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Research article

Explaining Acceptance and Acceptability of Connected Automated Vehicles: The Impact of Evaluations of Attributes and Traffic Complexity

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Connected Automated Vehicles (CAVs) may, when available, be able to reduce greenhouse gasses emissions caused by the transport sector, and may increase traffic safety. In order for CAVs to be adopted by the public, they first need to be accepted (i.e., evaluated positively). Therefore, it is critical to identify the predictors of CAVs' acceptability (general evaluation before experience) and acceptance (willingness to use after experience). We examined to what extent evaluations of different attributes of CAVs are related to acceptability and acceptance, and to what extent acceptability and acceptance are related. Specifically, we hypothesised that more positive evaluations of safety, trustworthiness, instrumental, and hedonic attributes would be related to higher acceptability before experiencing a CAV, and to acceptance after experiencing a CAV. To be able to assess acceptance, we conducted a driving simulator experiment (N = 46). This enabled participants to experience a CAV in both a low and high traffic complexity scenario, and we could examine to what extent experiencing a CAV influences the evaluation of CAVs. Our results show that experiencing a CAV can enhance perceived safety and trustworthiness of CAVs. Further, both acceptability and acceptance were higher when the CAV was evaluated more positively on the attributes before and after experiencing a CAV, respectively. Safety attributes were more strongly related to acceptability than acceptance, while hedonic and instrumental attributes were more strongly related to acceptance than acceptability. In contrast to our expectations, traffic complexity did not affect acceptance, perceived safety, or trustworthiness of CAVs after the simulated drive. These results suggest that policies aimed at enhancing safety, driving pleasure, trustworthiness of CAVs, and by ensuring that CAVs are able to meet people's mobility needs could increase both acceptability and acceptance of CAVs.

1. Introduction

Almost a quarter of Europe's greenhouse gas emissions are caused by transportation, and transportation is the main cause of air pollution in European cities (European Commission, 2020). As such, the European Green Deal aims to reduce transport emissions by 90% in 2050. In order to reach this goal, more smart and sustainable options for transportation can be introduced. One potentially sustainable option could be Connected Automated Vehicles (CAVs).

CAVs are entirely automated vehicles that are capable of communicating and sharing data with other devices both inside and outside the vehicles, such as public transport systems and other vehicles (Shladover, 2018). The present research focuses on CAVs that do not require passengers to take over driving (Level 4 – 5 of automation; SAE International, 2021). CAVs may be more sustainable than conventional cars through (1) more fuel-efficient driving than manual cars, (2) their ability to platoon with other CAVs, (3) more effective use of existing road infrastructure, and (4) their potential to be offered as a shared ride service as mobility on demand (see e.g. Gawron et al., 2019; Lu et al., 2019; Ma et al., 2019; Matin & Dia, 2022). Of course, CAVs may be fully electric vehicles that reduce the dependence on fossil fuels and thereby reduce CO_2 emissions. Further, CAVs may potentially be safer than manual vehicles, even at low market penetration rates (Papadoulis et al., 2019), as the computer system driving the vehicle is never tired or intoxicated, and its sensors may be able to detect more than a human's limited field of vision (Storsæter et al., 2021). This safety gain may also lead to less damages, meaning overall less resources may be needed to maintain CAVs compared to manual vehicles.

1.1. Acceptability and acceptance of CAVs

The automotive industry is already investing in developing CAVs (e.g. Arunasalam, 2023). However, CAVs will

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only achieve their potential if they are widely accepted and adopted by the general public. Therefore, we need to understand which factors affect acceptability and acceptance of CAVs, as this provides critical insights in which concerns should be addressed to secure acceptance and the likelihood of adoption of these vehicles. We define acceptability as the a-priori evaluation of CAVs before people have gained any experience with them, reflecting on whether the use of CAVs in general is acceptable. We define acceptance as the evaluation of the use of CAVs, and the intention and individual's willingness to use CAVs after people have experienced them (Schade & Schlag, 2003). We propose that both acceptability and acceptance of CAVs depend on the evaluations of their attributes, which reflect the perceived characteristics of CAVs.

Initial studies on the factors influencing the acceptability of CAVs have shown that acceptability is higher when the evaluations of CAVs' attributes are more positive (e.g. as Post et al., 2024 show for Level 4-5 CAVs). Although some studies have examined which factors affect acceptance of automated vehicles (AVs) in general, less is known on acceptance of CAVs, and factors influencing acceptance. Measuring acceptance is difficult, as CAVs are not on the market yet, meaning no one has had any experience with them. As CAVs are not available on the market yet, we will use a driving simulator to let people experience what driving in a CAV could be like.

