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'Talking with your Car' :Design of Human-Centered Conversational AI in Autonomous Vehicles

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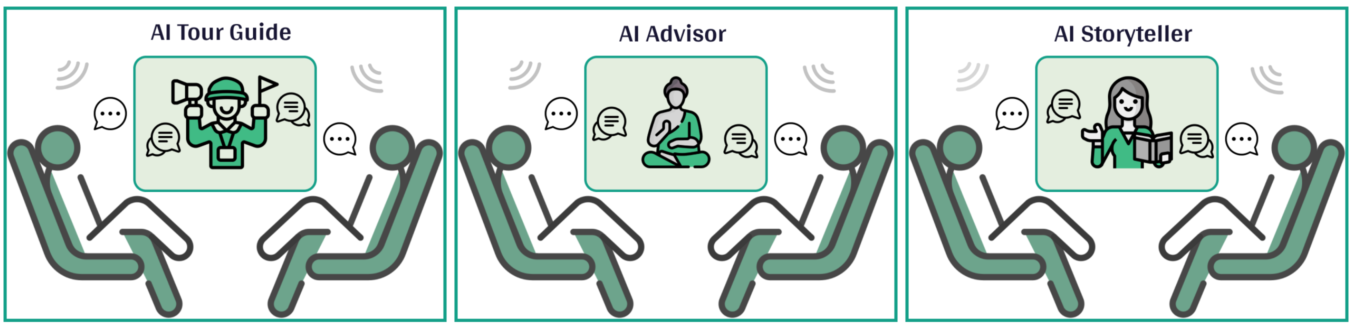

Figure 1: We identified the roles and relationships that Conversational AI can play towards users of Autonomous Vehicles. From left to right - AI Tour Guide, AI Advisor and AI Storyteller were the top 3 roles amongst others that users desired. Relationships would be formed and maintained when these CAI roles mediate in-vehicle user interactions, activities, sharing of control, modification of environment and conversational topics.

ABSTRACT

The Development of Fully Autonomous Vehicles (AVs) would fundamentally change the nature of in-vehicle user interactions, behaviors, needs, and activities. Passengers free from driving would expect to undertake diverse Non-Driving-Related Tasks to keep themselves occupied. Introducing Conversational Artificial Intelligence (CAI) in Level 5 AVs could improve the in-vehicle user experience (UX). To explore this, firstly, we identify what roles and relationships can CAI play towards end-users of AVs through end-user interviews and thematic analysis. Secondly, we examine how end-users qualitatively assess the embodied UX of the CAI roles and relationships through guided brainstorming, post simulator interaction experiments employing Wizard of Oz setup and Participant Enactment methods. Results show that Tour Guide, Mentor, and Storyteller were the most preferred CAI roles, and that Human-CAI relationships are maintained if the CAI mediates in-vehicle user activities, interactions, sharing of vehicle control, and deep conversations. We discuss the research implications and propose design guidelines.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

KEYWORDS

Design Guidelines, Human-Autonomous Vehicle interaction, Human-Artificial Intelligence interaction, Conversational AI Roles and Relationships, User Experience Evaluation

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1 INTRODUCTION

As Autonomous Vehicles (AVs) 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[57]. 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 AVs [23]. This will in turn inspire new forms of automobile and Human-AV interaction design due to drivers being freed from driving tasks and the alteration of in-vehicle controls and functions leading to new interaction mechanisms [58].

The main criticism put forth by the user automation research community toward technology-centered taxonomies is their limited consideration for the human element involved in automation [1]. Adopting a human-centred perspective is of utmost importance in achieving a successful integration of autonomous vehicles within lives of people, and for developing a conducive ecosystem wherein AI and HCI based systems can collaborate seamlessly [60] to build user-friendliness and trust [59] in their application. Further, the need for this approach has been evidenced by studies on behaviour of humans around autonomous vehicles, which show people like to get some form of explicit or implicit communication from AVs [50]. Human-AV interaction has found to have explicit communication methods such as eye contact and gestures as well as implicit communication methods such as gait or driving behavior [11].

Humans seek intelligent 'things' to collaborate and have a conversational dialogue with in order to function seamlessly, for which a socio-technical approach would be essential [[15], [35]]. It has been found that collaborative HMIs are essential in achieving mutual understanding between humans and vehicle's autonomy, and information transparency, such as in cases of enabling Situation Awareness, creating trust, providing entertainment and performing Non-Driving-Related Tasks (NDRTs) [64]. However, a gap exists in understanding the nature of conversations and interactions that human would seek out to facilitate a collaborative travel experience. To design for embodiment [[12], [13]] or the physical manifestation of conversations within Human- AV collaboration, the human-machine interaction design will have to be re-imagined, by being soundly grounded in research to understand customers', users' and other stakeholders' current experiences, expectations and aspirations for future experiences [24]. Hence, we investigated the following research questions in this work:

- *RQ1: What roles and relationships can Conversational AI (CAI) 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?*

To answer these questions, we first employed qualitative methodology of semi-structured end-user interviews based on a 5 day sensitising activity booklet involving 9 participants. Next, we employed a method combination of Wizzard of Oz with Participant Enactment to conduct Human-Technology interaction experiments involving 12 End-users in pairs and evaluated the interaction experience using Guided Brainstorming.

The main contribution of this work included (1) Identification of roles that Conversational AI can play towards End-users of Fully Autonomous Vehicles, (2) Identification of aspects that would enable forming of Human-Autonomous Vehicle relationships mediated by the Conversational AI, and (3) User Experience evaluation of the embodied concept of Conversational AI roles and relationships in autonomous vehicles. The research concludes by articulating Design Guidelines to inform the design of Conversational AI in Autonomous Vehicles.

