



# The Role of In-Car AI Assistants in Elevating User Experience and Simplifying the Shift to Autonomous Driving

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### **The Role of In-Car AI Assistants in Elevating User Experience and Simplifying the Shift to Autonomous Driving.**

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#### **Abstract**

In-car AI assistants emerged in the middle of the 2000s and quickly became an essential part of almost every modern vehicle. Such systems provide many advantages for users, and one of the essential benefits is a gradual shift to autonomous driving. However, in-car AI assistants also come with various problems related to user experience and accountability that affect the overall acceptance of these advanced technologies. In order to evaluate these in-car AI assistants and their future implementation, a decision was made to conduct research on how they elevate the user experience and simplify the shift to autonomous driving.

The triangulation method was used to collect necessary primary and secondary, as well as both qualitative and quantitative data. A total of 81 respondents participated in the survey, and three experts in the in-car AI assistants and automotive driving technologies were interviewed.

The results from the performed research allowed to review and evaluate the current situation of in-car AI assistants in relation to users. It was revealed that the key factors in elevating the user experience are customization and personalization, along with transparency, easy and intuitive interactions with in-car AI assistants, and overall safety of driving with such systems. Privacy and accountability of in-car AI assistants are the main concerns that slow down the shift to autonomous driving. Addressing these issues and further research of key components is crucial for achieving full autonomy of driving.

#### **Keywords/tags (subjects)**

Artificial Intelligence, in-car AI assistants, User Experience

#### **Miscellaneous (Confidential information)**

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## List of abbreviations

**ADAS** – Advanced Driver-Assistance System

**AI** – Artificial Intelligence

**AV** – Automotive Vehicle

**HMI** – Human-Machine Interface

**IoT** – Internet of Things

**IVCA** – In-Vehicle Conversational Assistants

**LiDAR** – Light Detection and Ranging

**NLP** – Natural Language Processing

**RQ** – Research Question

**SAE** – Society of Automotive Engineers

**UX** – User Experience

## 1. Introduction

As of 2024, there are approximately 1.4 billion cars in the world, and the global car population continues to grow by about 3% annually. It is needless to say a car has become a crucial part of many people's lives. At the same time, in the modern world, Artificial Intelligence is playing a big part, and more and more often, it can be seen implemented in the automotive industry, especially as in-car AI assistants. Nowadays, in mass-production cars, these assistants are mainly used for entertainment purposes or as additional safety measures. However, these systems and technologies show great promise for future implementations.

Automotive companies that prioritize the exploration and adoption of in-car AI assistants, as well as autonomous vehicles, are more prone to achieve leading positions in this industry, alongside being prepared for the possible massive shift to semi-and-autonomous means of transportation. Despite the evident potential of in-car AI assistants and autonomous vehicles, many companies in the automotive sector struggle with their implementation due to the higher costs of research, production, and maintenance of such cars compared to ones without these technologies. Another issue related to the implementation of Artificial Intelligence in mass-production cars is the reliability and data security of these systems. Linking the capabilities of AI assistants with the expectations and fears of vehicle owners is crucial for the successful unlocking of the full potential of this rapidly developing technology. Hence, a huge need for research is evident. The motivation behind conducting this research was to explore the fast-emerging area of in-car AI assistants, identify the possible barriers to adopting this technology, demonstrate the benefits and challenges, and provide useful insights for further research.

The importance of this topic is further supported by the personal interest of the author. Studying technological business and future foresight has provided many insights about the automotive industry, and combined with a passion for Artificial Intelligence, it inspired the author to research the ways of combining these vast areas, which resulted in this research. that tries to provide a deeper understanding of the opportunities, threats, and overall potential that in-car AI assistants pose in the modern world. The scope of this study is to provide a comprehensive yet focused analysis of the in-car AI assistants, their future possibilities, and threats they might impose in order to

contribute to general improvements in this area by providing helpful insights that could help to utilize the full potential of AI in the automotive sector.

## **1.1 Research objectives and questions**

The main objective of this research is to evaluate the impact of in-car AI assistants on user experience, the way such assistants support the shift to autonomous driving, and identify key problems and concerns that delay that shift.

It is necessary to pose and address specific research questions that will result in a solid conclusion in order to achieve this objective. Therefore, three main research questions (RQ) were created:

**RQ1: How do in-car AI assistants currently affect user trust, comfort, and overall experience in modern vehicles?**

This question aims to obtain answers related to the current implications of in-car AI assistants, and the ways they impact users in terms of trust, comfort, and overall experience, in order to provide a better understanding of the emerging technology.

**RQ2: What key problems and user concerns are affecting the shift to autonomous driving?**

The second question intends to research problems and user concerns about in-car AI assistants more deeply by offering solid conclusions based on the results of the research.

**RQ3: How do in-car AI assistants help users transition to autonomous driving?**

The last question is designed to study possible future implementations of in-car AI assistants as a part of fully self-driving vehicles.

## **1.2 Thesis structure**

This subchapter provides information about the structure of the study. The research consists of five main chapters, a list of references, and a tables section.

The first chapter serves as an introduction to the thesis, describing the phenomenon of in-car Artificial Intelligence assistants within the automotive industry, as well as providing background for this topic, defining the research objectives, questions, and importance, alongside the author's motivation to complete this work.

The second chapter focuses on a critical analysis of the literature chosen and researching the existing materials and articles related to this thesis. This chapter allows one to understand the theoretical part of in-car AI assistants, their history, and existing and future implementations.

The third chapter explains the methods chosen for the research and the ways they were implemented in this study.

Chapter four provides the reader with the results of the conducted research – collected primary data, which include surveys and interviews.

The last chapter is devoted to the results of this study, answering the research questions and specifying the practical limitations and future implications of in-car AI assistants. The structure of this study aims to provide an easy understanding of the chosen topic by following a logical composition of the chapters.

## **2. Literature Review**

"A literature review describes, summarises, evaluates, and clarifies the literature. It gives a theoretical basis for the research and helps you (the researcher) to determine the nature of your own research" (Saunders et al., 2016, p. 73). A thorough analysis of the literature, materials, and academic sources is crucial for successful research due to the variety of factors. First and foremost, it creates a knowledge base for further research and understanding of the chosen topic, alongside possible findings related to the study that might appear throughout the process of examining the literature sources. This literature review is divided into three subchapters that oversee crucial basic concepts of in-car AI assistants. The first subchapter is focused on providing clarity about what in-car AI assistants are and what is their history of development. The second subchapter is

dedicated to autonomous vehicle systems. The third subchapter explains in-car AI assistants integration and its vital and necessary components.

## 2.1 In-car AI assistants overview

Since the beginning of the 21<sup>st</sup> century, the automotive industry has undergone many changes, but one of the most significant ones was the implementation of in-car Artificial Intelligence (AI) assistants in the middle of the 2000s. (Pankaj et al., 2023). Before the invention of AI, the process of driving an automobile, as well as using the available functions inside a car, relied on the driver and passengers, which, in turn, resulted in reduced safety, complex user experience, and challenges related to the development of autonomous cars. The history of in-car AI assistants started in the middle of the 2000s with simple voice control for basic vehicle functions, such as adjusting heat or music (Garikapati & Shetiya, 2024). The next step happened in the early 2010s when smartphones started to gain popularity, as they allowed users to connect them to in-car AI systems, such as Siri or Google Assistant, which allowed people to use more functions and perform various tasks, for instance, navigation or even messaging. The mid-2010s and late 2010s were marked by advanced natural language processing (NLP) systems and onboard AI with predictive capabilities that allowed personalization and conversational interactions with such in-car AI assistants. The current state of in-car AI assistants is centered around semi-autonomous driving and multimodal interactions and is aimed at achieving full autonomy of the driving process.