In the present paper we focus on how and to what extent the evaluation of safety, instrumental, trust, and hedonic attributes are related to both acceptability and acceptance of CAVs, as the evaluation of these attributes may change after experiencing a CAV (see e.g. Shi et al., 2021). Safety attributes refer to the belief that CAVs are safe, which may be crucial as they take over all driving tasks, and thus CAVs are responsible for the safety of both its occupants and other road users. Indeed, higher perceived safety has been found to be related to a greater acceptability of CAVs (Howard & Dai, 2014; Kacperski et al., 2021 (for Level 5 CAVs)). Instrumental attributes refer to the belief that CAVs will meet people's mobility needs. The less people perceive CAVs as being able to meet their mobility needs, the less likely they are to consider these vehicles as a means of transportation. More positive evaluations of instrumental attributes have indeed been found to increase the acceptability of CAVs (Post et al., 2024 (Level 4-5 CAVs)), as well as a higher intention to use AVs (Benleulmi & Ramdani, 2022 (Level 5)). Trustworthiness attributes refer to the belief that CAVs will behave as intended, and thus can be trusted. Believing CAVs will function properly may reduce perceived risk of driving in a CAV, such as system errors and the potential of CAVs being hacked. Indeed, trustworthiness has been found to be a solid predictor of both acceptability and acceptance of AVs (Choi & Ji, 2015 (Level 4); Xu et al., 2018 (Level 3)). Hedonic attributes refer to the belief that driving in a CAV will be enjoyable. Driving in a CAV may be seen as enjoyable when CAVs perform manoeuvres that drivers sometimes dislike doing themselves, such as reverse parking and driving in traffic jams (Bjørner, 2017 (Level 2, 3, and 4)). Indeed, positive evaluations of hedonic attributes have been linked to more positive emotions towards AVs (Ribeiro et al., 2022), as well as a greater intention to use AVs (Keszey, 2020 (Level 4 and 5); Seuwou et al., 2020).

It is possible that actually experiencing an innovation such as CAVs changes people's perceptions about the vehicles. For example, the evaluation of characteristics of a tool, such as a machine or transporting device can change after people have used it, compared to having only observed the tool (Alexandre et al., 2021). Likewise, after experiencing a very short drive of 200 metres in an AV, participants evaluated the AV as more safe (Shi et al., 2021), and reported higher trust in a shared AV (Farmer et al., 2023) compared to before the drive. Based on this, we expect that experiencing a CAV may influence the evaluation of the attributes of CAVs.

Further, we aimed to examine whether evaluations of the attributes of CAVs influence acceptability and acceptance differently. Evaluations of different attributes may have a stronger relationship with acceptability or acceptance, as acceptability reflects the extent to which the use of CAVs in general is seen as acceptable, and acceptance reflects to what extent people would like to use CAVs themselves. For example, in a study examining people's evaluations of a shared AV before and after experiencing the vehicle, hedonic attributes had a stronger positive influence on acceptability, than on acceptance (Farmer et al., 2023). In particular for CAVs, we will examine to what extent the evaluations of attributes are differently related to acceptability or acceptance of CAVs.

Acceptability and acceptance are likely to be positively related, as both depend on the evaluations of attributes of CAVs. Overall, we expect that acceptability will be higher when the a-priori evaluations of CAVs' attributes are more favourable, and that acceptance will be higher when the a-posteriori evaluations of CAVs' attributes are more favourable. We expect that acceptability may influence acceptance, as they share predictors, and people's initial evaluation of the use of CAVs in general (i.e., acceptability judgement) may function as a first step for acceptance (Alexandre et al., 2018).

1.2. Traffic complexity

Next to the evaluation of CAVs' attributes, contextual factors, such as traffic complexity, may influence acceptance of CAVs. Driving in different contexts, such as in a busy city centre, with greater speed differences and many different types of road users, may lead to more unexpected situations than driving on a highway with less speed differences and fewer types of road users. For example, it is possible people have less trust in a CAV being able to handle more complex and unexpected situations, which may in turn affect acceptance. However, whether and how traffic complexity affects the evaluation of CAVs has not been studied.

Higher traffic complexity is related to increased mental workload for drivers in manual vehicles (Teh et al., 2014; Ünal et al., 2012), and it can increase the attentional processing requirements of driving (Baldwin & Coyne, 2003), especially for less experienced drivers (Patten et al., 2006).

To compensate for this greater workload demand, drivers tend to adjust their behaviour and lower their speed in more complex road environments (De Waard et al., 1995; Oviedo-Trespalacios et al., 2017). Although AVs and CAVs will be able to take over some or all of the driving tasks, this does not necessarily mean the (perceived) workload for its occupants is fully alleviated in complex traffic. For example, drivers in a partially automated vehicle (Level 2) still experienced greater perceived and objective workload in more complex traffic even when using automated driving functionalities (Stapel, Mullakkal-Babu, & Happee, 2018). Perceived workload was lower among experienced users compared to inexperienced users, although objective mental workload was still high for automated driving for both experienced and inexperienced users, especially in more complex traffic. A potential reason for this higher workload in complex traffic may be that the occupants may have lower trust in the vehicle's capabilities to handle more complex traffic situations, compared to less complex traffic situations, or they may believe it is less safe for a CAV to drive in highly complex traffic. In other words, people may more closely observe the vehicle's behaviour, which increases task demands, because they do not fully trust the vehicle to handle the situation correctly and safely. If this is the case, acceptance of CAVs may be lower in more complex traffic compared to less complex traffic.

1.3. Hypotheses

To conclude, we expect that the evaluation of the attributes of CAVs could influence both the acceptability and acceptance of CAVs. Additionally, we expect that traffic complexity as a contextual factor may influence acceptance. Our specific hypotheses are:

> *H1:* Experiencing a CAV can influence the evaluations of the attributes of CAVs.
> *H2:* The evaluations of the attributes of CAVs may be differently related to acceptability versus acceptance of CAVs.
> *H3:* Acceptability is higher when people evaluate the safety, instrumental, trustworthiness, and hedonic attributes of CAVs more positively before experiencing a CAV.
> *H4:* Acceptance is higher when people evaluate the safety, instrumental, trustworthiness, and hedonic attributes of CAVs more positively after experiencing a CAV.
> *H5:* Higher acceptability is related to higher acceptance.
> *H6:* CAVs will be evaluated as less acceptable, safe, and trustworthy when CAVs drive in highly complex traffic compared to less complex traffic.

