User Acceptance of Autonomous Vehicles: Review and Perspectives on the Role of the Human-machine Interfaces

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Abstract: Although autonomous driving has significantly developed in the last years, its acceptance by users is still low, even due to the different interaction modalities between the human agent and Autonomous Vehicles (AVs). Therefore, this paper proposes an analysis of the existing research on the influence of Human-Machine Interfaces (HMIs) on the user acceptance of AVs from the perspective of interaction design. The authors reviewed the fundamental changes in the way users interact with AVs. The paper focuses on the transfer of the vehicle control between the human and the artificial intelligence agent, the user experience of Non-Driving-Related Tasks (NDRTs) and sharing autonomous driving in public transportation, and the impact of external HMI on Vulnerable Road Users (VRUs). In addition, the paper analyzes the concept of acceptability and describes the existing user acceptance models. Finally, the paper explores the future challenges for promoting the design potential of autonomous vehicle HMIs and proposes areas worthy of research to increase the user's acceptance of this technology.

Keywords: autonomous vehicles, user acceptance model, human-machine interface, vulnerable road users
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1 INTRODUCTION

1.1 Motivation

Autonomous Vehicles (AVs), also known as self-driving cars, driverless cars, or robot cars, can perceive their environment and drive safely with little or no human input [27],[38]. Due to the vigorous development of technology, autonomous driving is gradually increasing, and users will be more and more released from driving tasks. At the same time, communication channels and interfaces established between users and AVs will become more prominent. Therefore, analyzing the changes in interacting with the car is fundamental [2]. According to several scholars [12],[59], the biggest obstacle to the large-scale adoption of AVs will be psychological factors, such as acceptance

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and trust, rather than technical. Improving the user's acceptance of autonomous driving technology is therefore a fundamental challenge. To this end, the research on the Human-Machine Interface (HMI) in AVs can make relevant contributions.

This paper examines HMI design for AVs to improve driver behavior and cognition and increase user trust and acceptance of the technology. The authors summarized the research results of the HMI of autonomous driving technology through a state-of-the-art literature review. The characteristics and status of the HMI design of AVs were reviewed from two perspectives: internal and external (i.e., in-vehicle HMI and out-of-vehicle HMI). The review's final aim was to understand the application status of the user acceptance model in autonomous driving and find existing research gaps and a promising direction for future research.

1.2 State-of-the-Art

According to the new SAE International Standards J3016 (2019), vehicle automation is divided into six levels (0-5), from SAE Level Zero (no automation) to SAE Level 5 (full vehicle autonomy) [25]. Although each level implies a different human intervention, levels 1-3 mandatorily require a human driver, while levels 4 and 5 support the unmanned operation of the vehicle. The medium used by the driver to interact and exchange information with the vehicle, the HMI, combines different hardware and software components to enable the most appropriate interaction modalities [59]. Hardware includes processors, display units, input units, communication interfaces, data storage, etc. The software includes low-level algorithms to control the hardware and high-level software, often with a Graphical User Interface (GUI), to interact with the vehicle. Due to the primary research interest in in-vehicle users' interaction, the interaction modalities of the AVs with the other road users have been poorly investigated. However, the interaction of users outside the vehicle is critical for a complete acceptance of this technology, leading a few scholars to consider this fundamental aspect.

First studies on pedestrian behavior date back to the early 1950s [51]. Many studies in behavioral psychology have shown that pedestrians mainly rely on recessive communication strategies when encountering a vehicle, including the speed and the distance of the car and eye contact with the driver [20]. It helps them make decisions, such as waiting or passing in front of the vehicle. Besides pedestrians, cyclists and motorcyclists must be considered Vulnerable Road Users (VRUs) for self-driving vehicles because they account for more than 50% of traffic fatalities [26]. The European Commission delimits VRUs as "non-motorized road users, such as pedestrians and cyclists; as well as motorcyclists and persons with disabilities or reduced mobility and orientation" [41]. VRUs must be able to communicate with AVs and understand their intentions [51]. The implicit communication between VRUs and vehicles is based on the vehicle's state and the inherent hidden details, such as the vehicle's trajectory and driver's facial expressions, and the action feedback [60]. Compared with standard vehicles, the invisible communication means of AVs are reduced due to the lack of drivers, and this aspect is scarcely researched. Most research on information communication outside the vehicle focuses on explicit communication, such as text, graphics, lights on the roof, windscreen, and grill in different positions. All these implicit and explicit interactions between the vehicle and the VURs are crucial, making the acceptance of AVs more likely in the face of a significant change in the coming years [13].

HMI occupies a strategic position in researching and developing the interactive design of AVs. Through a literature review, we explored the rationale of existing research areas by aggregating them and combining existing user acceptance models to understand the potential impact of the HMI on users' acceptance of autonomous driving technology. Finally, we identified valuable future research directions. The literature review intersected three main research fields: "Autonomous Vehicles," "Human-Machine Interface," and "User Acceptance." "Autonomous Vehicles" touches knowledge fields such as anthropology, marketing, physics, engineering, and information science. "HMI" is related to ergonomics, human factors, industrial design, computer science, and artificial intelligence. "User acceptance" deals with user research, interaction design, and humanities. Figure 1 summarizes all the disciplines and sub-disciplines considered in this study.

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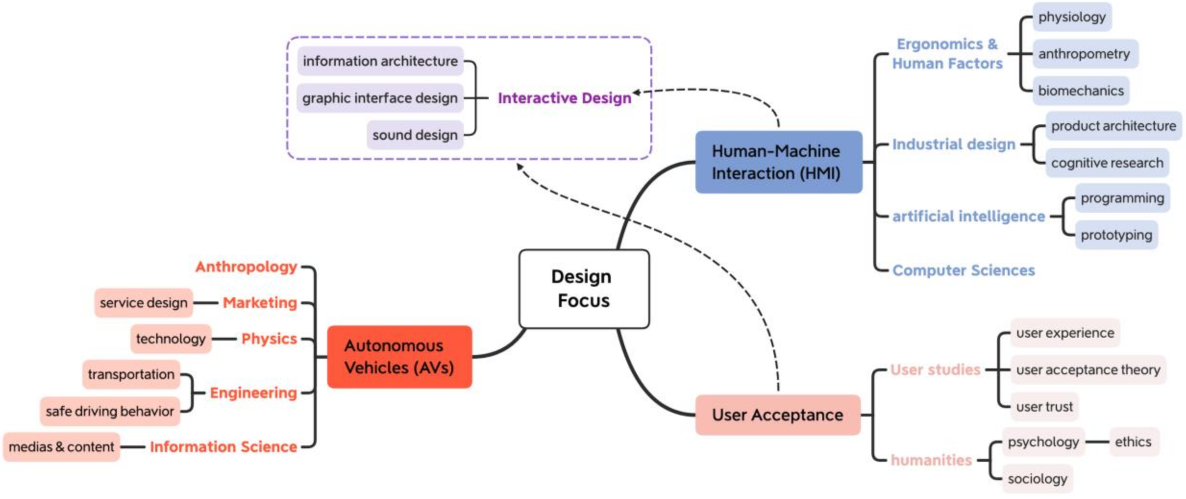

Figure 1: Specific disciplines of this research field.

