. The Conversational AI should understand the facial expressions of humans to communicate more humanistically. U8 thought that Conversational AI with screen-based systems could make the AV into a creative / art studio and would be a good example of developing Conversational AI in an eco-systematic manner. U2 suggested that connecting conversational AI to cameras can enable passengers to click pictures and shoot videos.

5.1.6 Aggregate Dimension 6: User in-vehicle interaction with external environment.

In this aggregate dimension, the participants discussed several user interactions with the external environment of autonomous vehicles, which could be mediated by Conversational AI. Conversational AI provides the option of interacting with the external environment using the voice-based interface as discussed below.

- **Conversations about the external environment for information** was the first theme that evolved (30 Codes) wherein participants discussed that it would be natural for passengers to have conversations and interact with the external environment of the vehicle which would in turn influence in-vehicle user experience. Participants frequently mentioned that a bad in-vehicle user experience can occur due to the external environment's influence such as traffic jams, pollution, bad road conditions, and so on. Participants also desired to have information about the vehicle's context such as location at that instance, weather conditions, shopping locations, and more. Last, U1 mentioned that bad experiences due to the external environment can lead to disruption in in-vehicle conversation which the conversational AI would have to be mindful about.

- **Desire for interaction with the external environment** was the second theme (27 Codes) that evolved where participants expressed a desire to interact with the external environment. While it was natural for participants to mention the activity of looking out, participants thought it would be a good idea to make this activity interactive. The Conversational AI could describe buildings, tourist places, scenery, and more.

5.1.7 Aggregate Dimension 7: Conversations for modifying in-vehicle environment.

In this aggregate dimension, participants discussed that having the ability to modify the in-vehicle environment was an important factor in having a good user experience. These modifications could be made through conversations employing conversational AI as a mediating technology. The themes arising from it have been discussed below:

- **Modification of in-vehicle environments for better ambiance** was a theme (83 Codes) where participants discussed various activities they would understand to create a better ambiance in vehicles. Playing music of choice and a conducive environment for conversations were most prominently discussed. An interesting idea mentioned by U1 was the dispersion of good fragrances for creating a pleasant environment for conversations on a leisure trip. Overall, participants were interested in positively enhancing the in-vehicle environment and looked for activities to improve their experience of traveling. These provide an opportunity for Conversational AI to act as a facilitator for the digitalization of these activities and service users.

- **Modification of in-vehicle environments for comfort** was a theme that evolved (43 Codes) where participants discussed that they were involved in activities that made in-vehicle environments comfortable. A major reason for discomfort was the lack of space in the vehicle which led users to constantly undertake the activity of getting in a comfortable body position. Further, participants desired to reduce the effect of bad traffic to improve the in-vehicle user experience. Conversational AI provides opportunities to facilitate these modifications.

5.1.8 Aggregate Dimension 8: Provision of options through Conversational AI

In this aggregate dimension, participants discussed that Conversational AI should be designed to provide options and not function rigidly. As AI has the possibility to be co-designed through conversations by the user, it should have the flexibility to meet the needs of different user groups as described below:

- **Freedom of choosing options** was a theme (18 Codes) that evolved where people always spoke about how Conversational AI should provide options and not act rigidly. Users should have the freedom to choose various options.

- **Initiation of conversations** was a theme (20 Codes) where participants mentioned that the initiation of conversations should be an option where depending on the situation, the conversational AI should sense whether it should initiate the conversations or let the user initiate the conversations.

- **Option of speakers as well as headsets** was the next theme (10 Codes) wherein participants discussed that the in-vehicle environment might be a shared scenario or an individual one, wherein users might have changing preferences of accessing conversational AI through speakers or use of headphones. Both options should be provided to meet user needs.

- **Ability of switching voice's genders** was the next theme (8 Codes) wherein participants discussed various preferred genders of voices. As there was no clear option yet strong opinions on this aspect, the conversational AI should provide options of genders for users to choose from.

5.1.9 Aggregate Dimension 9: Shared control of Autonomous Vehicles mediated by Conversational AI

In this aggregate dimension and theme, participants discussed that Conversational AI serves as a mediator in sharing the control of the vehicle between autonomy and humans. Though people expect Autonomous Vehicles to function on their own, there are certain aspects wherein people expect to retain and share control of, an option that can be effectively offered through Conversational AI. The aspects of shared control that participants discussed are:

- **Activity of route navigation** was mentioned where the user would want to retain decision-making capabilities over the route and destination of the journey. Further, the users want to maintain control over editing the route during the journey, taking detours, or adding places to randomly stop. Such aspects would be a negotiation or in many cases command from the user's end which the autonomy would have to adhere to.

- **Sense of control desired by people** is an aspect that is one of the basis why people enjoy driving cars. The challenge to adopting autonomous driving by users would be that they miss that sense of control. During the period of transition from manual driving to autonomous driving, there would be a period where users would struggle to choose between the two - First, Giving the agency to autonomous vehicles to exercise, and second to get a feel of some sense of control over the Autonomous Vehicle. An interesting idea mentioned by U4 was that humans should have the ability to change the nature and topic of conversation of the AI if they don't like it.

- **Co-determine preferences for Autonomous Vehicle's behavior or performance** was the next aspect discussed wherein participants were interested in having a role to play in deciding the behavior or performance of the autonomous vehicle such as speed control, fuel efficiency, smoothness of drive, and so on. These options can be provided through the medium of Conversational AI

- **Discussing and negotiating the best course of action with the vehicle** was another topic people discussed wherein there may be cases where the vehicle would have to make choices for the courses of various actions. Though its technology may enable it to independently do so, there may be socio-cultural or personal reasons influencing users to discuss and negotiate the best course of action with autonomous vehicles. Therefore, these possibilities can be effectively provided through conversational AI to the users.

5.1.10 Aggregate Dimension 10: Design Aspects of Conversational AI for Autonomous Vehicles

In this aggregate dimension, participants discussed design aspects they would prefer the in-vehicle Conversational AI to have. These are:

- **Personalization of experience by understanding the user** was a theme (78 Codes) where participants discussed that conversations with empathy towards the user's life were the most memorable ones and desired by users. Conversational AI should understand users' topics of interest to generate a focus of conversations as users desire for the system to adapt to them. The AI would have to remember user preferences for better service to users. U4 mentioned that a potential difficulty could be an intergenerational disconnect in topics of conversation that the conversational AI will have to be mindful of. U2 discussed that personalization would also increase ease of use, an important quality for mass adoption of technology.

- **Familiarity increases the amount of conversations** was the theme that evolved (61 Codes) where participants spoke about how if the characteristics of experience provided by Conversational AI are designed to give a sense of familiarity to the user's cognition, the amount of conversations increased. Participants discussed that their most preferred conversation companions were either members of their family or close friends. As these companions are those whom the participants can depend on and have longer relationships with, participants are more attached to the characteristics these companions offer. Further, humans are more familiar with anthropomorphic characteristics and therefore desire an extrapolation of those into the design of conversational AI. An aspect pointed out by U1 that designers would have to be careful about was fear or apprehension in having conversations with the conversational AI might reduce user interaction with the technology. This could also be caused by a drop in motivation from the user's side to have conversations. Hence, Conversational AI systems should be designed to give a sense of familiarity to develop relatability.

- **Design for civil behavior of Conversational AI** was a theme (31 Codes) wherein participants discussed that though users would try and test the system, the Conversational AI should display etiquette and manners in its behavior towards the users. Appropriate usage of vocabulary must also be ensured to contribute to this design of civil behavior.

- **Soothing and pleasant voice design of Conversational AI** was the subsequent theme (27 Codes) wherein participants discussed that it's important for the voice interface to have soothing and pleasant characteristics. Conversational AI should have the ability to engage in smooth-flowing conversations around topics that interest the user to ensure that the user is comfortable as well.

- **Authenticity and Acknowledgement of artificial characteristics of AI** was a theme (30 Codes) where participants discussed that they wanted to experience autonomous characteristics of vehicles through its design and not be a complete mimicry of humans. Further, there may be instances wherein participants may be unable to resonate with Conversational AI due to feelings of artificiality. Therefore, though the participants desire conversational AI to be heavily involved in the conversations, they desire authenticity from the AI and don't expect it to mimic humans per se. This aspect would have to be dealt with delicately in its design to achieve a balance.

- **Intelligent content of conversations** was a theme (32 Codes) where participants expected the AI to have intelligent content of information yet convey it in a comforting manner to users. Participants have expressed discontent over information that didn't satisfy their intent while having conversations. This aspect would be related to the development of technology itself. This development should seek to inform people with exciting new perspectives through data unknown by the user in the topics of interest to the user. People have stated that conversations that had deep insights that influenced their life's journey in some way were one of the most valuable and memorable ones to them. AI has the potential to provide deep insights through conversations due to its connections to large databases which would make conversations with AVs memorable. Lastly, despite intelligent conversations, the conversations' intent and message should be easy and simple to mutually comprehend.

- **Ability to discuss opinions and facts separately** was the subsequent theme (20 Codes) wherein people desired a dichotomous balance between AI having the ability to give its opinion versus providing information based on facts and truths. As users see AI as a medium to have conversations to get educated opinions on various matters, AI should be able to maintain a balance between the aforementioned aspects while being self-aware and stating that it's doing so.

- **Conversational AI should be productive for users** was a theme (7 Codes) where participants discussed briefly that at the heart of the design of technology, Conversational AI should increase the productivity of users in one form or another. Users should get a sense of satisfaction and a sense of accomplishment in some form at the end of the conversation with the AI.

- **Conversational AI's design in AVs should represent the Brand** as a theme (6 Codes) where participants discussed that Conversational AI provides an opportunity for brands to promote their brand's experience by designing qualities of conversations in line with brand standards. U7 spoke of an interesting idea wherein the product manual experience can be provided through Conversational AI.

- **Relationship between passengers influences conversational AI interaction** was the last theme that arose (4 Codes) wherein U4 reinstated that people's company with each other, qualities of extrovertedness versus introvertedness, apprehension in speaking to strangers, and hesitation to speak to technology would influence their interaction with Conversational AI. Therefore, designers would have to design Conversational AI to ease users into its usage.

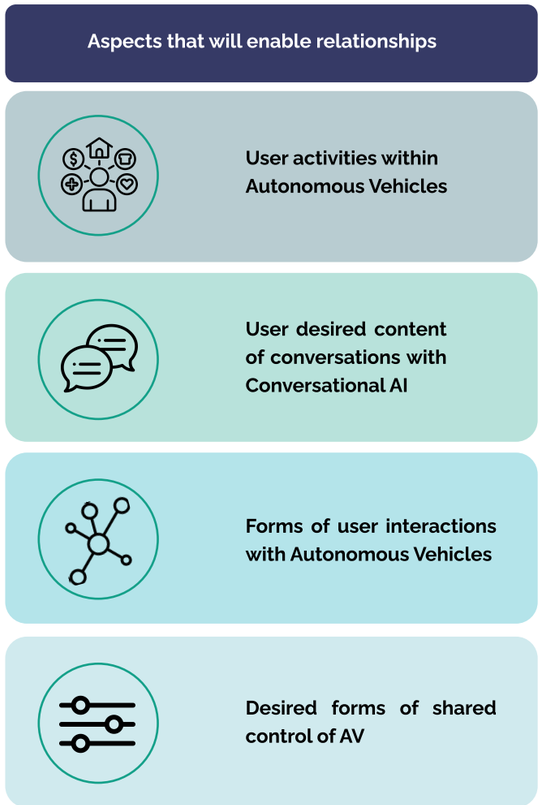


Fig 36: Aspects that will enable user relationships with the in-vehicle Conversational AI

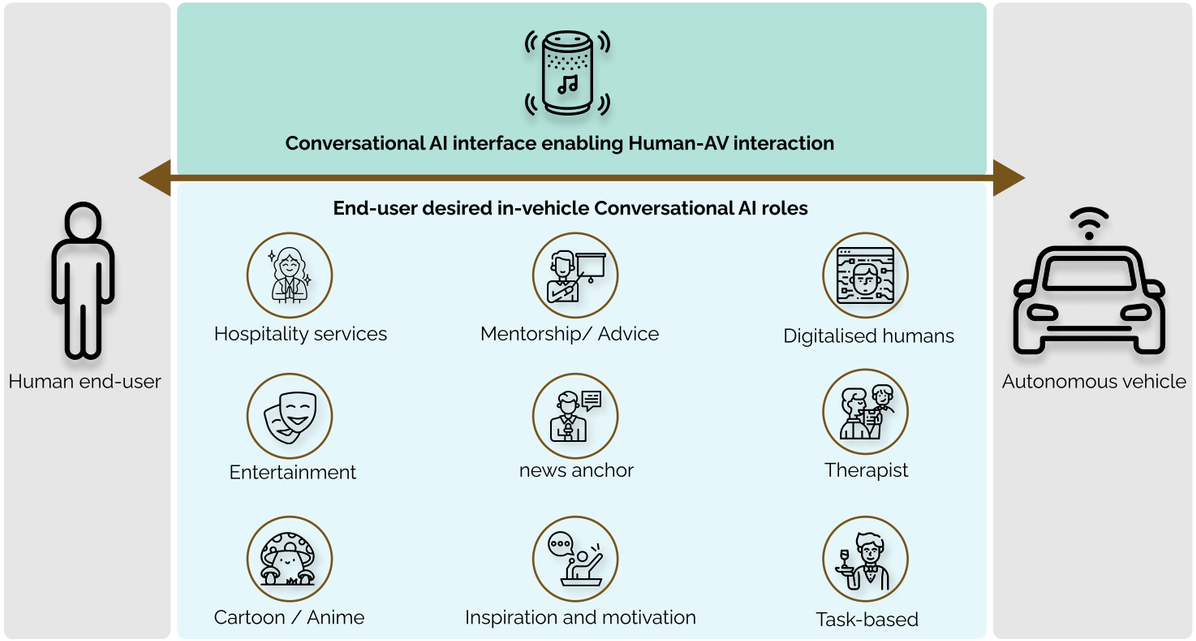


Fig 35: Types of roles the Conversational AI can play towards passengers of autonomous vehicles

5.2
Analysis of expert interviews

In this section, results from analysis of expert interviews are presented. These interviews were analysed for understanding barriers of design innovation, strategic opportunities and guidelines followed by experts to design of Conversational AI for AVs.

