Empathic vehicle design: Use cases and design directions from two workshops

Chihab Nadri
Virginia Tech, USA
cnadri@vt.edu

Ignacio Alvarez
Intel Labs, USA
Ignacio.j.alvarez@intel.com

Esther Bosch, Michael Oehl
German Aerospace Center (DLR), Germany, Esther.Bosch@dlr.de
Michael.Oehl@dlr.de

Michael Braun
BMW Group Research, Germany
michael.bf.braun@bmw.de

Jennifer Healey
Abode Research, USA
Jennifer.a.healey@gmail.com

Christophe Jallais
IFSTTAR TS2-LESCOT, France
Christophe.jallais@ifsttar.fr

Wendy Ju
Cornell Tech, USA
Wendyju@cornell.edu

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

Myounghoon Jeon
Virginia Tech, USA
myounghoonjeon@vt.edu

ABSTRACT

Empathic vehicles are expected to improve user experience in automated vehicles and to help increase user acceptance of technology. However, little is known about potential real-world implementations and designs using empathic interfaces in vehicles with higher levels of automation. Given advances in affect detection and emotion mitigation, we conducted two workshops (N_1 =24, N_2 = 22, N_{total} = 46) on the design of empathic vehicles and their potential utility in a variety of applications. This paper recapitulates key opportunities in the design and application of empathetic interfaces in automated vehicles which emerged from the two workshops hosted at the ACM AutoUI conferences.

CCS CONCEPTS

• **Human-centered computing**; • **Human-computer interaction (HCI)**; • **Accessibility**;

KEYWORDS

HCI, Empathy, Human Vehicle Interaction, Vulnerable Individuals

ACM Reference Format:
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 (CHI '22 Extended Abstracts), April 29–May 05, 2022, New Orleans, LA, USA.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3491101.3519623

1 INTRODUCTION

Advances in automation technology are facilitating the design of automated vehicles, removing many of the technological barriers to the development of fully automated vehicles. Nevertheless, the adoption of increasingly automated vehicles depends on user acceptance of the technology. Improving user experience has been demonstrated to increase user acceptance of automated technologies. As user acceptance of automated vehicles can depend on both the objective assessment of the technology's reliability [1] and the subjective opinion [2], the integration of emotional components with the traditional design principles has been suggested as a pathway to increase user acceptance of automated technology [3]. Thus, designing empathic vehicles which can determine and react to the emotional state of vehicle occupants has become an important research topic amongst automotive experts in academia and industry.

Empathic vehicles have been explored as part of broader investigations on the impact of driver emotions on driving performance. Past research has found that negative emotions can have a detrimental effect on driver attention and performance [4-6]. Drivers' anger and road rage have been extensively explored for their effects on decision-making behavior [7], as well as their effect on takeover performance in automated vehicles [8]. Researchers also found that drivers' angry state was a significant predictor of risky driving behavior [5]. A general overview of the influence of different emotions on driving has also further confirmed the effect of emotions on driving performance and driver behavior [3].

Emotion detection and mitigation techniques have emerged as ways to detect changes in user emotions and partially address these variations in user state. Either non-invasive (facial expression analysis, speech analysis) [7, 9, 10], or invasive methods have been explored for emotion detection (fNIRS, EEG, fEMG) [11, 12]. As for emotion mitigation, multiple intervention methods exist, including but not limited to the use of music and speech [12, 13] in reducing the effects of anger and boredom on driving performance. Emotion mitigation approaches have thus focused on providing appropriate countermeasures to emotional states that can induce detrimental effects on the driving experience.