1.3 Research Gaps and Paper Structure

The results of the literature review show that in the last ten years, the research on the HMI of autonomous driving vehicles has focused on the following aspects:

(1) transfer of driving rights in semi-autonomous scenes;

(2) collaborative construction of the human-machine environment inside the car;

(3) information exchange and communication between the vehicle, the people outside the car, and the environment in the fully automated driving scenario [16],[54],[69].

Few studies have focused on applying user acceptance models for designing the interface of AVs [47]. Most of these studies debated the status of human drivers through existing user acceptance models, focusing on regular populations and scenes [15],[29],[68]. There is a lack of research on exceptional circumstances (such as extreme weather conditions) and special populations (i.e., users with disabilities or reduced mobility and orientation). Therefore, we comprehensively analyzed human-machine interactions in AVs and user acceptance to reference future independent driving HMI design while considering these limitations. The paper's organization can be summarized as follows.

Section 1 introduces the writing motivations of this paper. Section 2 describes the methods used for performing the literature review. Section 3 draws the literature review results, introducing the classification of HMI in AVs and discussing the research scope and status of the HMI in different environments. Specifically, we focused on two critical aspects of collaborative construction of in-vehicle HMI and information exchange outside the vehicle. Existing problems, challenges, and future directions of HMI research are discussed in Section 4. Finally, Section 5 concludes the article.

2 LITERATURE REVIEW METHODOLOGY

This literature review aimed to explore the emerging and consolidated perspectives on users' acceptance of HMI in AVs. In detail, through the three keywords "HMI," "AVs," and "user acceptance," the two development directions of in-vehicle HMI, and out-of-vehicle HMI were identified. The scope of the literature review was narrowed according to the research gap identified. The specific steps are shown in Figure 2.

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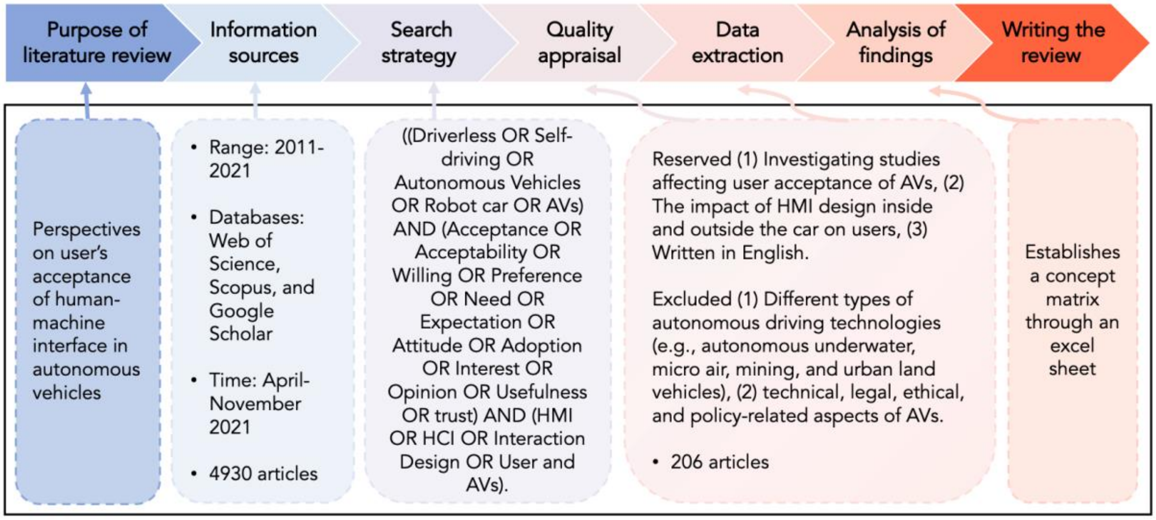

Figure 2: Literature Review Process.

2.1 Purpose of the Literature Review

This literature review started with theoretical research within the research methodology, also called clarification (RC) [45], a review-based study. The objective of this initial step was to narrow the scope and areas of the research. We investigated definitions, development processes, and the current state of AVs and user acceptance by focusing on the research gap of HMI inside and outside the car to demonstrate tactical significance toward solving these problems.

2.2 Information Sources and Search Strategy

The research topic intersects three main areas: "AVs", "HMI", and "User Acceptance". Since the definition of "autonomous driving" changes in each of them, we used multiple keywords, such as "driverless cars", "self-driving cars", "robot cars", or "AVs". The discussion on user acceptance relates to the users' attitudes towards this technology, and "willingness", "preference", "attitude" can be considered synonymous. In addition, even if HMI is an established disciplinary field, we consider this article's perspective of design and user research.

In conclusion, to cover all the identified research fields, we used the following query string: (Driverless OR Self-driving OR Autonomous Vehicles OR Robot car OR AVs) AND (Acceptance OR Acceptability OR Willing OR Preference OR Need OR Expectation OR Attitude OR Adoption OR Interest OR Opinion OR Usefulness OR trust) AND (HMI OR HCI OR Interaction Design OR User and AVs).

Being autonomous driving an emerging technology, the search was limited to the last decade, 2011-2021. It was conducted on the three primary databases for scholarly publication: Web of Science, Scopus, and Google Scholar. The initial search yielded 4930 results, including journal publications, conference proceedings articles, reports, posters, and presentation slides, excluding duplicates.

2.3 Quality Appraisal and Data Extraction

The retrieved articles were screened for relevance and quality [11]. As a result, valuable literature related to the research topic was identified. All the documents based on psychology and sociology research were discarded: this lowered the total number of articles to 1896. By reading the abstracts of the remaining literature, we determined inclusion and exclusion criteria, thereby selecting material

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considered relevant to our analysis. We considered all scientific papers written in English addressing studies affecting user acceptance of autonomous driving and the impact of HMI design on users inside and outside the car.

Conversely, we excluded research focusing on other autonomous driving technologies (e.g., autonomous underwater, micro air, mining, and urban land vehicles) and technical, legal, ethical, and policy-related aspects of AVs. We removed 776 records that did not fulfill our search criteria. Instead, we employed "backward" and "forward" searches to dig deeper into crucial literature. Backward searching refers to collecting relevant publications by screening the reference lists of the papers retrieved from the keyword search. Forward searching refers to collecting appropriate publications that have cited these papers [66].

Finally, we excluded review-based studies, which already discussed the results of some of the studies that met our eligibility criteria. In conclusion, 206 records were retained in the final stage of the qualitative analysis.

2.4 Analysis of Findings

By summarizing the theories and approaches of various authors, this paper obtains a more in-depth understanding of the identified concepts, the case studies using these theories were summarized, compared, and analyzed. All materials are divided into two categories:

(1) research on HMI inside and outside autonomous vehicles;

(2) development and application of user acceptance models.

The concepts to be tested, the evaluation methods, carrier platforms, and experimental results were summarized and analyzed for the first category. For the second category, the evolution of the user acceptance model was sorted out in a timeline, focusing on research related to autonomous driving. The literature review was performed through the search, selection, and synthesis phases described above. A glossary and a bibliography have been created as an output. This review allowed us to identify a promising research direction based on expanding existing theories.

3 MAIN FINDINGS

3.1 Human-Machine Interactions in Autonomous Vehicles

For the autonomous driving scenarios, HMI refers to the transmission of information between the human agent and the artificial intelligence by using a user interface or dashboard [9] to achieve the purpose of human-computer collaboration [8]. Researchers and engineers have developed interfaces to make the collaboration between the driver and the vehicle much more flexible in recent years. The analyzed studies have different theoretical frameworks and classification methods for autonomous driving HMI. The two mainstream classifications are hereafter described (see Figure 3).