2 RELATED WORK

2.1 Artificial Intelligence for Conversations

To understand and design CAI technology for AVs, we reviewed literature in that direction. The definition of AI is the science and engineering of making intelligent machines, intelligent computer programs and using computers to understand human intelligence, while not necessarily completely emulating human intelligence [39]. The technological advancements of advancement in algorithms, the availability of massive amounts of data, increasing computational power and low cost storage has made it possible for AI omnipresence [14]. Further, Conversational Artificial Intelligence (CAI) technology allows humans to "talk" with machines, in order to give commands, delegate tasks, have informal conversations and articulate other possibilities through human-machine voice interactions. Conversational AI has the potential of having social memory that can remember connections and relationships that track regularity of pattern of interaction [36]. It makes use of speech-based or text-based AI agents and has the capability to simulate and automate conversations and verbal interactions [26]. The underlying key technology push that bolstered the development of CAI was due to the advancements in Natural Language Processing (NLP) using Machine Learning [51]. Here, when users have a conversation with the system, the audio feed which is converted into a wave file of words, the background noise is removed and the volume is normalized, and the words are broken into basic sounds in English (phenoms). These phenoms are analyzed using statistical probability to deduce whole words and produce sentences [5]. Lastly, the Dialogue Management Systems (DMS) determines what conversations to display to users, tracks the current dialogue state, determines the next action to be taken, coordinate the activity of all components, control dialogue flows, and communicate with external applications [[48], [32], [2]). Together, they function by following the process of input generation, input analysis, output generation, and reinforcement learning to generate a conversation with users. This review gave us the insight that pleasant Human-CAI interactions can be designed by focusing on designing the qualities of the input and the output function of the CAI technology.

2.2 Human-Conversational Agent Interaction Design for In-vehicle voice interfaces

As our research focuses on design of in-vehicle Human-CAI interaction, we looked at numerous research studies in this direction which have indicated that voice assistants are desired and preferred within AVs at various levels of automation [41]. Voice assistants are effective in providing driving assistance, traffic monitoring [44], and aiding drivers at lower levels of automation. However, the current usage of CAI in AVs is towards task delegation, fulfillment of queries and accomplish tasks based on commands. CAI design has to transition to a relationship based interface designed on the concept of 'The 'theory of mind' as people apply their social and interpersonal skills to conversations with computers, and treat different voices as distinct social actors [[42], [19]]. Previous research has proposed

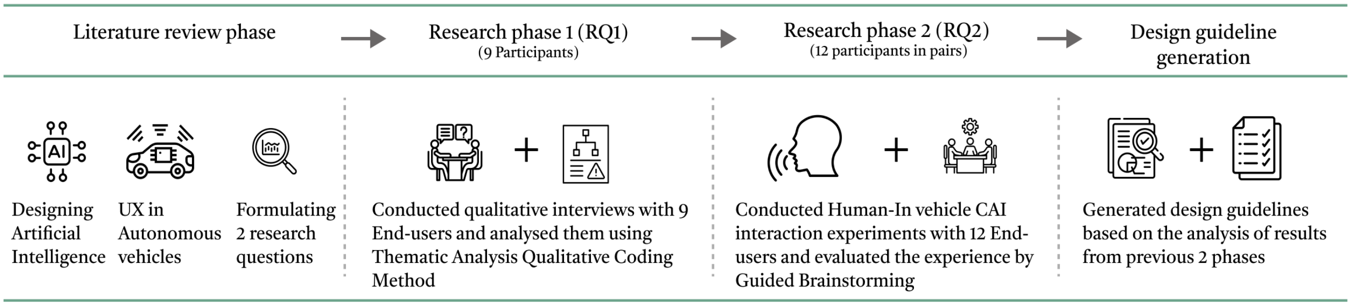

Figure 2: The design research process.

design of conversational voice interfaces should have social intelligence and personification characteristics [6] to fulfill user wants through conversation [18], right vocabulary and a forgiving interpretation of user's language [27], human like polite etiquette during conversations [56], and a good customer journey to reach the goal of the conversation that enable a synergy between humans and the voice interface. The parameters of (1) level of involvement, (2) Hierarchy in the relationship, (3) Negotiated willingness in making decisions, (4) Distinctive interactions, (5) Range of modalities of AI, play an important role in Human-Conversational AI interaction in AVs [55]. Factors for positive Human-Conversational AI interaction experience are identified are Gender, Anthropomorphism, Human-likeness, Natural vs. Synthetic Voices, Vocal Fillers, Affect and Emotion, Accent and Dialect, Paralinguistic Cues, Prosody, and Speech Style, Personality, Morphology and Medium, [[54], [45]. A focus on tone of vocabulary is important where Commanding/formal prompts convey information effectively whereas informal wording can have a delightful effect on drivers [[22], [29]]. Users prefer less intrusive sonic interactions, controlled level of information, mental models, foreseeing the system's behavior, avoid distracting eye gaze and human-like qualities while being polite in conversations [[31], [62]]. Further, three strategies to design conversational Human Voices for more engaging conversations are (1) Message Personalization (2) Informal Speech, and (3) Invitational Rhetoric [34]. A few disadvantages that designers have to be mindful about are lack flexibility and shortcuts, difficult to review edit, and adds additional auditory demand on speech input [[7], [49]]. These studies effectively bring forth the user preferred qualities of in-vehicle voice interfaces to draw from for this research.

2.3 Human-Centered Design Considerations for Conversational AI in AVs

Introducing Conversational AI in Autonomous Vehicles and designing the front-end for NDRTs requires an understanding of Human-Centered Design considerations such as the activities, needs, desires, behaviors and interests that users would like to engage in while traveling in AVs in order to provide a pleasant user experience. Previous studies suggest that users of AVs engage in sleeping, eating, undertaking office work, monitoring vehicle operation, using mobile phones, watching TV, social networking, leisure, eating, reading, focusing on road scene, repurposing their seating postures, resting, communication, self cleaning task, working, assisting, bonding, excercising control, educating, entertaining, guiding, and informing [[21], [25], [53], [28]]. Further, user behaviour study with CAI revealed the following six themes of turn-taking, back-channelling, fillers and hesitations, vague language, mitigating requests and politeness and praise [30]. Users enjoy discussions centered around localization of vehicles, arrangement of meeting places or intermediate stops, informing each other, expectations, assumptions, and unexpected driving behavior of the drivers [47]. Further, people would like to converse with social robots regarding 3 topics which are (1) the physical world of stuff and things, (2) the social world of people, agents and relations, and (3) the abstract world of ideas, information, data and thought [40]. 12 user needs identified within fully automated vehicles 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 [33]. The topics of conversations that people are interested in having with CAI are classified into six themes of conversation topics between users and CAI [43], 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). However, the industry needs to transition from designing voice interfaces as a "virtual butler" (reacting to the user) to that of a "virtual companion" (self-aware and autonomously acting) [37]. As it isn't clear how cooperative behavior between humans and AVs should be designed [36], a research gap exists that we explore further. Through our research and research questions, we make an effort to study if Conversational (Generative) AI can be employed to mediate and enable pleasant and effective Human-AV interaction for a collaborative driving experience.

