Cooperation through communication – Using headlight technologies to improve traffic climate

Matthias Powelleit, Susann Winkler, & Mark Vollrath
Technische Universität Braunschweig
Germany

Abstract

In order to promote cooperative interactions and positive encounters in daily road traffic and to improve traffic situations which lack communication, a cooperative laser beam based on new light technologies is developed. Via light projections, drivers can get in touch with other road users. In a first step, relevant traffic situations and the situation-specific needs of diverse road users were identified by means of an online survey and a one-week diary study including car drivers, cyclists and pedestrians. From the results, scenarios were derived, which may benefit from the use of new communication technologies. A selection of these scenarios was implemented and evaluated in a driving simulator using a small-scale prototyping study (n = 7) which is described in this paper. Generally, drivers reacted positively to the new communication possibilities, which differed in their understandability and emotional effects. Furthermore, a visualization of the predicted driving trajectory showed the potential to distract drivers and alter their self-reported gaze and driving behaviour. Overall, a cooperative laser beam offers great opportunities to improve the traffic climate. However, further applications and safety-relevant consequences should be discussed.

Introduction

Motivation

Traffic relies heavily on the smooth interaction between road users. A mutual understanding of intentions and the reasons for certain driving manoeuvres is of vital importance. Drivers are taught in driving school to drive vigilantly, cooperatively, and communicate their intentions clearly, especially when interacting directly with other road users.

Several forms of communication can be found in the traffic environment. De Ceunynck et al. (2013) differentiate *implicit* and *explicit* communication, using the example of vehicle interactions at intersections. While implicit communication is essentially conveyed via the vehicle's motion (e.g., accelerating, decelerating, steering), explicit communication comprises specific signals which are not essential for the driving task itself but are used for interacting more directly with other road users (e.g., gestures, turn indicators, horn honking, flashing headlights). However, communication (implicit or explicit) is often ambiguous and has to be understood in

In D. de Waard, K. Brookhuis, D. Coelho, S. Fairclough, D. Manzey, A. Naumann, L. Onnasch, S. Röttger, A. Toffetti, and R. Wiczorek (Eds.) (2019). Proceedings of the Human Factors and Ergonomics Society Europe Chapter 2018 Annual Conference. ISSN 2333-4959 (online). Available from http://hfes-europe.org

the current driving context. A driver may brake, for example, to turn at the next intersection. A pedestrian at the road side might understand this action as (implicit) invitation to cross the road, even though the driver might not have recognized the pedestrian. This scenario can easily turn into a critical situation. Enhanced communication between road users can serve to clarify such situations and contribute to traffic safety.

Additionally, enhanced communication might also contribute to an improved traffic climate, as missing or misleading information can cause frustration and anger (Dollard, 1939; Merten, 1977). Research has shown that driving anger is related to aggressive driving (Risser, 1985; review given by Zhang & Chan, 2016) and impairs attention allocation, reasoning, judgement, and decision making (Blanchette & Richards, 2010), which are crucial to the driving task and traffic safety.

In contrast to well investigated negative emotions in traffic, there might also be the chance to elicit positive emotions. For example, sharing clearer information about current and future behaviour as well as expressing appreciation for cooperative gestures might influence the traffic climate positively. However, the use of available communication channels and signals is not standardized, even though every vehicle has the same signalling devices. A specific signal can be used to convey different and even opposing messages. Flashing the headlights can mean “Please, go ahead” or “Caution, I am moving ahead” (Merten, 1977). As current vehicle signals are often ambiguous, the perceived message depends highly on the context and can only be understood correctly if the communicators share the same context. In addition, more personal forms of communication like gestures might not be applicable in every situation. For example, at large distances or at night the vehicle driver might not be visible so that such explicit communication forms cannot be utilized.

A new communication channel, designed to transmit specific messages, could address the described problems and support clearer communication in traffic. New signals can be designed with specific messages in mind and as such be more personal than, for instance, flashing headlights. A lot of research is starting to focus on communication between automated vehicles and other traffic participants, like pedestrians. Many of them are using external human machine interactions (HMI; see Deb, 2018; Dey et al., 2018; Dey & Terken, 2017; Hudson et al., 2018; Schieben et al., 2018; Song et al., 2018; Witzlack et al., 2016). The HMI concepts vary from displays in the windshield or on the vehicle roof to audio messages. This paper follows a different approach. Technological advances in the field of vehicle lights allow new ways of communicating by projecting information onto the road surface, for example, by using laser beams integrated into the vehicle’s headlights. Further information on the research aims and the development of scenarios will be given in the following.