In this section, insights from expert interviews are presented derived from the thematic analysis of qualitative interviews that were conducted. These interviews were analyzed for 4 themes which are (1) Barriers to Innovation, (2) Strategic Opportunities, and (3) Design Strategies Employed.

5.2.1 Barriers of Design Innovation

In this theme, the experts discussed various barriers of innovations that can present possible difficulties in the implementation of Conversational AI in Autonomous Vehicles.

Firstly, experts spoke about **user resistance in the adoption** of Conversational AI technology in Autonomous Vehicles. This could arise due to apprehension or unfamiliarity with using the technology could be major barriers and might lead users to reduced usage. Further, efforts have to be made to develop the right use cases and contexts of usage of Conversational AI's implementation within Autonomous Vehicles, as lower levels of perceived usefulness and perceived benefits would reduce Conversational AI's in-vehicle usage. These are discussed by ER-2 in the quote given below:

> *"There will be resistance to the adoption of technology due to unfamiliarity, especially if people don't understand the technology or haven't used the technology in another context. People might stop using the technology instead of learning how to communicate with Conversational AI due to lower levels of perceived usefulness or the perceived benefits are not directly observable." ER-2*

Secondly, experts discussed the **potential lack of desirability** amongst future users of Conversational AI technology in AVs due to fear or misguided perceptions of AI technology. They discussed that public perception of the AI technology may not be entirely positive and users may have fear or apprehensions in adopting the technology. Facilitating users to get over this fear to build confidence in using the technology may be necessary, as stated in this discussion by EP-4:

> *"I think public perception is one of the biggest barriers. Once we can change public perception of AI in general, I think then they'll be more accepting. But like I was saying before, I think to change public perception, we have to change utility. If people see the utility, then they'll gravitate to accepting it." EP-4*

Thirdly, experts discussed one of the barriers to implementation could be **organizational resistance to change** due to factors such as incompatible legacy systems being used, absence of the latest thinking based on future trends, and reluctance towards changing the development and production process of vehicles. Designers of conversational AI would have to think about the presence of legacy systems used by organizations that may be incompatible with other systems and facilitate transitions in organizational structures to bring in new thinking around the implementation of the latest technologies. Further, there may be a need to change the development and production process of vehicles for legacy automakers to incorporate artificial intelligence technologies in existing cars which the designers would have to be mindful about. Designing with considerations to production processes and integration with legacy systems would be essential, for example as stated by EP-3:

> *"Making sure that they are integrated, which is an issue with a lot of these legacy systems that companies and organizations have, is that they're often called legacy systems because they're not integrable with other systems. And that makes it very challenging to work within organizations, where slow adoption of new technologies as well as is a problem." EP-3*

Lastly and most importantly, the **absence of reliable and effective Natural Language Processing technology** for better cognition of human speech in the presence of background noise would be the bedrock of a good design. Wrong detection of intent or inability to understand what the user is trying to say would be a major barrier. Another important technological aspect is the inability of conversational technology to distinguish between the user's human voice from background noise. Designers would have to be mindful of technology capabilities to design solutions, as discussed by ER-2:

> *"I think one of the major challenges of Conversational AI specifically is the reliability it has. So when you have a chatbot that can fulfill, you know five tasks for example, and it misunderstands the users frequently or things like that, those are big. Those are significant barriers and users might also just stop using it straight away instead of learning how to communicate with it" ER-2*

5.2.2 Strategic Opportunities

In this theme, the experts discussed various strategic opportunities that exist in the implementation of Conversational AI in Autonomous Vehicles.

Firstly, experts discussed that a strategic opportunity exists **to increase human productivity and functionality while traveling** in Autonomous Vehicles. Vehicles are frequently used for traveling to work and Conversational AI would have the ability to improve and increase the productivity of knowledge workers while traveling in Autonomous Vehicles. Further, Conversational AI could be a knowledge manager for providing personalized learning experiences, high-quality advice, and recommendations based on huge knowledge bases while transiting. Its voice-only interface while being hands-free can be used for increasing human efficiency and functionality in Vehicles. ER-2 discusses some of these aspects for example:

> *"As a kind of knowledge manager to provide personalized learning experiences to provide high-quality advice and recommendations based on huge knowledge bases. The ability to improve, and increase productivity, especially of knowledge workers. Impacts in many ways are really hard to foresee at the moment, but there's definitely many, many different things that are going to change in the coming years." ER-2*

Secondly, Conversational AI presents a strategic opportunity for vehicle brands **to seamlessly integrate autonomous vehicles into a larger ecosystem of networks** accessed by the end user in day-to-day life. Conversational AI has the possibility to migrate through devices owned by the end user and provide a seamless integrated experience. Further, the vehicle is also part of a larger road context and would have to interact with various systems where conversational AI could play a role. An example would be EP-2's quotation:

> *"Brands have very strong portfolios and very strong ecosystems, but their Conversational AI experience is very bad. Conversational AI presents a tremendous opportunity not only for automakers but for tech companies in general for delivering this seamless integration that they've been promising to add over the last 20 years or something." EP2*

Third, a strategic opportunity for **managing autonomous vehicle customer experience** through conversational AI. Due to a personalized service that is empathetic to users, the user will feel a sense of care being given to them by the company and build relatability towards the vehicle, for example, as stated by ER-3:

> *"I think on a superficial level, people can relate to robots. That's my own hypothesis and it is because they can also relate to cats and cats do not have any social status. So the agency that humans hold due to which people can relate to each other, that's not an important criterion when it comes to developing a bond." ER-3*

5.2.3 Guidelines employed professionally by experts

In this theme, the experts discussed various design guidelines that they employ in their work with Conversational AI and/Or Autonomous Vehicles.

Firstly, experts stated that Conversational AI for Autonomous Vehicles must be designed from a **user experience-centric perspective** by understanding the use case, the context of the conversation, and the meaning of the conversation for the user. It is very important to understand the target audience who would be using conversational AI and involve the users in making design designs and get their feedback, through Co-design and Participatory design methods. The use cases should be well defined and the meaning of conversations in those instances should be determined, for example as discussed by EP-3:

> *"Then you have the branding which is another strategic part. And then there's that part of I think the whole user experience and putting that together involving users. And getting this AB testing and research cycle going." EP-3*

Secondly, experts discussed that **Co-branding Conversational AI personality** through the design of voice interface characteristics, based on the brand personality and brand identity of the autonomous mobility company as well as the Conversational AI company would be the way to proceed forward. The conversational AI presents an opportunity for companies to promote their brand through literal tone of voice, gender of voice, the sequence of words, and how that conveys a certain personality. As numerous stakeholders would be involved in this development, it would be essential for designers to maintain a balance in promoting brands through design, for example as discussed by ER-3:

> *"All the features that are in cars today, come from companies like Porsche and Valeo, but those are not consumer brands. So the consumer is not interested in them. Those components in the vehicle, you know, you buy a BMW, you think this is a BMW. You don't think this car has assorted this and the Siemens that and so that's the difference. Like Senseo coffee machines, which is a cooperation between Philips, an electronics company, and a coffee maker. So if Amazon also wants to express its brand identity, then you have two brands that need to be expressed. So you're what you are looking for, some sort of Co-branding and Co-brand name." ER-3*

Thirdly, experts stated that Conversational AI should be designed by **thinking holistically to seamlessly integrate** Autonomous Vehicles into a larger ecosystem of technologies accessed by the user, by taking into consideration appropriate stakeholders, legalities, and sharing of responsibilities. For example, as discussed by EP-1:

> *"For example, vehicle needs to have more of the screen reader kind of features, so the blind person can just touch and not like, what it is saying and all those kinds of things like we have in the lift. People who are disabled or need a wheelchair, or maybe I just had an accident and you know my leg is fractured. Then what happens? Right. So there may be those kinds of things where I have a cast. I'm not able to walk. So the vehicle needs to have all those accessibility features that none of us are talking about. Conversational AI is only going to help if you have all of these experiences in sync." EP-1*

5.2.4 Visualization of roles

Few Conversational AI roles were visualized using Imagine.Art AI (https://www.imagine.art/dashboard) to get an understanding of how their embodiment in autonomous vehicles would be visually experienced. Here are the renderings:



Fig 37: Conversational AI role of an Advisor

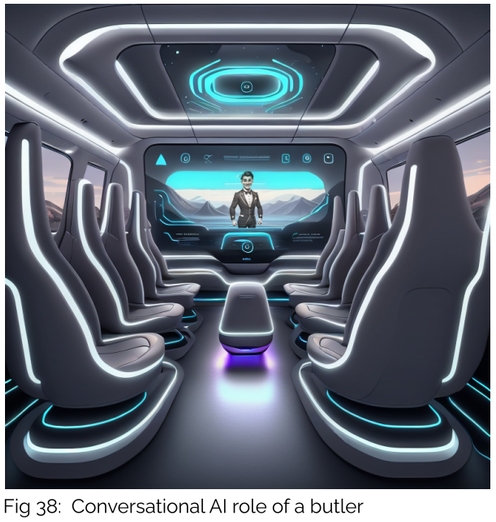


Fig 38: Conversational AI role of a butler



Fig 39: Conversational AI role of a Disk Jockey



Fig 40: Conversational AI role of a cartoon / anime

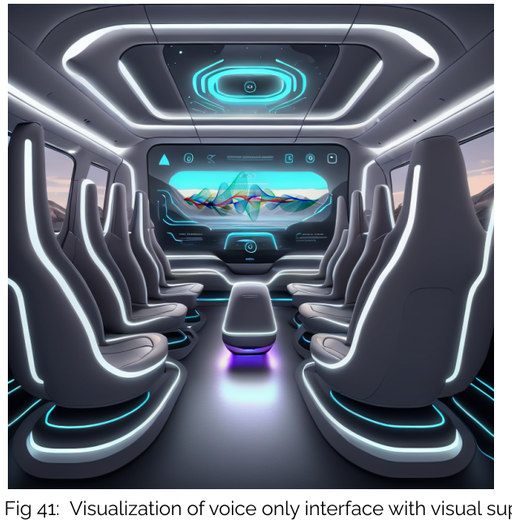


Fig 41: Visualization of voice only interface with visual support

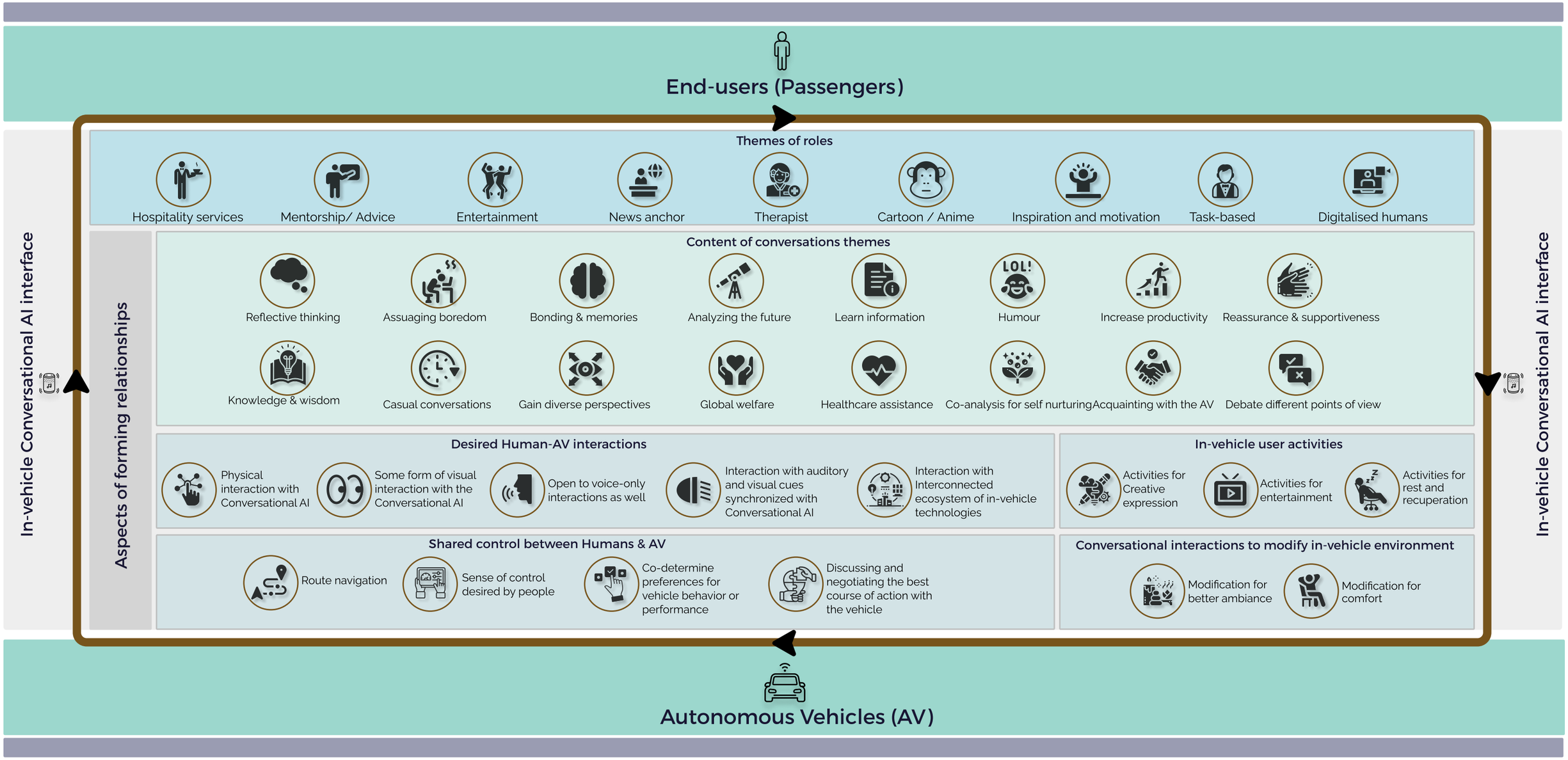


Fig 42: Diagram explaining user desired in-vehicle Conversational AI roles and components of forming Human-AV relationships mediated by the Conversational AI.

