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Investigating the influence of the role of a social robot on people's attitude towards that robot

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Investigating the influence of the role of a social robot on people's attitude towards that robot.

by Jin Smeding

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I wish all readers an enjoyable and hopefully interesting read!

Jin Smeding,

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Abstract

For social robots to be tailored to the needs of the user and become more accepted in domestic environments, we must understand how people perceive and interact with robots. As social robots can have different roles (i.e., a more practical/instrumental utilitarian role and a social oriented hedonic role), this study investigated people's attitudes toward robots in those roles, explored changes in attitude over interaction with the robot, and discussed relevant broader societal and ethical concerns. Participants had the Vector robot in their home for four days; two days provided with utilitarian interactions and two days provided with hedonic interactions. Quantitative measures of the affective, cognitive and behavioral attitude were conducted pre- and post-interaction and qualitative insights were gathered through semi-structured interviews at the end of the experiment. Results show that the robots were perceived and described differently when they had different roles, however further research is necessary to gain a better understanding of people's complex attitudes toward robots and dive deeper into the underlying processes. Short-term attitude change was suggested to be more dependent on utilitarian aspects and novelty effects, while hedonic aspects seemed more important in the long-term. Discussions of societal and ethical implications must be included in human-robot interaction research to expand and shape the developments in this field.

Keywords: *human-robot interaction; social robot; role of a robot; attitude toward robots; attitude change*.

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1. Introduction

1.1 The role of a social robot

There are many different types of robots, which can be deployed in a variety of application domains, perform different tasks and require social skills in varying degrees (Dautenhahn, 2007). Through a combination of these robot aspects, the role of a robot can be defined. For example, a robot that operates away from humans would have a specific and well-defined task and no need to be social. The role of such a robot is then quite clear. However, with social robots, their application requires social skills to perform their task and the role of social robots is often much more open and adaptive.

Social robots can be seen as a distinct category of robots. Hegel et al. (2009) argue that a robot needs specific communicative capabilities to be considered a social robot. While combining technical and social aspects, a social robot should be able to function socially within a context and it should have a form that explicitly expresses to be social with regard to a user (Hegel et al., 2009). Although this social aspect is crucial for a robot to be a social robot, many social robots also have more practical or technical aspects. For example, the NAO robot – a humanoid (resembling a human body in shape) social robot widely used in academic research – can move its fingers, arms and legs, enabling it to both dance (social aspect) and grab objects (practical aspect). Moreover, Kahn et al. (2013) found that social robots embody aspects of all three canonical categories of humans, animals and artifacts (i.e., objects made by humans, e.g., tools), and that social robots cannot merely be placed within one of those categories. They argue that people – especially children who will grow up with social robots around them – will see social robots as a new ontological category in addition to humans, animals and artifacts. This indicates that a social robot can have different roles, in which more human- or animal-like interactions and conceptualizations overlap more with the social aspects of the robot and the more artifact-like interactions and conceptualizations more with the practical aspects.

This is in line with the distinction between utilitarian and hedonic product aspects within the field of human-computer interaction (Hassenzahl & Tractinsky, 2006; van der Heijden, 2004). Utilitarian aspects are much more practical, providing instrumental value to the user. This implies that there is an objective external to the interaction with the product, such as increasing task performance. Hedonic aspects do not focus on such external objectives. Instead, the mere interaction with the hedonic product aspects can be considered an end in itself, providing self-fulfilling value to the user. Based on this, a social robot can be perceived as a utilitarian system - focusing on the tasks that the robot can perform – or a hedonic system – focusing on the opportunity for social interaction and relationship building with the robot (de Graaf et al., 2015). Dautenhahn (2007) makes a similar distinction, dividing the role of a robot into machines or tools on one end, and assistants, companions and partners on the other end.

Potential effects of such dual perception of the role of a social robot are not investigated extensively in human-robot interaction research. De Graaf et al. (2015) did investigate the acceptance of a domestic social robot (Nabaztag, now called Karotz) with regard to the role of the robot. They found that the utilitarian aspects are crucial in determining whether people use the robot or not, but once they do choose to use the robot, the hedonic social interactions seem to become much more important. Sung et al. (2008) found a similar importance of hedonic social interactions. When studying a vacuum robot (Roomba), they found that some – but not all – users named it, played with it, gave it a personality and gender, next to using it for its intended purpose of cleaning. This shows that people can assign different roles to a robot in their home. Moreover, Sung et al. (2008) found that such more social activities led to a significantly higher satisfaction with the robot compared to users who did not engage in such social activities. Furthermore, a social robot with low social interaction skills is evaluated more negatively in terms of sociability and competence compared to a robot with high social interaction skills (Horstmann & Krämer, 2020). This suggests that the perceived social aspects of a robot could lead to a more positive evaluation of the robot. Therefore, it might be possible to utilize a hedonic role of the robot to create a more positive human-robot experience.

In contrast, some studies have shown that a robot in a utilitarian role is preferred over a robot in a social role or as a friend. The idea of having an electronic assistant that makes life easier by carrying out tasks for you might be very appealing to most people (Horstmann & Krämer, 2019). The utility of a robot (e.g., usefulness and ease of use) has been shown to be an important influence on people's acceptance of that robot (Ezer et al., 2009; Davis, 1989). Fink et al. (2013) have pointed out the practical utility as one of the most important aspects in the adoption of a robot - similar to the aforementioned findings of de Graaf et al. (2015). Furthermore, they found the social impact of functional robots to be overestimated. The social activities with the robot that the participants engaged with – such as talking and playing with it – wore off when people became familiar with the robot, possibly due to a novelty effect. Moreover, de Graaf et al. (2017) found that social and companionship possibilities of domestic robots were not appreciated and evaluated negatively. Similar findings have indicated that people disapprove of robots performing social tasks (Arras & Cerqui, 2005; European Commission, 2012; de Graaf & Allouch, 2016), that the idea of an assistive robot is preferred over a robot as a friend (Dautenhahn et al., 2005), and that robots should serve as collaborators or assistants to people rather than replacing humans (Takayama et al., 2008; Ray et al., 2008). Due to the emphasis on the robot characteristics similar to those of social beings, a hedonic role of the robot might lead to it being perceived as more human-like and thus being able to replace humans more easily, compared to when a robot has merely a utilitarian role. Therefore, a utilitarian role of a social robot might be regarded more positively than a hedonic role.

1.2 Attitude toward a social robot

Based on these findings, people's evaluations of a robot might be dependent on the role of the robot. Such evaluations are captured in people's attitude. Rooted in the work of Allport (1935), an attitude is now often defined as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly & Chaiken, 1993, p. 1), and as Allport (1935) suggested it can profoundly shape people's social interactions with the world. Attitudes can be divided into an affective, cognitive and behavioral component (Rosenberg & Hovland, 1960). Regarding a social robot, a person's affective attitude reflects their feelings or emotions toward the robot, their cognitive attitude reflects their thoughts about the robot, and their behavioral attitude reflects their observable behavior toward the robot. They can differ in valence - ranging from negative to neutral to positive - and people can hold multiple attitudes (both across and within attitude components) towards an attitude object (Wood, 2000; Fishbein & Ajzen, 1975). Attitudes are not only relevant in investigating how people evaluate a social robot, but also in predicting behavior (Breckler, 1984; Ajzen, 2003). In line with this predictive power, attitudes are often studied as part of an acceptance framework (e.g., theory of planned behavior (TPB; Ajzen, 1991), technology acceptance model (TAM; Davis, 1985), unified theory of acceptance and use of technology (UTAUT; Venkatesh et al., 2003) and Almere model (Heerink et al., 2010). In such research, attitude is most often regarded as an affect that relates to beliefs and intention to use or actual use (Bhattacherjee & Sanford, 2009). Acceptance then encompasses this intention to use or actual use (Davis, 1989; Heerink et al., 2010; Venkatesh et al., 2003).

The distinction between affective, cognitive and behavioral attitude is not always explicitly made or made between all three components. However, this distinction is useful as it can provide a more in-depth view of a person's attitude, accounting for differences between a person's affective, cognitive or behavioral attitude (Naneva et al., 2020) and revealing underlying processes regarding people's evaluations of a robot. For example, people might believe a social robot to be worthwhile (positive cognitive attitude), while feeling uneasy when interacting with the robot (negative affective attitude). Furthermore, it can potentially account for some of the mixed findings identified in previous research (Naneva et al., 2020).

Such mixed attitudes might also lead to neutral ratings on survey items. According to Stapels and Eyssel (2021), neutral attitude ratings can be misleading as they can mask ambivalent attitudes. Whereas a neutral attitude refers to an attitude that lacks strong positive or negative evaluations, an ambivalent attitude is a state of evaluative conflict in which there are both strong positive and negative evaluations. An example of such ambivalent attitudes was found by Horstmann and Krämer (2019). Through a qualitative study they found that students expect social robots to be highly useful, but that they also fear humanity being threatened by conscious robots. As bipolar items cannot capture such ambivalence, giving people an opportunity to express their ambivalence – e.g., through an interview – could give much more meaningful insights into people's attitudes toward robots (Stapels & Eyssel, 2021).

Although some mixed findings were found regarding the valence of people's attitudes toward social robots in Naneva's et al. (2020) extensive literature review, studies generally supported overall positive attitudes toward robots. A study by Louie et al. (2014) found a positive attitude of elderly toward a human-like socially assistive robot (Brian 2.1), measured using the Almere model. Comments made by participants, such as "I love the idea of the robot and its applications" and the robot is "fascinating" and "very interesting with regard to assisting the elderly where necessary", further expressed their positive attitude. Similar results were found by Conti et al. (2017). Using the Almere model, they found a global positive attitude toward the use of the NAO robot. This study focused on the perception of practitioners and students of the robot as a tool for education and care, rather than the actual use.

Studies in which affective and cognitive attitudes could not be differentiated were more ambiguous and leaned more toward overall neutral attitudes toward robots (Naneva et al., 2020). Wu et al. (2014) investigated the acceptance of an assistive robot in older adults with the Almere model. The attitude toward robots was found to be slightly negative to neutral across the multiple measurements and there was a low intention to use the robot. However, qualitative findings showed that participants had a positive and satisfactory experience with the robot. As an explanation of this contradiction, Wu et al. (2014) indicate that participants did not consider themselves in a position of needing the robot.

Thus, attitudes toward robots can reveal how people perceive robots, which can help to inform the design of future robots and human-robot interaction. Attitudes also seem to be related to behavior, suggesting that a change in attitude can lead to behavior change. For example, influencing people's attitudes toward robots to become more favorable could lead to an interaction with a robot to be seen as more positive and their behavior toward robots to become more favorable (e.g., in the adoption or use of a robot).

1.3 Attitude toward different roles of a social robot

While previous work does indicate an influence of the role of a robot on people's attitude toward that robot, no previous research has yet been found that empirically compares attitudes across different roles of the same robot. As described before, a social robot can have a utilitarian or hedonic role, however, the impact of those roles on how people evaluate that robot is still unclear.

Lee et al. (2011) did look at differences in attitude across utilitarian and hedonic robots, but they used two different types of robots (the zoomorphic Pleo robot for the hedonic and the Roomba vacuum robot for the utilitarian condition). They found a higher enjoyment with the hedonic robot, while the utilitarian robot was perceived more useful and easier to use. Other research on different roles and types of robots has also suggested people’s evaluations of social robots to be different across those roles or types.

Enz et al. (2011) explored people's expectations and affective judgements across different societal roles of robots. However, the roles they used were presented as specific social scenarios, e.g., ownership of personal robots as status symbols, robots performing nursing tasks and personal assistant robots to store important and personal data. Overall, they found that the judgements were rather negative, especially if the scenario implied equality to humans. Furthermore, if it was seen as a solution to a pressing issue or in dangerous scenarios, robots were more positively regarded.

The categorization of robots in Haring et al. (2013) was a bit less specific; they distinguished four categories of robot type: pet robot (robot resembling an animal), service robot (robot carrying out a service task), humanoid robot (robot with gross human features but no details) and android robot (robot aiming to look like a human copy). The resemblance of pet, humanoid and android robots to social beings might provide more social affordances to those robot types, although it should be noted that some categories might overlap (for example, some humanoid robots can also be considered service robots). Even though these robot types might also have some social aspects to them, all four robot types were most associated with more utilitarian keywords, such as technology, machine, dangerous tasks, research, utility and help for humans. These findings are in line with research that reported that a robot in a utilitarian role is preferred over a robot in a social job or as a friend (e.g., Arras & Cerqui, 2005; European Commission, 2012; Ray et al., 2008; Dautenhahn et al., 2005).

However, the importance of hedonic social interactions for people’s experience and satisfaction with the robot has also been indicated by previous research (de Graaf et al., 2015; Sung et al., 2008). As there seems to be a contradiction in the related work and due to the little amount of research on this topic, the influence of the role of a robot on people's attitudes toward that robot merits further investigation. The dichotomous role of a social robot (utilitarian/hedonic) has not yet been studied thoroughly, let alone with regard to attitude.

1.4 The influence of interaction with the social robot

Attitude is generally regarded as something that can change, for example through experiences or interactions. According to dual process theories of attitude change, attitude can change through a spontaneous and affect-driven process, or through a conscious cognitive and evaluative process (Gawronski & Bodenhausen, 2006; Petty & Cacioppo, 1986).

There have been some mixed findings on whether interaction with a robot can change people's attitudes toward that robot. While previous research using short interactions (e.g., several minutes) mostly did not find significant changes in attitude, studies with longer term interactions (e.g., several months) did. Findings of Nomura et al. (2006) imply that short-term change in attitude toward a robot is dependent on individual situations such as real experiences of human-robot interaction, while more long-term change is influenced by cultural trends.

Some studies did not find a significant change in attitude after a short interaction with the robot. De Graaf & Allouch (2013b) measured attitude with the Negative Attitude toward Robots Scale (NARS) – which evaluates people's psychological states reflecting opinions people ordinarily have towards robots (de Graaf & Allouch, 2013b) – before and after an interaction of five to ten minutes with a social robot. They did not find a significant change between the pre- and post-test data. Similar results were found by Manzi et al. (2021); people's negative attitudes were independent of the interaction – introduction of the robot and game play – with the robot. Mirnig et al. (2017) did not find a difference in NARS ratings before and after a negative interaction with a faulty robot. Kim et al. (2016) studied the influence of different types of interactions with a robot – a short lecture, dancing with a robot, programming a robot and a driving simulator – on attitude toward robots. Their results show no significant difference between pre- and post-activity NARS ratings. However, it should be noted that the interaction duration in these studies was very short. The results of these studies therefore suggest that there might be a minimum duration of interaction with a robot for a short-term attitude change to be found. Based on this, a possible effect of the interaction might be more pronounced if the interaction with the robot is longer.

Other studies do support the notion that people's attitude toward robots can change. Reich-Stiebert et al. (2019) found that participation in the design process of a specific robot resulted in a more positive attitude toward robots. Furthermore, through a literature review, Savela et al. (2018) found that positive attitudes occurred more frequently in studies exposing participants to robots. This suggests that an interaction with the robot can positively affect people's attitude toward that robot. Stafford et al. (2010) measured people's attitude toward the robot before and after a short interaction among elderly. Their results showed a significant improvement in people's attitude toward robots, measured with the Robot Attitude Scale (RAS) which indicates people's evaluations of the robot at that moment. According to the researchers, this might be due to a high level of anxiety before meeting the robot and a positive experience with the robot. In a more long-time review, Gnambs and Appel (2019) found a negative trend in people's attitudes toward robots over five years (from 2012 to 2017), suggesting that people became more cautious toward the use of robots. De Graaf et al. (2016) placed a robot in the home of elderly for up to six months and measured a variety of attitudinal beliefs (such as ease of use, adaptability, enjoyment, and sociability) and use variables (such as use attitude, use intention and actual use) at six different points in time. They found that these variables all changed significantly over time. Participants' evaluations were most positive in their before-interaction measurement compared to the other measurements in time, which suggests that participants had higher expectations of the robot that were not met after meeting the robot. These studies show that attitudes toward a robot can change due to interactions with the robot.

Different types of interactions might also influence the change in attitude due to the interaction. Whereas the utilitarian role of the robot may utilize more informational question-and-answer type of interactions, more conversational or playful interactions may be more prevalent if the robot has a hedonic role. Based on this, the difference between the pre- and post-interaction attitude ratings might also differ across the different roles of a social robot (utilitarian or hedonic).

1.5 Research aims

Previous studies have indicated that the role of a robot might influence people's evaluations of that robot. However, how exactly such a relationship between the role of the robot and people's attitudes toward it works is still unclear. By investigating this in terms of their affective, cognitive and behavioral attitude, more detailed insights can be gathered, and people's evaluations can be linked to behavioral aspects. Furthermore, to ensure that social robots fit the user and their needs, better understanding should be gained about how people evaluate and behave toward robots and what the impact of the role of the robot is on this. Due to the (potential) complexities of the relationship between the role of a robot and people's attitude toward it, a more qualitative approach is needed to gain a more in-depth and meaningful understanding. Therefore, a mixed methods approach was used to answer the following research question.

***RQ**: How does the role of a social robot in a person's home environment influence their attitude towards that robot?*

Based on previous research on the role of a robot, in combination with attitude toward robots, it was expected that a utilitarian role is regarded more positively over a hedonic role. The utilitarian aspects of a robot can be very appealing and play an important role in people's attitude toward that robot (Horstmann & Krämer, 2019; Ezer et al., 2009; Fink et al., 2013; de Graaf et al., 2015). Robots are also mostly associated with utilitarian words, and a robot in a utilitarian role is preferred over a robot in a social job or as a friend (e.g., Haring et al., 2013; European Commission, 2012; de Graaf & Allouch, 2016; Ray et al., 2009; Takayama et al., 2008). Therefore, it was expected that the robot in the utilitarian role is regarded more positively than the robot in the hedonic role. The following hypotheses were formulated for this study.