Differences in age, culture or mental faculties between different population groups [3, 14, 15] have been speculated to harm the effectiveness of empathic vehicle displays. An inclusive design approach has been suggested as a way to account for differences

CHI '22 Extended Abstracts, April 29–May 05, 2022, New Orleans, LA, USA

ACM ISBN 978-1-4503-9156-6/22/04.
https://doi.org/10.1145/3491101.3519623

in user state anxiety [16], and familiarity and acceptance of automation technology [17]. Additionally, the increased adoption of vehicles with higher levels of automation could allow non-drivers to be the primary users of vehicles in some cases [18], such as children or individuals with disabilities that bar them from manual driving. In such cases, a flexible in-vehicle system that is able to provide user-specific information to maintain trust and clarity in the driving automation performance is required to be considered a viable mobility option.

To improve the design of future in-vehicle systems, we conducted two workshops that aimed to bring together researchers and practitioners interested in empathic interfaces and automated driving as a forum for the discussion on empathic vehicles and their use cases. To achieve this, both workshops utilized group work among automotive experts interested in affective computing principles and sparked discussions with the aim to identify potential research and knowledge gaps. During the workshops, we sought to expand the common understanding of empathic vehicle displays and generate new research directions in the field.

In the first iteration of the workshop [19], workshop participants discussed the importance of empathic vehicle displays and emotion detection technologies. Workshop participants also identified important emotional states and emotion detection techniques relevant to the future of automated driving. Although drivers were expected to be relegated to mere passengers, empathic vehicle displays were posited to become relevant mediums for improving user experience and driving performance. As such, different use cases were created in a rapid prototyping session. Moreover, important challenges at the time included evaluating empathic vehicle displays for vulnerable populations, a discussion point brought up at the end of the workshop.

In the second iteration of the workshop [20], we sought to address the challenges identified in the previous workshop by exploring use cases from the perspective of different user groups. Two short sessions of the online workshop were conducted in separate time zones due to the COVID pandemic. Experts from different regions developed use cases through insight combinations. Results from these workshop sessions identified differences in the implementation of empathic interfaces for vulnerable target groups and provided greater insight on expert perspectives on the use of empathic interfaces.

2 WORKSHOPS

Experts in the automotive field were gathered and discussed empathic vehicles in two separate workshops held at the AutoUI conference. In total, 46 experts volunteered to participate in the workshops.

2.1 Emotional GaRage Vol. I

Twenty-four experts participated in the first workshop held in conjunction with the AutoUI 2018 Conference [19]. The outline of the workshop was based on the 4mat System (Why, What, How and What if) [21], with the workshop being divided into four parts.

The workshop lasted four hours and started with an introduction session that consisted of introducing workshop organizers, as well as completing a small icebreaker exercise. Each participant was given a card that specified an emotion e.g., "Joy, Sadness, Insecurity, Embarrassment, and Anger" and a channel of expression, e.g., "Acoustic, Facial Expression, Gesture, and Drawing", and were instructed to keep its content a secret. Next, the participant went up to another attendee and expressed their emotion through the channel specified. If the other participant was able to guess the emotion, the guesser got a point.

Next, participants and workshop organizers spent 30 minutes in groups of six and did an exercise intended at recalling significant emotions experienced while driving. Each person in the group was asked to put the emotion on one post-it and the situation that inspired the emotion on a second post-it (as seen in Fig. 1). Participants then speculated on the future of driving, in whichever level of autonomy [22] they wanted to envision. Emotions that would be relevant in future driving situations were also discussed, as well as the technological advances that would enable new emotional experiences.

After two keynote sessions from workshop organizers that lasted 45 minutes in total, participants discussed common measurement methods and tools for emotion detection and emotion mitigation. These techniques were identified as countermeasures for one or two emotions previously mentioned in the prior brainstorming session. Additionally, rapid prototyping of the combined discussion points was conducted to design use cases for empathic vehicle displays.

Finally, all workshop participants discussed future research directions and application scenarios. Groups of five individuals made short videos explaining the importance of the topic and what was achieved through the workshop.