Chapter 6

Evaluating User Experience

This chapter presents results from guided brainstorming sessions conducted to evaluate user experience through interaction experiments of a prototyped set-up. Desired forms of Conversational AI embodiments are also visualised.

In this chapter:

6.1 **Analysis of Guided Brainstorming**
6.1.2 Forms of embodiment (Conceptual Sketches)

6.1
Analysis of Guided Brainstorming

This section presents results from the guided brainstorming sessions following the interaction experiments, to evaluate user experience of prototype Conversational AI roles in Autonomous Vehicle experimental setup.

6.1.1 User's qualitative assessment of the embodied user experience provided by Conversational AI roles and relationships designed for Fully Autonomous Vehicles.

6.1.1.1 Likability

Within this aspect, the participants were asked 1 reason each as to why they would like as well as dislike conversational AI interfaces in fully autonomous Vehicles. The findings are presented below firstly aspects they like and aspects they dislike.

6.1.1.1.1 Liked aspects of the interface

The participants liked that the concept of conversational roles provided a **user-friendly way of interacting** with fully autonomous vehicles, especially using voice which is natural and relatable to users due to its emulation of human qualities. The participants also felt the voice interface allowed for a reduction of time required to read and write their intents along with freeing up their eye gaze from the requirement of focusing on a particular visual interface while reading or writing, as derived from P1, P2, P11 & P12:

> *"It's a good interface, it's natural to humans and people don't have to spend time reading or writing." (Session 1 - P1 & P2)*
>
> *"There is more relatability because it emulates a human and acts like a smart human." (Session 6 - P11 & P12)*

Secondly, the concept of roles was appreciated by the participants because they would **have a companion for the journey**. This concept of a companion was found especially useful by the participants when they would be traveling alone or in smaller groups, as the amount of companions to have conversations within the autonomous vehicle would be less. With not much to do within fully autonomous vehicles for the passengers, loneliness, and lack of activities could be an issue that could arise. Conversational AI roles could cater to providing companionship to the passengers to keep them entertained, for example as mentioned by P3 & P4:

> *"There's a companionship to talk to in case one feels sad or lonely." (Session 2 - P3 & P4)*

Thirdly, the participants felt that the Conversational AI roles in general **increase user convenience** of gaining information, opinions, or services during the journey by providing them with a low barrier to access to desired knowledge. The participants found it convenient to talk to the Conversational AI interface instead of writing the commands on screen-based devices. Health concerns like eye strains also seemed to be reduced due to this interface which was an added advantage that the participants saw, as illustrated by P5, P6, P7 & P8:

> *"Convenient to know information while releasing eyes from straining .... convenient to get location related information and recommendations while traveling." (Session 3 - P5 & P6)*
>
> *"Saves time, is convenient, and provides a low barrier access to information." (Session 4 - P7 & P8)*

Lastly, participants appreciated the quality of the interface that **releases them from the stress of pre-thinking suitable commands** as one has to do for voice agents commercially available to get a good response. They enjoyed that through free-flowing conversations, one could arrive at the intent of having the conversation, as illustrated by P3 & P4:

> *"Saves time in terms of pre-thinking specific commands. The Conversational AI can discuss with you to understand your specific intent." (Session 2 - P3 & P4)*

6.1.1.1.2 Disliked aspects of the interface

The participants disliked that the AV's conversational AI may **not be able to have deep conversations personalized to the user** as AI cannot completely empathize with and understand human experience gained over the years. The participants felt that an understanding of personal circumstances is important for certain conversational AI roles for the conversations to be meaningful to the users. Non-personalized responses given by some roles may be intelligent, but irrelevant to a person's intent of having conversations with the AI, which may be frustrating. Though various systems can be employed to study and remember user preferences, the Conversational AI's physical attachment to the vehicle will limit its capacity to understand human preferences holistically outside the vehicle which may be important when having deeply personal conversations, as outlined by P1, P2, P5 & P6:

> *"It would be nice if the Conversational AI had a memory of human preferences, but it cannot empathize and know all the human experiences over the years being attached to a car." (Session 1 - P1 & P2)*
>
> *"In general, non-personalized answers can be irrelevant to a person, if not specific to the context/ situation of the person. Therefore, the Conversational AI in Autonomous Vehicles would have to specifically understand or study the passenger over time." (Session 3 - P5 & P6)*

Secondly, participants felt that the **tone of voice of the AI didn't match that of a human's way of speaking**. They would desire that the Conversational AI's voice should match a human's way of speaking, an important aspect for humans to develop a connection with each other. The participants also mentioned that the timing of responses and the tone of voice has to be in sync with their mood and context of the conversation for the conversational AI to feel realistic, for example, mentioned by P1, P2, P7 & P8:

> *"Timing of responses has to be great depending on the context of conversations and in sync with human speech." (Session 1 - P1 & P2)*
>
> *"Tone of voice should be in sync with the mood of the passenger and not robotic." (Session 4 - P7 & P8)*

Thirdly, the **amount of conversation desired from the AI will depend on the user's mood** which the AI will have to automatically sense. The automatic sensing is important for the AI to adjust its behavior to be entertaining and avoid being too imposing, overpowering, or imposing on the in-vehicle passengers, as shown below in P3, P4, P5, P6, P9 & P10.

> *"Without controlled behavior, it could be overpowering and distracting from the experience of the journey." (Session 2 - P3 & P4)*
>
> *"The amount of conversation will depend on the moods and needs of passengers, and conversations cannot be forced upon." (Session 3 - P5 & P6)*
>
> *"The conversational AI shouldn't be intrusive and mustn't force a conversation without the user desiring a conversation." (Session 5 - P9 & P10)*

Fourthly, the participants disliked the fact that the **journey started with choosing one particular role**. Journeys could often be multipurpose along with a changing nature of conversations going on in the car. Therefore, the participants pointed out that there should be one general role with one persona that can seamlessly transition to specific roles depending on the context and triggered by the user's conversations as mentioned by P11 & P12:

> *"The conversational AI should start with a general persona instead of a specific role and should provide the option of switching roles with a seamless transition. It should learn more about the user's preferences and choosing to play a role should be triggered by the user." (Session 6 - P11 & P12)*

6.1.1.2 System Response Accuracy

Under the scope of this parameter, the participants were asked to give one reason each about why they would think that the Conversational AI interface in Fully Autonomous Vehicles could improve as well as deteriorate the accuracy of conveying the passenger's intention that the autonomous vehicle should fulfil. The following are the findings:

6.1.1.2.1 Perspectives on the improvement of accuracy of conveying passenger's intention

The participants believed that the **intent of mental stimulation** through having a companion was fulfilled well by the Conversational AI. The users felt that their intent of reducing boredom met well and provided an avenue for the intent of venting out stress on your AI companion, as illustrated by P1 & P2:

> *"Intention of wanting to do away with boredom is conveyed efficiently, to provide mental stimulation. It also provides an avenue for releasing the user's stress with the AI buddy." (Session 1 - P1 & P2)*

Secondly, the participants believed that in the moments when they wanted to maintain some form of shared control over an Autonomous Vehicle, their **intent to do so was conveyed effectively** through the Conversational AI interface, as stated by P3 & P4:

> *"Gives humans more control over AVs and there is more sense of human involvement in the drive." (Session 2 - P3 & P4)*

Thirdly, the participants were optimistic that their intent would be **better understood over time with the improvement in technology**, and minor issues in this regard would be solved over time. When the system stores information and the AI learns about the user's preferences regarding the user's way of speaking, vernacular, and vocabulary over time, the intent will be understood better. Further, with time AI's databases will also be large enough to accommodate wider ranges of conversations which the participants believe will improve their understanding of intent, as stated by for example P7, P8, P9, P10, P11 & P12.

> *"Understanding user-specific manner of communication improves over time because of getting used to the passenger. One can mutually learn and adapt over time." (Session 4 - P7 & P8)*
> *"Memory of passenger routines and its connection to large databases will improve accuracy." (Session 5 - P9 & P10)*
>
> *"If it is personalized to the user's way of speaking, vernacular, and vocabulary the response can improve because it can automatically detect the sentiments of users through voice." (Session 6 - P11 & P12)*

6.1.1.2.2 Perspectives on the deterioration of the accuracy of conveying passenger's intention

The participants felt that Conversational AI would deteriorate in conveying the user's intentions if they **do not understand humans' intentions from an experiential or human psychology perspective** to give responses relevant to a human's personal circumstance. There is a possibility that the conversational AI understands an intent superficially or imprecisely, which would limit its ability to have deeper conversations. Further, a lot more details about the user's personal information would be required to be analyzed implicitly by the AI to give appropriate responses. Lastly, AI while having conversations may consider its best choice over what's best for the users and may lead to deterioration of accurately conveying intent, as stated by P3, P4, P5, P6, P9 & P10:

> *"It will not convey intentions accurately as it will not sense the emotion behind the person." (Session 2 - P3 & P4)*
>
> *"The conversational AI may understand the intent/ question superficially. It should ask deeper questions to empathize with the user." (Session 3 - P5 & P6)*
>
> *"AI would consider its own best choice, without considering specific human needs/ desires." (Session 5 - P9 & P10)*

Secondly, the **length of responses by the AI** will play an important role in improving the accuracy of conveying intent. The Conversational AI can misjudge the length of desired responses and either give long answers or short ones, both of which may be a problem depending upon the situation. For example, as stated by P7 & P8:

> *"May not understand the desired length of the response." (Session 4 - P7 & P8)*

Thirdly, a **lot of prior information may be required** for having conversations due to AI's vast knowledge base, leading to the deterioration of conversations that users can have with the AI. This can lead to a lot of prior thinking of a suitable prompt or conversation which will deteriorate the conveying of intention about the intention, as mentioned by P5 & P6:

> *"Thinking a lot about the right prompt isn't desirable. Therefore, the technology should be developed to enable natural conversations and not bother about how we organize sentences to convey to the AI." (Session 3 - P5 & P6)*

6.1.1.3 Annoyance

To gain responses under this parameter, the participants were asked to give 1 reason each as to why Conversational AI could be annoying as well as pleasant to have in a fully autonomous vehicle. The findings are mentioned below:

6.1.1.3.1 Pleasant aspects of the interface

Firstly, the fact that conversational AI enables you to have **free-flowing conversations without requiring a prior formulation of prompts** was found to be a pleasant aspect of the interface. The currently available conversational agents require users to spend some time thinking about what the right conversational prompt is. There may be cases where the participants may not know the specific terminology of the conversation they are looking to have, in which cases conversational agents are an unpleasant experience for people. On the contrary, conversational AI can help understand the intent with a wide range of vocabulary and free-flowing conversations, which the participants appreciated very much as stated by P1, P2, P9 & P10:

> *"Reduces much of your load for doing prior research to formulate a command or have conversations. The conversations are free flowing and all controls are through voice." (Session 1 - P1 & P2)*
>
> *"AI makes an effort to continue the free-flowing conversation with the user, that the user initiated." (Session 5 - P9 & P10)*

Secondly, participants found it to be **pleasant that there would be a companion to entertain and guide** the users with knowledge and opinions when traveling in the car. Traveling in an autonomous car could be a lonely experience especially when traveling as a single passenger. The Conversational AI could serve the triple purpose of accomplishing task-based commands, enabling sharing of vehicle control between the user and autonomous vehicle, and acting as a companion to build a relationship. The participants felt that Conversational AI companions through various roles could discuss and suggest decisions in the user's best interest, which felt like a 'responsible person having your back' as stated by P5, P6, P11, P12, P9 & P10:

> *"Was nice because it was motivating based on your situation which felt like someone who has your back. It felt like a responsible person who is always there for you like a companion." (Session 3 - P5 & P6)*
>
> *"Sometimes, when bored or alone in the car, the Conversational AI could be a good companion to entertain you as it's a speech interface." (Session 6 - P11 & P12)*
>
> *" It suggests decisions in the user's best interest to make the journey efficient." (Session 5 - P9 & P10)*

