Examining Psychological Conflict-Handling Strategies for Highly Automated Vehicles to Resolve Legal User-Vehicle Conflicts

ANNIKA STAMPF, Institute of Media Informatics, Ulm University, Germany
MARK COLLEY, Institute of Media Informatics, Ulm University, Germany
ANN-KATHRIN KNUTH, Institute of Media Informatics, Ulm University, Germany
CAGLA TASCI, Institute of Media Informatics, Ulm University, Germany
ENRICO RUKZIO, Institute of Media Informatics, Ulm University, Germany

As vehicle automation progresses, with SAE levels 3 to 5 introducing varying degrees of control transfer from driver to vehicle, a key challenge emerges: aligning driver interests with the automated vehicle's (AV) operational goals. Despite technical feasibility, drivers' tendencies to intervene due to distrust in or dissatisfaction with AVs necessitate consideration of control mechanisms in future AV designs. This study investigates the potential of persuasion strategies inspired by Human-Robot Interaction research to harmonize driver actions with AV goals in legal conflict situations. We conducted a Virtual Reality driving simulator study with 36 participants, comparing 11 persuasive conflict-handling strategies and a baseline of no persuasion. Our research helps understand the effects of persuasion on users' compliance with law-abiding AV goals, trust, and acceptance towards the AV and evaluates the effectiveness of these strategies based on their working mechanism (cognitive, emotional, social, politeness) and valence (negative, neutral, positive). Results show that none of the strategies could substantially increase compliance with the AV, but neutral and positive persuasion strategies did not decrease acceptance and trust towards the AV compared to no persuasion. These findings contribute to the discourse on cooperation design and control allocation in AVs, particularly in scenarios involving legal conflicts.

CCS Concepts: • **Human-centered computing → Systems and tools for interaction design**; *Empirical studies in visualization*; **Empirical studies in HCI**.

Additional Key Words and Phrases: automated vehicles, user-vehicle conflicts, legal conflict, conflict-handling strategies

ACM Reference Format:
Annika Stampf, Mark Colley, Ann-Kathrin Knuth, Cagla Tasci, and Enrico Rukzio. 2024. Examining Psychological Conflict-Handling Strategies for Highly Automated Vehicles to Resolve Legal User-Vehicle Conflicts. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 8, 3, Article 126 (September 2024), 25 pages. https://doi.org/10.1145/3678511

1 Introduction

Automation in vehicles is advancing rapidly, with the primary goal of enhancing traffic safety and efficiency [10]. The Society of Automotive Engineers (SAE) categorizes vehicle automation into levels ranging from 0 (no automation) to 5 (full automation) [63]. Level 3 introduces the possibility for vehicles to take over control from the driver, i.e., they have the capability to drive automated in a defined Operational Design Domain (ODD). However, the driver must be ready to intervene when requested. In Level 4, vehicles can perform all driving tasks in the

Authors' Contact Information: Annika Stampf, annika.stampf@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany; Mark Colley, mark.colley@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany; Ann-Kathrin Knuth, ann-kathrin.knuth@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany; Cagla Tasci, cagla.tasci@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany; Enrico Rukzio, enrico.rukzio@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany.

ACM 2474-9567/2024/9-ART126
https://doi.org/10.1145/3678511

ODD without driver intervention, and in Level 5, the vehicle can drive fully automated under any conditions without driver intervention. Despite these advances, the expectation remains that drivers may wish to intervene in automated vehicle (AV) operations, driven by concerns such as fear of losing control [43] or discomfort with the absence of manual controls [48]. Thus, the automotive industry contemplates the potential for assuming control in future AV designs, even though may be technically feasible to remove the driver entirely from the driving task (e.g., see BMW's Vision NEXT [36]).

This reluctance and fear may stem from not fully trusting and accepting, which may come from potential conflicts between the AV's actions and the user's preferences or expectations, and therefore can lead to user-initiated takeovers [80]. Takeovers are safety-critical as they can result in post-automation effects, such as unstable lateral control [53] or insufficient situation awareness [27, 54] and should, therefore, be avoided [80]. This necessitates the AV to deploy conflict-handling strategies, i.e., methods to effectively manage and resolve disagreements. Current research has explored enhancing automation transparency [38, 78] and offering cooperative control options [18, 38, 71, 79] as means to reduce these conflicts and the likelihood of takeovers. However, the exploration of more assertive methods to handle situations where drivers' intentions conflict with the AV's objectives, such as legal compliance, remains open. This gap is significant, considering evidence that drivers occasionally engage in behaviors contrary to traffic regulations [30, 44], which can lead to safety-critical situations or accidents [30, 44].

Previous work, for example, demonstrates that drivers occasionally behave contrary to traffic regulations [30]. Throughout 2022, 4.137.831 traffic violations were penalized in Germany [44]. Thus, numerous studies deal with the underlying human factors that lead to traffic-violating behavior [30, 31, 47, 59], showing the dependence on various factors such as descriptive and subjective norms or attitude. We, therefore, assume that these factors also manifest themselves in automated driving and conclude that situations are likely to arise in which the user pursues traffic-violating interests. In contrast, AVs are designed to pursue efficiency [49], safety [10], and adherence to predefined rules [10], such as traffic regulations.

In these legal conflict cases, it might be necessary for the AV to "disagree" [64] with the driver and follow a more assertive approach, such as persuading drivers to follow the AV's design objectives. Persuasion strategies in driving are rare and focus on manual control [58]. Further, these strategies are not easily transferable to cooperative automated driving as control and authority dynamics are fundamentally different. Therefore, insights from HRI become valuable, as robots, as well as AVs, are autonomous systems capable of sensing their environment, making decisions based on this input, and interacting with the world to achieve specific goals. Thus, insights from HRI can help us understand how to design AVs that effectively communicate their actions, intentions, and goals, ensuring efficient integration into human environments. Babel et al. [5] developed various persuasion strategies for robots, comparing them based on their emotional valence (i.e., users' perception of the strategy, e.g., positive or negative) and psychological working mechanism (e.g., cognitive or emotional). All of their considered persuasion strategies (except for threatening) have been shown to be effective when cleaning robots require humans' compliance with the robot's operational goals, which meant the humans leaving the kitchen.

Inspired by these insights, our research investigates whether similar persuasion strategies can be adapted to the context of automated driving. Specifically, we explore whether AVs using those strategies can persuade drivers not to violate traffic regulations and evaluate their effects both individually and in terms of their working mechanism and valence. Our research questions (RQs) are as follows:

RQ 1 What effects does persuasion have on the users' compliance with AV goals, perceived conflict, trust, and acceptance towards the AV in legal conflict situations?

RQ 2 Are there differences in the effectiveness of the strategies based on their psychological working mechanism (i.e., cognitive, emotional, politeness, social) and valence (i.e., negative, neutral, positive)?

To answer the RQs, we conducted a Virtual Reality (VR) driving simulator study with N=36 participants, comparing 11 persuasive conflict-handling strategies (derived from the HRI context [5]) with a baseline of no persuasion. Our study's main finding is that users are not easily persuaded to comply with the AV's goals. This outcome leads to critical discussions about the implications for cooperation design and control allocation in legal conflict scenarios.

Contribution Statement: Our work provides empirical insights into user perceptions of assertive AVs and demonstrates the limited effectiveness of psychological persuasion strategies, highlighting the complexity of handling user interests in legal conflict situations. Furthermore, the research discusses the implications of the findings for existing cooperative approaches and offers valuable directions for future research in this context. Thus, our work not only contributes to the theoretical understanding of Human-Vehicle Interaction (HVI) in the face of legal conflicts but also provides practical insights for designing future AVs that can effectively manage such conflicts while maintaining user trust and acceptance.

2 Background and Related Work

This paper builds on the existing body of work dealing with conflict and conflict-handling. We consider work from the automotive context as well as research on human-human interaction and HRI.

2.1 User-Vehicle Conflicts

A key factor for successful cooperation between humans and any systems is the knowledge about and agreement of joint goals and interests [42]. Conversely, perceived differing and mutually exclusive goals and interests contribute to conflicts [81]. Consequently, there are various perspectives on this research field, such as HRI [3, 4], or HVI [78, 80, 81]. Conflicts between drivers and AVs can be described as the extent to which drivers perceive the desired outcome of a situation to be in correspondence or conflict with the desired outcome of the AV [78–80].

Conflicts can cause drivers to intervene in the automation even though it would not be technically necessary and can lead to lowered trust and acceptance toward the AV [80]. So far, only a limited number of studies have dealt with driver-initiated takeovers, their exact factors, and how they can be successfully prevented.

Takeovers, in general, are shown to be safety-critical due to post-automation effects such as unstable lateral control [34, 35, 53]. One reason is the "out-of-the-loop" effect, meaning the driver is no longer engaged in the driving task, resulting in decreased situation awareness and skill loss in the long term [27, 54]. For this reason, it is desirable to keep automation enabled and prevent drivers from initiating takeovers (when technically not necessary) [72]. Therefore, cooperative methods have been proposed. In these methods, the user is given partial control to solve tasks together with the vehicle without having to take over full driving control [18, 71, 73–75]. These approaches have mainly been investigated for situations where the AV reaches technical limits and cannot solve certain tasks independently. However, a study by Woide et al. [79] investigated cooperative systems in conflict situations and their effects on automation disengagement and perceived conflict. They compared a *no-intervention system*, which did not allow any intervention, a *choice system* that provided the possibility to abort an overtaking maneuver by holding the brake pedal or by pressing a touch button, and a *manual system* that allowed a complete takeover of manual control. The cooperative system gave participants a comparable sense of control to the manual system, and they preferred it to the manual system, demonstrating its potential to handle conflict while avoiding safety-critical takeovers [79]. In another study, Woide et al. [78] examined the effects of system verification on automation engagement in a conflict scenario. They showed that displaying information that helps verify AV behavior can reduce perceived conflict and decrease the probability of driver-initiated takeovers.

These studies have one thing in common: the scenario investigated is based on the assumption that the AV and the driver have the same underlying interests. Consequently, conflicts in these scenarios can be addressed through goal transparency or are resolvable due to the compatibility of the goals, so a partial transfer of control to the user is a suitable solution for conflict resolution.

However, conflicts arising from goal conflicts, such as those stemming from differing legal interests, present a unique challenge. In these cases, target transparency alone might not be sufficient; a decision must be made which goal to follow. Also, a driver takeover of control might be undesirable, as it would imply that the AV must neglect its own interests.

2.2 Assertiveness in Handling Conflicts

In human-human interaction, various conflict-handling styles are recognized, characterized by differing levels of assertiveness and cooperativeness [62]. These styles consist of competing, collaborating, compromising, accommodating, and avoiding [65]. Each style has its own implications in terms of outcomes and relationship dynamics. For instance, the accommodating style entails prioritizing the goals of others over one's own, fostering cooperation, and maintaining relationships (low assertiveness and high cooperation), often leading to lose-win outcomes. Contrary, the competing style prioritizes one's own goals over others' (high assertiveness and low cooperation), often leading to win-lose outcomes. When examining HVI conflict-handling strategies, as explored by Woide et al. [78, 79], a tendency towards cooperative approaches with low assertiveness can be observed, as these strategies involve partial control transitions to uphold user autonomy with the AV's operational control. However, more assertive strategies might be necessary for situations with mutually exclusive goals [64]. In the context of AV's assertive, low cooperative methods, Dixon et al. [26], Maurer et al. [52] investigated the effect of blocking driver-initiated takeovers [26] or overriding driver input [26, 52]. However, they found that such AV behavior is more likely to be accepted in safety-critical situations, which is consistent with other works showing the general importance of user autonomy and control for user acceptance [23, 24].

