Deliverable 1.5 First version of mitigation strategies and interventions to effectively stimulate people towards a higher acceptance of CAV

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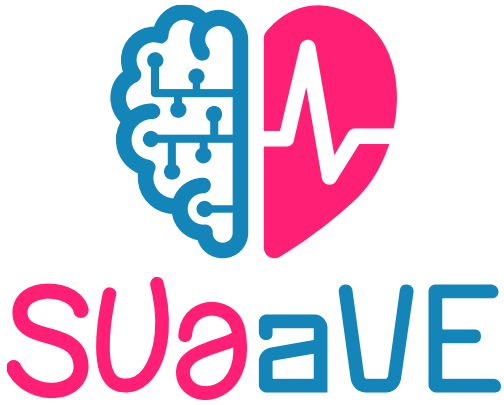

SUpporting acceptance of automated VEhicle

Deliverable 1.5. First version of mitigation strategies and interventions to effectively stimulate people towards a higher acceptance of CAV

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Legal disclaimer

Table of Contents

Terminology and Acronyms

EU	European Commission
D	Deliverable
CAV	Connected Automated Vehicle
M	Mean
SD	Standard Deviation
df	Degrees of Freedom
CI	Confidence Interval
CLT	Construal Level Theory

EXECUTIVE SUMMARY

The present deliverable's objective is to formulate a first version of possible mitigation strategies to enhance the public acceptance of Connected Automated Vehicles (CAV). We first briefly discuss the findings of previous acceptance research within SUaaVE, and the mitigation strategies defined based on these studies (as also discussed in D1.3). Then, we present two new acceptance studies that have not been discussed elsewhere.

One of these recent studies focused on cyclists specifically. In the Large Scale Survey (D1.2) we found that potential users of CAV evaluate it as more acceptable if they believe CAV is environmentally sustainable. We investigated whether environmental sustainability of CAV is also important for cyclists interacting with CAV. Additionally, we investigated if showing CAV as environmentally friendly could elicit a halo effect, making CAV seem more safe and trustworthy. We manipulated the environmental sustainability of CAV by adding a sustainability logo (of which the effectiveness was pilot tested beforehand). Adding a sustainability logo to CAV did elicit a small halo effect as trust in CAV technology was slightly higher for CAV with a logo compared to without a logo. We additionally found trends that CAV with a logo was rated higher on acceptability and perceived safety, although these results were non-significant. We did find that cyclists who rated CAV as more environmentally friendly also rated CAV as more acceptable, safer, and trustworthy. It is possible a stronger induction of environmental sustainability may also lead to a stronger halo effect.

The second new study focused on anthropomorphism. We investigated whether presenting a CAV in a more human-like manner (referred to as ALFRED from now on) compared to presenting a CAV in a regular, more machine-like manner would increase the acceptability of ALFRED and would make participants view ALFRED's perceived characteristics more positively. Additionally, we tested if these effects were stronger for people scoring high on need for control. As expected, we found that anthropomorphising CAV as ALFRED increased perceived status-enhancement, environmental sustainability, and trust in the vehicle's technology, compared to a machine-like CAV. Additionally, we found that participants who had a greater tendency to anthropomorphise the vehicle also rated the vehicle as more acceptable. Lastly, participants scoring high on need for control rated the vehicle as more acceptable, safer, pleasurable, convenient, and environmentally friendly if the vehicle was rated high on anthropomorphism. These results show that anthropomorphising CAV may have positive effects on how the vehicle is perceived, especially among people with a high need for control. It is possible a stronger manipulation instead of a textual one (for example through giving CAV a human voice, using an anthropomorphised icon or mascot for CAV, etc.) may elicit stronger positive effects.

Based on these two new acceptance studies we formulate additional potential mitigation strategies to enhance public acceptance of CAV. We conclude that several options to enhance acceptance of CAV exist.

1. INTRODUCTION AND OBJECTIVES

One of the general goals of SUaaVE is to enhance public acceptance of connected automated vehicles (CAVs) within the EU.

In work package 1, we examine the acceptance of connected automated vehicles (CAV) among potential users as well as other road users. Several studies and experiments have been conducted to determine which factors influence the acceptability and acceptance of CAV (see Deliverables 1.2, 1.3, and 6.3). The final task of work package 1, Task 1.3, is to design strategies and interventions to promote public acceptability of CAV.

The key objective of the present deliverable is to define the first version of mitigation strategies and interventions to effectively stimulate people towards a higher acceptance of CAV.

We will draw on the results of acceptance research done within SUaaVE to define these mitigation strategies and interventions. First, we will provide an overview of the acceptance research done within SUaaVE, as well as the acceptance research that will be conducted later. Then, we will report the results of the WP1 acceptance research that has not been reported in other deliverables. Based on these results we will provide suggestions for mitigation strategies and interventions that can enhance acceptance of CAV.

2. PREVIOUS ACCEPTANCE RESEARCH WITHIN SUAAVE

The suggestions for mitigation strategies and interventions to enhance acceptance of CAV that we will make at the end of this deliverable will be based on the acceptance research conducted within SUaaVE. The following studies and experiments included / will include measures of acceptance:

- Focus Groups (full report in D1.2)
- Large Scale Survey (full report in D1.2)
- First Loop Driving Simulator Experiments (full report in D6.3)
- Scenario Study with Cyclists (full report in present deliverable)
- Anthropomorphism Study (full report in present deliverable)
- Wizard of Oz On-Road Experiment (full report in later deliverable)
- Second Loop Driving Simulator Experiments (full report in later deliverable)

2.1. Acceptance requirements

In D1.3 we formulated acceptance requirements for ALFRED / CAV based on the Focus Groups, Large Scale Survey, and First Loop Experiments. We also reported the pilot of the Scenario Study with Cyclists. As can be seen in Table 1, our data revealed many useful insights that could be employed to increase acceptance of CAV, such as making the CAV interface more user-friendly or making the driving experience of CAV pleasurable. In the following sections we will report the findings from the recent Scenario Study with Cyclists (section 3), and the Anthropomorphism Study (section 4). In section 5 we will add suggestions for mitigation strategies to enhance acceptance of CAV based on these two recent studies.

Table 1. Acceptance requirements shown in D1.3.

Acceptance requirements
Focus on increasing perceived safety, perceived convenience, and perceived environmental sustainability.
CAV needs a user-friendly interface.
Make CAV drive electrically, or show how fuel- efficiently CAV drives.
Present CAV as a luxurious status product at deployment.
Allow users to personalize CAV's driving style (for example sporty or cautious).
Make CAV appealing for all types of users, including vulnerable road users, by giving the option to increase the font size on the display, or have a spoken menu.
Let potential users experience CAV to increase perceived safety and trust in the vehicle's technology.
Demonstrate CAV in a complex traffic environment first (instead of a low traffic complexity environment) in order to increase perceived pleasure.
Make the driving experience of CAV pleasurable to enhance acceptance.
CAV should avoid crashes or damage (even minor) at all costs.
The first experience with CAV should be positive at all costs.
CAV should have medium to low speed and acceleration levels, and should not have a fast vehicle motion.
CAV may not need to take cultural differences into account for acceptance.