Objectives

Within the research project “KoLa” (cooperative laser beam, Fraunhofer ISIT, Volkswagen AG, Universität Siegen, Technische Universität Braunschweig), new forms of communication are developed, which enable drivers to express unambiguous messages and show more cooperative behaviour. These enhanced communication possibilities might improve traffic climate and in turn support traffic safety.

To identify possible fields of application for the cooperative laser beam, two exploratory studies were conducted in collaboration with colleagues of the Universität Siegen and the Volkswagen AG. An audio diary study (N = 27) focused on situations in which road users could benefit from (better) communication and cooperation. For a time period of one week, participants documented everyday traffic situations that were characterized by the notable presence or absence of communication or cooperation. Using a voice recorder, data was collected as soon as possible after the occurrence of a situation (but not while driving). All modes of transport of the participants and interaction partners were regarded (by foot, bicycle or motorized vehicles). In addition, an online survey (N = 165) focused on factors that let a traffic situation be experienced as either positive or negative. Participants described a positive or negative situation (random assignment) they had encountered within the last four weeks. Again, all modes of transport were included as long as one of the interaction partners was a vehicle driver.

Using qualitative data analysis methods, profiles of the situations were generated to identify cases in which communication could have clarified or deescalated situations, motivated or facilitated cooperation and in turn created a more positive situation experience. This way, traffic scenarios were derived that could potentially be enhanced through improved communication and cooperation. In addition, the reported intentions, expectations, feelings, needs and wishes of the participants in the situations were used to derive cooperative messages that might have affected the situation experience positively. Finally, ideas and concepts were developed on how to articulate and present such cooperative messages in the according situations. More detailed information on the design of both studies and their results will be presented and discussed in a different publication.

Building upon this work, selected communication-relevant scenarios were implemented in a driving simulator environment to investigate different communication concepts, two of which will be presented in this paper (“Thanking” and “Trajectory display”). For all concepts, different design choices (graphics and animations) were compared regarding drivers’ ratings (e.g., comprehensibility, appeal, and distraction potential).

Method

Design

Since the aim of this study was to investigate multiple design parameters of the light communication concepts, a small-scale prototyping approach was used to gain first insights and then take the feedback into consideration for further design evaluations. Each participant experienced and rated different versions of two communication concepts (“Thanking” and “Trajectory display”). The sequence of the two concepts and the sequence of the different versions were randomized for each participant.

Participants

Seven test persons participated in this study. They were recruited through personal invitations. Six participants were experts in the fields of traffic psychology, safety, and human machine interaction, while one had no study-related professional background. The participants were aged between 25-54 years (M = 34.1 years; SD = 10.4 years). Five participants were female, two were male.

Driving simulator and implementation of light concepts

The study was conducted in the Department of Engineering & Traffic Psychology at the Technische Universität Braunschweig. A fixed base driving simulator was used, running SILAB 5.0 simulation software (Krüger et al., 2005; see www.wivw.de). The mock-up consisted of a driver seat, a steering wheel and pedals. Three TV screens (each 1920 x 1080 pixels, 55” diagonal) presented the simulated environment, covering approximately a 180° field of view. Sound was presented via stereo speakers and a subwoofer. The experimenters sat next to the participant, giving instructions and leading through the interview. No driving data was recorded during this study as the setup served a mere visualization purpose. The simulated environment was set to night time (see Figures 2 and 3).

The simulation software had no native support for user defined light projections. Pre-tests were done to find ways to a) implement individual light sources, b) customize the light sources in order to project custom graphics undistorted onto the road surface, and c) animate the projections. As a result, grayscale images were used as an alpha mask to define the shape and shade of the light projection, very similar to a slide projector (Figure 1). Simple animations of the projected graphic objects (translation, rotation, uniform scaling) were done within the simulation environment by moving and rotating the light source.