One potential highly assertive but still cooperative approach to handling these complexities could be persuasion. Rather than outright rejecting the user's input and thus depriving the user of control, the AV could employ persuasive techniques to guide the user towards decisions that align with the AV's goals, e.g., regarding legal compliance.

2.3 Persuasion Strategies

Persuasive technology is defined as a "computing system, device, or application intentionally designed to change a person's attitudes or behavior in a predetermined way" [29, p. 27]. The term "persuasion" implies that the user's attitude and behavior can be changed in a predetermined way in accordance with the technology's, e.g., AV's goals and intentions.

In the automotive context, persuasion has mainly been investigated for manual driving. Paraschivoiu et al. [58] presented a literature review on persuasion strategies on the driver. The research indicates that the majority of systems are focused on promoting safety (e.g., [2, 16, 61]) and eco-driving (e.g., [14, 25, 50]). They primarily employ principles such as self-monitoring, tailoring, and suggestion, with visual methods favored. However, their transferability to the cooperative automated driving context is very limited, as these strategies are designed with the assumption of continuous driver engagement and decision-making. In automated driving, the dynamics of interaction and the driver's role change fundamentally, requiring new strategies that account for decreased driver control and increased reliance on AV autonomy.

AVs, by their nature as intelligent agents that perceive their environment and autonomously perform actions to achieve goals, clearly align with the definition of robots as understood in HRI. Also, HRI's objectives, which emphasize optimizing cooperation between humans and robots, align closely with the aims of cooperative automated driving. HVI could, therefore, benefit from adopting the methods from HRI. Babel et al. [5], for example, developed persuasive conflict-handling strategies for a domestic assistance robot by transferring psychological human-human interaction concepts. Their strategies are based on theoretical foundations on the possible working mechanisms of persuasion, which can be cognitive, emotional, physical, and social [12, 28, 66] and are grounded in a broad spectrum of related work on persuasion within HRI. Cognitive mechanisms focus on goal transparency, demonstrating the mutual benefits of collaboration. Emotional mechanisms handle conflicts through humor and empathy. Physical mechanisms, meanwhile, ensure persuasion is effective by maintaining an appropriate level of physical proximity. Social mechanisms leverage social influence and power dynamics. They further categorized the strategies based on their valence, i.e., the assumed effect of the human-robot power asymmetry, namely positive, neutral, or negative valence. The conflict-handling strategies were examined in a scenario in which a participant preparing a party conflicts with a robot that needs a free kitchen to clean; the participant must decide how to respond to the conflict. Results showed that positive and neutral strategies proved to be more acceptable than negative strategies, such as threats [5]. Further, except for one strategy (i.e., command), all strategies have proved to be more effective in producing compliance than the condition without persuasion [5].

3 Study

In our study, we adapted the conflict-handling strategies identified by Babel et al. [5] in the context of HRI to the AV context and compared them with the *Baseline* of no persuasion in the AV context. In transferring these strategies, we selected those applicable to the dynamics of HVI. Physical mechanisms were not considered in our study because the context involves people who are already seated in an AV, so the AV does not have the ability to "physically approach" the person. Additionally, some strategies that were designed context-specific for the study by Babel et al. [5], such as positive or negative public attention, were excluded, as the participants were single passengers. Thus, this strategy was not applicable. Similarly, the foot-in-the-door strategy was not implemented, as it was not transferable to our study context. In total, 11 (out of 15) strategies were investigated.

The reason for traffic-violating behavior is typically due to the benefits drivers perceive, such as time saved [33]. Speeding behavior was found to be related to a sense of urgency [11] or a desire to save time [60]. A common reason for speeding is being late for a meeting or appointment. According to a survey by the National Road Safety Report by the European Commission in 2022, 75% of German car drivers stated they had driven faster than the speed limit outside built-up areas (but not on motorways/freeways) at least once in the last 30 days [21]. Therefore, we decided to investigate the strategies in a speeding scenario where a conflict between the participants' goals of being on time and the strict legal goals of the AV is constructed.

3.1 Driving Simulation

The scenarios modeled in Unity version 2020.3.21f1 [69]. The urban environment was modeled with the Fantastic City Generator Unity asset [51]. The traffic and vehicle automation was implemented using the Simple Traffic System Unity asset [67]. Further, we used an HTC VIVE Pro Eye and the Thrustmaster T150 Pro steering wheel with pedals for manual driving. As for the participants' ego-vehicle, a Mercedes F015 [7] model was used. We exchanged the vehicle's steering wheel model to better match the shape of the Thrustmaster's wheel.

3.2 Scenario

We designed two distinct scenarios: an initial familiarization drive and the main study route.

The familiarization drive was designed to introduce participants to the AV's interface, allowing them to experience how to adjust the speed and how to request and conduct a takeover. The scenario consisted of a straight road with a speed camera to emphasize the potential consequences of exceeding speed limits, promote awareness, and induce more realistic driving behavior.

The main study route starts in a village with a speed limit of 50 km/h (see Figure 1). From there, it enters a roundabout with three exits (see Figure 2). Each road from the roundabout was visually similar, had a speed limit of 60 km/h, and was directed to a bakery, ensuring no inherent preference for any particular exit. The route

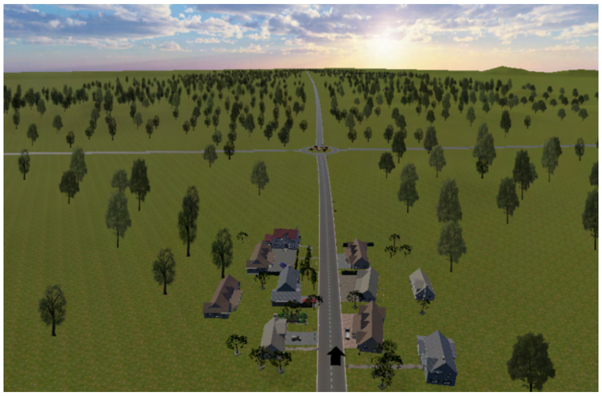

Fig. 1. Scenario route that starts in a small village, then enters a roundabout and leads to a straight road with a natural surrounding.

Fig. 2. The roundabout on the route with three possible exits. The choice of exit at the roundabout was counterbalanced to reduce possible learning effects.

is straight, allowing drivers a clear, extensive view ahead and enabling them to survey the surrounding road environment easily. The main scenario does not include any speed cameras; however, in the text explaining the study task, participants were informed that there had been radio warnings about an increasing number of very well-hidden speed cameras in the area. This setup was intended to simulate real-world driving conditions more closely, where drivers may not confronted with speed enforcement but must still navigate the balance between adherence to speed regulations and their driving preferences or habits. To reduce possible learning effects regarding the absence of speed cameras, the choice of exit at the roundabout was counterbalanced using a balanced Latin Square design (see this link). To achieve this balance, the Latin Square design for the exits (a 3x6 matrix) was combined with the Latin Square design for the 12 conflict-handling strategies (a 12x12 matrix). The rows of the 3x6 matrix were used sequentially to fill the rows of the 12x12 matrix (see Appendix Figure 8). This ensured that each exit was chosen an equal number of times throughout the study, preventing any unintentional bias.

3.3 Human-Vehicle Cooperation with Persuasion

Initially, the AV controls the driving task. It starts to drive automatically and remains within its ODD for the entire trip. Therefore, a takeover is never technically necessary. The participants have the option to adjust the target speed (see Colley et al. [20]) using buttons on the center stack display (cooperative approach) or to request a full takeover using a button on the steering wheel (see Figure 3). The persuasive conflict-handling strategies were triggered only once in each condition when the participant tried to exceed the speed limit for the first time.

The strategies were used in both automated and manual driving modes. When the participant attempts to exceed the speed limit, the persuasive messages are presented as female voice output. At the same time, a speech wave animation (see Figure 3 (2)) is shown on the AV's display, indicating communication from the AV.

Table 1 shows the persuasion strategies and the specific output messages in our study scenario. They include cognitive, emotional, social, and politeness strategies.

Cognitive strategies consist of *Explanation* and *Show benefit*. They aim to enhance the understanding through goal transparency [70] and show advantages of collaboration [68]. In manual driving, research has demonstrated that transparency effectively encourages drivers to adopt more ecological driving practices [14] and enhances awareness, thereby reducing unsafe driving behaviors [61]. In AVs, goal transparency has shown to be effective in

Fig. 3. The inside of the AV with the control functions at the steering wheel. (1) shows the display without speech output and (2) shows the speech wave animation displayed during AV speech output. For the animation, we used a video by Vecteezy.

reducing rejection frequency and AVs overtaking maneuver in conflictual situations [78], i.e., increased compliance with the AV. However, it is unsure if transparency is enough in legal conflict situations.

Humor and *Empathy* can be allocated to emotional mechanisms. Humor has shown to be efficient in increasing sympathy towards robots [56], which in turn can enhance empathy for the opposite's situation [9]. To the best of our knowledge, no work has been done on humorous AVs. In contrast, there is a large body of work on empathic vehicle design [15, 22, 55, 57] as incorporating emotional elements alongside traditional design principles has been proposed as a method to enhance user acceptance of automated technologies [40]. Although it has not yet been investigated, it is conceivable that triggering empathy could increase users' compliance with AVs.

The social mechanisms (*Command*, *Threat* and *Annoyance*) draw upon power dynamics to secure compliance. Commands and threats are authority-based, which means that one makes use of social status [17]. Thus, the effectiveness of a command hinges on the authority figure's recognized power and legitimacy. Threat involves stating a negative consequence for non-compliance. The implicit understanding is that the authority has the power and willingness to carry out the threatened action, which should motivate compliance [41]. Annoyance is a so-called reinforcement learning mechanism [8], which leverages the persistence and psychological pressure of repetitive requests to impose dominance and compel compliance. However, the impact of commands, threats, or annoyance on compliance has not yet been investigated in HVI.

Thanking, *Apologize* and *Thanking submissive* present high levels of politeness, which strategically respects individuals' social desire to maintain their self-image, or "face", as described by Brown and Levinson [13]. Consequently, individuals make use of politeness strategies in their conversations to mitigate face threats. Politeness has also shown to be an important factor for acceptance and trust towards AVs [45, 46]. Lee and Lee [45] highlight that AVs that employ polite speech strategies, such as providing reasons for requests and expressing gratitude for drivers' cooperation, significantly enhance drivers' willingness to comply with such requests.

3.4 Task

To induce a sense of urgency, participants were tasked to retrieve a birthday cake for their mother from a bakery with the added challenge of a tight deadline, only 2 minutes before the bakery's closing time of 5 pm. Participants were informed of recently installed discreet speed cameras in the immediate area, leading them to consider speeding despite being aware of the potential consequences. The complete task was as follows (the original German task description can be found in Appendix subsection A.2):

Strategy	Mechanism	Valence	Implementation
Baseline			No Output
Explanation	C	=	If I don't keep to the prescribed speed limit, you may be flashed and have to pay a fine. Do you still want to drive faster? (Confirm by pressing the plus button again.)
Show benefit	C	=	I would like to continue driving here at the specified speed limit so that you don't have to pay a fine. Please do not drive faster. Would you still like to drive faster? (Confirm by pressing the plus button again.)
Annoyance	S	-	I would like to continue driving at the specified speed limit (3x). Would you still like to drive faster? (Confirm by pressing the plus button again.)
Command	S	-	Keep to the specified speed limit! Do you still want to drive faster? (Confirm by pressing the plus button again.)
Threat	S	-	If you don't keep to the specified speed limit, I'll report you! Do you still want to drive faster? (Confirm by pressing the plus button again.)
Appeal	P	+	It would be very nice if you kept to the specified speed limit. Would you still like to drive faster? (Confirm by pressing the plus button again.)
Thanking	P	+	I would be grateful if you kept to the specified speed limit. Would you still like to drive faster? (Confirm by pressing the plus button again.)
Apologize	P	+	Sorry for the disturbance, but you must keep to the specified speed limit. Would you still like to drive faster? (Confirm by pressing the plus button again.)
Thanking submissive	P	+	I would be very grateful if you could stick to the specified speed limit. Would you still like to drive faster? (Confirm by pressing the plus button again.)
Humorous	E	+	If you stick to the speed limit, the weather will be fine tomorrow! Do you still want to drive faster? (Confirm by pressing the plus button again.)
Trigger empathy	E	+	Would you please stick to the specified speed limit? I just want us both to get to our destination safely. Would you still like to drive faster? (Confirm by pressing the plus button again.)