2. Method

2.1. Participants

To test our hypotheses and to be able to assess acceptance after experiencing CAVs, we let people experience a CAV in a driving simulator experiment in both a low and high traffic complexity context. Participants (N = 52) were recruited via a student participant portal from the University of Groningen. Only students with a valid driving licence were able to sign up for the experiment, and they received course credits as compensation for their time. Ethical approval to conduct the experiment was obtained beforehand from the ethical committee of the psychology department of the University of Groningen.

We had to exclude six participants from the final sample, as they experienced simulator sickness, or as technical issues arose during the experiment. Hence, the final sample consisted of 46 participants, of which 60.9% indicated to be female. The age of participants ranged from 18 to 26 years, with an average of 20.7 (SD = 1.89). About 35% drove at least a couple of times a week, while 26% drove rarely (a couple of times a month or less). Some participants indicated to have driven less than usual in the past months due to COVID-19 lockdowns in the Netherlands, which may have affected their answers about their driving frequency.

2.2. Procedure

First, participants read information about the study and what was expected from them, and then signed an informed consent form. After that, participants were seated in a moving base driving simulator (see Figure 1) and the test leader helped them adjust the seat to a comfortable position. Next, they made a test drive of about 5 minutes in a simulation of a car with automatic shifting where they had to cross several intersections, comply with the traffic rules, and park the car at the end of the simulation. The aim of the test drive was to familiarise participants with the driving simulator, and to check if they experienced symptoms of simulator sickness. If participants experienced sickness, the experiment was ended for them. Once they had completed the test drive, they filled out a simulator sickness scale and questions about their demographics.

Next, participants completed the first questionnaire including a short description of CAVs, and questions aimed to evaluate the safety, hedonic, trustworthiness, and instrumental attributes of CAVs, as well as the acceptability of CAVs. After that, they completed two rides in the driving simulator: one in a low traffic complexity scenario and a high traffic complexity scenario. The scenarios were shown in randomised order. After each scenario participants completed another questionnaire aimed to evaluate the safety, hedonic, trustworthiness, and instrumental attributes of CAVs, as well as acceptance of CAVs. Finally, they were thanked and debriefed.

2.3. Materials

2.3.1. Scenarios

In the low traffic complexity scenario the CAV drove on a highway with little traffic for about four and a half minutes, after which the CAV exited the highway and parked in a parking spot next to the road. The CAV drove at a constant speed of about 100 kilometres per hour, as is the speed limit on the Dutch highway during daytime.

Figure 1. The driving simulator with moving base

In the high traffic complexity scenario the CAV drove in an urban area with mixed traffic for about five minutes. Events that happened during the scenario were green, amber, and red traffic lights, pedestrian crossings, a large roundabout with cars and cyclists, and a priority intersection. The CAV adhered to all traffic rules and speed limits.

2.3.2. Simulator sickness

Participants filled out the standardised Simulator Sickness Questionnaire after the test drive (SSQ; Kennedy et al., 1993). They were asked for 16 possible symptoms of simulator sickness to what extent each symptom was affecting them right at that moment. The answer categories were (1) None, (2) Slight, (3) Moderate, or (4) Severe. The scale showed excellent internal reliability (Cronbach's alpha = 0.86). On average, participants who did not indicate to experience simulator sickness after the test drive scored 1.27 (SD = 0.24) on the SSQ, while participants who did indicate to experience simulator sickness after the test drive scored on average 1.88 (SD = 0.38).

2.3.3. Evaluation of CAV's attributes

Participants evaluated four attributes of CAVs. All items for the evaluation of the four attributes of CAVs were adapted from previous studies (Post et al., 2024). In the questionnaire that participants completed before they had experienced the CAV in the simulator all items were phrased as a conditional progressive tense (i.e. 'A CAV would be safe'), while after they had experienced the CAV the items were phrased in simple present (i.e. 'A CAV is safe'). All items were asked on a 7-point Likert scale ranging from 1 = completely disagree to 7 = completely agree. Means, standard deviations, and Cronbach's alpha of all attributes are reported in Table 1 below.

Hedonic attributes. The scale of hedonic attributes contained three items, namely 'Driving in a manual vehicle would be/is less pleasurable than driving in a CAV', 'Driving in a CAV would be/is pleasurable', and 'Connected automated driving would be/is enjoyable'.

Safety attributes. The evaluation of safety attributes was measured with three items, namely 'A CAV would be/is safe', 'CAV would pose/poses minimal risk to its driver and passengers', and 'CAV would pose/poses minimal risk to other road users'.

Instrumental attributes. Three items measured the evaluation of instrumental attributes, namely 'CAV would meet/meets my driving needs', 'Driving in a CAV would be/is convenient, since it would allow/allows me to spend my time on other things than driving', and 'Driving in a CAV would be/is convenient, since it would make/makes my journeys more efficient'.

Trustworthiness attributes. Trustworthiness attributes were evaluated with three items, namely 'I would trust/trust a CAV to behave as intended', 'I would trust/trust that CAV can correctly detect other road users', and 'I would trust/trust the computer systems of CAV can not get hacked'.

2.3.4. Acceptability and acceptance of CAVs

The items for acceptability and acceptance were based on previous studies (Noppers et al., 2015; Post et al., 2024). The means, standard deviations, and Cronbach's alpha of acceptability and acceptance are reported in Table 1 below.