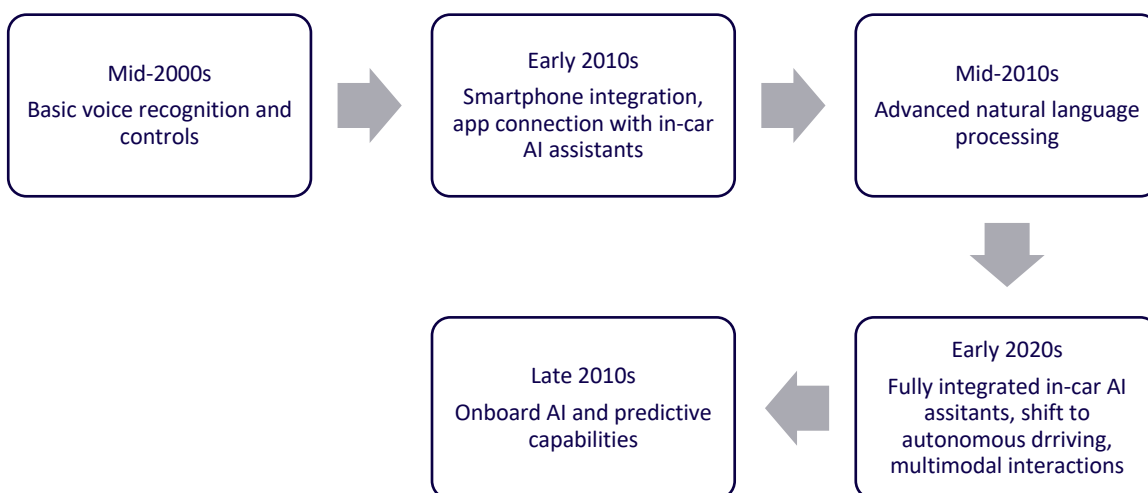


Figure 1. The history of in-car AI assistants

According to Huifang et al. (2024) “The current state of in-car AI assistants can be improved by proactive interactions from in-vehicle conversational assistants (IVCA), and large language models (LLM) that allow AI to enhance the recognition of user intent and context “(p. 78). The future of in-vehicle AI assistants can be described by four main functions, which are user-centric design, emotional intelligence, proactive assistance, and autonomous driving. Guo et al. (2023) mention that user-centric design heavily relies on the categorization of user expectations, which are divided into four groups: scenarios where customers expect intelligent vehicle agents (IVA) to operate efficiently, functions that potential clients prioritize, the appearance of the IVAs that appeal to end-users, and social attributes, for instance, the personality traits of AI. Emotional intelligence is crucial for the successful implementation of intelligent vehicle agents; Zhang and Jiaxin (2023) stated that providing emotional adaptation matched with driving scenarios and tasks and diversifying gender approaches and personality engagement is vital in creating intuitive and satisfying in-car experiences. Moreover, the important aspects of the proactive assistance of in-car AI agents are adaptivity to user behavior and the non-intrusive nature of questions and suggestions, according to Mathis et al. (2023).

The transition to fully autonomous driving is yet to be achieved, but the main functions that are being developed now are enhanced object detection and traffic management, as stated by Rawley & Gupta (2022), as well as Advanced Driver Assistance Systems (ADAS) are set to improve the overall level of safety in autonomous driving (Bukshetwar, 2024).

In-car AI assistants have revolutionized the idea of a car as a means of transportation, by using software to automate a large part of the functions inside the vehicle in order to ensure a smooth and improved user experience, as well as provide safety by reducing human errors. Although AI has been implemented into cars already in the 21<sup>st</sup> century, its full potential is yet to be uncovered, as it is constantly improving, and new specific areas are emerging where AI could be helpful. The emerging popularity and overall integration of in-car AI assistants are predicted to grow even more, as can be seen in Figure 2 below. Therefore, at this moment more than ever, there is an emerging need for researches that contribute to the topic of in-car AI assistants and their involvement in automotive industry.

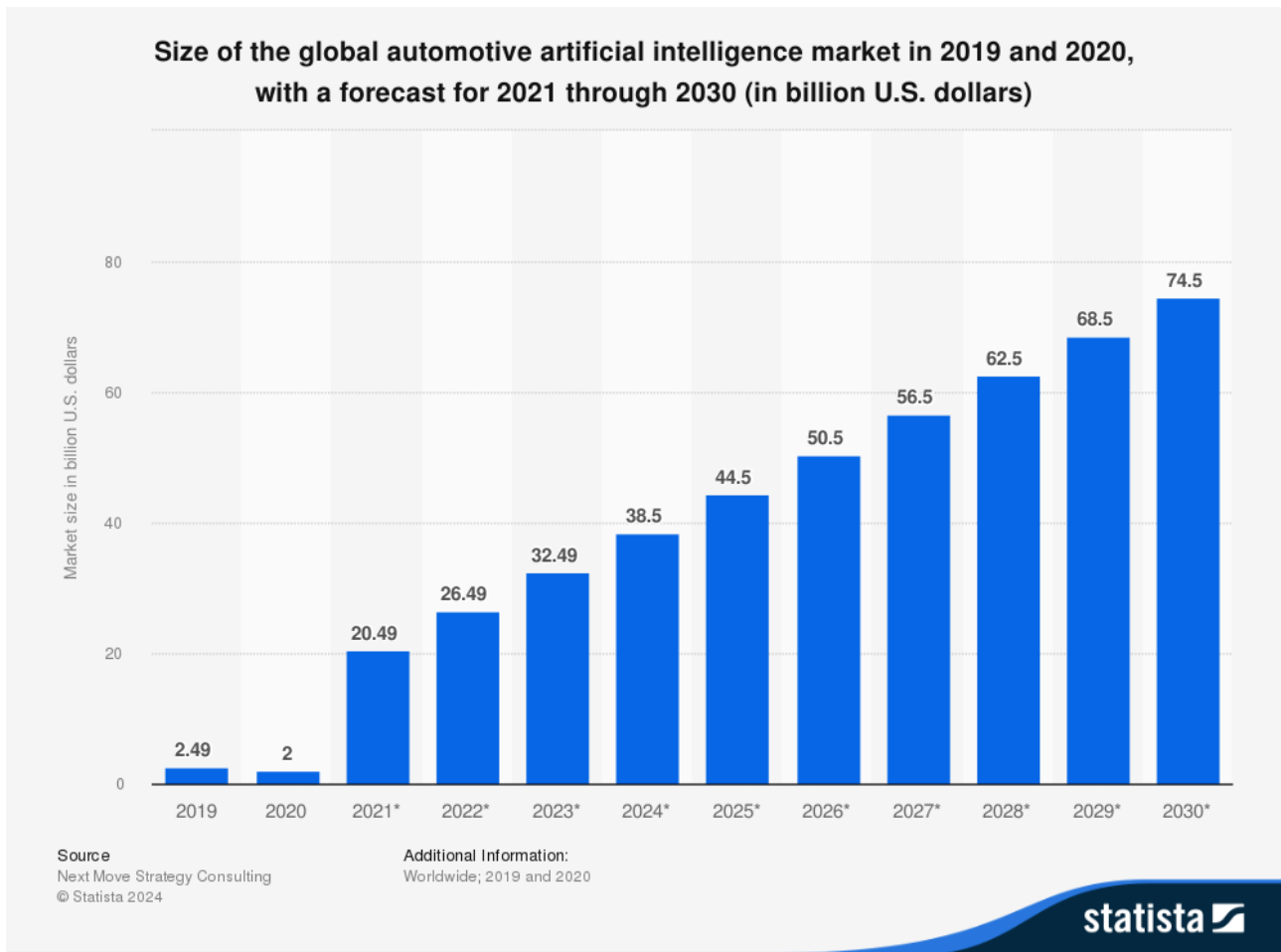


Figure 2. Size of the global automotive artificial intelligence market (Statista)

The worldwide automotive intelligence market is expected to expand between 2019 and 2030, according to Next Move Strategy Consulting. The market is anticipated to grow from its 2019 size of around 2.5 billion USD to its 2030 size of about 74.5 billion USD.

The importance of this topic for the automotive industry cannot be overstated. The continuous integration of AI assistants into mass-production vehicles foreshadows a significant paradigm shift within the automotive sector. Such benefits of AI integration as enhanced user experience, increased safety, and environmental benefits (Saini et al., 2024), also come with various problems related to AI assistant development and user adoption. Understanding these benefits and problems is crucial for a successful future of in-car AI assistants.

