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When do People Expect Effortless In-Car Interactions?

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ABSTRACT

Drivers have experienced various in-car interactions due to advanced infotainment systems and digital integration in cars. The scope of in-car interaction is likely to be further expanded in autonomous driving due to the increased free time in the car for focusing on non-driving activities. When designing in-car interactions, enhancing the in-car user experience by giving drivers new abilities and providing them with effortless and intuitive interactions is a worthy goal. Hence, understanding users' perspectives in the early phases is the critical first step to informing the design process. Although prior studies have revealed users' expectations and needs in an autonomous vehicle, there is a lack of understanding of when and in which context users might most desire effortless interaction. This investigation aims to examine users' expectations and identify themes for effortless in-car interaction. One hundred fifty participants were recruited using a purposive sampling strategy. The study consists of an open-ended online questionnaire that enquired about the context in which people desire effortless interaction within a car the most. Questionnaire responses were clustered into themes using a thematic analysis method. The study proposes a taxonomy of in-car contexts composed of six major themes, with 17 sub-themes, which include the following contexts: 1) switching-required, 2) emotion-underlain, 3) idle- away, 4) less-controllable, 5) time-sensitive and 6) task-oriented. The findings provide guidance regarding the critical contexts of effortless interaction, which designers can use to better understand and improve automotive user experiences.

Keywords: User experience, Effortless interaction, Human-centred design, User context, Autonomous vehicles, Taxonomy of in-car contexts

INTRODUCTION

Cars have become more complex systems with interactive digital technology and advanced infotainment systems (Svangren et al. 2017); consequently, drivers are experiencing a variety of in-car interactions (Schmidt et al. 2010). In-car interactions are more likely to be expanded in future due to increased car autonomy that enables drivers to focus on non-driving related activities (Viereckl et al. 2015). Drivers' behaviours, expectations and desires are thus expected to alter in an autonomous vehicle (AV) as it will not be necessary for drivers to pay attention to the road all the time. This opens up opportunities for designing in-car experiences as interactions within future vehicles will no longer be expected in one fixed spot. As such, how can we provide

drivers with easy, simple and intuitive interactions so that they effortlessly achieve what they want within an AV? To maximise effortless interactions within an AV that satisfy users' needs, designers require knowledge of users' expectations and requirements (Pettersson 2017; Lee et al. 2021).

Indeed, previous studies have explored users' expectations within an AV to support design decisions. Kim et al. (2015) created six expected activity categories by exploring the design direction of AV's full-windshield displays in the future. Many other studies (Jeon et al. 2018; Hecht et al. 2019; Stevens et al. 2019) identified a variety of users' expected non-driving related activities within an AV space such as sleeping, doing work and social networking. To move forward, understanding holistic views of different contexts that can assist drivers through effortless interactions will also be beneficial. This can expand the knowledge of drivers' needs in AV interaction and how an AV can support activities before introducing new interfaces. Therefore, we investigated users' expectations of effortless in-car interactions that do not require multiple steps of access. We attempted to understand user expectations through an open-ended questionnaire. The study has uncovered a taxonomy of in-car contexts in which users might desire effortless interactions in an AV. It will provide basic guidance for designers to better understand critical contexts of effortless interaction and consider how such information can be delivered and displayed when developing the future interface.

RESEARCH DESIGN

Open-Ended Online Survey

We conducted an open-ended online survey and adopted a qualitative approach as the overall outline to gain personal worldviews, desires and expectations about in-car experiences (Braun et al. 2021). This allowed us to produce rich and complex knowledge of subjects' experiences because subjects were prompted to respond in their own words instead of selecting pre-determined options (Braun et al. 2021). Also, it provided an opportunity to collect data from a large number of participants (Alessi and Martin 2010).

When using the open-ended survey as an instrument to reveal knowledge, designing the questions is one of the most crucial and complicated parts of the research (Smyth 2016). We have crafted four open-ended questions and centred them on the effortless interactions inside the car. The questionnaire was intended to emphasise participants' emotional experiences while extracting their most hidden desires for their future in-car interactions. Considering that emotion shapes people's attitudes, thoughts and behaviours in their in-car experiences (Martin et al. 2008; Pettersson 2016; Braun et al. 2018; Ike et al. 2021), both negative and positive emotional experiences were asked about in the questionnaire to understand in-car user interactions and behaviour (Vaa 2007; Cha 2019).