According to its function, HMI in AVs can be divided into "input" and "output" types. The input type includes the vehicle's channels to receive the human inputs, such as buttons, steering wheels, pedals, and touch screens. The output refers to the vehicle's media to provide status information to the user by transmitting multi-channel signals mainly based on visual and auditory stimuli (i.e., displays, lights, and voice). It is important to stress that with the term "user," we refer to the driver, the passengers, and other road users outside the car.

According to its attributes, HMI in AVs can be divided into "explicit communication" and "implicit communication" [7],[44]. Explicit communication refers to the information exchange between the vehicle and the user through external information, which manifests explicitly as the information obtained through multi-modal stimuli (e.g., lights, gestures, voice, etc.). Implicit communication refers to judging the vehicle's state through the inherent hidden details, such as the vehicle's trajectory.

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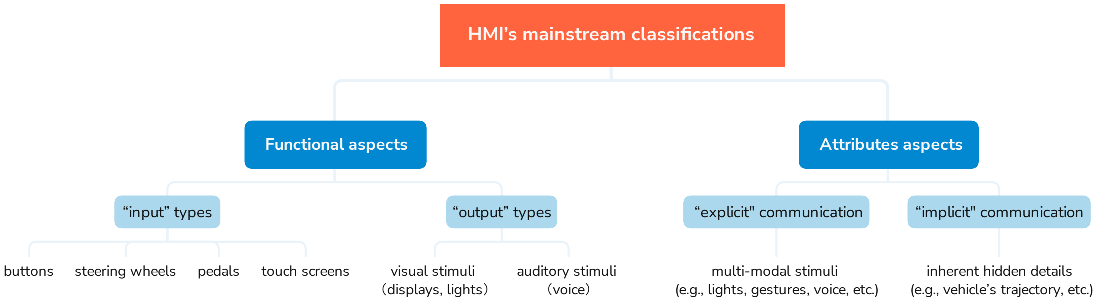

Figure 3: HMI's mainstream classifications.

With the continuous improvement of the degree of automation, the types of HMI are also continuously subdivided. Nowadays, five are the HMI types that AVs can display, including Dynamic HMI (dHMI), Automation HMI (aHMI); Vehicle HMI (vHMI); Infotainment HMI (iHMI), and External HMI (eHMI)[7].

The following paragraphs provide an overview of existing research on AVs and HMIs for users inside and outside the car according to the classification described above.

3.1.1 Collaborative construction of HMI inside the vehicle

Based on the level of automation, the research on in-vehicle HMIs focuses on different aspects: a summary of the research we consider relevant is shown in Table 1. With SAE levels between 1 and 3 (partial automation), the in-vehicle interaction grounds the seamless transfer and sharing of vehicle control between the human driver and the artificial intelligence to reduce the cognitive load and improve driving safety [34],[63]. With SAE levels between 4 and 5 (advanced automation), users in the car will gradually get rid of driving behavior and engage in some non-driving-related tasks (NDRTs) [71], such as entertainment and work. In any of these scenarios, the transparency of the information conveyed by the automated system to the users in the car is essential [48] to gain trust. Moreover, the user's emotional experience can be enhanced through various multi-modal and anthropomorphic interaction methods to improve reliability [55].

SAE	***Ref***	***Focus concept***	***Methods and Evaluation***	***Conclusion***	***Remark***
	[28]	Human-machine transition (HMT)	Simulators. After 50 minutes automated rides, a take-over situation occurred	Participation in NDRTs may harm the efficiency and effectiveness of the takeover tasks.	Monitoring the driver's status and providing appropriate assistance in a takeover situation seems to be an effective way to ensure safety.
L1-3	[49]	Takeover of Control. Four concepts: RepB, ResB, MB, CB	Simulators. Participants were instructed to play a tablet memory game and come back to driving whenever requested.	The shorter and simpler interaction of the CB system-a button presses by the driver to assume control -was the most accepted.	User experience and success rate of taking over tasks can be improved by increasing driver situation awareness.
	[24]	Non-driving-related	Simulators. Take over driving after answering the phone in three traffic	The traffic state seems more influential than the driver's state.	The representation of the external traffic environment is equally helpful in designing and evaluating

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		tasks (NDRTs)	densities (0 vehicles, 10 vehicles, and 20 vehicles/km).		human-computer interaction in highly automated vehicle takeover situations.
L3	[21]	Takeover system	Simulators. Compare two different interaction scenarios: (1) steering wheel with lights; (2) steering wheel without lights.	Adding light strips to the steering wheel and changing the flashing interval and color to distinguish different functions is a manner to improve the transparency of the information	It improves the user's trust and satisfaction and the efficiency of the takeover. Trust and takeover efficiency show a positive correlation.
L3-5	[6]	Issue of the handover/takeover	Literature review; Summary	Propose an HMT method as a general conceptual framework that unifies the consideration of HMI, connectivity, and ethics.	Despite the many technical challenges and HMI ethical and legal issues to be resolved, the core question is how, when, and under which conditions user should take over the vehicle.

Table 1: Studies of in-vehicle HMIs in different SAE levels.

In a semi-autonomous scenario, the Human-Machine Transition (HMT) [5] is the core of the research carried out on simulators to reduce the risk and cost of the experiment and ensure the safety of the tested subjects. Researchers require the subject to experience an extended period of autonomous driving. After that, the system gives the user instructions to take over the driving task, which requires the participant to control the car [64]. Politis et al. offer a different point of view, who believe that NDRTs should not be restricted [49]. They evaluated four concepts in a driving simulator: Repetition-Based (RepB), Response-Based (ResB), Multimodality-Based (MB), and Countdown-Based (CB). An inclusive set of participants with a broad age spectrum tested the four interfaces. Gold, Christian, et al. also agree that NDRTs is not the most crucial reason for the driver's state [24]. They concluded that the traffic state seems more influential than the driver's state.

The HMI research of highly automated vehicles is gradually being combined with inclusive design. This emerging research strand uses qualitative analysis - such as interviews, focus groups, surveys, and field research. It combines car design and inclusive design with user-centricity by targeting a more comprehensive range of users and the public's acceptance of autonomous driving. Scholars have suggested improving HMI through user research by understanding the critical issues of user sensitivity to AVs [35]. Under the phenomenon of shared driving between human and artificial intelligence agents, the takeover of driving rights has made the issue of the integration of driving responsibilities prominent. Many studies in the fields of law and morality explored this situation from the responsibility system and applied ethics perspective.

3.1.2 Information exchange of HMI outside the vehicle

Concerning the eHMI research, the communication between AV and other road users can be confusing because AVs do not provide them with the necessary information. Automated vehicles provide signals when they start moving (ringtone and flashing lights), but these do not seem sufficient [41]. There is uncertainty about whether the vehicles are driving or stopping in situations with unclear priority rules. For instance, people waiting for an autonomous bus do not know if it stops and if they are in the right place to be picked up. Indeed, the human operator typically communicates with people waiting for the bus via looks and gestures.

Most case studies have compared the effects of different forms, types, and locations of eHMIs on user behavior [17]. However, the results differ due to the different experimental and data analysis

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methods. In Table 2, the most significant studies have been summarized with their objectives, evaluation methods, experiment platforms, conclusions, and remarks on eHMI assessment.