According to Garikapati & Shetiya (2024), in-car AI assistant applications can be divided into three main categories: enhancing overall user experience, managing safety and sustainability, and

smoothing the transition to autonomous driving. Stappen (2023) mentions that the current key characteristics of AI assistants in elevating the user experience are speech interactions, audio enhancement, vision systems, and multimodal interactions. According to Saini (2024), in-car AI assistants are pivotal in enhancing both safety and sustainability, for instance, Advanced Driver-Assistance Systems (ADAS) are crucial in preventing accidents and detecting possible threats while driving, while other AI systems evaluate driving patterns and fuel emissions to ensure environmental benefits. The last main function of AI assistants is to help smooth the transition to autonomous driving.

## **2.2 Autonomous driving systems**

Autonomous vehicles (AV) are vehicles that use technologies that allow partial or full replace a human driver and get to the destination point in the so-called “autopilot mode”. These autonomous vehicles are able to react and estimate road conditions, avoid collisions and various hazards, as well as provide increased safety for their passengers. Such vehicles use a variety of sensors, radars, lasers, active steering, and other advanced technologies in order to be able to drive independently and, therefore, be called autonomous. According to the Society of Automotive Engineers (SAE), all autonomous vehicles can be classified into six levels, each of them related to the amount of human intervention required. The list is as it is follows:

Level 0: A car is not responsible for driving, a human is fully controlling it and responsible for every action.

Level 1: Advanced Driver-Assistance System (ADAS) goes beyond usual warnings and is able to help the driver with steering and braking. The rest of the actions are performed solely by a human.

Level 2: Advanced Driver-Assistance System can control acceleration, steering, and braking in some circumstances, although the driver is fully responsible for the process of driving itself.

Level 3: Advanced Driver-Assistance System can perform the whole driving process under some circumstances, such as good weather, but a driver needs to be ready to take action in case of emergency.

Level 4: At this level, high driving automation is achieved, and the Advanced Driver-Assistance System can perform all tasks related to driving a vehicle, although only in certain areas.

Level 5: The improved Advanced Driver-Assistance System is able to perform all tasks related to driving under all conditions whatsoever, there is no need for a human driver at all. At this level, a full automation of the driving process is achieved.

Nowadays, self-driving cars have begun to quit the development stage and even exist as mass-production cars, such as the Tesla Model S, but they still require the driver's supervision. Therefore, the AI systems that are in charge of fully autonomous driving are yet to be made and implemented. Mazurkiewicz (2019) states that the Intelligent Driving Assistance System provides the necessary functions for autonomous driving, such as enhanced active safety, effective real-time processing, and support for driver decision-making. By implementing such systems, the transition to autonomous vehicles is much easier and smoother, as the system overtakes the driver's reaction time and gets better information from the sensors around the car. Such advantages of in-car AI assistants that were mentioned before come with potential problems related to responsibility and trust issues.

### **2.3 In-car AI integration and vital components**

In order to successfully integrate an AI assistant into a car, a number of vital requirements must be met. Communication, personalization, and trust management are the key factors of success when implementing AI into vehicles. Kaufman (2024) states that:

As such, the effectiveness of an AI coach may be dependent on how trustworthy it is. The implications are clear and supported by a plethora of past research: without trust, HMIs will fail. According to our participants, trust can be built through repeated positive exposure, helpfulness, and explainability validating the AV's ability and reliability. (Discussion section)

Therefore, transparent and precise communication from the AI assistant side, supported by a balance of the complexity of information with comprehensive coverage of a certain topic, combined with complete trust from a human based on a clear AI explainability, is crucial for the effective implementation of future human-machine interfaces (HMI) and AI assistants. Personalization and

adaption are other vital components of effective AI assistant implementation. User interface design is fundamental, as well as the quality and quantity of information tailored for the specific person (Alpers et al., 2020), because the overall experience affects the willingness of a person to ride again in an autonomous vehicle, which directly affects the success of self-driving cars.

To sum up everything that has been stated so far, it is important to mention, that the integration of in-car AI assistants is inevitably changing and transforming the user experience within the automotive industry by providing a more seamless, smooth, and safe driving environment. As AI systems advance and develop, they are playing a crucial role in closing the gap between conventional and autonomous driving by providing safety, minimizing human error, and boosting user confidence. In-car AI assistants are predicted to reach even higher potential with continuous technical developments, solidifying their position as the vital components of the transition to fully autonomous driving.

### **3. Methodology and Implementation**

This chapter aims to provide an overview of the data collection methods used in this study and offer a summary of the research process.

#### **3.1 Research preparation**

According to Saunders et al. (2016), exploratory research can be defined as a study that aims to examine a relatively unknown or emerging area. This type of research usually involves acquiring qualitative data, such as interview results, and is rather focused on providing findings that can be used for further research than creating theories or assumptions. Exploratory research concentrates on finding instead of confirming.

Saunders et al. (2016) also mention that collected data can be primary or secondary based on the ways and goals to obtain it. Primary data refers to the information that was retrieved by the author from various original sources, such as interviews or surveys, while secondary data comes from previously published or disclosed studies or materials. Both types of data serve a different purpose – primary data is usually centered around a specific goal or research questions, whereas secondary data offers a wide perspective of what has been done before.

In the pursuit of creating a thorough study, a triangulation method was chosen to collect the necessary data. The triangulation method includes the collection of quantitative data (survey results) and qualitative data (interview results) to collect primary data and conduct a literature review to obtain secondary data.

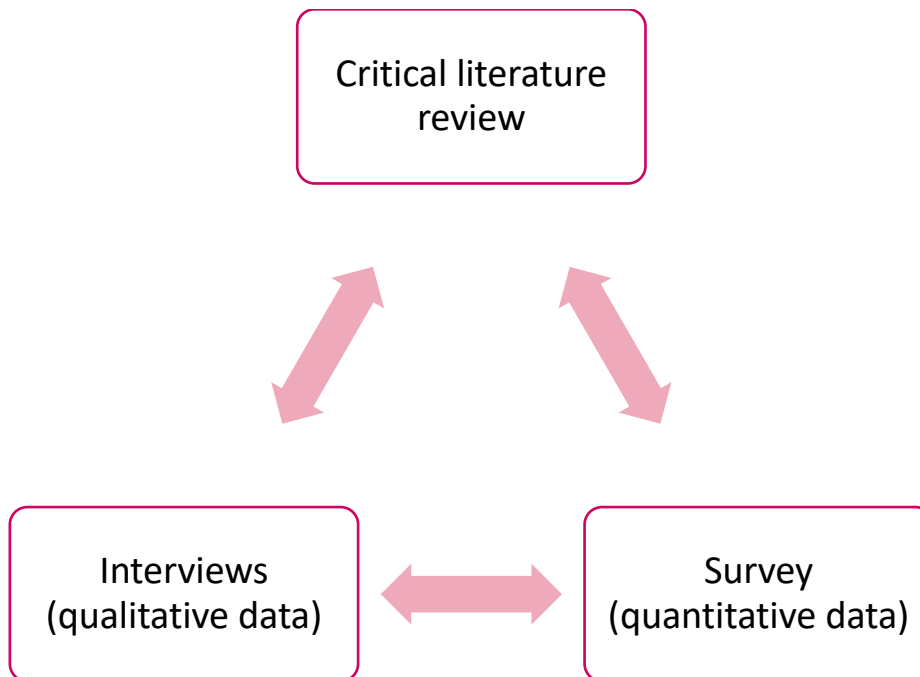


Figure 3. Triangulation method

### Interviews

Due to the nature of the research, interviews were chosen as the main way to collect primary data. Nowadays, in-car AI assistants and autonomous driving systems are still in the developing stage. Therefore, valuable insights and findings could only be acquired from researchers and professionals working in that area.