2.2 Emotional GaRage Vol. II

We conducted two one-hour workshop sessions with experts from different regions during the virtual conference of AutoUI 2020 [20]. The workshop aimed to develop use cases that can suit different user groups. The perspective of experts from different regions was sought, as cultural differences could play a part in empathic vehicle design [15]. As such, the two workshop sessions were designed to recruit experts from different regions and time zones, with participants providing demographic information. Experts hailed from a variety of countries (as seen in Table I), with 17 participants belonging to academia and five industry experts, for a total of 22 participants.

Table 1: Nationality of workshop participants, workshop II

Nationality	Frequency
Germany	5
USA, India	4
China	3
France	2
United Kingdom, Spain, Korea, Iran	1

The workshop consisted of short discussions and an insight combination activity [15]. After a short introduction and presentation of the previous workshop by the organizers, workshop participants presented themselves in order (around 30 seconds per participant).

Figure 1: Participants discussing emotional experiences in current and future driving experiences after presenting post-it notes.

Table 2: Emotional states discussed during the first workshop

Emotion	Frequency
Stress, Frustration	4
Joy, Peacefulness	3
Fear, Trust, Relief	2
Wonder, Rage, Curiosity, Excitement, Indifference, Nostalgia, Relaxation, Surprise	1

Participants were then grouped into three teams by workshop organizers. To structure a compact online workshop, we adopted the method of insight combination [15] to quickly generate initial solution ideas and empathic vehicle use cases. Teams were separated into online breakout rooms on Zoom and generated use cases through the Miro whiteboard online tool. With this tool, participants could generate ideas for empathic vehicle interfaces, and were presented with potential in-car emotion sets on yellow cards, e.g., "road rage", and some methods of emotion detection and regulation in blue cards, e.g., "speech analysis" or "the use of music" (as seen in Fig. 2). Both sets of yellow and blue cards were also provided earlier to participants as insight and review material before the workshop. During the workshop, each of the three teams generated use cases in multiple rounds by combining notes for user groups, in-car emotions, and detection and mitigation techniques. Then, every group recorded on green cards potential concepts and use case descriptions for the set of notes gathered (as seen in Figure 2).

Each team presented the use case concepts they created in the insight combination activity. Then, the workshop organizers concluded the session with closing remarks. An additional survey was conducted at the end to determine interest in the subject and potential feedback for future workshops on empathic vehicle interfaces.

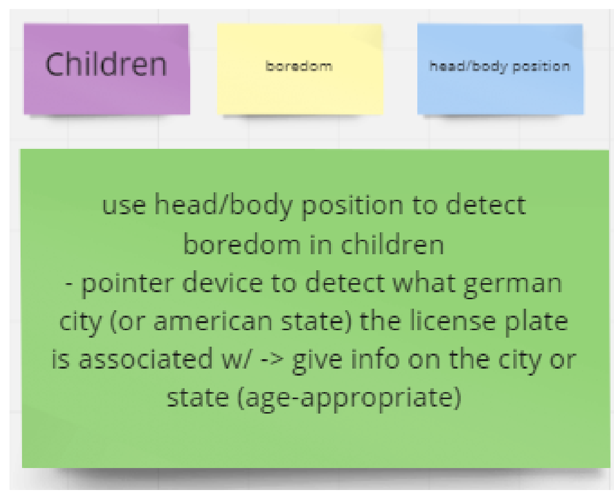

Figure 2: Use case example created during the second workshop, with sticky notes describing the user group (purple), emotion (yellow), emotion detection technique (blue), and general use case description (green).

3 RESULTS

3.1 Emotions in automated vehicles

During both workshops, a variety of emotional states and situations were envisioned to be important for the future of driving. For the future emotional driving states and use cases developed in the first workshop, 28 emotions (including overlap) were discussed, with 12 positive emotions, 12 negative emotions, as well as four neutral emotional states. Recurring emotions included stress, frustration, joy, and peacefulness (as seen in Table II).