Two retrospective questions were asked about participants' lived negative emotional experiences inside the car, for example, 'When you are inside the car, can you describe the specific moments when you experienced negative emotion (e.g., frustration, irritation, urgency, anger, confusion or disappointment) because an activity or feature of the car requires too many steps to

access?'. These helped them to infer from their negative and effortful experiences to find if they would seek effortless interaction for it in future. Two other prospective questions were used to reveal their positive expectations. One focused on their positive emotions about the effortless interactions in a future autonomous car: '*You got into your self-driving car after a busy busi- ness trip on that Friday evening. What situations or activities would improve your mood (e.g. make you feel more comfortable, joyful, entertained and ple- asant) if they were accessible in just one step?'*. Another question *('Imagine that you are in 2050! Your fully self-driving car can anticipate your targeted commands and make arrangements accordingly. In that case, which situati- ons would you desire the car to anticipate and take action? How?')* was used to elicit future desires by offering a mini future in-car scenario where the car is proactive, intuitive and effortless.

Participant Sampling

In taking a purposive sampling strategy (Campbell et al. 2020), our inclusion criteria for recruiting participants were them being older than 18, having the ability and experience to drive, being willing to participate and contribute to this topic, and having access to a necessary digital device to complete the survey. Online channels such as social media platforms, research websites and online discussion forums were used for participant recruitment. In total, 150 participants completed the survey over two weeks. The participants' ages ranged between 18 and 61. Of the participants, 74 were male and 71 were female. The average age was 30. The remaining five participants either identified themselves as Questioning/Unknown or preferred not to mention their gender. Since our priority was to identify the potential in-car contexts, the information related to their names, titles and occupations was not relevant. The research participation was anonymous, which allowed participants to express themselves more freely and without the fear of being judged when expressing their emotions (Alessi and Martin 2010).

Data Collection

Firstly, full ethics approval was granted by the university before starting data collection. To gather appropriate types of responses, a pilot test was performed to have clarity on the qualitative survey questionnaire and relevant process (Braun et al. 2021) before circulating the survey. After receiving responses from 10 participants, the question wordings were amended, and the survey platform was checked to ascertain whether it was accessible from both desktop and mobile devices. Pilot testing helped us to determine a clearer direction and to decide upon using a creative platform. After that, the survey link was circulated among the channels. The approximate survey completion time was 10–15 minutes. The quality and validity of research are impacted by the failure to reach data saturation in qualitative research (Fusch and Ness 2015). After gathering 120–130 responses, data saturation was observed as the topic of responses started to repeat themselves. However, we continued until we reached 150 participants to more precisely confirm data saturation.

Table 1. A taxonomy of in-car contexts where intuitive interaction would be critical.

Themes:	In-car Contexts	f	Subthemes
1	Switching-required	27.17%	Adjusting, Changing, Setting up
2	Emotion-underlain	24.59%	Emotionally-charged, Perfect aura, Sensorily-loaded
3	Idle-away	18.64%	Being recommended, Being served, Consuming Media
4	Less-controllable	15.75%	Other road users, Outer conditions, Breakdown
5	Time-sensitive	9.8%	Personal schedule, Immediate danger, Waiting/impatience
6	Task-oriented	4.02%	Consequtive Tasks, Clutter activities

Data Analysis

Thematic analysis was employed to transfer and identify patterned themes in the participants' implicit responses, which provided expanded flexibility and ease for in-car context categories to evolve (Braun and Clarke 2012; Javadi and Zarea 2016). Following the guidelines of the coding process (Braun and Clarke 2012), qualitative responses initially gathered in written form were read and reviewed. Then preliminary notes and highlights of ideas related to the data were created. Initially, 622 codes were derived and clustered to form 17 subthemes based on their relevancy. Finally, six main themes appeared, which represent a categorization at a higher semantic level (see Table 1). For example, the moments of adjusting, changing and setting up inside the car have been clustered under Theme 1: "Switching-required context"—meaning that users (might) seek effortless interaction in the moments that requires switching inside the car. Similarly, users seek effortless interaction in the moments in which there is an emotional underlayer. For example, when they are emotionally charged inside the car, when they seek to create the perfect aura and when they are sensorialy loaded. This formed Theme 2: "Emotion-underlain".

