Designing Emotion-Aware In-Car Interactions for Unlike Markets

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AutomotiveUI '19 Adjunct , September 21–25, 2019, Utrecht, Netherlands

ACM ISBN 978-1-4503-6920-6/19/09.
https://doi.org/10.1145/3349263.3351324

Abstract
Interior cameras and other sensors facilitate affective automotive UIs reacting to the driver's detected emotional state and providing customized support. Previous research mainly presents single prototypes designed in western countries. A comprehensive view of relevant use cases and possible cultural differences between markets, however, is missing. This is particularly important as the significance of emotions is quite different between, e.g., western and eastern cultures. We present use case clusters for affective in-car UIs based on ideation workshops with German and Chinese participants. Our focus lies on the requirements arising from cultural differences, such as more rule-consistent driving in Germany or more important social components in China. Our ideation approach aims to enrich use cases for empathetic vehicles with the user's culture in mind. The use case clusters we present can inspire future concepts for improving user experience through affective interaction and for boosting acceptance by observing cultural peculiarities.

Author Keywords
Automotive UI; affective computing; emotion detection; ideation; interaction design; human-computer interaction

CCS Concepts
•Human-centered computing → HCI theory, concepts and models;

Figure 1: Emotional driver taxonomy: safe driving is most likely with positive valence and medium arousal levels [1]

Introduction

Modern cars come with a range of built-in sensing devices such as driver cameras or skin conductance sensors. While currently these are primarily used as attention indicators to allow longer hands-off times during semi-automated driving, they could also serve as ubiquitous input devices for emotion detection algorithms. Related work provides valuable use cases for driver state detection, focusing mostly on influencing the driver to stay in a safe condition (cf. Figure 1). For example, Nass and Brave propose adapting voice assistants to the emotional state of the user [13]. Displaying simplified representations to facilitate state awareness [15] and taking direct influence on the driver with speech and ambient light [2] have also been investigated in previous studies. Other ideas for emotional interactions include social feedback to others regarding their driving behavior [16] or gamification to protect vulnerable road users [14].

Related work so far consists mostly of ideas which have been studied and developed in western countries. Exploring all possibilities of emotion detection in the car, however, requires a more comprehensive ideation which also includes other markets. Especially China is becoming more and more important for car manufacturers as sales in the east are increasing and Asian customers apparently expect different products than westerners. HCI research has applied various cultural models to comprehend cultural influences in UI design, one of which is based on work by Hofstede [4, 8]. According to Hofstede's cultural dimensions, Germany and China differ in individualism, power distance, uncertainty avoidance and indulgence [8], thus it is to be expected that requirements for user interfaces differ between both countries. A design process with culture in mind, or "culturally sensitive design" [12, 11] has become an important discussion point in automotive UI design.

There is a general disparity between eastern and western countries in terms of preferences [9], comprehension [18] and interaction behavior [7] when using in-vehicle information systems. Aside from variations in traffic composition and road infrastructure, also driver behavior and traffic characteristics can be highly diverse between countries [17]. A focus on cultural disparities between the main markets is therefore critical for the design of interfaces which are meant to prosper in a global market.

Contribution Statement

We close this gap by presenting our vision for affective in-car interfaces consisting of a research approach for ideation with culture in mind and six use case clusters created with it. These are the results of ideation workshops with 63 participants from Germany and China, iterating on ideas for emotion detection in the car with a focus on cultural differences.

Ideation

Following a design thinking approach, we organized several ideation workshops in Munich, Germany, in order to iteratively conceive of viable use cases for emotion detection in the car.

German Workshops

The first round consisted of 4 workshops with a total of 50 German participants with backgrounds in either automotive management (13), automotive user interfaces (8), or other fields of expertise within HCI. Participants applied different ideation techniques to a set of given technological possibilities for detecting emotions within the car interior. This resulted in a vast amount of ideas, which we first screened and sorted. Then we filtered out physically impossible or illegal ideas (e.g., "give me drugs when I'm sad"), and we combined similar ideas for a better overview. With these ideas we proceeded into iterations with feedback from Chinese users.

Figure 2: Chinese participants taking part in a "car-storming" session while driving.

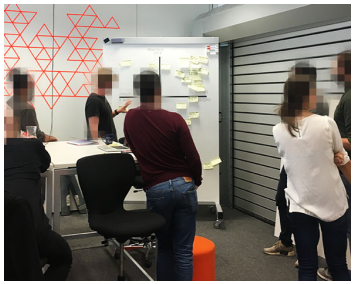

Figure 3: Idea assessment with automotive experts.

Chinese Workshops

A total of 13 Chinese participants followed an invitation to a think-aloud "car-storming" session [10] to discuss emotion detection use cases. The workshops were held in groups of 2 or 3 inside a BMW 7-series driving through the city for approximately 60 minutes (see Figure 2). The groups were intentionally small to achieve more focused feedback. Hosted by a native Chinese speaker, all conversations were held in Chinese language to encourage liberal expression and frequent mind exchanges among participants.