Experts highlighted negative emotions could emerge from driving-related situations in automated driving that included loss

Table 3: Emotional states discussed during the second workshop

Emotion	Frequency
Stress	6
Rage	5
Confusion	2
Boredom, Excitement, Fear, Joy, Sadness	1

Table 4: User groups associated with use cases generated through both workshop sessions

Workshop session	User groups
Emotion GaRage Vol. I	General users (3), children (1)
Emotion GaRage Vol. II	Older users (4), children (3), Individuals with traumatic brain injuries (2), Individuals with unspecified disabilities (1), Teenagers (1), Blind (1), and Deaf (1) people

of control, technical failure, mistrust/insecurity about the functionality of the automation, being late, and sudden take-over requests. Means to detect these emotions comprise some invasive methods (electrocardiogram, skin conductance) and less invasive measurements (facial expression and gesture recognition by camera, microphone, heart rate watch).

For the second workshop, 18 emotional states were considered by participants within the context of the use cases generated. Out of the 18 emotions, 16 emotions were negative in valence, whereas there were only two positive emotions associated with use cases created. Stress was a recurring emotion again, whereas rage was also a prominent emotional state evaluated (as seen in Table III). Excitement and joy were the only two positive emotions recorded. Feelings of confusion were associated with the operation of the automated vehicle, whereas rage and stress were associated with traffic behavior (being followed by another vehicle, traffic issues) or general user state. Similar emotion detection techniques were mentioned, with a focus on non-invasive methods (heart rate watch, camera, facial expression).

3.2 Use cases

Use cases developed for empathic vehicles and displays differed based on the emotion addressed, the emotion detection and mitigation techniques used, and the target user groups identified for each case. Use cases were extracted from the rapid prototyping session in the first workshop and the insight combination activity in the second workshop. Use cases could be grouped into three different target groups (as seen in Table IV): general users, age-defined groups, and vulnerable users.

3.2.1 For general users. Empathic vehicle use cases for general users focused on negative emotions felt during the driving task and represented the most common demographic group in the first edition of the workshop (with three prototypes accounting for that group of users).

In one use case, speech recognition was used to detect anger in users and adapt the speech style of the in-vehicle voice assistant to a more pleasing tone. Surrounding traffic state was used to calculate the stress level of drivers and employ the car assistant to announce a meeting delay.

One group from the second workshop identified confusion and fear as emotional states that could be associated with driving assistance system errors. They suggested the use of facial EMG, speech recognition, and cameras to compare emotional states before and after the detected error (false positive obstacle recognition) and convey to users that the error was identified and logged in to reinforce trust in the system's self-analysis ability. Finally, the use of cabin color, smell, games, and music were suggested to mitigate negative emotions in automated vehicles.

3.2.2 For different age groups. Children and seniors were the most frequently discussed age groups (with four use cases discussing each group), followed by teenagers (one use case). One group considered using speech recognition to identify anger and fights to break out between children, employing physical separators within the vehicle to interrupt conflict. One group considered helping children experiencing stress in the car, detected through a vehicle toy equipped with a heartbeat sensor, by incorporating a massage or cooling function. For automated car takeovers, using soothing sounds and music was suggested to manage overexcitement. Finally, a group suggested the use of body position to detect boredom in children, providing location information on nearby landmarks.

For teenagers, empathic in-vehicle displays were envisioned to provide audio-driven breathing exercises and explanations to mitigate road rage.

Groups that designed empathic vehicles for senior users focused on negative emotional states. Stress felt during automated driving was a prominent issue, which can be solved by virtual assistants or adapting vehicle speed and external vehicle displays when followed too closely. Confusion with the operation of the vehicle, detected with an eye-tracker, was proposed to be solved by using dynamic lights to indicate useful controls to the user. One design group also suggested changing vehicle temperature to reduce road rage.

3.2.3 For vulnerable users. Calming scents (such as ones used in Dmitrenko et al. [23]), visuals, and displaying images of loved ones were suggested as ways to reduce stress and anxiety (detected by wearable devices; heart rate sensors and facial electromyogram) for deaf users, individuals with traumatic brain injuries, and other individuals with other disabilities. Road rage, detected from user gestures identified by a camera, was mitigated for individuals with traumatic brain injuries with a medication dispenser and a dynamic robot companion who could hug the user.