3 METHODOLOGY

In this research, we wanted to understand (1) the roles and relationships that Conversational AI could play towards end-users while traveling in Autonomous Vehicles, and (2) end-user's evaluation of the aforementioned roles and relationships during various

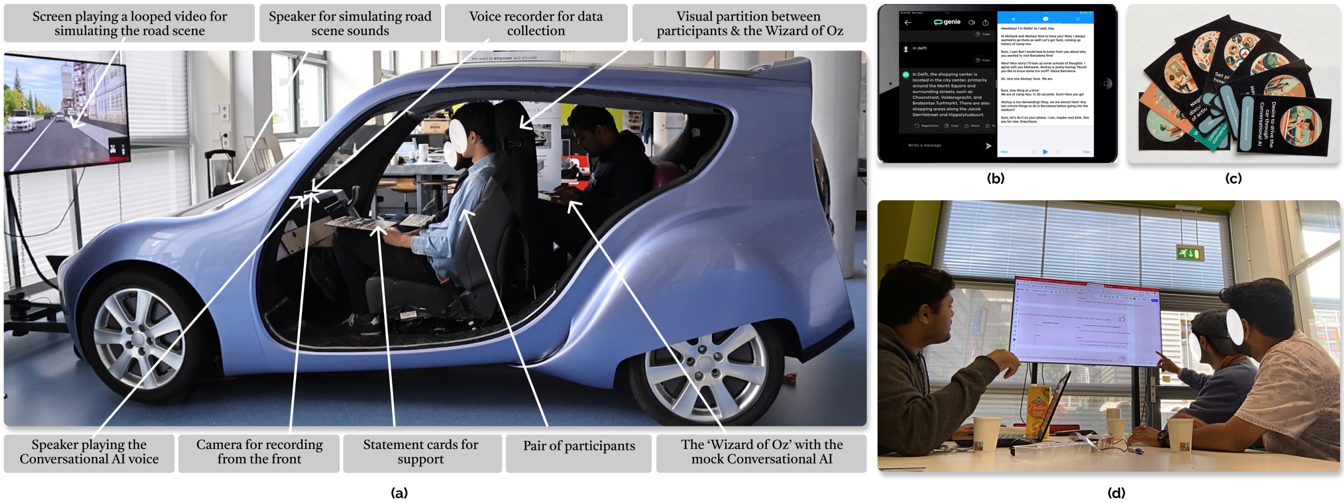

Figure 3: (a) The simulator setup using a prototype Autonomous Vehicle. (b) The Conversational AI mock set-up operated by the 'Wizard of Oz': Genie App + Text to speech software. (c) Statement cards for support (d) A brainstorming session in progress.

scenarios of usage. The research was conducted in two phases dedicated to investigating one research question each, as displayed in figure 2.

3.1 Qualitative Interviews to answer RQ1

To identify Conversational AI roles and relationships, we employed a qualitative method of conducting semi-structured interviews [46], because it allowed for flexibility in words, spontaneous formation questions and inquiring deeper into specific topics. To streamline this session, interview guides were formed beforehand. To identify Conversational AI roles and relationships, we employed a qualitative method of conducting semi-structured interviews [46], because it allowed for flexibility in words, spontaneous formation questions and inquiring deeper into specific topics. To streamline this session, interview guides were formed beforehand.

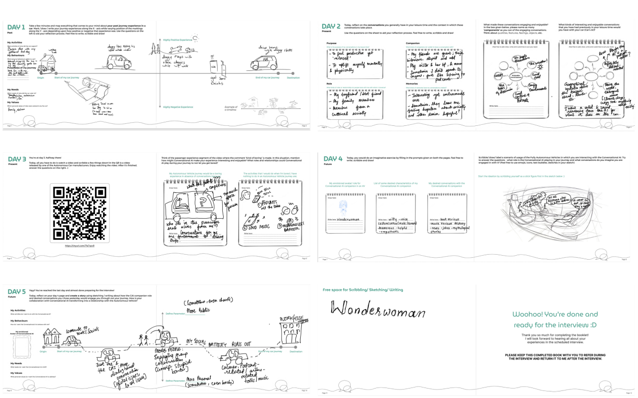

Figure 4: Pages of sensitising activity booklets filled-in by participants over 5 days as a preparation for the qualitative interview.

Further, to prepare participants for the interviews, they were provided with a sensitizing booklet to reflect (write and draw) over 5 days prior to the interview, created using the learnings of the literature review. It was developed based on the path of expression line of inquiry [52] encompassing past, present, and future experiences. Contextmapping as a design research method was used as it enables the investigation of contexts of user-product relations and interactions in which tacit knowledge is gained [61]. The booklet as displayed in figure 4 had the following content: (1) Day 1 - Past experience of a car journey, (2) Day 2 - Enjoyable conversation topics and companions, (3) Day 3 - Reflection on positive and negative travel experiences in AVs, (4) Day 4 - Envisioning future conversations with AVs and ideating CAI companions, and (5) Day 5 - Envisioning future journeys with the CAI companion in AVs. Interviews conducted had questions for each day wherein participants could refer to the filled in booklet while answering.