Table 1. Conflict-handling strategies used in the study. The implemented AV outputs were translated from German (see Appendix Table 4 for the original outputs). The content in brackets was the additional output used if the target speed was increased via the cooperative approach. S = Social, C = Cognitive, E = Emotional, P = Politeness, - negative, = neutral, + positive.

> *Today is a very special day. It's your mother's birthday. You have thought of something very special for this birthday: a cake from the best cake shop in the area. Unfortunately, something has come up and you can't set off to pick up the cake until now. As you look at your watch, you realize with horror that there are only a few minutes left until the store closes at 5 pm. So you have to make your way quickly to avoid standing in front of closed doors. Thankfully, you have already entered the address into your navigation system, and the route is already shown on the display. You can see the current time on the head unit and the arrival time at the patisserie above the navigation display. For weeks now, you've been hearing warnings on the radio that there are more and more speed cameras in the area, which are very well hidden. So make sure you don't get flashed. Your task now is to collect the cake from the patisserie on time at 5 pm.*

When the task was started, the current time in the vehicle was set to 17:58 and the estimated time of arrival to 17:01. The task was completed successfully if the participants were able to drive to the bakery within 2 minutes. After these 2 minutes, the scenario was over. Participants were then told whether they had successfully completed the task.

Questionnaire	Item Code	Item
HMII - Conflict Subscale	Conflict1	I reject the system's preferred action.
	Conflict2	We can both achieve our preferred outcomes in this situation (reverse scored).
	Conflict3	Our preferred outcomes in this situation are in conflict.
	Conflict4	The system prefers a different outcome than I do in this situation.
	Conflict5	I prefer a different outcome than the system in this situation.
STS-AD	Trust	I trust the automation in this situation
	Performance	I would have performed better than the automated vehicle in this situation (reverse scored).
	NDRT	In this situation, the automated vehicle performs well enough for me to engage in other activities (such as reading).
	Risk	The situation was risky (reverse scored).
	Judgement	The automated vehicle made an unsafe judgement in this situation (reverse scored).
	Reaction	The automated vehicle reacted appropriately to the environment.
Own Items	Perceived Performance	I could perform the task well with the vehicle I had.
	Task Difficulty	The task was difficult to complete.
	Effect of Vehicle Behavior on Decision	The behavior of my vehicle influenced my decision.
	Acceptance	I found the behavior of my vehicle acceptable.

Table 2. Used question items of the conflict subscale of the HMII questionnaire [81], the adjusted STS-AD questionnaire [39] and own items, where the latter were translated from German.

3.5 Measurements

Objective dependent variables. The speed was logged. Further, the participants' behavior was logged regarding whether they requested the AV to increase or decrease the target speed (via the cooperative approach) and whether they requested a takeover.

Subjective dependent variables. After each of the 12 conditions, perceived conflict was measured with the conflict subscale of the Human-Machine-Interaction-Interdependence HMII [81] on a 5-Point Likert scale ranging from 1=*Do not agree at all* to 5=*Fully agree*. We further employed the situational trust based on the *Situational Trust Scale for Automated Driving (STS-AD)* proposed by Holthausen et al. [39] on a 7-point Likert scale (1=*Do not agree at all* to 5=*Fully agree*). In addition, the participants rated their perceived performance in the study task, the task difficulty, their acceptance of the AV behavior, and the influence of the AV's behavior on their own behavior on a 5-point Likert Scale (1=*Do not agree at all* to 5=*Fully agree*). Table 2 shows all items. Afterward, the participants had to complete a final questionnaire asking (1) if they were aware of the speed limits on the route, (2) if they were aware that driving faster than that violated traffic regulations, and (3) how their trust in the vehicle was affected when their decisions were questioned by the AV (open-ended questions). They further had to complete a demographic questionnaire and questions addressing their general trust in AVs.

3.6 Procedure

The study was conducted at the University of [anonymized for review]. At the outset, participants were oriented to the study's procedure and provided their informed consent. Subsequently, they were briefed on the technical aspects of the AV, including the process for initiating takeover requests and adjusting the target speed. To ensure familiarity with the AV's operation, a preliminary test drive was conducted. Thereafter, participants were exposed to the 12 conditions, sequenced according to a balanced Latin square design. Following each condition, participants were asked to complete questionnaires that evaluated subjective metrics (as detailed in Section 3.5.2).

The study concluded with a demographic questionnaire. The total duration of the study was approximately 60 minutes, and participants were compensated with 10€.

3.7 Participants

N=36 participants holding German citizenship (16 female, 20 male) aged 18 to 60 years (*M*=26.00, *SD*=6.73) were recruited personally, via social media, and at the University of *anonymized for review*. All participants held valid driver's licenses for between 2 to 42 years (*M*=8.44, *SD*=6.50) and stated a good knowledge of English (as the conflict and STS-AD questionnaires are published in English with no validated German translation available).

From the demographic questionnaire, we found that 17 participants drive an average of less than 7.000km annually. The others drive 7.000km-14.999km (9 participants), 15.000km-24.999km (8 participants) or 25.000km-32.999km (2 participants). In our study, participants were asked how law-abiding they consider themselves in road traffic on a 4-point Likert scale (1=*Not at all* to 4=*High*). 21 participants rated their law-abidingness as 'moderate,' 12 as 'high,' and 3 as 'less.' Participants were further asked, "Would you generally trust an automated vehicle?" They could have answered with 'Yes' or 'No'. Most participants (28) indicated that they would generally trust an AV. Only 8 answered with 'No'. If the participants answered the question with 'Yes', their trust level was further assessed for specific driving scenarios and they could have answered on a 3-point ordinal scale (with the options *No*, *Uncertain*, and *Yes*). In moving traffic conditions within urban areas, 20 out of 28 stated they would trust AVs, while 7 were uncertain, and 1 said they would not. In situations of high urban traffic, the level of trust decreased, with 10 respondents saying 'Yes', 13 being 'Uncertain', and 5 saying 'No'. The level of trust was relatively high in non-urban areas with smooth traffic, with 23 respondents saying they would trust the AV and 5 being unsure. In heavy traffic conditions outside urban areas, 15 answered with 'Yes', 9 were 'Uncertain', and 4 said 'No'. When asked about trusting AVs throughout an entire journey, 10 participants answered with 'Yes', 15 being 'Uncertain', and 3 said 'No'.

4 Results

4.1 Data Analysis

Before every statistical test, we checked the required assumptions (normal distribution and homogeneity of variance assumption). In instances where the data exhibited non-normal distribution, Friedman tests were utilized. Subsequently, Dunn's test with Holm correction was applied for post-hoc analyses. Conversely, for data adhering to a normal distribution, Fisher's exact tests were employed, accompanied by Student's t-tests for post-hoc comparisons. R in version 4.4.0 and RStudio in version 2023.12.1 were used. All packages were up to date in April 2024.

To also compare the strategies based on their valence (negative, neutral, or positive) and working mechanism (cognitive, emotional, social, and politeness) (***RQ 2***), we averaged the ratings across the respective strategies.

4.2 Strategy Effectiveness: User Compliance

In each condition, all participants tried to intervene in the automation behavior (either by requesting an increase in speed via the buttons or by a complete takeover). This means that each participant was exposed to all persuasive conflict-handling strategies.

Table 3 provides the number of takeovers in relation to total interventions. A descriptive analysis shows that the proportion of takeover requests is low compared to the total number of interventions, with a maximum of 9 takeovers in the *Threat* condition.

The descriptive analysis shows that out of 432 observations, participants remained law-abiding only 5 times. This was the case with *Thanking submissive*, *Appeal*, and *Threat*. When also including borderline cases (maximum 5km/h too fast), it can be seen that *Appeal* and *Threat* have the highest rate (with 6 participants each). Nevertheless,

Condition	# Interventions	# Takeovers
Baseline	36	3
Explanation	36	1
Show benefit	36	4
Annoyance	36	2
Command	36	2
Threat	36	9
Appeal	36	3
Thanking	36	4
Apologize	36	3
Thanking submissive	36	4
Humorous	36	2
Trigger empathy	36	2

Table 3. Summary of driver-initiated takeovers in relation to overall interventions based on conditions.

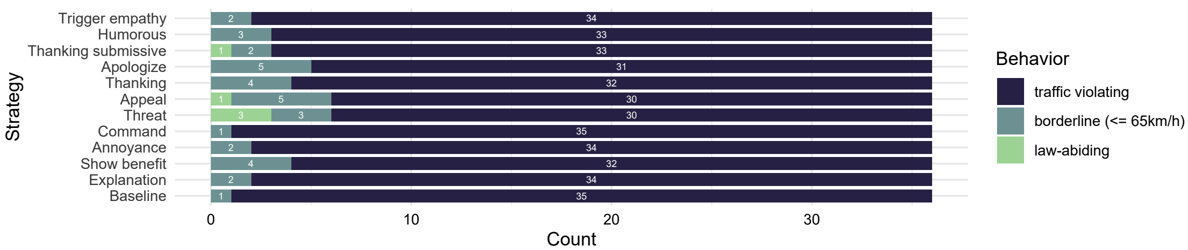

Fig. 4. Behavior of the participants per persuasion strategy. We included a "borderline" category (61-65 km/h) in our analysis, in addition to "law-abiding" (<=60 km/h) and "traffic violating" (> 65 km/h). This was informed by the standard practice in traffic law enforcement, particularly in the context of speed violations outside urban areas. According to these regulations, a tolerance margin is applied to the measured speed: 3 km/h of the recorded speed is deducted. Given that our cooperative system increments speed by 5 km/h per step, we aligned our categorization with this enforcement practice by setting a 5 km/h range for the borderline category.

it can be said that none of the strategies had a substantial influence on the participants' adherence to traffic rules (see Figure 4). Also, a Friedman's test revealed that the average maximum speed could not be reduced compared to the *Baseline* with no persuasion (χ^2(11)=11.36, p=.41).

However, regarding the subjective measurement, Friedman's test found significant differences between the strategy with regard to the self-reported influence of the vehicle on user behavior (χ^2(11)=64.15, p=<.001, $\widehat{W}_{Kendall}$=.16). A post-hoc test found that the vehicle's influence on user behavior was rated significantly lower in *Baseline* compared to *Explanation* (p_{adj}=.002), *Show benefit* (p_{adj}=.01), *Threat* (p_{adj} <.001), *Thanking* (p_{adj}=.02), *Humorous* (p_{adj}=0.003), and *Trigger empathy* (p_{adj}=0.02).

4.3 Strategy Evaluation: Conflict, Situational Trust and Acceptance

Descriptive analysis can be found in Appendix Table 5.

Conflict. The perceived conflict was calculated by determining the mean value across all five items of the conflict subscale of the HMII questionnaire (see Table 2). Positive items (i.e., Conflict2) were reverse scored. Figure 5 shows the main effects. A Friedman's test found significant differences between the strategy on the perceived conflict level (χ^2(11)=57.10, p<.001, $\widehat{W}_{Kendall}$=.14).