4 DISCUSSION

We organized two workshops on the design of empathic vehicle interfaces. While differences existed in the aim, direction, and organization of the different workshop sessions, recurrent themes can be identified in terms of relevant emotional states and potential empathic interface configurations.

Workshop participants identified a wide range of emotions to be relevant to empathic vehicle displays and automated driving. These emotional states are mostly the same as the set of critical emotions identified in the manual driving context [24]. In general, experts considered positive emotions to be linked to increased trust in the automated driving system, and subsequently acceptance of automation. On the other hand, negative emotions were linked to system mistrust, with both results largely aligning with previous research on the effect of user emotions on trust [3, 13, 25-27].

In both workshops, experts highlighted the importance of detecting and mitigating negative emotions with empathic vehicle interfaces. While the first workshop had an even mix of positive and negative emotions mentioned, experts in the second workshop developed most use cases with the aim to address negative emotions in automated driving. This can be attributed to the effect of negative emotions on trust [28], in addition to the specific effect stress and anxiety has on trust in automation and driving perception [4, 26]. This result further reinforces the notion that the design of empathic vehicle interfaces should prioritize the mitigation of negative emotions in driving to help facilitate user acceptance and trust of automated systems [1, 2, 25, 29].

This focus was also relevant to age-defined user groups described for empathic vehicle interfaces. Use cases for older drivers were also aimed at mitigating negative emotional experiences that are expected to occur for them in driving due to increased anxiety and decreased driving skills [4, 14, 30]. For children, workshop participants determined that empathic interfaces should mitigate conflict situations in vehicles, with other states being related to positive and neutral emotional states, such as boredom and excitement [6]. These considerations can be interpreted as ways that empathic vehicles can help fulfill user requirements from a parent's perspective when allowing children in fully automated vehicles without supervision [18] and, in a broader sense, mitigating worries and negative emotions from both parents and children.

While stress, fear, and confusion were emotional states shared between individuals with and without disabilities, workshop participants highlighted that mitigation and regulation would take different shape for individuals with disabilities. Mitigating confusion for blind and visually impaired individuals was envisioned to not only use an appropriate auditory modality but also provide additional feedback when compared to other users to provide as much situation awareness to the user as that attained by other users. Employing an inclusive design approach would not only fulfill personal user requirements [18] but also provide a better user experience for all users [31, 32].

Emotion detection techniques explored for empathic vehicles included both non-invasive devices (such as smart-watches or camera footage analysis) and invasive equipment. Invasive equipment, such as brain imaging devices, has been successfully used in the past to determine user emotions and driving behavior [33, 34]. Workshop results indicate non-invasive techniques would be used more often, such as video analysis and facial emotion detection, as they have shown promise in detecting facial expressions for both adults and children [35]. These methods were recommended by experts to be implemented through multimodal approaches. The attending experts furthermore concluded that personalization could critically improve the successful recognition of users' emotions.

As for emotion mitigation techniques, workshop participants advocated for the use of multimodal approaches and varied techniques depending on the emotion detected and user characteristics. Multimodal displays and the use of music have been successful in past in-vehicle applications to increase safety and situation awareness [36, 37]. The present findings indicate their importance in empathic vehicle interfaces and aligns well with past research on the beneficial influence of music on emotions while driving [12].

Participants from different regions participated in the second workshop, which was aimed at developing use cases for different target groups and identifying cultural differences. While workshop participants generated many use cases for vulnerable and other target groups, no use case was created for a specific culture. This might be explained in part by the short nature of the workshop and the small number of participants. Additionally, cultural factors are suggested to influence user priorities and values [15, 38], mainly affecting user response to the different empathic vehicle use cases [39]. This effect would require more informed modifications to the use case implementation, which we were unable to investigate in this short workshop.