Interview questions had a specific structure to comply with the research questions and data needed to conduct a study. The first question intended to obtain the background and experience of the interviewee with in-car AI assistants and autonomous driving systems. Questions 2-4 were related to the overall user experience (UX) with the in-car AI assistants. Questions 5-6 sought to gain information about the ethical and technical aspects of in-car AI assistants. Questions 7-10

were aimed at getting insights and opinions on the future implementation of in-car AI assistants into the systems of autonomous driving.

Taking into account a specific topic and a relatively new area of research, it was somewhat difficult to find suitable experts, but due to the previously conducted analysis of the field of the study, the author managed to find relevant people.

A total of 10 specialists in in-car AI systems and autonomous driving were reached throughout the process of finding interviewees. Due to the problems with finding experts in Finland, where the author resides, for a one-to-one meeting, requests were made through e-mail and various social media. Six persons responded, but only three were able to participate in the interviews. Ultimately, the author managed to get three interviews with professionals from different areas of developing and researching AI related to the automotive industry. Two of them were conducted through social media and email answers, whereas one was made in Discord by audio call. All results are further explained in the “Collected Data Results” chapter.

## **Survey**

A survey was selected as a second way of getting primary data. It was designed for people with driving experience in order to understand how widely are in-car AI assistants being used, what barriers to the adoption of autonomous driving there are, and what seems to be the future of AI when it comes to autonomous driving. In other words, the goal was to gather as much information as possible about awareness of in-car AI assistants, consumer preferences related to these systems, and expectations from the potential shift to autonomous driving.

To make this survey suitable for most participants, rather simple questions were used without delving into the topic of in-car AI assistants, although when testing the survey the author realized that sometimes respondents lacked an understanding of what in-car AI assistants are, hence a short explanation and examples were provided in the description. The survey questions were made in a way that they could be divided into three categories to provide clarity and ensure that they correspond with the research questions. The first part of the survey focused on the respond-

ents' basic data, such as age and driving experience (questions 1-3). The following part of the survey centered around the current state of the in-car AI assistants (questions 4-7). The last part was oriented toward the future implementations of such AI assistants and their role in simplifying the shift to autonomous driving (questions 8-12).

The survey was made anonymous in order to prevent a leak of personal information, respondents were warned before the start of the questionnaire about the goals and voluntary engagement in the research process.

An anonymous Google Forms questionnaire was created and sent through email and various social media, including Instagram and WhatsApp, to a total of 210 people, but it got only 81 responses throughout the research process. All results are further explained in the “Collected Data Results” chapter.

### **Personal experience**

The author observed and tested various in-car AI assistants throughout the years as well, such as entertainment systems, but only as a passenger due to the lack of a driver's license. Therefore, data and experience related to, for instance, in-car AI assistants responsible for safety could only be gathered from the survey and interviews.

### **Literature review**

The critical literature review is crucial for the research process, as one gets a knowledge base and a better understanding of the topic throughout conducting it. A variety of academic sources were carefully studied. They included Google Scholar, Research Gate, ScienceDirect, and other types of credible sources. Moreover, different websites, books, and videos related to AI in the automotive industry were examined for the purpose of acquiring vital knowledge, although they were not used as direct references to keep the research academically correct.

### 3.2 Research process

The research process began in September 2024, with selecting the broad topic of AI in the automotive industry, which later evolved into the in-car AI assistants-related concept. At the same time, the author started to acquire the necessary knowledge base by researching the area of in-car AI assistants, as well as gathering the necessary materials for carrying out the literature review. The last step during that month was to create research questions, which was done after the author collected enough academic resources and baseline knowledge. The main goal for October 2024 was to critically review the collected literature and sources in order to obtain a sufficient conceptual framework while working on the research. The survey was created, conducted, and assessed in November 2024, while interviews took longer time due to the problems related to finding several suitable specialists who were willing to participate in the research process. Ultimately, interviews were conducted at the beginning of December 2024. Later that month, the results and insights were analyzed, which led to answering research questions, conducting a comprehensive summary, and finishing the study.



Figure 4. Research process

## 4. Collected Data Results

This chapter of the research focuses on the results from collecting the primary data: interviews and surveys. Due to their different natures and goals, each method is described and analyzed separately in this chapter.

### 4.1 Interview analysis and findings

In this subchapter findings from the interviews are demonstrated.

Due to difficulties finding a suitable and available in-car AI specialist in Finland for a one-on-one interview and the inability to travel a lot, the author decided to conduct email and audio call interviews instead. As mentioned in the “Research preparation” subchapter, three experts could participate in the interviews. The list of participants is provided below:

Specialist 1: A Russian research engineer who focuses on autonomous driving and predictive analytics. The interview was conducted through a Discord audio call.

Specialist 2: A Russian lead AI developer specializing in sensor fusion and real-time data analysis for self-driving taxis. The interview was conducted through a social media chat.

Specialist 3: An AI systems engineer from the US working in natural language processing. The Internet-mediated interview was conducted.

Interviews with Specialist 1 and Specialist 2 were conducted in Russian language and then translated into English language by the author. The interview with Specialist 3 was conducted in English language.

All interview questions were divided into three groups: “User experience related to in-car AI assistants,” “Concerns and barriers of in-car AI assistant adoption,” and “The shift to autonomous driving.” The findings are presented in a table for ease of reading and comprehension.

#### **User experience related to in-car AI assistants**

Table 1. User experience

|                        |   |
|------------------------|---|
| <p><b>Expert 1</b></p> | <p>“...customization is absolutely critical for [in-car] AI assistants.”</p> <p>“The whole system should feel natural to use, without too much data or prompts that might overwhelm [the driver].”</p> <p>“People are more likely to trust and use a system that adapts to their needs and preferences, [like] voice tone, driving habits in real time, whether it’s a family van, or a single guy driving a truck, [AI] assistants need to be versatile and flexible.”</p> <p>“I would say that I was shocked by [in-car AI assistant’s] the ability to predict the drivers needs in some cases...”</p> <p>“... these systems need to recognize and comprehend not only verbal, but nonverbal [inputs] as well, gestures, nods, etc”</p> <p>“Imagine the [in-car AI] assistant as an iPhone, it is easy to use,you can customize the iPhone in the way that you like, you can talk to Siri, it can send a SOS signal in case of emergency...[in-car AI] assistants need to be even better [than that] because your life and safety relies on it”</p> |
| <p><b>Expert 2</b></p> | <p>“Reliability and simplicity is the key”</p> <p>“Simplifying the decision-making process for a driver leads to a better adoption [of in-car AI assistants]”</p> <p>“Customization [of in-car AI assistants] stimulates the feeling of ownership... when the system understands and comprehends the [driver’s] needs and reacts [back] to the driver in a</p>  |

|                        |  |
|------------------------|--|
|                        | <p>way that the driver wants and understands... that's where the good user experience starts"</p> <p>"Constant feedback and transparency matter a lot, system needs to provide validations for [its] actions..."</p>   |
| <p><b>Expert 3</b></p> | <p>"In-car AI assistants can reduce some of the driver's cognitive load by simplifying the interactions between a human and an assistant."</p> <p>"Personalization truly makes the system feel noticeably less generic. It also creates rather a "co-pilot" experience perfectly tailored to each driver."</p> |

All experts agreed that customization and personalization are key factors in user experience in the successful implementation of in-car AI assistants. Moreover, a system that adapts, understands, and acts accordingly to a specific driver's needs and wants can provide a much better user experience. The simplicity of the in-car AI assistant, along with constant feedback and judgment of its actions also affects the overall user experience.

A general conclusion that can be retrieved from the interview results about the user experience related to in-car AI assistants is the following:

1. Customization and personalization of in-car AI assistants are key factors in enhancing the user experience.
2. An in-car AI assistant that is able to adapt, understand, act, and even predict the driver's actions is highly crucial.
3. Reliability, transparency, and simplicity are vital components of in-car AI assistants.

