“Play Your Anger”: A Report on the Empathic In-vehicle Interface Workshop

Jiayuan Dong
Mind Music Machine Lab, Virginia Tech, Blacksburg, Virginia, United States, djia9@vt.edu

Chihab Nadri
Mind Music Machine Lab, Virginia Tech, Blacksburg, Virginia, United States, cnadri@vt.edu

Ignacio Alvarez
Autonomous Driving Research, Intel Labs, Portland, Oregon, United States, ignacio.j.alvarez@intel.com

Cyriel Diels
Intelligent Mobility Design Centre, Royal College of Art, London, UK, cyriel.diels@rca.ac.uk

Myeongkyu Lee
Graduate School of Automotive Engineering, Kookmin University, Seoul, Korea, myeongkyu@kookmin.ac.kr

Jingyi Li
LMU Munich, Munich, Germany, jingyi.li@ifi.lmu.de

Pei Hsuan Liao
Rytass, Taipei, Taiwan, ena9105888@gmail.com

Carina Manger
Human-Computer Interaction Group, Technische Hochschule Ingolstadt, Ingolstadt, Germany, carina.manger@carissma.eu

Shadan Sadeghian
Autonomous Interactive Systems, University of Siegen, Siegen, Germany, shadan.sadeghian@uni-siegen.de

Martina Schuß
CARISSMA, Technische Hochschule Ingolstadt, Ingolstadt, Germany; Johannes-Kepler Universität, Linz, Austria, martina.schuss@carissma.eu

Bruce N. Walker
Sonification Lab, Georgia Institute of Technology, Atlanta, Georgia, United States, bruce.walker@gatech.edu

Francesco Walker
Cognitive Psychology Unit, Leiden University, Leiden, Netherlands, f.walker@fsw.leidenuniv.nl

Yiyuan Wang
Design Lab, Sydney School of Architecture, Design and Planning, The University of Sydney, Sydney, Australia, yiyuan.wang@sydney.edu.au

Myounghoon Jeon
Mind Music Machine Lab, Virginia Tech, Blacksburg, Virginia, United States, myounghoonjeon@vt.edu

Empathic in-vehicle interfaces are critical in improving user safety and experiences. There has been much research on how to estimate drivers’ affective states, whereas little research has investigated intervention methods that mitigate potential impacts from the driver’s affective states on their driving performance and user experiences. To enhance the development of in-vehicle interfaces considering emotional aspects, we have organized a workshop series to gather automotive user interface experts to discuss this topic at the International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutoUI). The present paper focuses particularly on the intervention methods created by the experts and proposes design recommendations for future empathic in-vehicle interfaces. We hope this work can spark lively discussions on the importance of drivers’ affective states in their user experience of automated vehicles and pose the right direction.

CCS CONCEPTS •Human-centered computing • Interaction design • Interaction design process and methods • Interface design prototyping

Additional Keywords and Phrases:

HCI, Empathy, Human Vehicle Interaction, In-Vehicle User Interface

ACM Reference Format:

First Author's Name, Initials, and Last Name, Second Author's Name, Initials, and Last Name, and Third Author's Name, Initials, and Last Name. 2018. The Title of the Paper: ACM Conference Proceedings Manuscript Submission Template: This is the subtitle of the paper, this document both explains and embodies the submission format for authors using Word. In Woodstock '18: ACM Symposium on Neural Gaze Detection, June 03–05, 2018, Woodstock, NY. ACM, New York, NY, USA, 10 pages. NOTE: This block will be automatically generated when manuscripts are processed after acceptance.

1 Introduction

In-vehicle display technologies provide users with the necessary information on the road. Although diverse features are included in current in-vehicle interfaces, more driving-related factors should still be addressed to enhance driving performance. Emotions have been found to contribute to individual cognitive appraisal, which refers to how an individual interprets and responds to the stress stimuli in the surrounding environment [7]. Previous research studies have discovered that emotions impact drivers' takeover performances [10,18] and trust [20] differently in partially automated vehicles. Because driving could be stressful and unpredictable, considering the affective states of drivers while designing in-vehicle displays is crucial to enhance driving performance, user trust, and traveling experiences. Intervention methods involving different technologies are necessary to mitigate the negative impacts on driver safety from the driver's affective states [6,12]. To tackle this issue, we have hosted a series of workshops on empathic driving at the previous AutoUI conferences [3,16]. Following the successful workshops, we hosted the third workshop [15] aimed at gathering the collective experience of multidisciplinary researchers and practitioners in automotive displays and systems to address how empathic in-vehicle displays can be implemented to prevent or respond to affective events in vehicles and mitigate driver emotions.