Other challenges exist in the design of empathic vehicles and implementation approaches. Privacy is a concern of users helping differentiate user perceptions of automated technologies between older and younger drivers [40], as some vehicle users might negatively view these systems and only enable partial emotional display configurations. Mistrust in the driving system could also be generated from cybersecurity threats affecting the envisioned empathic connected vehicles [18]. Also, ride-sharing is expected to constitute a growing part of traffic [41], which could alter the types and nature of emotions felt while riding an empathic vehicle.

Workshop results indicate the importance of using different mitigation strategies to transition user state and maintain it. How efficiently empathic vehicles will be able to shift users away from negative states and maintain it will be a key goal and concern in the future. Further investigation of these challenges and research questions must be conducted to expand the range of possibilities with empathic in-vehicle interfaces. Nevertheless, empathic vehicles show potential in significantly aiding the acceptance of automated vehicle technology and improving safety.

5 CONCLUSION

Through conducting two workshops on empathic vehicle design and use case ideation with automotive experts, we were able to determine several key areas for the design of these vehicles. Results suggest emotion mitigation techniques should be adapted to the unique characteristics of unrepresented user groups such as vulnerable drivers, drivers from different cultural backgrounds, and other drivers as identified in the workshops. Additionally, experts highlighted the initial focus of empathic interfaces on mitigating negative emotional states to improve user acceptance of automated vehicle technologies. In this paper we provided expert-supported empathic interface use cases that were to be implemented and evaluated would advance the user acceptance of vehicle automation. We encourage the CHI affective computing community to use the learnings and discussions presented in this paper as a foundation for the advance of empathic automotive user interfaces because the importance of emphatic vehicle design is rapidly increasing and represents a major research direction in automated technology.

REFERENCES

[1] Gold, C., Körber, M., Hohenberger, C., Lechner, D., & Bengler, K. (2015). Trust in automation–Before and after the experience of take-over scenarios in a highly automated vehicle. Procedia Manufacturing, 3, 3025-3032.

[2] Feldhütter, A., Gold, C., Hüger, A., & Bengler, K. (2016). Trust in automation as a matter of media influence and experience of automated vehicles. Proceedings of the Human Factors and Ergonomics Society, 0, 2017-2021. doi:10.1177/1541931213601460

[3] Jeon, M. (2015). Towards affect-integrated driving behaviour research. Theoretical Issues in Ergonomics Science, 16(6), 553-585. doi:10.1080/1463922X.2015.1067934

[4] Taylor, J. E., Connolly, M. J., Brookland, R., & Samaranayaka, A. (2018). Understanding driving anxiety in older adults. Maturitas, 118(September), 51-55. doi:10.1016/j.maturitas.2018.10.008

[5] Dahlen, E. R., Martin, R. C., Ragan, K., & Kuhlman, M. M. (2005). Driving anger, sensation seeking, impulsiveness, and boredom proneness in the prediction of unsafe driving. Accident Analysis and Prevention, 37(2), 341-348. doi:10.1016/j.aap.2004.10.006

[6] Jeon, M., Walker, B. N., & Yim, J. B. (2014). Effects of specific emotions on subjective judgment, driving performance, and perceived workload. Transportation Research Part F: Traffic Psychology and Behaviour, 24, 197-209. doi:10.1016/j.trf.2014.04.003

[7] Underwood, G., Chapman, P., Wright, S., & Crundall, D. (1999). Anger while driving. Transportation Research Part F: Traffic Psychology and Behaviour, 2(1), 55-68. doi:10.1016/S1369-8478(99)00006-6

[8] Sanghavi, H. (2020). Exploring the Influence of anger on takeover performance in semi-automated vehicles.

[9] Jones, C., & Jonsson, I. M. (2008). Using paralinguistic cues in speech to recognise emotions in older car drivers. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 4868 LNCS, 229-240. doi:10.1007/978-3-540-85099-1_20

[10] Ihme, K., Dömeland, C., Freese, M., & Jipp, M. (2018). Frustration in the face of the driver: a simulator study on facial muscle activity during frustrated driving. Interaction Studies, 19(3), 487-498.