H1a: *People will have a more positive affective attitude if the robot has a utilitarian role.*
H1b: *People will have a more negative affective attitude if the robot has a hedonic role.*

H2a: *People will have a more positive cognitive attitude if the robot has a utilitarian role.*
H2b: *People will have a more negative cognitive attitude if the robot has a hedonic role.*

The investigation into the behavioral attitude was more exploratory, as the measurement of this is specific to the robot used in this study.

H3a: *If the role of the robot is utilitarian, a high number of utilities used and a short duration of petting are expected.*
H3b: *If the role of the robot is hedonic, a low number of utilities used and a long duration of petting are expected.*

As attitudes can change, for example through experiences or interactions, this study will measure attitude pre- and post-interaction to investigate the influence of the interaction with the robot. Although some studies did not find a significant change in attitude after a short interaction with the robot (de Graaf & Allouch, 2013b; Manzi et al., 2021; Mirnig et al., 2017; Kim et al., 2016), other studies did find that people's evaluations of robots can change due to interaction with the robot (Reich-Stiebert et al., 2019; Stafford et al., 2010; de Graaf et al., 2016; Savela et al., 2018). Therefore, the following question were explored as well.

Exploratory Question: *How does the interaction with a social robot influence people's attitude towards it?*

In addition, this study and its results – and human-robot interaction research in a more general sense – were put into a broader societal context by discussing relevant ethical concerns. As research and discussions on such ethical and moral issues can influence the direction of technological developments, it is important to think about and discuss such issues early in the research and development of technology – rather than creating something and evaluating related ethical issues after the fact.

2. Method

2.1 Participants

In total, 20 people participated in this study (M_{age} = 23.35, SD_{age} = 1.785, range$_{age}$ = 20-28). There were 16 female, 3 male and 1 bigender participants. The participants were recruited through the researcher's social network using convenience sampling and they were compensated with €20,- (based on duration of the study) at completion of the experiment. All participants were either current higher education students or recently graduated, and they all lived in Eindhoven, the Netherlands. There were 15 participants living in a student house (shared commodities) and 5 participants living alone (in either an apartment or studio, no shared commodities). Requirements for participation were a 2.4GHz Wi-Fi connection at home and the participant's home being in or near Eindhoven, as the researcher had to visit them several times across the duration of the experiment. The sample size was mainly determined by more practical restrictions; there were five robots available with four weeks of data collection, enabling the experiment to be conducted with 20 participants in total (five participants per week). The mixed methods approach allowed for a smaller sample size, as it utilizes both quantitative and rich qualitative data.

The experiment was approved by the Ethical Review Board of the University of Technology Eindhoven, and it adheres to the Code of Scientific Conduct ("TU/e Code of Scientific Conduct", 2019). More specifically, measures such as the anonymization and handling of the data, the voluntary basis of participation, and COVID-19 measures are all explained in the informed consent form (Appendix A). This form was read and signed by the participants before the experiment started, making sure they understood and agreed to their participation. After completion of the experiment, the participants were debriefed and compensated.

2.2 Design

A within-subjects design with a mixed method approach was used for this experiment. The role of the robot was the independent variable (utilitarian and hedonic) and the attitude toward the robot was the dependent variable (divided into the affective, cognitive and behavioral attitude). All participants used the robot in both a utilitarian role and a hedonic role. In both conditions, their attitude was measured through an online survey, behavior statistics and qualitative interviews. These measurements were done pre- and post-interaction with the robot.

2.3 Setting and materials

The robot used in this experiment is the Anki Vector robot (Figure 1; Digital Dream Labs, n.d.), which is a small programmable home robot. Vector is made to explore and react to its surroundings. This interaction with its surroundings is very intuitive and it uses both sight and sound to do this. A variety of interactions can be had with this robot, such as using the robot to set a timer, asking it questions, playing a game with it and petting it. Vector can also recognize the user's face and name, as well as objects. In order to interact with Vector, the user must say "hey Vector", then the robot will indicate that it is listening, after which the desired command can be given to Vector. If no command is given, Vector automatically explores its environment.

The Vector robot has a variety of sensors, including a camera, touch sensors, an accelerometer and several microphones. Furthermore, it combines a processor with cloud connectivity, which allows it to process its environment, react as things unfold and respond accurately to the user's commands. Vector can communicate with its voice and the lights on its back, as well as through its eyes and arm. This arm is also used to interact with Vector's cube, which is its favorite toy. If the robot is low on battery, it will return to its charger automatically.

Vector gathers substantial information to function well. This data is processed and stored either locally or in the cloud. More sensitive data, such as names, faces and photos, are stored locally on Vector and can be erased by the user at any time. The voice commands are sent to the cloud, where it is transferred into text. This text is then stored and used for service optimization, while the audio recordings themselves are deleted.

Figure 1: A blue set up of the Vector robot with its charger and cube.

Vector is a commercially available robot, but it has been used in previous human-robot interaction studies (e.g., Weiss et al., 2021; Tsiourti et al., 2020; Odekerken-Schröder, 2020; Chu & Fung, 2019; Tsoi et al., 2021). Furthermore, the study was conducted in the participant's home environment. Compared to a lab experiment, this approach considers the broader, social and situational context of robots in the home. This improves the ecological validity of this study, ensuring that the results of the study are much more applicable to real world settings.

2.4 Manipulation

In order to manipulate the role of the robot, the participants were told to only use either utilitarian aspects (e.g., setting a timer, asking the weather, unit conversions, general knowledge questions) or hedonic aspects (e.g., petting the robot, playing a game with it, general conversation) of the robot. This was done by providing the participants with an information sheet that explained the interactions with the robot relevant to the condition they were in (Table 1, Appendix B). These information sheets were used to be able to distinguish between the utilitarian and hedonic role of the robot. To install the Vector robot, a Wi-Fi connection is required, and this is established through the mobile app, and in this app, all possible interactions with the robot are explained. Therefore, the use of the information sheets makes sure that the participants only use the interactions relevant to their condition, that they do not see the interactions of the other condition and that they do not look in the app. This ensures that the app does not interfere with the manipulation. The conditions were counterbalanced, and the order of the conditions was assigned randomly (Figure 2).

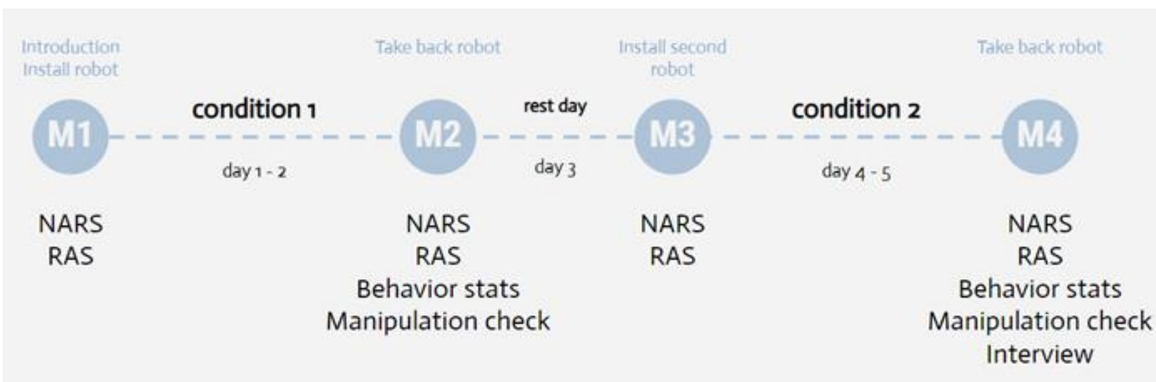


Figure 2: Overview of the experiment. M1-4 are measurement points. During M1 and M3 the robot was installed in the participant's home, and during M2 and M4 the robot was retrieved from the participant's home. The measurements done are noted below each measurement point, and the conditions were counterbalanced.

In the information sheets, first some basic information about the robot is explained. This includes information about the Wi-Fi, the cube, the button on the robot, the meaning of different lights on the robot, volume settings and charging. This information was provided in both conditions. More informational interactions were included in the utilitarian condition (e.g., setting a timer, asking about the weather and knowledge questions). The hedonic condition contained more social interactions (e.g., petting, cube tricks and conversational interactions). Table 1 provides a full overview of the interactions provided to the participants in each condition.

The number of interactions on the information sheet and the duration of those interactions were similar across the conditions. However, it should be noted that the variety of interactions (e.g., duration of Vector's response, multiple commands for the same interaction, sequences of interactions) may have influenced participants' interaction durations, frequencies, times or patterns. For example, a question-and-answer question might not be asked multiple times as the information would have already been provided, while a cube trick might be done multiple times a day.

Table 1: Interactions provided to the participants in the information sheets for each condition (utilitarian/hedonic).

Utilitarian condition	**Hedonic condition**
weather	name and face registration and recognition
time	petting
setting a timer	celebrating
taking a photo	dancing to the music
	playing a game of blackjack
chance:	come here
flipping a coin	going to sleep / waking up
rolling a dice	
	cube tricks:
question-and-answer:	finding it
unit conversions	rolling it over
currency conversion	picking it up
equation solver	bringing it to the user
general knowledge questions	doing a wheel stand
word definitions	
nutrition	*conversational:*
stock markets	e.g., "hello", "I am back", "how are you?",
flights	"how was your day?", "thank you",
sports	"I am happy", "good robot", "well done",
places	"bad robot"
people	

As the Vector robot was used in both conditions, it was important to separate the conditions. If the robot in the second condition would be seen as the same robot as in the first condition, the manipulation of the role of the robot might not work well. Therefore, the robot for the second condition was introduced as a new robot with a different eye color and differently colored tracks (Figure 3). Furthermore, the robot was taken back at the end of the first condition, then the participants had a rest day and after that the second robot was installed for the second condition. During this rest day, they did not interact with the robot at all. This also helped to introduce the second robot as a new robot.

Figure 3: The differently colored set ups of the Vector robot. From left to right: green eyes and tracks, orange eyes and black tracks, purple eyes and tracks, yellow eyes and black tracks, and blue eyes and tracks.

2.5 Measurements

People's attitudes toward the Vector robot were measured through their affective, cognitive and behavioral attitude. This distinction allows for a more holistic exploration of their attitude. During each measurement point, the participants filled in a survey (Appendix C) in order to gather insight into their affective and cognitive attitude towards the robot. The questionnaires were provided to the participants in an online survey format, using the LimeSurvey platform. All questions in the survey were in English. Both questionnaires were conducted pre- and post-interaction to investigate the influence of the interaction.

2.5.1 Negative Attitudes toward Robots Scale (NARS)

The Negative Attitudes toward Robots Scale (NARS; Nomura et al., 2006) - adapted to the Vector robot - was used to measure their affective attitude towards the robot. This scale has 14 items and is rated using a 5-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*). This questionnaire is very popular and has been shown to be a good measure of affective attitude (Nomura et al., 2006; Naneva et al., 2020). This scale includes three subscales: S1: Negative Attitude toward Situations of Interaction with Robots (6 items; e.g., "*I would feel nervous operating the Vector robot in front of other people*"), S2: Negative Attitude toward Social Influence of Robots (5 items; e.g., "*I am concerned that Vector would be a bad influence on children*"), and S3: Negative Attitude toward Emotions in Interaction with Robots (3 items, reversed; e.g. "*I would feel comforted being with Vector if it had emotions*"). Although the reliability of this scale is generally good (Nomura et al., 2006: $\alpha = .756$ for S1, $\alpha = .647$ for S2 and $\alpha = .735$ for S3), the reliability of the adapted NARS used in this study was borderline acceptable ($\alpha = .657$ overall, $\alpha = .543$ for S1, $\alpha = .403$ for S2 and $\alpha = .623$ for S3). Excluding items did not lead to improvements in the reliability of the scale or subscales. As Nomura et al.

(2004) suggest, a general affective attitude score was created by reversing the ratings of subscale 3 and then summing all ratings per participant per measurement point. The lower this score, the more positive the participant's affective attitude at that time.

2.5.2 Robot Attitude Scale (RAS)

The participant's cognitive attitude was measured with the Robot Attitude Scale (RAS; Broadbent et al., 2009). This scale is an 8-point semantic differential scale with 11 items, e.g., "1 = *advanced*, 8 = *basic*", "1 = *reliable*, 8 = *unreliable*", and "1 = *safe*, 8 = *unsafe*". Although this questionnaire is not a very well-known scale, its internal consistency has been shown to be high (Stafford et al., 2010: α = .92; present study: α = .777) and its items are very relevant to this study. An overall cognitive attitude score was generated by summing all ratings per participant per measurement point, with a lower overall score indicating a more positive attitude.

Behavioral attitude was measured through the behavioral statistics that are automatically collected in the mobile app. They include the number of wake words (#, the "hey vector" command that must be used to initiate an interaction with the robot), the distance driven (cm), the petting duration (sec) and the number of utilities used (#). These behavior statistics were collected at the end of each condition (M2 and M4).

Additionally, a manipulation check was done at the end of each condition, in which the participant was asked to describe the function of the robot in a few sentences. This question was added to the end of the online survey for M2 and M4 (at the end of each condition).

Lastly, an in-depth semi-structured interview (Appendix C) was conducted at the end of the experiment (M4) to gain more meaningful insights, be able to explain the findings and better understand how interaction between the person and the robot works. During this interview, the participants were asked about their experience with Vector, how they used the robot (e.g., placement, frequency, duration), and their experience with the different conditions. This interview was aimed at really understanding how the participant saw and used the robot. After this interview, the participants were compensated and thanked for their participation in this study.

2.6 Procedure

Before the experiment started, the participants were briefed on the experiment and their informed consent (Appendix A) was recorded. In total, the participants had a robot in their home for four days with one rest day in between the conditions. During each measurement point (M1-4, Figure 2) the researcher visited the participants home to install or retrieve the robot and the attitude measurements were conducted. During M1, the robot was installed in their home, together with the introduction of the condition with the information sheet, and the survey - including the demographic questions - was filled in by the participants. After two days, the robot was retrieved (M2) and the survey, behavior statistics and manipulation check were done. After a rest day, a new robot was installed with the information sheet for the second condition (M3), and the survey was conducted again. Two days later, the robot was retrieved again (M4) and the survey, behavior statistics, manipulation check and interview were done. The participants were asked to use the robot for at least 10 minutes each day the robot was in their home according to the interactions on the information sheet they received.

2.7 Data processing and analyses

The data from the online survey was exported and processed in a long format, meaning that each row consisted of the survey responses for one participant for one measurement point. Binary variables indicating the condition (utilitarian/hedonic), the starting condition (starting with the utilitarian/hedonic condition) and the time (pre-/post-interaction) were added manually. The statistical analyses were done with Stata, version 16.1.

A two-way repeated measures ANOVA with the role of the robot (utilitarian/hedonic) and the time (pre-/post-interaction) both as within factors was conducted. This was done for the affective and cognitive attitude, as well as for the investigation of the change in attitude. For the affective attitude, the NARS score was used as the dependent variable. This NARS score was created by summing the ratings of all items of the NARS per participant and per measurement point, as Nomura et al. (2004) suggested. The lower this score, the more positive the affective attitude. Similarly, the RAS score was included as the dependent variable for analyzing the cognitive attitude, which was created by summing the ratings of all items of the RAS per participant and per measurement point, as Broadbent et al. (2009) suggested. For this score, a lower rating also reflects a more positive attitude. In the collected data, no outliers were found with $|z| > 3$ and there were no missing values. Assumptions of normality (Shapiro-Wilk test: $p > .05$) and homogeneity of variances (Levene's test: $p > .05$) were met. As the repeated measures variables only had two categories, sphericity was assumed (the variances of the differences between the categories could not be compared).

For the behavioral attitude, several behavioral statistics were collected through the mobile app: number of wakewords used, distance driven, petting duration and the number of utilities used. Due to an error of the app during the data collection, the behavioral statistics of one participant of the utilitarian condition is missing.

Differences in behavioral attitude across the role of the robot (H3a and H3b) were investigated through paired samples t-tests. In the collected data, one outlier was found with $|z| > 3$. As dropping the outlier did not drastically affect the outcomes of the analyses, the reported results are with the outlier included (results without the outlier are reported in the footnotes). Due to violations of normality (Shapiro-Wilk test: $p < .05$, Skewness-Kurtosis test: $p < .05$), the data was transformed by taking the square root of the raw data. After transformation, assumptions of normality were met for all transformed variables, except for the number of utilities used in the utilitarian condition. As this was only a very slight violation (Shapiro-Wilk test: $p = .052$, Skewness-Kurtosis test: $p = .049$) and all other behavioral statistics variables could be regarded as having a normal distribution, further analyses were performed on this transformed data. The results are reported based on the transformed data, except for the descriptive statistics and the effect sizes which represent the raw data.

For the exploratory question, no hypotheses were formulated. The influence of the interaction with the robot was measured through pre- (M1 and M3) and post-interaction (M2 and M4) measurements of people's affective and cognitive attitude. Due to the two within-subjects factors, the aforementioned two-way repeated measures ANOVA was also used to measure the difference between the pre- and post-interaction attitude ratings.

Furthermore, correlations between the affective, cognitive and behavioral attitude were investigated. Because all three components should be measuring the person's attitude, an overlap in variance is expected. A repeated measures correlation was used for this (Bakdash & Marusich, 2017), as the affective, cognitive and behavioral attitude data was repeated across the conditions and over time.