Ref	***Concept to be tested***	***Methods and Evaluation***	***Platform***	***Illustrations***	***Conclusion***	***Remark***
[65]	Four visual signs	Co-design; Survey study	Workshop		Pedestrians considered anthropomorphic signs the preferred and most effective way to understand the intentions of the AVs.	Anthropomorphic sign can have a broad application prospect in public transportation.
[19]	Light Signal Evaluation	Wizard-of-Oz	Real place		Stable and flashing signals are more user-friendly than scanning lights.	The influence of color should be considered.
[40]	28 HMI conceptual design prototypes	Questionnaires, Interviews and Observations	Virtual Reality		Participants preferred simple and highly visible cues: projecting a zebra-crossing on the street and turning it green as a traffic light metaphor to stress the invitation to cross.	Subjective and objective research methods should be used together.
[17]	12 eHMIs	Confirmatory experiment	Virtual Reality	 	The interaction efficiency and pedestrian safety in multimodal eHMI design were satisfactory. The visual modality by "arrow" was more intuitive than "smile."	Multi-modal eHMI should be proposed from the visual, auditory, and physical to promote interaction.
[18]	36 display positions	Eye tracker	Virtual Reality		eHMIs on the grill, windscreen, and roof were regarded as the clearest and they evoked the highest compliance rate for approaching.	The location of eHMIs has an essential impact on communication.
[4]	28 eHMIs	Online questionnaires	Online		Text eHMIs are usually considered the clearest. In non-text, the projected crossing is clear, while light-based eHMIs are considered relatively unclear.	The method is single, and results are conflicting. The subjective and objective methods should be used.

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[32]	Vehicles' behavior and eHMI type	A head-mounted display coupled to a motion-tracking suit	Virtual Reality		eHMIs improve the understanding of the vehicle crossing intentions.	The motion suit allows investigation of pedestrian behaviors related to bodily attention and hesitation.
[62]	eHMI locations	Wizard of Oz	Augmented Reality		In the case of multiple in-line vehicles, the most prominent information display part is not the front of the car but the side.	Different positions of eHMI impact the speed and accuracy of transmission.
[37]	3 eHMI signs	Lab experiments; Usability testing	Virtual Reality		The same eHMI format could convey different messages equally well.	An eHMI indicating the AV's behavior is sufficient for conveying intention.

Table 2: Studies of eHMI assessment selected in the literature review.

Some scholars believe that explicit eHMIs may lead to people's over-reliance, and the implicit information about the vehicle is equally important [30]. Among them, Moore et al. think that implicit details are sufficient for the communication between AVs and pedestrians [44]. Whether an explicit and evident communication between the AVs and the pedestrians can distract other road users by attracting their attention is an issue that needs further exploration [53].

Our review on eHMIs highlighted that a shared understanding of VRUs in HMI research is still missing. Holländer, et al. proposed a road user classification method centered on VRUs to clarify this concept [26]. They believe that the interplay of fully automated vehicles and VRUs is the future direction. Therefore, the design of inclusive eHMIs for visual and hearing impairments appears significant. Such research should also focus on visual impairment caused by environmental conditions and adopt multi-modal interfaces to increase social inclusion [13].

Autonomous driving in public transportation seems to be an exciting topic for future development directions where "Sharing" becomes an essential feature, and users must be equally served. Therefore, participatory design has become the design method commonly used for studying eHMI. Verma, et al. assessed the perception and response of pedestrians to different intentions by showing participants the changes in the position of the information displayed on the AVs [65]. Experiments show that the display positions of different eHMIs outside the car impact the speed and the accuracy of information transmission to the users [18]. Dey et al. also studied the impact of vehicle appearance (the perceived "aggressiveness" or "friendliness" provided by the vehicle form, size, and type) on pedestrians' perception of AVs risk. Zandi, et al. divided the communication messages of eHMI into three classes: instruction, intention, and base message [69]. The relationship between different levels of abstraction in information communication and VRUs' subjective and cognitive perception is another future direction worth studying.

3.2 Acceptability and User Acceptance

3.2.1 Definition of "acceptability" and "acceptance"

Two concepts, "acceptability" and "acceptance," are commonly used to study the general attitude towards new technology [47]. However, there are specific differences between them.

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"Acceptability" is the characteristic of being subject to acceptance for some purpose. A thing is acceptable if it is sufficient to serve the purpose for which it is provided, even if it is far less usable than the ideal example. A thing is unacceptable (or has the characteristic of unacceptability) if it deviates significantly from the ideal. Therefore, it is no longer sufficient to serve or against the desired purpose. In this article, we refer to "acceptability" as the prospective judgment of potential users towards introducing new technology. It implies that the potential users have not yet experienced this technology [56]. Applying this concept means that the designed product should be suitable for people of different abilities, without specific changes or modifications. Acceptability design has four characteristics: recognizability, operability, simplicity, and inclusiveness [14].

"Acceptance" is the opposite of rejection, indicating a favorable decision to use innovation [22]. In design, "user acceptance" often appears in research. After trying the product, it represents potential users' judgment, attitude, and behavioral responses [58]. There are three measurement standards for testing user acceptance in the market economy: general acceptance, willingness to pay (WTP), and behavior intention (BI) [39]. Research on acceptance can indirectly improve users' desire to buy and has a particular role in promoting the commercial value of autonomous driving technology. In this article, the definition of "acceptance" refers to a positive attitude from potential users about autonomous driving technology before experiencing it and positive feedback after trying it. The user acceptance of autonomous taxis (Robo-taxi) is a significant example. While many studies statistically analyze user data obtained by surveying individuals' perceptions or indirectly through simulators, Sunghee Lee et al. obtained user experience data directly from Robo-taxi service experiences in downtown Seoul and Daejeon in South Korea in 2021 [36]. Similar experiments are gradually gaining attention in various countries. Due to their different roles, such as passengers, pedestrians on the road, drivers of other vehicles, staff who operate it, etc., these potential users have multiple manifestations of acceptance. Trusting in this technology and willingness to pay for it for consumers with purchasing power appears to be the most common acceptance behavior.

In summary, acceptance of AVs results from four decision-making steps: 1) exposure to an automated vehicle, 2) formation of a positive attitude towards it, 3) decision to adopt it, and 4) actual use. We are interested in the second step and explore how to stimulate users' positive attitudes through interaction design, thereby improving user acceptance. While engineering research aims to implement autonomous driving technology, it is essential to improve the user's acceptance before the technology is fully developed and further increase public awareness of it to ensure its smooth adoption [39],[57-58]. Virtual Reality technologies can play an important role because they can provide users with an autonomous driving experience before any actual implementation.

3.2.2 User acceptance model

In interaction design, the user's acceptance of new products is used to predict the consumers' buying behavior. The research is aimed to reduce consumer resistance to new products when they appear [61]. Although AVs can provide a potentially effective solution for improving road safety, their benefits can only be realized upon users' acceptance. Existing surveys show that the public's willingness to use or purchase AVS is still low [10],[31],[43],[70]. Therefore, improving the public recognition of this technology is a crucial issue that scholars have studied in recent years, developing different versions of user acceptance models intended to guide the design and implementation process, thereby minimizing the risk of user resistance or rejection. The historical evolution of the user acceptance model related to the AVs is summarized in Figure 4.