6.1.1.3.2 Annoying aspects of the interface

Firstly, the participants felt annoyed when the **AI-generated unintelligent general responses** that were not tailored to the user's specific query and related to personal circumstances. They felt that if the responses were not filtered based on the user's personal context and expectations, the conversation might be pointless to have with the AI. Deeper conversations and meaningful relationships would be dependent upon mutually having an understanding of the personal circumstances and understanding of the context of conversations developed over time as displayed below by P1, P2, P5 & P6:

> *"It might give general responses which may not be desired in a situation." (Session 1 - P1 & P2)*
>
> *"If the information is not filtered or tailored based on the AI's understanding of a person's context and expectations." (Session 3 - P5 & P6)*

Secondly, the participants discussed that the AI may be annoying when it **does not accurately detect the intent of conversations**, leading to unrelated conversations that deviate from the topic. Along with difficulty in identifying intent, continuing with conversations based on the limited dataset it has access to might lead the conversations to be skewed towards a particular direction that may not resonate with the users. In such cases, the inability to stop the AI from continuing the conversations can further aggravate the conversations as shown below by P3, P4, P9 & P10:

> *"Difficulty in intent identification and jumping to conclusions based on its limited dataset." (Session 2 - P3 & P4)*
>
> *"When AI gives answers unspecific to the user's intention/ query and the user cannot stop it from continuing to re-ask a conversation." (Session 5 - P9 & P10)*

Thirdly, an annoying factor for people was when the Conversational AI **content was not of a high standard**, and may not understand how to convey information comfortably to the user. Users often have a higher standard for quality from AI over humans, which requires the AI to have certain criteria for selecting information to have a conversation on. Further, along with the selection of information, the amount of information to convey in conversations and the length of responses should be tailored to the users, by sensing their moods and emotions as mentioned below by P5, P6, P7 & P8:

> *"Criteria of selection of content for conversation by the AI might not be good which leads to reduction of quality desired. There is often a higher expectation of a perfect answer from AI. Also, over-information and long waiting times can be irritating and lead to a reduction in the quality of conversations. Shorter to the point answers and smoother transitioning in conversation are required from the AI." (Session 3 - P5 & P6)*
>
> *"Length of answers should be tailored to the passenger's mood, possibly by detecting emotions based on the passenger's tone of voice." (Session 4 - P7 & P8)*

Fourthly, participants might be annoyed **when the AI interrupts a good conversation or silent moment** going on in the vehicle to have undesired conversations. There may be events where the users want to travel silently in the car or there may be cases where there is an entertaining conversation going on already within the car. In such cases, the participants feel that it might be annoying for the AI to keep having conversations and interrupt a desirable atmosphere in case it is not sensitive to the aforementioned situations as stated below by P7, P8, P9 & P10:

> *"Annoying when the AI interrupts an already good conversation going on between passengers." (Session 4 - P7 & P8)*
>
> *"Could be annoying if you want to have a quiet time but the AI is insisting on the conversation." (Session 5 - P9 & P10)*

Lastly, participants felt that **over-dependence on conversational AI technology to accomplish tasks and exercise desired interactions** may be annoying and overwhelming. There may be a tendency to employ conversational AI to exercise options in every instance, but this over-dependence on AI may be overwhelming and annoying for users. Sometimes, providing alternative modes of exercising those options would be a more desirable way. Further, if users have to put in too much effort to co-design options and choose from them, this may be annoying over time. A balanced dependence on the AI and a controlled provision of options for users to decide about would be preferable for the AI to be less annoying as derived from P11, P12, P7 & P8:

> *"It could be annoying if one has to depend completely on conversational AI, where manual options may be preferred. Too much technology dependence itself can be annoying. Also, making decisions to co-design the conversational AI would be annoying if too many options are presented to choose from the users. Some options, the AI must provide on its own." (Session 6 - P11 & P12)*
>
> *"Should not create barriers and complicate tasks that can be done manually or simply." (Session 4 - P7 & P8)*

6.1.1.4 Cognitive Demand

Under cognitive demand, the participants were asked to give 1 reason each as to why Conversational AI in AVs could decrease as well as increase the perceived amount of effort (cognitive demand) needed to interact with the fully autonomous vehicle from passengers. The responses are discussed below:

6.1.1.4.1 Aspects of the interface that decrease Cognitive Demand

A decrease in cognitive demand is a positive case that would be desirable when interacting with Conversational AI. The participants stated that the interface would decrease the cognitive load as Conversation AI **provides a possibility of effortless interaction with the AV** employing a natural form of interaction for humans through conversations while improving the ease of access to information and the process of getting suggestions and advice from a source of knowledge. The Conversational AI also provides more options for users to choose in various regards and this would allow the interface to be flexible to cater to a wide range of possibilities from the user's end. These aspects are illustrated by P3, P4, P11 & P12:

> *"Would decrease the efforts, give ease of access to information and more options to choose from while traveling in an AV." (Session 2 - P3 & P4)*
>
> *"Would reduce cognitive load because it provides quick access to answers, possibility to ask anything and the AI follows up if it doesn't understand your conversation's intent." (Session 6 - P11 & P12)*

Secondly, the **personalization of services to the users and relatability generated due to a human voice** would contribute to reducing cognitive load as per the participants. Further, the possibility to interrupt the AI when required and have free-flowing conversations would additionally be desired. One of the other reasons for the reduction of cognitive load is the easier framing of sentences as the mutual understanding between humans and AI increases. This is supported by P7, P8, P11 & P12 for example:

> *"Relatability due to a human voice will decrease the Cognitive Load. Relatability helps to interrupt the AI when required and have free-flowing conversations." (Session 4 - P7 & P8)*
>
> *"Personalisation of the AI to users can lead to a better understanding of the user's conversation and easier framing of sentences." (Session 6 - P11 & P12)*

Thirdly, participants discussed that the **rapid change in styles of roles** every time the purpose of the journey or nature of conversation changes and the absence of a general role with a persona should be avoided. Designing for seamless transitioning between the roles would reduce cognitive load. Further, these roles should have an understanding of the desired length of answers by naturally sensing it through emotion and sentiment detection to make the roles more believable and human-centered. These aspects would enable cognitive load reduction as explained by P7, P8, P9 & P10:

> *"Seamless transition in roles will decrease the effort." (Session 4 - P7 & P8)*
>
> *"Requirement of giving shorter, to-the-point answers to the users to quickly do tasks." (Session 5 - P9 & P10)*

6.1.1.4.2 Aspects of the interface that increase Cognitive Demand

An increase in Cognitive Load is a negative and undesirable factor in speech-based interfaces. The participants mentioned that the cognitive load would increase if Conversational AI **doesn't inform humans of the spectrum of possibilities** that AI would have as opposed to those that humans may think of or invent. This could arise due to being trained on a limited data set or a data set that's not holistic enough. Further, limiting interactions to conversations when humans use many other forms of interactions might increase cognitive load as per participants. These are discussed by P5 & P6:

> *"Conversational AI can reduce our interactions because it's trained on a limited dataset and doesn't provide all options/conversations/interactions that humans can think of or invent. It can increase cognitive demand as it limits interactions to conversations, while humans use many other forms of interactions." (Session 3 - P5 & P6)*

Second, if the AI does not have a **suitable tone of voice**, does not maintain a suitable length of statements, and does not have control over the amount of information to be given can increase cognitive demand for users, for example as stated by P7 & P8:

> *"Long sentences with unfamiliar vocabulary can lead to an increase in cognitive demand. Also, not having a suitable tone of voice matching the job to be done." (Session 4 - P7 & P8)*

Third, an **unfamiliarity in knowing how to address** different roles of the AI interface and a lack of understanding of the amount of **effort required to hold the conversation** for a long time are aspects that participants believe could make the Conversational AI cognitively demanding, as stated by P1 & P2:

> *"Efforts required to hold the conversation for a long time might be cognitively demanding for people who are not used to speaking to CAI." (Session 1 - P1 & P2)*

Lastly, participants found that **doing a simpler task with Conversational AI which is done easier with other means** will unnecessarily increase cognitive demand. Though conversational AI would provide the possibility to access many options, its usage should mindfully be designed to avoid over usage of Conversational AI in AVs, for example as explained by P11 & P12:

> *"Doing a simpler task with Conversational AI done easier with other means will increase the demand." (Session 6 - P11 & P12)*

6.1.1.5 Intuitiveness

Under this parameter, also mentioned as Habitability in the questionnaire, participants were asked to mention 1 reason as to why and why not they would intuitively understand what to do with the Conversational AI in the AV and consequently understand what the system is doing. Their responses are discussed below:

6.1.1.5.1 Reasons why the interface is intuitive

Firstly, the participants discussed that the intuitiveness will increase once the AI stores the user's personal information, which would **increase the co-understanding** between the user and the system. The storing of personal data specific to the user will enable the AI to understand the user's behaviors and way of speaking better increasing the intuitiveness of the interface. A representative example of the above discussion is P11 & P12:

> *"It is natural to convey intent through conversations as it's a human quality. With time, based on storage of personalized information/data, the AI will feel natural and comfortable to adapt to it." (Session 6 - P11 & P12)*

Secondly, participants believed that the interface is intuitive because **it's user-friendly and naturally relatable for users** to gain information through conversations as it represents some qualities of humans. Interaction through conversations reduces barriers of a physical nature or barriers related to the lack of knowledge about exercising options, as through conversations one can co-evolve the intent to exercise options provided by the roles and the autonomous vehicle, as discussed by:

> *"There is more intuitiveness because it's playing the role of a real human and passengers have an idea how to interact with humans." (Session 3 - P5 & P6)*
>
> *"As AI has access to the internet which would allow for wide choices of topics of conversations." (Session 3 - P5 & P6)*

Thirdly, participants discussed that an **understanding of the possibilities and limitations of Conversational AI** would increase the intuitiveness of the interface for the users, as it would enable users to understand the boundaries of Conversational AI. This is important as the inability to respond to commands would not frustrate the users, as derived from by:

> *"Explanation to the users of what are the possibilities that AI can be of help." (Session 2 - P3 & P4)*

Fourthly, participants stated that **AI displaying social etiquette and polite behavior** towards users would increase the intuitiveness of the interface. This would increase user's understanding and comfort levels of how to interact with the AI, as stated by P7 & P8:

> *"The welcoming message while entering the car and signifying its presence is nice, though the message should be personalized and short. Initiating the conversation to make people comfortable (at least initially)." (Session 4 - P7 & P8)*

Lastly, the participants stated that the **communication of task-based topics with AI is easier and more desirable than other free-flowing topics** that could arise in a conversation. This is because task-based conversations serve a functional purpose for the users to achieve whereas longer conversations would depend on the situation and the user's mood at that point in time, for example as stated by P9 & P10:

> *"Communication of task-based aspects is easier with conversational AI than deeper, longer conversations." (Session 5 - P9 & P10)*

6.1.1.5.2 Reasons why the interface is not intuitive

Firstly, participants stated that there may be **difficulties for new users in understanding how to use the interface**, as the purpose of its usage may not be easy to grasp. There may be a requirement for a sensitization period where users get used to interacting with the technology. The difficulty may also be due to language and vocabulary barriers, where the AI doesn't understand the spoken words, accents, or style of speaking. These factors will reduce intuitiveness, as displayed by:

> *"Formulation of the right language for AI may be difficult for people due to which AI should be more flexible than it is now." (Session 3 - P5 & P6)*
>
> *"New people may not understand how they should interact and the conversational AI could prompt. There could be a language or speech barrier." (Session 1 - P1 & P2)*

Secondly, participants felt that without a **visual support system for conversational interfaces** such as screens and cues, the intuitiveness of the interface would be lower. Developing an ecosystem of conversational and visual systems would result in users having an opportunity to glance at the visual interface to take cognition of what the conversational interface is conveying, for example as stated below by P3, P4, P7 & P8:

> *"Feedback such as visual cues and auditory cues are important." (Session 2 - P3 & P4)*

> *"Only having a voice interface, without visuals or other senses may be difficult to communicate with. It should help construct a mental model with a support system like a screen." (Session 4 - P7 & P8)*

Thirdly, the participants felt that a **system of signifiers is important to understand who is or should speak** at that particular instance. They found it to be less intuitive when users and AI start speaking at the same time or conversely when both are silent waiting for each other to speak. Having a good timing of sentences in a conversation will help improve intuitiveness as stated by P3 & P4:

> *"Signifiers are important such as signals for the passengers to speak after the conversational AI has stopped speaking." (Session 2 - P3 & P4)*

Fourthly, the **AI's lack of understanding of interpersonal dynamics** between passengers of the autonomous vehicle and not understanding the context of communication would lead to the system becoming less intuitive. Understanding these factors is important to have rich conversations that are relevant to the passengers traveling in the car, as discussed by P9 & P10:

> *"The AI would not understand interpersonal dynamics and may not be able to give situation or context-specific responses." (Session 5 - P9 & P10)*

6.1.1.6 Speed

Under the parameter of speed, the participants were asked to mention 1 instance each where they would expect a faster response and a slower response over the perceived normal speed from the Conversational AI in the AV. The following are the responses the participants discussed:

6.1.1.6.1 Instances where faster responses are desired from Conversational AI roles

Firstly, the participants thought that **information and task-based conversations** could be conveyed in a faster and more to-the-point manner. This comprises conversations concerning navigation, orders, tasks, and specific points of information that audiences may seek, for example as mentioned below:

> *"When the conversation is objective or specific points of information, the response should be instant one-word answers. If the purpose of the trip is a task-based one or routine planned, then the responses should be faster." (Session 6 - P11 & P12)*