3. SCENARIO STUDY WITH CYCLISTS

In the Large Scale Survey we found that perceived environmental sustainability was one of the three strongest predictors of acceptability of CAV. However, the Large Scale Survey contained data from mostly drivers (92.6%). Potential users of CAV may experience benefits of green consumption, by for example affirming their sense of self-identity when using or buying CAV (Peattie, 2010). We wanted to know if perceived environmental sustainability of CAV is important for the evaluation of CAV by other road users too, even though they do not receive any direct benefit from interacting with an environmentally friendly CAV. Moreover, we wanted to know if a halo effect can be triggered if CAV is presented as a sustainable vehicle. A halo effect is the tendency of not being able to evaluate separate aspects of an entity without being influenced by other aspects of the entity (Thorndike, 1920). This means that positive evaluations on an aspect can unconsciously lead to positive evaluations of other aspects (Nisbett & Wilson, 1977; Lachman & Bass, 1985). Following from this reasoning, we expected that if CAV is presented as a sustainable vehicle, CAV may also be perceived as safer, and may elicit a greater trust in CAV technology. We also expected that if CAV is presented as a sustainable electric vehicle (compared to a fossil fuel vehicle), the acceptability of CAV will be higher for cyclists. Lastly, we expected that the effect of environmental sustainability on acceptability of CAV is stronger for cyclists who hold stronger biospheric values, meaning those who have a key concern to protect the environment. Values are guiding principles in life that can affect beliefs, attitudes, and behaviours, and can colour perceptions and cognitions (Schwartz, 1992). As we have shown in prior deliverables, people's values could also affect their acceptability judgements of CAV. As shown in D1.2, biospheric values are related to giving greater importance to environmental sustainability. Therefore, in the present study we expected that the effect of perceived environmental sustainability of CAV on acceptability is stronger for cyclists who hold stronger biospheric values.

Earlier research on manual vehicles found that just a vehicle's appearance could already evoke beliefs about the characteristics of the car (Davies, 2009). In the present study we manipulated the appearance of the vehicle by adding a sustainability logo (see Figure 1) to elicit the belief that CAV is environmentally sustainable. We tested the following hypotheses:

- H1: CAV with a sustainability logo is seen as more acceptable, safer, and will elicit a higher trust in CAV technology than CAV without a sustainability logo.
- H2: Higher perceived environmental sustainability of CAV is related to a higher acceptability, perceived safety, and trust in CAV technology.
- H3: The effects of perceived environmental sustainability on acceptability, perceived safety, and trust in CAV technology is stronger for people scoring high on biospheric values.

We first conducted a pilot test to ensure the manipulation of the logo would work correctly in the main experiment.

3.1. Pilot test

The goal of the pilot test was (1) to select a logo that worked best in signalling the car was environmentally friendly, (2) to check if participants understood they had to take the perspective of a cyclist, and (3) to check if participants understood which car was a traditional manual car and which was a CAV. The full report of the pilot test is available in D1.3. We found that a sustainability logo with a leaf and electric plug worked best in making participants believe the car drove electrically and was environmentally friendly. Nearly all participants understood they had to take the perspective of a cyclist. Participants were also generally able to tell which car was a traditional car and which car was a CAV.

3.2. Main study method

Ethical approval to conduct the study (both the pilot and main experiment) was obtained beforehand from the ethical committee of the psychology department of the University of Groningen. The study was conducted as an online questionnaire. Participants received course credits for their participation. First, participants read the information form and gave informed consent. Then participants filled out a scale assessing their values (egoistic, altruistic, hedonic, and biospheric), ranging from -1 (opposed to their personal values) to 7 (most important to their personal values). Afterwards, participants read a short neutral description of CAV (the same was used in the Focus Groups, Large Scale Survey, and First Loop Driving Simulator Experiments). After that, they were shown four pictures in random order of an intersection with a car coming from the right (see Figure 1). The car was either a traditional car or a CAV (indicated by a sensor on the hood), and the car either had a sustainability logo or not. The participant took the perspective of a cyclist. After looking at each picture, the participant answered some questions about the car assessing acceptability, perceived safety, trust in the car's technology, and perceived environmental sustainability, all on a 7-point Likert scale ranging from 1 (very low) to 7 (very high). After rating the cars in each picture, the participants also answered some questions regarding their demographics. Finally, they were thanked and debriefed, and had the opportunity to leave comments.

Figure 1. Pictures used in the study.

Note. Participants saw larger versions. The top row is the traditional car, the bottom row is CAV.

3.3. Sample

Participants were recruited via the participant platform for first-year Psychology students at the University of Groningen. In total 117 complete responses were recorded. Two participants who indicated they answered the questions from the viewpoint of a pedestrian instead of a cyclist were excluded from the sample. The final sample consisted of 115 participants.

The majority of the participants was female (68.7%), with a mean age of 20 (SD = 1.86, range = 18 to 28). Most participants were from the Netherlands (86.1%), followed by Germany (10.4%), Ireland (1.7%), or a different country (1.8%). Over half of the participants held a valid driving license (56.5%), while 13% was currently taking driving lessons, and the remaining 30.5% had no driving experience at all. On average, participants cycled 2 to 5 times a week (range = almost every day to less than once a month). Some participants left comments that their current cycling frequency was lower than usual due to the COVID-19 lockdown in the Netherlands.

3.4. Results

We first inspected the data by examining the descriptives, the reliability of the scales, and the effectiveness of the manipulation.

3.4.1. Descriptives

Below are the means, standard deviations, and the ranges of all scales. A higher score indicates a more positive view of the vehicle or a stronger value.

Table 2. Descriptives of scales for the scenario study with cyclists.

Scale	M	SD	Range
Acceptability CAV	4.15	1.45	1.0 – 7.0
Acceptability traditional car	4.93	1.13	1.0 – 7.0
Perceived safety CAV	4.56	1.28	1.0 – 7.0
Perceived safety traditional car	5.10	1.04	1.5 – 7.0
Perceived environmental sustainability CAV	4.55	1.18	1.0 – 7.0
Perceived environmental sustainability traditional car	3.60	1.07	1.0 – 6.0
Trust in CAV technology	4.21	1.28	1.0 – 6.8
Biospheric values	6.63	1.54	2.5 – 9.0
Altruistic values	7.17	1.29	3.0 – 9.0
Egoistic values	4.84	1.21	2.2 – 8.8
Hedonic values	7.29	1.33	3.7 – 9.0

3.4.1.1. Reliability of scales

To test the internal reliability of the scales, we calculated Cronbach's Alpha, as reported in Table 3 below. Although all scales showed sufficient internal reliability, several participants left comments that they had misunderstood one of the acceptability items. This item showed lower inter-item correlations within the acceptability scales than the other items. We decided to exclude the misunderstood item. The acceptability of CAV scale now has two items, with Cronbach's Alpha = 0.887, and the acceptability of the traditional car scale now also has two items, with Cronbach's Alpha = 0.770.

Table 3. Reliability of scales scenario for the study with cyclists.