The present paper reports the third workshop's outcomes by describing the prototypes of intervention method experts designed and discussing the potential design recommendations for future empathic in-vehicle interfaces' intervention methods in four categories. To successfully intervene in the driver's affective state, the empathic in-vehicle system should be capable of 1) detecting the driver's affective states, 2) empathizing with the driver's emotions, and 3) understanding the source of emotions and providing adaptive assistance.

2 Workshop

Nine automotive user interface researchers and practitioners gathered and volunteered to participate in the workshop at the AutoUI 2022 conference in Seoul, South Korea. The previous two iterations of the workshops contributed to developing the workshop activities in the present paper [14].

2.1 Procedure

The three-hour workshop began by introducing the workshop background and presentations of the previous workshop results. The workshop outline followed the 4mat System (Why, What, How, and What if) [9]. In the first iteration of the workshop, participants discussed the importance of empathic displays in vehicles and ideated emotion detection techniques. Twenty-eight emotions were discussed to have negative impacts on driving. With the second iteration of the workshop, participants explored different user groups that could be beneficial from empathic in-vehicle designs and how the designs could adapt to users' unique characteristics, e.g., identifying stress from the heart rate of elderly drivers. In sum, the first iteration focused on why empathic displays are essential in driving, and the second iteration figured out who requires empathic in-vehicle displays. With the results, the first session of the group activities in the present workshop collaborated with the use cases from the previous two iterations to discuss how empathic in-vehicle displays can be implemented to respond to affective events on the road.

After a keynote talk from one of the workshop organizers, there were two sessions for the group activities. Nine experts were separated into two groups (four to five people per group). The first session focused on the rapid prototyping of intervention methods for the presented use cases. An intervention specification sheet and a use cases list were provided to each expert. In the intervention specification sheet, each expert ideated intervention methods for their selected use cases and explained the advantages and potential shortfalls of the method. Once completed, experts shared their invention methods with others in the group and finalized their top choice(s) for the next session of group activities. In the second session, experts discussed their design directions and the creation of concept prototypes expanding on the use cases, including but not limited to writing down or sketching specific design features for the empathic in-vehicle interface (Figure 1). Finally, each group presented their ideas and received feedback at the end of the workshop.

Figure 1: Participants discussing and prototyping empathic in-vehicle display features adapting to use cases.

3 Results

Each group had ten minutes to present its design concepts for the empathic in-vehicle interfaces adapting the selected use case(s). The first group presented two interfaces, and the second group presented their intervention ideas from an analytical perspective describing its design process.

3.1 Use case 1: Anger or frustration from being late to a meeting or an important date.

3.1.1 Intervention Method 1: "Shut up and Drive".

The group's first intervention method was a head-up display (HUD) with a driving progress bar and a unique parking request icon associated with built-in map software in a vehicle with level-2 automation (Figure 2 left). This intervention aims to mitigate the drivers' frustration and redirect their attention back to the road by identifying the sources of frustration and providing solutions. The sources of frustration were recognized as traffic delays, dissatisfaction from other parties, and concerns about later parking spots.

To reduce the frustration from the annoyance of traffic delays, the progress bar visualized how much was left to complete the route. The colors of the bar would change based on the traffic density as the current personal navigation system does; for example, red represents a slow traffic flow and green represents a fast traffic flow. The group stated that this color-changing feature empathized with the drivers' affective states. To comfort others who waited for the drivers, there was also an option in the software for the drivers to send the current progress and location to their colleagues or loved ones. Finally, to avoid further delays due to limited parking slots at the destination, drivers could send a parking request to the software, and the software would find a free parking spot near the destination and direct the vehicle to it. A green parking icon would show up on the HUD and provide feedback regarding the parking request by including two check marks: the first check mark represents the request was submitted, and the second check mark represents the request was completed. This feedback aimed to provide positivity and ease drivers' frustration from worrying about the parking spot.

3.1.2 Intervention Method 2: "Play Your Anger".

The second intervention method the group prototyped was a drumming interface on the steering wheel linking to the driver's music player in a level-3 automated vehicle (Figure 2 right). Differing from the first intervention method, the second method focused on shifting the driver's attention away from being angry. The inspiration for this intervention was based on the tapping behavior when someone is angry.