At the start of the journey, participants talked about their experiences with unfamiliar driving customs in Germany in contrast to what they were used to from China. This way, we hoped to raise awareness towards the cultural differences between driving on western and eastern roads. Participants then brainstormed on new ideas for emotion detection use cases for a Chinese market, until we finally introduced them to ideas from the German workshops which they discussed and – if possible – improved to fit their expectations.

Workshop Results

The car-storming session generated 46 ideas in the context of the target situation. We clustered both the German and Chinese use cases into a set of categories (see Figure 4). Participants generally expressed that China has an entirely different driving culture compared to Germany in terms of lane changing frequency, right of way, merging habits, traffic regulations (e.g., permitted alcohol level) and forms of rage behavior. Nevertheless, participants from both cultures shared a common ground on certain use cases such as navigation and connected emotion. We found that emotional states were isolated between the driver or co-pilot (front row) and passengers (back row) due to the current seat arrangement in vehicles. In particular, the concept of three generations under one car roof plays a critical role in Chinese use cases. Chinese participants also took shared emotional states of family members into consideration on a journey. In most circumstances, they are of different age groups and go about their respective tasks (driving or non-driving related), which even escalates the problem of emotional discrepancy. Additionally, inconsistent emotional states also occurred between internal and external vehicle space. In comparison to highly relaxed states (low arousal, high valence) [1] of skilled drivers in the surroundings, novice drivers often undergo extreme nervous emotion states (high arousal, low valence).

Use Cases for Emotion-Aware Interfaces

We invited eight German experts working in automotive HMI to assess concepts based on the workshop results (see Figure 3). We presented a set of the 50 most promising use cases on sticky notes and evenly distributed them on two whiteboards. The experts were divided into two groups, which discussed and evaluated each use case according to a coordinate system with the vertical axis ranging from “promising idea” to “bad idea” and the horizontal axis from “unrealistic to build” to “feasible experience”. At the end, each of the experts was entitled to vote for their favorite use cases with colored dots. Finally, we adopted ideal use cases (upper right quadrant) and eliminated unrealistic and bad ideas (bottom left quadrant). We selectively kept some use cases in the other two sectors which were either marked as a favorite, or ignited enough discussion to be further considered. Then we summarized the set of ideas into the following six use case clusters of emotion-aware in-car interaction:

Sharing Emotions are a social phenomenon which have impact when shared and perceived by others [5]. Social media already provides manifold ways to share emotional experiences through digital channels, which can be expanded by the influence of ever-changing sceneries during car rides and the eager availability of sensing devices inside the car.

Figure 4: Initial categories of German and Chinese use cases.

We can improve the user experience by providing enriched memories, e.g. through automatic documentation of outside and inside events, easy sharing, and the expression of emotions to other road users through external displays.

Transparency With advancing digitization, users run danger of losing track of the data they disclose. Transparency on one hand enables them to monitor the accuracy of the system and on the other hand allows them to perceive the external image they emit, reported by an impartial sensing algorithm. This way, drivers might improve their own emotional states and with that their road safety, through self-reflection.

Proactivity Understanding and acting upon the driver's state is important to stimulate the hedonic component of User Experience in vehicles [6]. In future cars, a proactive in-car voice assistant could respond to certain situations, considering varying user needs and personalities. For the purpose of empathizing with drivers' emotional state, proactive suggestions from this intelligent assistant would let users experience more natural interaction.

Navigation The driver's emotional state often changes during a trip, which is potentially also influenced by routing factors. New navigation algorithm using accumulated emotion data in combination with GPS signals could avoid areas which caused negative feelings for other drivers, maybe even without knowing the cause, and instead propose a route with more positive connotations.

Controls While most concepts are based on the detection of implicitly emoted states, explicit facial gestures like smiling can also be used to control vehicle functionalities. Future cars could, for example, enhance the security of face detection with facial gestures to allow a "smile to unlock" feature, or the user could set preferences during music playback with directed smiling gestures [3].

Family Support Different numbers and demographics of passengers can shape diverse emotional experiences inside the vehicle. A senior couple (>65 years old) and a young couple (20-30 years old) will potentially undergo different levels of emotional arousal along the same route. Similarly, parents traveling with kids will experience the same route quite differently when traveling alone. Particularly, a mixed group of passengers could create internal influences on one another's emotional state. A family concept thus aims to communicate concurrent emotional states among all travellers, especially by informing the driver of others' emotions in order to reduce driver distraction.

Outlook

We present an ideation approach and potential use cases of emotion-aware in-car interaction, considering distinctive driving cultures from two unlike markets. Insights from ideation sessions with German and Chinese drivers led to six use case clusters we propose as a foundation for future affective automotive UIs. Future work to implement distinct use cases for each of these clusters in the car and evaluate the user experience with drivers in Germany and China are in preparation as of the submission of this manuscript.

Our aim is to investigate whether such a system could achieve a desirable UX across markets and increase participant's trust and willingness to use the new technology. Through this work in progress, we provide researchers and practitioners insights into affective automotive design. We hope to inspire a discussion on the future of emotion-aware automotive interfaces and the shape their future with the findings of upcoming validation studies.

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