The Technology Acceptance Model (TAM) [23], proposed by Davis in 1989, is an extension of the Theory of Reasoned Action Model (TRA) [1] proposed by Fishbein and Azjen in 1975. The TAM has made significant contributions to developing and testing new technologies. It explains users' motivation by three factors: Perceived Usefulness (PU), Perceived Ease of Use (PEOU), and attitude toward use. However, since it is mainly based on personal characteristics, it ignores the social impact of technology adoption [66].

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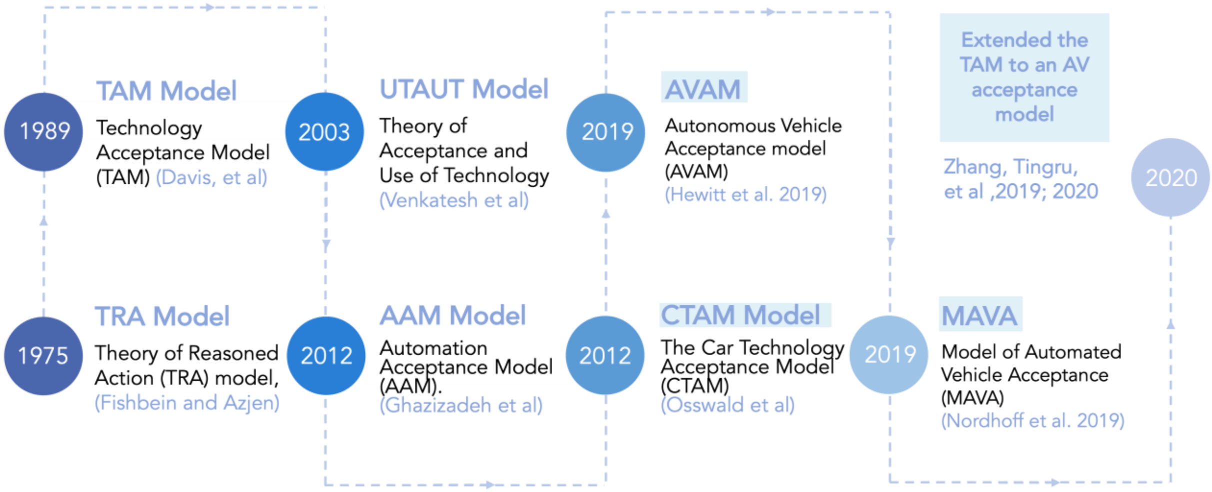

Figure 4: Development timeline of user acceptance model.

In recent years, the TAM has been expanded and adapted to research in autonomous driving. Venkatesh et al. created the Unified Theory of Acceptance and Use of Technology (UTAUT)[29] in 2003, integrating acceptance determinants in multiple models. In 2012, Ghazizadeh et al. added compatibility and trust to the TAM model structure and proposed the Automation Acceptance Model (AAM) [72]. "Compatibility" refers to the degree of matching between users, technology, task performance, and context. It is an indicator that measures the consistency of technology and user values, experience, and needs. "Trust" directly determines behavioral willingness. The AAM model is precious in the era of artificial intelligence [50]. Osswald et al. (2012) developed the Car Technology Acceptance Model (CTAM)[33],[52], which is an extension of UTAUT while introducing some other attitudinal constructs such as safety and anxiety. Hewitt et al. (2019) developed the Autonomous Vehicle Acceptance Model (AVAM). Nordhoff et al. (2019) proposed the Model of Automated Vehicle Acceptance (MAVA) based on personal exposure to AVs and systematic evaluation, and individual differences (e.g., socio-demographics, personality, and travel behavior) [46]. MAVA incorporates 28 acceptance factors that represent seven main acceptance classes. On this basis, Zhang, Tingru, et al. extended the Theoretical Acceptance Model (TAM) to an AV acceptance model in 2019 [73]. This model adds initial trust and two perceived risks: perceived security risk (PSR) and Perceived Privacy Risk (PPR). The authors argue that for AVs, the initial trust is based on perceptual factors: PU and PEOU, while PSR and PPR are the critical determinants of user acceptance. In 2020, they extended the TAM to social and personal factors (initial trust, social influence, five personalities, and pursuit of feeling traits) and proposed an improved AV acceptance model [74].

Future research on user acceptance of autonomous driving technology should focus on a specific level of automation. Moreover, the challenges that affect user acceptance will also include security and privacy, trust and transparency, performance, capability and control, and positive experiences [33],[52]. Therefore, to overcome users' biases (i.e., anxiety, the feeling of low safety, bad attitudes towards usage, and low task-related self-efficacy), designers of automated vehicles will be required to focus on a wide variety of factors: clear communication of system benefits (usefulness), the usability of features and trust, safety, security, control, comfort, fun, social, and well-being factors [46].

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4 FUTURE CHALLENGES

Understanding users' decisions and making them more receptive to new technologies can help businesses and researchers find better ways to design products. It also helps to predict users' reactions to new technologies [3],[61]. Although the user acceptance model's research has improved our understanding of AVs, most of them are limited to the overall perception of autonomous driving, analyzing which cognitive factors impact user acceptance and focusing on each factor's proportion and relationship [42]. User acceptance surveys for specific driving functions and interaction modes have not been thoroughly tested [67]. Trust and perceived risk are the two most common reasons why users do not accept AVs [76]. When cars are given autonomy, their communication with people becomes critical. Users' perception, information classification, and human-machine interaction are the primary research focus for AVs design. Consequently, it is strongly recommended to use user acceptance models as the basis for user behavior research.

For in-car HMI, with the gradual transition to full automation, the impact of the transparency of the HMI on user acceptance cannot be underestimated. The automated system clearly shows the operation mode and status to the user, which can help the user grasp the control more quickly in an emergency. So, it is necessary to synchronize automated data and information to enable users to understand the AV status more clearly. Future research directions should pay more attention to displaying HMI's vehicle status. However, humans have a reaction time and cannot immediately take over the driving task. As a result, the issue of vehicle control transfer is undoubtedly essential. In addition, with the reduction in driving activities, the role of vehicles will shift from a personal to a shared operating experience, such as in public transportation, where different users will share the exact vehicle. Consequently, the distribution and conversion of control rights for different users will become a relevant research focus.

On the other hand, the research for HMI outside the car focuses on the information exchanged between vehicles and VRUs. Till now, researchers have compared the effects of different forms, types, and locations of eHMI on user behavior. However, the results are not entirely coherent due to the specific experimental and data analysis methods employed. Furthermore, the current research is mainly conducted in general scenarios, and the attention to WRU is low. Future research should be more in-depth and comprehensive, such as comparing the impact of different vehicles (cars, buses, trucks, etc.) and their appearance in the interaction with VURs. From the perspective of inclusive design, research should involve different user groups in various extreme weather and road conditions to evaluate the effectiveness of different eHMIs.

5 CONCLUSION

We conducted a literature review on the HMI and user acceptance of autonomous driving. In driving scenarios with increasing automation, the possibility for users inside and outside the vehicle to understand and communicate with AVs has a considerable impact on users' acceptance of this technology. In this article, internal and external HMI have been analyzed, comparing the effects of different HMIs and the impact of the experience on users' behavior. Then, the concepts of "acceptability" and "user acceptance" have been defined. Finally, the development of user acceptance models in time has been outlined. This allowed us to identify research gaps and research challenges. In the future, the internal and external HMI design should consider several human factors, guiding the design of human-centered AVs and increasing user trust and acceptance of this technology.