Acceptability was measured with three items on a 7-point Likert scale ranging from 1 = completely disagree to 7 = completely agree. The items were 'The use of CAV is acceptable', 'It is acceptable that a part of the traffic will consist of CAV', and 'It is acceptable that people will use CAV'. Acceptability was only measured before participants experienced a CAV in the simulator and reflected the acceptability of general use of CAVs. As shown in Table 1, the mean score on acceptability is relatively high (M = 5.46).

Acceptance was also measured with three items that were created for this experiment on the same 7-point Likert scale. The items were 'I intend to travel in a CAV in the future', 'I would consider a CAV when purchasing a (next) car', and 'The prospect of travelling in a CAV appeals to me'. Acceptance was measured after participants experienced a CAV in the simulator and reflected the acceptance related to personal willingness to use CAVs.

3. Results

We first inspected the Pearson correlations between all variables. Correlations between all variables were both positive and significant (see Table 6 in the Appendix). Notably, evaluations of safety and trustworthiness attributes correlated strongly, while evaluations of hedonic attributes correlated strongly with evaluations of instrumental attributes. Despite these strong correlations, there were no signs of multicollinearity (all VIF < 5).

3.1. Effect of experiencing a CAV on the evaluation of attributes

We examined if the evaluation of the attributes changed after experiencing the CAV in the simulator compared to their evaluations before the experience (Hypothesis 1). For the evaluations after experiencing a CAV, we averaged the scores on each attribute across the low and high complex traffic scenarios, as in real life people would most likely ex-

Table 1. Means, standard deviations, and Cronbach's alpha of all scales

	Pre-measure (general)		Low complexity simulated drive		High complexity simulated drive		Post-measure (personal)	
	M/SD	CA	M/SD	CA	M/SD	CA	M/SD	CA
Acceptability	5.46/1.19	.95	–	–	–	–	–	–
Acceptance	–	–	4.43/1.55	.90	4.32/1.64	.91	4.37/1.54	.95
Safety attributes	4.48/1.63	.96	5.16/1.38	.95	5.20/1.26	.94	5.18/1.28	.96
Instrumental attributes	4.73/1.35	.79	4.89/1.57	.87	4.80/1.53	.83	4.84/1.51	.92
Trustworthiness attributes	3.86/1.42	.84	4.28/1.29	.79	4.33/1.25	.79	4.30/1.24	.90
Hedonic attributes	4.14/1.14	.71	3.99/1.33	.82	4.24/1.06	.68	4.12/1.15	.87

M = Mean; *SD* = Standard Deviation; *CA* = Cronbach's Alpha; Post-measure is the average score after experiencing the low and high complexity scenarios combined

Table 2. Comparison of evaluation of CAVs' attributes before and after the experience

Attributes	Mean Diff.	*SE* Mean Diff.	*t*	*df*	*p*	95% *CI* of Diff.
Hedonic	-0.02	0.10	-0.20	45	.845	[-0.22 – 0.18]
Safety	0.47	0.11	4.34	45	<.001***	[0.25 – 0.68]
Trustworthiness	0.29	0.09	3.22	45	.002**	[0.11 – 0.48]
Instrumental	0.07	0.07	1.06	45	.296	[-0.07 – 0.22]

Mean Diff = difference between mean score after and before the experience; ** = significant at the .01 level, *** = significant at the .001 level.

perience both lowly and highly complex traffic while driving in a CAV. We ran paired samples t-tests for hedonic, safety, trustworthiness, and instrumental attributes.[1] Considering a total of four separate tests were run, we applied a Bonferroni-correction and only considered *p*-values below 0.05/4 = 0.0125 as significant effects. For these analyses, we had a power of 0.78 to be able to detect a medium effect of *Cohen's dz* = 0.5 and a power of 0.99 to be able to detect a large effect of *Cohen's dz* = 0.8, both with α = 0.0125, and *N* = 46 with paired samples. Participants evaluated CAVs as more safe and trustworthy after experiencing the CAV. However, the evaluations of instrumental and hedonic attributes did not change after the experience, and the mean differences were very small (see Table 2). The results indicate that Hypothesis 1 is partly supported.

3.2. Relationships between acceptability, acceptance, and the evaluation of attributes of CAVs

We next examined to what extent acceptability is predicted by the evaluation of CAVs' safety, instrumental, trustworthiness, and hedonic attributes before experiencing a CAV (Hypothesis 3). We first inspected the correlations between acceptability and the a-priori evaluations of safety, instrumental, trustworthiness, and hedonic attributes. We had a power of .88 to be able to detect a medium correlation of r = .40 with α = 0.05 and *N* = 46. Supporting Hypothesis 3, all correlations were significant at the .001 level. Acceptability had the strongest relationship with the evaluation of safety attributes (*r* = 0.70), followed by the evaluations of trustworthiness (*r* = 0.64), instrumental (*r* = 0.57), and hedonic attributes (*r* = 0.46).

We then explored which attributes are uniquely related to acceptability by conducting a linear regression analysis, entering the evaluations of CAV's safety, instrumental, trustworthiness, and hedonic attributes before experiencing a CAV as predictors of acceptability. For this analysis, we had a power of 0.48 to be able to detect a medium effect of f^2 = 0.15 and a power of 0.88 to be able to detect a large effect of f^2 = 0.35, both with α = 0.05 and *N* = 46. The linear regression model revealed that the evaluation of the four attributes explained 58.4% of variance in acceptability (*F* (*df* = 4, 41) = 14.38, *p* < .001). Table 3 shows that only the evaluation of safety attributes was uniquely and significantly related to acceptability: more positive evaluations of the safety attributes were associated with higher acceptability of CAVs.