### **User concerns and barriers to in-car AI assistants adoption**

Table 2. User concern and barrier for adoption

|                        |  |
|------------------------|--|
| <p><b>Expert 1</b></p> | <p>“Obviously the trust and accountability is crucial, but what I [personally] noticed is that people doubt the ability of [in-car] AI assistants to make right decisions in critical situations...”</p> <p>“...people use such systems but they doubt [that in-car AI assistants] will act reliably in harsh winter conditions or crowded streets...”</p> <p>“People do not understand the full potential of the [in-car AI] assistants, and fears come from that fact...consumer education is vital for successful implementation [of in-car AI assistants]”</p> <p>“In-car AI assistants lack consistent performance in terms of homogeneity, if a person buys a car, [in-car AI] assistants would be different [in different cars], and most consumers like overall clarity, like with a new iPhone model, you expect something new, but you also know what kind of product [you are] buying...”</p> |
| <p><b>Expert 2</b></p> | <p>“When it comes to self-driving cars [the main problem is] who is going to be responsible, for instance, when a taxi gets into an accident and the passenger is injured”</p> <p>“...data privacy and ethicality of the [in-car] AI assistants’ actions are [another] concerns as well...”</p>  |

|                        |   |
|------------------------|---|
|                        | <p>“From the technical side, our task is to provide a real-time seamless data transmission from sensors to the car hardware, and it is a major problem for the autonomous [driving systems].”</p> <p>“...there isn’t yet a single set of laws and regulations that would clearly state all [necessary] details, consequences, and accountability for in-car AI assistants in case [something] goes wrong”</p> |
| <p><b>Expert 3</b></p> | <p>“Safeguarding extremely sensitive personal and private data is the most meaningful moral concern, along with providing truly effective personalization.”</p> <p>“Many important legal problems remain unsolved regarding the responsibility for incidents caused by in-car AI assistants.”</p> <p>“Slang words, dialects and accents impair the understanding from in-car AI assistant’s side...”</p>      |

According to the experts, the main concerns and barriers for the adoption of in-car AI assistants are as follows:

1. **Accountability and law regulation for such in-car AI assistants**  
The main concern of consumers that leads to delays in adopting such assistants is accountability and law regulations. People do not understand who is going to be responsible in the case of an accident due to an in-car AI assistant malfunction, for example. Another issue is the lack of general laws and regulations that would affect such situations.
2. **A lack of trust from consumers regarding the in-car AI assistants’ actions**  
As it appears, consumers do not trust in-car AI assistants when it comes to either critical situations or harsh driving conditions. Generally speaking, there is also a level of distrust related to the fact,

that people do not understand the way in-car AI assistants work, therefore they prefer to take action themselves.

3. Personal data privacy

It is a quite obvious problem that appears whenever the AI issue is raised. In the case of in-car AI assistants, as it was mentioned earlier, customization and personalization matter a lot. At the same time, developers need to keep a balance between personalization and the safety of personal data.

4. Technical problems related to the development and upgrade of the in-car AI assistants

As for the developing side, technical problems are a major obstacle to improving such in-car AI. Assistants. These problems include language processing issues, data transmission, etc.

### The shift to autonomous driving

Table 3. The shift to autonomous driving

|                        |   |
|------------------------|---|
| <p><b>Expert 1</b></p> | <p>“Fully autonomous driving is not possible without AI assistants”</p> <p>“From the consumer’s side, personalization and prediction [of needs] is the next area of development in [in-car AI] assistants that help [to smooth the shift to autonomous driving]”</p> <p>“...as soon as people are comfortable with in-car [AI] assistants playing a larger role in driving [process], and [assistants] prove that we can take it to the next level”</p> <p>“...there is a vast area of [in-car AI assistants] development, full autonomy is yet to be achieved... for example, off-road or heavy snow are hard conditions [for AI assistants] to perform an autonomous driving”</p> |
| <p><b>Expert 2</b></p> | <p>“First of all we need advancements in [autonomous driving] technologies, better cameras and sensors quality, increased data processing speed, and solutions for decision-making...”</p>  |

|                        |   |
|------------------------|---|
|                        | <p>better technologies mean faster and more precise shift [to autonomous driving]</p> <p>“...it is crucial to gradually introduce autonomy to consumers... early adopters provide a lot of feedback but we need the majority of people”</p> <p>“...potential connection of the car AI assistant with smart home systems, city traffic data, other ecosystems [in short] is what we think might help [with the shift to autonomous driving]”</p>   |
| <p><b>Expert 3</b></p> | <p>“Voice recognition and multi-lingual capabilities of in-car AI assistants are developing rapidly.”</p> <p>“Advanced predictive AI will incredibly quickly create human-like voice interfaces, hence smoothly erasing the barrier between machine and human by anticipating consumer needs based on contextual data.”</p> <p>“...general technology advancement inevitably leads to autonomous driving, whether people accept it or not...”</p> |

Experts provided the author with a variety of ways the in-car AI assistants are simplifying the shift to autonomous driving. The main takeaways included the advanced predictive AI with voice recognition and potential connections of in-car AI assistants to smart home systems or to the Internet Of Things in general. Experts also noted that without such in-car AI assistants, a shift to autonomous driving is simply impossible and impractical.

Ultimately, interviews provided the author with a significant amount of useful insights and results. Experts from various fields were able to present facts related to their field of work that contributed to the research in a great way. Not only were the results helpful in adding even more information to a knowledge base, but they assisted the author with answering the research questions and creating a solid conclusion.

## 4.2 Survey analysis and findings.

This subchapter is focused on providing the results from the conducted survey. Results are presented according to the applied categories earlier mentioned in the “Research preparation” subchapter. As it was stated before, the survey was made to be rather simple without going deeper into the technicalities of the in-car AI assistants, yet it covered all the necessary topics for this particular research.

### Participant’s data

What is your age?  
81 responses

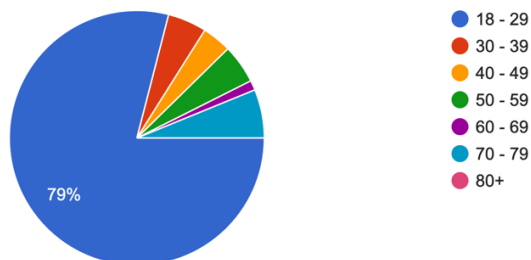


Figure 5. Age

Out of 81 participants, 79% were 18-29 years old, which was a predictable outcome. Nevertheless, the author managed to get useful results from older people up to 79 years old, contributing to raising the level of heterogeneity.

### What is your gender?

81 responses

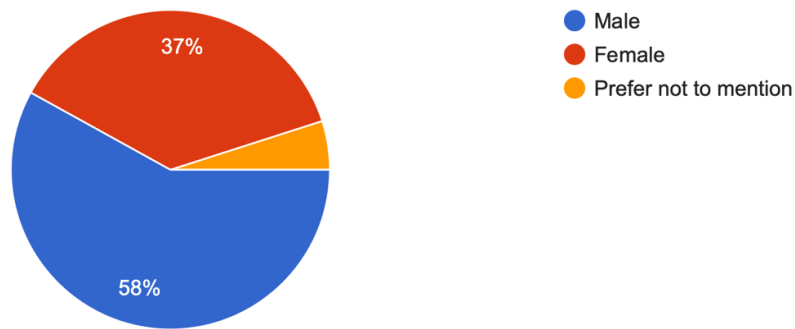


Figure 6. Gender

Male respondents prevailed in this survey, with 58% of the total answers. The number of female respondents was lower, consisting of 37% of the final results, and only 5% of participants decided not to mention their gender.

### How many years of driving experience do you have?

81 responses

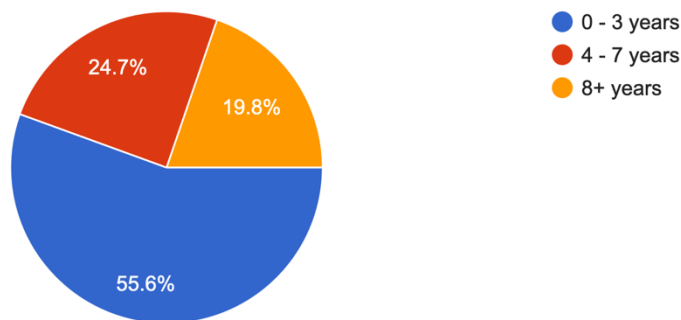


Figure 7. Driving experience in years

This question was aimed at gaining an understanding of driving experience in years of respondents. The majority of answers – 55.6% - indicated that people who took the questionnaire were mainly mature drivers with less than 3 years of driving experience. It correlates with the results of

the first question in the given survey, where 79% of answers indicated the rather young age of respondents.