Another important part of this study is the qualitative data from the interviews. During the semi-structured interviews conducted with each participant at the end of the experiment, notes were taken, and the audio was recorded to assist in the analysis of this qualitative data. The interviews were conducted in Dutch as that was the native language of both the participants and the researcher. The recordings and notes from the interviews were summarized – in English – per participant and patterns and recurring themes were obtained from this data. These qualitative results are used to provide context for, support and explain the quantitative findings described previously.

3. Results

3.1 The effect of the role of the robot

First, the main research question is investigated: what is the influence of the role of the robot on people's attitudes toward that robot? The descriptive statistics of all dependent variables across the utilitarian and hedonic role of the robot are provided in table 2.

Table 2: Descriptive statistics of the affective attitude scores (Negative Attitudes toward Robots Scale, NARS) - divided into the three subscales of the NARS -, cognitive attitude scores (Robot Attitude Scale, RAS) and behavioral attitude statistics (wakeword, distance, petting and utilities) across the conditions (utilitarian/hedonic).

	variable	**condition**	***M***	***SD***	***95% CI***
affective attitude	Total Negative Attitudes toward Robots Scale (NARS) score	utilitarian*	35.5	6.272	[33.494, 37.506]
		hedonic*	33.65	4.918	[32.077, 35.223]
	NARS-S1: situations of interaction	utilitarian*	14.85	3.409	[13.760, 15.940]
		hedonic*	14	3.021	[13.034, 14.966]
	NARS-S2: social influence	utilitarian*	12.825	2.754	[11.944, 13.706]
		hedonic*	12.075	2.043	[11.422, 12.728]
	NARS-S3: emotions in interaction	utilitarian*	7.825	2.341	[7.076, 8.574]
		hedonic*	7.575	2.074	[6.912, 8.238]
cognitive attitude	Total Robot Attitude Scale (RAS) score	utilitarian*	41.525	9.199	[37.804, 43.246]
		hedonic*	40.525	8.509	[38.583, 44.467]
behavioral attitude	number of wakewords used (#)	utilitarian**	52.95	37.90	[34.680, 71.215]
		hedonic***	66.45	48.79	[43.618, 89.282]
	distance driven	utilitarian**	4906.11	3481.76	[3227.951, 6584.26]

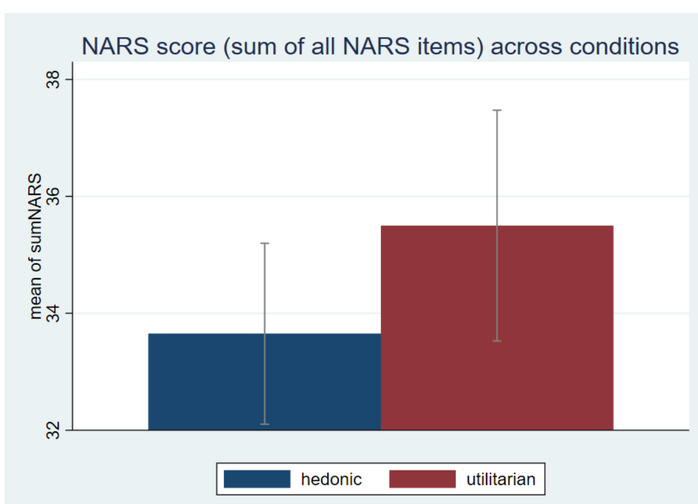
(cm)	hedonic***	4994.55	3862.46	[3186.864, 6802.236]
petting duration (sec)	utilitarian**	55	72.49	[20.059, 89.941]
	hedonic***	139.8	158.63	[65.558, 214.042]
number of utilities used (#)	utilitarian**	15	10.95	[9.720, 20.280]
	hedonic***	3.7	4.14	[1.760, 5.639]

* n = 40, ** n = 19, *** n = 20.

3.1.1 Affective attitude

A significant main effect of the role of the robot on people's affective attitude toward that robot was found, $F(1,19) = 8.10$, $p = .010$, $\eta^2_{partial} = .299$. Contrasting hypotheses H1a and H1b, participants' affective attitude was less positive when the robot had a utilitarian role ($M = 35.5$, $SD = 6.272$) compared to a hedonic role ($M = 33.65$, $SD = 4.918$) (Figure 4a). With the NARS score having a range of 14 to 70, the mean NARS scores suggest the overall affective attitude toward the robot to be slightly positive.

Table 2 and Figures 4b-d show that this difference in attitude across the roles of the robot still holds for each of the separate subscales of the NARS. However, the differences across the roles of the robot per subscale were not statistically significant (NARS-S1: $F(1,19) = 3.61$, $p = .073$, $\eta^2_{partial} = .160$; NARS-S2: $F(1,19) = 4.34$, $p = .051$, $\eta^2_{partial} = .186$; NARS-S3: $F(1,19) = 1.07$, $p = .315$, $\eta^2_{partial} = .053$). It should also be kept in mind that the reliability of the subscales was poor (α = .543 for S1, α = .403 for S2 and α = .623 for S3).



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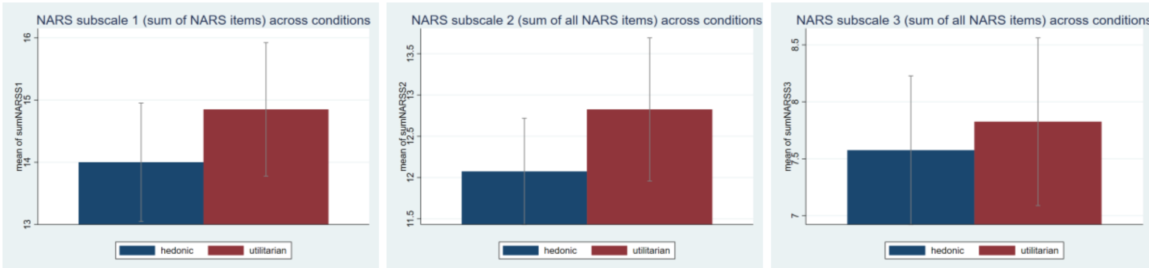


b) NARS-S1: attitude toward situations of interaction with robots

c) NARS-S2: attitude toward social influence of robots

d) NARS-S3: attitude toward emotions in interaction with robots

Figure 4: The means of the total NARS score and the subscales of the NARS across the conditions (hedonic/utilitarian). The lower the score, the more positive the attitude. **a)** mean NARS score, **b)** subscale 1: situations of interaction, **c)** subscale 2: social influence, and **d)** subscale 3: emotions in interaction.

3.1.2 Cognitive attitude

The cognitive attitude toward the robot was similar across the utilitarian (M = 40.525, SD = 8.509) and hedonic (M = 41.525, SD = 9.200) roles of the robot (Figure 5). This main effect was not statistically significant with $F(1,19) = 0.57$, $p = .461$, $\eta^2_{partial} = .029$. Thus, hypotheses H2a and H2b were not supported. As the RAS score can range from 11 to 88, the aforementioned mean RAS scores can be considered to indicate a slightly positive cognitive attitude toward the robot.

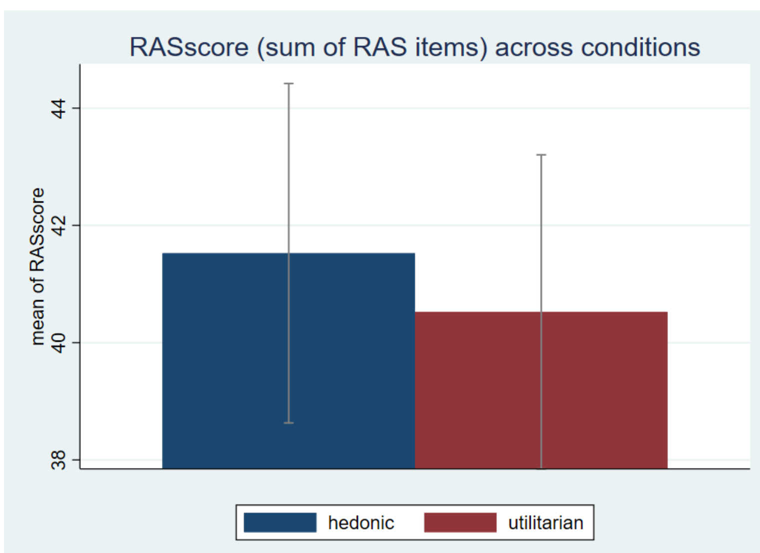


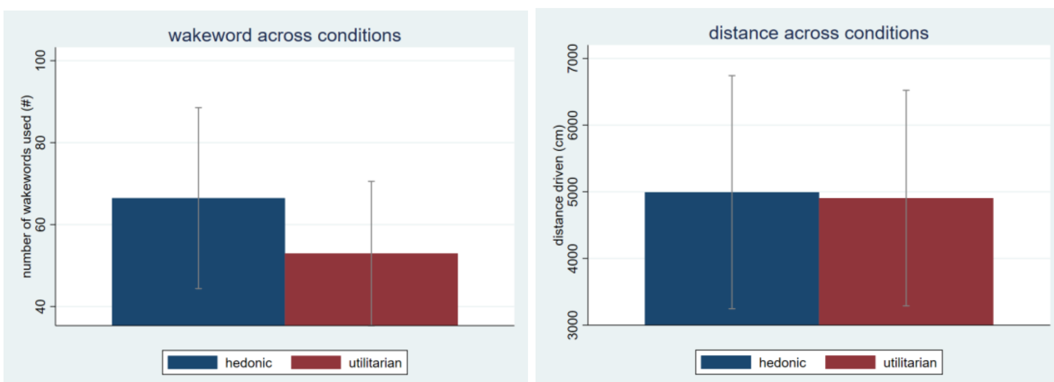
Figure 5: The mean of the total RAS score across the conditions (hedonic/utilitarian). The lower the score, the more positive the attitude.

3.1.3 Behavioral attitude

The wakeword and distance statistics are an indication of the frequency/duration of use of the robot. In general, higher number of wakewords used and larger distance driven suggest that the robot has been online – rather than turned off – for a longer time than with lower wakeword and distance statistics. The number of wakewords used and the distance driven do not differ significantly across the roles of the robot (Figure 6a and 6b). The paired t-tests of the number of wakewords used ($t(18) = -0.930$, $p = .365$, $d = -.229$)[1] and distance driven ($t(18) = -0.137$, $p = .892$, $d = -.051$)[1] across the conditions showed no statistically significant differences.

Participants petted the robot longer in the hedonic condition ($M = 139.8$, $SD = 158.632$)[1] compared to the utilitarian condition ($M = 55$, $SD = 72.494$)[1], $t(18) = -2.374$, $p = .029$, $d = -.464$[1] (Figure 6c). As the petting interaction was only provided on the information sheet for the hedonic condition and not for the utilitarian condition, this difference was expected (hypothesis H3a).

Participants used significantly more utilities when the robot had a utilitarian role ($M = 15$, $SD = 10.954$)[1] compared to a hedonic role ($M = 3.7$, $SD = 4.143$)[1], $t(18) = 5.842$, $p < .001$, $d = .971$[1] (Figure 6d), confirming hypothesis H3b.



a) **b)**

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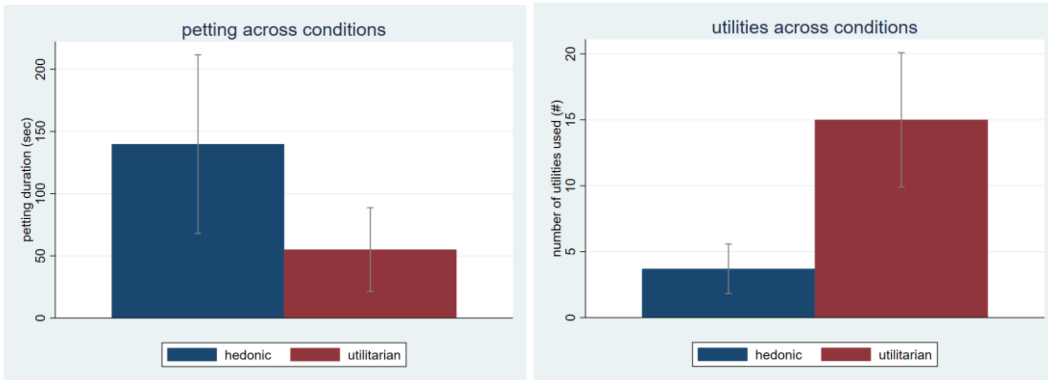
[1] Results without outlier:

Paired t-test of number of wakewords used across conditions: $t(17) = -0.548$, $p = .591$, $d = -.121$
Paired t-test of distance driven across conditions: $t(17) = 0.054$, $p = .958$, $d = -.005$
Petting duration in hedonic condition: $M = 114.211$, $SD = 112.863$
Petting duration in utilitarian condition: $M = 54.278$, $SD = 74.526$
Paired t-test of petting duration across conditions: $t(17) = -2.038$, $p = .057$, $d = -.406$
Number of utilities used in hedonic condition: $M = 14.611$, $SD = 11.136$
Number of utilities used in utilitarian condition: $M = 3.632$, $SD = 4.245$
Paired t-test of number of utilities used across conditions: $t(17) = 5.474$, $p < .001$, $d = .924$



c) **d)**

Figure 6: Behavioral statistics across conditions (hedonic/utilitarian). **a)** number of wakewords used (#), **b)** distance driven (cm), **c)** petting duration (sec), and **d)** number of utilities used (#).

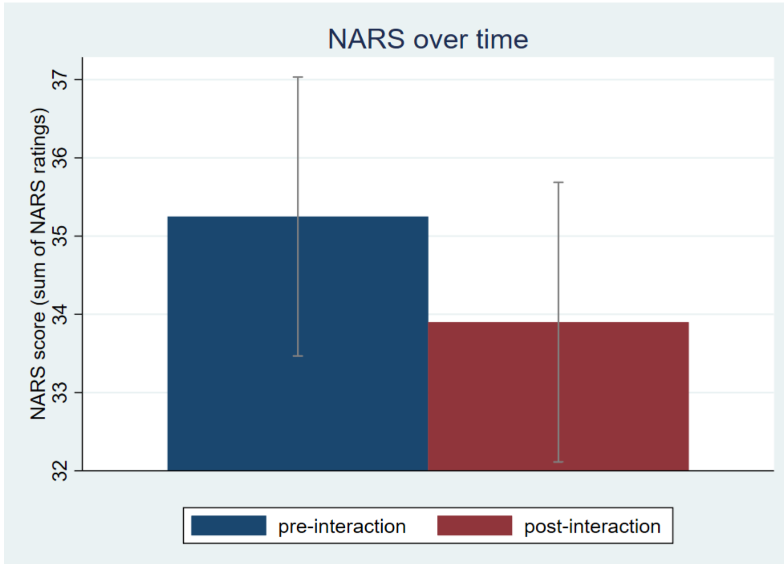
3.2 The effect of interaction with the robot

To determine the effects of the interaction with a social robot on attitudes toward that robot (the exploratory question), the pre- and post-interaction measures of the affective and cognitive attitude were compared.

3.2.1 Attitude change in affective attitude

Using the same two-way repeated measures ANOVA as previously, the effect of time (pre-/post-interaction) was investigated. The results indicate a statistically significant main effect of time (pre-/post-interaction) on people's attitude toward the robot ($F(1,19) = 4.63$, $p = .045$, $\eta^2_{partial} = .196$). As figure 7a visualizes, the NARS score is lower – and thus more positive – after the interaction with the robot ($M = 33.9$, $SD = 5.679$) compared to before the interaction ($M = 35.25$, $SD = 5.665$). When divided into the three subscales of the NARS (Figures 7b-d), no statistically significant effect of the time on participants' affective attitude was found (NARS-S1: $F(1,19) = 4.38$, $p = .050$, $\eta^2_{partial} = .187$; NARS-S2: $F(1,19) = 0.67$, $p = .423$, $\eta^2_{partial} = .034$; NARS-S3: $F(1,19) = 0.51$, $p = .482$, $\eta^2_{partial} = .026$).

The interaction effect between the role of the robot and the time was not statistically significant, ($F(1,19) = 1.83$, $p = .192$, $\eta^2_{partial} = .088$), which means that the effect of the time (pre-/post-interaction) is not significantly different across the conditions of the role of the robot (utilitarian/hedonic).



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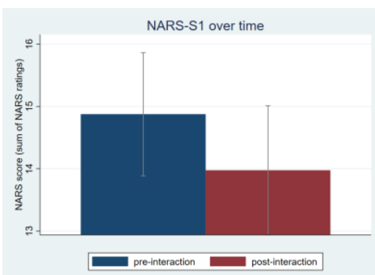

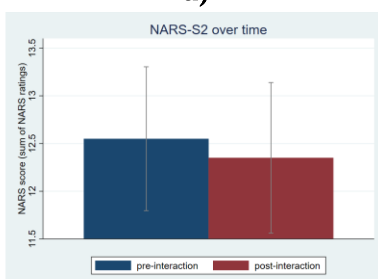

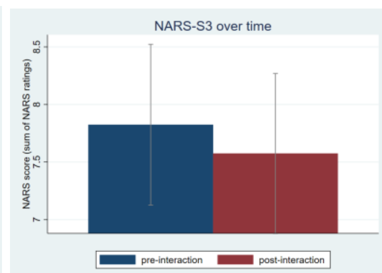

b) NARS-S1: attitude toward situations of interaction with robots

c) NARS-S2: attitude toward social influence of robots

d) NARS-S3: attitude toward emotions in interaction with robots

Figure 7: The means of the total NARS score and the subscales of the NARS across the time (pre-/post-interaction). The lower the score, the more positive the attitude. **a)** mean NARS score, **b)** subscale 1: situations of interaction, **c)** subscale 2: social influence, and **d)** subscale 3: emotions in interaction.