Next, we examined to what extent acceptance is related to the evaluation of CAVs' attributes after experiencing a CAV by inspecting the correlations between acceptance and the averaged a-posteriori evaluations of safety, instrumental, trustworthiness, and hedonic attributes across both

1 The evaluation of safety attributes both before and after the simulated drive was not normally distributed. We repeated all analyses using non-parametric tests, which yielded very similar results. For ease of interpretation we report the parametric tests.

Table 3. Linear regression of acceptability predicted by the a-priori evaluation of CAVs' attributes

Attribute	*B*	*SD*	*t*	*p*	95% *CI* for *B*	η^2
Safety	.31	.10	3.14	.003**	[.11 – .52]	.44
Instrumental	.18	.12	1.57	.125	[-.05 – .41]	.24
Trustworthiness	.17	.12	1.36	.182	[-.08 – .42]	.21
Hedonic	.09	.13	0.71	.484	[-.17 – .35]	.11

** = significant at the .01 level; *B* = unstandardized coefficient.

Table 4. Linear regression of acceptance predicted by the a-posteriori evaluation of CAVs' attributes

Attribute	*B*	*SD*	*t*	*p*	95% *CI* for *B*	η^2
Safety	.01	.13	0.06	.953	[-.26 – .28]	.01
Instrumental	.32	.12	2.62	.012*	[.07 – .57]	.38
Trustworthiness	.30	.14	2.11	.041*	[.01 – .59]	.31
Hedonic	.63	.14	4.36	<.001***	[.34 – .91]	.56

* = significant at the .05 level, *** = significant at the .001 level; *B* = unstandardised coefficient.

scenarios (Hypothesis 4). All correlations were significant at the .001 level. Acceptance had the strongest relationship with the evaluation of hedonic attributes (r = 0.84), followed by the evaluation of instrumental (r = 0.83), trustworthiness (r = 0.69), and safety attributes (r = 0.57). These results support Hypothesis 4.

Again, we explored which attributes uniquely contribute to the explanation of acceptance of CAVs after experiencing a CAV, by conducting a linear regression. For this analysis, we had a power of 0.48 to be able to detect a medium effect of f^2 = 0.15 and a power of 0.88 to be able to detect a large effect of f^2 = 0.35, both with α = 0.05 and N = 46. The linear regression model revealed that the evaluations of the four attributes after participants had experienced a CAV in the simulator explained 82.0% of all variance within acceptance (F (df = 4, 41) = 46.73, p < .001). Table 4 shows that the strongest relationship was between acceptance and the evaluations of hedonic attributes, followed by the evaluations of instrumental and trustworthiness attributes. The evaluation of safety attributes did not significantly contribute to the explanation of acceptance when the other attributes were controlled for. Not surprisingly, the beta coefficients reveal the same pattern as the bivariate correlations.

As noted earlier, the evaluation of safety and trustworthiness attributes correlated strongly both before (r = .67), as well as after (r = .78) the experience of a CAV in the simulator. This could be the reason why only one of them is a significant predictor in the regression models of acceptability and acceptance[2].

Hypothesis 2 stated that the evaluations of the attributes of CAVs may be differently related to acceptability versus acceptance of CAVs. Our results indicate that this is indeed the case. The evaluation of safety of CAVs correlated more strongly with acceptability (r = 0.70), than with acceptance (r = 0.57). In contrast, the evaluation of hedonic and instrumental attributes of CAVs correlated more strongly with acceptance ($r_{hedonic}$ = 0.84; $r_{instrumental}$ = 0.83), than with acceptability ($r_{hedonic}$ = 0.46; $r_{instrumental}$ = 0.57).

Next, we inspected the correlation between acceptability and acceptance. As expected in Hypothesis 5, a high acceptability of the general use of CAVs before experiencing a CAV in the driving simulator was related to a high acceptance of personal willingness to use a CAV after the experience (r = 0.68, p < .001).

3.3. Relationship between traffic complexity, acceptance, and evaluation of attributes

Finally, we tested whether CAVs are less acceptable, safe, and trustworthy when CAVs drive in highly complex traffic compared to less complex traffic (Hypothesis 6). We ran a paired samples t-test to compare acceptance, and the evaluations of the safety and trustworthiness attributes of CAVs after participants had experienced the low and high traffic complexity scenarios. Considering a total of three separate tests were run, we applied a Bonferroni-correction and only considered p-values below 0.05/3 = 0.0167 as significant effects. For this analysis, we had a power of 0.81 to be able to detect a medium effect of *Cohen's dz* = 0.5 and a power of 0.99 to be able to detect a large effect of *Cohen's*

2 If the evaluations of safety and trustworthiness attributes are combined into a single scale, this combined scale is significantly and positively related to both acceptability (B = .50, SD = .11, p = <.001) and acceptance (B = .30, SD = .11, p = .013), when controlling for the effects of the evaluation of hedonic and instrumental attributes. Combining safety and trustworthiness attributes does not influence the significance nor the direction of relationships between the evaluations of instrumental and hedonic attributes, and acceptability and acceptance, respectively.