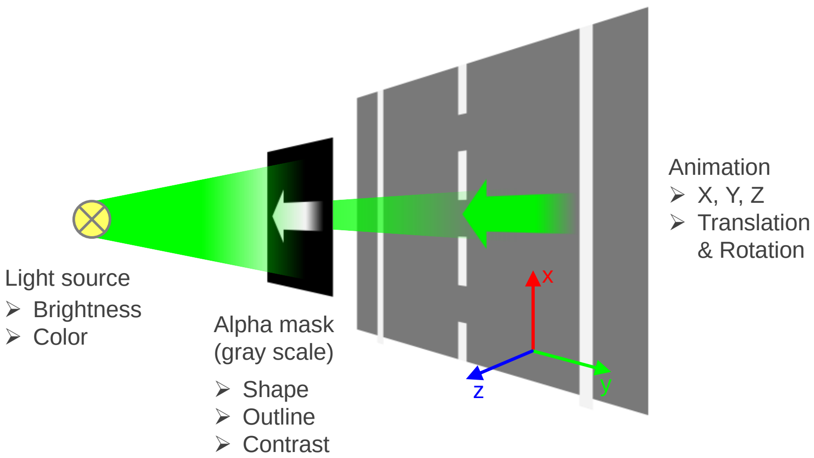

Figure 1. Illustration of how the light projections were implemented in the driving simulator.

For more complex animations (unidimensional scaling and bending of texture graphics) the grayscale image was replaced by a video source that acts as a dynamic texture (available in SILAB software since version 5.0). To trigger and control the video animations, an application was written in Processing 3 (www.processing.org, Processing Foundation), which realized custom vertices animation, based on driving parameters from the driving simulation software. The animations were then handed to the simulation software via video stream, integrated as a dynamic texture for the light source, and finally rendered as light projection onto the street, similar to a film projector.

Scenarios and communication concepts

To simplify the interaction and at the same time be more realistic with regard to the penetration rate of new technologies, always only one vehicle was equipped with a projection-based communication system.

Scenario "Thanking"

In the scenario "Thanking", the participant had the opportunity to give way to another driver (waiting at the driveway of a property) by flashing the headlights. In the previous studies, participants reported that the recognition of their gesture by the other road user (nodding the head, raising the hand, or smiling back) was an important part for the interaction to be perceived as positive. Hence, for this scenario, different variants of a concept were developed to acknowledge the participant's gesture. After the participant let the waiting vehicle turn into the lane, the now leading vehicle expressed gratitude via a backwards light projection.

Symbols served as light-based "Thank you!" messages as written language comes with several disadvantages (language barriers, takes longer to be understood, required resolution). To vary the tone of the message, three different symbols were presented to the drivers: A) a check mark, B) a smiley, and C) a thumbs up (Figure 2, left). Furthermore, three animation styles were varied to check if the participants feel differently addressed by the messages. In version A, the check mark symbol appeared at a fixed distance behind the leading vehicle. In version B, the smiley symbol seemed to be laid down onto the road by the leading vehicle as it stays at the same location (fixed to the road), while the leading vehicle moved on. Just before the participants reached the location of the projected smiley and were about to drive over the projection, the symbol popped up slightly and then shrank until it vanished completely. This animation should give the impression that the symbol responded to the participant's vehicle. In version C, the thumbs up symbol appeared at the rear end of the leading vehicle, then moved towards the participant's vehicle, and finally faded out before "touching" the participant's vehicle.

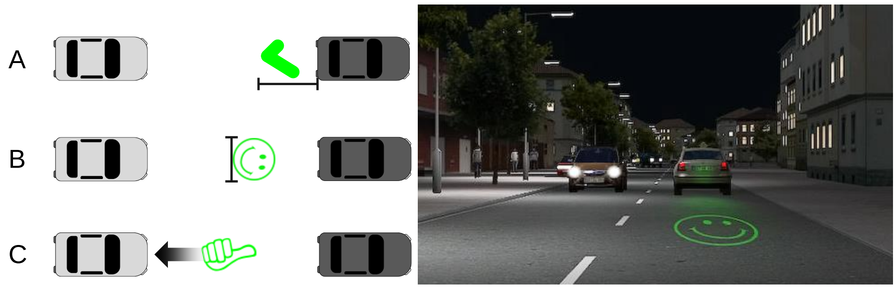

Figure 2. The three versions of the "Thank you!" message: A) check mark, in fixed distance to the leading vehicle, B) smiley, in fixed location on the road, and C) thumbs up, moving towards the participant's vehicle (left). Screenshot taken from the simulated environment with version B implemented (right).