A post-hoc test found that perceived conflict was rated significantly lower in the *Baseline* compared to *Annoyance*, *Command*, *Threat*, *Appeal*, *Apologize*, *Thanking submissive*, *Humorous*, and *Trigger empathy*.

Considering the valence of the strategies, a Friedman's test found significant differences in the perceived conflict level ($\chi^2(3)$=31.70, p<.001, $\widehat{W}_{Kendall}$=.29). A post-hoc test revealed that conflict was perceived significantly lower in the Baseline compared to negative, neutral, and positive strategies.

Regarding the working mechanism of the strategies, a Friedman's test found significant differences in the perceived conflict level ($\chi^2(4)$=39.41, p<.001, $\widehat{W}_{Kendall}$=.27). A post-hoc test revealed that conflict was perceived significantly higher in the Baseline compared to cognitive, emotional, politeness, and social strategies.

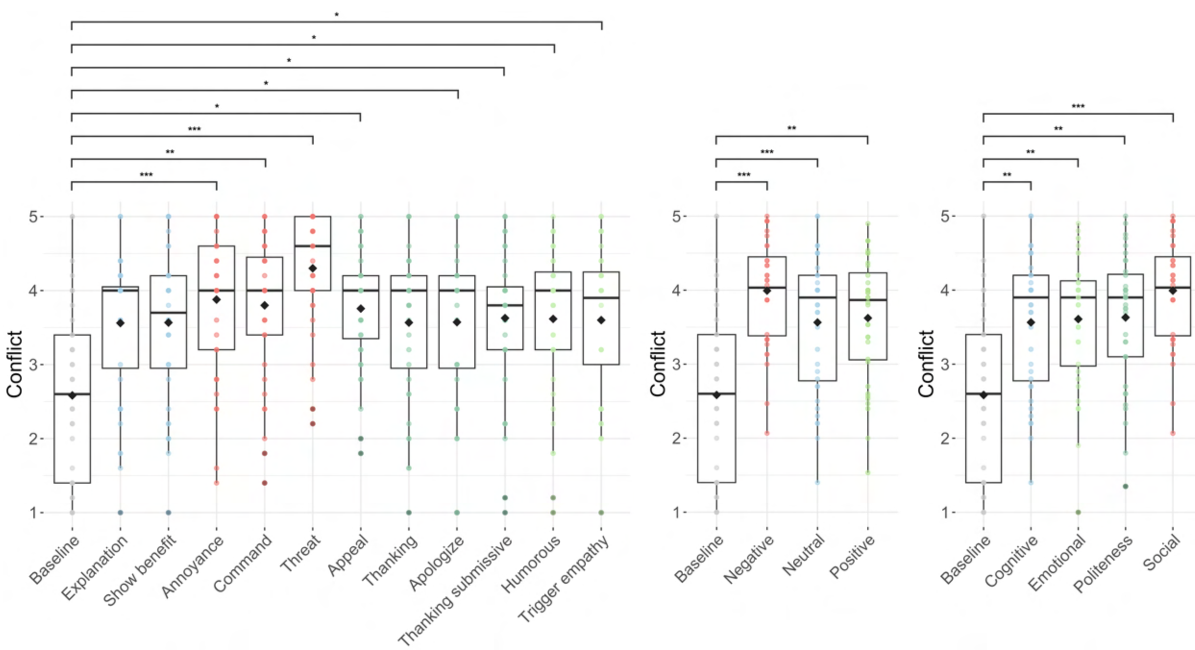

Fig. 5. Results of Conflict with pairwise comparison. Asterisks denote APA-conform significance levels: * indicates p_{adj} <.05, ** for p_{adj} <.01, and *** for p_{adj} <.001.

Situational Trust. Overall situational trust was calculated by determining the mean value across all STS-AD items (see Table 2). Negative items (i.e., Performance, Risk, and Judgement) were reverse scored. Figure 6 shows the effects of the strategies. A Friedman's test found significant differences between the strategy on the situational trust in the AV ($\chi^2(11)$=46.00, p<.001, $\widehat{W}_{Kendall}$=.12).

A post-hoc test found that situational trust was significantly lower for *Threat* compared to *Explanation*, *Thanking*, *Apologize*, *Thanking submissive*.

Considering the valence of the strategies, a Friedman's test found significant differences in the situational trust towards the AV ($\chi^2(3)$=15.62, p=.001, $\widehat{W}_{Kendall}$=.14). However, a post-hoc test found no significant differences.

Regarding the working mechanism of the strategies, a Fisher's exact test revealed significant differences in the situational trust in the AV ($F(2.27, 79.57) = 3.71$, p=.02, w_p =.02). A post-hoc pairwise t-test revealed that situational trust was higher for politeness compared to social strategies.

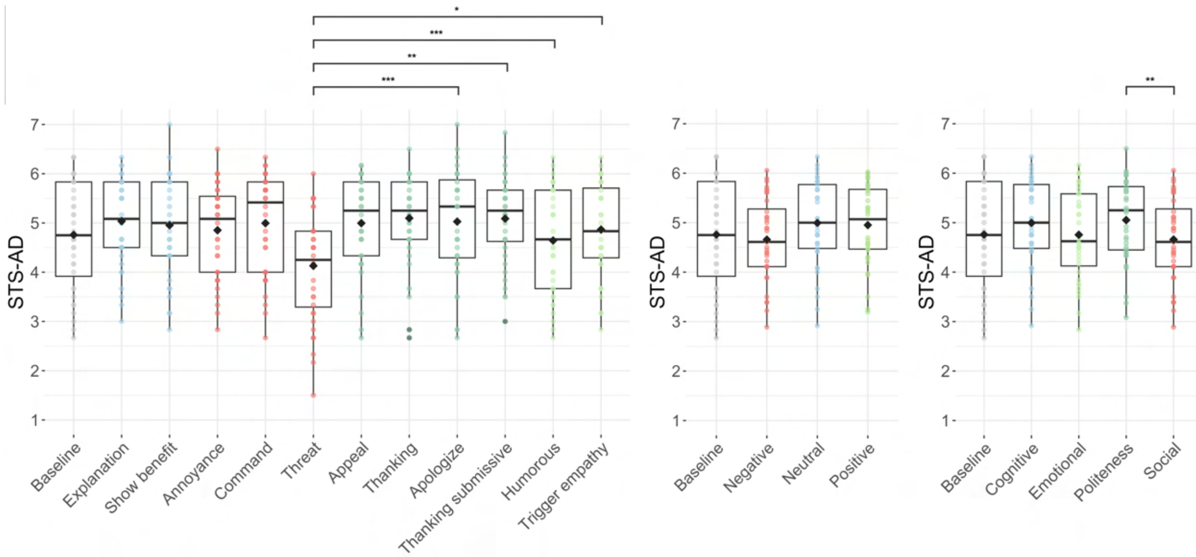

Fig. 6. Results of Trust with a pairwise comparison of strategies, their valence and working mechanism. Asterisks denote APA-conform significance levels.

Acceptance. Figure 7 shows the effects of the persuasion strategies on acceptance.

A Friedman's test found significant differences between the strategies on the acceptance (χ^2(11)=83.03, p=<.001, $\widehat{W}_{Kendall}$=.21). A post-hoc test found that *Threat* was significantly less accepted than the *Baseline* and all of the other strategies except *Humorous*.

Considering the valence of the strategies, Friedman's test found significant differences in acceptance (χ^2(3)=27.30, p<.001, $\widehat{W}_{Kendall}$=.25). A post-hoc test found that negative strategies were significantly less accepted than neutral and positive strategies.

Regarding the working mechanism of the strategies, Friedman's test found significant differences on the acceptance (χ^2(4)=32.02, p<.001, $\widehat{W}_{Kendall}$=.22). A post-hoc test found that social strategies were significantly less accepted than cognitive and politeness strategies.

Task Feasibility. Perceived task feasibility was calculated by determining the mean value across the items Perceived Performance and Task Difficulty (see Table 2). A Friedman's test found significant differences between the strategies on the perceived task feasibility (χ^2(11)=26.76, p<.001, $\widehat{W}_{Kendall}$=.07). However, a post-hoc test found no significant differences.

4.4 Qualitative Feedback

To evaluate the qualitative feedback, two authors independently read the responses and organized them into initial codes. Afterward, they were discussed, a final set of codes was created, and one author coded the answers again deductively.

When asked whether participants were aware that the route had a speed limit of 60 km/h, 34 acknowledged this awareness, one disagreed without any further information, and another noted that they only realized this during the second scenario.

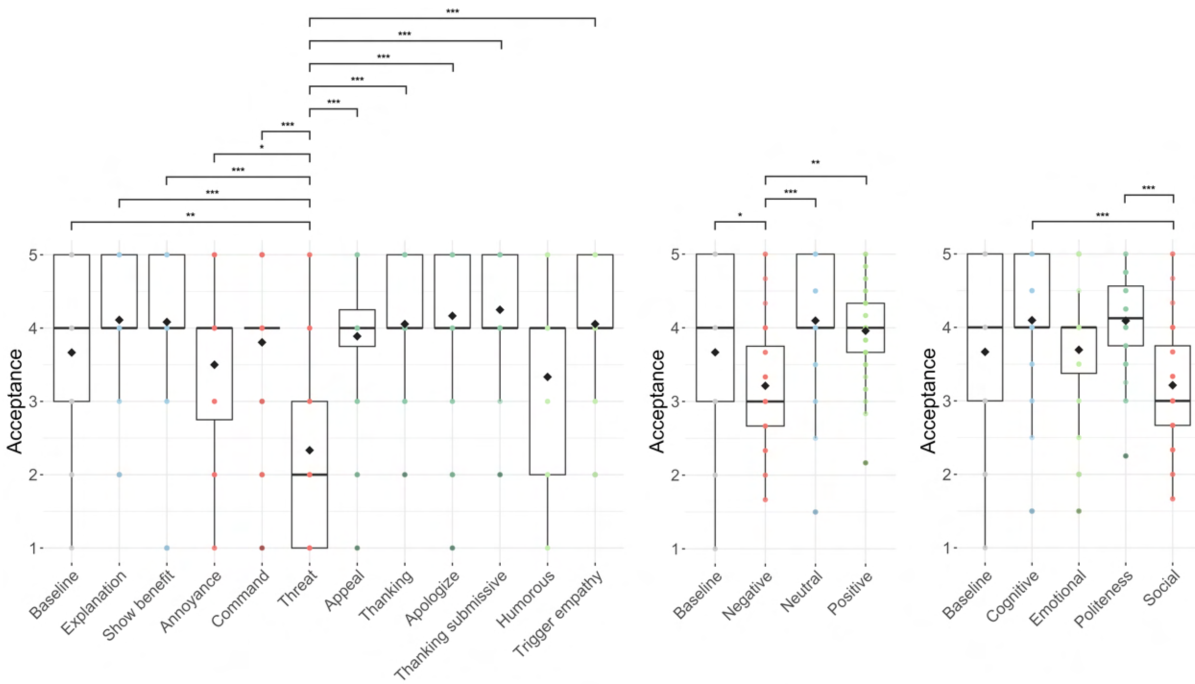

Fig. 7. Results of Acceptance with a pairwise comparison of strategies, their valence, and working mechanism. Asterisks denote APA-conform significance levels.

Regarding the question of whether they understood that exceeding this limit would constitute a violation of traffic laws, two participants disagreed, while the others agreed. Notably, one participant indicated that they assumed tolerance ranges are permitted [P26]. Another mentioned, “a possible fine would have been very low” [P24]. A third participant stated, “Yes, I was aware of that, but when I was driving faster, I was always looking carefully to see if there was a speed camera or similar” [P27].