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REFERENCES

[1] Adnan, N.; Md Nordin, S.; bin Bahruddin, M. A.; & Ali, M.: How trust can drive forward the user acceptance to the technology? In-vehicle technology for autonomous vehicle, Transportation Research Part A: Policy and Practice, 118, 2018, 819–836. https://doi.org/10.1016/j.tra.2018.10.019

[2] Ahangar, M. N.; Ahmed, Q. Z.; Khan, F. A.; & Hafeez, M.: A survey of autonomous vehicles: Enabling communication technologies and challenges, In Sensors (Switzerland), (Vol. 21, Issue 3, 2021, 1–33). MDPI AG. https://doi.org/10.3390/s21030706

[3] Aylward, K.; Weber, R.; Man, Y., Lundh, M.; & Mackinnon, S. N.: "Are you planning to follow your route?" The effect of route exchange on decision making, trust, and safety, Journal of Marine Science and Engineering, 8(4), 2020. https://doi.org/10.3390/JMSE8040280

[4] Bazilinskyy, P.; Dodou, D.; & de Winter, J.: Survey on eHMI concepts: The effect of text, color, and perspective, Transportation Research Part F: Traffic Psychology and Behaviour, 67, 2019, 175–194. https://doi.org/10.1016/j.trf.2019.10.013

[5] Bellet, T.; Banet, A.; Petiot, M.; Richard, B.; & Quick, J.: Human-centered ai to support an adaptive management of human-machine transitions with vehicle automation, Information (Switzerland), 12(1), 2021, 1–18. https://doi.org/10.3390/info12010013

[6] Bellet, T.; Cunneen, M.; Mullins, M.; Murphy, F.; Pütz, F.; Spickermann, F.; Braendle, C.; & Baumann, M. F.: From semi to fully autonomous vehicles: New emerging risks and ethico-legal challenges for human-machine interactions, Transportation Research Part F: Traffic Psychology and Behaviour, 63, 2019, 153–164. https://doi.org/10.1016/j.trf.2019.04.004

[7] Bengler, K.; Rettenmaier, M.; Fritz, N.; & Feierle, A.: From HMI to HMIs: Towards an HMI framework for automated driving, Information (Switzerland), 11(2), 2020, 1–17. https://doi.org/10.3390/info11020061

[8] Bevan, N.; Carter, J.; Earthy, J.; Geis, T.; & Harker, S.: New ISO standards for usability, usability reports and usability measures, Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 9731, 2016, 268–278. https://doi.org/10.1007/978-3-319-39510-4_25

[9] Bischoff, S.; Ulrich, C.; Dangelmaier, M.; Widlroither, H.,;& Diederichs, F. (n.d.): Emotion Recognition in User-Centered Design for Automotive Interior and Automated Driving.

[10] Bjørner, T.: Aalborg Universitet A Priori User Acceptance and the Perceived Driving Pleasure in Semi-autonomous and Autonomous Vehicles, Paper Presented at European Transport Conference 2015, Frankfurt, Germany, 2015, 1–13.

[11] Bornholt, J.; & Heidt, M.: Association for Information Systems Association for Information Systems To Drive or not to Drive-A Critical Review regarding the Acceptance of Autonomous Vehicles Completed Research Paper, 2019, https://aisel.aisnet.org/icis2019/human_computer_interact/human_computer_interact/5

[12] Burns, C. G.; Oliveira, L.; Thomas, P.; Iyer, S.; & Birrell, S.: Pedestrian decision-making responses to external human-machine interface designs for autonomous vehicles, IEEE Intelligent Vehicles Symposium, Proceedings, 2019-June, 70–75.

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https://doi.org/10.1109/IVS.2019.8814030
[13] Carmona, J.; Guindel, C.; Garcia, F.; & de la Escalera, A.: Ehmi: Review and guidelines for deployment on autonomous vehicles, In Sensors (Vol. 21, 2021, Issue 9). MDPI AG. https://doi.org/10.3390/s21092912
[14] Cleo, G.; Scott, A. M.; Islam, F.; Julien, B.; & Beller, E.: Usability and acceptability of four systematic review automation software packages: A mixed method design, In Systematic Reviews (Vol. 8, 2019, Issue 1). BioMed Central Ltd. https://doi.org/10.1186/s13643-019-1069-6
[15] De Winter, J. C. F.; Happee, R.; Martens, M. H.; & Stanton, N. A.: Effects of adaptive cruise control and highly automated driving on workload and situation awareness: A review of the empirical evidence, Transportation Research Part F: Traffic Psychology and Behaviour, 27(PB), 2014, 196–217. https://doi.org/10.1016/j.trf.2014.06.016
[16] Dicianno, B. E.; Sivakanthan, S.; Sundaram, S. A.; Satpute, S.; Kulich, H.; Powers, E.; Deepak, N.; Russell, R.; Cooper, R.; & Cooper, R. A.: Systematic review: Automated vehicles and services for people with disabilities, Neuroscience Letters, 2021, 761. https://doi.org/10.1016/j.neulet.2021.136103
[17] Dou, J.; Chen, S.; Tang, Z.; Xu, C.; & Xue, C.: Evaluation of multimodal external human–machine interface for driverless vehicles in virtual reality, Symmetry, 13(4), 2021. https://doi.org/10.3390/sym13040687
[18] Eisma, Y. B.; van Bergen, S.; ter Brake, S. M.; Hensen, M. T. T.; Tempelaar, W. J.; & de Winter, J. C. F.: External human-machine interfaces: The effect of display location on crossing intentions and eye movements, Information (Switzerland), 11(1), 2020. https://doi.org/10.3390/info11010013
[19] Faas, S. M.; & Baumann, M.: Yielding Light Signal Evaluation for Self-driving Vehicle and Pedestrian Interaction, Advances in Intelligent Systems and Computing, 1026, 2020, 189–194. https://doi.org/10.1007/978-3-030-27928-8_29
[20] Faas, S. M.; Mathis, L. A.; & Baumann, M.: External HMI for self-driving vehicles: Which information shall be displayed? Transportation Research Part F: Traffic Psychology and Behaviour, 68, 2020, 171–186. https://doi.org/10.1016/j.trf.2019.12.009
[21] Fang, Y.; Zhang, J.-H.; Zhang, J.; Deng, H.-J.; & Liu, Y.-J. (n.d.).: Interaction Design for Trust-based Takeover Systems in Smart Cars. https://doi.org/10.19554/j.cnki.1001-3563.2021.06.004
[22] Fraedrich, E.; Cyganski, R.; Wolf, I.; & Lenz, B.: User Perspectives on Autonomous Driving, 2016.
[23] Frison, A. K.; Liu, T.; Wintersberger, P.; & Riener, A.: Why do you like to drive automated? A context-dependent analysis of highly automated driving to elaborate requirements for intelligent user interfaces, International Conference on Intelligent User Interfaces, Proceedings IUI, Part F1476(February), 2019, 528–537. https://doi.org/10.1145/3301275.3302331
[24] Gold, C.; Körber, M.; Lechner, D.; & Bengler, K.: Taking over Control from Highly Automated Vehicles in Complex Traffic Situations, Human Factors, 58(4), 2016, 642–652. https://doi.org/10.1177/0018720816634226
[25] Hewitt, C.; Politis, I.; Amanatidis, T.; & Sarkar, A.: Assessing public perception of self-driving cars, Proceedings of the 24th International Conference on Intelligent User Interfaces, Part F1476, 2019, 518–527. https://doi.org/10.1145/3301275.3302268
[26] Hollander, K.; Colley, M.; Rukzio, E.; & Butz, A.: A taxonomy of vulnerable road users for hci based on a systematic literature review, Conference on Human Factors in Computing Systems