Overall, this section revealed that, on average, a person who took this survey was a young male with a small amount of driving experience.

### The current state of in-car AI assistants

How frequently do you use in-car AI assistants? (e.g., voice assistants for navigation, entertainment, and communication)

81 responses

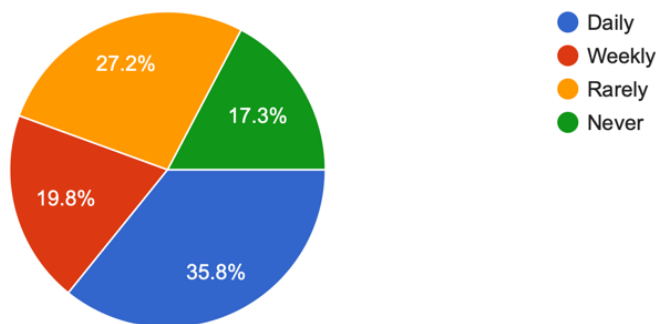


Figure 8. Frequency of usage

Surprisingly, "Daily", the prevailing option that respondents chose, consisted only of 35.8% of the total amount of answers, and the second most chosen option was "Rarely" with 27.2%, hence providing ambiguous results. Although 17.3% of the respondents selected "Never" option, more people opted for the "Weekly" option – 19.8%. In this case, one can calculate the amount of rather frequent users by adding the amount of percentages for "Daily" option to the "Weekly" option. The final result is 55.6% of frequent users, therefore indicating a rather high involvement in the utilization of in-car AI assistants.

On a scale from 1 to 5, how effective are these in-car AI assistants for you? (1 – Not useful at all, 5 – Very useful)

81 responses

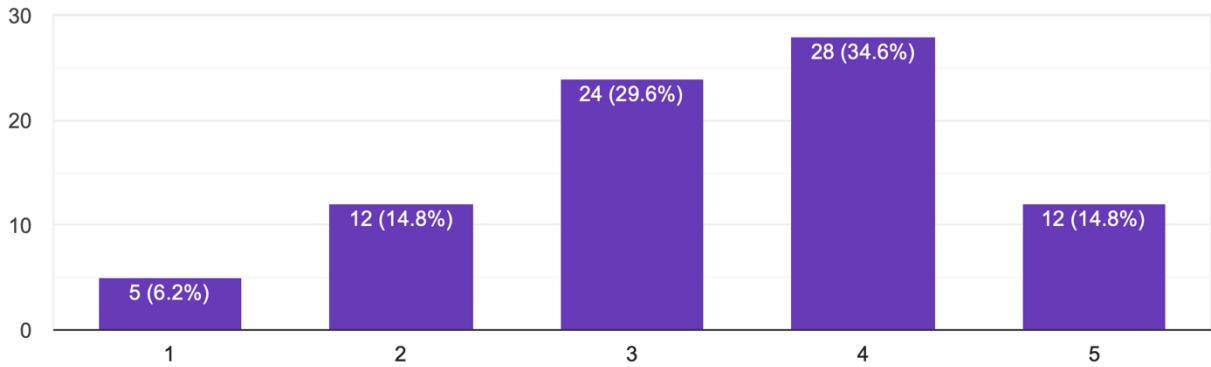


Figure 9. In-car AI assistants effectiveness

According to the results, respondents noted that existing in-car AI assistants are rather useful for them, as the two biggest percentages came from 3 and 4 on a scale from 1 to 5 mentioned in figure 2, 29.6% and 34.6%, respectively.

Do you think that in-car AI assistants can improve the overall safety of driving? (by providing voice commands or timely alerts, for instance)

81 responses

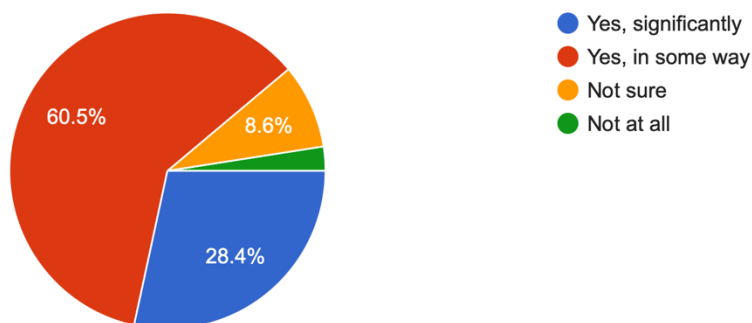


Figure 10. Improving the safety of driving

The majority of the respondents' answers, which accounted for 60.5% of responses for the "Yes, in some way" option, indicated that the respondents have a rather positive attitude towards the opinion that in-car AI assistants can improve the overall safety of driving. An additional 28.6% of participants chose a "Yes, significantly" option, therefore proving the hypothesis that such in-car AI assistants are very helpful in improving driving safety.

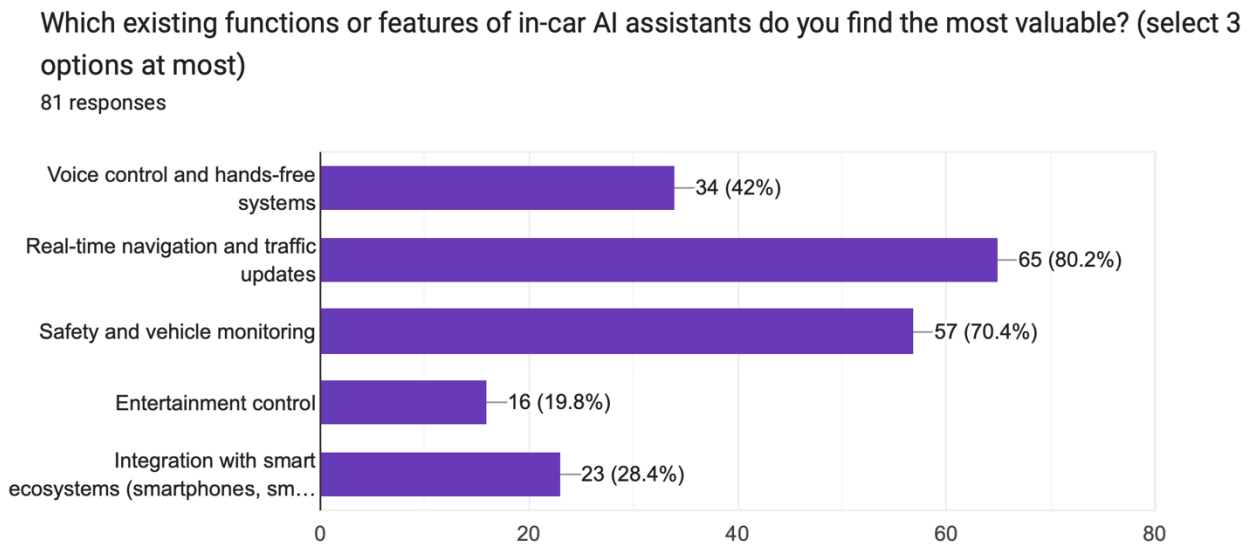


Figure 11. Valuable existing features of in-car AI assistants

Real-time navigation and traffic updates, along with safety and vehicle monitoring, are two of the most chosen options in this question, with 80.2% and 70.4%, respectively. The voice control and hands-free systems options had the third biggest percentage – 42%. The results from the questions show that the most valuable existing features of in-car AI assistants are the ones mentioned above. Interestingly, one of the initial functions of in-car AI assistants that was presented more than 10 years ago - entertainment control, gained the least amount of answers – 19.8%, which indicates a shift in paradigm towards more important functions. As new functions of in-car AI assistants emerge, they become more crucial for consumers to use and rely on. A small amount of answers towards the integration with smart systems – 28.4%, can be explained by the backwardness of this technology compared to other, that emerged earlier and were tested and adopted by users.

