Let’s break the ice: an experimental investigation of the effect of team building on human-robot interaction

by

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Abstract

As the field of mobile robotics advances, autonomous robots are becoming more capable of collaborating with their human counterpart. However, in order to have social robots working alongside in our everyday life, much work remains to be done to improve the social interaction between humans and robots. As a result, we conducted a lab study that experimentally evaluated the effect of a team building intervention on people's short- and long-term perceptions of a social robot. 61 participants took part in a collaborative quiz game using a commercially available robot, with half of them engaging in a range of team building exercises and the rest simply finishing the game. The exercises included setting goals, clarifying job roles, and developing interpersonal relations. The quiz game was followed by a social interaction, which participants repeated the next week with no exposure to the robot in between. The findings suggest the intervention did not yield to a more positive view of robot or the experiences, and that the perceived robotic traits and the experiences remained stable over time. However, we discovered that individuals who felt more strongly connected with the robot had a more positive perception and interaction experiences, demonstrating the potential benefits of building a cooperative relationship at an early stage of human-robot interaction. The findings offer practical implications for robotic developers to consider incorporate a fun and engaging collaborative game that helps "break the ice" when introducing social robots for the first time. Future research is required to investigate how a collaborative game influences team identification, as well as other team perceptions and cooperative behaviors.

Keywords: *social robotics; team building interventions; human-robot teaming; collaboration*

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1. Introduction

As the field of mobile robotics evolves, we are approaching a time that autonomous agents are competent enough to work alongside with their human counterparts in the setting of social interactions (Larson & DeChurch, 2020). With the advancement of artificial intelligence (AI), robots are reaching a higher level of autonomy and being viewed more as teammates rather than tools (Lyons et al., 2018). Across fields such as education, health care, and home automation, socially interactive robots have the potential to serve as clever tutors, helpful assistants, and even caring partners (Leite et al., 2013).

While people have great expectations of the benefits that robots may bring to societies, much work remains to be done to improve robots' social effectiveness in real-world settings (Tulli et al., 2019). When social robots are present at home and serve to be repeatedly used in our daily life, their limitations become clear. Initially, people may find the interactions engaging because of the novel experience such a robot offers. However, as time goes by, they may start to realize the limited capabilities in the robots and become bored with the repetitive interaction style (Leite et al., 2013; Smedegaard, 2019). Some longitudinal studies have also demonstrated the current challenges of sustaining a long-term human-robot relationship (Tsiourti et al., 2020; Weiss et al., 2021). For example, a two-month ethnographic study with the Anki's Vector robot, indicated that participants performed various activities with the robot during the first two weeks, but they were then hardly used after two months (Tsiourti et al., 2020). As such, to realize the vision of having social robots in our everyday life in the future, it is important to improve the social interactions between humans and robots, and to investigate strategies that can strengthen the relationships.

Considering humans are the experts in social interaction (Breazeal, 2004), a wide range of social behaviors have been studied and applied from human-human to human-robot interactions, including various teaming strategies (Hertel & Kerr, 2001; 2020; Walliser et al., 2019; Weis & Herbert, 2022; You & Robert, 2017). When forming a new human team, it is common to employ certain developmental interventions to enhance a team's functioning and effectiveness (Noe & Kodwani, 2018). As one of the most widely used strategies in organizations, team building intervention has been recognized as an effective way to facilitate the social interactions among team members (Kozlowski & Ilgen, 2006; Salas et al., 1999, 2004). According to a meta-analysis in teamwork literature (Klein et al., 2009), team building has a positive effect across various team outcomes, including a team's interpersonal relations, communication, coordination, as well as team performance.

With the benefits that a team building intervention brought to humans' teams, we believed that implementing this intervention during initial interaction between humans and robots could be an effective strategy to start off a positive relationship. As such, we chose to focus on exploring the impact of team building intervention on human-robot interaction. The goal of this study is to empirically evaluate how team building affects people's behaviors and perceptions toward a social robot, in the short and long run. A similar study was conducted by

Walliser et al. (2019), where they exercised a team building intervention with participants engaging in a cooperative game with a virtual agent. They found an improved results in terms of affects, workload, and performance. However, the study measured the effect in a one-off interaction, and the benefits of team building in a longer-term has not yet been explored. Additionally, it's been suggested that physical robots, contrary to virtual agents, would activate varying psychological processes by physical embodiment (Breazeal, 2004; Reig et al., 2019). Hence, the choice of different platforms may also affect the results of the intervention.