Scale	Cronbach's Alpha	Number of items
Acceptability CAV	.817	3
Acceptability traditional car	.693	3
Perceived safety CAV	.943	3
Perceived safety traditional car	.921	3
Perceived environmental sustainability CAV	.890	3
Perceived environmental sustainability traditional car	.725	4
Trust in CAV technology	.901	3
Biospheric values	.920	4
Altruistic values	.794	4
Egoistic values	.716	5
Hedonic values	.871	3

3.4.1.2. Manipulation effectiveness

Although the pilot test showed the manipulation should be effective, we checked this again in the main experiment to be certain. We performed paired samples t-tests comparing the perceived environmental sustainability of CAV with and without a logo, and of the traditional car with and without a logo. CAV with the logo scored on average 0.54 points higher on perceived environmental sustainability than CAV without logo ($t (df = 114) = 4.18$, $p < .001$). The traditional car with the logo also scored on average 1.10 points higher on perceived environmental sustainability than the traditional car without the logo ($t (df = 114) = 6.99$, $p < .001$). The manipulation was effective.

3.4.2. Effect of car type (CAV vs. traditional)

First, we investigated what cyclists thought of CAV compared to a traditional vehicle. We combined the scores of CAV with and without a logo, as well as the scores of the traditional car with and without a logo. Then we performed paired samples t-tests to compare CAV and the traditional car on acceptance, perceived safety, and perceived environmental sustainability. The full results are reported in Table 4 below. CAV was rated significantly lower on acceptability and perceived safety than a traditional car, but CAV was also rated significantly higher on perceived environmental sustainability. Please refer to Figure 2 in section 3.5.3 for a visual representation.

Table 4. Paired samples t-tests of differences in acceptance, perceived safety, and perceived environmental sustainability between CAV and a traditional car.

Dependent variable	CAV M	Traditional car M	SD	t	df	p
Acceptability	4.15	4.93	1.32	-6.34	114	< .001***
Perceived safety	4.56	5.10	1.32	-4.43	114	< .001***
Perceived environmental sustainability	4.55	3.60	1.48	6.89	114	< .001***

Note. *** = significant at the .001 level.

3.4.3. Effect of sustainability logo

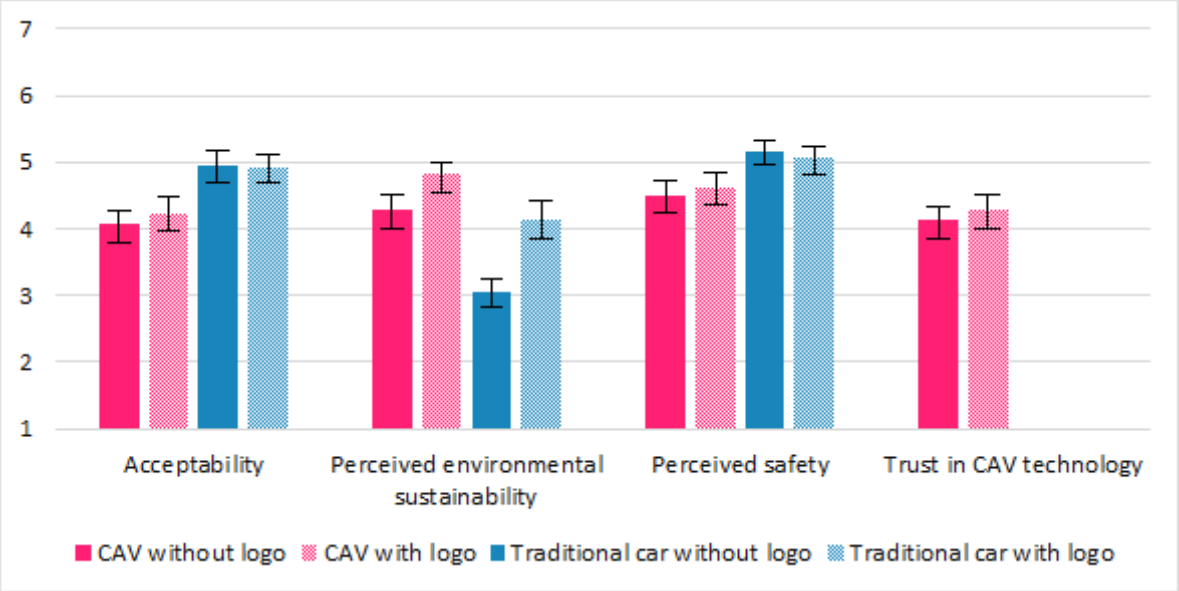
We hypothesized that cars with a sustainability logo would be viewed more positively (more acceptable, safer, and trustworthy) than cars without such a logo. To assess this, we performed several paired sample t-tests. We compared CAV with a logo versus no logo and a traditional car with a logo versus no logo on their acceptance, perceived safety, and trust. The full results are reported in Table 5 below. CAV with a logo was significantly rated more positively on trustworthiness than CAV without a logo. We also found trends, although non-significant, of CAV with a logo being rated as more acceptable and safer than CAV without a logo. No differences were found between the traditional car with and without a logo. Please refer to Figure 2 below for a visual representation.

Table 5. Paired samples t-tests of differences in acceptance, perceived safety, and trust in CAV technology based on the presence of a logo.

Dependent variable	Without logo M	With logo M	SD	t	df	p
Acceptability CAV	4.08	4.23	0.08	1.76	114	.081
Perceived safety CAV	4.49	4.62	0.07	1.74	114	.085
Trust in CAV technology	4.14	4.28	0.07	2.07	114	.041*
Acceptability traditional car	4.96	4.91	0.08	-0.60	114	.549
Perceived safety traditional car	5.15	5.06	0.07	-1.41	114	.161

Note. * = significant at the .05 level.

Figure 2. Comparison of CAV and the traditional car with and without the sustainability logo.



Note. 1 = a very negative evaluation, 7 = a very positive evaluation. Error bars display 95% confidence intervals.

3.4.4. Effects of perceived environmental sustainability

Aside from the effect of the sustainability logo, we also examined if in general a higher perceived environmental sustainability of CAV was related to greater acceptability, perceived safety, and trust in CAV technology. We ran three separate linear regressions in which perceived environmental sustainability of CAV was always the predictor, and acceptability, perceived safety, and trust in CAV technology were the outcome variables respectively. The full results are reported in Table 6 below. When CAV was rated higher on perceived environmental sustainability, CAV was also seen as significantly more acceptable, safer, and trustworthy.

Table 6. Regression analyses of the effect of perceived environmental sustainability of CAV on its acceptability, perceived safety, and trust in CAV technology.

Dependent variable	B	SD	t	df	p	R^2
Acceptability CAV	0.38	0.11	3.42	1, 113	.001***	.094
Perceived safety CAV	0.35	0.10	3.59	1, 113	< .001***	.102
Trust in CAV technology	0.29	0.10	3.00	1, 113	.003**	.074

Note. ** = significant at the .01 level, *** = significant at the .001 level.