3.2 In-vehicle Human-Conversational AI Interaction and evaluation experiment to answer RQ2

To assess the embodied user experience of CAI roles and relationships, Human-technology interaction experiments were conducted using the design research methods of Participant Enactment [[55], [4]] and Wizard of Oz [9]. Upon the interaction experiments, we conducted Guided Brainstorming sessions having questions developed using the Subjective Assessment of Speech System Interfaces (SASSI) questionnaire [20].

3.2.1 Experimental Procedure. Participants in pairs had to sit in a laboratory vehicle prototype, with a multimedia system simulating the road scene consisting of a screen, 2 speakers, 1 voice recorder and 3 cameras placed around it as displayed in figure 3. The road scene was that of a car driving in loops from a city through a rural area amidst traffic with the purpose of providing a background experience while having in-vehicle conversations. The experiment was conducted in pairs to increase the chatty-ness of conversations in setup and make it easier to enact a scenario together. Further, results from the first phase pointed out the participants saw AVs to be predominantly a shared form of mobility. They then had to interact with the top 3 Conversational AI roles found in the phase 1 of the research and personally enact roles based on the top 3 purposes of travel identified in the research. Each sub-session specific to one role continued for 10 minutes and three of such sessions took place per participant pair. A 5-minute priming session was conducted before the start, to get used to speaking with the Conversational AI, practice enactment, and get a feel of how the conversations will go. The order of the roles was randomized to avoid order effect. The Wizard of Oz controlled 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. Two significant limitations of this experiment that the participants were asked to ignore were: (1) The delay or occasional mistakes in Conversational AI responses, and (2) The vehicle would be stationary and participants would have to imagine its movement.

Users imagined a journey based on a specific purpose of the journey and enacted a role related to the aforementioned journey scenario using speech or explicit form of human interaction. The 'Wizard of Oz' listened to their conversations and generated responses from the Conversational AI setup using a voice-based readout application. Statement cards developed based on phase 1 research results were made use of by the participants to support themselves in having free- flowing conversations in case they needed reference to continue with conversations and to avoid the participants from going silent. 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. Following this Human-Technology interaction experiment, a guided brainstorming session of 45 minutes was be conducted in which the participants had to brainstorm on the parameters of (1) Likeability, (2) System Response Accuracy, (3) Cognitive Demand, (4) Annoyance, (5) Intuitiveness, and (6) Speed, which were adapted from the SASSI questionnaire. The line of questioning during Brainstorming specifically asked for positive aspects and negative aspects for participants to formulate clear qualitative responses.

3.3 Data collection and analysis

The qualitative interviews were conducted online and recorded for video and audio using Microsoft Teams. The audio was transcribed and analyzed using the Thematic analysis method [3] wherein all recommended phases of familiarization with the data, noting down of initial ideas, and undertaking two rounds of in-vivo coding to reveal codes, themes, aggregate dimensions [16] were followed. The 5 day sensitizing books were also coded and analyzed for creative visual expressions of the end-user's experiences for deeper insights. Intercoder triangulation was achieved through review of codes and peer-debrief of various interpretations by all the authors. Further, the interaction experiments were recorded with video and audio, and the additionally digital Miro canvas was used for the Guided Brainstorming session. The notes from the guided brainstorming session, written qualitative statements of the participants on Miro as well as the transcripts of 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 [38] to map out the brainstormed qualitative responses received under parameters of SASSI [20].

3.4 Participant characteristics

We used convenience sampling through email invitations as well as public advertisements on social media to recruit participants within the authors' institution. Consent in accordance to EU GDPR was recieved from participants in advance. The age ranged from 19 to 29 (5 male and 4 female). The participants had to have driving experience and represent Generation - Z who would be future users of this technology. For the qualitative interviews, 9 participants were recruited from around the world (referred with 'U' notation). For the interaction experiments, 12 participants (referred with 'P' notation) were recruited and paired randomly in 6 groups (5 same-gender pairs and 1 mixed-gender pairs), 9 male and 3 female, living in the Netherlands. They were familiar with each other being from the same institute.

4 RESULTS

We present findings from the two research phases in two sections of (1) End-user interviews based on the Contextmapping exercise, and (2) Guided Brainstorming on the user's interaction experience with embodied CAI. In the first section, analysis of End-user interviews are presented under the 8 aggregate dimensions which convey (1) Conversational AI roles for Autonomous Vehicles, (2) user requirement for information about the journey, (3) desired content of conversations with in-vehicle CAI, (4) in-vehicle user activities, (5) user interactions with in-vehicle environment, (6) user interactions with out of vehicle environment, (7) CAI mediated shared control over AVs, and (8) design aspects of CAI. In the second section, we present findings from the guided brainstorming session conducted to analyze in-vehicle Human-CAI interaction experience.

4.1 Findings from semi-interviews based on the Contextmapping exercise by participants.

Here, the insights from participant interviews based on a 5-day sensitizing are presented as aggregate dimensions and themes that emerged from the thematic analysis. These are also summarised in figure 5

4.1.1 ***Aggregate Dimension 1: Elicited Conversational AI roles for Fully Autonomous Vehicles.*** Roles for hospitality services was the theme with the most number of codes (41 codes), with the Roles of a CAI Tour Guide (20 codes), CAI Party Host (1 Code), and roles related to food services (20 codes cumulative). Roles for mentorship and advice was next theme (40 Codes) suggesting the role of CAI Mentor (Advisor)(18 codes). Subsequently, roles to entertain users evolved (30 codes) which described CAI Storyteller (14 codes), CAI Podcaster (12 codes) and CAI Disk Jockey (4 codes). CAI roles for inspiring and motivating was next (23 codes) where AI Motivational Speaker (9 codes) was suggested. Subsequent findings were Anime/Cartoon characters theme (19 codes), CAI Butler role