The drumming interface could be activated in two ways. First, the driver could start tapping the steering wheel, and the music player in the head-down display would recommend a list of songs based on the driver's tapping rhythm. Then, the driver could choose a song and remix it with the drumming beats. Another way to activate the interface is to choose a song from the music player and remix the song directly. There were two feedback displays to avoid aggressive drumming due to anger: ambient lights on the steering wheel and a mood bar in the HUD. The ambient lights would show up on the driver's tapping, and the light color would change from red to yellow or green based on the driver's tapping strength. The mood bar showed similar, colorful feedback to the ambient lights but with a detailed portion on a scale. Towards the end of drumming, having green feedback was considered ideal, indicating the driver's anger was calmed by this intervention. The remix would also be recorded, and the driver could decide whether to upload it to the music platform for socializing.

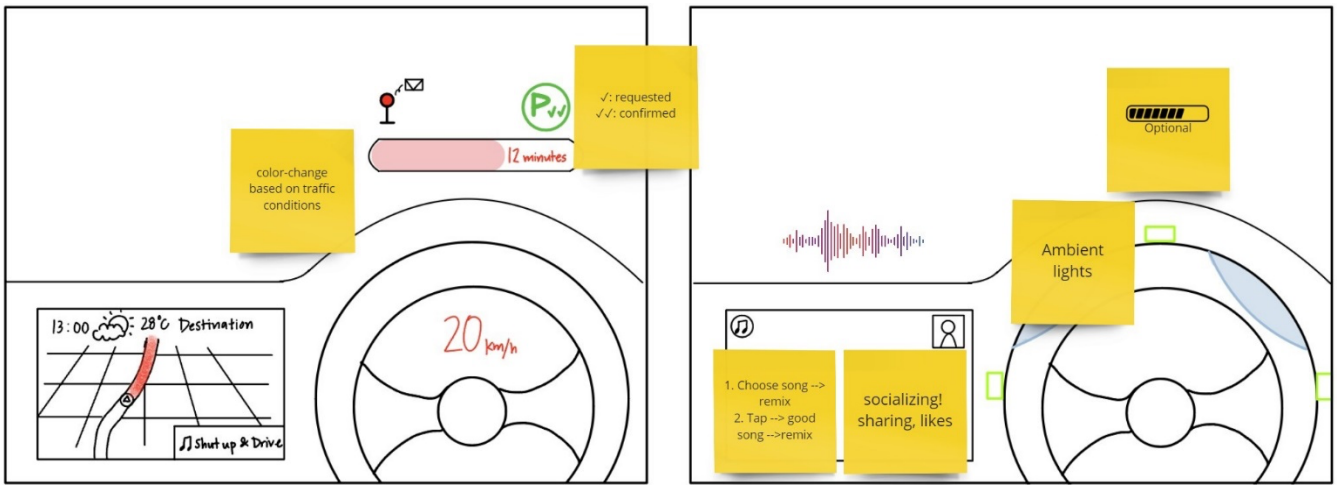

Figure 2: Sketches of the first group's empathic in-vehicle interface designs.

3.2 Use case 2: Fear of automated vehicles in older adults.

The second group presented their design process for creating empathic in-vehicle displays to intervene in older adults' fear of automated vehicles due to general anxiety and unfamiliarity with automated vehicles (Figure 3). The group identified three phases for the interface design: Sensing, Diagnosing/Classifying, and Intervention. First, in the Sensing stage, the empathic display should **detect** the driver's fear from physiological data or the change in the driver's behavior. Next, the vehicle should **classify** the driver's sources of fear: 1) unexpected behaviors of the vehicle, e.g., a sudden stop made by the vehicle; 2) fear of being hurt, e.g., a truck was passing by the vehicle; and 3) fear of hurting someone else, e.g., pedestrian walking ahead. After comprehending the driver's fear, the empathic in-vehicle interface should **intervene** in the driver's fear depending on the source. The group provided two user scenarios applying this empathic in-vehicle display design concept to understand the intervention process in different driving situations. Both user scenarios involved unexpected vehicle behaviors; therefore, the empathic display should intervene in the driver's fear by demonstrating situation awareness of the environment and communicating its next movement to the driver to provide further comfort.

