Participatory Design Process for an In-Vehicle Affect Detection and Regulation System for Various Drivers

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ABSTRACT
Considerable research has shown that diverse affective (emotional) states influence cognitive processes and performance. To detect a driver's affective states and regulate them may help increase driving performance and safety. There are some populations who are more vulnerable to issues regarding driving, affect, and affect regulation (e.g., novice drivers, young drivers, older drivers, and drivers with TBI (Traumatic Brain Injury)). This paper describes initial findings from multiple participatory design processes, including interviews with 21 young drivers, and focus groups with a TBI driver and two driver rehab specialists. Depending on user groups, there are distinct issues and needs; therefore, differentiated approaches are needed to design an in-vehicle assistive technology system for a specific target user group.

Categories and Subject Descriptors
H.5.2 **[Information Interfaces and Presentations (e.g., HCI)]**: User Interfaces, user-centered design, voice I/O

General Terms: Design, Human Factors

Keywords
Participatory Design, Affect Detection, Emotion Regulation, Adaptive User Interfaces

1. PARTICIPATORY DESIGN

1.1 Emotion and Drivers with TBI
Even though affect-related in-vehicle assistive technology may be able to help various classes of drivers, those with Traumatic Brain Injury (TBI) are of primary interest. There are more than 5.3 million Americans with an identified traumatic brain injury and 1.5 million new brain injuries are reported per year [1]. In addition to cognitive and executive dysfunctions, they frequently show emotion regulation issues, such as a "*short fuse*", uncontrolled *aggression,* and *irritability* [2]. However, most TBI patients hope to continue independent driving to facilitate community reintegration [3].

1.2 Interviews with TBI Drivers and Driver Rehab Specialists
One TBI driver (male) and two driver rehab specialists (mean years of experience = 16) in the Shepherd Center rehabilitation hospital participated in three successive sessions. In these interviews, researchers demonstrated a prototype of the affect detection system using facial expression [4] and obtained feedback for the system, general regulation approach, and plausible design directions. Participants generally favored the attempt to cope with emotional issues as well as cognitive issues and were satisfied with the current system's performance for facial detection. They suggested that the system would be more helpful if it could detect a "*black out*" state that TBI patients often show. They felt a speech based-system could also be useful because motivated TBI patients would like to talk through the system in order to engage more in driving. With respect to affect regulation, driver rehab specialists recommended direct mitigation (e.g., simple commands like *"take a deep breath"* or *"relax your grip on the wheel"* to help *anxious* drivers find a way to relax—complex commands might overwhelm them). Sometimes TBI patients get "*tunnel vision*" and focus only on a particular space. To avoid this, giving them prompts such as *"keep moving your eyes"* can help. Rehab specialists said to use female voices for perceived calming attributes. Also, a family member's voice has also worked well. Currently, we continue to collect data from TBI drivers through other TBI rehabilitation programs, such as "Pathways" and "Share".

1.3 Young Drivers
Research shows that young drivers are overrepresented in crashes involving excessive speeds, curves, alcohol, fatigue, distraction, and passengers [5]. Specifically, young drivers tend to engage in distracting activities while driving, such as texting [e.g., 6]. Moreover, young drivers are more likely to exhibit aggressive driving behaviors [7]. For example, young drivers low in emotional adjustment and high in sensation seeking showed high levels of aggressive driving and speeding in competition with others and accordingly, performed poorly in a simulated driving experiment [8]. All those reasons add to novice-level skills and coping strategies, and cause young and beginning drivers to be in a highly vulnerable group.

1.4 Focus Groups with Young Drivers
Twenty-one undergrads with a driving license and driving experience (12 female; mean age = 21.8; mean years of driving = 5.6) received course credit. A total of five focus groups were conducted, each with one to five participants.