Secondly, participants discussed that it might be necessary for the Conversational AI to **sense the nature of the conversation as well as the purpose of the trip** to decide the pace of conversations. Understanding the mental context and intention behind conversations will necessitate the development of conversational AI in an ecosystemic manner. This is supported by the following statement by P7 & P8:

> *"It should understand the mental context and passenger's emotions, and respond faster accordingly." (Session 4 - P7 & P8)*

Thirdly, participants expressed that the responses from AI should be faster when people are in a **hurry or an emergency situation**. The Conversational AI should have the ability to detect emergencies through voice and change its more to speaking faster, for example as stated by P7 & P8:

> *"It understands the passenger is in a hurry and gives faster responses." (Session 4 - P7 & P8)*

Lastly, participants observed that when there are multiple members in the AV having conversations, the Conversational AI might be **annoying if it gives long responses.** Further, if there is a heated discussion on any particular topic going on, users may prefer shorter and faster interjections from Conversational AI. The pace of conversation should be faster in such cases, as stated by P7 & P8:

> *"When a lot of people are speaking in the vehicle, it should respond faster and shorter." (Session 4 - P7 & P8)*

6.1.1.6.2 Instances where slower responses are desired from Conversational AI roles

Firstly, the participants discussed that **there should be gaps in the conversation** to make the conversational AI look less robotic. Further, they mentioned that sufficient gaps in conversations must be kept for the users to finish completing their statements. These are cases where the AI must speak at a slower rate, for example as stated by P3 & P4:

> *"The Conversational AI should wait for users to finish their conversation." (Session 2 - P3 & P4)*

Secondly, in conversations where users may have to **process the information with higher cognitive functioning**, the conversational AI must speak at a slower rate as per participants. Conversations concerning recommendations, information of a complex nature, information having subjectivity and in general when the cognitive functioning is higher, the conversational AI should be speaking at a slower rate, for example as conveyed by P9 & P10:

> *"When the cognitive functions are higher, the response should be slow and vice versa." (Session 5 - P9 & P10)*

Lastly, participants stated that if users desire **to set a mood of calmness** in the AV, the conversational AI speaks at a slower rate. Activities such as storytelling, giving advice, and in general developing an environment to give a feel of calmness and pleasantness, as stated below by P11 & P12:

> *"If the purpose of the trip is exploratory trips to enjoy the driving experience then the conversations should be slower." (Session 6 - P11 & P12)*

6.1.1.7 Participant's reflection on the idea of Conversational AI roles for Autonomous Vehicles

Under this parameter, the participants were to be asked to reflect upon and justify whether they thought it a good or a bad idea to develop Conversational AI roles for Autonomous vehicles. Participants discussed both aspects, as mentioned below.

6.1.1.7.1 Reasoning for Conversational AI roles being a good idea

Most of the participants believed that the concept of conversational AI roles was good enough to be implemented in fully autonomous vehicles.

P1 & P2 in session 1 discussed that it was a good idea because while one doesn't have to drive, the **roles improve the safety of driving** around in the autonomous vehicle and enhance the user experience by providing an option to not feel lonely.

P3 & P4 in session 2 discussed that the concept would be a good idea if fewer people were traveling in the car with the clause the users should be able to **select the amount of conversations** they desire to have with the conversational AI.

P5 & P6 in Session 3 articulated that **combining the roles as one persona** while emphasizing various areas of expertise when playing the roles without stating it explicitly would be the way to implement this concept. They discussed that the AI should have a general scenario, with specific characters for roles as a choice and free-flowing conversations should lead to seamless transitioning within these roles. Further, the participants also discussed that an important factor in **making the roles believable** would be if they behaved as per their roles and **were genuine to their unique qualities** of being an Artificial Intelligence technology.

P9 & P10 in session 5 were in favor of the idea because the user's tasks would be done in an easier, faster, and efficient manner. They also mentioned that it is nice that there is a **non-judgemental companion** to talk with during the journey, along with the option of switching the conversational AI system off unlike in the case of humans.

P11 & P12 in Session 6 discussed that the idea would be a good one if users don't have to differentiate in roles and there would be one persona with domain knowledge that these roles represent. This persona with roles should also be in a migratable form available across devices. This led to the discussion that the Conversational AI roles should be **developed in an ecosystemic manner** with screens and sensors for a better user experience.

Lastly, P7 & P8 in Session 4 stated that the roles would give a character to the car and a feeling of understanding the car better which would make implementing them a good idea.

6.1.1.7.2 Reasoning for Conversational AI roles being a bad idea

There was a comparatively lesser number of participants who thought that the concept of conversational AI roles was a bad idea.

P7 & P8 in Session 4 thought it would be a bad idea if too many different conversational AI roles and over-branding by the parent company could reduce the feeling of a personalized role being played. The feeling of connection with the roles would be reduced due to the aforementioned factors. There should be a **personalized role that understands the user** to build a deeper connection.

P9 & P10 in Session 5 observed that the roles would be a bad concept to implement if the AI doesn't **understand the difference in addressee of the conversation**, between the AI and the passengers versus between in-vehicle passengers themselves. Further, they will also potentially **reduce human-to-human interactions** which would be unfavorable socially.

6.1.1.8 Desired physical manifestations for conversational AI roles.

Under this criteria, participants were asked about their preferences on what type of physical manifestation would they like the Conversational AI roles to take within Fully Autonomous Vehicles if implemented.

Firstly, a sizable number of participants were in **favor of an ecosystem of visual interfaces such as screens or holograms paired with Conversational AI in AVs to display visuals.** P1 & P2 stated that a screen would be helpful to glance at and better understand what's being said by the conversational AI, along with a face to build relatability with and identity of the AI. Further, P11 & P12 in Session 6 also state that Conversational AI should be connected to a visual interface with an avatar displayed on the screen. P9 & P10, bolster the case for having a visual interface supporting Conversational AI by employing technologies such as screens and holograms that seamlessly appear if required. For example, representative quotations are given below:

> *"Screen paired with the conversational AI to display what's being said. Maybe the Conversational AI should have a face displayed on the screen." (Session 1 - P1 & P2)*

> *"Would be nice to have a visual interface supporting the CAI such as a screen & hologram." (Session 5 - P9 & P10)*

P5 & P6 in Session 3 expressed a slightly different point of view expressing that it might not be necessary to have a face, but **some form of graphics and transcription of words** on the windscreen as a display to represent conversations.

> *"Interface can be on the windscreen, but in only voice format not necessarily having a face." (Session 3 - P5 & P6)*

Secondly, a few participants expressed a desire for **visual, auditory, or haptic cues or effects paired with Conversational AI** over screen-based visualizations. This they believe would still retain the essence of voice interfaces while supporting it for a better user experience, as explained by P7 & P8:

> *"More than the auditory response, lights, haptics, screen-based connection to voice interface would lead to more connection. Visual cues through lights or maybe the whole roof panel with changing light colors would be great. The feeling of its presence through visual cues." (Session 4 - P7 & P8)*

Lastly, participants P5 & P6 in Session 3 mentioned that objects to see and touch in a non-human form paired with Conversational AI in AVs would be an interesting way to interact with Conversational AI.

6.1.2 Forms of embodiment for in-vehicle Conversational AI (Conceptual Sketches)

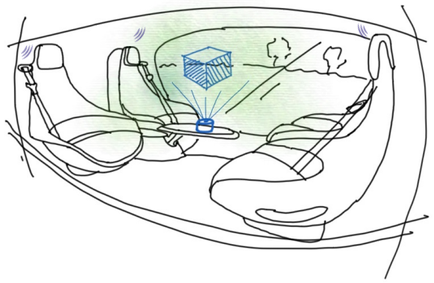


Fig 43: Holographic display paired to Conversational AI

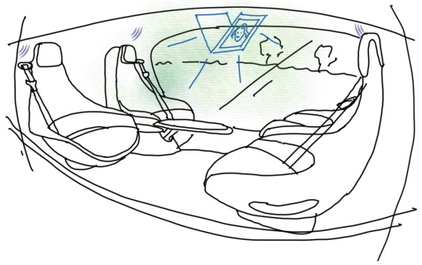


Fig 44: Screen based visuals paired with Conversational AI

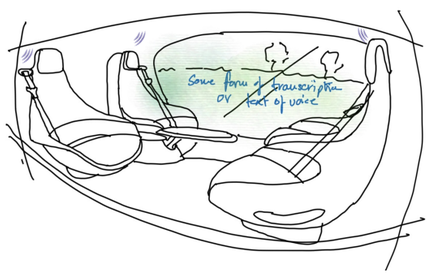


Fig 45: Transcription of AI's conversations

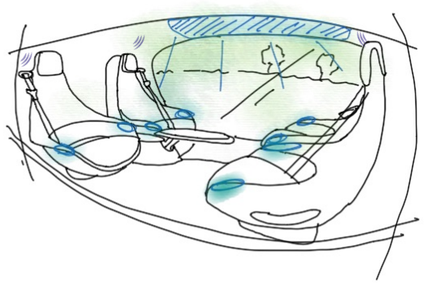


Fig 46: Visual and haptic cues paired with Conversational AI



"You've got to start with the customer experience and work backwards to the technology. You can't start with the technology and try to figure out where can I sell it."

-Steve Jobs
Co-founder & former CEO, Apple Inc.

Chapter 7

Design Guidelines

Recommendations resulting out of our study are presented in the form of design guidelines in this chapter.

In this chapter:

7.1.1 Guidelines for user interface design
7.1.2 Guidelines for design process

7.1 Design Guidelines

In this section, recommendations in the form of design guidelines are provided. These are guidelines to inform the design of Conversational AI interface in Autonomous Vehicles and guidelines to inform the design process.

Evolving out of this research, we articulate recommendations in the form of design guidelines for autonomous mobility and artificial intelligence organizations to aid in the process of designing Conversational AI for Autonomous Vehicles employing a Human-Centered design approach. These encompass the identified roles and relationships that Conversational AI can play towards users of fully autonomous vehicles as well as users' qualitative assessment of the user experience provided by them. The guidelines are discussed under two categories - first, guidance on the interface design of Conversational AI in Autonomous Vehicles, and second, guidance on the process of designing such interfaces.

7.1.1 Guidelines to inform the design of Conversational AI user interface in Autonomous Vehicles

These sets of guidelines are developed to aid designers and engineers in designing Conversational AI interfaces for Autonomous Vehicles. Unlike physical products, designing voice interfaces presents a different set of challenges in designing the qualities of the voice interface. Hence we propose:

(1) Conversational AI interfaces should integrate into an ecosystem of technologies within and beyond Autonomous Vehicles to provide a seamless user experience.

First, though Conversational AI would have the ability to process and respond to spoken dialogue within the vehicle, it would require an extensive technological set-up within vehicles to gather data through varied sensors. This is because human intentions and conversations would have to be understood from an experiential or human psychology perspective, as discussed in section 5.1.10, 6.1.1.2.2 & 6.1.1.1.2. Further, the technology should understand the in-vehicle human dynamics to avoid interruption of conversations or long silent moments.

Secondly, a systems-thinking-based design approach would be necessary for vehicle brands to seamlessly integrate autonomous vehicles into a larger ecosystem of networks accessed by the end user outside of the vehicle, as outlined in section 5.2.2. Conversational AI has the possibility to migrate through devices owned by the end user and provide a seamlessly integrated experience wherein the user has a unique companion across all devices. This would be extremely useful in the shared scenario of vehicle usage when users switch modes of transport between various autonomous vehicles. Designers therefore should take an approach to develop conversational AI to be a component of a larger ecosystem.

(2) The design of in-vehicle Conversational AI should not conceal characteristics that reflect its artificial nature but rather leverage them in implementing the roles to provide an authentic user experience.

Artificial intelligence as a metaphor refers to an artificial version of human intelligence. This may lead designers to outright mimic humans in adopting design characteristics for AI systems. This research discovered that users wanted to experience characteristics of the underlying technology as they valued the genuineness of experience. However, there are instances wherein users are unable to resonate with Conversational AI due to feelings of artificiality. Therefore, the design should be an amalgam of being true to artificial characteristics and unique qualities of the role being played, as outlined in section 6.1.1.1.2, 5.1.10 & 6.1.1.7.

(3) The design of Conversational AI should apply a relationship-based rather than task-based user interaction paradigm, to establish and maintain user perception of its usefulness over time.

For users to continuously interact over time with Conversational AI, their perception of its usefulness and benefits should be continually maintained if not increased over time. Transitioning to user relationships with Conversational AI from its task-based utilization can be achieved through the interface serving as a mediator of the user's desired in-vehicle activities, interactions with features, and topical conversations with roles, as brought forth in section 5.1. Relationship-based AI interactions are useful for users as they provide an opportunity to remain entertained during travel, speak their minds on topics of their choice, and learn from each other. Further, engaging users with relationships based on the aforementioned facets could facilitate the formation of a bond between users and the vehicle. Therefore, designing Conversational AI as an enabling medium would keep the users entertained during journeys reducing feelings of boredom and loneliness.

(4) Conversational AI roles should be aware of and be able to converse about the vehicle's external environment regardless of the role it's playing.

Participant interaction experiments showed that irrespective of roles being played by the Conversational AI, conversations between passengers and AI tended to be influenced by the nature of the user's trip as noticed in the interaction experiments and in section 5.1.2. Participants had conversations about thoughts that came to their minds about the journey, irrespective of the role being played as highlighted in section& 6.1.1.6.1. These were influenced by the road scene and things they saw outside the vehicle that may not be restricted to the role being played.

An example of such a case was that participants had conversations about the system of traffic lights on the road even though they were interacting with the advisor's role while on a work-related trip. The Conversational AI advisor role had to be adept at having conversations about the vehicle's external environment. This should also be extended to every role.