3.2.2 Attitude change in cognitive attitude

The two-way repeated measures ANOVA did not show a statistically significant effect of time on participants' cognitive attitude (Figure 8), $F(1,19) = 0.87$, $p = .362$, $\eta^2_{partial} = .044$. The interaction effect between the role of the robot and the time ($F(1,19) = 0.11$, $p = .742$, $\eta^2_{partial} = .006$) was also not statistically significant, indicating no significant difference in the effect of time on the cognitive attitude toward the robot across the roles of the robot.

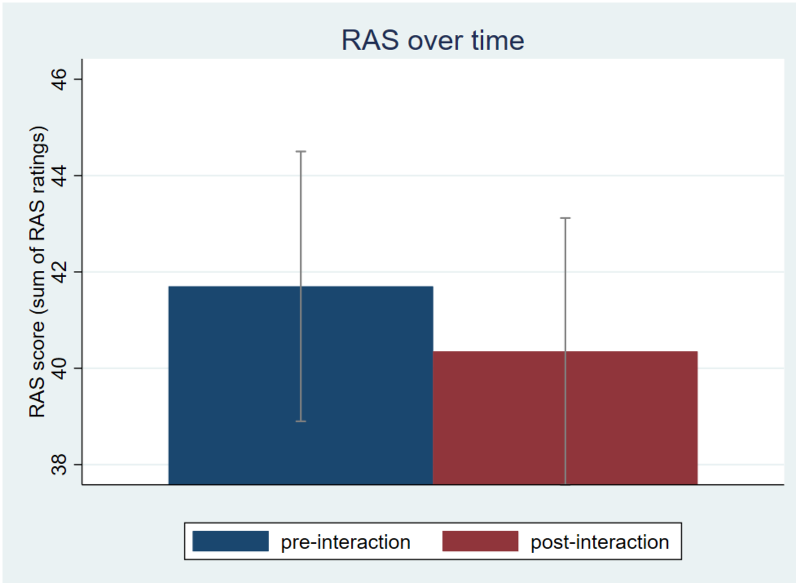

Figure 8: The mean of the total RAS score across the time (pre-/post-interaction). The lower the score, the more positive the attitude.

3.3 Correlation between attitude components

As all measurements should be measuring the participant's attitude, some correlation between the NARS, RAS and behavioral statistics was expected. To investigate these correlations, a repeated measures correlation was used (Table 3; Bakdash & Marusich, 2017). This analysis accounts for the attitude variables being repeated across both the condition and the time.

Table 3: Repeated measures correlation (r_{rm}) between the affective attitude (NARS), cognitive attitude (RAS) and behavioral attitude (wakeword, distance, petting and utilities). Statistically significant correlations ($p < .05$) are shown in bold.

Correlating variables		r_{rm}	p	95% CI
NARS score	RAS score	**.29***	**.024**	**[0.036, 0.508]**
	wakeword	.01**	.976	[-0.461, 0.472]
	distance	- .05**	.830	[-0.506, 0.426]
	petting	- .34**	.149	[-0.693, 0.156]
	utilities	.20**	.396	[-0.294, 0.61]
RAS score	wakeword	.17**	.485	[-0.326, 0.587]
	distance	.05**	.846	[-0.43, 0.502]

	petting	- .11**	.642	[-0.549, 0.376]
	utilities	- .05**	.822	[-0.508, 0.424]
wakeword	distance	**.62****	**.003**	**[0.222, 0.845]**
	petting	**.75****	**< .001**	**[0.427, 0.899]**
	utilities	.27**	.246	[-0.223, 0.656]
distance	petting	.28**	.239	[-0.219, 0.658]
	utilities	.21**	.073	[-0.07, 0.736]
petting	utilities	- .19**	.426	[-0.602, 0.305]

* *df* = 59, ** *df* = 18

A statistically significant positive correlation was found between the affective (NARS) and cognitive (RAS) attitude, indicating that with a higher NARS score (more negative affective attitude), the RAS score also increased (more negative cognitive attitude). No significant correlations were found between the affective or cognitive attitude and the behavioral attitude.

3.4 Interview data

3.4.1 General findings

Overall, participants compared the robot in the hedonic role most often to a pet and considered it a social being. For example, it was described as a companion and cozy (*Dutch: gezellig*), and as more informal and personal compared to the utilitarian role. The robot in the utilitarian condition was often compared to voice assistants such as Google Home, Alexa or Siri, and described as a small machine or computer and more formal, intelligent or serious than the hedonic one. This indicates that the manipulation of the role of the robot was successful, and the answers to the manipulation check question in the survey also support this.

However, there were three participants that did not notice a difference between the conditions except for the change in eye color. Two of these participants also mentioned not being home much, and thus they might not have interacted with the robot much. This also points to a minimum duration of interaction in order to notice a change in attitude. When interacting with the robot very little, it might be more difficult to get a good feel for the robot, possibly influencing participants' perception of the robot in the different roles. The mixing of interactions across the conditions also might have influenced the success of the manipulation. Although they were asked to stick to the interactions of the condition they were in, some participants did use interactions of their first condition in their second condition. This mixing might have decreased the difference between the two conditions and thus decreased the success of the manipulation. After these participants were told about the difference after the ending of the experiment, they did agree and notice that difference when looking back at their experience.

As for the context of use, the majority of participants (15 out of 20) lived in a student house with shared commodities, with the other five participants living alone in either a studio or apartment with no shared commodities. The robot was most often placed either on a table/desk or on the floor in their own room or studio/apartment. The interaction times varied, depending on when the participant was home (e.g., before leaving for work, after coming home, in the evening or while studying at home). Many participants also mentioned demonstrating (in-person or through video calling) or showing pictures/videos of the robot to roommates, friends or family.

3.4.2 Affective attitude

The outcomes of the statistical analyses showed a more negative affective attitude in the utilitarian condition compared to the hedonic condition. Although this contrasts the hypotheses for the affective attitude, the interviews corroborated the findings, indicating that most participants preferred the robot in the hedonic condition over the one in the utilitarian condition.

As participants perceived the robot in the hedonic role much more as a social being compared to the robot in the utilitarian role, this gave rise to feelings of pride (e.g., when the robot correctly executed a command), guilt (e.g., when turning the robot off), loss (after the robot was retrieved from their home) or companionship (e.g., having something to come home to). These feelings indicate that participants formed a bond/attachment to the robot, which might explain their preference for the hedonic role over the robot in the utilitarian role to which they did not feel strongly attached.

Furthermore, frequently mentioned negative aspects of the robot – such as slow responses of the robot, robot often not understanding the participant and having to say the wakeword repeatedly before it recognizes it – might have affected participants’ affective attitude toward the robot more heavily in the hedonic role than in the utilitarian role. While all utilitarian interactions must be initiated with the wakeword (during which these negative aspects are more prevalent), the more social and emotional behaviors of the robot do not necessarily require user initiative (e.g., the robot automatically shows emotions through its eyes and sounds, and it can start playing with its cube on its own). This might also have played a role in participants’ affective attitude being more negative toward the robot in the utilitarian role and more positive toward the robot in the hedonic role. However, no significant difference in number of wakewords used between the two conditions was found. This behavioral statistic only records the number of wakewords that the robot recognized, so the failed attempts – which might be higher in the utilitarian condition than in the hedonic condition as explained before – are not recorded.

3.4.3 Cognitive attitude

While the participants did describe and think of the robot in the utilitarian role differently than the robot in the hedonic role, the statistical analysis did not show a significant difference in cognitive attitude toward the robot across the conditions.

Although most participants acknowledged the limited capabilities of the robot, its intelligence or knowledge also impressed some participants, as it was higher than expected (but still limited). As one participant put it, when trying something new they thought "oh this is also something it can do", which may have positively influenced their cognitive attitude toward the utilitarian role of the robot.

Additionally, there were some participants that mentioned not needing the social connection provided by the hedonic role of the robot. Their need for social interactions was already satisfied by seeing their friends and family regularly, so having the robot was not necessary for them. Two participants also thought the robot would be better suited for elderly or people who are lonely, as they might have more time and a lack of social interactions that the robot could fill in and support them with. This suggests that the hedonic aspects of the robot were less important to them, perhaps influencing their cognitive attitude toward the hedonic role negatively.

Moreover, some participants found some items of the RAS a bit ambiguous. For example, one participant was not sure about the "simple-complex" item, as they found the interaction simple, but the robot itself quite complex. Another participant mentioned that they found the robot "easy to use" if it worked properly but it often did not respond, and someone else found the item "strong" a bit vague. This might have influenced participants' rating and thus possibly explain the non-significance of the difference in participants' cognitive attitude across the roles of the robot.

3.4.4 Behavioral attitude

As expected, the behavioral attitude of the participants was quite clearly visible in the quantitative behavior statistics measured. Through the interviews it became clear that participants did not notice many behavioral differences or changes themselves. They were asked to stick to the interactions on the information sheet corresponding to the condition they were in, so differences related to that might not have been considered noteworthy for the interview. One participant did mention that they used the timer function of the robot to show how long they had before they had to leave in the morning, which they had never done before. Furthermore, several participants reported that the robot could be distracting – mainly due to the noise the robot makes –, which sometimes led to participants turning the robot off. Most participants indicated an intention to use the robot, but not for longer than several weeks or months, due to the limited capabilities and low usefulness (e.g., "after a while you have finished the robot", "googling it myself is quicker").

3.4.5 Attitude change due to interaction

Participants' experiences with the robot were generally positive, as the majority (16 out of 20 participants) reported that they would want to keep the robot, regardless of which role of the robot they had last. Even though most would only want to keep it for a limited time and without paying for it, they did like it enough to want to spend more time or experiment with it. The few participants that did not want to keep the robot explained that they did not see the practical/added value, found it very annoying or were concerned about privacy. Moreover, one participant mentioned not really being into robots or voice commands previously, but they emphasized having a positive experience with this robot. Such positive views on the robot clearly indicate the aforementioned positive effect of the interaction with the robot on people's affective (statistically significant) and cognitive (not statistically significant) attitude found in the quantitative analysis.

4. Discussion

The aims of this study were to investigate the influence of the role of a social robot (utilitarian or hedonic) on people's attitude toward that robot. Hedonic aspects seemed to be more important – as opposed to utilitarian aspects – in the affective attitude, showing results opposite to hypotheses H1a and H1b. No significant difference was found in the cognitive attitude across the roles of the robot, leading to the rejection of hypotheses H2a and H2b. The role of the robot has been found to influence specific behaviors toward the robot, as petting duration was higher with the hedonic role of the robot and number of utilities higher in the utilitarian condition (confirming hypotheses H3a and H3b). Through the qualitative data, it became clear that participants saw the robot very differently when the robots had different roles. The exploratory investigation into changes in attitude due to interaction with the robot showed a positive effect. Short-term attitude change seems to be more dependent on utilitarian aspects and the novelty effect, while hedonic aspects might play a larger role in the long-term.

Both the quantitative and the qualitative results have indicated that there were differences in people's attitude toward a robot across the roles of that robot. Overall, the robot in the utilitarian role and the robot in the hedonic role were regarded as two different robots, indicating that people do view robots differently if they have a different role. Whereas the manipulation of the role of the robot only consisted of providing different information sheets – containing a different set of interactions – for the two Vector robots, participants took it a step further as they ascribed different roles to the two robots themselves. The robot in the utilitarian role was often compared to assistants and described as a small machine, computer or tool, while the robot in the hedonic role was mostly compared to a pet and described as a companion. This is in line with the distinction between utilitarian and hedonic aspects of a robot as described in previous literature (de Graaf et al., 2015; Hassenzahl & Tractinsky, 2006; van der Heijden, 2004; Dautenhahn, 2007), and it underlines the success of the manipulation of the role of the robot. When looking at the means of the affective and cognitive attitude in general, a slightly positive attitude was found. This supports the findings of the extensive literature review by Naneva et al. (2020) that reported an overall positive attitude toward robots.

Diving deeper into the differences in attitude between the roles of the robot, participants' affective attitude was significantly more positive when the robot had a hedonic role compared to a utilitarian role. This finding contrasts the corresponding hypotheses, which were based on the importance of utilitarian aspects of the robot (Horstmann & Krämer, 2019; Ezer et al., 2009; Fink et al., 2013) and the preference of an assistive robot over a companion robot (e.g., Enz et al., 2011; European Commission, 2012; de Graaf & Allouch, 2016; Ray et al., 2009; Takayama et al., 2008). Through the interviews it became apparent that the majority of participants liked the social aspects of the robot the most and that those aspects elicited feelings of companionship, pride, guilt and loss. As previously emphasized by Sung et al. (2008) and Horstmann & Krämer (2020), this suggests that hedonic aspects of social robots are very important to people's evaluation of (the interaction with) a robot.

No significant differences were found in participants' cognitive attitude across the conditions of the role of the robot, even though the descriptions of the robot given in the interviews do show that the robot in the utilitarian condition was thought of differently from the robot in the hedonic condition. A possible explanation for this could be that different items of the RAS might appeal more to different roles of the robot (e.g., "useful" relating more to utilitarian aspects and "friendly" more to hedonic aspects). However, when looking at the individual items of the RAS across the conditions (Appendix D), there did not seem to be large differences between the utilitarian and hedonic condition. Furthermore, the explicit measurement of the cognitive attitude led participants to think about their attitude toward the robot, allowing them to rationalize their answers. When having to think about the specific items of the RAS with regard to the robot, some participants found the RAS to be a bit ambiguous. As Stapels and Eyssel (2021) suggested, the participants were asked about their doubts and ambivalence regarding the survey items during the interview. In this cognitive effort, overall negative aspects of the robot (e.g., slow responses of the robot, the robot often not understanding the voice commands) might have been weighed against the benefits of the utility (in the utilitarian condition) or the companionship (in the hedonic condition) of the robot, leading to a similar cognitive attitude in both conditions. The interview responses revealed some ambivalence toward items of the RAS, for example participants finding the robot to be smarter than expected but still quite stupid or finding the interaction simple but the robot itself complex. Such ambivalence within individual items of the RAS might have invoked uncertainty-related negative feelings (Rothman et al., 2016; Dang & Liu, 2021). This might have impacted the responses to the RAS and possibly resulted in the non-significance of the effect.

The behavioral statistics revealed that participants did use the robot differently – in terms of petting duration and number of utilities used – across the roles of the robot. As utilitarian aspects are related to more extrinsic objective in the interaction with the robot, and hedonic aspects more to intrinsic value (Hassenzahl & Tractinsky, 2006; van der Heijden, 2004), people's motivation to interact with the robot might also play a role in their behavior toward the robot. According to the Self-Determination Theory (SDT; Deci, 1975; Deci & Ryan, 1985), intrinsic motivation leads to a higher motivation for a certain behavior than merely extrinsic motivation. In this case, this suggests that people might be more motivated to use the robot in the hedonic role (due to its intrinsic value) – and thus use it more – than the robot in the utilitarian role. During the interviews, participants often mentioned the low usefulness of the robot (e.g., "googling it myself is quicker") as one of the reasons not to use the robot, whereas the hedonic interactions were generally liked. Such low extrinsic motivation for interaction with the robot in the utilitarian role may have influenced participants' behavior toward the robot. However, no significant difference in the number of wakewords or distance driven was found. This might have been due to participants trying to comply with the instructions given by the researcher, as they were asked to interact with the robot for at least 10 minutes per day. Differences in petting duration and number of utilities used across the utilitarian and hedonic condition were part of the manipulation, as the utility interactions were only provided on the utilitarian information sheet and the petting interaction only on the hedonic information sheet.

Aside from the differences in the roles of the robot, participants generally viewed the Vector robot as a gadget or toy; something to try out or show to others. As some participants explained, it was nice to have at home, but not necessary. When asked whether they would want to keep the robot, participants either would not want to (due to having no use for it) or only for a limited time (thinking they would not use it as much long-term). This is in line with findings by Weiss et al. (2021) on the adoption of the Vector robot in households, who indicate that the hedonic aspects of the robot (e.g., entertainment value) decrease over time, while the social gains (e.g., social status and connecting people) are more long-term. Similar conclusions were drawn in the long-term study by de Graaf et al. (2015). This shows that utilitarian aspects such as usefulness could play a larger role in short-term interactions, while hedonic aspects might be more important in long-term interactions.

An explanation for these findings could be the novelty effect; the fact that it is something new and unfamiliar may affect people's responses to it. This effect wears off after some time – it has been suggested that this takes around two months of use (de Graaf et al., 2016; Sung et al., 2009; Fink et al., 2013) –, which might then lead to a decrease in interest and a more negative attitude. Additionally, the limited capabilities of the robot may also have played a role in this. As there was a limited number of interactions a person can have with the Vector robot, participants explained that they started to feel like they "had finished" the robot toward the end of the experiment and became more bored with it. While the technology could still be entertaining even after the novelty effect has worn off, most participants thought this robot would be collecting dust in the closet several weeks or months later.

However, the results of the participants' attitude over time (pre- and post-interaction) also show that their attitude became more positive over time. A statistically significant difference in affective attitude across the pre- and post-interaction measurements was found, contrasting other studies that did not find an attitude change using the NARS (Mirnig et al., 2017; de Graaf & Allouch, 2013b; Manzi et al., 2021; Kim et al., 2016). The experiment duration (2 days per condition, 4 days in total) might have been too short for the novelty effect to wear off, which may have allowed the attitude to become more positive over the experiment duration. The overall positive experience with the robot may also be reflected in this positive attitude change. Anxiety (de Graaf et al., 2013b; Stafford et al., 2010) and initial expectations (Edwards et al., 2019) have been pointed out to influence attitude change. For example, being able to try the robot out might positively affect a person's apprehension of robots (as one participant mentioned) and the capabilities of the robot might exceed people's expectations, making their experience with the robot more positive. Based on this, a relatively short interaction with a social robot can lead to a more positive attitude toward that robot, but this effect might not stay the same over a longer time.