Affective States Need to Be Regulated. First of all, participants commonly reported that they generally feel 'relaxed' while driving. For the affective states that need to be regulated while driving, they answered in the following order using 7-point scales (1 = "need not at all" and 7 = "need very much"): *urgent* (5.1), *angry* (5.1), *fearful* (4.4), *confused* (4.1), *bored* (3.9), *depressed* (3.4), *relieved* (2.9), *happy* (2.6), and *embarrassed* (2.5). In addition, they were encouraged to add other affective states to be

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regulated while driving. Answers included *fatigue* and *tired* (*N* = 7), *distracted* (*N* = 3), *excited* (*N* = 3), *preoccupied* (*N* = 2), *frustrated* (*N* = 2), and *stressed* (*N* = 2). Although most participants felt that positive emotions need not be regulated, several participants said that *'excited'* needs to be regulated because if a driver is too excited, he or she may be distracted from driving.

Current Regulation Strategies. When participants experience negative affective states, their regulation strategies involved *"rationalize their situations," "turn on music loud," "drive faster," "eat," "drink," "make myself uncomfortable in the seat," "talk with passengers," "pull over the car and take a rest or calm down,"* etc. Most agreed that having a passenger would be helpful. Nonetheless, they said that it depends on the person, with friends being more helpful than parents.

Plausible Issues of the Facial Detection System. Participants pointed to several issues, including individual differences in expressing one's emotions, *"some people are not very expressive, being reserved by nature,"* an aversion about machine's control, *"many people might not want an artificial system to take control of them and their emotions and it might get them even more angry,"* security and privacy, *"people might not want people/others to monitor their emotions,"* and *"who is getting this data and how will they use it?"* Additionally, some participants worried about reversal effects that might make drivers distracted or feel worse. We also discussed topics such as facial recognition in the dark, while wearing sunglasses, frowning due to sunlight, timing for detection and regulation, as well as basic issues such as system's discernability and accuracy.

Plausible Issues of the Speech Detection System. Music, conversation, or phone calls might interfere with voice commands and speech detection. Of note, all of our participants said they always listen to music while driving. How to overcome that situation using multimodal displays is one of the critical issues. Further, there is noise from the external environment of the car especially when the windows are open. Additionally, sensing grip pressure on the wheel and heart rate sensors similar to the ones used in treadmills were proposed by several participants.

Directions Regarding Regulation Interfaces. Investigators demonstrated four different types of regulating voice clips (male, female, male TTS, and female TTS) and a couple of music pieces. Participants preferred human voices over synthesized ones because they were more like a person, related better to the driver, and sounded nicer. Although the human voices were recordings of graduate students, participants said that they were acceptable. However, many participants felt that they would prefer voices of famous people over non-familiar voices or even family members. Female participants wanted a British-accented male voice. One participant suggested the system could tell the driver that his or her action is merely due to current emotions and not his or her ability to drive. Another proposed that when a driver is frustrated, the system could phone the driver's friend. In some cases, making a joke would also help. A previous study showed that an empathetic adaptive system that matched its prosody to the driver's emotion yielded better driving and higher subjective ratings [9], but most participants wanted a more consistent system, *"want static rather than empathizing," "when I am angry, I don't want another angry person or system in my car."*

Overall, participants rated the face recognition (*M* = 3.95 out of 5) method higher than speech analysis (*M* = 3.54) on the usefulness scale. For the regulation methods, participants preferred non-speech sounds including music (*M* = 3.65) over speech (*M* = 2.59). However, a non-speech approach also has to be cautiously used. Participants did not want their music to be changed into classics automatically. One said that synchronizing the music with the driver's favorite songs in the iPod would be a better alternative than playing predefined classics. Regardless of speech or non-speech, it should be optional, configurable, and easily turned off. Some participants recommended that this system be more useful for people with extreme emotional problems or drivers who have experienced accidents or are recovering from the aftermaths of seeing one.

2. DISCUSSION & FUTURE WORKS

In this participatory design loop, we attained invaluable suggestions and found that specific approaches are needed for different populations. For motivated TBI drivers, direct input from the speech-based system might be helpful, whereas for young drivers, the same method might make them feel as if the system is a back-seat driver. As stated at the outset, older drivers are also a vulnerable class and need to be considered. They know their physical limitations and regulate their emotional state better than young adults, but they still have a significantly higher rate of accidents due to other reasons. Based on this, we are devising a more robust affect detection and adaptive interface that can timely help various drivers. Also, we plan to conduct an in-car case study embedding our system as well as an in-lab simulation study.

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