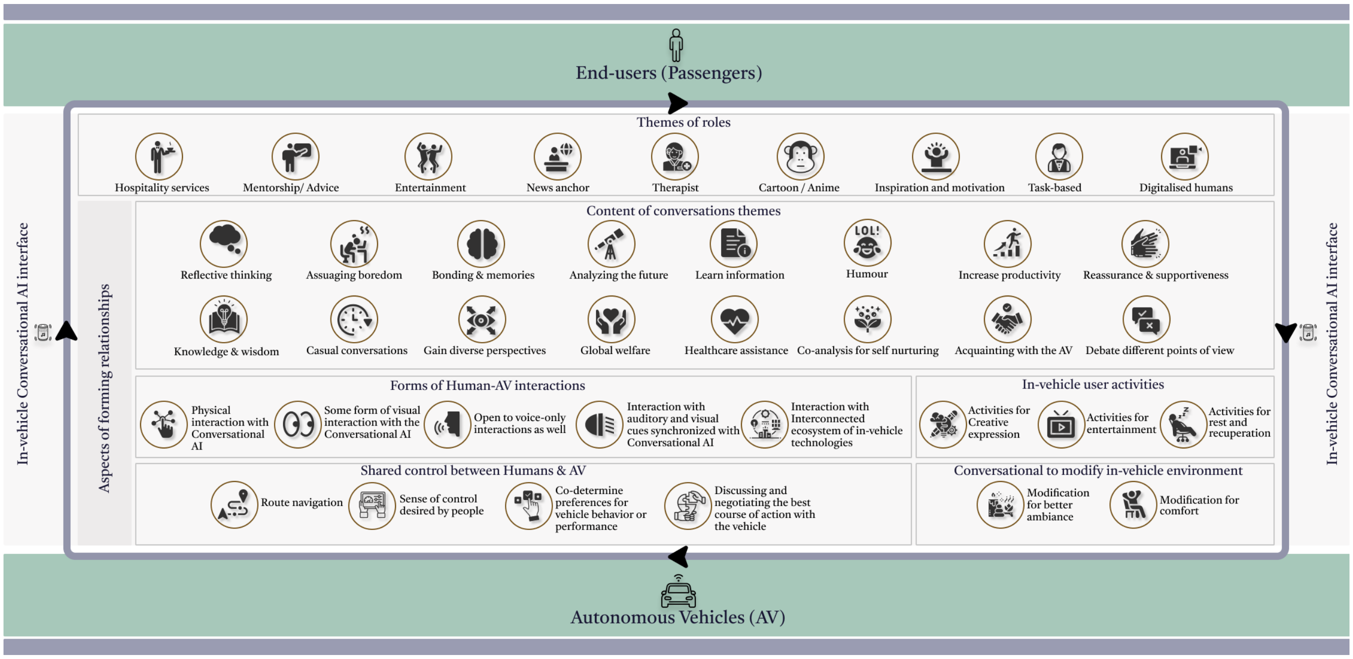

Figure 5: Roles and aspects of relationships that the in-vehicle Conversational AI interface can play towards users of AVs.

(16 codes) under task-based CAI roles theme, CAI roles under news anchor theme (14 codes), CAI roles for therapy theme (8 codes), and CAI roles under lovers theme (7 codes). In CAI roles under digitalized humans theme (6 Codes), Participant U4 felt that a digital twin or a dear one could be played by the CAI. Thematic roles with low code amounts were CAI role of providing security by U4 (4 codes), Conversational AI role of a shopping assistant by U3 (3 codes), and Conversational AI role of an emergency service provider by U1 and U2 (3 codes). In summation, CAI Tour Guide, CAI Mentor (Advisor), and (3) CAI storyteller emerged as the top three CAI roles desired for AVs.

4.1.2 ***Aggregate Dimension 2: Information about the journey.*** Participants discussed that the nature of the journey would influence the kind of role the users would desire to interact with during the journey. Gauge the purpose of travel was the most coded theme (37 Codes) where user's purpose of travel would influence the choice of role they would desire to interact with. Most popular purposes of journeys were (1) Professional work, (2) Leisure, (3) Shopping, and (4) Health and Well-being. Cultural and religious, adventure, and the transportation of luggage were the lesser mentioned ones. Information about the vehicle's journey was the second theme (33 Codes) where a desire was expressed for status update on vehicle performance such as fuel efficiency, fuel level, energy need, air pressure, engine temperature, estimation of the time, localities while transiting, information about the destination, distance of travel, and weather outside. AVs as shared mobility services was next (18 Codes) in which participants thought that autonomous vehicles would most commonly be used in a shared scenario with multiple passengers and would desire information about fellow travelers. Travel duration influences interaction was the last theme where participants noticed that the duration of in-vehicle presence due to the length of the journey would influence the nature of interactions with CAI roles.

4.1.3 ***Aggregate Dimension 3: desired content of conversations with Conversational AI in Autonomous Vehicles.*** Themes under this dimension are self explanatory. In descending order code amount, the themes were Conversations for knowledge and experience-based wisdom (74 Codes), followed by Conversations for reflective thinking (72 Codes) where a desire for deep and healthy conversations on philosophical topics that enable people to reflect back on various pursuits of life and allow to articulate a possible future course of life ahead. The next themes were, Conversations to assuage boredom in AVs (64 Codes), Conversations for emotional bonding and memories (61 Codes), and Conversation about analyzing the future (42 codes) where participants wanted to critically co-analyze with AI to chart a future course for themselves, for the vehicle's journey itself and take a negotiated decision with the vehicle. After these, Conversations to learn information (38 Codes), Humorous and playful conversations (37 codes), and Conversations to increase professional productivity was a theme (30 Codes) where participants described would increase their professional productivity, such as scheduling assistance, drafting emails, preparing for meetings and sending messages. Next in order were reassuring and mentally supportive conversations (29 Codes) where the participants spoke about how conversations were a key in providing mental and emotional support to them with an empathetic personality in their lives, and desired this from the AI. The desired that good intentions of the AI to be conveyed through transparent ethical design of Conversational AI's technology wherein an assurance of passenger's data security and privacy should be regularly provided.