3.4.5. Moderation effects of biospheric values

In the Large Scale Survey (D1.2) we found that for potential users of CAV, the effect of perceived environmental sustainability on the acceptability of CAV was influenced by biospheric values. People who scored high on biospheric values thought CAV was acceptable if they also thought CAV was environmentally friendly. We examined if the same interaction effect is at play for other road users. To test this, we ran several regression analyses in which acceptability, perceived safety, and trust in CAV technology were the outcome variables, and perceived environmental sustainability, biospheric values, and the interaction between those two were the predictors. None of the interaction effects were significant, indicating

biospheric values are not a moderator among other road users. The full results are reported in Table 7 below.

Table 7. Regression analyses of the interaction effect of biospheric values on the effect of perceived environmental sustainability on acceptability, perceived safety, and trust in CAV technology.

Dependent variable	Predictor	B	t	p	R^2 full model	R^2 interaction only
Acceptability	Perceived environmental sustainability	0.40	0.85	.399	.097	.00
	Biospheric values	-0.04	-0.11	.909		
	Interaction	-0.01	-0.07	.946		
Perceived safety	Perceived environmental sustainability	-0.13	-0.32	.748	.128	.011
	Biospheric values	-0.41	-1.50	.137		
	Interaction	0.07	1.18	.241		
Trust in CAV technology	Perceived environmental sustainability	0.04	0.09	.929	.087	.003
	Biospheric values	-0.25	-0.89	.374		
	Interaction	0.04	0.61	.542		

3.5. Conclusion

The results show that a traditional manual car is seen as safer and more trustworthy than CAV, but also as less environmentally friendly. Adding a sustainability logo to CAV, to manipulate the perceived environmental sustainability, did elicit a small halo effect as trust in CAV technology was slightly higher for CAV with a logo compared to without a logo. The data further revealed trends that CAV with a logo was rated higher on acceptability and perceived safety, although these results were non-significant. We did find that participants who rated CAV as more environmentally friendly also rated CAV as more acceptable, safer, and trustworthy. It is possible a stronger induction of environmental sustainability (for example through marketing, describing the fuel efficiency of CAV, etc.) may lead to a stronger halo effect. Unlike for potential users, the effect of perceived environmental sustainability on acceptability of CAV was for other road users not stronger among participants scoring high on biospheric values.

4. ANTHROPOMORPHISM STUDY

The goal of the Anthropomorphism Study was to determine whether anthropomorphism could increase acceptability of CAV, and could make people view CAV more positively.

Anthropomorphism is perceiving human-like characteristics in something that is not human, such as pets, gadgets, or religious agents (Epley et al., 2008[1]). It is a widespread phenomenon, which can be found in art, philosophy, science, and religion (Guthrie, 1993). Whether or not a person anthropomorphizes an agent can affect their behaviour towards the agent (e.g. Puzakova et al., 2013). An anthropomorphized appearance also affects our perception of an agent. Robots that have a human-like appearance are ascribed greater agency (the capacity to act, plan, and to do) and greater experience (the capacity to feel and sense) than robots with a mechanical-like appearance (Gray & Wegner, 2012). Epley et al. (2008)[1] proposed that two motivational factors, sociality and effectance motivation, are important determinants of anthropomorphism.

The first motivation, sociality, is the fundamental need for social connection with other human beings. If a social connection with humans is lacking, people may compensate for this lack through anthropomorphism. Indeed, people who feel momentarily or chronically lonely tend to anthropomorphize more than those who are socially connected to other humans (Epley et al., 2008[1]; Epley et al. 2008[2]). The second motivation, effectance, is a need to understand, predict, and control a nonhuman agent by explaining the agent's behaviour using the concept of "human" or the self as a knowledge structure. Those who have a high need for control (Burger & Cooper, 1979) tend to anthropomorphize more, as anthropomorphism can provide a knowledge structure to understand a nonhuman agent (Epley et al., 2008[2]). Anthropomorphizing a nonhuman agent can make it more predictable and understandable, which suggests that anthropomorphism can indeed satisfy an effectance motivation (Waytz et al., 2010). Adding more anthropomorphic elements to an autonomous car has been found to increase trust in the car, most likely because people saw the anthropomorphized autonomous car as more predictable and understandable (Waytz et al., 2014).

People may already be inclined to anthropomorphize CAV and ALFRED to some degree as (1) CAV can plan the most optimal route (agency), (2) ALFRED can detect the passengers' emotional state and respond to that (experience), and (3) ALFRED is a human name. We wanted to test if anthropomorphism could have a positive effect on how people view CAV in general and ALFRED specifically. In the present study, we wanted to increase the degree to which people anthropomorphized ALFRED by describing its functions in a more human-like manner (compared to a more machine-like CAV). We did this to test several hypotheses:

- H1: A more human-like ALFRED is seen as more acceptable, and rated higher on perceived characteristics than a more machine-like CAV.
- H2: People with a greater tendency to anthropomorphize see CAV or ALFRED as more acceptable, and rate its perceived characteristics more positively than people with a lower tendency to anthropomorphize.
- H3: The effects of anthropomorphism on acceptability and the perceived characteristics of CAV or ALFRED is stronger for people with a high need for control.

In addition to these hypotheses regarding anthropomorphism, we also investigated the possible effect of psychological distance as described in Construal Level Theory (CLT). Construal Level Theory posits that the psychological distance that people experience to objects or events can influence their evaluations of those objects or events (Trope & Liberman, 2010). For example, when diffusion of an innovation such as CAV is further away from the self in the more distant future, one can evaluate it more positively than when the diffusion of the innovation is closer by.

Research has shown that desirability concerns receive greater weight over feasibility concerns as psychological distances increases (Liberman et al., 2007). In terms of CAV, desirability concerns may be the concerns related to the value of CAV for personal use and the benefits of CAV, while feasibility concerns may be the concerns related to the existence of a legal framework to use CAV or the availability of technology to function properly. In other words, people who believe CAV is more psychologically distant may put greater value on the desirability of CAV, while people who believe CAV is psychologically closer may put greater value on the feasibility of CAV. As we have seen in the Large Scale Survey (D1.2), people generally evaluate the desirability of CAV (in other words the perceived characteristics of CAV) slightly positively, while the Focus Groups (D1.2) show that people are worried about the feasibility of CAV (absence of a legal framework, the infrastructural changes required for CAV, etc.). In the present study we wanted to investigate if people who believe CAV is psychologically further away rate CAV as more acceptable (as CAV's desirability is rated positively) than people who believe CAV is psychologically closer to them (as CAV's feasibility at present is likely rated negatively). We included this as the last hypothesis.

- H4: As psychological distance towards CAV increases, CAV is rated higher on acceptability.

4.1. Method

Ethical approval to conduct the study was obtained beforehand from the ethical committee of the psychology department of the University of Groningen. The study was conducted as an online questionnaire on the international participant platform MTurk. Participants first read the information form and provided informed consent. Then they were randomly assigned to one of two conditions: CAV or ALFRED. Participants in the CAV condition read a description about CAV's functions, written in a way that emphasized CAV is a machine. Participants in the ALFRED condition read about ALFRED's functions (which were the same as CAV's functions), except it was written in a way that emphasized that ALFRED is human-like. The used descriptions of CAV and ALFRED in the study can be found in the Appendix (section 9). Participants then answered questions about CAV or ALFRED assessing anthropomorphism, acceptability, perceived safety, control, pleasure, convenience, status-enhancement, environmental sustainability, and their trust in the vehicle's technology. Lastly, participants answered questions regarding their demographics, their need for control, and how many years they expected it would take until CAV or ALFRED would be available on the market (psychological distance). After finishing the questionnaire, participants were thanked and debriefed. As compensation for their participation, participants received $1.50 (only if the quality of their provided data was good).