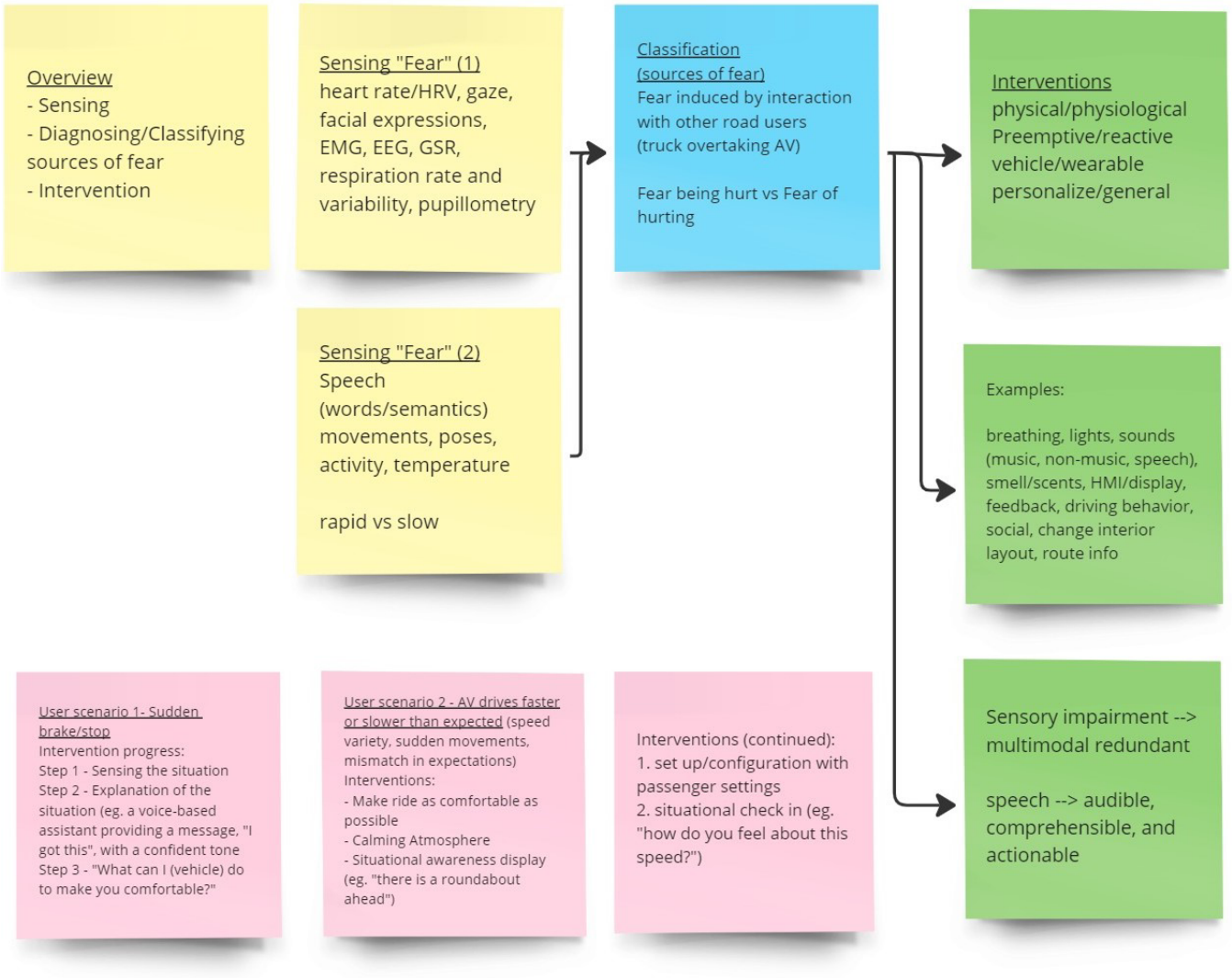

Figure 3: The intervention process of the second group's empathic in-vehicle interface design.

4 Discussion

In the workshop, two groups of automotive user interface experts presented their design ideas for empathic in-vehicle interface intervention methods in specific use cases. Some discussion points were organized and contributed to providing general design guidelines for future empathic in-vehicle interfaces to intervene in the driver's emotions.

4.1 Emotion detection

Identifying emotions in drivers is the initial step for an empathic in-vehicle system to understand the timing to intervene in affective events. The experts mentioned that accurate emotion recognition with a short reaction time would give the driver a sense of high system reliability and situation awareness. In addition, detecting the driver's emotions quickly intervenes with the driver's aggressive behaviors in the early stage and provides instant assistance. A previous workshop and a previous research study suggested that emotion detection engages implicit cooperation between human and automated systems [4,17]. Finally, experts discussed different categories of user data that the in-vehicle system can evaluate to detect emotions, such as physiological or physical data; however, respecting user privacy and understanding user preferences will be important in this implication.