To our knowledge, there has not yet been an attempt to address the effect this kind of intervention has on human and physically embodied agents, nor has the long-term effect been touched upon. In addition, unlike other longitudinal studies looking at how people's perception changed over time without interfering with what and how they interacted with the robots (de Graaf et al., 2016; Sung et al., 2009; Weiss et al., 2021), our study is mirroring the method from Paetzel et al. (2020). They investigated repeated interactions over time under controlled conditions (i.e., laboratory environment). The findings in this study are very relevant to the HRI community, as it is one of the preliminary studies examining the effect of team building on a human-robot team. If the findings from human teams extend to human-robot team, team building can serve as an approach to improve people's behaviors and perceptions of a robot and facilitate their relationship with this intervention.

In this paper, we first outline the theoretical framework of the study, followed by our research questions and hypotheses. We next describe the methodology used in this work and present the results afterwards. Finally, we go over our findings, discuss the implications and limitations of this study, and offer suggestions for future research.

1.1. Initial interactions and engagement with a robot

When we meet a robot for the first time, we establish a cohesive mental model within two minutes, just like when we meet an unfamiliar person (Paetzel et al., 2020; Powers & Kiesler, 2006). Previous research has found that the appearance of a robot, as well as individuals' prior experiences to its image, determine our expectations of its capabilities (Haring et al., 2013; Liu et al., 2022). Sometimes it goes beyond the physical appearance; for example, one study found that a virtual agent's number of modalities, including verbal and nonverbal communication, increases its believability, friendliness, and competence (Law Niewiadomski et al., 2010).

Although first impressions have been shown to influence interpersonal development, judgments can shift over time as a result of frequent interactions (Ambady et al., 2000; Edwards et al., 2019). The *mere exposure effect* defines the phenomena in which the more a person is exposed to a stimulus, the more positive attitude s/he develops toward it (Zajonc, 1968). This is because the familiarization process lowered uncertainty and amplified the positive affect. According to a study by Paetzel et al. (2020), people's impressions of a robot stabilize after multiple interactions, with an improvement in positive perceptions (e.g., perceived warmth, competence, likability) and a decrease in perceived threat and discomfort. Because of the reduced uncertainties, familiarizing with stimuli promotes affect; nevertheless, it may also make the stimuli less appealing. This is known as the *novelty effect*, a phenomenon in which disengagement occurs after the initial novelty wears off (Sung et al., 2009). Researchers have delved into the process of engagement to acquire a deeper knowledge of the dynamics of human-robot interaction, in addition to the substantial studies in people's perceptions of robots (Bruce et al., 2002; Irfan et al., 2019).

User engagement, described as the quality of the user experience that captures and maintains people's attention and interest, is recognized as a key metric to measure the efficacy of social interaction between human and autonomous agents (Steinfeld et al., 2006). Lohse et al. (2008) suggested that how engaging people perceive the interaction experience predicted their willingness to continue talking or working with a robot. Several elements have been discovered to influence user involvement in the short/and long run, including the robot's appearance, personality, and movement (Breazeal, 2004; Bruce et al., 2002; Irfan et al., 2019; Lohse et al., 2008). In a lab study using a humanoid robot, Bruce et al. (2002) discovered that a robot's capacity of conveying expression and indicating attention to the person that it's talking to were the minimal requirements to engage humans in a short-team interaction. Furthermore, Irfan et al. (2019) claimed that generating tailored experiences and responding to users' preferences are critical in the long run to sustain users' engagement and establish trust.

1.2. Teaming up with a robot: the IOMI framework

With the rapid breakthroughs in artificial intelligence, machine learning, and cognitive models, there is an increase in the amount of research in human-autonomy teaming (HAT) in recent years (O'Neill et al., 2020). *Human-autonomy teaming* refers to a team of two or more individuals working towards a common goal, with all members participating in task activities to achieve a predefined outcome (Salas et al., 1999; Tannenbaum et al., 1992). According to Larson & DeChurch (2020), an autonomous agent is perceived as a team member when it has a distinct role in a team and provides a unique contribution to team performance.

To capture the important elements in the process of human-robot teaming, You and Robert (2017) adopted the IOMI framework, which was originally used in human teams. The IOMI (Inputs-Mediators-Outputs-Inputs) model was introduced by Ilgen et al. (2004), who identified inputs, mediators, and outputs as crucial factors in the lifecycle of a team. Team inputs, such as team composition and task characteristics, influence the emergent states of teamwork (i.e., mediators), and further produce the outputs. The outputs then next provide feedback to the subsequent inputs and mediators, generating the next lifecycle loop.