Table 5. Influence of traffic complexity on acceptance and the evaluation of CAVs' safety and trustworthiness attributes

	Low traffic complexity (*M*/*SD*)	High traffic complexity (*M*/*SD*)	*t*	*p*	*df*
Acceptance	4.43/1.55	4.32/1.64	0.90	.373	45
Trustworthiness attributes	4.28/1.29	4.33/1.25	0.36	.722	45
Safety attributes	5.16/1.38	5.20 1.26	0.54	.593	45

dz = 0.8, both with α = 0.0167, and N = 46 with paired samples. In contrast to our expectations we found no support for Hypothesis 6, as traffic complexity did not influence acceptance, nor the evaluations of safety and trustworthiness attributes of CAVs (refer to Table 5).

4. Discussion

The introduction of CAVs may lead to several benefits, such as increased road safety compared to manual vehicles (Storsæter et al., 2021), and CAVs may be more sustainable than conventional vehicles (Gawron et al., 2019; Lu et al., 2019; Ma et al., 2019; Matin & Dia, 2022). In order for CAVs to be successfully implemented, CAVs need to be accepted by the public, that is, people need to evaluate them positively (i.e., high acceptability) and be willing and likely to use CAVs (i.e. high acceptance). However, research examining which factors influence CAVs' acceptance is scarce, as CAVs are not available yet. In order to assess acceptance we let people experience what driving in a CAV could be like in a driving simulator.

In the present paper we examined if the evaluations of four attributes (i.e. safety, trustworthiness, hedonic, and instrumental) change after experiencing a CAV, compared to before the experience. We also examined whether the evaluations of the four attributes of CAVs may be differently related to acceptability versus acceptance. We expected that acceptability would be higher when people evaluate the attributes more positively before experiencing a CAV, and that acceptance would be higher when people evaluate the attributes more positively after experiencing a CAV. Additionally, we expected that higher acceptability would be related to higher acceptance. Further, we examined whether traffic complexity influences acceptance, and the evaluations of safety and trustworthiness attributes.

First, we found that people evaluated CAVs as more safe and trustworthy after experiencing the CAV in the simulator. This indicates that letting people have (a positive) experience with CAVs may make people feel safer and help build trust in the performance of CAVs. However, people did not evaluate CAVs as more pleasurable to drive or better fitting with their mobility needs after experiencing the CAV in the simulator, compared to before the experience. These findings are partly in line with studies reporting more positive evaluations of AVs in general after participants had experienced AVs (Farmer et al., 2023; Shi et al., 2021). Perhaps the participants did not evaluate CAVs more positively on hedonic and instrumental attributes because we did not manipulate any aspects of the CAV in particular. However, the absence of an accident and the CAV following all traffic rules may have naturally highlighted the CAV's safety and trustworthiness. Future research could examine whether highlighting hedonic or instrumental aspects in the designed scenarios could lead to more positive evaluations of hedonic and instrumental attributes of CAVs after the experience. For example, people have indicated to like the idea that CAVs could performing driving tasks that people tend to dislike doing themselves, such as reverse parking or driving in a traffic jam (Bjørner, 2017). Perhaps a scenario showing a CAV taking over these disliked driving tasks might enhance the evaluation of hedonic attributes.

As expected, we found that more positive evaluations of safety, trustworthiness, instrumental, and hedonic attributes of CAVs were related to higher acceptability of CAVs. The evaluations of safety and trustworthiness attributes had the strongest relationship with acceptability. This indicates that people first and foremost may require CAVs to be safe and trustworthy, before they are introduced on public roads. The strong positive relationship between the perceived safety and acceptability of CAVs is in line with other studies reporting safety and trust as a solid predictor of acceptability of AVs in general (Howard & Dai, 2014; Kacperski et al., 2021). More positive evaluations of instrumental, hedonic, and trustworthiness attributes were also significantly related to higher acceptability of CAVs, in line with earlier online questionnaire studies (Post et al., 2024). However, in the present study the relationships between acceptability and the evaluations of trustworthiness, instrumental, and hedonic attributes were no longer significant when controlling for the evaluations of all attributes. These last results should be interpreted with some caution, as we had a relatively small sample as we conducted a driving simulator experiment, and thus were not able to detect smaller effects in the linear regression.

Acceptance was higher when participants evaluated CAVs' hedonic, instrumental, trustworthiness, and safety attributes more positively after experiencing the CAV. This indicates that CAVs are more likely to be adopted when they offer enjoyable rides, fit with people's driving needs, function properly and trustworthy, and are safe. The evaluations of hedonic and instrumental attributes had the relatively strongest relationship with acceptance. When controlling for evaluations of hedonic, instrumental, and trustworthiness attributes, acceptance was not significantly related to the evaluation of safety attributes. The lack of a unique significant relationship between the perceived safety and acceptance of CAVs may be due to the evaluations of safety and trustworthiness attributes being rather strongly related. Indeed, both safety and trustworthiness attributes were significantly and positively correlated with acceptance. This indicates that participants perceive safety and trustworthiness to be closely related. Future research could shed light on why the evaluation of safety and trustworthiness attributes of CAVs are strongly related, and whether and how they may be disentangled.