Some of the other self explanatory themes were Conversations to gain diverse perspectives (27 Codes), casual conversations (24 Codes), conversations for healthcare assistance (20 Codes), non-judgemental CAI for co-analysis of users to nurture themselves (20 Codes), acquainting with the AV through Conversational AI (12 Codes), conversations to debate various points of view (11 Codes), and Conversations about global welfare (11 Codes).

4.1.4 ***Aggregate Dimension 4: User activities for interaction with Conversational AI.*** Participants discussed activities they would undertake in a car to assuage boredom. User activities for creative expression was the most discussed theme (76 Codes) where participants felt that the free time within the Autonomous Car would be best spent being engaged in creative activities. They discussed activities such as making paintings, singing, and learning instruments where in Conversational AI could play the role of a prompt suggestor, facilitator of ideas or a co-ideator inspiring creativity. User activities for entertainment was the next theme (61 Codes) where AI- generated music, videos, karaoke, games, and comedy could entertain users. User activities for rest and recuperation was the last theme (43 Codes) wherein participants would rest and remain silent and the CAI could create a conducive environment for it.

4.1.5 ***Aggregate Dimension 5: User in-vehicle interaction with internal environment.*** Participants discussed that Conversational AI could provide users the option of interacting with the internal environment using the voice-based interface. Desire for physically interacting with Conversational AI was the first theme that evolved (23 codes) where physical interaction through physical elements connected to the voice interface were desired using body movements, gestures, facial expressions and other nonverbal means. Visual technology support for Conversational AI was a theme (20 codes) where forms of visual support through screen-based visualizations or cues would be required while interacting with the CAI interface to increase legibility and relatability, using either the faces of roles or text and graphics to display conversations. U8 suggested flexible and modular interfaces that can seamlessly appear and disappear while U3 proposed holographic projections. Voice-only interfaces was an equally discussed theme (20 Codes) where people would enjoy mental visualization generated from conversational voice only interfaces freeing up their eye gaze. Few other interesting themes were Conversational AI synchronized with auditory and visual cues, to indicate the turn to speak improving quality of interaction. This was followed by, Centrally accessible in-vehicle location of the Conversational AI and Interconnected ecosystem of in-vehicle technologies. U8 & U2 suggested that conversational AI must be developed as an ecosystem of technologies interconnected for a better user experience. Lastly, CAI mediated modification of the in-vehicle environment were discussed. Modification of in-vehicle environments for better ambiance (83 Codes) and Modification of in-vehicle environments for comfort (43 Codes) were two themes identified.

4.1.6 ***Aggregate Dimension 6: User in-vehicle interaction with external environment.*** Conversations about the external environment for information was the first theme (30 Codes) wherein participants discussed that it would be natural for passengers to have conversations and interact with the external environment of the vehicle mediated by Conversational AI. They would be interested in knowing the vehicle's context such as location, weather conditions, and shopping locations. U1 mentioned that bad external environments such as traffic jams, pollution, and bad road conditions can create a bad in-vehicle user experience. Desire for interaction with the external environment was the second theme (27 Codes) wherein the Conversational AI could describe buildings, tourist places, scenery, and the activity of looking outside could be made interactive.

4.1.7 ***Aggregate Dimension 7: Shared control of Autonomous Vehicles mediated by Conversational AI.*** Though people expect Autonomous Vehicles to function independently, there are certain aspects wherein people expect to retain and share control of, an option that can be effectively offered through Conversational AI. The themes identified in this dimension are activity of route navigation (23 Codes), co-determining preferences for Autonomous Vehicle's behavior or performance (8 Codes), and discussing and negotiating the best course of action with the vehicle (6 Codes). U4 mentioned that users would miss the sense of control in autonomous cars (12 Codes), the very reason they enjoy driving.

4.1.8 ***Aggregate Dimension 8: Design Aspects of Conversational AI for Autonomous Vehicles.*** Personalization of experience by understanding the user was a theme (78 Codes) where conversations with empathy towards the user's life were the most memorable ones. Familiarity increases the amount of conversations was the theme (61 Codes) where participants mentioned that Conversational AI should be designed to give a sense of familiarity to the user's cognition, to have qualities of dependability, anthropomorphism and to maintain long term relationships. Few other themes were Design for civil behavior of Conversational AI (31 Codes), Authenticity and Acknowledgement of artificial characteristics of AI (30 Codes), Soothing and pleasant voice design of Conversational AI (27 Codes), Intelligent content of conversations (32 Codes), and Ability to discuss opinions and facts separately (20 Codes).

4.2 Guided Brainstorming on the user's interaction experience with embodied CAI

We studied how users qualitatively assess the real world scenrio of embodied user experience of CAI roles and relationships for AVs by conducting a Guided Brainstorming exercise using the parameters of SASSI questionnaire [20].The findings are presented below and are extensively described in table 1.

Likability: The participants liked the user-friendly way of interaction with the AV provided by CAI which releases them from the stress of pre-thinking suitable commands, and disliked the inability to control the verbosity or brevity of the AI depending on the user's mood as articulated here: *"Saves time in terms of pre-thinking specific commands. The Conversational AI can discuss with you to understand your specific intent." (P3 and P4).*

System Response Accuracy: The participants believed that the intent of mental stimulation through having a companion was accurately fulfilled, however the conveying of user's intentions if