What concerns, if there are any, do you have towards the in-car AI assistants? (select 3 options at most)

81 responses

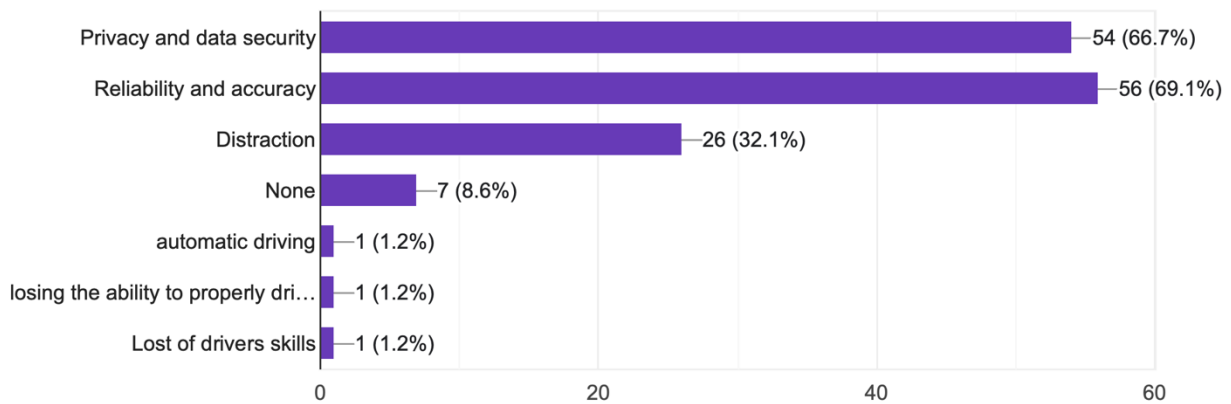


Figure 12. User concerns

One of the most important questions in this survey was about user's concerns regarding in-car AI assistants. Two of the most chosen options were "Privacy and data security" and "Reliability and accuracy", with 66.7% and 69.1%, respectively. This indicates an area in which adjustments must be made to provide customer satisfaction and ensure a wider usage of in-car AI assistants.

Notably, the answers to this question correlate with the experts' opinions about the user concerns and barriers to adopting in-car AI assistants mentioned earlier in the "Interview analysis and findings" subchapter.

This question was designed in a way that a respondent could choose an open-ended answer and provide some insights, some of which were considered useful to mention here:

"Losing the ability to properly drive a vehicle"

"Lost of drivers skills" (The original spelling is kept intact)

**The future of in-car AI assistants and shift to autonomous driving**

Are you comfortable with in-car AI assistants playing a bigger role as vehicles tend to get autonomous?

81 responses

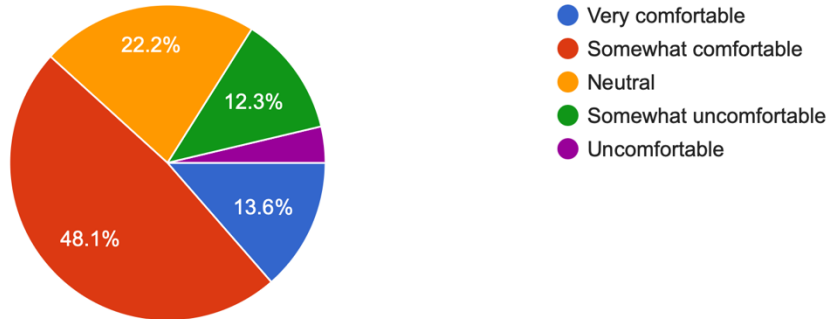


Figure 13. A bigger role of in-car AI assistants

Almost half of the responses – 48.1% - that the author got from the survey displayed a rather comfortable attitude towards the possibility of in-car AI assistants playing a larger role, as the vehicles tend to get autonomous. The smaller part of participants – 22.2% - were neutral towards the given fact, and only 13.6% of respondents answered strictly positive.

Do you believe that in-car AI systems can simplify the shift to fully autonomous vehicles?

81 responses

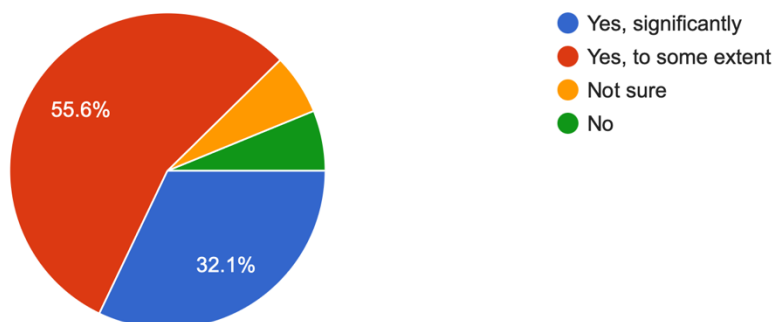


Figure 14. Simplifying the shift to autonomous driving

Surprisingly, most of the participants have a positive attitude toward the fact that in-car AI assistants could help with the shift to fully autonomous vehicles. Out of 81 respondents, 87.7% answered positively, choosing either “Yes, significantly” or “Yes, to some extent” options.

What additional features would you like to see in in-car AI assistants to improve their future implementation?

81 responses

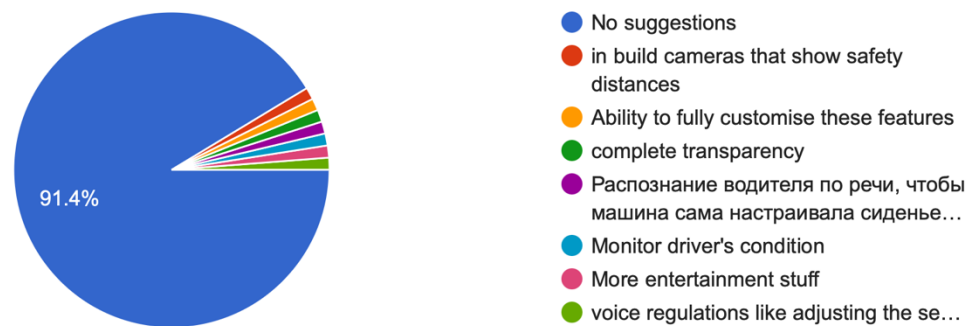


Figure 15. Additional features.

The last question of the survey was an open-ended one, with an option to choose “no suggestions.” Three comments provided useful insights for this research:

1. “Complete transparency”
2. “Monitor driver’s condition”
3. “Ability to fully customize these features”

Interestingly, these comments matched with the insights provided by experts in the “Interview analysis and findings” subchapter.

## 5. Discussion and Conclusions

In the final chapter, conclusions are drawn and presented to mark the end of the research. This chapter features a “Research questions answers” subchapter, a “Theoretical and practical implications” subchapter, and a “Research limitations” subchapter.

## 5.1 Research questions answers

The primary data, including interviews and the survey results, along with the secondary data consisting of the conducted critical literature review helped the author to draw conclusions and answer the research questions.

### **RQ1: How do in-car AI assistants currently affect user trust, comfort, and overall experience in modern vehicles?**

According to the results of the research, the main factors affecting user trust are:

#### **1. The reliability, accuracy, and transparency**

Consumers tend to trust in-car AI assistants more if they can understand and trust the way such systems work, which comes from the reliability and accuracy of the decisions made by these assistants. Without consistently positive examples of performed tasks from the in-car AI assistants and educational information provided by the automotive companies regarding reliability, transparency, and accuracy, it is impossible to gain user trust and faith in such assistants.

#### **2. Privacy concerns**

Major privacy concerns regarding the safety of personal data related to the amount of such data requested by an in-car AI assistant to operate efficiently and according to the specific requirements of the consumer is inevitably negatively affecting the user trust.