Scenario "Trajectory"

In contrast to the "Thank you!" scenario, the participant is the sender of a message in the "Trajectory" scenario. However, in this case no specific situation was realized. Instead, the participant's car was continuously projecting the own driving path in front of the vehicle. This was done passively without any actions being required by the driver. Such visualization could help other road users to recognize the driver's actions and intentions even from a distance. For example, participants of the previous studies reported that, as pedestrians, they have difficulties to recognize speed changes when a driver slows down to give them way. Furthermore, due to reflections or dim lighting, gestures of the driver may not be visible through the wind shield. In such a situation, the projection of the vehicle's driving path could visualize the speed reduction, e.g. by retracting the size of the display and even further explicate the driver's intention by projection gestures onto the street. Independently of the specific use case, the effects of such dynamic displays on the driver's sensation of the driving environment were of interest to this part of the study. As it might be the case with all additional information displays, this visualization may cause irritation, especially as it dynamically feedbacks the driver's behaviour.

Figure 3. Examples of the textures used for the trajectory display (left) and a screenshot taken from the simulated environment with version B implemented (right).

In this scenario, a flexible light band was projected directly in front of the own vehicle that changed its appearance in order to represent the anticipated driving path of the vehicle. Thus, it extended with acceleration and retracted with deceleration and finally disappeared when the vehicle came to a full stop. When the participants used the steering wheel, the light band bent accordingly. The animation parameters for the length and curvature of the projected light band were adjusted to match the driving path within the next second, based on the current speed and steering wheel angle. Ten different texture styles (designed by project partners of the University of Siegen) of the light band were implemented, with varying contrasts, shapes, and line widths (Figure 3, left).

Procedure

Participants were introduced to the procedure and general aim of the study, then gave informed consent to audio and video recording. They sat down on the driver seat and were told to drive through a short urban track, adhering to traffic rules and a speed limit of 50 km/h.

Both scenarios were first experienced in a baseline drive without any additional communication concepts. This way, participants could compare their driving experience without and with light projections. Afterwards, participants were shown each version of the light concepts. Participants were instructed to think aloud while driving, expressing their spontaneous thoughts, emotions, and reactions to the presented concepts openly. In addition, a structured interview and rating scales (Heller, 1982) were used to evaluate factors like appearance and understandability of the concepts. Finally, the participants were asked to pick their favourite version for both scenarios, make improvement suggestions for future designs. The evaluation of each scenario took around 20-40 minutes, resulting in a total of 40-80 minutes per participant.

Results

As the aim of this study was to gain first insights into the design of light-based communication concepts, data analysis focussed on the audio recordings (thinking aloud and open interview questions).

Scenario "Thanking"

Animations
With regard to the animation of the symbols, participants felt less addressed by version A (locked distance to leading vehicle) compared to version B and C. The locked distance gave the impression that the symbol (check mark) belongs to the leading vehicle and represents some kind of vehicle status rather than a message directed to the participant. Furthermore, with increasing distance to the leading vehicle, the projected symbol became smaller and thus more difficult to recognize for the participant in the following vehicle.

Version B and C differed strongly in their presence. The smiley symbol (B) "rested" steadily on the road until the participant reached its position, whereas the thumbs up symbol (C) was visible shorter as it moved towards the participant's vehicle. As the participants reported, the resting smiley was perceived more clearly but might bind the driver's attention more. The moving thumbs up symbol was perceived as more subtle, but drivers might oversee it more easily. Furthermore, if the symbol moves too fast towards the following vehicle, the message might be perceived as hasty and less sincere, as one participant indicated. Regarding the pop-up animation of the smiley symbol, some participants expressed having an enjoyable experience comparable to collecting tokens that they can take home like "karma points".