4.2. Sample

We used several participation criteria to filter which participants could enter the questionnaire: (1) participants had to have completed at least 100 other tasks on MTurk, (2) participants had to have an approval rate of at least 90%, and (3) participants must speak and understand English. We also used several criteria to filter out data of poor quality, namely we filtered out (1) participants who answered less than 80% of the questions, (2) participants who took less than 10 seconds to read the description of CAV or ALFRED, (3) participants who completed the entire questionnaire in less than 1 minute, (4) participants who failed the attention check, and (5) participants who wrote answers in open-ended questions that were not related to the question.

The final sample consisted of 105 participants. The mean age was 36 (SD = 11.51, range = 20 to 72). Although we did not use gender criteria, the majority of participants was male (67.6%), and most participants had a valid driving license (94.3%). The majority of the participants lived in the United States (62.9%), followed by India (17.1%), Brazil (8.6%), Italy (4.8%), the United Kingdom (3.8%), or lived in another country (3.0%). Participants were randomly and

evenly spread over the conditions, with 53 participants in the CAV condition and 52 participants in the ALFRED condition.

4.3. Results

We first inspected the data by examining the descriptives, calculating the internal reliability of the scales, and checking the effectiveness of the manipulation.

4.3.1. Descriptives

All items were measured on a scale from 1 (strongly disagree) to 7 (strongly agree), except for the expected number of years until the vehicle will be on the market. This item was asked on a scale from 0 (within 1 year) to 100 (100 years or longer), or participants could check a box that the vehicle would never be on the market. The means, standard deviations, and ranges of all scales are reported in Table 8 below.

Table 8. Descriptives in the anthropomorphism study.

Scale	M	SD	Range
Anthropomorphism	3.90	1.92	1.00 – 7.00
Acceptability	5.57	1.36	1.40 – 7.00
Perceived safety	5.04	1.13	1.00 – 7.00
Perceived control	2.97	1.41	1.00 – 6.50
Perceived pleasure	4.85	1.35	1.00 – 7.00
Perceived convenience	5.65	1.12	1.00 – 7.00
Trust in the vehicle's technology	5.08	1.33	1.00 – 7.00
Perceived status-enhancement	4.55	1.57	1.00 – 7.00
Perceived environmental sustainability	5.12	1.24	1.00 – 7.00
Need for control	5.94	0.85	3.00 – 7.00
Expected number of years until vehicle will be on the market	17.56 (median = 10.00)	21.20	0.80 – 94.20

4.3.1.1. Reliability of scales

To examine the internal reliability of the scales, we calculated Cronbach's Alpha. The scores are listed in Table 9 below. The internal reliability of the perceived control and need for control scales were below the preferred .6, and thus could be unreliable. Moreover, we found that in both these scales one item correlated poorly with the other two items (Pearson's r below .2). We decided to delete these poorly correlating items from the scales. The internal validity of the perceived control scale with the remaining two items was .781, and the internal validity of need for control scale with two items was .671.

Table 9. Reliability of scales in the anthropomorphism study.

Scale	Cronbach's Alpha	Number of items
Anthropomorphism	.944	5
Acceptability	.950	5
Perceived safety	.620	3
Perceived control	.575	3
Perceived pleasure	.780	3
Perceived convenience	.871	3
Trust in the vehicle's technology	.797	3
Perceived status-enhancement	.875	3
Perceived environmental sustainability	.910	3
Need for control	.383	3

4.3.1.2. Manipulation effectiveness

We compared the scores on anthropomorphism between participants who read about CAV and who read about ALFRED. On average, participants who read about ALFRED scored 0.42 points (SD = 0.37) higher on anthropomorphism on a scale from 1 to 7, compared to participants who read about CAV. The manipulation was effective.

4.3.2. Effects of car type (CAV vs. ALFRED)

In order to examine if the anthropomorphised ALFRED scored higher on acceptability and the perceived characteristics than the machine-like CAV, we ran several regression analyses. As the outcome variable we entered acceptability and the perceived characteristics, and as predictor we entered the vehicle type (CAV or ALFRED). The full results of these analyses are reported in Table 10 below.

Table 10. Regression analyses of car type on acceptability and perceived characteristics.

Dependent variable	CAV M	ALFRED M	SD	t	df	p	R^2
Acceptability	5.36	5.79	0.26	1.64	1, 103	.105	.025
Perceived safety	4.95	5.14	0.22	0.86	1, 103	.390	.007
Perceived control	3.03	2.91	0.28	-0.42	1, 103	.678	.002
Perceived pleasure	4.79	4.91	0.27	0.47	1, 103	.641	.002
Perceived convenience	5.57	5.74	0.22	0.81	1, 103	.421	.006
Trust in the vehicle's technology	4.79	5.38	0.25	2.31	1, 103	.023*	.049
Perceived status-enhancement	4.06	5.05	0.29	3.40	1, 103	.001***	.092
Perceived environmental sustainability	4.86	5.39	0.24	2.20	1, 103	.030*	.045

Note. * = significant at the .05 level, *** = significant at the .001 level.

Participants rated ALFRED significantly higher on trust in its technology, perceived status-enhancement, and perceived environmental sustainability compared to CAV. These results

show that anthropomorphizing ALFRED has a positive effect on how the vehicle is perceived. In this study we used a textual description of CAV and ALFRED. A visibly more anthropomorphized ALFRED may potentially lead to a stronger effect.

4.3.3. Effects of general tendency to anthropomorphise

Some people have a stronger tendency to anthropomorphise than others (as a personality trait). We wanted to examine if people with a stronger tendency to anthropomorphise the vehicle were also more positive towards the vehicle in general. We ran several regression analyses to investigate this. As the dependent variable we again entered acceptability and the perceived characteristics, and as the predictor we entered the participants' score on anthropomorphism. The full results are reported in Table 11 below.

Table 21. Regression analyses of anthropomorphism scores on acceptability and perceived characteristics.

Dependent variable	B	SD	t	df	p	R^2
Acceptability	.18	.07	2.63	1, 103	.010**	.063
Perceived safety	.07	.06	1.28	1, 103	.204	.016
Perceived control	-.12	.07	-1.71	1, 103	.090	.028
Perceived pleasure	.13	.07	1.91	1, 103	.059	.034
Perceived convenience	.12	.06	2.10	1, 103	.038*	.041
Trust in the vehicle's technology	.25	.06	4.00	1, 103	<.001***	.134
Perceived status-enhancement	.45	.07	6.60	1, 103	<.001***	.297
Perceived environmental sustainability	.33	.05	6.11	1, 103	<.001***	.266

Note. * = significant at the .05 level, ** = significant at the .01 level.

As can be seen in Table 11, participants with a stronger tendency to anthropomorphise rated the vehicle significantly higher on acceptability, perceived convenience, status-enhancement, and environmental sustainability, and had significantly higher trust in the vehicle's technology.