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

- Proceedings, 2021. https://doi.org/10.1145/3411764.3445480
[27] Hu, J.; Bhowmick, P.; Arvin, F.; Lanzon, A.; & Lennox, B.: Cooperative Control of Heterogeneous Connected Vehicle Platoons: An Adaptive Leader-Following Approach, IEEE Robotics and Automation Letters, 5(2), 2020, 977–984. https://doi.org/10.1109/LRA.2020.2966412
[28] Jarosch, O.; Bellem, H.; & Bengler, K.: Effects of Task-Induced Fatigue in Prolonged Conditional Automated Driving, Human Factors, 61(7), 2019, 1186–1199. https://doi.org/10.1177/0018720818816226
[29] Johnsen, A.: D2.1 Literature review on the acceptance and road safety, ethical, legal, social and economic implications of automated vehicles Trafiksyn View project Methods and metrics for assessing societal effects of transport automation View project, 2018. https://www.researchgate.net/publication/325786957
[30] Kaleefathullah, A. A.; Madigan, R.; & Garcia, J.: External Human-Machine Interfaces Can Be Misleading: An Examination of Trust Development and Misuse in a CAVE-Based Pedestrian Simulation Environment, In HUMAN FACTORS (Vol. 00, 2020, Issue 0).
[31] Kim, H.-C.; & Kim, H.-C.: Acceptability engineering: the study of user acceptance of innovative technologies, In Journal of Applied Research and Technology, Vol. 13, 2015. www.gartner.com
[32] Kooijman, L.; Happee, R.; & de Winter, J. C. F.: How do eHMIs affect pedestrians' crossing behavior? A study using a head-mounted display combined with a motion suit, Information (Switzerland), 10(12), 2019. https://doi.org/10.3390/info10120386
[33] Kruse, D.: Consumer acceptance of Shared Autonomous Vehicles, Copenhagen Business School Number, 2018.
[34] Kun, A. L.; Heeman, P. A.; Paek, T.; Miller, W. T.; Green, P. A.; Tashev, I.; Froehlich, P.; Reimer, B.; Iqbal, S.; & Kern, D. (n.d.).: Cognitive Load and In-Vehicle Human-Machine Interaction.
[35] Langdon, P.; Politis, I.; Bradley, M.; Skrypchuk, L.; Mouzakitis, A.; & Clarkson, J.: Obtaining design requirements from the public understanding of driverless technology, Advances in Intelligent Systems and Computing, 597, 2018, 749–759. https://doi.org/10.1007/978-3-319-60441-1_72
[36] Lee, S.; Yoo, S.; Kim, S.; Kim, E.; & Kang, N.: Effect of Robo-Taxi User Experience on User Acceptance: Field Test Data Analysis, 2676(2), 2021, 350–366. https://doi.org/10.1177/03611981211041595
[37] Lee, Y. M.; Madigan, R.; Garcia, J.; Tomlinson, A.; Solernou, A.; Romano, R.; Markkula, G.; Merat, N.; & Uttley, J.: Understanding the messages conveyed by automated vehicles. Proceedings - 11th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI, 2019, 134–143. https://doi.org/10.1145/3342197.3344546
[38] Lim, H. S. M.; & Taeihagh, A.: Autonomous vehicles for smart and sustainable cities: An in-depth exploration of privacy and cybersecurity implications, Energies, 2018, 11(5). https://doi.org/10.3390/en11051062
[39] Liu, X.; He, P.; Chen, W.; & Gao, J.: Improving Multi-Task Deep Neural Networks via Knowledge Distillation for Natural Language Understanding, 2019. http://arxiv.org/abs/1904.09482
[40] Löcken, A.; Golling, C.; & Riener, A.: How should automated vehicles interact with pedestrians? A comparative analysis of interaction concepts in virtual reality, Proceedings - 11th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI, 2019, 262–274. https://doi.org/10.1145/3342197.3344544
[41] Malik, R. Q.; Ramli, K. N.; Kareem, Z. H.; Habelalmatee, M. I.; Abbas, A. H.; & Alamoody, A.:

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

An overview on V2P communication system: Architecture and application, 2020 3rd International Conference on Engineering Technology and Its Applications, IICETA 2020, 2020, 174–178. https://doi.org/10.1109/IICETA50496.2020.9318863
[42] Merat; Natasha; Ruth Madigan; and S. N.: Human factors, user requirements, and user acceptance of ride-sharing in automated vehicles, 2017.
[43] Miglani, A.; Diels, C.; & Terken, J.: Compatibility between trust and non - Driving related tasks in UI design for highly and fully automated driving, AutomotiveUI 2016 - 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, Adjunct Proceedings, 2016, 75–80. https://doi.org/10.1145/3004323.3004331
[44] Moore, D.; Currano, R.; Strack, G. E.; & Sirkin, D.: The case for implicit external human-machine interfaces for autonomous vehicles, Proceedings - 11th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2019, 2019, 295–307. https://doi.org/10.1145/3342197.3345320
[45] Nordhoff, S.; Kyriakidis, M.; van Arem, B.; & Happee, R.: A multi-level model on automated vehicle acceptance (MAVA): a review-based study, Theoretical Issues in Ergonomics Science, 20(6), 2019, 682–710. https://doi.org/10.1080/1463922X.2019.1621406
[46] Paddeu, D.; Shergold, I.; & Parkhurst, G.: The social perspective on policy towards local shared autonomous vehicle services (LSAVS), Transport Policy, 98, 2020, 116–126. https://doi.org/10.1016/j.tranpol.2020.05.013
[47] Pigeon, C.; Alauzet, A.; & Paire-Ficout, L.: Factors of acceptability, acceptance and usage for non-rail autonomous public transport vehicles: A systematic literature review, Transportation Research Part F: Traffic Psychology and Behaviour, 81, 2021, 251–270. https://doi.org/10.1016/j.trf.2021.06.008
[48] Pokam, R.; Debernard, S.; Chauvin, C.; & Langlois, S.: Principles of transparency for autonomous vehicles: first results of an experiment with an augmented reality human–machine interface, Cognition, Technology and Work, 21(4), 2019, 643–656. https://doi.org/10.1007/s10111-019-00552-9
[49] Politis, I.; Langdon, P.; Adebayo, D.; Bradley, M.; Clarkson, P. J.; Skrypchuk, L.; Mouzakitis, A.; Eriksson, A.; Brown, J. W. H.; Revell, K.; & Stanton, N.: An evaluation of inclusive dialogue-based interfaces for the takeover of control in autonomous cars, International Conference on Intelligent User Interfaces, Proceedings IUI, 2018, 601–606. https://doi.org/10.1145/3172944.3172990
[50] Rahman, M. M.; Deb, S.; Strawderman, L.; Burch, R.; & Smith, B.: How the older population perceives self-driving vehicles, Transportation Research Part F: Traffic Psychology and Behaviour, 65, 2019, 242–257. https://doi.org/10.1016/j.trf.2019.08.002
[51] Rasouli, A.; & Tsotsos, J. K.: Autonomous vehicles that interact with pedestrians: A survey of theory and practice, IEEE Transactions on Intelligent Transportation Systems, 21(3), 2020, 900–918. https://doi.org/10.1109/TITS.2019.2901817
[52] Reig, S.; Norman, S.; Morales, C. G.; Das, S.; Steinfeld, A.; & Forlizzi, J.: A field study of pedestrians and autonomous vehicles. Proceedings - 10th International ACM Conference on Automotive User Interfaces and Interactive Vehicular Applications, AutomotiveUI 2018, 2018, 198–209. https://doi.org/10.1145/3239060.3239064
[53] Rettenmaier, M.; Albers, D.; & Bengler, K.: After you?! – Use of external human-machine interfaces in road bottleneck scenarios, Transportation Research Part F: Traffic Psychology and Behaviour, 70, 2020, 175–190. https://doi.org/10.1016/j.trf.2020.03.004
[54] Rouchitsas, A.; & Alm, H.: (2019). External Human–Machine Interfaces for Autonomous