Symbols

Participants perceived very different messages from the presented symbols. The smiley symbol conveyed a message which can be summarized as "I am happy (with your actions)". The thumbs up symbol was understood as saying something like "Your actions were good". In contrast, the check mark symbol was understood as "Your actions were correct".

Participants perceived the smiley symbol as very friendly and the other driver as open and communicative. Participants reported that the other driver felt very happy and wanted to share his or her feelings with them. The driver, who projected the thumbs up symbol, was perceived as cool but more distanced than the driver with the smiley. Thus, the thumbs up symbol was rated as more neutral than the smiley but friendlier than the check mark. Participants considered the check mark symbol to be very impolite as they felt judged from a higher moral ground by the other driver, such as in a student-teacher setting. Thus, the driver with the check mark was perceived as know-it-all and arrogant.

The results from the rating scales were in line with the statements that were verbally expressed while driving. As Figure 4 shows, the smiley symbol was overall judged the most positively and was rated as very understandable, very distinct and very pleasant. None of the symbols was perceived as disturbing.

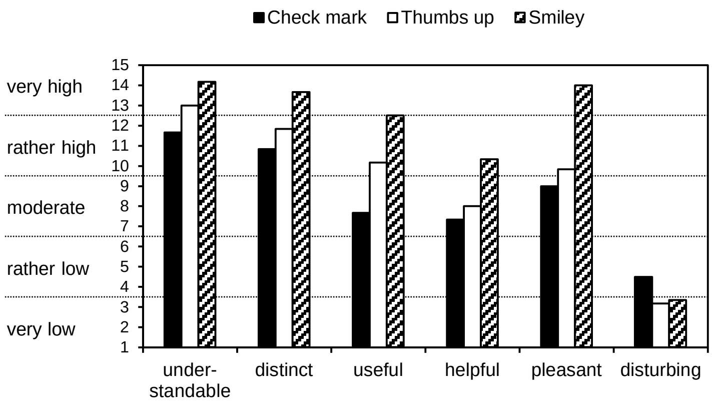

Figure 4. Average ratings of the three "Thank you!" symbols.

Scenario "Trajectory"

The projected light band was designed to represent the vehicle's path one second ahead. When drivers enter an intersection or tight curve this bar could overlap other lanes (Figure 5, left) or the side walk (Figure 5, right). This overlap reportedly influenced drivers' steering behaviour. For example, drivers started steering earlier than necessary for the given road geometry. In general, the projected light band confused participants, as they tried both staying in the lane with their vehicle and avoiding overlaps of the light band with lane markings.

Figure 5. Light band of the "trajectory display" overlapping with lane markings (left) and the side walk (right).

In addition, the light band was perceived as rather intrusive and hard to ignore during driving. Participants reported to show less attention to peripheral objects (e.g., traffic lights and pedestrians) and the area near the horizon which is normally focused for foresighted driving. Instead, participants described a tendency to fixate the tip of the projected light band to avoid overlaps with the lane markings. Such distractive effects were especially high when the texture of the projected light band had strong contrasts, contours, and high opacity (see Figure 3, left, e.g. texture D and E). An additional problem arose when the light band had patterns or contours that were similar to road markings, such as zebra crossings or lane markings (see Figure 3, left, e.g., texture C to E).

Drivers rated the trajectory display as moderately understandable, distinct, helpful, and pleasant. The usefulness was rated as rather low. Participants wondered about the purpose and meaning of the light band. Most participants misinterpreted the light band as the stopping distance; some regarded the curved light band as an instruction to where they should steer. While participants reported that they might find the trajectory display useful for the external world like pedestrians or cyclists, they would not want to have it in their own vehicle as it was distracting and disturbing and added no additional information or value for themselves.

Discussion

This study investigated how a new communication channel (light-based projections onto the road) can be used to promote cooperative behaviour in road traffic and thus positively influence the overall traffic climate. Using the example of two scenarios "Thanking" and "Trajectory display" an explorative driving simulator study analysed the potential of light-based communication.

In the scenario “Thanking”, participants took on the role of a prosocial road user by giving up their right of way to let another vehicle turn into their lane. The turning vehicle expressed its gratitude by utilizing light projections that were directed towards the participant in the following vehicle. The influence of different symbols (check mark, smiley, and thumbs up) and animations (fixed to the leading vehicle, fixed on the road, and moving towards the following vehicle) on the content and tone of the messages were investigated.