4.3.4. Moderation effects of need for control

Previous research indicated that for persons with a high need for control, effects of anthropomorphism might be stronger. We checked for this interaction effect by running several two-step regression analyses. As a dependent variable we entered acceptability and the above described perceived characteristics. As predictors we entered in the first step need for control and anthropomorphism scores. In the second step we added the interaction between need for control and anthropomorphism. This way we could check if the interaction significantly explained more variance than just the main effects of need for control and anthropomorphism. First, the results of the full models with the interaction included are reported in Table 12 below.

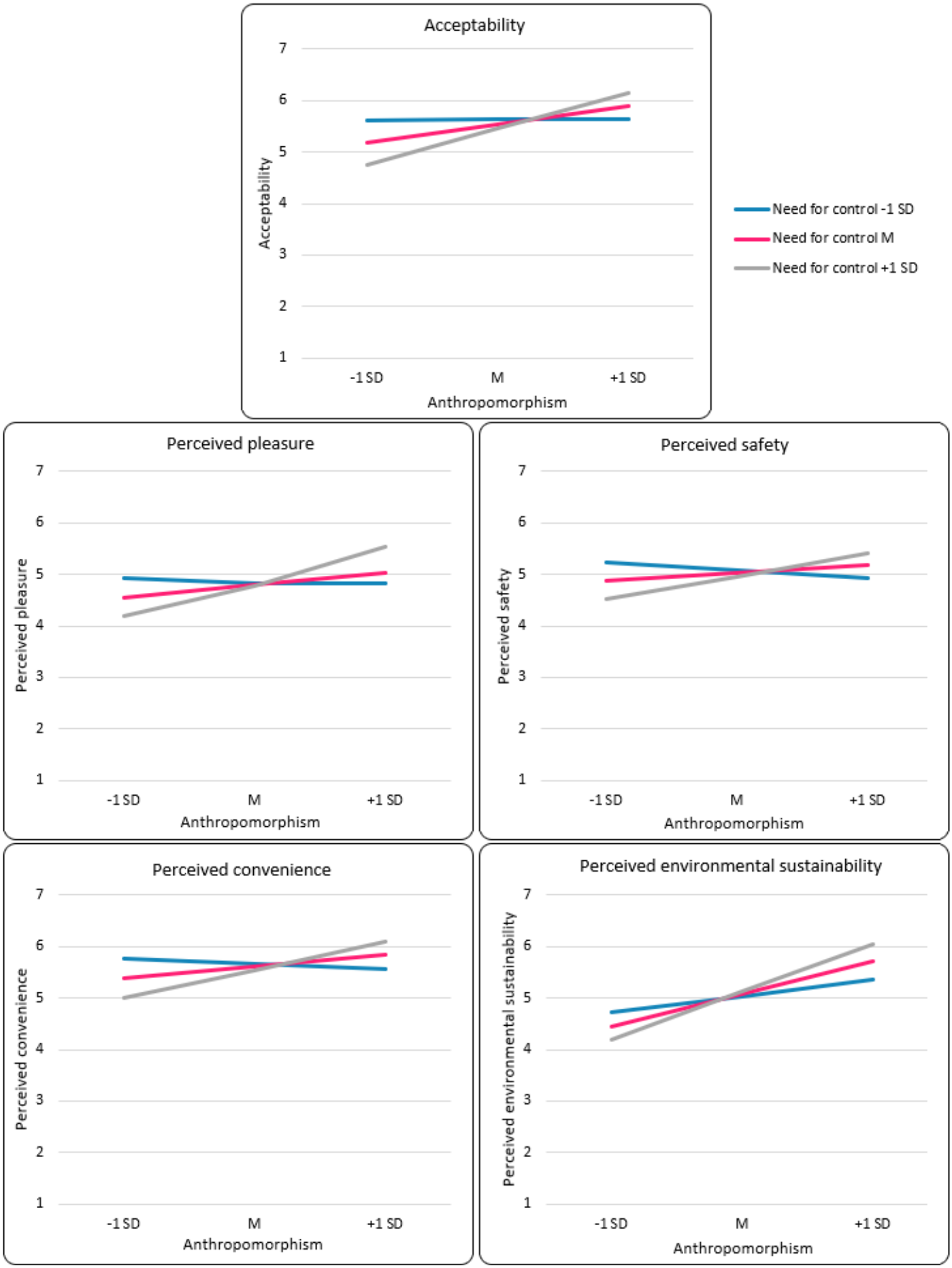
Table 32. Regression analyses of the interaction effect of need for control on the effect of anthropomorphism on acceptability and perceived characteristics.

Dependent variable	Predictor	B	t	p	R^2 full model	R^2 interaction only
Acceptability	Need for control	-0.67	-2.34	.021*	.313	.047
	Anthropomorphism	-0.77	-1.82	.072		
	Interaction	0.18	2.62	.010**		
Perceived safety	Need for control	-0.78	-2.60	.011*	.078	.054
	Anthropomorphism	-1.00	-2.24	.027*		
	Interaction	0.18	2.44	.016*		
Perceived control	Need for control	-0.45	-1.16	.247	.042	.007
	Anthropomorphism	-0.60	-1.05	.297		
	Interaction	0.08	0.85	.395		
Perceived pleasure	Need for control	-0.87	-2.43	.017*	.091	.055
	Anthropomorphism	-1.16	-2.19	.031*		
	Interaction	0.22	2.46	.016*		
Perceived convenience	Need for control	-0.86	-2.93	.004**	.117	.069
	Anthropomorphism	-1.08	-2.49	.014*		
	Interaction	.20	2.80	.006**		
Trust in the vehicle's technology	Need for control	-0.28	-0.82	.416	.148	.001
	Anthropomorphism	0.10	0.20	.839		
	Interaction	0.03	0.32	.749		
Perceived status-enhancement	Need for control	-0.52	-1.45	.150	.315	.018
	Anthropomorphism	-0.42	-0.78	.435		
	Interaction	0.15	1.63	.106		
Perceived environmental sustainability	Need for control	-0.67	-2.34	.021*	.313	.047
	Anthropomorphism	-0.77	-1.82	.072		
	Interaction	0.18	2.62	.010**		

Note. * = significant at the .05 level, ** = significant at the .01 level.

The interaction effect of need for control was significant for the effects of anthropomorphism on acceptability, perceived safety, pleasure, convenience, and environmental sustainability. To gain a better understanding of these effects, please refer to Figure 3 below. Inspection of the graphs reveals that for people with a high need for control, a high level of anthropomorphism is related to a more positive view of the vehicle (more acceptable, safer, pleasurable, convenient, and environmentally friendly), and a low level of anthropomorphism is related to a more negative view of the vehicle.