(5) The design of the Conversational AI should communicate to users the limits of its capabilities to avoid unsuccessful user interactions.

It was distressing to participants when they attempted to have conversations on a topic and did not get relevant responses. to be unfamiliar with Conversational AI's spectrum of possibilities as opposed to those that humans may think of or invent, as discussed in section 6.1.1.5.1. There are instances when participants expect the Conversational AI to accomplish a particular command, but it is unable to do so as the technology isn't built to act on that command. This could arise due to being trained on a limited data set or a data set that's not holistic enough as mentioned in section 6.1.1.3.2. Therefore, indicating such limitations would increase the intuitiveness of the interface and reduce cognitive load arising out of dissatisfaction with the unaccomplishment of commands.

(6) A system of reassuring users regarding ethical usage of their data should be developed, as part of Conversational AI's recurring maintenance and update procedure to nurture customer-organization relationships.

As discussed in previous sections, participants were concerned with the misuse of their data gathered while interacting with in-vehicle Conversational AI. While ethical guardrails would be put into place, participants expressed their need for mental reassurance from the voice interface about the ethical usage of their data. As sensing good intentions behind the usage of their data is important for users, it would be necessary to design Conversational AI to convey its ethical as outlined in 5.1.10 and 5.1.3. This exercise of conveying ethical usage should be assimilated into the design process as maintaining ethical standards is a continuous procedure.

(7) Conversational AI should be judiciously implemented in order not to annoy or overwhelm the passengers of Autonomous Vehicles.

Due to the user-friendliness of speech interfaces in vehicles, there may be a tendency to overuse Conversational AI for many of the functions and features that are offered to users as mentioned in section 6.1.1.3.2. However, this over-dependence of users on Conversational AI technology is annoying and cognitively burdensome, especially in cases where simpler alternatives exist as discussed in section 6.1.1.4.2. Therefore, limit the usage of Conversational AI to situations and applications where it would be the most effective or appropriate interface. Further, the amount of conversations that users desire to have on a particular day can vary. Due to this, the AI will have to ensure that its verbosity or brevity doesn't disturb the user.

This would necessitate providing users with control options to tailor the Conversational AI experience towards their preferences. Ensuring a balanced usage of in-vehicle Conversational AI would be essential for a positive experience.

7.1.2 Guidelines to inform the design process

These guidelines are developed to aid the design process adopted by designers and engineers within organizations. Designing voice interfaces is a continuous process that continues after deployment as well. Therefore, an evolved form of the design process will have to be adopted within organizations for which we propose:

(1) Autonomous Mobility and AI companies should imbibe user-centric thinking into their design process to increase designer attentiveness to providing a personalized user experience.

Participants desired a personalized experience from the vehicle's Conversational AI. To provide this, the design process should incorporate empathizing with users to understand their preferences and intents better. This will help ensure that user preferences are prioritized over those of the AI system as discussed in section 5.2.3. Further, the designers in this case will have to be mindful of differing local idioms, usage of civil vocabulary, and natural manner of conversations to be sensitive to users' conversational style, as documented in section 6.1.1.5.1 & 6.1.1.5.2. To cater to differing preferences of user segments, flexibility and adaptability will have to be built into the interface. Therefore, adopting a user-centric design process that allows designers to step into the user's shoes would be necessary for designing Conversational AI for Autonomous Vehicles.

(2) Develop an organization-passenger feedback loop to detect and ameliorate undesirable effects of Conversational AI towards passengers in Autonomous Vehicles.

Designing Conversational AI will be an iterative process where continuous improvement will have to be made based on user feedback. A component of developing a bond between companies and customers would be to ameliorate untoward behavior of the Conversational AI interface, as outlined in section 5.2.3. These behaviors could result from incorrect detection of the user's intent and a limited dataset with a narrow conversational spectrum of the user's interest. Further imperfections in factors such as a suitable tone of voice, length of responses, and quantity of information conveyed by the Conversational AI could cause undesirable effects, as stated in section 6.1.1.4.2 . As observed during the interaction experiments, it may be difficult to preempt these during initial deployment and therefore requires organizations to develop a design process to iteratively update the Conversational AI.

Chapter 8

Toolkit Ideation

Ideation for design strategy toolkit to involve users in the design process of Conversational AI for Autonomous Vehicles by companies is presented in this chapter.

In this chapter:

8.1 Toolkit design and usage protocol

8.1
Toolkit design and usage protocol

This research could also lead to development of design strategy toolkits for involving users in the design process of Conversational AI for Autonomous Vehicles by companies. One such idea is presented in this section.

8.1.1 Why this toolkit?

Designing Conversational AI in Autonomous Vehicles will require organizations to follow participatory design methods for involving users. Our research has shown that users would love to interact with Conversational AI personas which can play various roles in their lives. Further, user retention would be achieved by organizations if the formation of user relationships with in-vehicle Conversational AI is facilitated through design. These relationships would be enabled if the Conversational AI serves as a host or a mediator of the user's desired in-vehicle activities, interactions with vehicle features, and user-desired content of conversations. Therefore, involving users in the design process and understanding their desired roles and aspects of relationships is crucial in formulating a design strategy for in-vehicle Conversational AI.

This toolkit enables design strategy professionals to facilitate user participation in the design process of Conversational AI for Autonomous Vehicles.

8.1.2 Practical guidelines

This toolkit should be used in a workshop setting of a duration of 4 to 5 hours including a break. If the workshop is in a remote setting, this toolkit can be provided with digital tools such as a Miro board. If in person, a printed version can be supplied to the participants.

The workshop should be conducted by a host who will serve as a facilitator. Teams of 2 to 4 people should be formed who can work through the canvases to generate ideas for in-vehicle Conversational AI Design.

The participants must be made familiar with the toolkit which has two components. The first is the ideation canvas which will guide the participants to come up with ideas. The second component is the set of statement cards specific to each canvas which have the purpose of aiding the participants in the ideation process. The participants have to fill in each canvas for which they can make use of the statement cards.

The facilitator should remain neutral and should not let personal ideas influence participants. The facilitator should ensure that the step-by-step process is followed by the participants. Any questions the teams may have should be clarified without giving any hint of the solution per se.

8.1.3 Step-by-Step Process

Designing Conversational AI in Autonomous Vehicles will require organizations to follow participatory design methods for involving users. Our research has shown that users would love to interact with Conversational AI personas which can play various roles in their lives. Further, user retention would be achieved by organizations if the formation of user relationships with in-vehicle Conversational AI is facilitated through design. These relationships would be enabled if the Conversational AI serves as a host or a mediator of the user's desired in-vehicle activities, interactions with vehicle features, and user-desired content of conversations. Therefore, involving users in the design process and understanding their desired roles and aspects of relationships is crucial in formulating a design strategy for in-vehicle Conversational AI.

This toolkit enables design strategy professionals to facilitate user participation in the design process of Conversational AI for Autonomous Vehicles.

8.1.3.1 Before the workshop: Simulation of traveling in Autonomous Vehicles

Give the users a simulated experience of traveling in a fully autonomous vehicle. This can simply be done by playing a looped video of a road scene or showing a sketch of a vehicle interior. Simulating such an experience will help participants envision the experience of traveling in an Autonomous Vehicle which in turn will enable them to suggest relevant designs for conversational AI roles and relationships. Further, the participants should be familiarized with how the statement cards might be used while filling in the canvas.

8.1.3.2 Workshop exercise 1: Persona and Roles Canvas
(45 minutes)

Participants should sketch out a persona of their choice and list out desired characteristics the person should have. This will be a general character the conversational AI would assume when interacting with the user. Designers can then design into the Conversational AI various options of persona that users can select through conversations while traveling in the AV along with a default option.

Next, the participants should map out various purposes of journeys for which they would travel in an autonomous car. Mapping these will contextualize the roles and relationships that participants will come up with in the subsequent steps.

The subsequent step for the participants in this exercise is to decide roles they would desire conversational AI to play towards them. These roles would be an interface between the users and the in-vehicle Conversational AI to enable user interaction within the scope of their interest. Participants should arrange these in descending order of importance. This will aid designers in developing narrow AI technology to function well during these forms of journeys.

8.1.3.3 Workshop exercise 2: Preferred content of conversations canvas
(45 minutes)

In this exercise, the participants should map out content categories of conversations that they would enjoy having with the Conversational AI roles. They should also indicate their desired tone of voice from the in-vehicle Conversational AI by marking a point in the given visual scale under each parameter.

8.1.3.4 Workshop exercise 3: In-vehicle user activities canvas
(45 minutes)

For this exercise, first, the participants should map out various activities they would love to do in the car. Next, they should classify these activities into those in which they would like the conversational AI to mediate or be a co-participant in keeping passengers entertained.

8.1.3.5 Workshop exercise 4: In-vehicle user interactions
(45 minutes)

Participants should map out various forms of user interactions they would prefer to have with their Autonomous Vehicle. These can be in the form of interaction with features of the vehicle, modifications to in-vehicle environment, exercising choice of options, and exercising shared control of autonomous vehicles behavior.

8.1.3.6 Workshop exercise 5: Embodiment and creation of mind map canvas
(45 minutes)

Participants at this stage should think about what form of an embodiment or physical manifestation of these personas would they prefer. Thinking of embodiment is important as it makes the Human-Conversational AI interface more tangible to users. After this, participants should now integrate everything they have produced on this canvas in the form of a map mind. Start by choosing and placing the persona in the center. Next, map out various roles that the persona should play. Further, map out the content of conversations, in-vehicle user activities, and in-vehicle user interactions in that order. This will generate a comprehensive ideation chart that designers and engineers can refer to while building Conversational AI for Autonomous Vehicles.

8.1.3.7 Workshop exercise 6: Presentation!
(Time will depend on the number of teams present)

The final stage of the workshop would be to present the mind map participants came up with (exercise 6). Each team should present their work to the rest of the teams. Such a presentation will facilitate the sharing of ideas and create a conducive environment for inter-team debate of ideas. The ideas discussed during such sessions will broaden the designer's understanding of the subject.

8.1.4 Toolkit design



Fig 47: Example of statement cards for the tool kit (Print)