Depending on the symbol, the driver of the leading vehicle was perceived differently, ranging from “friendly” and “open” (smiley) to “cool” and “reserved” (thumbs up) to “arrogant” and “know-it-all” (check mark). Participants preferred the smiley symbol as it conveyed a simple emotional response of the other driver (“I am happy”). This message seems to work similar to facial expressions in personal interaction: No explicit message is conveyed, but rather an emotional state that is implicitly related to the context. As the driver of the leading vehicle decides to send this state explicitly, he or she is perceived as very open and communicative, and as someone who cares about other road users.

Most of the participants started smiling themselves and some continued even long after the scenario had finished. This observation shows that emotions can be conveyed by light projections of a vehicle, even though the driver is not visible and enveloped by the car’s shell. Furthermore, these emotions had a positive effect on the participants’ own emotional state, which might have implications for the traffic climate more generally. Especially regarding the large effect driving anger can have on the driving behaviour and traffic climate (see Bliersbach et al., 2002; Levelt, 2003; Maag, 2004), there might also be potential of beneficial safety effects when drivers feel happy while driving.

In the scenario “Trajectory display”, the effects of a dynamic visualization of the vehicle’s driving path were investigated. The visualization was projected in front of the own vehicle in the form of a flexible light band with different versions of textures. The visualization was perceived as rather intrusive and distracting, especially when textures with high contrast and opacity were used. At the same time, the trajectory display offered no value for the drivers. Even more, participants reported negative influences of the display on their gaze and driving behaviour. This finding revealed conceptual problems that arise when predicted trajectories are to be displayed, based on current vehicle dynamics parameters. As the trajectories were predicted one second ahead, the visualization was incongruent with short term changes of the driver’s behavioural intentions. This was especially contradicting for lateral movements, like turning at intersections or short corrective actions.

While other road users may benefit from a trajectory display that enhances the predictability of a vehicle, the findings of this study strongly suggest looking for alternative ways of visualization. One solution may be to disregard the steering wheel action and only focus on longitudinal movements in order to avoid overlapping of the projection and lane markings. In this case, the light band may follow the shape of the road geometry. Future studies should also consider the perspective of other road users in order to verify their need for such a system.

Furthermore, varying levels of information detail will be evaluated to find out if a generic message can be used for multiple scenarios without compromising understandability of the message. In addition, further investigations may focus on situational factors (visibility, movement, and type of the sending vehicle) more closely, as the perceived message might depend on these factors.

Conclusion

In this study, light projections were tested for their applicability as a novel communication channel. In the context of expressing gratitude, it is recommended to use simple emotional messages as found in non-verbal communication in personal interactions to create positive experiences. Furthermore, a dynamic visualization of the driving path in front of the own vehicle was experienced as distracting and disturbing without offering any additional value for drivers. Future evaluations will investigate the influences of varying levels of information detail and situational parameters on the understandability of perceived messages.

References

Blanchette, I., & Richards, A. (2010). The influence of affect on higher level cognition: A review of research on interpretation, judgement, decision making and reasoning. *Cognition & Emotion, 24*, 561–595. doi:10.1080/02699930903132496

Bliersbach, G., Culp, W., Geiler, M., Heß, M., Schlag, B., & Schuh; K. (2002). *Gefühlswelten im Straßenverkehr – Emotionen, Motive, Einstellungen, Verhalten*. Bonn, Germany: Deutscher Verkehrssicherheitsrat e.V.