Further, evaluations of CAVs' attributes were differently related to acceptability and acceptance. Notably, the evaluation of safety attributes was found to be less strongly related to acceptance than acceptability. On the other hand, the evaluations of hedonic and instrumental attributes were found to be more strongly related to acceptance than acceptability. Our findings may indicate that the pleasure of driving a CAV and the degree to which CAVs can meet one's mobility needs are relatively more important for people personally wanting to use a CAV in the future (acceptance) than for people accepting the use of CAVs in general (acceptability). However, our results are not in line with a study about shared AVs, in which hedonic attributes were measured with a single item. In this study, hedonic attributes had a strong relationship with acceptability, while hedonic attributes had a weaker relationship with acceptance after gaining more experience (Farmer et al., 2023). Possibly, further research could determine if people have a stronger intention to use a private CAV (i.e. acceptance) if they believe driving CAVs is enjoyable, but that they may care less about driving enjoyment of shared CAVs due to having to share or not personally owning the CAV. In other words, future research could shed light on whether the evaluation of hedonic attributes are of lesser importance for acceptance of shared compared to privately owned CAVs.

As expected, acceptability and acceptance were positively related (Schade & Schlag, 2003), indicating that acceptability may function as a first step for acceptance; people's personal acceptance after experiencing the vehicle may be influenced to a degree by the initial evaluation (i.e. acceptability) of the use of CAVs in general (Alexandre et al., 2018), or because acceptability and acceptance share to some extent the same determinants.

Lastly, we found no support for the idea that people would evaluate CAVs more positively and accept CAVs more in relatively low traffic complexity settings, such as on a highway or in a traffic jam, compared to high traffic complexity settings, such as in a busy city centre. Specifically, traffic complexity did not affect acceptance, or the evaluations of safety and trustworthiness attributes. On average, acceptance, safety attributes, and trustworthiness attributes were all evaluated above the midpoint of the scale in both highly and lowly complex traffic scenarios. This indicates that participants were on average positive towards CAVs in both lowly and highly complex traffic scenarios. A possible reason for the lack of significant effect of traffic complexity on safety, trustworthiness, and acceptance may be the high automation level of CAVs. For a partially automated vehicle, it is still possible and needed for the person in the driver's seat to interfere and resume control over the vehicle's behaviour. Therefore, drivers should monitor the vehicle at all times and remain vigilant. However, with a fully automated vehicle like CAV, the occupants no longer can influence the vehicle's behaviour. In this case, they may be less likely to monitor the vehicle to remain vigilant, but instead take an inactive role. Traffic complexity may thus be less important for CAVs, as the occupants are never able to take over control, and their role changes from driver to passenger (SAE International, 2021).

4.1. Strengths & limitations

The present research was conducted using a driving simulator to let participants experience what it could be like driving a CAV, instead of using a real-life vehicle. This setup was required, as CAVs do not exist yet. The setup allowed us to let people experience driving in a CAV, and we could collect data on both acceptability and acceptance, providing us with insights into which factors are important for acceptability and acceptance of CAVs. Additionally, letting people gain experience with CAVs was necessary to assess whether the evaluations of CAVs could change after the experience.

However, the setup also has some limitations. First, it is possible that driving a CAV in real life may be a different experience than driving one in a simulator. Hence, the question remains whether similar effects are observed when people actually use CAVs on public roads. Future research could for example examine whether and how critical events during driving, such as harsh braking, may impact acceptance. Second, with CAVs not being available we also were unable to measure actual adoption as an indicator of acceptance, but could only ask about their willingness to use CAVs. Likewise, we could not examine whether a long-term use of CAVs could have different effects on acceptance; future research is needed to test this. Further research, once CAVs are available, could include actual adoption decisions. Third, we had a relatively small sample due to conducting the experiment in a driving simulator, which is costly and time consuming. As such, we had sufficient power for comparing the mean scores across time and conditions, and to examine the bivariate relationships between variables, but we were not able to identify small to medium effects in our (explorative) regression analyses. Yet, we think that the relatively small sample is not a major problem, as the bivariate correlations between our model variables were comparable to those found in large-scale questionnaire studies on acceptability of CAVs (e.g. Post et al., 2024). Future studies could further examine the unique relationships between the evaluation of the attributes, and acceptability and acceptance by recruiting larger samples. Lastly, the participants were all relatively young with little driving experience, so the question remains whether similar results are found for older adults, for more experienced drivers, and for people with no driving experience. Yet, current young drivers may be the first future adopters of CAVs.

4.2. Practical implications

Our findings indicate that similar strategies may be effective at enhancing acceptability and acceptance of CAVs, with different focus points. For enhancing both acceptability and acceptance of CAVs, improving perceived safety, instrumental, and hedonic attributes of CAVs could be effective. For enhancing acceptability, the focus could particularly be on improving the perceived safety and trustworthiness of CAVs, for example by emphasising the reduction of accidents when CAVs would be on the road, and by providing active protection against hackers to enhance trustworthiness. For acceptance, the focus could be on hedonic and instrumental attributes, by for example offering pleasurable and the most efficient rides, by allowing occupants to spend time on other things than driving, such as entertainment systems. As no differences in acceptance, safety, or trustworthiness of CAVs between low and high traffic complexity were found, this may indicate that the evaluation of CAVs does not depend on the traffic condition. This would also indicate that CAVs could be marketed towards both people who mainly drive in more complex traffic, such as in urban areas, as well as towards people who would mainly use a CAV in less complex traffic, such as on highways and in traffic jams.

Further, allowing people to experience a CAV may help in making them feel safer and help in building trust in the CAV's performance. Our findings show that even a positive experience in a driving simulator may enhance perceived safety and trustworthiness of CAVs.