8.1.4.1 Design of cards



Fig 48: Example of a card set theme cover

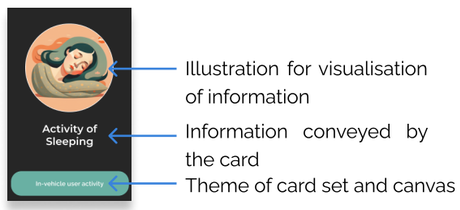


Fig 49: Example of a card's front face

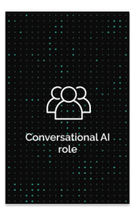


Fig 50: Example of a back cover

8.1.4.2 Set of cards for various themes (Full set available in appendix)

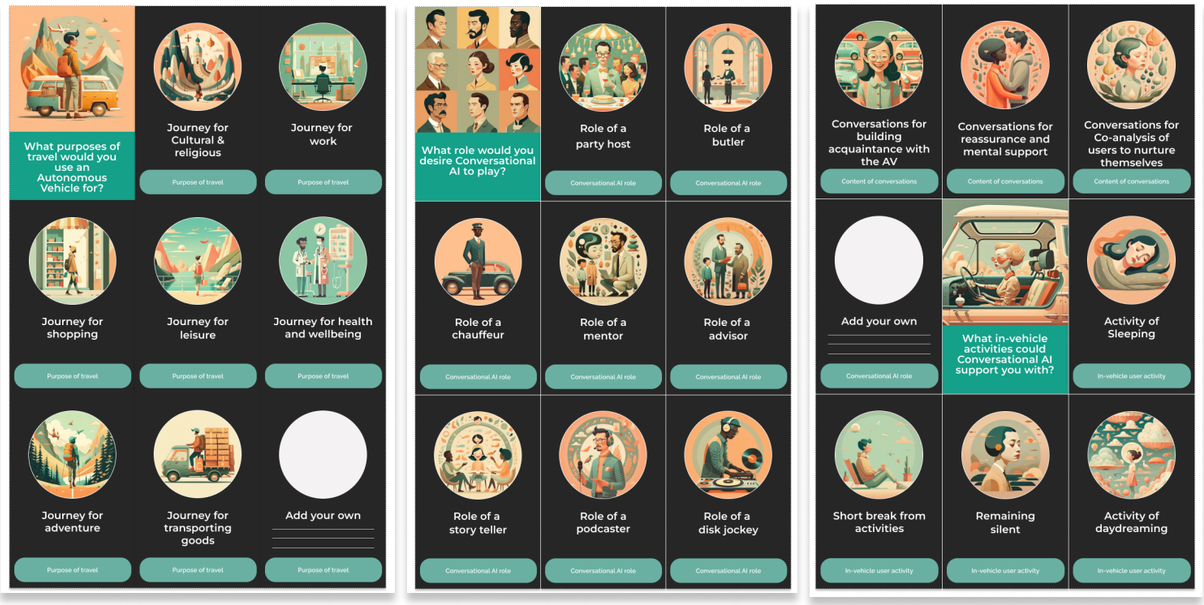
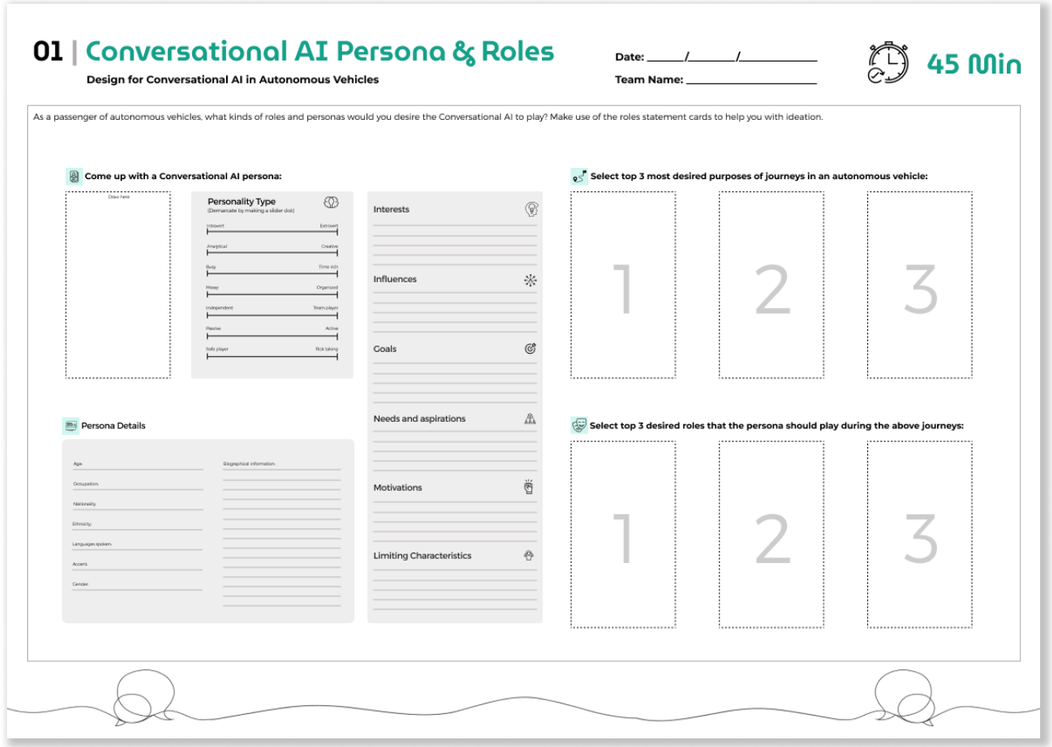
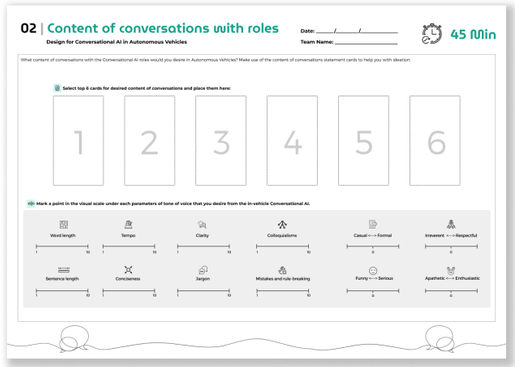


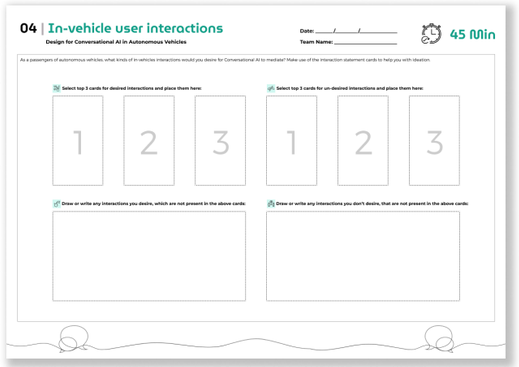


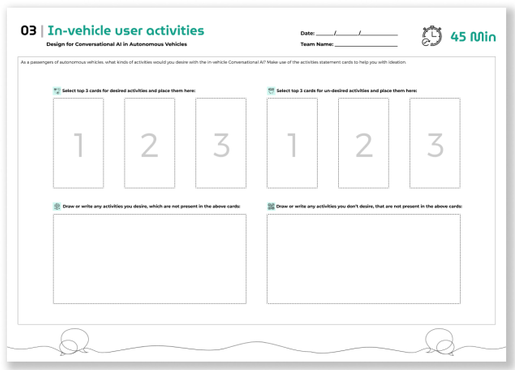
Fig 51: Set of cards as part of the toolkit

8.1.4.3 Set of canvases paired with cards for conducting the workshop









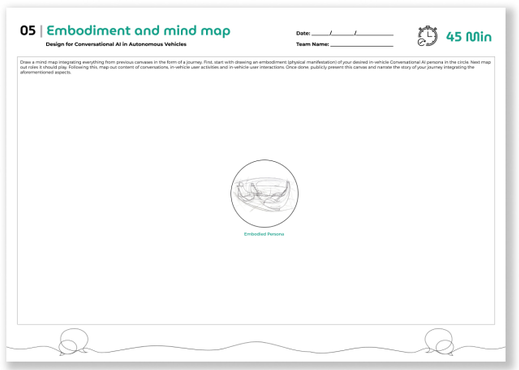


Fig 52: Set of canvases for workshop sessions as part of the toolkit

Chapter 9

Project Conclusion

This final chapter consists of a discussion of our methodological approach as well as implications for professional practice and sheds light on the limitations of this research with directions for future work. Lastly, it concludes with a deliberation on the strategic implications of this project and personal reflection on my graduation journey.

In this chapter:

9.1 Discussion
9.2 Limitations and future work
9.3 Conclusion
9.4 Strategic implications of this project
9.5 Personal Reflection

9.1 Discussion

In this section, an analysis of our methodological approach and implications for professional practice are discussed through correlation with related literature.

9.1.1 Reflections on our methodological approach

To research this interdisciplinary topic encompassing Conversational AI, Autonomous Vehicles, and Design Strategy, we had to adapt existing methods into a new form and employ them in combination with each other. In the first phase, employing the Contextmapping technique of providing a 5-day sensitizing booklet developed based on the path of expression line of inquiry (Sanders & Stappers, 2012) proved effective in establishing roles and relationships that Conversational AI can play towards users of Fully Autonomous Vehicles. As interviewed users had the time to ponder upon their activities, needs, behaviors, values, and memories journeying through the past, the present, and the future desired experiences, the semi-structured interviews conducted based on this exercise led to deriving tacit and latent knowledge insights. Further, semi-structured interviews conducted with experts presented an interesting and insider view of these disciplines, through which an understanding of how design guidelines are employed in their work, what barriers to innovation they face, and strategic opportunities that exist were extracted. As qualitative interview approaches involve understanding cultured, every day, and situated aspects of human thinking, learning, knowing, acting, and ways of understanding humans as living beings (Brinkmann & Kvale,2014), this method proved fruitful in extracting human experiences by facilitating the participants to reflect, explain and share upon their experiences.

In the second phase, we tried to understand if these roles are implemented in real-world scenarios to enable relationships, and how users qualitatively assess the embodied user experience. This was important to examine to compare and contrast what users verbalize they would desire versus what they would desire experientially, a sense of which would be important for designers. We employed a combination of Wizard of Oz plus enactment methods to conduct the interaction experiments and a guided brainstorming method for discussing participants' review of the idea using the SASSI questionnaire parameters.

This methodological combination proved effective in giving people an idea of the imagined concept and sparked their imagination despite employing a low-tech medium fidelity technical set-up that enabled participants to brainstorm about their expected experiences from this concept. The enactment helped to bring both context and system-human relations to the design research activity (Strömberg et al., 2020) whereas the Wizard-of-Oz method had the advantage of allowing for in-situ observation of user behavior and interaction in a natural environment (Rothenbücher et al., 2016). This approach facilitated the shifting of the participants' mindset to relate to different scenarios they would travel for in the Autonomous Vehicle while making use of Conversational AI, which could serve as a quick prototyping and testing method for designing Conversational AI for Autonomous Vehicles. As expected, the use of statement cards resulting from the first phase of research supported participants to continue with conversations during the experiment. The participants while having free-flowing conversations were found mixing topics present in the cards. The guided brainstorming allowed for collaboratively reflecting on the interaction experience and verbalizing desired future experiences, wherein the guide could streamline the discussion and put varied thoughts into articulate sentences.

There were some shortcomings noticed while employing this method. The absence of a moving vehicle and employing a simulated environment though effective in giving a taste of the future envisioned experience, lacked the provision of situational on-road experiences which would have effects of distractions, movements, dangers, and interactions with various external mobility systems. Further, the mock setup of Conversational AI had delays between users speaking and the system responding. These delays may have affected user's perception of how Conversational AI would function in the future, in turn affecting their judgment and discussion during the brainstorming session about flaws of the system and their desired experiences. However, this method makes it possible to validate the findings of our results by using an on-road vehicle with fully function Conversational AI to gather further insights.

9.1.2 Implications for professional practice

Autonomous technology and Conversational AI present new challenges as well as opportunities for organizations to design them in a Human-Centered manner. Designers who develop novel technologies may face the challenge of mapping their invention onto a very large search space of potential problems (J. W. Lee et al., 2020). They may also lack insights to envision future use cases with these novel technologies from a human experience perspective. Through this research, we (1) Identify user desired Conversational AI roles and relations in Autonomous Vehicles and (2) Explore desired user experiences from the developed roles and relationships when implemented in a real-world scenario. Based on the results, we derive guidelines to inform design innovation strategies within AI and mobility organizations.

Customer retention is of great importance as the market environment reshapes due to the introduction of novel technologies such as AI and Autonomous Vehicles (Rosenberg & Czepiel, 1984). To facilitate customer retention, this research points out the roles that users would naturally desire to have conversations with based on their needs, activities, and behaviors. Further, this research implies that user retention could naturally take place through the development of relationships with these roles, which would be based on (1) the content of conversations, (2) information about the journey, (3) in-vehicle user interactions, (4) in-vehicle user activities, and (5) aspects of shared control of the autonomous vehicle engendered through this research. Furthermore, through exploring user interaction with the embodied experience, the research provides insights by contrasting and comparing the roles and relationships derived from qualitative interviews to the user's interaction experience with 3 Wizard of Oz exemplar roles. Therefore, designers and engineers working in this discipline are provided with a theoretical framework and a point of reference to design positive user experiences for continued user engagement with the conceptualized technology.

Designing Conversational AI for Autonomous Vehicles will require an understanding of new forms and new meanings of existing fundamental human needs (Desmet & Fokkinga, 2020). To ensure that these are met in the design of future autonomous experiences, fostering creative idea generation-based design processes will be required (Gomez-Beldarrain et al., 2023). This research provides creative insights for further development of Conversational AI in Autonomous Vehicle technology by considering fundamental human needs.

Further, Arzberger et al. (2022) identify AI roles to facilitate Designer-AI collaboration and classify these as per their function in the designer's design process. They highlight that AI's function in the design process can be to inspire, mediate, and critique. Identifying such functions can aid in developing narrow AI applications specific to user's requirements. Learning from this, designers can identify such functions for roles presented in this research for Human-autonomous vehicle collaboration.

Furthermore, as the level of complexity of user interfaces affects in-vehicle user experiences (Currano et al., 2021), designing Conversational AI interfaces in Autonomous Vehicles would require deciding upon a suitable level of complexity of interaction with the voice interface. On the contrary, due to the effect of novelty, users might adhere to existing interaction patterns (Rothenbücher et al., 2016) avoiding the use of the conversational AI interface. These design decisions would have to be made through iterative user testing of prototypes employing co-design and participatory design methods as part of the design process with organizations and companies.

For future professional practice, the generated knowledge in this research could serve as a suggestion for developing new products/services. These are targeted towards presenting (1) use cases of Conversational AI roles and relationships in Autonomous Vehicles, and (2) how these roles played out during interaction with users to gauge negative and positive qualitative of the experience. It could also guide in conducting iterative user testing to validate the developed concept. Further, recommendations are provided in the form of design guidelines for practitioners who aspire to commercialize the technology to make informed design decisions. Accordingly, this research provides a direction for the ideation, conceptualization, and implementation of Conversational AI roles and relationships in Autonomous Vehicles.

9.2
Limitations and future work

Limitations and their aspects that have a potential for being explored in future work are discussed.

This research has limitations that are brought forth here which however could be interesting future avenues for research.

Firstly, users' behavior, activities, and needs with the Conversational AI in Autonomous Vehicles, might differ based on in-vehicle occupants and fellow travelers. This research hasn't tested the effect of individual versus shared in-vehicle occupancy on user interaction with Conversational AI. Secondly, the scenarios of vehicle ownership versus vehicle as shared public transport could have an effect on user interaction with its Conversational AI. Thirdly, as this study was conducted in a simulated environment, it wasn't able to account for the effects of on-road conditions such as distractions, changing visuals, motion so on and so forth on in-vehicle passengers and their experience.

Fourthly, conversations being part of a cultural phenomenon could have effects on technology interaction and usage patterns. This study hasn't been able to test the effect of different language cultures as well as road cultures of user interaction with Conversational AI in AVs. Fifth, this study was specifically focused on users from Generation Z who like talking and how other user segments would interact with the system would need to be studied. Relatedly, the study, having been conducted in a university location, had participants who may have a higher level of awareness about Autonomous and Artificial Intelligence technologies. Expanding the user base to participants from outside the university would address this limitation.