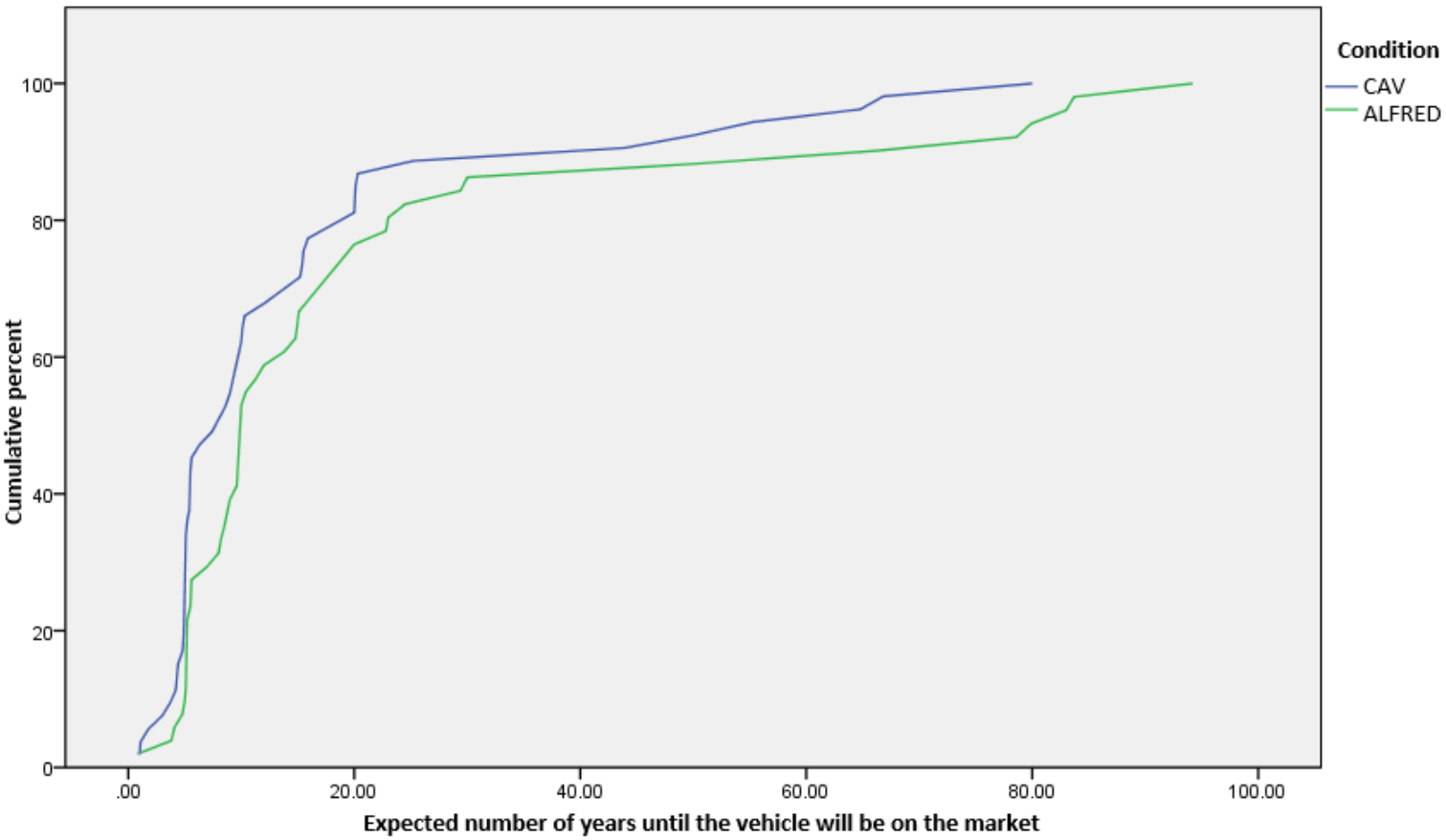
Figure 3. Moderation effects of need for control on the effects of anthropomorphism on acceptability, perceived safety, convenience, pleasure, and environmental sustainability.



4.3.5. Psychological distance

We asked participants how many years they think it will take until CAV or ALFRED will be available on the market to measure their psychological distance towards the vehicle. Participants could enter any number between 0 (within 1 year) to 100 (100 years or longer), or answer that it will never become available. One participant (in the ALFRED condition) indicated they thought the vehicle will never be on the market. The figure below illustrates in how many years participants thought either CAV or ALFRED will be on the market.

Figure 2. Expected number of years until the vehicle will be on the market by condition.



Inspection of the graph indicates that participants tend to expect it will take longer until ALFRED is on the market compared to CAV. However, this difference was not significant (t (df = 102) = -1.371, mean difference = -5.71, p = .171). Additionally, the graph indicates that participants expect both CAV and ALFRED to be on the market relatively soon, roughly 80% of the participants believed the vehicle will be on the market within 20 years.

In order to assess if psychological distance towards the vehicle affected the vehicle's acceptability, we ran a linear regression with acceptability as the outcome variable, and expected number of years as the predictor. The model was non-significant (F (df = 1, 102) = 0.477, p = .491). This indicates that acceptability of the vehicle is not directly related to the psychological distance participants experienced towards the vehicle.

We finally examined whether people who anthropomorphised the vehicle more also expected it will take longer until the vehicle will be on the market. Perhaps an anthropomorphised vehicle is seen as more difficult to create, for example. We ran a linear regression with expected number of years as the outcome variable, and anthropomorphism as the predictor. This model was significant (F (df = 1, 102) = 6.069, p = .015, B = 2.62, SD = 1.06). Participants who scored 1 SD below average on anthropomorphism expected the

vehicle to be on the market in 12.6 years, while participants who scored average on anthropomorphism expected it to be on the market in 17.6 years, and participants who scored 1 SD above average on anthropomorphism expected it to be on the market in 22.6 years.

4.4. Conclusion

The goal of the study was to determine whether anthropomorphism could increase the acceptability of ALFRED, and could make people view a human-like ALFRED more positively compared to a more machine-like, regular CAV.

As expected, we found that anthropomorphising ALFRED increased perceived status-enhancement, environmental sustainability, and trust in the vehicle's technology, compared to a machine-like, regular CAV. Additionally, we found that participants who had a greater tendency to anthropomorphise the vehicle also rated the vehicle as more acceptable. Lastly, participants scoring high on need for control rated the vehicle as more acceptable, safer, pleasurable, convenient, and environmentally friendly if the vehicle was rated high on anthropomorphism.

These results show that anthropomorphising CAV may have positive effects on how the vehicle is perceived, especially among people with a high need for control. This is an important discovery, as we found in the Large Scale Survey (D1.2) that people with a high need for control rated CAV more negatively. In the present study we used only a textual manipulation of anthropomorphism. It is possible a stronger manipulation (for example through giving CAV a human voice, using an anthropomorphised icon or mascot for CAV, etc.) may elicit stronger positive effects.

5. ADDITIONAL MITIGATION STRATEGIES AND INTERVENTIONS TO ENHANCE PUBLIC ACCEPTANCE OF CAV

In section 2.1 we repeated our suggestions for enhancing the acceptance of CAV based on the results from the Focus Groups, Large Scale Survey, and First Loop Driving Simulator Experiments. Based on the Scenario Study with Cyclists, and the Anthropomorphism Study, we suggest three additional mitigation strategies to enhance the acceptance of CAV aside from these already mentioned suggestions.