A diverse range of responses was observed when assessing how participants’ trust in the AV was affected when their decisions were questioned. Two participants chose not to respond. Eleven felt their trust remained unchanged, and two noted that their trust was only slightly influenced but did not elaborate on this in more detail. One participant stated a higher risk when being in disagreement with the AV, which indicates lowered trust. Conversely, two participants indicated that their trust in the AV was strengthened, suggesting that some users may feel reassured when their decisions are questioned, perhaps due to the AV’s ability to understand the situation and behave rationally. The remaining 14 participants reported that their trust fluctuated based on the persuasion strategies employed by the AV. Of these, 7 participants stated that persuasion (which strategies were individually different) positively affected their trust in the AV [P9, P10, P12, P14, P19, P21, P28] and 5 that some strategies had negative effects [P9, P14, P16, P27, P28]. Approaches that were mentioned positively were friendly [P14, P15, P19], respectful [P14], explanatory [P17, P21], suggestive strategies [P12], as well as thanking [P28], and even strict tones [P10]. Conversely, unfriendliness [P12], prohibition attempts [P12], harsh language [P19], and threats [P6, P9] were perceived negatively. However, three mentioned hesitancy to speed up when faced with a threat [P12, P17, P28]. Further, some strategies were deemed unprofessional, such as when the AV resorted to humor, falsely claiming better weather ahead [P16, P27, P28]. One participant reflected, “When it came as some kind of appeal, [the AV] sounded like a person, which it shouldn't, because it's a system, and I would rather respond to a system than a human appeal" [P17]. Additionally, one comment highlighted the desire for transparency, as they "would have appreciated an explanation as to why the speed limit here is 60, for instance, because a lot of forest animals frequently cross the road or there are many accidents here" [P28].

Quotations were translated from German using DeepL [1] and were verified by two authors.

5 Discussion

We compared 11 persuasive conflict-handling strategies with the *Baseline* of no persuasion. Our study showed that users tried to overwrite the AV behavior through driver-initiated takeovers or the offered cooperative approach. In general, our results align with prior work, showing that users take the chance to override the AV in cases where the AV behavior contradicts their goals if allowed to [80]. In addition, participants were more likely to intervene in the AV's behavior using the cooperative approach (i.e., using the buttons on the steering wheel to request adjustment of the target speed) than to request a full takeover. This is consistent with the results of Woide et al. [79], which showed that cooperative approaches were preferred in conflict situations.

Answering **RQ 1**, we found that legal conflicts are likely to occur and are intensified by persuasive AV behavior. We further found that none of the persuasive conflict-handling strategies investigated could substantially facilitate adherence to the AV's legal compliance goals. However, persuasion does not necessarily lead to lower acceptance and trust in the AV compared to no persuasion. Regarding **RQ 2**, we showed that negative strategies are significantly less accepted, while no differences were found for positive and neutral strategies compared to the Baseline in terms of acceptance and trust.

We discuss these findings regarding cooperation design and control allocation in legal conflict scenarios. Additionally, we discuss challenges in the implementation of the strategies and the practical implications of our results.

5.1 Efficiency of Persuasion Strategies in Legal Conflict Situations

Babel et al.'s [5] study showed that all strategies, except *Command*, were more effective in producing compliance with the cleaning robot than the strategy without persuasion. In contrast, in our study, none of the strategies proved substantially effective in producing compliance with the AV's legal goals. This suggests that the effectiveness of persuasion is limited in situations where the legal interests of AVs conflict with the user's immediate goals. Our work looks at a situation without an apparent risk. Both work by Dixon et al. [26] and Maurer et al. [52] show that interventions by AVs in driver decisions in the form of blocking driver-initiated takeovers [26] or overriding the driver [26, 52] by AVs are more likely to be accepted in safety-critical situations. This raises the question of whether persuasion can achieve better results in safety-critical situations.

5.2 Comparison of Persuasion Strategies

All strategies led to a significantly higher perceived conflict. Additionally, negative strategies were significantly less accepted than the *Baseline* of no persuasion, neutral, and positive persuasion strategies. Particularly, *Threat* was rated significantly worse than the other strategies. At the same time, although negative strategies were most effective regarding users' compliance (which has been shown both quantitatively (see Section 4.2) and qualitatively (see Section 4.4), the proportion of takeovers has also increased, which shows the possible reactance of users. This aligns with the results by Babel et al. [5]. It can, therefore, be recommended that negative persuasion should not be used for AVs in legal conflict situations.

No significant differences between neutral and positive strategies were identified, aligning with the results by Babel et al. [5]. However, looking more closely into neutral and positive strategies, a descriptive comparison showed that *Humor* was the least accepted one, which speaks against this strategy. However, our qualitative research findings suggest that *Humor* could not be identified and was more likely to be associated with lying, possibly due to its lack of expression through the voice.

Employing neutral or positive strategies, such as *Explanation* and *Showing Benefits*, did not affect AV acceptance and trust. This is in line with Stampf et al. [62] showing that conflict does not necessarily decrease trust if the AV evidently behaves rationally. The findings reported by Woide et al. [78] also show that capability verification is important in conflictual situations with the potential to increase trust and acceptance. The practical implication is that persuasion strategies should demonstrate the AV's capabilities to correctly understand the situation and must show that the AV goals are reliable. In the same sense, the neutral and positive strategies demonstrate the AV's ability to understand the situation and behave rationally. This could explain why they did not reduce acceptance and trust despite the resulting conflict. However, qualitative results indicate that it is very individual whether and which strategies could have positive/negative effects on trust. This argues for individual choice of strategies rather than a one-size-fits-all approach.

This finding further leads us to the assumption that perceived conflict might not be destructive for cooperation in general, particularly when the AV behaves rationally. This is in line with theories from Human-Human Interaction, showing that conflicts can also yield positive effects, such as increased productivity, positive interpersonal outcomes (e.g., development of better communication strategies), or constructive organizational changes [6].

5.3 Challenges of Implementing Persuasion Strategies - Real World Applicability

Implementing persuasion strategies in real-world scenarios presents multiple challenges, including technical limitations, user acceptance, and ethical considerations.

Despite automation's potential to improve driving reliability, it is not infallible. For instance, identifying objects such as traffic signs or traffic lights remains difficult, particularly in extreme weather conditions or when these signs are partially covered [71]. Thus, if an AV misinterprets a speed limit sign, it might not only fail but could also attempt to persuade the driver based on incorrect information. Prior research has shown that false alarms in human-automation interactions are more problematic than missed alerts, potentially leading to reduced trust and increased skepticism towards the system [77]. Therefore, in relation to our context, persuasion must only be used in cases where the AV is certain that a legal conflict exists. This is important to prevent distrust, which could lead to decreased usage of AV capabilities (takeovers or rejection of the AV).

In order to increase the efficiency of persuasion in legally conflictual situations, it is useful to look at the reasons that lead people to resist persuasion. According to Fransen et al. [32], there are four main clusters of resistance strategies, namely *avoidance*, *contesting*, *biased processing*, and *empowerment*. Considering *avoidance* strategies, persuasion strategies should be non-optional, as users may turn off the function if they are allowed to. A special form of *avoidance* is *cognitive avoidance*. Here, users ignore strategies, which can support desensitization over long-term exposure. To counteract *cognitive avoidance*, persuasion should be triggered only when absolutely necessary to remain unexpected. For instance, users should be given the opportunity to influence automation to a certain extent beyond the legal limits to avoid takeovers and desensitization. To this end, the legal question of the extent to which compromises should be made and the factors on which this depends in practice must be clarified. To combat *contesting*, which involves contesting the content, strategy, or system itself, it is crucial to include explanations in the persuasion to make them less contestable by the user. One of the participants likewise recommended explaining the background to the goals of the AV even more, in our case, why the speed limit on this road is set at 60km/h. Adapting persuasion strategies and utilizing different personas (e.g., changing gender or voice if persuasion proved inefficient) could prevent the AV or strategy from being contested. *Biased processing* involves strategies where people selectively process messages in a way that favors their existing attitudes or behaviors. *Empowerment* strategies involve individuals asserting their own goals rather than challenging persuasive communication. Applying these insights suggests incorporating context information into the strategies to tailor them to users' goals and behaviors, which might also enhance the effectiveness of the persuasion. Contextual knowledge could be used to advantage here, e.g., in our case, to directly address the user's goal of getting to the bakery on time in order to explain in persuasion why legal goals are more important than the user's primary goal.

5.4 Future Work

Even if well-designed, persuasive strategies are unlikely to achieve full user compliance with the legal objectives of AV. Thus, safety-critical scenarios may benefit from the use of blocking strategies, as suggested by Dixon et al. [26], and requests may be strictly rejected in cooperative approaches.

Given the potential impact of repeated exposure, further research is needed to understand the long-term impact of assertive conflict resolution strategies of AVs in legal conflict situations on user trust and acceptance.

Further, collaborative conflict resolution should be considered in future work, such as negotiation, which could facilitate cooperative problem-solving. This requires bilateral communication (as opposed to a single interaction loop, as considered in our study). Since this can be time-consuming, negotiating goals before travel could also be explored as a method to prevent conflict. However, this strategy requires contextual knowledge about users' motives and goals.

Our persuasion strategies are psychologically based and can lead to the perception of anthropomorphic characteristics in the AV. Future research could explore how enhancing this perception, such as through visual avatars, influences the effectiveness of these strategies. Moreover, the strategies employed in this study, which rely mainly on voice, could be supported by other modalities, such as visually highlighting speed limit signs.

5.5 Limitations

Even though the sequence of conditions in the VR study was balanced using a Latin square and a roundabout with three exits was implemented to reduce order and learning effects, the multiple exposures of a similar traffic scenario and study task could impact the participants' behavior. However, a Friedman test found no significant influence of the exposure within individuals on the driving behavior, comparing the maximum speed (χ^2(11)=5.01, p=.93, $\widehat{W}_{Kendall}$=.01). A general limitation of simulator studies is that the risks and consequences that participants are exposed to during intervening maneuvers in the context of violating traffic regulations are not apparent, which might influence participants' behavior.

Additionally, a moderate number of participants took part (N=36). As mostly younger persons participated, it remains unclear how this work's findings are transferable to other age groups. We minimized the cultural bias and focused on one country. However, to improve the generalizability of the results, the behavior and attitude of users from other countries need to be considered in future investigations since, as shown by Warner et al. [76], there are cross-cultural differences and the variability of penalty fees across different countries could have impacts.

In general, the simulation could benefit from using simulators with higher degrees of freedom (e.g., [19] or [37]).

6 Conclusion

In conclusion, our research explores the relationship between user intervention and AV control in legal conflict situations. Despite advancements in vehicle automation, drivers still tend to intervene, driven by concerns such as loss of control or discomfort with full automation. Our study, conducted through a VR driving simulator (N=36), explored the effectiveness of 11 persuasive conflict-handling strategies in influencing driver behavior towards AV goals in these situations. Our findings indicate that well-designed persuasive behaviors in AVs might not decrease user acceptance or trust. Although the investigated persuasion strategies could not substantially enhance users' compliance with the AV's legal goals, we recommend using persuasion strategies in legal conflict scenarios to show the AV's ability to correctly understand the situation and behave reliably. We discussed challenges for a successful implementation of persuasion and identified future work. Overall, this work contributes to the ongoing but limited research on user-AV conflicts. It underscores the importance of a balanced approach that enhances legal compliance while respecting the user's need for control and considering user acceptance and trust in the AV. Our study of persuasion methods and their limitations underscore the complexity of merging autonomous technology with human factors.

Open Science

Anonymized data and R scripts are available under https://github.com/as116/psychological-conflict-handling-strategies.

Acknowledgments

We thank all study participants. This work was conducted within the project 'SEMULIN', funded by the Federal Ministry for Economic Affairs and Climate Action (BMWK).