4.2 Empathizing with the driver's emotions

The experts frequently introduced the importance of expressing empathy for the driver's emotions in the intervention. Responding to affective events with empathy in the empathic in-vehicle system can manage the driver's emotional responses and engages in safe driving. Certain in-vehicle display technologies, like the colorful ambient light participants used in their intervention methods,

could calm the driver's emotions and improve driving performance [8]. According to Anyasodo and Burnett's findings [1], recognizing the driver's emotional state and returning empathic responses are critical to enhancing in-vehicle user experiences. Moreover, participants identified more personalized options to demonstrate compassion for the driver's emotions from the in-vehicle environment, such as temperature and scents [2,11,13].

4.3 Understanding the sources of emotions and providing adaptive solutions

In both groups' intervention methods, diagnosing the source of the emotions and demonstrating situation awareness was instrumental to intervening in the driver's emotions in automated vehicles. Emotion research has shown that mere awareness of an individual's emotion or the source of the emotion can even mitigate the emotional effects [19]. The experts mentioned that supporting drivers by addressing concerns due to traffic situations or delaying future events might reduce stress and enhance driving performance. This requires a high level of situation awareness, which reflects on the vehicle's capabilities of understanding the driving situation, determining appropriate decisions, and communicating its next steps to the driver. In addition, the empathic in-vehicle system should deliver driving-related information with confidence and determine whether the driver has any further instructions, such as turning the music down to be focused on the road or turning on their favorite music [5,6]. With comprehensive communication with the vehicle, the emotional impact of unexpected vehicle movements would be mitigated.

5 Conclusion

The workshop in the present paper engaged discussions in the intervention methods in empathic in-vehicle interfaces. Automotive user interface experts brainstormed empathic interface designs from no driving automation to partially automated vehicles and created prototypes of empathic displays that can intervene with drivers' emotions in different use cases. With the workshop's outcomes, we provided several expert-supported discussion points that may contribute to the direction of future empathic in-vehicle interface design and research topics.