It should be noted that this investigation of the effect of interaction with a robot on attitude was exploratory. Other relevant variables were not directly included in the current study, and thus the results of this study do not go in-depth into the mechanisms underlying this effect. Further research on attitude change due to interaction with a robot is needed – including the aforementioned relevant variables – to better understand such changes in attitude.

When taking a closer look at the interplay between the three attitude components, a significant positive correlation between the affective and cognitive attitude was found. The medium correlation found here indicates the affective attitude to be congruent with the cognitive attitude. This is in line with previous research proposing a moderate correlation between the three components of attitude (Breckler, 1984; Ostrom, 1969). However, the affective nor the cognitive attitude correlated significantly with the behavioral attitude. This corroborates previous research that has suggested that the NARS has limited predictive power of user behavior towards robots (Fraune & Sabanovic, 2014; Walker & Bartneck, 2013). Thus, the relevance of (affective or cognitive) attitude in behavior prediction as suggested in previous literature (Ajzen, 2003; Davis, 1989; Heerink et al., 2010; Venkatesh et al., 2003) cannot be supported by the results of the current study.

4.1 Limitations and recommendations for further research

The small and largely homogenous participant sample – 20 participants, mostly females, and all young adults, (former) higher education students and living in Eindhoven, the Netherlands – was recruited through convenience sampling, making it prone to several sample biases. As gender (e.g., Beraldo et al., 2018; Nomura et al., 2006), age (e.g., Chien et al., 2019; Kuo et al., 2009) and culture/nationality (e.g., Lim et al., 2021; Nomura et al., 2006; Bartneck et al., 2007) effects on attitude toward robots have been previously indicated, they might have influenced the results of this study as well. The use of random sampling can ensure that the probability of being selected is equal for each participant, allowing for more accurate inference and generalization. Although the statistical analyses might have been limited by the sample size, the quantitative and qualitative data do provide more insight into the dichotomous roles of a social robot and people's attitude toward and perceptions of robots, which revealed directions for further research.

Another important note is that – as most previous research on attitudes toward robots – self-report measures were used to measure attitude. This means that only the explicit attitude – and not the implicit attitude – was investigated, making the results more vulnerable to several biases (Fischer & Katz, 2000). While explicit responses need cognitive resources and are made more consciously, implicit responses relate more to subconscious affective reactions (Sanders et al., 2016; Smith & Nosek, 2011). A person's implicit attitude can differ from their explicit attitude, for example due to not being aware of or understanding their attitude, or due to concealing their attitude (e.g., self-presentation or social desirability biases) (MacDorman et al., 2009). Especially as implicit measures are related to the affective attitude, it would be very insightful to investigate the implicit attitude toward social robots – both in general and across the roles of a robot – in more depth.

The home setting of the experiment enabled more ecological valid results, allowing the participants to respond to and interact with the robot as they find comfortable and how they naturally would. However, this also meant that it was more difficult to control all variables compared to a lab study. The manipulation of the role of the robot was not very strict and not in a controlled environment. From the interviews it became clear that not all participants kept strictly to the interactions provided on the information sheet corresponding to the condition they were in. This may have reduced the success of the manipulation by decreasing the differences between the roles of the robot. However, the distinction between the utilitarian and hedonic roles of a social robot was very pronounced in the qualitative data, highlighting this distinction as a very interesting topic for further research. A more controlled setting allows for a much more focus on the role of the robot, through which more insights into the exact influence of the role of the robot – on perceptions of and interactions with the robot – and the underlying processes can be gained.

Lastly, it should be noted that a variety of interpersonal differences may have influenced participants' perceptions of and interactions with the robot across the utilitarian and hedonic conditions. anthropomorphism – the tendency to attribute human characteristics to non-humans – (e.g., Lee et al., 2011; Sheinbaum et al., 2015), attachment style (e.g., Wan & Chen, 2021; Reich & Eyssel, 2013), anxiety and trust (e.g., Naneva et al., 2020; de Graaf & Allouch, 2013b; Nomura et al., 2008), and prior knowledge, experiences and expectations (e.g., Sanders et al., 2017, Horstmann & Krämer, 2020; Arras & Cerqui, 2005) to be related to people's attitude toward a robot. While the exact effects of these interpersonal differences on the results of this study cannot be inferred, it is very plausible that they are related to the effect of the role of the robot on attitude toward the robot (e.g., higher anthropomorphizing of the robot in a hedonic role, relating to a stronger attachment to that robot (Wan & Chen, 2021); feeling of being watched (Klamer et al., 2010) – related to hedonic aspects – or concern about data collection (Sharkey & Sharkey, 2010) – related to utilitarian aspects – impacting anxiety and trust). These variables provide interesting opportunities for further research, enabling a better understanding of (the interplay between) these variables and the roles of, interactions with and attitudes toward a social robot.

5. Ethical concerns

While discussing the outcomes of the study in the broader context of the research field is a common practice, extending this with a discussion from a larger societal and ethical perspective can provide a much more insightful and holistic view of the research topic. This discussion of relevant ethical concerns goes beyond research ethics such as ethical approval, codes of scientific conduct and informed consent. Whereas technological development often strives for efficiency and innovation, it is important to also consider the ethical and societal implications of such technological developments. Such issues can be very difficult moral questions that might not have a clear answer, and the answers most likely differ across societies, groups and individuals. Although some important ethical concerns relevant to this study are touched upon below, it should be noted that the issues mentioned are not a complete and exhaustive list.

5.1 Regulatory issues

As the Vector robot used in this study is a commercially available robot, several more regulatory issues become very relevant. There is quite some uncertainty for consumer use of robots, mainly due to legislation and regulation being absent or unclear. Although there are some regulatory initiatives revolving around robots and artificial intelligence (AI) technologies (e.g., the European Parliament Resolution on Civil Law Rules on Robotics (European Parliament, 2017); the Ethics Guidelines from the European High-Level Expert Group on Artificial Intelligence (European Commission, n.d.-a)), the EU does not yet have specific legislation on robotics (García Molyneux & Oyarzabal, 2017). There are several issues relevant to the legislation around robots, such as the responsibility and liability of robots, accessibility (also relating to discrimination), and (data) security and privacy, which makes the legislation quite complex.

First of all, who is responsible for maintaining the robot and ensuring that it is working properly? And what would happen if something went wrong due to robot actions, errors or malfunctions? Who would be liable; the robot manufacturer, the owner or the robot itself? Moral and legal responsibility issues regarding robots often seem to come down to robots being viewed as moral agency or not (Sharkey, 2017). The control over and the autonomy of the robot comes into play here as well. Programming or training robots to make moral decisions in social situations could be a solution to minimize wrong robot actions (Sharkey, 2017). However, this would require determining of which decisions are moral and which are not – which can be highly debated. If the robot is programmed by a person, can the responsibility and liability then still be put on the robot itself? In the case of human-robot interaction research, the researchers are another stakeholder that can be held responsible. Here, informed consent is crucial for participants to be made aware of and agree to the responsibility distribution. As for now, robots and AI are generally seen more as tools and not as morally responsible agents (Gogoshin, 2021; Henz, 2021), and thus responsibility and liability is often assigned to the person in control of the machine (e.g., the court indicated the human co-driver in a fatal accident with Uber's autonomous test drive for criminal negligence; Henz, 2021). However, through technological developments, robots might become much more advanced in such a way that moral responsibility can be assigned to robots more easily. As this issue of responsibility is very complex and highly debated, other research provides a much more in-depth evaluation (e.g., Tigard, 2020; Gogoshin, 2021; Henz, 2021).

Secondly, an important issue is the accessibility of robots – and advanced technology in general. Technology can be quite expensive, especially new and state-of-the-art technologies. There is a digital divide in which some might have less access to digital resources than others (van Dijk, 2020). Whereas physical access used to be the focus of the divide, nowadays the divide is more focused on skills and usage. Factors such as income, education and health status may play an important role in this (Cullen, 2001). Is this divide something that should be tackled through regulatory measures, for example subsidies for certain technologies (e.g., robots) to ensure equal access? But then, what would be the rules for who can get those subsidies and for which kind of technologies? While such regulations might be meant to improve equality and accessibility, they might also exclude others. This is also closely tied to issues of discrimination. Solutions to such digital divide can refer to the distribution of the technology (e.g., sharing programs), financial investment in the development of technology, public policy or improving related user characteristics such as education or social economic status (Houston & Erdelez, 2002; Kim, 2011). Researching and implementing such solutions and evaluating their effects can help us to narrow the divide and improve the accessibility of technology.

Lastly, as also has been mentioned by the participants in the current study, (data) security and privacy are important issues. In this information society, data is collected, stored, analyzed and disseminated in bulk, with online services and platforms often being based on a trade-off between access to the service or platform and sharing personal data (and thus a loss of privacy) (Mitchell & Clapperton, 2013). Awareness and understanding of this trade-off might be very important, but this also frames the consumer as the burden to protect their data (Draper, 2017). Nowadays there are several data protection and privacy laws, such as the European Union's General Data Protection Regulation (GDPR; European Commission, n.d.-c) and the European Cybersecurity Act (European Commission, n.d.-b), which protects people's right to protection of their personal data and boosts the cybersecurity of online services and consumer devices. While privacy is generally seen as something that needs to be protected, there is still debate about what exactly should be protected, who is responsible for this data protection and how exactly should this data be protected (Martin & Murphy, 2017)? Although privacy issues are included in Codes of Conduct (e.g., American Psychological Association, 2017; "TU/e Code of Scientific Conduct", 2019), human-robot interaction research often depends on data collected with the robot and digital tools and technologies are often used to assist in the experiment or analyses (e.g., crowdsourcing to analyze video data (Lasecki et al., 2015)). This makes the human-robot interaction research very vulnerable to privacy violations. To minimize potentially damaging consequences, a conservative approach to privacy protection can be beneficial and the methodology of the experiment should be designed carefully (Kelman, 1977; Punchoojit & Hongwarittorrn, 2015). Additionally, in this digital age, the concept of the "right to be forgotten" has become increasingly popular – and it's now also included in the GDPR (Villaronga et al., 2018; GDPR.eu., n.d.). Whereas humans naturally forget things, data can be stored eternally in the digital world. The erasure of personal data may therefore be as important as the generating and collecting of data, although exact regulation of this might be quite complex (Villaronga et al., 2018).

As robots are becoming much more prevalent in our daily lives, such more regulatory issues are very important to address. However, there are also many broader issues regarding the ethics and morality of robots that are relevant and merit discussion.

5.2 The model for and aims of human-robot interaction

Human-robot interaction research (especially regarding social robots) often models it after human-human interaction. For example, research directions within this field are how to make robots understand humans and how to make robots behave, think or feel like humans do. However, the question is: do we want our interactions with robots to be the same as with other humans?

If this would not be a desirable direction for robot research and development, what would be? Another possible direction might be a completely different way of interacting with robots. Similar to how we adapted to and created new ways of interacting with other technologies (such as smartphones), human-robots interaction might also develop into a new interaction style. Not striving for innovation at all (i.e., not developing robots or AI any further) might go against personal or societal values and norms.

On the other hand, if robots would become very similar to humans, several issues might arise. The robot used in the current study – Vector – can be considered still quite limited in its utilitarian and hedonic aspects. But what would happen if those robot aspects became much more advanced, as this seems to be the direction for robot development? What if social robots can perform tasks as well as humans do, or interact with humans as humans do? Advancements in both the utilitarian and hedonic aspects of robots can lead to a variety of consequences. As the development of utilitarian aspects of robots is more advanced – at least for now – than that of hedonic aspects, issues regarding these utilitarian aspects might be more prevalent in the near future. However, much of the human-robot interaction research is nowadays focused on more hedonic aspects of robots, so concerns about these aspects might become much greater in the coming decades.

5.3 Issues regarding the utilitarian aspects of robots

Robots are often seen as very useful, effective and efficient machines that can do certain tasks for us. These practical aspects of robots allow us to offload tasks, which could make our lives and jobs easier. Furthermore, robots can be deployed in natural disasters, dangerous situations or unsafe environments instead of humans, and thus decrease (potential) risks for humans and improve our health and quality of life. Although robots could be very beneficial, there could also be some negative consequences.

As is already partly happening (e.g., automated machines taking over factory work), the development of robots could lead to most – or even all – of our tasks and jobs being taken over. While this could allow us to have more free time, enjoy this time and organize it as we want, an issue of over-dependence on technology might also arise. Humans might then become incapable or unwilling to do even simple tasks, becoming lazy or even helpless without the support of robots. This is already happening with other technologies, such as computers and smartphones. We often store a lot of information on such devices, so that we only have to remember where we stored the information rather than the information itself (Risko & Gilbert, 2016). It has been shown that this cognitive offloading can decrease our memory skills (Grinschgl et al., 2021).

Moreover, if robots have replaced our work and tasks, what would be the purpose of humans? Nowadays, labor is a basic part of the human condition (Gransche, 2018), so removing this part of human life could lead to drastic changes. It should be noted that our lives have changed to revolve around labor, as this was not a main part in life in the early years. Similarly, humans are likely to reinvent what constitutes life if robots take over our labor. On one hand, it might allow humans to flourish, pursue meaningful tasks and spend their time as they wish. On the other hand, it might also lead to a lack of interest or desire, a decrease in people's feeling of self-worth or purpose and an increase in illegal or criminal activity.

Lastly, there is a question whether the use of assistive and obedient robots (e.g., a social robot that is merely used in a utilitarian role) are morally permissible. Especially if those robots – next to utilitarian aspects – also have more social qualities, the relationship between humans and that robot might resemble a master-slave relationship. As such a relationship is considered reprehensible between humans, would this be different if the relationship was between humans and robots? Is such a way of treating another not always wrong, regardless of whether that other is a human, animal, object or robot? And what about the robot's rights? If the robot would have rights, a master-slave relationship would most likely fundamentally diminish the robot's individual rights (depending on the rights the robot would get).

5.4 Issues regarding the hedonic aspects of robots

Next to assisting humans, social aspects of robots could provide people with social support or mitigate loneliness. Though this is often thought to be beneficial for elderly, there are many other (groups of) people that could benefit from a social robot companion. However, there could also be downsides to attachment to or relationships with robots. Advancements in the social aspects of robots might lead to robots being perceived as equal to humans, as this is one of the areas where robots are not yet on par with humans. It must be noted that while the effects of more long-term interaction are being researched more and more, they are still largely unclear or unknown. So, what would happen if the social skills of robots reached a similar level as humans, facilitating human-robot attachment and relationships?

First of all, there is the question whether human-robot relationships in any shape or form (e.g., platonic, romantic or sexual) can be considered moral. People can become attached very easily and even to inanimate objects. As with human-human relationships, human-robot relationships could become very strong and impact people's lives immensely. However, robots are generally seen as different to humans, in the sense that robots might only be able to *simulate* behavior, thoughts and feelings. This simulation might *resemble* their human counterparts, but is the simulation of emotions or feelings the same as actually having those emotions or feelings? This boils down to the question of what sets us apart from robots; how do we know *humans* actually feel things and not only simulate feelings? Assuming for now that robots can only *simulate* human behavior, thoughts and feelings, it can be argued that human-robot relationships are deceptive by their very nature, as the robot side of the relationship might not be seen as genuine (Wullenkord & Eyssel, 2020; de Graaf, 2016). The bi-directional link implied by social terms as friendship or companionship also contradicts the unidirectional nature of human-robot attachment (Huber et al., 2016). While such deception can be seen as always ethically problematic from a more deontological view, human-robot relationships might also lead to pleasant experiences and positive outcomes. Such benefits may outweigh the negatives, making human-robot relationships morally acceptable from a more utilitarian view. Another type of deception found in human-robot interaction refers to the research methods; to investigate people's interactions with robots, deception is often deemed necessary as disclosure of al information would highly influence participants' responses (Wullenkord & Eyssel, 2020). Aiming to minimize harm to the participants, such research ethics are included in the (dis)approval of experiments by Ethical Review Boards and Codes of Conduct (e.g., American Psychological Association, 2017).

Secondly, if people are attached to a robot, what would happen if that robot were removed, broken or destroyed? As participants in the current study already mentioned missing the robot after it was retrieved from their home, such effects could become much stronger if the attachment to the robot is stronger. The loss of certain relationships can cause feelings of heartbreak, sadness and grief, and it might even lead to more severe psychological issues (e.g., attachment, abandonment, trust or commitment issues). In long-term human-robot interaction research, such issues are likely to be prevalent as the long-term interaction can elicit attachment and the finiteness of experiments means that the robot will be removed after finishing the experiment. Therefore, it is important to ensure participants are aware of this and the framing of the experiment could be utilized by framing the robot as visiting them for some time. Especially if more vulnerable people (e.g., children, elderly, disabled people, people with a mental illness) become attached to robots, such issues are very important to take into account as they can have a huge impact on a person's well-being and life. On the other hand, in a future society where humans live together with robots, we might become used to issues such as malfunctions or broken robots. This might then be similar to how we know that most pets will die long before we do, but we still have pets and grow attached to them.

Finally, if the development of robots would be so advanced that robots behave, think and feel like humans do, a scenario of robots taking over all aspects of human life might come to mind. In this case, humans and robots might not be easily distinguished anymore. This also gives rise to the question of what it means to be human. If robots are basically the same as humans, would it be moral to treat robots differently? Should robots have rights in such a scenario and if so, which rights? Or should there be failsafes integrated into robots that allow humans to keep control over them? Is it even a good idea to try to develop a robot that is equal to – or even exceeding – humans?