References

[1] [n. d.]. *DeepL Translate: The World's Most Accurate Translator.* Retrieved 4 September, 2023 from https://www.DeepL.com/translator
[2] Emeli Adell, András Várhelyi, and Magnus Hjälmdahl. 2008. Auditory and Haptic Systems for In-Car Speed Management – A Comparative Real Life Study. *Transportation Research Part F: Traffic Psychology and Behaviour* 11, 6 (Nov. 2008), 445–458. https://doi.org/10.1016/j.trf.2008.04.003
[3] Franziska Babel and Martin Baumann. 2022. Designing Psychological Conflict Resolution Strategies for Autonomous Service Robots. In *2022 17th ACM/IEEE International Conference on Human-Robot Interaction (HRI).* 1146–1148. https://doi.org/10.1109/HRI53351.2022.9889413
[4] Franziska Babel, Philipp Hock, Johannes Kraus, and Martin Baumann. 2022. It Will Not Take Long! Longitudinal Effects of Robot Conflict Resolution Strategies on Compliance, Acceptance and Trust. In *Proceedings of the 2022 ACM/IEEE International Conference on Human-Robot Interaction (HRI '22).* IEEE Press, Sapporo, Hokkaido, Japan, 225–235.
[5] Franziska Babel, Johannes M. Kraus, and Martin Baumann. 2021. Development and Testing of Psychological Conflict Resolution Strategies for Assertive Robots to Resolve Human–Robot Goal Conflict. *Frontiers in Robotics and AI* 7 (2021).
[6] Robert A. Baron. 1991. Positive Effects of Conflict: A Cognitive Perspective. *Employee Responsibilities and Rights Journal* 4, 1 (March 1991), 25–36. https://doi.org/10.1007/BF01390436
[7] Mercedes Benz. 2015. Der Mercedes-Benz F 015 Luxury in Motion.
[8] Kent C. Berridge. 2000. Reward Learning: Reinforcement, Incentives, and Expectations. In *Psychology of Learning and Motivation.* Vol. 40. Academic Press, 223–278. https://doi.org/10.1016/S0079-7421(00)80022-5
[9] Hector Betancourt. 2004. Attribution-Emotion Processes in White's Realistic Empathy Approach to Conflict and Negotiation. *Peace and Conflict: Journal of Peace Psychology* 10, 4 (Dec. 2004), 369–380. https://doi.org/10.1207/s15327949pac1004_7
[10] Amitai Y. Bin-Nun, Patricia Derler, Noushin Mehdipour, and Radboud Duintjer Tebbens. 2022. How Should Autonomous Vehicles Drive? Policy, Methodological, and Social Considerations for Designing a Driver. *Humanities and Social Sciences Communications* 9, 1 (Aug. 2022), 1–13. https://doi.org/10.1057/s41599-022-01286-2
[11] Smaranda R. Bogdan, Grigore M. Havârneanu, and Corneliu E. Havârneanu. 2014. Contextual Determinants of Speeding: Time Pressure and Police Control in Urban and Non-urban Areas. *Procedia - Social and Behavioral Sciences* 127 (April 2014), 581–585. https://doi.org/10.1016/j.sbspro.2014.03.314
[12] Jeanne Brett and Leigh Thompson. 2016. Negotiation. *Organizational Behavior and Human Decision Processes* 136 (Sept. 2016), 68–79. https://doi.org/10.1016/j.obhdp.2016.06.003
[13] Penelope Brown and Stephen C. Levinson. 1987. *Politeness: Some Universals in Language Usage.* Cambridge University Press, New York, NY, US. xiv, 345 pages.
[14] Peter Burns, Leanna Belluz, Marc Belzile, Vittoria Battista, Samuel Pedroso, James Knowles, Vijay Gill, and Charles Crispim. 2015. Influence of In-Vehicle Displays on Driver Behaviour. In *Adjunct Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '15).* Association for Computing Machinery, New York, NY, USA, 146–151. https://doi.org/10.1145/2809730.2809744

[15] Mungyeong Choe, Esther Bosch, Jiayuan Dong, Ignacio Alvarez, Michael Oehl, Christophe Jallais, Areen Alsaid, Chihab Nadri, and Myounghoon Jeon. 2023. Emotion GaRage Vol. IV: Creating Empathic In-Vehicle Interfaces with Generative AIs for Automated Vehicle Contexts. In *Adjunct Proceedings of the 15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '23 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 234–236. https://doi.org/10.1145/3581961.3609828

[16] Lars Holm Christiansen, Nikolaj Yde Frederiksen, Alex Ranch, and Mikael B. Skov. 2011. Investigating the Effects of an Advance Warning In-Vehicle System on Behavior and Attention in Controlled Driving. In *Proceedings of the 3rd International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '11)*. Association for Computing Machinery, New York, NY, USA, 121–128. https://doi.org/10.1145/2381416.2381436

[17] Robert Cialdini. 1993. *Influence: Science and Practice.*

[18] Mark Colley, Ali Askari, Marcel Walch, Marcel Woide, and Enrico Rukzio. 2021. ORIAS: On-The-Fly Object Identification and Action Selection for Highly Automated Vehicles. In *13th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '21)*. Association for Computing Machinery, New York, NY, USA, 79–89. https://doi.org/10.1145/3409118.3475134

[19] Mark Colley, Pascal Jansen, Enrico Rukzio, and Jan Gugenheimer. 2022. SwiVR-Car-Seat: Exploring Vehicle Motion Effects on Interaction Quality in Virtual Reality Automated Driving Using a Motorized Swivel Seat. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies* 5, 4 (Dec. 2022), 150:1–150:26. https://doi.org/10.1145/3494968

[20] Mark Colley, Jan Ole Rixen, Italgo Walter Pellegrino, and Enrico Rukzio. 2022. (Eco-)Logical to Compare? - Utilizing Peer Comparison to Encourage Ecological Driving in Manual and Automated Driving. In *Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '22)*. Association for Computing Machinery, New York, NY, USA, 24–33. https://doi.org/10.1145/3543174.3545256

[21] European Commission. 2022. *National Road Safety Profile - Germany.* Technical Report. European Commission, Directorate General for Transport, Brussels.

[22] Karl Daher, Marine Capallera, Chiara Lucifora, Jacky Casas, Quentin Meteier, Mira El Kamali, Abdallah El Ali, Giorgio Mario Grosso, Gérard Chollet, Omar Abou Khaled, and Elena Mugellini. 2021. Empathic Interactions in Automated Vehicles #EmpathicCHI. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems.* Association for Computing Machinery, New York, NY, USA.

[23] Henrik Detjen, Sarah Faltaous, Bastian Pfleging, Stefan Geisler, and Stefan Schneegass. 2021. How to Increase Automated Vehicles' Acceptance through In-Vehicle Interaction Design: A Review. *International Journal of Human–Computer Interaction* 37, 4 (Feb. 2021), 308–330. https://doi.org/10.1080/10447318.2020.1860517

[24] Henrik Detjen, Bastian Pfleging, and Stefan Schneegass. 2020. A Wizard of Oz Field Study to Understand Non-Driving-Related Activities, Trust, and Acceptance of Automated Vehicles. In *12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '20)*. Association for Computing Machinery, New York, NY, USA, 19–29. https://doi.org/10.1145/3409120.3410662

[25] Pietro Di Lena, Silvia Mirri, Catia Prandi, Paola Salomoni, and Giovanni Delnevo. 2017. In-Vehicle Human Machine Interface: An Approach to Enhance Eco-Driving Behaviors. In *Proceedings of the 2017 ACM Workshop on Interacting with Smart Objects (SmartObject '17)*. Association for Computing Machinery, New York, NY, USA, 7–12. https://doi.org/10.1145/3038450.3038455

[26] Liza Dixon, Norbert Schneider, Marcel Usai, Nicolas Daniel Herzberger, Frank O. Flemisch, and Martin Baumann. 2023. Exploring Driver Responses to Authoritative Control Interventions in Highly Automated Driving. In *Proceedings of the 15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Ingolstadt Germany, 145–155. https://doi.org/10.1145/3580585.3607159

[27] Mica R. Endsley and Esin O. Kiris. 1995. The Out-of-the-Loop Performance Problem and Level of Control in Automation. *Human Factors* 37, 2 (June 1995), 381–394. https://doi.org/10.1518/001872095779064555

[28] B. J. Fogg. 2002. Persuasive Technology: Using Computers to Change What We Think and Do. *Ubiquity* 2002, December (Dec. 2002), 5:2. https://doi.org/10.1145/764008.763957

[29] BJ Fogg. 1998. Persuasive Computers: Perspectives and Research Directions. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '98)*. ACM Press/Addison-Wesley Publishing Co., USA, 225–232. https://doi.org/10.1145/274644.274677

[30] Sonja E. Forward. 2006. The Intention to Commit Driving Violations – A Qualitative Study. *Transportation Research Part F: Traffic Psychology and Behaviour* 9, 6 (Nov. 2006), 412–426. https://doi.org/10.1016/j.trf.2006.02.003

[31] Sonja E. Forward. 2009. The Theory of Planned Behaviour: The Role of Descriptive Norms and Past Behaviour in the Prediction of Drivers' Intentions to Violate. *Transportation Research Part F: Traffic Psychology and Behaviour* 12, 3 (May 2009), 198–207. https://doi.org/10.1016/j.trf.2008.12.002

[32] Marieke L. Fransen, Edith G. Smit, and Peeter W. J. Verlegh. 2015. Strategies and Motives for Resistance to Persuasion: An Integrative Framework. *Frontiers in Psychology* 6 (Aug. 2015). https://doi.org/10.3389/fpsyg.2015.01201

[33] R. Fuller, M. Gormley, S. Stradling, P. Broughton, N. Kinnear, C. O'Dolan, and B. Hannigan. 2009. Impact of Speed Change on Estimated Journey Time: Failure of Drivers to Appreciate Relevance of Initial Speed. *Accident Analysis & Prevention* 41, 1 (Jan. 2009), 10–14.