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Vehicle-to-Pedestrian Communication: A Review of Empirical Work, In Frontiers in Psychology, Vol. 10, 2019, Frontiers Media S.A. https://doi.org/10.3389/fpsyg.2019.02757
[55] Row, Y. K.; Kim, S. Y.; & Nam, T. J.: Using pet-dog behavior traits to enhance the emotional experience of in-car interaction, International Journal of Design, 14(1), 2020, 19–34.
[56] Schade, J.; & Schlag, B.: Acceptability of urban transport pricing strategies, Transportation Research Part F: Traffic Psychology and Behaviour, 6(1), 2003, 45–61. https://doi.org/10.1016/S1369-8478(02)00046-3
[57] Schoettle, B.; & Sivak, M.: A survey of public opinion about autonomous and self-driving vehicles in the US, UK and Australia, UMTRI, Transportation Research Institute, July, 2014, 1–38.
[58] Schuitema, G.; Steg, L.; & van Kruining, M.: When Are Transport Pricing Policies Fair and Acceptable? Social Justice Research, 24(1), 2011, 66–84. https://doi.org/10.1007/s11211-011-0124-9
[59] Shariff, A.; Bonnefon, J. F.; & Rahwan, I.: Psychological roadblocks to the adoption of self-driving vehicles, In Nature Human Behaviour, Vol. 1, Issue 10, 2017, pp. 694–696, Nature Publishing Group. https://doi.org/10.1038/s41562-017-0202-6
[60] Tabone, W.; de Winter, J.; Ackermann, C.; Bärgman, J.; Baumann, M.; Deb, S.; Emmenegger, C.; Habibovic, A.; Hagenzieker, M.; Hancock, P. A.; Happee, R.; Krems, J.; Lee, J. D.; Martens, M.; Merat, N.; Norman, D.; Sheridan, T. B.; & Stanton, N. A.: Vulnerable road users and the coming wave of automated vehicles: Expert perspectives, Transportation Research Interdisciplinary Perspectives, 2021, 9. https://doi.org/10.1016/j.trip.2020.100293
[61] Taherdoost, H.: A review of technology acceptance and adoption models and theories, Procedia Manufacturing, 22, 2018, 960–967. https://doi.org/10.1016/j.promfg.2018.03.137
[62] Troel-Madec, M.; Alaimo, J.; Boissieux, L.; Chatagnon, S.; Borkoswki, S.; Spalanzani, A.; & Vaufreydaz, D.: eHMI positioning for autonomous vehicle/pedestrians interaction, IHM 2019 - Annexes Des Actes de La 31e Conference Francophone Sur l'Interaction Homme-Machine, 2019. https://doi.org/10.1145/3366551.3370340
[63] Ulahannan, A.; Jennings, P.; Oliveira, L.; & Birrell, S.: Designing an adaptive interface: Using eye tracking to classify how information usage changes over time in partially automated vehicles, IEEE Access, 8, 2020, 16865–16875. https://doi.org/10.1109/ACCESS.2020.2966928
[64] van der Vecht, B.; van Diggelen, J.; Peeters, M.; Barnhoorn, J.; & van der Waa, J.: Sail: A social artificial intelligence layer for human-machine teaming, Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 10978 LNAI(September), 2018, 262–274. https://doi.org/10.1007/978-3-319-94580-4_21
[65] Verma, H.; Pythoud, G.; Eden, G.; Lalanne, D.; & Evéquoz, F.: Pedestrians and Visual Signs of Intent, Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies, 3(3), 2019, 1–31. https://doi.org/10.1145/3351265
[66] vom Brocke, J.; Simons, A.; Riemer, K.; Niehaves, B.; Plattfaut, R.; & Cleven, A.: Standing on the shoulders of giants: Challenges and recommendations of literature search in information systems research, Communications of the Association for Information Systems, 37(August), 2015, 205–224. https://doi.org/10.17705/1cais.03709
[67] Vrščaj, D.; Nyholm, S.; & Verbong, G. P. J.: Is tomorrow's car appealing today? Ethical issues and user attitudes beyond automation, AI and Society, 35(4), 2020, 1033–1046. https://doi.org/10.1007/s00146-020-00941-z

© 2023 CAD Solutions, LLC, http://www.cad-journal.net

[68] Waytz, A.; Heafner, J.; & Epley, N.: The mind in the machine: Anthropomorphism increases trust in an autonomous vehicle, Journal of Experimental Social Psychology, 52, 2014, 113–117. https://doi.org/10.1016/j.jesp.2014.01.005

[69] Xing, Y.; Lv, C.; Cao, D.; & Hang, P.: Toward human-vehicle collaboration: Review and perspectives on human-centered collaborative automated driving, Transportation Research Part C: Emerging Technologies, 2021,128. https://doi.org/10.1016/j.trc.2021.103199

[70] Xu, Z.; Zhang, K.; Min, H.; Wang, Z.; Zhao, X.; & Liu, P.: What drives people to accept automated vehicles? Findings from a field experiment, Transportation Research Part C: Emerging Technologies, 95, 2018, 320–334. https://doi.org/10.1016/j.trc.2018.07.024

[71] Yang, Y.; Karakaya, B.; Dominioni, G. C.; Kawabe, K.; & Bengler, K.: An HMI Concept to Improve Driver's Visual Behavior and Situation Awareness in Automated Vehicle, IEEE Conference on Intelligent Transportation Systems, Proceedings, ITSC, 2018, 650–655. https://doi.org/10.1109/ITSC.2018.8569986

[72] Zhang, B.-H.; & Fang, Y.: Foundation items： Shanghai Automotive Industry Technology Development Fund (1717), 41(6), 1994. https://doi.org/10.11996/JG.j.2095-302X.2020061012

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

[74] Zhang, T.; Tao, D.; Qu, X.; Zhang, X.; Zeng, J.; Zhu, H.; & Zhu, H.: Automated vehicle acceptance in China: Social influence and initial trust are key determinants, Transportation Research Part C: Emerging Technologies, 112(January), 2020, 220–233. https://doi.org/10.1016/j.trc.2020.01.027

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