Parameter	Value	Description	Representative Quote
Likeability	Liked aspects	Participants liked the user-friendly way of interaction using voice which is natural and relatable due to its emulation of human qualities. Further, it frees up eye gaze, increases convenience of gaining information / services, relives stress of pre-thinking suitable commands, and provides for a companion during the journey.	*"Convenient to know information while releasing eyes from straining .... convenient to get location related information and recommendations while traveling." (Session 3 - P5 & P6)*
	Disliked aspects	The interface was disliked as it was unable to have deep conversations personalized to the user as it' unable to understand human experience gained over the years. Further, AI's tone of voice not matching a human's way of speaking and not having the flexibility in transitioning of roles was disliked. Lastly, the amount of conversation desired from the AI will depend on the user's mood and users should have the option to determine it.	*"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)*
System Response Accuracy	Instances of improvement	The intent of (1) mental stimulation through having a companion, and (2) maintaining some form of shared control over the AV were effectively fulfilled. The were positive that intent detection will improve over time with advancement in technology.	*"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)*
	Instances of deteorioration	The instances of deteoration were when (1) AI doesn't understand humans' intentions from an experiential or human psychology perspective, (2) the length of responses of AIisn't in sync with the mood of users, and (3) lot of prior information is required for users to formulate a query for the AI.	*"The conversational AI may understand the intent/ question superficially. It should ask deeper questions to empathize with the user." (Session 3 - P5 & P6)*
Annoyance	Pleasant aspects	The aspects which were pleasant to users were(1) the free-flowing conversations by AI without requiring a prior formulation of prompts, and (2) the presence of a companion to entertain and guide the users with knowledge or information.	*"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)*
	Annoying Aspects	Participants felt annoyed when (1) the AI-generated unintelligent general responses, (2) did not accurately detect the intent of conversations, (3) the content was not of high standard, (4) interrupts a good conversation unintelligently, and (5) the design forces humans to be overdependent on AI to accomplish basic tasks and interactions.	*"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." (Session 3 - P5 & P6)*
Cognitive Demand	Decrease in Cognitive Demand	There is a decrease in Cognitive Demand as (1) a possibility of effortless interaction is provided with the AV, (2) personalisation of services to the users and relatability is generated due to a human voice, and (3) seamless transitioning between the roles with a general persona is provided.	*"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)*
	Increase in Cognitive Demand	The Cognitive Demand increases when (1) the AI doesn't inform humans of it' s spectrum of possibilities, (2) does not have a suitable tone of voice, (3) humans don't understand the amount of effort required to hold the conversation, and (4) doing a simpler task with Conversational AI when it's easier done with other means.	*"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)*
Intuitiveness	Reasons for intuitiveness	Intuitiveness increases when (1) AI stores the user's personal information, which would increase the co-understanding increase the co-understanding, (2) it is user-friendly and naturally relatable for users, (3) humans understand AI's possibilities and limitations, and (4) AI displays social etiquette and polite behaviour.	*"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)*
	Reasons for un - intuitiveness	Intuitiveness decreases when (1) new users face difficulties in understanding how to use the interface, (2) a visual support system for the AI is absent, (3) a system of signifiers to indicate who is to speak is absent, and (4) there is a lack of understanding of interpersonal dynamics.	*"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)*
Speed	Faster response	Faster responses where desired when (1) information and task based responses are wanted, (2) there is an emergence, and (3) shorter responses are expected. It's expected that the AI should sense the situation and nature of conversations to decide a pace.	*"It should understand the mental context and passenger's emotions, and respond faster accordingly." (Session 4 - P7 & P8)*
	Slower responses	Slower response speed is desired when (1) lack of gaps in conversations makes the voice look robotic, (2) users have to be given sufficient to process information with higher cognitive demands, and (3) to set a mood of calmness.	*"When the cognitive functions are higher, the response should be slow and vice versa." (Session 5 - P9 & P10)*

Table 1: Findings of the Guided Brainstorming exercise analysed under the parameters of SASSI questionnaire

the CAI does not understand humans' intentions from an experiential or human psychology perspective will lead to a deterioration of the system's response accuracy as described here: *"It will not convey intentions accurately as it will not sense the emotion behind the person." (P3 and P4)*.

Annoyance: People found it pleasant that there would be a companion to entertain and guide them while it was annoying when the AI generated unintelligent general responses that were not tailored to the user's specific query as stated here: *"When AI gives answers unspecific to the user's intention/ query and the user cannot stop it from continuing for re-asking the question." (P9 and P10)*.

Cognitive Demand: Although personalization of services to the users and relatability generated due to a human voice reduces Cognitive Demand for people, they found it to be more Cognitively Demanding when the CAI doesn't inform humans of the spectrum of possibilities as described here: *"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." (P5 and P6)*.

Intuitiveness: While conversations are an intuitive way of interaction for users, without a system of signifiers to understand who should speak the system would be unintuitive as mentioned here: *"Only having a voice interface, without visuals or other signifiers may* *be difficult to communicate with as it should help construct a mental model." (P7 and P8).*

Speed: While information and task- based conversations should have higher speed of conversations, but they should be at a slower speed when users need to process the information with higher cognitive functioning as articulated here: *"It should understand the mental context and passenger's emotions, and respond accordingly." (P7 and P8).*

5 DISCUSSION

Our End-user interviews revealed that the lack of driving-related tasks for users and the absence of human control over the vehicle will require an understanding of new needs [10] related to enhancing the user experience of traveling in AVs, which will aid in the design of CAI in AVs.To meet new needs in future autonomous experiences, a creative idea generation-based design process, as articulated by Gomez-Beldarrain et al. [17], would help designers infuse flexibility and adaptability into the voice interface to accommodate different user preferences.

Further, though CAI allows for free flowing conversations, it may lack the provision of meaningful experiences [17] and relationships as CAI doesn't understand conversations from a human life experiences point of view, thus reducing the scope for deeper conversations. Our Guided Brainstorming session to evaluate interaction experience revealed that although users wanted to speak to the CAI about interesting observations of the external vehicle environment and the road scene, these conversations may not relate to both the theme of the CAI role being played and the purpose of the user's journey.

While our research pointed out that CAI improves the in-vehicle User Experience, we discovered that users would also want to make use of CAI as a mediator for sharing control of the driving experience with the AV, and for interacting with the vehicle's mechanisms on the lines of the findings by Xing et al. [63] whose research articulates that the human driver and the automation should be allowed to jointly evaluate the actions from both sides and generate optimized solutions for a better driving experience.

Furthermore, we noticed that designing CAI interfaces in AVs would require determining a suitable level of complexity of interaction with the voice interface while giving users the option to co-design the qualities of the interface. Although participants preferred an intelligent conversational interface, an overly complex of user interface negatively affected their in-vehicle user experiences similar to findings of Currano et al. [8] due to which they preferred CAI for simplified use cases and disliked its overuse to mediate in-vehicle interactions. On the contrary, due to the effect of novelty, users might adhere to existing interaction patterns they are accustomed to, as noticed by Rothenbucher et al. [50] and avoid the use of the CAI interface altogether.