De Ceunynck, T., Polders, E., Daniels, S., Hermans, E., Brijs, T., & Wets, G. (2018). Road Safety Differences between Priority-Controlled Intersections and Right-Hand Priority Intersections. *Transportation Research Record: Journal of the Transportation Research Board, 2365*, 39–48. doi:10.3141/2365-06

Deb, S., Strawderman, L.J., & Carruth, D.W. (2018). Investigating pedestrian suggestions for external features on fully autonomous vehicles: A virtual reality experiment. *Transportation Research Part F: Traffic Psychology and Behaviour, 59*, 135–149. doi:10.1016/j.trf.2018.08.016

Dey, D., Martens, M., Wang, C., Ros, F., & Terken, J. (2018). Interface Concepts for Intent Communication from Autonomous Vehicles to Vulnerable Road Users. In *Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. (pp. 82–86). New York, NY: ACM. doi: 10.1145/3239092.3265946

Dey, D., & Terken, J. (2017). Pedestrian Interaction with Vehicles: Roles of Explicit and Implicit Communication. In *Proceedings of the 9th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. (pp. 109–113). New York, NY: ACM. doi:10.1145/3122986.3123009

Dollard, J., Miller, N.E., Doob, L.W., Mowrer, O.H., & Sears, R.R. (1939). *Frustration and aggression*. New Haven, CT, US: Yale University Press. doi:10.1037/10022-000

Heller, O. (1982). Theorie und Praxis des Verfahrens der Kategorienunterteilung (KU). In O. Heller (Ed.), *Forschungsbericht 1981*. (pp. 1–15). Würzburg, Germany: Psychologisches Institut der Universität Würzburg.

Hudson C.R., Deb S., Carruth D.W., McGinley J., Frey D. (2019). Pedestrian Perception of Autonomous Vehicles with External Interacting Features. In I. Nunes (Ed.), Advances in Human Factors and Systems Interaction. *Proceedings of the AHFE 2018*. (AISC, vol. 781). Cham: Springer International Publishing. doi:10.1007/978-3-319-94334-3

Krüger, H.-P., Grein, M., Kaussner, A., & Mark, C., 2005. SILAB – A task-oriented driving simulation. In *Proceedings of the Driving Simulator Conference* (pp. 323–331).

Levelt, P.B.M. (2003). *Literature study of emotions in traffic.:Use and possibilities of an affective approach to traffic behaviour* [Literatuurstudie naar emoties in het Verkeer. Nut en mogelijkheden van een affectieve benadering van verkeersgedrag]. Leidschendam, the Netherlands: SWOV. https://www.swov.nl/sites/default/files/publicaties/rapport/r-2002-31.pdf

Maag, C. (2004). Fahrer und Verkehrsklima: eine verkehrswissenschaftliche Untersuchung zu den Ursachen und Folgen von Emotionen im Straßenverkehr. In *VDI Fortschritt-Bericht, Reihe 22: Mensch-Maschine-Systeme*. (Nr. 18). Düsseldorf: VDI-Verlag.

Merten, K. (1977). Kommunikationsprozesse im Straßenverkehr. In Bundesanstalt für Straßenwesen (Ed.) *Symposium Unfallforschung und Verkehrssicherheit 1977*. (Heft 14, S. 115–126). Köln: Bundesanstalt für Straßenwesen.

Risser, R. (1985). Behavior in traffic conflict situations. Accident Analysis & Prevention, 2(17), 179–197. doi:10.1016/0001-4575(85)90020-X

Schieben, A., Wilbrink, M., Kettwich, C., Madigan, R., Louw, T., & Merat, N. (2018). Designing the interaction of automated vehicles with other traffic participants: Design considerations based on human needs and expectations. *Cognition, Technology & Work, 109,* 1–17. doi:10.1007/s10111-018-0521-z

Song, Y.E., Lehsing, C., Fuest, T., & Bengler, K. (2018). External HMIs and their effect on the interaction between pedestrians and automated vehicles. In W. Karwowski, and T. Ahram (Eds.) *Advances in Intelligent Systems and Computing* (vol. 722, pp. 13–18). doi:10.1007/978-3-319-73888-8_3

Witzlack, C., Beggiato, M., & Krems, J. (2016). Interaktionssequenzen zwischen Fahrzeugen und Fußgängernim Parkplatzszenario als Grundlage für kooperativ interagierende Automatisierung. In VDI (Eds.) *Fahrerassistenz und automatisiertes Fahren, VDI-Berichte 2288* (pp. 323–336). Düsseldorf, Germany: VDI-Verlag.

Zhang, T., & Chan, A.H.S. (2016). The association between driving anger and driving outcomes: A meta-analysis of evidence from the past twenty years. *Accident Analysis and Prevention, 90*, 50–62. doi:10.1016/j.aap.2016.02.009