References

<bib id="bib1"><number>[1]</number>Ben Anyasodo and Gary Burnett. 2021. Empathy consideration in the design of natural language interfaces for future vehicles. Retrieved June 7, 2023 from https://nottingham-repository.worktribe.com/index.php/output/5330385/empathy-consideration-in-the-design-of-natural-language-interfaces-for-future-vehicles</bib>
<bib id="bib2"><number>[2]</number>Monica Bordegoni, Marina Carulli, and Yuan Shi. 2016. Investigating the Use of Smell in Vehicle-Driver Interaction. In Volume 1A: 36th Computers and Information in Engineering Conference. https://doi.org/10.1115/DETC2016-60541</bib>
<bib id="bib3"><number>[3]</number>Esther Bosch, Michael Oehl, Myounghoon Jeon, Ignacio Alvarez, Jennifer Healey, Wendy Ju, and Christophe Jallais. 2018. Emotional GaRage. In Adjunct Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 44–49. https://doi.org/10.1145/3239092.3239098</bib>
<bib id="bib4"><number>[4]</number>Henrik Detjen, Stefan Geisler, and Stefan Schneegass. 2020. Implicit Cooperation: Emotion Detection for Validation and Adaptation of Automated Vehicles' Driving Behavior. Retrieved June 7, 2023 from http://arxiv.org/abs/2003.13044</bib>
<bib id="bib5"><number>[5]</number>S. Maryam FakhrHosseini and Myounghoon Jeon. 2019. How do angry drivers respond to emotional music? A comprehensive perspective on assessing emotion. Journal on Multimodal User Interfaces 13, 2: 137–150. https://doi.org/10.1007/s12193-019-00300-3</bib>
<bib id="bib6"><number>[6]</number>Seyedeh Maryam Fakhrhosseini, Steven Landry, Yin Yin Tan, Saru Bhattarai, and Myounghoon Jeon. 2014. If You're Angry, Turn the Music on. In Proceedings of the 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 1–7. https://doi.org/10.1145/2667317.2667410</bib>
<bib id="bib7"><number>[7]</number>Susan Folkman, Richard S. Lazarus, Christine Dunkel-Schetter, Anita DeLongis, and Rand J. Gruen. 1986. Dynamics of a stressful encounter: Cognitive appraisal, coping, and encounter outcomes. Journal of Personality and Social Psychology 50, 5: 992–1003. https://doi.org/10.1037/0022-3514.50.5.992</bib>
<bib id="bib8"><number>[8]</number>Mariam Hassib, Michael Braun, Bastian Pfleging, and Florian Alt. 2019. Detecting and Influencing Driver Emotions Using Psycho-Physiological Sensors and Ambient Light. In Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). Springer Verlag, 721–742. https://doi.org/10.1007/978-3-030-29381-9_43</bib>
<bib id="bib9"><number>[9]</number>W Huitt - Educational Psychology Interactive and undefined 2009. Individual differences: The 4MAT system. edpsycinteractive.org. Retrieved June 7, 2023 from http://www.edpsycinteractive.org/topics/instruct/4mat.html</bib>
<bib id="bib10"><number>[10]</number>Myounghoon Jeon, Bruce N. Walker, and Jung-Bin Yim. 2014. Effects of specific emotions on subjective judgment, driving performance, and perceived workload. Transportation Research Part F: Traffic Psychology and Behaviour 24: 197–209. https://doi.org/10.1016/j.trf.2014.04.003</bib>
<bib id="bib11"><number>[11]</number>Hodam Kim, Suhye Kim, Hongmin Kim, Youngsoo Ji, and Chang-Hwan Im. 2022. Modulation of Driver's Emotional States by Manipulating In-Vehicle Environment: Validation With Biosignals Recorded in An Actual Car Environment. IEEE Transactions on Affective Computing 13, 4: 1783–1792. https://doi.org/10.1109/TAFFC.2022.3206222</bib>
<bib id="bib12"><number>[12]</number>Sandra Krüger, Esther Bosch, Klas Ihme, and Michael Oehl. 2021. In-Vehicle Frustration Mitigation via Voice-User Interfaces – A Simulator Study. In Communications in Computer and Information Science. Springer Science and Business Media Deutschland GmbH, 241–248. https://doi.org/10.1007/978-3-030-78645-8_30</bib>
<bib id="bib13"><number>[13]</number>Prajval Kumar Murali, Mohsen Kaboli, and Ravinder Dahiya. 2022. Intelligent In‐Vehicle Interaction Technologies. Advanced Intelligent Systems 4, 2: 2100122. https://doi.org/10.1002/aisy.202100122</bib>
<bib id="bib14"><number>[14]</number>Chihab Nadri, Ignacio Alvarez, Esther Bosch, Michael Oehl, Michael Braun, Jennifer Healey, Christophe Jallais, Wendy Ju, Jingyi Li, and Myounghoon Jeon. 2022. Empathic vehicle design: Use cases and design directions from two workshops. In CHI Conference on Human Factors in Computing Systems Extended Abstracts, 1–7. https://doi.org/10.1145/3491101.3519623</bib>
<bib id="bib15"><number>[15]</number>Chihab Nadri, Jiayuan Dong, Jingyi Li, Ignacio Alvarez, and Myounghoon Jeon. 2022. Emotion GaRage Vol. III: A Workshop on Affective In-Vehicle Display Applications. In 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 186–188. https://doi.org/10.1145/3544999.3550161</bib>
<bib id="bib16"><number>[16]</number>Chihab Nadri, Jingyi Li, Esther Bosch, Michael Oehl, Ignacio Alvarez, Michael Braun, and Myounghoon Jeon. 2020. Emotion GaRage Vol. II: In 12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 106–108. https://doi.org/10.1145/3409251.3411736</bib>
<bib id="bib17"><number>[17]</number>Pramila Rani, Nilanjan Sarkar, Craig A. Smith, and Leslie D. Kirby. 2004. Anxiety detecting robotic system – towards implicit human-robot collaboration. Robotica 22, 1: 85–95. https://doi.org/10.1017/S0263574703005319</bib>

<bib id="bib18"><number>[18]</number>Harsh Sanghavi, Yiqi Zhang, and Myounghoon Jeon. 2020. Effects of Anger and Display Urgency on Takeover Performance in Semi-automated Vehicles. In 12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, 48–56. https://doi.org/10.1145/3409120.3410664</bib>
<bib id="bib19"><number>[19]</number>Larissa Z. Tiedens and Susan Linton. 2001. Judgment under emotional certainty and uncertainty: The effects of specific emotions on information processing. Journal of Personality and Social Psychology 81, 6: 973–988. https://doi.org/10.1037/0022-3514.81.6.973</bib>
<bib id="bib20"><number>[20]</number>Scott Zieger, Jiayuan Dong, Skye Taylor, Caitlyn Sanford, and Myounghoon Jeon. 2023. Happiness and high reliability develop affective trust in in-vehicle agents. Frontiers in Psychology 14. https://doi.org/10.3389/fpsyg.2023.1129294</bib>