Negative media attention after an accident may be detrimental for acceptability of CAVs, as evaluations of safety attributes of CAVs before having experience with the vehicles was strongly related to acceptability. Thus, extensive safety tests and addressing any safety issues of the implementation of CAVs on public roads would aid in maintaining acceptability. Additionally, an option would be to allow CAVs on public roads in phases, while monitoring the safety of the vehicles and the public acceptability between phases and making adjustments where needed.

4.3. Conclusion

In conclusion, people evaluated CAVs as more safe and trustworthy after experiencing a CAV compared to before the experience. We found that acceptability was higher when the CAV was perceived as safer, more trustworthy, more fitting with people's mobility needs, and more pleasurable to drive before experiencing the CAV. Likewise, acceptance was higher when hedonic, instrumental, trustworthiness, and safety attributes were evaluated more positively after experiencing the CAV. Further, the evaluation of safety attributes was more strongly related to acceptability than acceptance, while the evaluations of hedonic and instrumental attributes was more strongly related to acceptance than acceptability of CAVs. We found that higher acceptability was related to higher acceptance of CAVs. Traffic complexity did not affect the acceptance of CAVs, nor the evaluation of safety and trustworthiness attributes, suggesting that CAVs may be evaluated similarly in different traffic conditions.

CRediT contribution statement

Jorick M. M. Post: Conceptualization, Methodology, Formal analysis, Investigation, Data Curation, Writing – Original Draft, Writing – Review & Editing, Visualization. **Ayça Berfu Ünal:** Conceptualization, Validation, Writing – Review & Editing, Supervision, Funding acquisition. **Janet L. Veldstra:** Conceptualization, Validation, Writing – Review & Editing, Supervision, Funding acquisition. **Dick de Waard:** Validation, Writing – Review & Editing, Supervision. **Linda Steg:** Validation, Writing – Review & Editing, Supervision.

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Data availability

The data are available on request to the authors.

Declaration of competing interests

The authors report no competing interests.

Ethics statement

The research in the present study have been approved by the ethical committee of the psychology department of the University of Groningen (Decision PSY-1920-S-0524).

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The authors declare that no generative AI was used in this work.

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Appendix A.

Table 6. Pearson correlations between all variables

	1. Acceptability	2. Pre Hedonic	3. Pre Safety	4. Pre Instr.	5. Pre Trust.	6. Low Accept.	7. Low Hedonic	8. Low Safety	9. Low Instr.	10. Low Trust.	11. High Accept.	12. High Hedonic	13. High Safety	14. High Instr.	15. High Trust.	16. Post Accept.	17. Post Hedonic	18. Post Safety	19. Post Instr.	20. Post Trust.
19.																				**.63**
18.																			**.59**	**.78**
17.																		*.40*	**.77**	**.52**
16.																	**.84**	**.57**	**.83**	**.69**
15.																**.66**	**.52**	**.75**	**.60**	**.98**
14.															**.63**	**.80**	**.76**	**.62**	**.97**	**.65**
13.														**.56**	**.78**	**.56**	*.39*	**.96**	**.52**	**.78**
12.													*.44*	**.75**	**.52**	**.81**	**.94**	*.44*	**.74**	**.52**
11.												**.78**	**.62**	**.78**	**.68**	**.97**	**.77**	**.60**	**.79**	**.68**
10.											**.66**	**.49**	**.75**	**.63**	**.91**	**.69**	**.50**	**.78**	**.63**	**.98**
9.										**.61**	**.76**	**.69**	*.45*	**.90**	**.55**	**.82**	**.75**	**.53**	**.97**	**.59**
8.									**.57**	**.75**	**.55**	*.42*	**.87**	**.63**	**.67**	**.54**	*.39*	**.97**	**.62**	**.73**
7.								.33	**.73**	**.47**	**.69**	**.82**	.32	**.71**	*.47*	**.79**	**.97**	.34	**.74**	**.48**
6.							**.84**	**.48**	**.82**	**.67**	**.87**	**.78**	**.47**	**.78**	**.60**	**.97**	**.85**	**.49**	**.82**	**.65**
5.						**.69**	**.51**	*.44*	**.58**	**.74**	**.69**	*.46*	**.48**	**.51**	**.75**	**.71**	**.51**	**.47**	**.59**	**.76**
4.					**.56**	**.76**	**.75**	*.39*	**.87**	*.46*	**.70**	**.64**	.32	**.84**	*.44*	**.75**	**.74**	.37	**.88**	*.46*
3.				**.48**	**.67**	**.55**	*.41*	**.71**	**.50**	**.60**	**.61**	.35	**.73**	**.49**	**.60**	**.60**	*.40*	**.74**	**.50**	**.61**
2.			*.39*	**.52**	**.47**	**.60**	**.56**	*.46*	**.57**	*.39*	**.55**	**.63**	*.40*	**.57**	.36	**.59**	**.61**	*.44*	**.59**	*.38*
1.		**.46**	**.70**	**.57**	**.64**	**.64**	**.53**	**.51**	**.55**	**.54**	**.67**	*.39*	*.43*	**.55**	**.48**	**.68**	**.49**	**.49**	**.56**	**.52**

Pre = measure before experiencing the CAV; Low = measure after experiencing the low traffic complexity scenario; High = measure after experiencing the high traffic complexity scenario; Post = combination of measures after low and high traffic complexity scenarios; Accept. = Acceptance; Instr. = Instrumental; Trust. = Trustworthiness; underlined coefficients are significant at the .05 level; coefficients printed in cursive are significant at the .01 level; coefficients printed in bold are significant at the .001 level.