[11] Ngamsomphornpong, K., & Punsawad, Y. (2019). Development of Hybrid EEG-fEMG-based Stress Levels Classification and Biofeedback Training System. ACM International Conference Proceeding Series, 25-28. doi:10.1145/3332340.3332349

[12] Fakhrhosseini, S. M., Landry, S., Tan, Y. Y., Bhattarai, S., & Jeon, M. (2014). If you're angry, turn the music on: Music can mitigate anger effects on driving performance. AutomotiveUI 2014 - 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, in Cooperation with ACM SIGCHI - Proceedings(September). doi:10.1145/2667317.2667410

[13] Lee, S. C., Ko, S., Sanghavi, H., & Jeon, M. (2019). Autonomous driving with an agent: Speech style and embodiment. Adjunct Proceedings - 11th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2019(September), 209-214. doi:10.1145/3349263.3351515

[14] Dellinger, A. M., Sehgal, M., & Sleet, D. A. (2001). Driving Cessation : What Older Former Drivers Tell Us. 431-435.

[15] Li, J., Butz, A., Braun, M., & Alt, F. (2019). Designing emotion-aware in-car interactions for unlike markets. Adjunct Proceedings - 11th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2019, 352-357. doi:10.1145/3349263.3351324

[16] Taylor, J. E., Alpass, F., Stephens, C., & Towers, A. (2011). Driving anxiety and fear in young older adults in New Zealand. Age and ageing, 40(1), 62-66.

[17] Li, S., Blythe, P., Guo, W., & Namdeo, A. (2019). Investigation of older drivers ' requirements of the human- machine interaction in highly automated vehicles. Transportation Research Part F: Psychology and Behaviour, 62, 546-563. doi:10.1016/j.trf.2019.02.009

[18] Lee, S. C., Nadri, C., Sanghavi, H., & Jeon, M. (2020). Exploring User Needs and Design Requirements in Fully Automated Vehicles. Paper presented at the Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems.

[19] Bosch, E., Oehl, M., Jeon, M., Alvarez, I., Healey, J., Ju, W., & Jallais, C. (2018). Emotional GaRage: A workshop on in-car emotion recognition and regulation. Adjunct Proceedings - 10th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2018, 44-49. doi:10.1145/3239092.3239098

[20] Nadri, C., Bosch, E., Oehl, M., Alvarez, I., Braun, M., & Jeon, M. (2020). Emotion GaRage Vol . II. II, 106-108.

[21] Huitt, W. (2009). Individual differences: The 4MAT system. Educational Psychology Interactive.

[22] SAE-International. (2014). Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems (J3016 Ground Vehicle Standard).

[23] Dmitrenko, D., Maggioni, E., Brianza, G., Holthausen, B. E., Walker, B. N., & Obrist, M. (2020). Caroma therapy: pleasant scents promote safer driving, better mood, and improved well-being in angry drivers. Paper presented at the Proceedings of the 2020 chi conference on human factors in computing systems.

[24] Jeon, M., & Walker, B. N. (2011). What to detect? Analyzing factor structures of affect in driving contexts for an emotion detection and regulation system. Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting.

[25] Dunn, J. R., & Schweitzer, M. E. (2005). Feeling and believing: the influence of emotion on trust. Journal of personality and social psychology, 88(5), 736.

[26] Kraus, J., Scholz, D., Messner, E. M., Messner, M., & Baumann, M. (2020). Scared to Trust? – Predicting Trust in Highly Automated Driving by Depressiveness, Negative Self-Evaluations and State Anxiety. Frontiers in Psychology, 10(January), 1-15. doi:10.3389/fpsyg.2019.02917

[27] Yokoi, R., & Nakayachi, K. (2020). Trust in autonomous cars: exploring the role of shared moral values, reasoning, and emotion in safety-critical decisions. Human Factors, 0018720820933041.