FINDINGS

A taxonomy of in-car contexts composed of six major themes resulted from the iterative thematic coding process. These themes indicate where an effortless interaction would be critical. Each context is shown in Table 1 in the order of the frequency (f) which it appeared in the total responses.

Switching-Required Context

The most frequently mentioned in-car context was the switching-required context. This theme refers to 'in-between' moments of switching, arranging, adjusting, setting up and remodelling certain in-car spaces and features. It was referred to 169 times (27.17%) in the dataset. Examples consisted of the moments of arranging physical space for the fitness of the occupant, changing between modalities, or trying to connect and synchronise devices. These were identified as switching-required in-car moments where participants are

most likely to request effortless interactions. One participant expressed irritation with the disruption when switching between users: 'Sometimes I get frustrated trying to get the car to find my phone after other family members have paired theirs'. Another participant mentioned multistep interactions as a situation where they desired to be effortless: 'Problems connecting to the car via Bluetooth go through many stages'.

Emotion-Underlain Context

The second frequently appearing context relates to being emotionally and sensually attentive and focused inside the car, which was mentioned 153 times (24.59%) in the dataset. In an emotionally-loaded context, effortless in-car interactions are likely to be requested by the occupants. Example circumstances are when the occupant is emotionally charged due to an event that had happened before or while they got into the car, or when the occupant experienced sensory triggers inside the car. The representative excerpts include: *'If I had a bad day at work'; 'If the stress gets too high and if I cannot self- regulate myself'; 'If I feel emotions of panic and anger';* and *'If I broke up with my boyfriend and sat in the car crying'*. Similarly, a participant mentioned phobias or remembering a traumatic car crash that would trigger their emotional and cognitive behaviours.

Idle-Away Context

Idle-away context is the third most frequent in-car context where effortless interactions are required. It was mentioned 116 times (18.64%) in the data- set. These are passive moments for passing the time with easy, ready and quick consumption desires. In this context, the occupant's openness for inspiration and influence is high and the desire for mobility is low. The idle-away context includes circumstances such as consuming media, receiving recommendations for content to consume, being served, and passively listening, watching and playing various media. For example, the participants expressed the moments in this context as follows: *'If the car puts on the music for me…'; 'If the car serves me food or drink…'; 'If the car orders the dinner by the time I get home'; 'If I can be provided with the exact media that I want at that moment – podcasts, radio shows, YouTube videos';* and *'My car introduced me to new things so I would not bother searching for them'.*

Less-Controllable Context

Moments in which the occupant has less or no control over the situation were emphasised as another in-car context where effortless interactions are desired. This context was mentioned 98 times (15.75%) in the dataset. These circumstances are caused mostly by external factors such as the behaviours of other drivers, accidents, road works, unexpected weather conditions or system faults. Participants revealed these circumstances in comments such as: *'When I see erratic drivers…'; 'When someone makes an illegal unexpected move…'; 'When driving in rough terrain that can be scary…';* and '*When there are excessive road works and road closures'.*

Time-Sensitive Context

Another in-car context where effortless interactions are critical is the time-sensitive context. This theme indicates the urgent moments that are highly influenced by some form of time trigger. For instance, when the occupant is running late for an important meeting, when an issue should immediately be addressed, when a hazard, danger or risk emerges, when a specific event has a time restriction, and when time becomes an emphasised factor. It was mentioned 61 times (9.8%) in the dataset. Participants expressed their rush and urgency in comments such as: *'When I am in a hurry or have important appointments'; 'When I am on the urgent business'; 'When it takes ages…';* and *'When my calendar is full, and the car would arrive as I finish a meeting to take me to the next one immediately'.*