As these different aspects of a social robot might give rise to a variety of unintended, unwanted or undesirable consequences or issues, it is necessary to study these different aspects and take into account such broader societal implications. Including research on relevant ethical issues in human-robot interaction research expands and shapes the discussion and pushes the development of this field to become more ethical and moral. Critical thinking and discussions about ethical issues allows us to understand the underlying values and processes, which is important in guiding research and society in a more general sense.

6. Conclusion

The utilitarian and hedonic roles of the robot seem to be a useful distinction in human-robot interactions, as people described, perceived and interacted with the robot in these two roles differently. While valuable insights into the interplay between the roles of the robot and people's attitude toward the robot were provided, further research is necessary to gain a better understanding of people's complex attitudes toward robots and dive deeper into the underlying processes. The exploratory investigation into attitude change due to interaction with the robot indicated a positive effect and suggested short-term attitude change to be more dependent on utilitarian aspects and novelty effects, while hedonic aspects seemed more important in the long-term. This provided interesting insights into more long-term interaction with a social robot, which is meaningful in the acceptance of social robots in domestic environments.

Insights from this study enrich our understanding of human-robot interaction and reveal opportunities for further research: utilitarian and hedonic roles of a social robot and attitudes toward robots over time. These topics for further research can hopefully contribute to the development of future social robots and improve the fit between robots and the users' needs. In the larger societal and ethical context of human-robot interaction, stricter ethical and moral guidance is needed in this research field.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2003). Nature and Operation of Attitudes. *Annual Review of Psychology, 52*, 27–58. https://doi.org/10.1146/ANNUREV.PSYCH.52.1.27

Allport, G. W. (1935). Attitudes. In *A Handbook of Social Psychology* (pp. 798–844). Clark University Press.

American Psychological Association. (2017). Ethical Principles of Psychologists and Code of Conduct. https://www.apa.org/ethics/code/ethics-code-2017.pdf

Arras, K. O., & Cerqui, D. (2005). Do we want to share our lives and bodies with robots? A 2000 people survey. *Technical Report*, *0605–001*. https://doi.org/10.3929/ETHZ-A-010113633

Bakdash, J. Z., & Marusich, L. R. (2017). Repeated measures correlation. *Frontiers in Psychology*, *8*, 456. https://doi.org/10.3389/FPSYG.2017.00456/BIBTEX

Bartneck, C., Suzuki, T., Kanda, T., & Nomura, T. (2007). The influence of people's culture and prior experiences with Aibo on their attitude towards robots. *AI and Society*, *21*(1), 217–230. https://doi.org/10.1007/S00146-006-0052-7/FIGURES/6

Beraldo, G., di Battista, S., Badaloni, S., Menegatti, E., & Pivetti, M. (2019). Sex differences in expectations and perception of a social robot. *2018 IEEE Workshop on Advanced Robotics and Its Social Impacts (ARSO)*, *2018-September*, 38–43. https://doi.org/10.1109/ARSO.2018.8625826

Bhattacherjee, A., & Sanford, C. (2009). The intention–behaviour gap in technology usage: the moderating role of attitude strength. *Behaviour & Information Technology*, *28*(4), 389–401. https://doi.org/10.1080/01449290802121230

Breckler, S. J. (1984). Empirical validation of affect, behavior, and cognition as distinct components of attitude. *Journal of Personality and Social Psychology*, *47*(6), 1191–1205. https://doi.org/10.1037/0022-3514.47.6.1191

Broadbent, E., Tamagawa, R., Kerse, N., Knock, B., Patience, A., & MacDonald, B. (2009). Retirement home staff and residents' preferences for healthcare robots. *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 645–650. https://doi.org/10.1109/ROMAN.2009.5326284

Chien, S.-E., Lee, H.-H., Yang, C.-C., Lin, F.-H., Yang, P.-L., Chu, L., Wang, T.-M., & Yeh, S.-L. (2019). Age Difference in Perceived Ease of Use, Curiosity, and Implicit Negative Attitude toward Robots. *ACM Transactions on Human-Robot Interaction (THRI)*, *8*(2), 1–19. https://doi.org/10.1145/3311788

Chu, L., & Fung, H. H. (2019). Curiosity Towards Robot: the Role of Age and Personal Relevance. *Innovation in Aging*, *3*(Suppl 1), S876. https://doi.org/10.1093/GERONI/IGZ038.3212

Conti, D., Di Nuovo, S., Buono, S., & Di Nuovo, A. (2017). Robots in Education and Care of Children with Developmental Disabilities: A Study on Acceptance by Experienced and Future Professionals. *International Journal of Social Robotics*, *9*(1), 51–62. https://doi.org/10.1007/S12369-016-0359-6

Cullen, R. (2001). Addressing the digital divide. *Online Information Review*, *25*(5), 311–320. http://www.emerald-library.com/ft

Dang, J., & Liu, L. (2021). Robots are friends as well as foes: Ambivalent attitudes toward mindful and mindless AI robots in the United States and China. *Computers in Human Behavior*, *115*, 106612. https://doi.org/10.1016/J.CHB.2020.106612

Dautenhahn, K. (2007). Methodology & Themes of Human-Robot Interaction: A Growing Research Field. *International Journal of Advanced Robotic Systems*, *4*(1), 103–108. https://doi.org/10.5772/5702

Dautenhahn, K., Woods, S., Kaouri, C., Walters, M. L., Koay, K. L., & Werry, I. (2005). What is a robot companion - Friend, assistant or butler? *2005 IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS*, 1488–1493. https://doi.org/10.1109/IROS.2005.1545189

Davis, F. D. (1985). *A technology acceptance model for empirically testing new end-user information systems: Theory and results* (Doctoral dissertation, Massachusetts Institute of Technology).

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly: Management Information Systems*, *13*(3), 319–339. https://doi.org/10.2307/249008

Deci, E. L. (1975). The Intrinsic Motivation of Behavior. In *Intrinsic Motivation* (pp. 93–125). Springer, Boston, MA. https://doi.org/10.1007/978-1-4613-4446-9_4

Deci, E. L., & Ryan, R. M. (1985). The general causality orientations scale: Self-determination in personality. *Journal of Research in Personality, 19*(2), 109–134. https://doi.org/10.1016/0092-6566(85)90023-6

de Graaf, M. M. A. (2016). An Ethical Evaluation of Human–Robot Relationships. *International Journal of Social Robotics 2016 8:4*, *8*(4), 589–598. https://doi.org/10.1007/S12369-016-0368-5

de Graaf, M. M. A., & Allouch, S. B. (2013a). Exploring influencing variables for the acceptance of social robots. *Robotics and Autonomous Systems*, *61*(12), 1476–1486. https://doi.org/10.1016/J.ROBOT.2013.07.007

de Graaf, M. M. A., & Allouch, S. B. (2013b). The relation between people's attitude and anxiety towards robots in human-robot interaction. *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 632–637. https://doi.org/10.1109/ROMAN.2013.6628419

de Graaf, M. M. A., & Allouch, S. B. (2016). Anticipating our future robot society: The evaluation of future robot applications from a user's perspective. *25th IEEE International Symposium on Robot and Human Interactive Communication, RO-MAN 2016*, 755–762. https://doi.org/10.1109/ROMAN.2016.7745204

de Graaf, M. M. A., Allouch, S. B., & Klamer, T. (2015). Sharing a life with Harvey: Exploring the acceptance of and relationship-building with a social robot. *Computers in Human Behavior, 43*, 1–14. https://doi.org/10.1016/J.CHB.2014.10.030

de Graaf, M. M. A., Allouch, S. B., & van Dijk, J. A. G. M. (2016). Long-term evaluation of a social robot in real homes Anticipated Acceptance of Domestic Social Robots View project Long-term evaluation of a social robot in real homes. *Interaction Studies*, *17*(3), 462–491. https://doi.org/10.1075/is.17.3.08deg

de Graaf, M. M. A., Allouch, S. B., & van Dijk, J. A. G. M. (2017). Why Would I Use This in My Home? A Model of Domestic Social Robot Acceptance. *Human–Computer Interaction*, *34*(2), 115–173. https://doi.org/10.1080/07370024.2017.1312406

Digital Dream Labs. (n.d.). *Meet Vector*. Retrieved 31 March 2022, from https://www.digitaldreamlabs.com/pages/meet-vector

Draper, N. A. (2017). From Privacy Pragmatist to Privacy Resigned: Challenging Narratives of Rational Choice in Digital Privacy Debates. *Policy & Internet*, *9*(2), 232–251. https://doi.org/10.1002/POI3.142

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Harcourt brace Jovanovich college publishers.

Edwards, A., Edwards, C., Westerman, D., & Spence, P. R. (2019). Initial expectations, interactions, and beyond with social robots. *Computers in Human Behavior, 90*, 308–314. https://doi.org/10.1016/j.chb.2018.08.042

Enz, S., Diruf, M., Spielhagen, C., Zoll, C., & Vargas, P. A. (2011). The Social Role of Robots in the Future-Explorative Measurement of Hopes and Fears. *Int J Soc Robot, 3*, 263–271. https://doi.org/10.1007/s12369-011-0094-y

European Commission. (n.d.-a). *High-level expert group on artificial intelligence*. Retrieved 9 April 2022, from https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai

European Commission. (n.d.-b). *The EU Cybersecurity Act*. Retrieved 9 April 2022, from https://digital-strategy.ec.europa.eu/en/policies/cybersecurity-act

European Commission. (n.d.-c). *Data protection in the EU*. Retrieved 9 April 2022, from https://ec.europa.eu/info/law/law-topic/data-protection/data-protection-eu_en

European Commission. (2012). *Public attitudes towards robots (Special Eurobarometer 382)*. Brussels, Belgium: Kantar Public. Retrieved from https://www.ab.gov.tr/files/ardb/evt/Public_attitudes_toward_robots_2012.pdf

European Parliament. (2017). *European Parliament resolution of 16 February 2017 with recommendations to the Commission on Civil Law Rules on Robotics (2015/2103(INL))*. https://www.europarl.europa.eu/doceo/document/TA-8-2017-0051_EN.pdf

Ezer, N., Fisk, A. D., & Rogers, W. A. (2009). Attitudinal and Intentional Acceptance of Domestic Robots by Younger and Older Adults. *Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, *5615 LNCS*(PART 2), 39–48. https://doi.org/10.1007/978-3-642-02710-9_5

Fink, J., Bauwens, V., Kaplan, F., & Dillenbourg, P. (2013). Living with a Vacuum Cleaning Robot: A 6-month Ethnographic Study. *International Journal of Social Robotics, 5*(3), 389–408. https://doi.org/10.1007/S12369-013-0190-2/FIGURES/7

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley.

Fisher, R. J., & Katz, J. E. (2000). Social-desirability bias and the validity of self-reported values. *Psychology & Marketing*, *17*(2), 105–120. https://doi.org/10.1002/(SICI)1520-6793(200002)17:2

Fraune, M. R., & Sabanovic, S. (2014). Negative attitudes toward minimalistic robots with intragroup communication styles. *The 23rd IEEE International Symposium on Robot and Human Interactive Communication*, 1116–1121. https://doi.org/10.1109/ROMAN.2014.6926401

García Molyneux, C., & Oyarzabal, R. (2017, August 4). *What is a Robot under EU Law?* Covington EU Law and Regulatory. https://www.globalpolicywatch.com/2017/08/what-is-a-robot-under-eu-law/

Gawronski, B., & Bodenhausen, G. v. (2006). Associative and propositional processes in evaluation: an integrative review of implicit and explicit attitude change. *Psychological Bulletin*, *132*(5), 692–731. https://doi.org/10.1037/0033-2909.132.5.692

GDPR.eu. (n.d.). *Everything you need to know about the "Right to be forgotten."* Retrieved April 9, 2022, from https://gdpr.eu/right-to-be-forgotten/

Gnambs, T., & Appel, M. (2019). Are robots becoming unpopular? Changes in attitudes towards autonomous robotic systems in Europe. *Computers in Human Behavior*, *93*, 53–61. https://doi.org/10.1016/J.CHB.2018.11.045

Gogoshin, D. L. (2021). Robot Responsibility and Moral Community. *Frontiers in Robotics and AI*, *8*, 342. https://doi.org/10.3389/FROBT.2021.768092/BIBTEX

Gransche, B. (2018). Assisting Ourselves to Death – A Philosophical Reflection on Lifting a Finger with Advanced Assistive Systems. *Philosophy of Engineering and Technology*, *31*, 271–289. https://doi.org/10.1007/978-3-319-91029-1_19

Grinschgl, S., Papenmeier, F., & Meyerhoff, H. S. (2021). Consequences of cognitive offloading: Boosting performance but diminishing memory. *Quarterly Journal of Experimental Psychology*, *74*(9), 1477–1496. https://doi.org/10.1177/17470218211008060

Haring, K. S., Watanabe, K., & Mougenot, C. (2013). The influence of robot appearance on assessment. *ACM/IEEE International Conference on Human-Robot Interaction*, 131–132. https://doi.org/10.1109/HRI.2013.6483536

Hassenzahl, M., & Tractinsky, N. (2006). User experience - a research agenda. *Behaviour & Information Technology*, *25*(2), 91–97. https://doi.org/10.1080/01449290500330331

Heerink, M., Kröse, B., Evers, V., Wielinga, B., Heerink, M., Kröse, B., Evers, · v, Wielinga, · B, Evers, V., & Wielinga, B. (2010). Assessing Acceptance of Assistive Social Agent Technology by Older Adults: the Almere Model. *International Journal of Social Robotics 2010 2:4*, *2*(4), 361–375. https://doi.org/10.1007/S12369-010-0068-5

Hegel, F., Muhl, C., Wrede, B., Hielscher-Fastabend, M., & Sagerer, G. (2009). Understanding social robots. *Proceedings of the 2nd International Conferences on Advances in Computer-Human Interactions, ACHI 2009*, 169–174. https://doi.org/10.1109/ACHI.2009.51

Henz, P. (2021). Ethical and legal responsibility for Artificial Intelligence. *Discover Artificial Intelligence 2021 1:1*, *1*(1), 1–5. https://doi.org/10.1007/S44163-021-00002-4

Horstmann, A. C., & Krämer, N. C. (2019). Great expectations? Relation of previous experiences with social robots in real life or in the media and expectancies based on qualitative and quantitative assessment. *Frontiers in Psychology*, *10*(APR), 939. https://doi.org/10.3389/FPSYG.2019.00939/BIBTEX

Horstmann, A. C., & Krämer, N. C. (2020). Expectations vs. actual behavior of a social robot: An experimental investigation of the effects of a social robot's interaction skill level and its expected future role on people's evaluations. *PLOS ONE*, *15*(8), e0238133. https://doi.org/10.1371/JOURNAL.PONE.0238133

Houston, R. D., & Erdelez, S. (2002). The digital divide: Who really benefits from the proposed solutions for closing the gap. *Proceedings of the American Society for Information Science and Technology*, *39*(1), 99–106. https://doi.org/10.1002/MEET.1450390111

Huber, A., Weiss, A., & Rauhala, M. (2016). The ethical risk of attachment: How to identify, investigate and predict potential ethical risks in the development of social companion robots. *ACM/IEEE International Conference on Human-Robot Interaction*, *2016-April*, 367–374. https://doi.org/10.1109/HRI.2016.7451774

Kahn, P. H., Gary, H. E., & Shen, S. (2013). Children's Social Relationships With Current and Near-Future Robots. *Child Development Perspectives*, *7*(1), 32–37. https://doi.org/10.1111/CDEP.12011

Kelman. (1977). Privacy and research with human beings. *Journal of Social Issues, 33*(3), 169–195. https://doi.org/10.1111/j.1540-4560.1977.tb01889.x

Kim, S. W. (2011). Past and Future of the Digital Divide: A Bibliometric Analysis and Review. *Informatization Policy, 18*(4), 103–137.