Accordingly, we realized that the potential roles and relationships that CAI can play towards future users of AVs fall short in their quality of user experiences due to (1) inability to understand conversations from human life experiences point of view, (2) lack of flexibility and adaptability to provide users with a personalized experience, and (3) apprehension with the complexity of the voice interface while undertaking in-vehicle interactions. Hence, to provide people with a positive user experience, there is a need to infuse qualities of Human-centeredness into the design of CAI for AVs. Towards this, we propose a set of design guidelines, based on both phases of our research.

5.1 Design Guidelines

To tackle the breadth of challenges of designing the qualities of voice-based interactions while following a suitable design process for designing Conversational AI interfaces in Autonomous Vehicles, we recommend that:

5.1.1 ***Conversational AI interfaces should integrate into an ecosystem of technologies within and beyond Autonomous Vehicles to provide a seamless user experience.*** Though Conversational AI has the ability to process and respond to in-vehicle spoken dialogue, it would require an extensive technological set-up within vehicles to gather data to understand human intentions and conversations from an experiential or in-vehicle human dynamics perspective, as discussed in Section 4.1.5. A systems-thinking-based design approach is necessary for its integration into a larger ecosystem of networks accessed by the end user outside of the vehicle, as outlined in Section 4.1.6. The possibility of Conversational AI to migrate across many devices could provide the user with a unique conversational companion present throughout.

5.1.2 ***The design of in-vehicle Conversational AI should not conceal characteristics that reflect its artificial nature but rather leverage them in implementing the roles it takes on to provide an authentic user experience.*** This research discovered that users wanted to experience characteristics of the underlying technology, as they valued the genuineness of experience and disliked the outright mimicking of human characteristics to design Artificial Intelligence as a metaphor for Human intelligence. 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 sufficiently human-like in exhibiting the unique qualities of the role being played, as outlined in Section 4.1.8.

5.1.3 ***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.*** 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, learn from each other, and facilitate the formation of a bond between users and the vehicle, while bolstering user's perception of the interfaces' usefulness. Transitioning to user relationships with Conversational AI from its task-based utilization can be achieved through the interface mediating the user's desired in-vehicle activities, interactions, and topical conversations, as described in various sections of 4.1.

5.1.4 ***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.*** Our research showed that irrespective of AI roles being played, conversations between passengers and AI tended to be influenced by the nature of the user's trip, the road scene and the things they saw outside the vehicle as described in Section 4.1.6.

5.1.5 *The design of the Conversational AI should communicate to users the limits of its capabilities to avoid unsuccessful user interactions.*

Being unfamiliar with Conversational AI's spectrum of possibilities, it is distressing for users to attempt and not get relevant responses as discussed in Section 4.2. Similar dissatisfaction arises due to unaccomplishment of user's commands, when the technology isn't built to act on those commands. Indicating such limitations would increase the user-friendliness of the interface and reduce cognitive load.

5.1.6 *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.*

Participants expressed the need for mental reassurance from the voice interface about the ethical usage of their data, since sensing good intentions behind the usage of their data is important for users, as outlined in Section 4.1.3. As maintaining ethical standards is a continuous procedure, communicating with users is important.

5.1.7 *Conversational AI should be judiciously implemented in order not to annoy or overwhelm the passengers of Autonomous Vehicles.*

The tendency to overuse Conversational AI for many of the in-vehicle functions and features is annoying and cognitively burdensome, especially in cases where simpler alternatives exist as discussed in Section 4.2. Limit the usage of Conversational AI to situations and applications where it's most effective, while providing users with control options such as setting the verbosity or brevity of the Conversational AI.

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

Empathizing with users to understand their preferences and intents better, will help ensure that user preferences are prioritized over those of the AI system, while being mindful of local idioms, usage of civil vocabulary, and sensitivity to users' conversational style as discussed in Section 4.1.8. Flexibility and adaptability of interface will enable mass personalisation.

5.1.9 *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 to ameliorate untoward behavior of the Conversational AI interface since it may be difficult to preempt these during initial deployment, as mentioned in Section 4.2.

6 LIMITATIONS AND FUTURE WORK

This research has limitations as outlined below, however these could be interesting opportunities for future research. Firstly, users' behavior, activities, and needs while interacting with in-vehicle Conversational AI, might differ based on individual versus shared in-vehicle occupancy which hasn't been tested. 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, this study hasn't been able to test the effect of different language cultures as well as road cultures on user interaction with Conversational AI in AVs. Fifth, this study was specifically focused on users from Generation Z who like talking and the study being conducted in a university location had participants who may have a higher level of tech- awareness. Looking outside these participant segments may lead to new insights. Sixth, validating the desire for shared control and the effectiveness of conversational AI to serve as a medium to do so, as mentioned by participants, could be taken up by future work. 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

7 CONCLUSIONS

In this research, the intent was to discover design innovation opportunities for Conversational AI to be developed for Autonomous Vehicles. We did so by first identifying Conversational AI roles and relationships desired by users through qualitative interviews based on context mapping techniques and applying thematic analysis to analyze them. Further, we studied how end-users interact with and assess the concept of roles and relationships when embodied in Autonomous Vehicles through an experimental setup of Conversational AI in a vehicle simulator, followed by a brainstorming session. The top 3 Conversational AI roles that emerged were AI Advisor (Mentor), AI Tour guide and AI Storyteller. The aspects that will enable Conversational AI mediated Human-AV relationships are (1) user desired content of conversations, (2) in-vehicle user activities, (3) in-vehicle user interactions and (4) some forms of shared control. Furthermore, along with positive and negative UX evaluation of the embodied concept, design guidelines are presented to inform the work of industry professionals and academic researchers. We hope that the knowledge generated in our research will inspire future design research projects.

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