Task-Oriented Context

The task-oriented context indicates decision-making circumstances such as multitasking, completing a task, getting things done, clearing away clutter and unwanted tasks, and performing work. Participants expressed their confusion and annoyance in these circumstances, and they desire effortless interactions to ease their cognitive load. This theme was mentioned 25 times (4.02%) in the dataset. Finding a parking spot or gas filling station while already having other things to do and getting work done quickly while other stimuli are present were representative examples of this context. The participants supported this context in their comments: *'When issues like disconnection of phones, lacking internet, having to keep my eye on the road at the same time'; 'When making critical decisions in the car'; 'When all negativities happened on top of each other';* and *'When annoyed with activity overload'.*

DISCUSSION

The study set out to explore users' expectations of effortless contexts in an autonomous vehicle. The presented in-car contexts is not an exhaustive list of moments in a car. However, the expectations of effortless contexts can be understood using vehicle occupants' dynamic and transforming physical, cognitive and/or psychological states. The occupant's varied states can shape key considerations in designing in-car interaction for a pleasurable experience (Jordan 2002).

A state where an occupant physically engages in the car space relates to the switching-required context. The occupant physically interacts with their car by adjusting, changing or setting up activities. The emphasis on 'switching' implies users' desires for effortlessness through flexible, adaptable, alterable and versatile experiences within a car space. This aligns with the studies that show the importance of adapting in-car systems in accordance with individual user requirements and contexts through flexing the in-car space and interactions (Krome et al. 2015; Rittger et al. 2022). Users reflect their needs into context, and context provides the right assistance in terms of how information is conveyed and how systems respond (Rittger et al. 2022).

Analysing users' 'switching' needs and behaviours within an automobile can help in understanding how the in-between moments are shaped and could be reflected in the design.

A state where an occupant is cognitively anxious and overloaded in the car is manifested in the context of being time-sensitive, task-oriented and emotion-underlain. The occupant cognitively engages in focused tasks, is highly attentive due to time limits, is overloaded with emotions or is in immediate need of having their worry addressed. The impact of the occupant's cognitive state implies how urgency in the car should be prioritised and managed through in-car interaction between occupants and displays (Politis et al. 2013, 2014; Li et al. 2018). Additionally, it has been a common pro- mise of autonomous vehicles to involve working and being productive while commuting (Mathis et al. 2021). The cognitive state emphasizes the importance of users' perspectives about completing focused tasks and working inside autonomous cars (Stevens et al. 2019; Mathis et al. 2021) to guide how car interiors and interactions can be shaped.

Lastly, psychologically engaged states in the car are apparent in the emotion-underlain context, the idle-away context and the less-controllable context. The occupant psychologically interacts with the car by experiencing intense emotions such as stress, pleasure, satisfaction, surprise or feeling out of control. The psychological state can support the affective in-car user experience design (Braun et al. 2018; Li et al. 2019). It shows the effects of emotional states on the driver, the contexts they evolve in and how user experience design can navigate that. Thus, looking at linked contexts might be a starting point. Further, it has been confirmed that the taxonomy has similarities with the automotive contexts that trigger intense emotions in automobiles, such as infotainment, usability issues and external environment conditions (Cha et al. 2022). Thus, it could be worth considering the occupant's emotional experiences with an automobile, which can help highlight key areas when designing effortless in-car interactions.

By understanding when and in which context users might most desire effortless interaction, this study can assist automotive designers and researchers to develop in-car systems and products that provide effortless and intuitive interaction with an automobile.

CONCLUSION

The research identified six in-car contexts via an open-ended questionnaire with 150 participants to examine users' expectations for effortless in-car interaction. The implications of the study suggest how potential occupants desire to interact effortlessly in each context, which can assist designers and researchers to consider these sentiments when designing context-centred interaction in future cars.

Effortless and intuitive experience is one of the core desires of autonomous car occupants. The interactions they seek, however, change based on the context they are in. Thus, the findings can provide a groundwork to determine specific moments when an in-car effortless experience is desired, which may help improve user experiences in future automobile designs.

Future research could further detail and define effortless contexts and explore how different in-car interactions and tasks can be recognized and completed to maximize the greater multimodal experience with an autonomous vehicle.

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