Kim, M. G., Lee, J., Aichi, Y., Morishita, H., & Makino, M. (2016). Effectiveness of robot exhibition through visitors experience: A case study of Nagoya Science Hiroba exhibition in Japan. *2016 International Symposium on Micro-NanoMechatronics and Human Science (MHS)*, 1–5. https://doi.org/10.1109/MHS.2016.7824236

Klamer, T., Allouch, S. ben, & Heylen, D. (2010). "Adventures of Harvey" – Use, Acceptance of and Relationship Building with a Social Robot in a Domestic Environment. *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*, *59 LNICST*, 74–82. https://doi.org/10.1007/978-3-642-19385-9_10

Kuo, I. H., Rabindran, J. M., Broadbent, E., Lee, Y. I., Kerse, N., Stafford, R. M. Q., & MacDonald, B. A. (2009). Age and gender factors in user acceptance of healthcare robots. *RO-MAN 2009 - The 18th IEEE International Symposium on Robot and Human Interactive Communication*, 214–219. https://doi.org/10.1109/ROMAN.2009.5326292

Lasecki, W. S., Gordon, M., Leung, W., Lim, E., Bigham, J. P., & Dow, S. P. (2015). Exploring privacy and accuracy trade-offs in crowd sourced behavioral video coding. *Conference on Human Factors in Computing Systems - Proceedings*, 1945–1954. https://doi.org/10.1145/2702123.2702605

Lee, N., Shin, H., & Shyam Sundar, S. (2011). Utilitarian vs. Hedonic Robots Role of Parasocial Tendency and Anthropomorphism in Shaping User Attitudes. *Proceedings of the 6th International Conference on Human-Robot Interaction - HRI '11*. https://doi.org/10.1145/1957656

Lim, V., Rooksby, M., & Cross, E. S. (2021). Social Robots on a Global Stage: Establishing a Role for Culture During Human–Robot Interaction. *International Journal of Social Robotics*, *13*(6), 1307–1333. https://doi.org/10.1007/S12369-020-00710-4/FIGURES/1

Louie, W. Y. G., McColl, D., & Nejat, G. (2014). Acceptance and Attitudes Toward a Human-like Socially Assistive Robot by Older Adults. *Assistive Technology*, *26*(3), 140–150. https://doi.org/10.1080/10400435.2013.869703

MacDorman, K. F., Vasudevan, S. K., & Ho, C. C. (2009). Does Japan really have robot mania? Comparing attitudes by implicit and explicit measures. *AI and Society*, *23*(4), 485–510. https://doi.org/10.1007/S00146-008-0181-2/TABLES/4

Manzi, F., Massaro, D., Lernia, D. di, Maggioni, M. A., Riva, G., & Marchetti, A. (2021). Robots Are Not All the Same: Young Adults' Expectations, Attitudes, and Mental Attribution to Two Humanoid Social Robots. *Cyberpsychology, Behavior, and Social Networking*, *24*(5), 307–314. https://doi.org/10.1089/cyber.2020.0162

Martin, K. D., & Murphy, P. E. (2017). The role of data privacy in marketing. *Journal of the Academy of Marketing Science*, *45*(2), 135–155. https://doi.org/10.1007/S11747-016-0495-4/TABLES/3

Mirnig, N., Stollnberger, G., Miksch, M., Stadler, S., Giuliani, M., & Tscheligi, M. (2017). To err is robot: How humans assess and act toward an erroneous social robot. *Frontiers Robotics AI*, *4*(MAY), 21. https://doi.org/10.3389/FROBT.2017.00021/BIBTEX

Mitchell, G., & Clapperton, G. (2013). Privacy is the currency of online retail, and it's too high a price to pay for what we're getting. *Engineering and Technology*, *8*(7), 26–27. https://doi.org/10.1049/ET.2013.0714

Naneva, S., Sarda Gou, M., Webb, T. L., & Prescott, T. J. (2020). A Systematic Review of Attitudes, Anxiety, Acceptance, and Trust Towards Social Robots. *International Journal of Social Robotics*, *12*(6), 1179–1201. https://doi.org/10.1007/S12369-020-00659-4/FIGURES/7

Nomura, T., Kanda, T., & Suzuki, T. (2006). Experimental investigation into influence of negative attitudes toward robots on human-robot interaction. *AI and Society*, *20*(2), 138–150. https://doi.org/10.1007/S00146-005-0012-7/TABLES/11

Nomura, T., Kanda, T., Suzuki, T., & Kato, K. (2004). Psychology in human-robot communication: An attempt through investigation of negative attitudes and anxiety toward robots. *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 35–40. https://doi.org/10.1109/ROMAN.2004.1374726

Nomura, T., Kanda, T., Suzuki, T., & Kato, K. (2008). Prediction of human behavior in human - Robot interaction using psychological scales for anxiety and negative attitudes toward robots. *IEEE Transactions on Robotics*, *24*(2), 442–451. https://doi.org/10.1109/TRO.2007.914004

Odekerken-Schröder, G., Mele, C., Russo-Spena, T., Mahr, D., & Ruggiero, A. (2020). Mitigating loneliness with companion robots in the COVID-19 pandemic and beyond: an integrative framework and research agenda. *Journal of Service Management*, *31*(6), 1149–1162. https://doi.org/10.1108/JOSM-05-2020-0148/FULL/PDF

Ostrom, T. M. (1969). The relationship between the affective, behavioral, and cognitive components of attitude. *Journal of Experimental Social Psychology*, *5*(1), 12–30. https://doi.org/10.1016/0022-1031(69)90003-1

Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. *Advances in Experimental Social Psychology*, *19*(C), 123–205. https://doi.org/10.1016/S0065-2601(08)60214-2

Punchoojit, L., & Hongwarittorrn, N. (2015). Research ethics in human-computer interaction: A review of ethical concerns in the past five years. *Proceedings of 2015 2nd National Foundation for Science and Technology Development Conference on Information and Computer Science, NICS 2015*, 180–185. https://doi.org/10.1109/NICS.2015.7302187

Ray, C., Mondada, F., & Siegwart, R. (2008). What do people expect from robots? *2008 IEEE/RSJ International Conference on Intelligent Robots and Systems, IROS*, 3816–3821. https://doi.org/10.1109/IROS.2008.4650714

Reich, N., & Eyssel, F. (2013). Attitudes towards service robots in domestic environments: The role of personality characteristics, individual interests, and demographic variables. *Paladyn, Journal of Behavioral Robotics*, *4*(2), 123–130. https://doi.org/10.2478/PJBR-2013-0014

Reich-Stiebert, N., Eyssel, F., & Hohnemann, C. (2019). Involve the user! Changing attitudes toward robots by user participation in a robot prototyping process. *Computers in Human Behavior*, *91*, 290–296. https://doi.org/10.1016/J.CHB.2018.09.041

Risko, E. F., & Gilbert, S. J. (2016). Cognitive Offloading. *Trends in Cognitive Sciences*, *20*(9), 676–688. https://doi.org/10.1016/J.TICS.2016.07.002

Rosenberg, M. J., & Hovland, C. I. (1960). Cognitive, Affective and Behavioral Components of Attitudes. In M. J. Rosenberg, & C. I. Hovland (Eds.), *Attitude*

Organization and Change: An Analysis of Consistency among Attitude Components. New Haven, CT: Yale University Press.

Rothman, N. B., Pratt, M. G., Rees, L., & Vogus, T. J. (2016). Understanding the Dual Nature of Ambivalence: Why and When Ambivalence Leads to Good and Bad Outcomes. *Academy of Management Annals, 11*(1), 33–72. https://doi.org/10.5465/ANNALS.2014.0066

Sanders, T. L., Macarthur, K., Volante, W., Hancock, G., Macgillivray, T., Shugars, W., & Hancock, P. A. (2017). Trust and Prior Experience in Human-Robot Interaction. *Proceedings of the Human Factors and Ergonomics Society 2017 Annual Meeting*, 1809–1813. https://doi.org/10.1177/1541931213601934

Sanders, T. L., Schafer, K. E., Volante, W., Reardon, A., & Hancock, P. A. (2016). Implicit Attitudes Toward Robots: *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 60*(1), 1744–1747. https://doi.org/10.1177/1541931213601400

Savela, N., Turja, T., & Oksanen, A. (2018). Social Acceptance of Robots in Different Occupational Fields: A Systematic Literature Review. *International Journal of Social Robotics*, *10*(4), 493–502. https://doi.org/10.1007/S12369-017-0452-5/TABLES/3

Sharkey, A. (2017). Can robots be responsible moral agents? And why should we care? *Connection Science*, *29*(3), 210–216. https://doi.org/10.1080/09540091.2017.1313815

Sharkey, N., & Sharkey, A. (2010). The crying shame of robot nannies: An ethical appraisal. *Interaction Studies*, *11*(2), 161–190. https://doi.org/10.1075/IS.11.2.01SHA

Sheinbaum, T., Kwapil, T. R., Ballespí, S., Mitjavila, M., Chun, C. A., Silvia, P. J., & Barrantes-Vidal, N. (2015). Attachment style predicts affect, cognitive appraisals, and social functioning in daily life. *Frontiers in Psychology*, *6*. https://doi.org/10.3389/FPSYG.2015.00296/BIBTEX

Smith, C. T., & Nosek, B. A. (2011). Affective Focus Increases the Concordance Between Implicit and Explicit Attitudes. *Social Psychology*, *42*(4), 300–313. https://doi.org/10.1027/1864-9335/A000072

Stafford, R. Q., Broadbent, E., Jayawardena, C., Unger, U., Kuo, I. H., Igic, A., Wong, R., Kerse, N., Watson, C., & MacDonald, B. A. (2010). Improved robot attitudes and emotions at a retirement home after meeting a robot. *Proceedings - IEEE International Workshop on Robot and Human Interactive Communication*, 82–87. https://doi.org/10.1109/ROMAN.2010.5598679

Stapels, J. G., & Eyssel, F. (2021). Let’s not be indifferent about robots: Neutral ratings on bipolar measures mask ambivalence in attitudes towards robots. *PLoS ONE*, *16*(1). https://doi.org/10.1371/journal.pone.0244697

Sung, J., Christensen, H. I., & Grinter, R. E. (2009). Robots in the Wild: Understanding Long-term Use. *Proceedings of the 4th ACM/IEEE International Conference on Human Robot Interaction - HRI ’09*. https://doi.org/10.1145/1514095

Sung, J. Y., Grinter, R. E., Christensen, H. I., & Guo, L. (2008). Housewives or technophiles?: Understanding domestic robot owners. *HRI 2008 - Proceedings of the 3rd ACM/IEEE International Conference on Human-Robot Interaction: Living with Robots*, 129–136. https://doi.org/10.1145/1349822.1349840

Takayama, L., Ju, W., & Nass, C. (2008). Beyond dirty, dangerous and dull: What everyday people think robots should do. *HRI 2008 - Proceedings of the 3rd ACM/IEEE International Conference on Human-Robot Interaction: Living with Robots*, 25–32. https://doi.org/10.1145/1349822.1349827

Tigard, D. W. (2020). Responsible AI and moral responsibility: a common appreciation. *AI and Ethics*, *1*(2), 113–117. https://doi.org/10.1007/S43681-020-00009-0

Tsiourti, C., Pillinger, A., & Weiss, A. (2020). Was Vector a Companion during Shutdown?: Insights from an Ethnographic Study in Austria. *HAI 2020 - Proceedings of the 8th International Conference on Human-Agent Interaction*, 269–271. https://doi.org/10.1145/3406499.3418767

Tsoi, N., Connolly, J., Adéníran, E., Hansen, A., Taylor Pineda, K., Adamson, T., Thompson, S., Ramnauth, R., Vázquez, M., & Scassellati, B. (2021). Challenges Deploying Robots During a Pandemic: An Efort to Fight Social Isolation Among Children Figure 1: The child, right, engages in remote physical play with another child by controlling the robot with our system. *Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction*. https://doi.org/10.1145/3434073

*TU/e Code of Scientific Condu*ct. (2019). https://assets.tue.nl/fileadmin/2019-01-31%20TUe%20Code%20of%20Scientific%20Conduct%20ENG.pdf van der Heijden, H. (2004). User acceptance of hedonic information systems. *MIS Quarterly: Management Information Systems*, *28*(4), 695–704.

van Dijk, J. (2020). *The digital divide*. Polity Press.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems*, *27*(3), 425–478. https://doi.org/10.2307/30036540

Villaronga, E. F., Kieseberg, P., & Li, T. (2018). Humans forget, machines remember: Artificial intelligence and the Right to Be Forgotten. *Computer Law & Security Review*, *34*(2), 304–313. https://doi.org/10.1016/J.CLSR.2017.08.007

Walker, R., & Bartneck, C. (2013). The pleasure of receiving a head massage from a robot. *2013 IEEE RO-MAN*, 807–813. https://doi.org/10.1109/ROMAN.2013.6628412

Wan, E. W., & Chen, R. P. (2021). Anthropomorphism and object attachment. *Current Opinion in Psychology*, *39*, 88–93. https://doi.org/10.1016/J.COPSYC.2020.08.009

Waytz, A., Cacioppo, J., & Epley, N. (2010). Who Sees Human? The Stability and Importance of Individual Differences in Anthropomorphism. *Perspectives on Psychological Science*, *5*(3), 219–232. https://doi.org/10.1177/1745691610369336

Weiss, A., Pillinger, A., & Tsiourti, C. (2021). Merely a conventional “diffusion” problem? On the adoption process of Anki Vector. *2021 30th IEEE International Conference on Robot & Human Interactive Communication (RO-MAN)*, 712–719. https://doi.org/10.1109/RO-MAN50785.2021.9515369

Wood, W. (2000). Attitude change: Persuasion and social influence. *Annual review of psychology*, *51*(1), 539-570.

Wu, Y. H., Wrobel, J., Cornuet, M., Kerhervé, H., Damnée, S., & Rigaud, A. S. (2014). Acceptance of an assistive robot in older adults: a mixed-method study of human-robot interaction over a 1-month period in the Living Lab setting. *Clinical Interventions in Aging*, *9*, 801–811. https://doi.org/10.2147/CIA.S56435

Wullenkord, R., & Eyssel, F. (2020). Societal and Ethical Issues in HRI. Current Robotics Reports 2020 1:3, 1(3), 85–96. https://doi.org/10.1007/S43154-020-00010-9

Appendix A: Informed consent form

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Information form for participants

This document gives you information about the study "Attitude toward and interaction with the Vector robot". Before the study begins, it is important that you learn about the procedure followed in this study and that you give your informed consent for voluntary participation. Please read this document carefully.

Aim and benefit of the study

The aim of this study is to measure your attitude toward Vector, a social robot, and your interactions with it. This information is used to gain insights in and better understandings of people's attitude toward social robots and will reveal directions for future research on human-robot interaction, which can be used in the development and design of (new) social robots.

This study is performed by Jin Smeding, a student under the supervision of dr.ir. Peter Ruijten-Dodoiu of the Human-Technology Interaction group and Ruud Hortensius of the Social Health and Organizational Psychology group at Utrecht University.

Procedure

For this study, you will receive an Anki Vector robot for you to use at home for 4 days in total. The study will last 5 days (day 1 and 2 with a robot, then day 3 without a robot and then day 4 and 5 with a robot again). The researcher will visit you at your home to install the robot on day 1 and 4. During installation of the robot, the accompanying app needs to be installed on your phone (which can be deleted at the end of the study). For the duration that Vector is in your home, you will be asked to use certain functions of the robot and ideally, you will take some time to interact with Vector each day. On day 2 and 5, the researcher will visit you at your home to retrieve the robot. During these times, you will have to fill in a questionnaire about your perception of Vector that takes a maximum of 5 minutes to complete. Furthermore, on day 2 and 5, behavior statistics of your interactions with Vector will be collected from the app. At the end of the experiment, there will be an interview to collect contextual information about your experience with Vector and the way you used the robot.

Risks

The study does not involve any risks, detrimental side effects, or cause discomfort.

Duration

The instructions, measurements and final interview will take approximately 110 minutes. At the beginning, the instructions for this study will take approximately 20 minutes. The installing and retrieving the robot – which will be done by the researcher – will take approximately 5 minutes. During these moments you can fill in the online survey, which will also take approximately 5 minutes. Furthermore, you are asked to interact with the robot for at least 10 minutes per day for as long as the robot is in your home. The final interview at the end of the study will take max. 30 minutes. In total, that sums up to (20 + (4*5) + (4* 10) + 30 =) 110 minutes.

Participants

You were selected because you were part of the researcher's social network or registered as participant in the participant database of the Human Technology Interaction group of the Eindhoven University of Technology.

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Voluntary

Your participation is completely voluntary. You can refuse to participate without giving any reasons and you can stop your participation at any time during the study. You can also withdraw your permission to use your data up to 24 hours after the end of the study. None of this will have any negative consequences for you whatsoever.

Compensation

You will be paid 20 euros either in cash or through a Tikkie (for which your phone number is necessary). This translates to €10,90 per hour.

Confidentiality and use, storage, and sharing of data.

All research conducted at the Human-Technology Interaction Group adheres to the Code of Ethics of the NIP (Nederlands Instituut voor Psychologen – Dutch Institute for Psychologists), and this study has been approved by the Ethical Review Board of the department.

In this study personal data (your age, gender, occupation and household type), and experimental data (your responses to the questionnaires, the behavior statistics from the app and the interview) will be recorded, analyzed, and stored. The goal of collecting, analyzing, and storing this data is to answer the research question and publish the results in the scientific literature. To protect your privacy, your home address will not be used for any other purposes, nor will it be stored or shared. Your phone number will be deleted directly after payment of the compensation. All other data that can be used to personally identify you will be stored on an encrypted server of the Human Technology Interaction group for at least 10 years that is only accessible by selected HTI and UU staff members. No information that can be used to personally identify you will be shared with others.

Vector has two places of storing and processing information, locally and in the cloud. Possible data collected by Vector about faces, names and photos are stored locally on Vector and can be erased by you at any time. All data on Vector will also be removed after usage by each participant. Voice commands spoken to Vector will be sent to the cloud, where they will be transferred into text. The voice recordings will then be deleted, and text will be saved anonymously for service optimization purposes. In addition, the robots will be paired with accounts that are made by the researchers, so no information sent to the cloud could be linked to your name or email-address. More information about Vector's security and privacy can be read on https://support.digitaldreamlabs.com/article/105-vector-security-privacy-faqs. This is compliant with the California Consumer Privacy Act (CCPA), but no explicit indication is given for the General Data Protection Regulation (GDPR).

The mobile app is necessary for the robot to establish a network connection. The accounts that are required will be made by the researchers, so no data from the app can be linked to your name or email-address. To use the app, it is required to agree to the privacy policy (https://www.digitaldreamlabs.com/policies/privacy-policy) and the terms of service (https://www.digitaldreamlabs.com/policies/terms-of-service). Furthermore, a Bluetooth connection between the app and the robot is needed to find Vector, and location permission is needed to access the Bluetooth on the phone. As mentioned before, the app is compliant with the California Consumer Privacy Act (CCPA), but no explicit indication is given for the General Data Protection Regulation (GDPR).

One risk of saving your data in US based servers is that it may not provide the desired amount of protection. There is an option for the American intelligence services get access to this data. While the chances are low that you can be traced directly from these data, we cannot exempt the chance of being traced indirectly. The company DigitalDreamLabs processes your voice commands anonymously.