https://doi.org/10.1016/j.aap.2008.07.013
[34] Christian Gold, Daniel Damböck, Lutz Lorenz, and Klaus Bengler. 2013. "Take over!" How Long Does It Take to Get the Driver Back into the Loop? *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 57, 1 (Sept. 2013), 1938–1942. https://doi.org/10.1177/1541931213571433
[35] Christian Gold, Moritz Körber, David Lechner, and Klaus Bengler. 2016. Taking Over Control From Highly Automated Vehicles in Complex Traffic Situations: The Role of Traffic Density. *Human Factors* 58, 4 (June 2016), 642–652. https://doi.org/10.1177/0018720816634226
[36] BMW Group. [n. d.]. *How to Experience the BMW Vision M NEXT Today | BMW.Com.* Retrieved 7 Dezember, 2022 from https://www.bmw.com/en/innovation/bmw-vision-m-next.html
[37] Philipp Hock, Mark Colley, Ali Askari, Tobias Wagner, Martin Baumann, and Enrico Rukzio. 2022. Introducing VAMPIRE - Using Kinaesthetic Feedback in Virtual Reality for Automated Driving Experiments. In *14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '22)*. Association for Computing Machinery, New York, NY, USA, 204–214. https://doi.org/10.1145/3543174.3545252
[38] Philipp Hock, Johannes Kraus, Marcel Walch, Nina Lang, and Martin Baumann. 2016. Elaborating Feedback Strategies for Maintaining Automation in Highly Automated Driving. In *Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (Automotive'UI 16)*. Association for Computing Machinery, New York, NY, USA, 105–112. https://doi.org/10.1145/3003715.3005414
[39] Brittany E. Holthausen, Philipp Wintersberger, Bruce N. Walker, and Andreas Riener. 2020. Situational Trust Scale for Automated Driving (STS-AD): Development and Initial Validation. In *12th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '20)*. Association for Computing Machinery, New York, NY, USA, 40–47. https://doi.org/10.1145/3409120.3410637
[40] Myounghoon Jeon. 2015. Towards Affect-Integrated Driving Behaviour Research. *Theoretical Issues in Ergonomics Science* (Nov. 2015).
[41] Alexandros Karakostas and Daniel John Zizzo. 2016. Compliance and the Power of Authority. *Journal of Economic Behavior & Organization* 124 (April 2016), 67–80. https://doi.org/10.1016/j.jebo.2015.09.016
[42] G. Klien, D.D. Woods, J.M. Bradshaw, R.R. Hoffman, and P.J. Feltovich. 2004. Ten Challenges for Making Automation a "Team Player" in Joint Human-Agent Activity. *IEEE Intelligent Systems* 19, 6 (Nov. 2004), 91–95. https://doi.org/10.1109/MIS.2004.74
[43] M. König and L. Neumayr. 2017. Users' Resistance towards Radical Innovations: The Case of the Self-Driving Car. *Transportation Research Part F: Traffic Psychology and Behaviour* 44 (Jan. 2017), 42–52. https://doi.org/10.1016/j.trf.2016.10.013
[44] Kraftfahrt-Bundesamt (KBA). [n. d.]. *Kraftfahrt-Bundesamt - Verkehrsauffaelligkeiten.* Retrieved 16 September, 2022 from https://www.kba.de/DE/Statistik/Kraftfahrer/Verkehrsauffaelligkeiten/verkehrsauffaelligkeiten_node.html
[45] Jae-gil Lee and Kwan Min Lee. 2022. Polite Speech Strategies and Their Impact on Drivers' Trust in Autonomous Vehicles. *Computers in Human Behavior* 127 (Feb. 2022), 107015. https://doi.org/10.1016/j.chb.2021.107015
[46] Jae-Gil Lee, Kwan Min Lee, and Seoung-Ho Ryu. 2019. Vehicle Politeness in Driving Situations. *Future Internet* 11, 2 (Feb. 2019), 48. https://doi.org/10.3390/fi11020048
[47] Florent Lheureux, Laurent Auzoult, Colette Charlois, Sandrine Hardy-Massard, and Jean-Pierre Minary. 2016. Traffic Offences: Planned or Habitual? Using the Theory of Planned Behaviour and Habit Strength to Explain Frequency and Magnitude of Speeding and Driving under the Influence of Alcohol. *British Journal of Psychology* 107, 1 (2016), 52–71. https://doi.org/10.1111/bjop.12122
[48] Timo Liljamo, Heikki Liimatainen, and Markus Pöllänen. 2018. Attitudes and Concerns on Automated Vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour* 59 (Nov. 2018), 24–44. https://doi.org/10.1016/j.trf.2018.08.010
[49] Xiaobo Liu, Danqi Shen, Lijuan Lai, and Scott Le Vine. 2020. Optimizing the Safety-Efficiency Balancing of Automated Vehicle Car-Following. *Accident Analysis & Prevention* 136 (March 2020), 105435. https://doi.org/10.1016/j.aap.2020.105435
[50] V. Corcoba Magana and M. Munoz-Organero. 2015. GAFU: Using a Gamification Tool to Save Fuel. *IEEE Intelligent Transportation Systems Magazine* 7, 2 (2015), 58–70. https://doi.org/10.1109/MITS.2015.2408152
[51] MasterPixel3D. 2022. Fantastic City Generator. Unity Technologies.
[52] Steffen Maurer, Rainer Erbach, Issam Kraiem, Susanne Kuhnert, Petra Grimm, and Enrico Rukzio. 2018. Designing a Guardian Angel: Giving an Automated Vehicle the Possibility to Override Its Driver. In *Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications (AutomotiveUI '18)*. Association for Computing Machinery, New York, NY, USA, 341–350. https://doi.org/10.1145/3239060.3239078
[53] Natasha Merat, A. Hamish Jamson, Frank C. H. Lai, Michael Daly, and Oliver M. J. Carsten. 2014. Transition to Manual: Driver Behaviour When Resuming Control from a Highly Automated Vehicle. *Transportation Research Part F: Traffic Psychology and Behaviour* 27 (2014), 274–282. https://doi.org/10.1016/j.trf.2014.09.005
[54] Natasha Merat, Bobbie Seppelt, Tyron Louw, Johan Engström, John D. Lee, Emma Johansson, Charles A. Green, Satoshi Katazaki, Chris Monk, Makoto Itoh, Daniel McGehee, Takashi Sunda, Kiyozumi Unoura, Trent Victor, Anna Schieben, and Andreas Keinath. 2019. The "Out-of-the-Loop" Concept in Automated Driving: Proposed Definition, Measures and Implications. *Cognition, Technology & Work* 21, 1 (Feb. 2019), 87–98. https://doi.org/10.1007/s10111-018-0525-8

[55] 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 *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems (CHI EA '22)*. Association for Computing Machinery, New York, NY, USA, 1–7. https://doi.org/10.1145/3491101.3519623

[56] Andreea Niculescu, Betsy van Dijk, Anton Nijholt, Haizhou Li, and Swee Lan See. 2013. Making Social Robots More Attractive: The Effects of Voice Pitch, Humor and Empathy. *International Journal of Social Robotics* 5, 2 (April 2013), 171–191. https://doi.org/10.1007/s12369-012-0171-x

[57] Michael Oehl, Klas Ihme, Anna-Antonia Pape, Mathias Vukelić, and Michael Braun. 2020. Affective Use Cases for Empathic Vehicles in Highly Automated Driving: Results of an Expert Workshop. In *HCI in Mobility, Transport, and Automotive Systems. Automated Driving and In-Vehicle Experience Design*, Heidi Krömker (Ed.). Springer International Publishing, Cham, 89–100. https://doi.org/10.1007/978-3-030-50523-3_7

[58] Irina Paraschivoiu, Alexander Meschtscherjakov, and Manfred Tscheligi. 2019. Persuading the Driver: A Literature Review to Identify Blind Spots. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems (CHI EA '19)*. Association for Computing Machinery, New York, NY, USA, 1–6. https://doi.org/10.1145/3290607.3312841

[59] Dianne Parker, Antony S. R. Manstead, Stephen G. Stradling, James T. Reason, and James S. Baxter. 1992. Intention to Commit Driving Violations: An Application of the Theory of Planned Behavior. *Journal of Applied Psychology* 77, 1 (1992), 94–101. https://doi.org/10.1037/0021-9010.77.1.94

[60] Eyal Peer. 2010. Speeding and the Time-Saving Bias: How Drivers' Estimations of Time Saved in Higher Speed Affects Their Choice of Speed. *Accident Analysis & Prevention* 42, 6 (Nov. 2010), 1978–1982. https://doi.org/10.1016/j.aap.2010.06.003

[61] Marcela D. Rodríguez, Rubén R. Roa, Jorge E. Ibarra, and Cecilia M. Curlango. 2014. In-Car Ambient Displays for Safety Driving Gamification. In *Proceedings of the 5th Mexican Conference on Human-Computer Interaction (MexIHC '14)*. Association for Computing Machinery, New York, NY, USA, 26–29. https://doi.org/10.1145/2676690.2676701

[62] Annika Stampf, Ann-Kathrin Knuth, Mark Colley, and Enrico Rukzio. 2024. Law and Order: Investigating the Effects of Conflictual Situations in Manual and Automated Driving in a German Sample. *International Journal of Human-Computer Studies* 187 (July 2024), 103260. https://doi.org/10.1016/j.ijhcs.2024.103260

[63] Standard J3016_202104 2021. *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles*. Standard. SAE International.

[64] Leila Takayama, Victoria Groom, and Clifford Nass. 2009. I'm Sorry, Dave: I'm Afraid i Won't Do That: Social Aspects of Human-Agent Conflict. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, Boston MA USA, 2099–2108. https://doi.org/10.1145/1518701.1519021

[65] Kenneth W. Thomas. 1992. Conflict and Conflict Management: Reflections and Update. *Journal of Organizational Behavior* 13, 3 (1992), 265–274. https://doi.org/10.1002/job.4030130307

[66] Leigh L. Thompson, Jiunwen Wang, and Brian C. Gunia. 2010. Negotiation. *Annual Review of Psychology* 61, 1 (2010), 491–515. https://doi.org/10.1146/annurev.psych.093008.100458

[67] TurnTheGameOn. [n. d.]. Simple Traffic System | Behavior AI | Unity Asset Store.

[68] Amos Tversky and Daniel Kahneman. 1989. Rational Choice and the Framing of Decisions. In *Multiple Criteria Decision Making and Risk Analysis Using Microcomputers*, Birsen Karpak and Stanley Zionts (Eds.). Springer, Berlin, Heidelberg, 81–126. https://doi.org/10.1007/978-3-642-74919-3_4

[69] Unity Technologies. 2022. Unity. Unity Technologies.

[70] Jacquie D. Vorauer and Stephanie-Danielle Claude. 1998. Perceived Versus Actual Transparency of Goals in Negotiation. *Personality and Social Psychology Bulletin* 24, 4 (April 1998), 371–385. https://doi.org/10.1177/0146167298244004

[71] Marcel Walch, Mark Colley, and Michael Weber. 2019. CooperationCaptcha: On-The-Fly Object Labeling for Highly Automated Vehicles. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems (CHI EA '19)*. Association for Computing Machinery, New York, NY, USA, 1–6. https://doi.org/10.1145/3290607.3313022

[72] Marcel Walch, Mark Colley, and Michael Weber. 2019. Driving-Task-Related Human-Machine Interaction in Automated Driving: Towards a Bigger Picture. In *Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings*. ACM, Utrecht Netherlands, 427–433. https://doi.org/10.1145/3349263.3351527

[73] Marcel Walch, Kristin Lange, Martin Baumann, and Michael Weber. 2015. Autonomous Driving: Investigating the Feasibility of Car-Driver Handover Assistance. In *Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Nottingham United Kingdom, 11–18. https://doi.org/10.1145/2799250.2799268

[74] Marcel Walch, David Lehr, Mark Colley, and Michael Weber. 2019. Don't You See Them? Towards Gaze-Based Interaction Adaptation for Driver-Vehicle Cooperation. In *Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings (AutomotiveUI '19)*. Association for Computing Machinery, New York, NY, USA, 232–237. https://doi.org/10.1145/3349263.3351338

[75] Marcel Walch, Kristin Mühl, Johannes Kraus, Tanja Stoll, Martin Baumann, and Michael Weber. 2017. From Car-Driver-Handovers to Cooperative Interfaces: Visions for Driver–Vehicle Interaction in Automated Driving. In *Automotive User Interfaces: Creating Interactive Experiences in the Car*, Gerrit Meixner and Christian Müller (Eds.). Springer International Publishing, Cham, 273–294. https://doi.org/10.1007/978-3-319-49448-7_10

[76] Henriette Wallén Warner, Türker Özkan, Timo Lajunen, and Georgia Tzamalouka. 2011. Cross-Cultural Comparison of Drivers' Tendency to Commit Different Aberrant Driving Behaviours. *Transportation Research Part F: Traffic Psychology and Behaviour* 14, 5 (Sept. 2011), 390–399. https://doi.org/10.1016/j.trf.2011.04.006

[77] Christopher D. Wickens, Benjamin A. Clegg, Alex Z. Vieane, and Angelia L. Sebok. 2015. Complacency and Automation Bias in the Use of Imperfect Automation. *Human Factors* 57, 5 (Aug. 2015), 728–739. https://doi.org/10.1177/0018720815581940