[28] Braun, M., Pfleging, B., & Alt, F. (2018). A survey to understand emotional situations on the road and what they mean for affective automotive UIs. Multimodal Technologies and Interaction, 2(4). doi:10.3390/mti2040075

[29] Du, N., Haspiel, J., Zhang, Q., Tilbury, D., Pradhan, A. K., Yang, X. J., & Robert, L. P. (2019). Look who's talking now: Implications of AV's explanations on driver's trust, AV preference, anxiety and mental workload. Transportation Research Part C: Emerging Technologies, 104(September 2018), 428-442. doi:10.1016/j.trc.2019.05.025

[30] Liddle, J. (2014). Is planning for driving cessation critical for the well-being and lifestyle of older drivers? SSRN Electronic Journal, 5(564), 1-19. doi:10.4324/9781315853178

[31] Clarkson, P. J., Coleman, R., Keates, S., & Lebbon, C. (2013). Inclusive design: Design for the whole population: Springer Science & Business Media.

[32] Metatla, O., Oldfield, A., Ahmed, T., Vafeas, A., & Miglani, S. (2019). Voice user interfaces in schools: Co-designing for Inclusion with Visually-Impaired and Sighted Pupils. Conference on Human Factors in Computing Systems - Proceedings, 1-15. doi:10.1145/3290605.3300608

[33] Fakhrhosseini, M., Jeon, M., & Bose, R. (2015). Estimation of drivers' emotional states based on neuroergonmic equipment: An exploratory study using fNIRS. Adjunct Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive VehicularApplications, AutomotiveUI 2015(January), 38-43. doi:10.1145/2809730.2809751

[34] Foy, H. J., Runham, P., & Chapman, P. (2016). Prefrontal cortex activation and young driver behaviour: A fNIRS study. PLoS ONE, 11(5), 1-18. doi:10.1371/journal.pone.0156512

[35] Zheng, Z., Li, X., Barnes, J., Park, C.-H., & Jeon, M. (2019). Facial expression recognition for children: Can existing methods tuned for adults be adopted for children? Paper presented at the International Conference on Human-Computer Interaction.

[36] Baldwin, C. L., Eisert, J. L., Garcia, A., Lewis, B., Pratt, S. M., & Gonzalez, C. (2012). Multimodal urgency coding: Auditory, visual, and tactile parameters and their impact on perceived urgency. Work, 41(SUPPL.1), 3586-3591. doi:10.3233/WOR-2012-0669-3586

[37] Bazilinskyy, P., Petermeijer, S. M., Petrovych, V., Dodou, D., & de Winter, J. C. F. (2018). Take-over requests in highly automated driving: A crowdsourcing survey on auditory, vibrotactile, and visual displays. Transportation Research Part F: Traffic Psychology and Behaviour, 56, 82-98. doi:10.1016/j.trf.2018.04.001

[38] Lee, S. C., Stojmenova, K., Sodnik, J., Schroeter, R., Shin, J., & Jeon, M. (2019). Localization vs. internationalization: research and practice on autonomous vehicles

across different cultures. Paper presented at the Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings.

[39] Braun, M., Li, J., Weber, F., Pfleging, B., Butz, A., & Alt, F. (2020). What If Your CarWould Care? Exploring Use Cases For Affective Automotive User Interfaces. Preprint. ACM, New York, NY, USA. doi:10.1145/

[40] Zhang, T., Tao, D., Qu, X., Zhang, X., Lin, R., & Zhang, W. (2019). The roles of initial trust and perceived risk in public's acceptance of automated vehicles. Transportation Research Part C: Emerging Technologies, 98(June 2018), 207-220. doi:10.1016/j.trc.2018.11.018

[41] Merat, N., & Lee, J. D. (2012). Preface to the special section on human factors and automation in vehicles: Designing highly automated vehicles with the driver in mind. Human Factors, 54(5), 681-686. doi:10.1177/0018720812461374