- Add a sustainability logo to CAV as it enhances trust in CAV technology for other road users.
- In the marketing of CAV, emphasize the environmental sustainability of CAV (for example mentioning its fuel efficiency). Higher perceived environmental sustainability of CAV is related to a higher acceptability, perceived safety, and greater trust in CAV technology for other road users.
- Present CAV as more human-like (i.e. anthropomorphise CAV), as it increased perceived status-enhancement, environmental sustainability, and trust in the vehicle's technology, especially among people with a high need for control.

6. TECHNICAL & SCIENTIFIC IMPACTS

In the present deliverable we have described two new acceptance studies. Based on these new studies we have added three new mitigation strategies to enhance the public acceptance of CAV. The contents of this deliverable can be used to develop CAV and ALFRED in such a way that the human side of the potential users and other road users is taken into consideration, and it gives an overview of what marketing should focus on to increase public acceptability.

A key technological impact of our findings is that CAV's design should be human-like in order to make CAV's perceived characteristics be evaluated more positively. Anthropomorphising CAV can also increase the acceptability of CAV among people with a high need for control. In addition, it is important to invest in sustainable technologies in designing CAV, such as making it fuel-efficient or make it run on clean energy, because such green technology could enhance the acceptability of CAV.

Additionally, the two new acceptance studies have a scientific impact. To our knowledge, our study is the first that investigated whether anthropomorphising CAV would lead to more positive evaluations of its perceived characteristics and its acceptability, as well as the interplay of anthropomorphism and need for control. The Scenario Study with Cyclists adds to the literature that a vehicle's appearance could trigger a halo effect.

7. CONCLUSION

The present deliverable's key objective was to formulate a first version of possible mitigation strategies to enhance the public acceptance of CAV. This objective has been achieved. After discussing two new acceptance studies, we have included three new suggestions as mitigation strategies to enhance public acceptance of CAV.

The first two suggestions are related to environmental sustainability. In the Large Scale Survey (D1.2) we already found that environmental sustainability of CAV is important for potential users' acceptability of CAV. In the Scenario Study with Cyclists as discussed in this deliverable we found that cyclists who interact with CAV also rate CAV more positively if they believe CAV is environmentally sustainable. Additionally, we found that adding a sustainability logo to CAV leads to a small halo effect, increasing trust in CAV technology among cyclists. We conclude that both adding a sustainability logo and emphasizing CAV's environmental sustainability in marketing could increase the acceptance of CAV among potential users and other road users.

The last suggestion is related to anthropomorphism. We found that anthropomorphizing CAV as ALFRED leads to more positive evaluations of ALFRED compared to a machine-like, regular CAV. Moreover, these positive effects were stronger for participants who scored high on the need for control. Participants with a greater tendency to anthropomorphize also rated the vehicle more positively. These results show that anthropomorphizing the vehicle could enhance the acceptability of CAV.

By adding these new suggestions to the list of suggestions as defined in D1.3, we now have several options to enhance the public acceptance of CAV. Our suggestions should provide an overview of what aspects need to be taken into account in the development of CAV and ALFRED to enhance its acceptance.

8. REFERENCES

Burger, J. M., & Cooper, H. M. (1979). The desirability of control. *Motivation and Emotion*, *3*(4), 381-393.

Davies, G. M. (2009). Estimating the speed of vehicles: The influence of stereotypes. *Psychology, Crime & Law*, *15*(4), 293-312.

Epley, N., Akalis, S., Waytz, A., & Cacioppo, J. T. (2008)[1]. Creating social connection through inferential reproduction: Loneliness and perceived agency in gadgets, gods, and greyhounds. *Psychological Science*, *19*(2), 114-120.

Epley, N., Waytz, A., Akalis, S., & Cacioppo, J. T. (2008)[2]. When we need a human: Motivational determinants of anthropomorphism. *Social Cognition*, *26*(2), 143-155.

Gray, K., & Wegner, D. M. (2012). Feeling robots and human zombies: Mind perception and the uncanny valley. *Cognition*, *125*(1), 125-130.

Guthrie, S. E. (1993). *Faces in the Clouds: A New Theory of Religion*. Oxford University Press.

Lachman, S. J., & Bass, A. R. (1985). A direct study of halo effect. *The Journal of Psychology*, *119*(6), 535-540.

Liberman, N., Trope, Y., & Stephan, E. (2007). Psychological distance. In Kruglanski, A. W., Higgins, E. T. (Eds.). *Social psychology: Handbook of basic principles. Vol. 2* pp. 353-383). Guilford Press.

Nisbett, R. E., & Wilson, T. D. (1977). The halo effect: Evidence for unconscious alteration of judgments. *Journal of Personality and Social Psychology*, *35*(4), 250-256.

Peattie, K. (2010). Green consumption: Behavior and norms. *Annual Review of Environment and Resources*, *35*, 195-228.

Puzakova, M., Kwak, H., & Rocereto, J. F. (2013). When humanizing brands goes wrong: The detrimental effect of brand anthropomorphization amid product wrongdoings. *Journal of Marketing*, *77*(3), 81-100.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In M. Zanna (Ed.), *Advances in Experimental Social Psychology* (Vol. 25, pp. 1-65). Orlando, FL: Academic Press.

Steg, L., & De Groot, J. I. (2012). Environmental values. In *The Oxford Handbook of Environmental and Conservation Psychology*.

Thorndike, E. L. (1920). A constant error in psychological ratings. *Journal of Applied Psychology*, *4*(1), 25-29.

Trope, Y., & Liberman, N. (2010). Construal-level theory of psychological distance. *Psychological Review*, *117*(2), 440-463.

Waytz, A., Heafner, J., & Epley, N. (2014). The mind in the machine: Anthropomorphism increases trust in an autonomous vehicle. *Journal of Experimental Social Psychology*, *52*, 113-117.

Waytz, A., Morewedge, C. K., Epley, N., Monteleone, G., Gao, J. H., & Cacioppo, J. T. (2010). Making sense by making sentient: Effectance motivation increases anthropomorphism. *Journal of Personality and Social Psychology*, *99*(3), 410.

9. APPENDIX

Description used for machine-like CAV in the Anthropomorphism Study:

> *A Connected Automated Vehicle (CAV) is a fully automated car. You, the passenger, only have to enter your destination and CAV's computer system will calculate the most efficient route. CAV is equipped with Internet access, which allows sharing data with other cars and transportation systems to avoid busy streets and traffic jams, and CAV is always updated with the current traffic situation. With CAV you can reach your destination safely, as it can detect and avoid obstacles, other road users, and other vehicles. While driving to your destination in CAV, you can spend your time on other things than driving, such as reading or watching a movie.*

Description used for human-like ALFRED in the Anthropomorphism Study:

> *ALFRED is a fully self-driving car. You, the passenger, only have to tell ALFRED what your destination is and ALFRED will consider the most efficient route. ALFRED has Internet access and can share data with other cars and transportation systems to avoid busy streets and traffic jams, and ALFRED is always informed of the current traffic situation. ALFRED can drive you to your destination safely, as he can see and avoid obstacles, other road users, and other vehicles. While ALFRED drives you to your destination, you can spend your time on other things, such as reading or watching a movie.*

Consortium:

Project Title:
SUpporting acceptance of automated VEhicle

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