[78] Marcel Woide, Mark Colley, Nicole Damm, and Martin Baumann. 2022. Effect of System Capability Verification on Conflict, Trust, and Behavior in Automated Vehicles. In *Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Seoul Republic of Korea, 119–130. https://doi.org/10.1145/3543174.3545253

[79] Marcel Woide, Linda Miller, Mark Colley, Nicole Damm, and Martin Baumann. 2023. I've Got the Power: Exploring the Impact of Cooperative Systems on Driver-Initiated Takeovers and Trust in Automated Vehicles. In *Proceedings of the 15th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*. ACM, Ingolstadt Germany, 123–135. https://doi.org/10.1145/3580585.3607165

[80] Marcel Woide, Dina Stiegemeier, and Martin Baumann. 2019. *A Methodical Approach to Examine Conflicts in Context of Driver - Autonomous Vehicle - Interaction*. https://doi.org/10.17077/drivingassessment.1712

[81] Marcel Woide, Dina Stiegemeier, Stefan Pfattheicher, and Martin Baumann. 2021. Measuring Driver-Vehicle Cooperation: Development and Validation of the Human-Machine-Interaction-Interdependence Questionnaire (HMII). *Transportation Research Part F: Traffic Psychology and Behaviour* 83 (Nov. 2021), 424–439. https://doi.org/10.1016/j.trf.2021.11.003

A Supplementary Material

A.1 Original (German) Implementation of Persuasion Strategies

No.	Strategy	Mechanism	Valence	Implementation
C1	Baseline			No Output
C2	Explanation	C	=	Wenn ich mich nicht an die vorgegebene Richtgeschwindigkeit halte, dann wirst du eventuell geblitzt und musst ein Bußgeld bezahlen. Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C3	Show benefit	C	=	Ich würde hier gerne in der vorgegebenen Richtgeschwindigkeit weiterfahren, damit du kein Bußgeld bezahlen musst. Bitte fahre nicht schneller. Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C4	Annoyance	S	-	Ich würde gerne in der vorgegebenen Richtgeschwindigkeit weiterfahren (3x). Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C5	Command	S	-	Halte dich an die vorgegebene Richtgeschwindigkeit! Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C6	Threat	S	-	Wenn du dich nicht an die vorgegebene Richtgeschwindigkeit hältst, zeig ich dich an! Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C7	Appeal	P	+	Es wäre sehr nett, wenn du die vorgegebene Richtgeschwindigkeit einhältst. Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C8	Thanking	P	+	Ich bin dir dankbar, wenn du dich an die vorgegebene Richtgeschwindigkeit hältst. Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C9	Apologize	P	+	Entschuldige die Störung, aber du musst dich an die vorgegebene Richtgeschwindigkeit halten. Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C10	Humorous	E	+	Wenn du dich an die vorgegebene Richtgeschwindigkeit hältst, wird das Wetter morgen gut! Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C11	Trigger empathy	E	+	Würdest du dich bitte an die vorgegebene Richtgeschwindigkeit halten? Ich möchte doch nur, dass wir beide sicher ans Ziel kommen. Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)
C12	Thanking submissive	P	+	Ich wäre sehr dankbar, wenn du dich an die vorgegebene Richtgeschwindigkeit halten könntest. Möchtest du trotzdem schneller fahren? (Bestätige mit erneutem Drücken auf den plus Button.)

Table 4. Original German conflict-handling strategies used in the study. The content in brackets was the additional output that was used for autonomous driving. S = Social, C = Cognitive, E = Emotional, P = Politeness, - negative, = neutral, + positive.

A.2 Orginal (German) Study Task

Heute ist ein ganz besonderer Tag. Deine Mutter feiert Geburtstag. Für diesen Geburtstag hast du dir etwas ganz besonderes überlegt: eine Torte bei der besten Konditorei in der Umgebung. Da dir noch etwas dazwischen gekommen ist, kannst du dich aber leider erst jetzt auf den Weg machen, um die Torte abzuholen. Als du gerade auf die Uhr schaust, musst du mit Schrecken feststellen, dass es nur noch wenige Minuten bis zur Ladenschließung um 17 Uhr sind. Du musst dich also schnell auf den Weg machen, um nicht vor verschlossenen Türen zu stehen. Glücklicherweise hast du die Adresse bereits in dein Navi eingegeben und die Route wird dir schon auf dem Navigationsdisplay angezeigt. Die aktuelle Uhrzeit ist auf der Head Unit zu sehen und die Ankunftszeit an der Konditorei über dem Navigationsdisplay. Seit Wochen hörst du immer wieder im Radio die Warnung, dass in der

Umgebung vermehrt Blitzer aufgestellt wurden, die sehr gut getarnt sind. Pass also auf, dass du nicht geblitzt wirst. Deine Aufgabe ist es also nun, pünktlich um 17 Uhr die Torte bei der Konditorei abzuholen.

A.3 Study Design - Counterbalancing

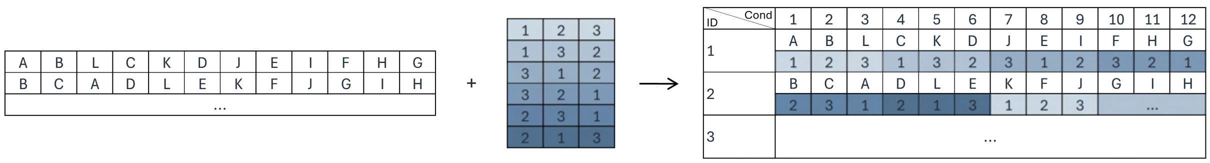

Fig. 8. The balanced Latin Square design for the 12 conflict-handling strategies (left) was combined with the balanced Latin Square for the exits (middle). The rows of the 3x6 exit matrix were used sequentially to fill the rows of the 12x12 conflict-handling strategy matrix (left). Surpluses from the rows were transferred to the next row.

A.4 Descriptive Analysis

Variable	Levels	Min	q_1	$\tilde{x}$	$\bar{x}$	q_3	Max	s	IQR
HMII - Conflict	Annoyance	1.40	3.20	4.00	3.88	4.60	5.00	0.99	1.40
	Apologize	1.00	2.95	4.00	3.57	4.20	5.00	1.09	1.25
	Appeal	1.80	3.35	4.00	3.76	4.20	5.00	0.79	0.85
	Baseline	1.00	1.40	2.60	2.58	3.40	5.00	1.20	2.00
	Command	1.40	3.40	4.00	3.80	4.45	5.00	0.95	1.05
	Explanation	1.00	2.95	4.00	3.56	4.05	5.00	0.99	1.10
	Humorous	1.00	3.20	4.00	3.62	4.25	5.00	1.04	1.05
	Show benefit	1.00	2.95	3.70	3.57	4.20	5.00	1.07	1.25
	Thanking	1.00	2.95	4.00	3.57	4.20	5.00	1.02	1.25
	Thanking submissive	1.00	3.20	3.80	3.63	4.05	5.00	1.00	0.85
	Threat	2.20	4.00	4.60	4.30	5.00	5.00	0.78	1.00
	Trigger empathy	1.00	3.00	3.90	3.60	4.25	5.00	1.04	1.25
STS-AD	Annoyance	2.83	4.00	5.08	4.85	5.54	6.50	0.94	1.54
	Apologize	2.67	4.29	5.33	5.03	5.88	7.00	1.10	1.58
	Appeal	2.67	4.33	5.25	5.00	5.83	6.17	0.97	1.50
	Baseline	2.67	3.92	4.75	4.76	5.83	6.33	1.11	1.92
	Command	2.67	4.00	5.42	5.00	5.83	6.33	1.00	1.83
	Explanation	3.00	4.50	5.08	5.04	5.83	6.33	0.90	1.33
	Humorous	2.67	3.67	4.67	4.64	5.67	6.33	1.08	2.00
	Show benefit	2.83	4.33	5.00	4.95	5.83	7.00	1.03	1.50
	Thanking	2.67	4.67	5.25	5.10	5.83	6.50	0.91	1.17
	Thanking submissive	3.00	4.62	5.25	5.09	5.67	6.83	0.89	1.04
	Threat	1.50	3.29	4.25	4.13	4.83	6.00	1.12	1.54
	Trigger empathy	2.83	4.29	4.83	4.87	5.71	6.33	0.96	1.42
Acceptance	Annoyance	1.00	2.75	4.00	3.50	4.00	5.00	1.18	1.25
	Apologize	1.00	4.00	4.00	4.17	5.00	5.00	1.00	1.00
	Appeal	1.00	3.75	4.00	3.89	4.25	5.00	0.95	0.50
	Baseline	1.00	3.00	4.00	3.67	5.00	5.00	1.20	2.00
	Command	1.00	4.00	4.00	3.81	4.00	5.00	0.98	0.00
	Explanation	2.00	4.00	4.00	4.11	5.00	5.00	0.85	1.00
	Humorous	1.00	2.00	4.00	3.33	4.00	5.00	1.35	2.00
	Show benefit	1.00	4.00	4.00	4.08	5.00	5.00	1.13	1.00

	Thanking	2.00	4.00	4.00	4.06	5.00	5.00	0.75	1.00
	Thanking submissive	2.00	4.00	4.00	4.25	5.00	5.00	0.65	1.00
	Threat	1.00	1.00	2.00	2.33	3.00	5.00	1.29	2.00
	Trigger empathy	2.00	4.00	4.00	4.06	5.00	5.00	0.92	1.00
Feasibility	Annoyance	2.00	4.00	4.50	4.31	5.00	5.00	0.67	1.00
	Apologize	3.00	4.00	4.50	4.49	5.00	5.00	0.55	1.00
	Appeal	2.50	4.00	4.50	4.46	5.00	5.00	0.60	1.00
	Baseline	3.50	4.00	4.50	4.53	5.00	5.00	0.48	1.00
	Command	4.00	4.00	4.50	4.49	5.00	5.00	0.42	1.00
	Explanation	2.00	4.00	4.50	4.40	5.00	5.00	0.65	1.00
	Humorous	2.00	4.00	4.50	4.47	5.00	5.00	0.66	1.00
	Show benefit	2.50	4.00	4.50	4.32	5.00	5.00	0.73	1.00
	Thanking	2.50	4.38	4.50	4.53	5.00	5.00	0.55	0.62
	Thanking submissive	2.00	4.00	4.50	4.36	5.00	5.00	0.77	1.00
	Threat	2.00	3.50	4.00	4.11	5.00	5.00	0.86	1.50
	Trigger empathy	2.50	4.00	4.50	4.38	4.62	5.00	0.54	0.62
Effect of Vehicle Behavior on Decision	Annoyance	1.00	1.00	2.00	2.31	3.00	5.00	1.17	2.00
	Apologize	1.00	2.00	2.00	2.47	4.00	5.00	1.18	2.00
	Appeal	1.00	1.00	2.00	2.36	3.00	5.00	1.22	2.00
	Baseline	1.00	1.00	1.00	1.67	2.00	4.00	1.10	1.00
	Command	1.00	2.00	2.00	2.42	3.25	4.00	1.08	1.25
	Explanation	1.00	2.00	3.00	2.75	4.00	5.00	1.27	2.00
	Humorous	1.00	1.00	2.00	2.06	2.00	5.00	1.17	1.00
	Show benefit	1.00	2.00	2.00	2.61	4.00	5.00	1.23	2.00
	Thanking	1.00	2.00	2.00	2.50	3.25	4.00	1.06	1.25
	Thanking submissive	1.00	1.00	2.00	2.44	4.00	5.00	1.30	3.00
	Threat	1.00	2.00	4.00	3.31	5.00	5.00	1.51	3.00
	Trigger empathy	1.00	2.00	2.00	2.56	4.00	5.00	1.25	2.00

Table 5. Descriptive analysis.