Sixth, this study didn't access all stakeholders and experts who would potentially have a say in the development of such technologies, such as those involved in legal, data management, security, and other related professions. Seventh, the study didn't test whether conversational AI could be effective in providing an interface for shared control of autonomous vehicles, which participants mentioned would be desirable. Validating the desire for shared control and the effectiveness of conversational AI to serve as a medium to do so could be taken up by future work. Eight, future work could also study how partnering organizations can co-brand Conversational AI in Autonomous Vehicles. Lastly, this study raises some deeper philosophical questions that can be tested by future work such as what leads people to have deeper conversations with fellow human beings over artificial intelligence in autonomous vehicles. These limitations present interesting avenues for future research wherein studies could translate these limitations into research questions.

9.3
Project Conclusion

Concluding thoughts summarising the research are shared.

In this research, the intent was to discover innovation opportunities for designing Conversational AI for users of Autonomous Vehicles.

We did so by first establishing Conversational AI roles and relationships desired by users through qualitative interviews based on context mapping techniques and applying thematic analysis to analyze them. We then undertook an exploration of how users would experience and assess the concept of roles and relationships when embodied in Autonomous Vehicles in a real-world scenario by conducting interaction experiments and employing a mock Conversational AI setup in a simulated Autonomous Vehicle environment.

This generated a list of roles and aspects of relationships with the in-vehicle AI that design and engineering organizations can access to further develop and implement in the products and services they offer. The top 3 conversational AI roles that emerged were AI Advisor (Mentor), AI Tour guide & AI Storyteller. Further, aspects that will enable Conversational AI mediated Human-AV relationships are user desired content of conversations, in-vehicle user activities, in-vehicle user interactions & some forms of shared control.

Further, qualitative assessment of the user experience presented in the paper can give a sense of direction to organizations when designing product/ service embodiments of Conversational AI in Autonomous Vehicles. This was based on the parameters of (1) Likeability, (2) System Response Accuracy, (3) Cognitive Demand, (4) Annoyance, (5) Intuitiveness, (6) Speed, (7) Embodiment & (8) quality of idea. This assessment can enable organizations to think from a human-centered perspective by understanding the positive and negative qualities of the embodiment of roles and relationships while allowing organizations to design such systems for a positive user experience.

Based on our exploration, this research concludes with articulating design guidelines to inform professionals in designing user experiences for Conversational AI interfaces in Autonomous Vehicles. Lastly, we hope that this research will inspire other interesting design research explorations building on top of the knowledge generated in this work.

9.4
Strategic implication of this project

This section elaborates on the strategic implications of this project by correlating it with strategic design discipline-related academic literature.

This project from its inception was conceived as one that would be pursued as a combination of strategic design and interaction design disciplines. However, being a part of the Strategic Product Design master track at TU Delft's Industrial Design Engineering Faculty, I would like to reflect on how this thesis contributes to the professional field of Strategic Design and its alignment with the degree being granted.

Calabretta and Gemser (2017b) define Strategic design as a professional field in which designers use their design practices to co-determine strategy formulation and implementation toward innovative outcomes that benefit people and organizations alike. The aim that this thesis worked on was to formulate design guidelines to inform internal design strategies of autonomous mobility and artificial intelligence organizations looking to innovate with Conversational AI in Autonomous Vehicles. The contents of this research with its user experience exploration would present designers with a component of knowledge required to co-determine design strategy formulation and strategy implementation during the process of exploring the integration of Conversational AI in Autonomous Vehicles.

Further, Calabretta and Gemser (2017b) present a three-step model to approach strategic design projects which are (1) preparing the ground, (2) co-creating the outcome and (3) embedding the outcome. This project follows the three steps by first framing the problem and understanding stakeholders' perspectives. This is done through a first literature review and second, qualitative user and expert interviews to elucidate insights through thematic analysis. This process brings forth a vision for Conversational AI in Autonomous Vehicles by establishing roles and relationships that users would desire from it. Upon preparing the ground by establishing an opportunity for innovation, this thesis proceeds to co-create the outcome by involving users as stakeholders. It further employs a mock set-up of the proposed concept as a tool to study user interaction and evaluate the user experience of the aforementioned concept. This use of the envisioned concept's prototype and methodologically structured involvement of stakeholders allowed this research to evaluate directions for the future based on users experiencing the concept through interaction with it and discussing the preferred manner of implementation. Lastly, though implementation was not in the scope of this project, efforts were made to recommend possible embedments by developing design guidelines and a design toolkit. The design guidelines would provide supporting knowledge to design engineering professionals on how to proceed with its implementation.

The design toolkit idea would act as an interface between organizations and their customers by involving potential users of the envisioned technological intervention by designers and thereby functioning as a strategic decision-making toolkit.

Furthermore, Kim et al. (2022) report that in a radically changing landscape which in this case could be applied to an innovation landscape, research was an absolute requirement for organizations to find their way. Accordingly, the research methodologies employed in this research and our learnings from making use of them could provide future research studies with an understanding of how user experience studies with intelligent and autonomous technologies could be undertaken to generate actionable results. These reflections could aid organizations conducting research not just to access our results but also to illuminate a method of researching a similar landscape in a more customized manner to the organization's direction of interest. This aspect adds an additional strategic layer to the contributions of this project.

In conclusion, through human-centered exploration of innovation opportunities for a futuristic technological concept, this research sheds light on directions for innovation that organizations can pursue, backed by a rigorous research methodological approach. The generation of knowledge through this research itself would provide professionals within organizations with a strategic foothold in making informed design decisions. Hence, this thesis endeavors to contribute to the professional field of Strategic Design as per the aforementioned points of discussion.

9.5
Personal Reflection

To conclude this project, my self-analysis on the graduation project journey and initially defined personal development goals are shared in this section.

9.5.1 Background of the graduation project

"Reflective practice is a dialogue of thinking and doing through which one becomes more skillful." - Donald Schon

As I reflect on my graduation project journey at TU Delft's Faculty of Industrial Design Engineering, I realize that it is an amazing opportunity to integrate everything one has learned over the previous 3 semesters and formulate a project that enables you to deepen your knowledge in a specific domain of design. Throughout my master's education within the track of Strategic Product Design, there were a couple of domains I got fascinated with that I wanted to further explore through my graduation project. Firstly, right from my first semester here, I became very interested in design research which inspired me to pursue a research-oriented graduation project. Secondly, I was captivated by the potential of the Industrial Design Engineering discipline to contribute towards developing technologies of Artificial Intelligence and Autonomous Mobility in a Human-Centered manner. I wanted to explore this possibility further through my graduation project to understand how I can create value and innovate with such technologies. Lastly, I developed a keen interest in design innovation sub-discipline to guide the creation of innovative products. Therefore, through my graduation project, I wanted to knit all my interests together and pursue an interdisciplinary research project.

9.5.2 Reflection on the Graduation Journey

9.5.2.1 Formulating the project

This master thesis project was formulated in a unique manner, unlike any project I had done before, as this project was pursued as a collaboration between two separate universities located in two different geographical locations. At the outset, I wanted a committee with expert researchers working in Artificial Intelligence, Autonomous Vehicles, and Design Strategy discipline to guide me with this project. Therefore, I first began by contacting professors from the university that I wanted to study under. One of the professors was initiating a research collaboration between TU Delft and Stanford University. After having attended the first research round table between researchers from the two universities, I was fascinated with the research group from Stanford working on Human-AV interaction design research. I worked with my professor to take the research collaboration ahead and began developing a research proposal that would align the research interests of all the committee members and me. This experience of contacting 4 individual researchers and bringing about a consensus to take this project ahead was a difficult one.

It required proactive communication, understanding individual research interests, and finding a common research interest. This experience has made me confident in forming and maintaining collaborations.

9.5.2.2 Working on the project

Through this project, I challenged myself to undertake a journey down an unknown path. Though I had taken a few courses on Artificial Intelligence, I was still unsure in a practical sense of how designers could make a meaningful contribution to its development. Secondly, the field of Autonomous Mobility was very new to me and I had no experience working in it. I challenged myself to have the ability to quickly learn new domains of knowledge outside my comfort zone and decide upon a direction in which to pursue the project ahead. Further, my love for reading helped me to read a fair amount of literature and gain an understanding of the topic in a short while. This process has inspired me to be bold and daring to explore topics that lie outside of my knowledge domain.

My confidence and skills in undertaking research studies involving people have also improved. This process gave me an idea of how to advertise and recruit participants. Further, developing the patience to allow for participants to respond and factor in their schedules is an important mindset I could develop. Before the project, I was apprehensive about reaching out to experts and participants. The fear of 'not knowing as much' always has held me behind in reaching out to have conversations with expert practitioners. As a result of this project, I gained confidence and learned the method of reaching out to people to have informed conversations.

Further, as this project required coordinating between 4 mentors, this came with a new set of challenges. Firstly, this project required coordination with mentors across different time zones and geographical regions. This required my mentors as well as me to be very flexible with timings and empathetic with each other's situation. Secondly, as my mentors coordinated 3 different groups, they brought in 3 different perspectives, which was the foundation of the project and very valuable to the aim of the research. However, considering everyone's opinions and assimilating the knowledge they contributed required me to have a high level of receptivity and broadmindedness. An important aspect for me was balancing everyone's opinions and ideas on the project in the process of moving ahead. This was a constant worry during the project for me to avoid being skewed towards one perspective to make everyone feel inclusive by incorporating a piece of everyone's advice. This required a lot of mental flexibility and maturity in considering everyone's ideas to decide on the acceptable path to adopt.

I am also thankful to my mentors for understanding this complexity and being understanding and flexible themselves.

9.5.2.3 Looking back on the project

As I look back on the project towards the end, I ask myself - *'If I had to undertake this project once more, how would I have done it differently?'*

I certainly feel having the skills for computer programming would have allowed me to develop quick prototypes of artificial Intelligence user interfaces. Using this skill, I probably would have been able to develop a tangible prototype of conversational AI roles discovered during my first phase of research. I would then involve participants to evaluate this prototype through quantitative methods.

Further, I had originally intended to strengthen my quantitative as well as qualitative analysis skills. However, as the project evolved in a way that required only qualitative study, this original intention remained unfulfilled. I would have perhaps articulated the research questions in such a manner that would require the second phase to gather quantitative data. In doing so, I would have honed both methods of analysis.

Lastly, I certainly missed having access to an Autonomous Vehicle while conducting the interaction experiments. Having an autonomous vehicle would have given a higher fidelity of experience to participants and the insights would have been rooted in a moving vehicle context. However, arranging a vehicle required financial resources that I didn't have access to. Perhaps involving another stakeholder in the form of a mobility company would have made this possible. However, getting everyone on board would have delayed the project timeline by a substantial amount.

9.5.3 Reflection on personal ambitions

9.5.3.1 Strengthen my process of undertaking academic research

Through this project, I was fortunate to have the opportunity to work with top researchers in their fields. Their coaching combined with my passion for research led to a very fulfilling journey of research. It allowed me to dive much deeper into the research process than I have ever dived before. This project has given me the training to conduct qualitative interviews with users and experts. Further, it has trained me to set up and conduct user-technology interaction experiments while working with participants. During this research, communicating and recruiting participants was another process I got trained in. Separately, I had to work on forging a path of research that would combine knowledge in interaction design and strategic design to balance out the demands of the project as well as the aim of my master track. For this, I had to quickly learn domains outside of what was known to me, including research methods to gather relevant data for the project. One aspect that I felt I missed out on was working on strengthening my quantitative analysis as mentioned earlier, due to the project's demands for analyzing qualitative data. Overall, undertaking this research has given me the confidence to undertake other such projects.

9.5.3.2 Improve my interviewing and facilitating skills

Through this project, I wanted to get adept at interviewing and facilitating skills. While conducting interviews, I realized I people enjoyed having conversations about their experiences if you ask the right questions. Not only does asking people the right questions matter, but having the skills to listen and follow up to dig deeper matters as well. As a designer, I was trained to develop ideas evolving originally out of the designer's brain. This process brought me the humility to respect public opinion and bring in people's ideas into the design process. It also brought in the patience to listen to different points of view over pushing my own. Further, these processes required me to do a lot of prior research and develop materials to facilitate a period of reflection by the participants. I learned that interviews lead to much more data when sensitizing materials to enable participant reflection are provided rather than those where people haven't had a chance to pre-think experiences. Further, the project also gave me an opportunity to undertake a guided brainstorming session. The difficulty in such a session after a user interaction experiment is that people love to discuss a lot and very much in depth. This made trying to accomplish such a brainstorming session within the given time very hard. Therefore, an important skill I learned here was not just to formulate the right questions backed by research, but to politely guide the participants to accomplish such a discussion within the given time.

9.5.3.3 Developing an innovation mindset

Though innovation has multiple components to its process, this project allowed me to strengthen two specific parts of the innovation process. These were to conduct thorough research and provide directions for future technological development. I learned though one may have great ideas, innovation happens when people desire and use the product. Though it is difficult to predict usage patterns before product launch, one may get some sense of it if studies are conducted involving users. User behaviors, activities, needs, and values are important to be studied for understanding how to design products that would be adopted. Therefore, having conducted this research, I am confident in undertaking user studies and providing a design direction which is an important component of the innovation process.

9.5.3.4 Time management

I think from my side, I was sufficiently able to manage time along various components of the project. However, when it comes to working with participants, it may take a while to get responses from people. It is always necessary to maintain flexibility in your schedule to factor in people's response times and schedules. I have learned that time management is a process of planning out the macro level of the project well while maintaining a high level of flexibility at the micro level. Further, having a deadline-based approach for every stage helped me come to a resolution of choices very well. Hence, despite having quite a heavy workload, I was able to finish the project within the given time.

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Appendices

All appendices are provided separately to the supervisory committee. In case of a requirement to view them, contact me personally via email at akshayasrege@gmail.com.



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