The main factors affecting user comfort are:

#### **1. Customization and personalization**

As the interviews' results show, it is crucial to customize and personalize in-car AI assistants to offer more comfort and satisfaction for users. Even the smallest details, such as the tone of voice of the in-car AI assistant or the way it reacts to the commands, provide a whole new seamless experience that directly affects the user's comfort.

## **2. Increased safety**

The advanced level of safety offered by cars with in-car AI assistants due to a variety of technologies such as Advanced Driver-Assistance System (ADAS) or Light Detection and Ranging (LiDAR) and the ability of such assistants to take action in critical situations it is safe to say that it has a direct consequence of the level of user comfort.

## **3. Convenience and ease of use**

Complex interfaces or ways to interact with in-car AI assistants negatively affect user comfort. According to the experts, it is necessary to establish a “natural” and easy way to communicate and use in-car AI assistants, in order to establish and maintain a sufficient level of user comfort.

Ultimately, all the main points mentioned above enhance the overall user experience, as comfort and trust are parts of it. System transparency and accuracy, along with the handling of privacy concerns, define the user’s trust, while customization and safety features, in addition to easy and convenient interactions, improve comfort. Altogether, they outline the ways in-car AI assistants affect user experience.

### **RQ2: What key problems and user concerns are affecting the shift to autonomous driving?**

Based on the results from the interviews, survey, and literature review, it is safe to say that there is a variety of key problems and user concerns that affect the shift to autonomous driving, First and foremost is the lack of trust from the human side, and the accountability of the in-car AI assistants. Due to the fact that in-car AI assistants are a relatively new technology that constantly improves and takes more and more control of the driving process, people tend to lack trust in it without the required knowledge acquisition that explains all the unclear aspects of such assistants. Accountability of the in-car AI assistants is another crucial problem that is yet to be solved; it

would be relatively hard to clearly define the accountable person or a system in the case of an accident that directly involved such assistants due to the lack of unified laws and regulations regarding in-car AI assistants and autonomous driving technologies.

Personal data security and privacy is another crucial problem that affects the shift to autonomous driving. While it is necessary to provide personalization and customization, as it was mentioned earlier, it is equally essential to maintain the safety of this data. As the results show, this problem is one of the most concerning ones. Sustaining the balance between the personalization and customization of in-car AI assistants and the safety of this data is vital for a successful shift to autonomous driving.

The ethicality of the in-car AI assistants, possible distractions related to such assistants, and the users' distrust in the ability of AI to make critical decisions are also problems and concerns that emerged throughout the process of the research.

Ultimately, addressing these issues is the next necessary step in maintaining a stable and smooth shift to autonomous driving.

Additionally, there is an area of key problems that affect the shift to autonomous driving that is not directly related to the users but was mentioned in the interviews – the technical side of the development of autonomous driving systems. Experts mentioned that the data transmission speed, along with natural language processing and overall complexity of autonomous driving, impacts the speed of the development of in-car AI assistants, and therefore directly influences the shift to autonomous driving.

### **RQ3: How do in-car AI assistants help users transition to autonomous driving?**

While the full autonomy of self-driving cars is yet to be achieved, there are ways in which in-car AI assistants help users prepare for that transition and make it smooth. First of all, as it was mentioned by experts, the transition to autonomous driving is not possible without the in-car AI assistants. Currently, the main role that in-car AI assistants serve in helping users transition to autonomous driving is simply to give an understanding of what such systems are, gradually increasing the

awareness among users about possible functions and the overall notion of autonomous driving. At the same time, in-car AI assistants continue to build trust in the eyes of users, which will be crucial when it comes to fully autonomous driving on level 5. By constant testing of these systems and collecting feedback from users, automotive companies can smoothly integrate the refined versions of in-car AI assistants until autonomy is achieved.

Enhancing the overall user experience related to the in-car AI assistants is another way these systems help users transition to autonomous driving.

To sum up everything that has been stated so far, it is safe to say that currently, in-car AI assistants mainly serve as a test for both users and automotive companies to provide the best results when the time comes for autonomous driving. Although the current in-car AI assistants are advanced enough not to be considered tests or prototypes, their main role is to enhance the user experience and inevitably bring closer the emergence of autonomous driving.

By answering these research questions, a study goal was achieved, therefore explaining the role of in-car AI assistants in elevating user experience, and showing the ways to simplify the shift to autonomous driving.

## **5.2 Implications for further research**

In-car Artificial Intelligence assistants are a vital component of modern cars. Such assistants serve a variety of roles, and there are more to emerge in the future as humanity gets closer to the full automation of the driving process. It is impossible to conduct comprehensive research on in-car AI assistants due to the limitations of the research explained in the “Research limitations” subchapter, although the author covered a range of topics related to the mentioned area. In order to promote further research, a list of implications is provided below.

1. The first suggestion is to further research the customization and personalization of in-car AI assistants. As can be seen from the results of interviews and the survey, the ability to tailor such systems for a certain individual is crucial in terms of user experience and overall acceptance of in-car AI assistants.

2. Broader research with more respondents and experts is highly needed to provide a better picture of the current state of in-car AI assistants. Eighty-one respondents and three experts are the bare minimum for such a study therefore a larger number of participants is required to conduct a more thorough and quality research.
3. Researching the means of accuracy, transparency, and reliability of in-car AI assistants from the user side is vital. These key components of the in-car AI assistants seem to be easy and understandable, but when it comes to actual research, a huge amount of user data is needed to evaluate and define these components to provide automotive companies with much-needed results.
4. The last but not least implication for further research is the shift to autonomous driving. This shift seems to be inevitable, given the amount of progress achieved in the last years, but there is still a lot of work left. While only a few cars could achieve level 4 autonomy in certain areas on the Earth, the research for such a shift is much needed by automotive companies and the developers of in-car AI assistants.

### **5.3 Research limitations**

A variety of factors contributed to the research limitations. The main research limitation regarding this study is the amount of primary data collected from the interviews and the survey. As mentioned before, due to the problems with finding a suitable and available in-car AI specialist in Finland for a one-on-one interview and the inability to travel a lot, interviews had to be done online, which obviously worsened the quality of the final outcome. Furthermore, only three experts out of two countries (Russia and the USA) were reached out of the expected ten, therefore reducing the amount of potential useful insights. As of the survey outcomes, the author got only 81 responses from the 210 people who received the questionnaire. Meanwhile, this amount of answers is suitable for the bachelor thesis, but it is still counted as a low amount of results, which in turn affects the overall research.

Another limitation was the limited amount of time during which this research had to be performed, which also affected the quality and quantity of the presented results.

Ultimately, the main research limitations were a low amount of responses received from the survey, combined with only three conducted interviews, and the short amount of time to perform and finish the study.

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## Appendices

### Appendix 1. Interview Sample Questions

1. Could you briefly describe your background and experience with autonomous driving technology and/or in-car AI assistants?
2. In your view, what are the most important ways that in-car AI assistants now improve the user experience of vehicles?
3. In order to optimize customer comfort and happiness, what should developers focus on when creating in-car AI assistants?
4. How crucial is it to be able to customize in-car AI assistants, and how does it improve the user experience?
5. How can consumers of autonomous driving trust in-car AI?
6. What are some of the most significant ethical and technical obstacles to the integration of AI assistants in automobiles?
7. What legal and safety concerns need to be resolved to guarantee a smooth and seamless integration of AI assistants into autonomous vehicles?
8. How do you envision in-car AI assistants helping users transition to fully autonomous vehicles?
9. What developments do you anticipate in the future of in-car AI systems that could enhance the driving experience even more?
10. Is there anything else you think is essential to recognize regarding the role of in-car AI assistants in transforming contemporary modes of transportation?

## Appendix 2. Survey

[https://docs.google.com/forms/d/e/1FAIpQLSckTjjouwyNMKyvzqYecV-satmK\\_E6\\_5EGZ6eV3d-m6HSyoTw/viewform?usp=sf link](https://docs.google.com/forms/d/e/1FAIpQLSckTjjouwyNMKyvzqYecV-satmK_E6_5EGZ6eV3d-m6HSyoTw/viewform?usp=sf_link)