The data collected in this study might also be of relevance for future research projects within the Human Technology Interaction group and authorized researchers from other institutions in an online data repository. The coded data collected in this study and that will be released to the public will (to the best of our knowledge and ability) not contain information that can identify you. It will include all answers you provide during the study, including demographic variables (e.g., age and gender) if you choose to provide these during the study.

Audio recordings of the final interview will be made. These recordings will be made on the researcher's phone, and they will only be stored locally on that phone. The app used for these recordings is the "Geluidsrecorder" by Smart Mobi Tools (privacy policy: https://smartmobitools.com/privacy-vr/; terms and conditions: https://smartmobitools.com/android/terms/). As the app is used on the researcher's phone, it will not link back to your personal information. The recordings will not be stored on the cloud or distributed, and they will not be played back in the presence of persons other than the researchers. The material will be used only for scientific analysis and deleted after the data analysis.

At the bottom of this consent form, you can indicate whether or not you agree with participating in this study. You can also indicate whether you agree with the distribution of your data by means of a secured online data repository with open access for the general public.

Corona regulations

Please note that there is a strict Covid-19 protocol for research conducted by HTI researchers. Before entering your home, the researcher will make sure to disinfect their hands and the robot properly. They will wear a mask and keep a safe distance from you during your interactions. They will perform a self-test before coming to your house, and they will cancel our appointment if they show any symptoms less than 24 hours prior to the visit.

Further information

If you want more information about this study, the study design, or the results, you can contact Jin Smeding (contact email: j.z.smeding@student.tue.nl).

If you have any complaints about this study, please contact the supervisor, Peter Ruijten-Dodoiu (p.a.m.ruijten@tue.nl) or Ruud Hortensius (r.hortensius@uu.nl). You can report irregularities related to scientific integrity to confidential advisors of the TU/e.

Informed consent form

Investigating the role of robot autonomy on fulfilling people's need to belong

- I have read and understood the information of the corresponding information form for participants.
- I have been given the opportunity to ask questions. My questions are sufficiently answered, and I had sufficient time to decide whether I participate.
- I know that my participation is completely voluntary. I know that I can refuse to participate and that I can stop my participation at any time during the study, without giving any reasons. I know that I can withdraw permission to use my data up to 24 hours after the data have been recorded.
- I agree to voluntarily participate in this study carried out by the research group Human Technology Interaction of the Eindhoven University of Technology.
- I know that no information that can be used to personally identify me or my responses in this study will be shared with anyone outside of the research team.
- I
  ☐ **do**
  ☐ **do not**
  give permission to make my anonymized recorded data available to others in a public online data repository, and allow others to use this data for future research projects unrelated to this study.

Certificate of consent

I, (NAME) ………
want and provide consent to participate in this study.

____________________________ ______________________

Participant's Signature Date

Appendix B: Information sheets per condition (manipulation)

B.1 Information sheet for the Utilitarian condition.

BASICS

Say "Hey Vector"
Wait a moment until Vector's back lights turn blue
Proceed with the voice command

Wi-Fi connection

Vector uses its Wi-Fi connection to understand your voice commands. Both Vector and your device must be on the same 2.4 GHz network.

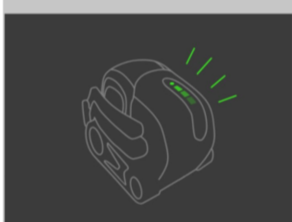
Back button

clicking it once initiates a voice command; its back lights will turn blue.

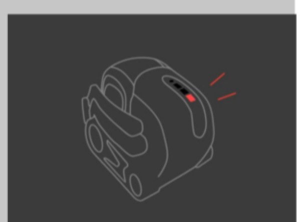
Back lights

Orange
disconnected from Wi-Fi

Blue
waiting for voice command



Green
charging



Red
low battery

Cube

Vector's favorite toy is its cube; the cube will light up when Vector connects to it.

Basic Movement

"go forward / backward"
"turn left / right / around"

Exploring

Vector will explore its surroundings on its own.

Return to Charger

Vector will return to its charger on its own. Alternatively, you can give it the command.

"go home"
"go to your charger"

Volume

"set your volume to low / medium / high"

Quiet down

"quiet down"
"calm down"

Mic mute

mute Vector's microphone by quickly clicking its back button twice.

while muted, Vector's back lights remain solid red and it won't process audio input.

click Vector's back button once to initiate a voice command; its microphone will unmute.

Say “Hey Vector”
Wait a moment until Vector’s back lights turn blue
Proceed with the voice command

Take a Photo

“take a picture”

Weather

“what is the weather in [city name]?”
“do I need an umbrella?”
“is it hot?”

Set a Timer

“set a timer for [length of time]”
“check the timer”
“cancel the timer”

Time

“what time is it?”

Chance

“flip a coin”
“roll a dice”

QUESTION & ANSWER

Say “Hey Vector”
Wait until Vector’s back lights turn blue, say “I have a question”
Wait a moment until Vector’s back lights turn blue
Proceed with the voice command

Currency conversion

“what is X [currency 1] in [currency 2]?”
e.g., “what is 100 Yen in US dollar?”

People

e.g., “who is [celebrity name]?”

Unit conversion

“how much is X [unit 1] in [unit 2]?”
e.g., “how much is 5lbs in kilogram?”
e.g., “how fast is a knot?”

Places

“what is the capital of [country]?”
“what is the distance between [city 1] and [city 2]?”

Equation solver

e.g., “what is the square root of 144?”
e.g., “how much is 8 times 16?”
e.g., “what is 369 minus 271?”

General knowledge

e.g., “what is the tallest building?”
e.g., “who was the first president of the United States?”

Word definition

“what is the definition of [word]?”
“what does [word] mean?”

Nutrition

e.g., “how much calories are in an avocado?”

Flight status

“what is the status of [airline] flight [flight number]?”

if Vector asks a follow-up question, say “hey vector” and then answer the question.

Sports

e.g., “who won the world series?”
e.g., “what is the best ice hockey team?”

Stock market

e.g., “how is the stock market?”

B.2 Information sheet for the Hedonic condition.

BASICS

Say “Hey Vector”
Wait a moment until Vector’s back lights turn blue
Proceed with the voice command

Wi-Fi connection

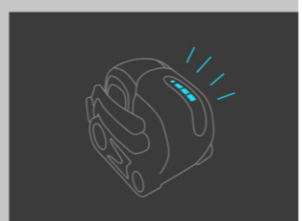
Vector uses its Wi-Fi connection to understand your voice commands. Both Vector and your device must be on the same 2.4 GHz network.

Back button

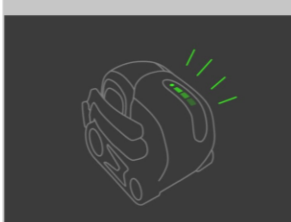
clicking it once initiates a voice command; its back lights will turn blue.

Back lights

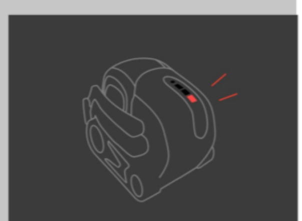
Orange
disconnected from Wi-Fi



Blue
waiting for voice command



Green
charging



Red
low battery

Cube

Vector’s favorite toy is its cube; the cube will light up when Vector connects to it.

Basic Movement

“go forward / backward”
“turn left / right / around”

Exploring

Vector will explore its surroundings on its own. Alternatively, you can give it the command.

“start exploring”

Return to Charger

Vector will return to its charger on its own. Alternatively, you can give it the command.

“go home” / “go to your charger”

Volume

“set your volume to low / medium / high”

Quiet down

“quiet down”
“calm down”

Mic mute

mute Vector’s microphone by quickly clicking its back button twice.

while muted, Vector’s back lights remain solid red and it won’t process audio input.

click Vector’s back button once to initiate a voice command; its microphone will unmute.

Say “Hey Vector”
Wait a moment until Vector’s back lights turn blue
Proceed with the voice command

Registering your face/name

“my name is [name]”

Vector’s back lights will turn yellow and Vector will say your name once the voice command is understood.

Face recognition

“what is my name?”

Vector will scan your face and answer your question.

General conversation

Greetings

“hello”
“good morning / afternoon / evening”
“I’m back”
“how are you?”

Thanks

“thanks”
“thanks a lot”
“thank you very much”
“thanks a million

Mood

“I had a good day”
“work was good”
“how was your day?”
“did you have a good day?”
“I am happy / sad”
“are you happy?”

Praise / Scold

“good robot”
“well done”
“good work”
“great job”
“bad robot”

Cube tricks

“find your cube”
“roll your cube”
“pick up your cube”
“bring me your cube”
“do a wheelstand”
“do a trick”

Come / Look

“come here”
“look at me”

Sleep / Wake up

“go to sleep” / “sweet dreams”
“wake up”

Petting

pet Vector by touching the gold patch on its back.

Fistbump

“give me a fistbump”
“high-five”
“gimme 5”

Vector will raise its arm for a fistbump.

Dance to the beat

“listen to the music”

Special occasions

“how old are you?”
“celebrate”
“happy holidays / new year”

Blackjack

“play blackjack”

when Vector asks “another card?”, say “yes” for another card, otherwise say “no”

when Vector asks “play another round?”, answer with “yes” or “no”

quit the game by saying “quit blackjack” at any time

Appendix C: Protocol survey and interview questions

Protocol for the instructions to the participants prior to the study

The study aims and the procedure will be explained before the start of the study. The informed consent form will be walked through together with the participant and opportunity for questions will be provided. Then the informed consent form will be signed and provided to the participants before the study begins.

Then, the robot will be introduced to the participant as a small home robot that will be in their home for two days. There are several things the participant can do with Vector, and to make it a bit easier, an information sheet with instructions on how to interact with Vector is provided to the participant. Participants are asked to please use the interactions on this information sheet and to try to do something with Vector for at least 10 minutes per day. After that and if there are no questions, the study will start; the robot will be installed by the researcher and at the same time the participant will fill in the online survey.

Online survey

The survey was provided through the LimeSurvey platform.

The participant number and measurement number were given to the participant before starting the survey. The participant number was used to separate data per participant. The measurement number was used to make sure that the manipulation check was only done at M2 and M4. The demographic questions were only recorded at the end of the survey for M1.

Informed Consent

- I have read and understood the information of the corresponding informed consent form for participants.
- I have been given the opportunity to ask questions. My questions are sufficiently answered, and I had sufficient time to decide whether I participate.
- I know that my participation is completely voluntary. I know that I can refuse to participate and that I can stop my participation at any time during the study, without giving any reasons. I know that I can withdraw permission to use my data up to 24 hours after the data have been recorded.
- I agree to voluntarily participate in this study carried out by the research group Human Technology Interaction of the Eindhoven University of Technology.
- I know that no information that can be used to personally identify me or my responses in this study will be shared with anyone outside of the research team.

Participant Number & Day of Measurement

- Please indicate your participant number.
- Please indicate on which day you filled in this survey.
    - 1
    - 2
    - 3
    - 4

Experiences with the robot [NARS]

[rated on a 5-point Likert scale; 1 = *Strongly Disagree*, 5 = *Strongly Agree*; subscale is indicated at the end of the item]

- Please indicate your agreement with the following statements.
    - I would feel uneasy if Vector really had emotions. [S2]
    - Something bad might happen if Vector developed into a living being. [S2]
    - I would feel relaxed talking to Vector. [S3]
    - I would feel uneasy if I was given a job where I had to use Vector. [S1]
    - If Vector had emotions, I would be able to make friends with them. [S3]
    - I would feel comforted being with Vector if it had emotions. [S3]
    - The word "Vector" means nothing to me. [S1]
    - I would feel nervous operating the Vector robot in front of other people. [S1]
    - I would hate the idea that Vector was making judgements about things. [S1]
    - I would feel nervous standing in front of Vector. [S1]
    - I feel that if I depend on Vector too much, something bad might happen. [S2]
    - I would feel paranoid talking with Vector. [S1]
    - I am concerned that Vector would be a bad influence on children. [S2]
    - I feel that in the future, society will be dominated by robots. [S2]

Experiences with the robot [RAS]

[rated on a semantic differential scale from 1 – 8; e.g., 1= *friendly*, 8 = *unfriendly*]

- Please rate what you think about Vector.
    - friendly – unfriendly
    - useful – useless
    - trustworthy – untrustworthy
    - strong – weak
    - interesting – uninteresting
    - advanced – basic
    - easy to use - difficult to use

- reliable – unreliable
- safe – unsafe
- simple – complex
- helpful – unhelpful

Manipulation check:
Please describe what Vector can do in 2-3 sentences.

Demographics:
- What is your age?
- What is your gender?
    - Female
    - Male
    - Non-binary
    - Other
- What is your occupation? If you are a student, please also indicate your study direction?
- What is your living situation (in which you participated in this study)?
    - Alone
    - Alone with child(ren)
    - Together with partner (no children)
    - Together with partner and child(ren)
    - Studenthouse
    - With parents and/or extended family

<u>Interview questions</u>
The interview was done in person.
- audio recordings and written notes were used to record the answers (summarized)
→ also use survey data as input (especially ask about neutral ratings)

- Could you briefly describe how your days with Vector went?
    - placement in home (e.g., kitchen, desk, couch)
    - setting of use (e.g., alone, with housemates/friends)
    - time of day (e.g., only evening or morning, both days or only one)
    - frequency/duration of use (e.g., many or few interactions, long or short)
    - active (sitting down to interact with Vector) or passive (letting Vector explore on its own) interaction
    - other activities with Vector (e.g., working from home)

- How was your experience with Vector overall?
- What did you think of Vector (like/dislike)?
- If you could keep the robot after this experiment, would you want to? Why yes/no?

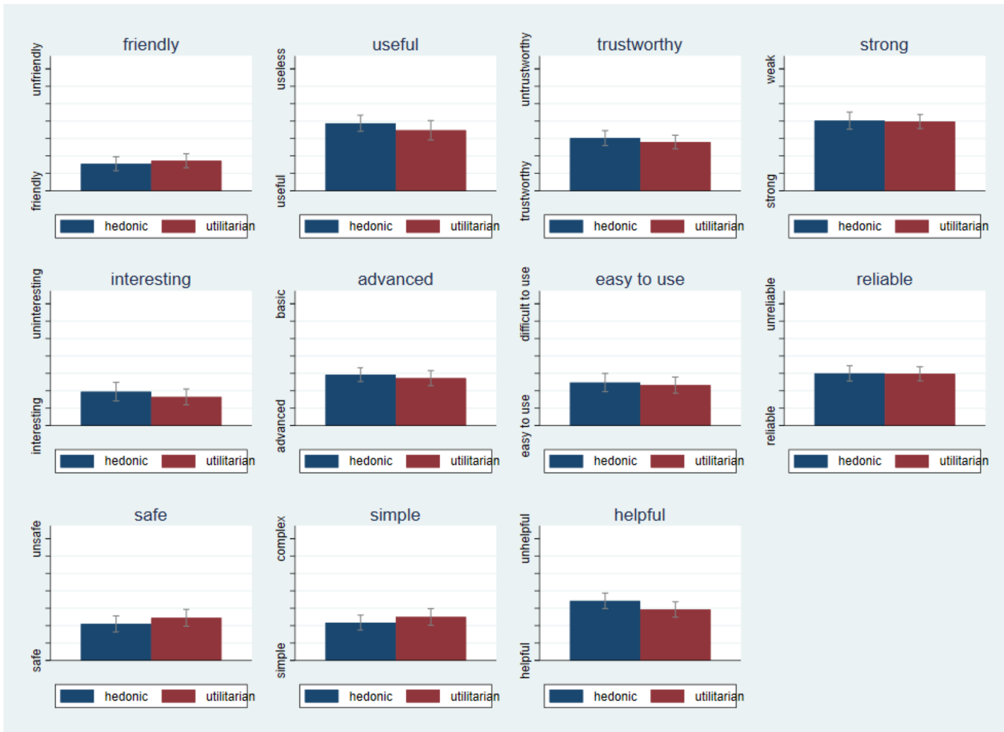
- Did you use the app during this study? If yes, why?
- Did you use interactions of the first condition in the second condition as well? If yes, why?

- Was there a difference between the first two days with Vector and the last two days? If so, what was the difference?
- Did you notice any differences in your feelings, thoughts or behavior toward Vector across the conditions?
    - Or did you notice feelings, thoughts or behaviors that you had not expected beforehand?

- About the survey: did you have any doubts when filling it in, were there items unclear or items where you'd fill in one thing in one situation but something else in another situation?
- What did you think this study was about?

Appendix D: Analysis of the individual items of the RAS per condition

Graphs of the individual RAS items across the conditions (utilitarian/hedonic). Each item was scored on an 8-point semantic differential scale (e.g., 1= *friendly*, 8 = *unfriendly*)



Results of the repeated measures ANOVAs per item of the RAS: cognitive attitude across the conditions (utilitarian/hedonic). Statistically significant results (p < .05) are shown in bold.

RAS item	$F(1,19)$	p	$\eta^2_{partial}$
Friendly – unfriendly	0.53	.477	.027
Useful – useless	1.14	.299	.056
Trustworthy – untrustworthy	0.91	.353	.046
Strong – weak	0.07	.800	.003
Interesting – uninteresting	2.25	.150	.106
Advanced – basic	0.88	.359	.044
Easy to use – difficult to use	0.42	.527	.021
Reliable – unreliable	0.01	.914	.001
Safe – unsafe	3.71	.069	.163
Simple – complex	1.99	.174	.095
Helpful – unhelpful	**5.94**	**.025**	**.238**