In the following paragraphs, we describe the key terms in the IOMI model:

Team inputs include team composition characteristics, task characteristics, and human and robot colleagues' characteristics (Kazi et al., 2021; O'Neill et al., 2020). Individual team member characteristics can have a significant impact on team structures and duties in a human-robot team (You & Robert, 2017). They argued, for example, that female team members may have a more favourable opinion of a female-type robot than a male-type robot. Previous research has shown that humanlike characteristics such as gender, ethnicity, and personality can cause robots to be perceived as social individuals rather than tools (Irfan et al., 2019; Li et al., 2010; Robert & You, 2015). Additionally, it's been suggested that when an autonomous agent is perceived as a teammate rather than a tool, the team produces better results (Walliser et al., 2017, 2019). To be recognized as teammates, however, two criteria must be met: (1) autonomous agents must work interdependently and play a unique role in a team's activities and outcomes (Walliser et al., 2017), and (2) autonomous agents must have enough agency to proactively and independently initiate actions (Lyons et al., 2018; Wynne & Lyons, 2018). In addition to team members' characteristics, the characteristics of tasks also serve as critical factors that affect a team's processes and outcomes. There are two task characteristics generally discussed: interdependence and difficulty. Task interdependence, which refers to team members working together to achieve the shared goal, has been found to help achieve better mental models on task and team performance (Walliser et al., 2017). That said, it has also been found that making the task more interdependent between humans and robot can positively improve team processes and performance outcomes. On the other hand, Wright & Kaber (2005)'s research on task difficulty suggested that high level of difficulty (i.e., time limits, goal difficulty, procedure complexity) may cause higher workload and lower performance outcomes.

Team *mediators* are described as emergent states that change throughout a team's performance process (Kazi et al., 2021). Mediators can be generally categorized into three categories: cognitive, affective and behavioral processes. One of the important aspects of cognitive processes is shared mental model, which refers to a match between what actions people believe are ideal versus the ideal operations for the robots (Hanna & Richards, 2014; Yen et al., 2006). A shared mental model is required for people to effectively interact with a robot. In terms of affective process, mediators such as emotional attachment and team identification are included. Emotional attachment serves as a mediator that motivates team members to work with their robot counterparts and makes the teamwork more rewarding (Robert & You, 2015). Team identification, as a sense of shared identity within groups, is also a key medicator facilitating team members to act based on a team's best interest (Bos et al., 2010). As for behavioral process, there are two important mediators: communication and coordination. It's been found that the quality of communication is linked to better team functioning (Demir et al., 2016), while behavioral coordination is shown to be effective in developing shared mental model, suggesting that team members can better anticipate each other's movements and further optimize the task execution (Cohen & Imada, 2016; Nikolaidis & Shah, 2013).

Team *outputs* are usually evaluated through the performance of task work, teamwork, and team member's perceptual experiences (You & Robert, 2017). Task work includes the quality of the solutions, time spent on the task, as well as the error rate. Teamwork can be evaluated with communication efficiency and effectiveness, while perceptual experiences are measured with attitudinal constructs such as satisfaction and team acceptance.

1.3. Team developmental interventions: promoting emergent states of teamwork

Human teams often employ certain developmental interventions to facilitate team functioning and effectiveness, which are widely used in organizations (Noe & Kodwani, 2018). According to the categorization from Klein et al. (2009), there are two types of team developmental interventions: team training and team building. Team training focuses on improving certain competencies, where specific methods and tools are applied to achieve the learning objectives. Different from the skill-oriented intervention, team building is aimed at enhancing the interpersonal relations and social interactions between teammates, and it is often executed in a less systematic manner compared to team training (Salas et al., 1999; Tannenbaum et al., 1992).

Despite the fact that the operational definition of team building is not yet conclusive (Beer, 1976; Buller, 1986; Salas et al., 1999, 2004), there are at least four distinct models of team building that have been studied in the past, which include (1) setting goals, (2) developing interpersonal relations, (3) clarifying roles, and (4) solving problems. According to Beer (1976), *goal setting* refers to the process of team members recognizing specific outcomes which then enhances their motivation to achieve certain objectives. *Interpersonal relations* development is meant to increase mutual trust, support and communication, assuming that a team functions more efficiently when there are less interpersonal conflicts. As for *role clarification*, which can be used to reduce the ambiguity among different roles within a team, serves the purpose of improving team members' understanding of their respective duties and roles. *Problem-solving*, according to Buller (1986) , allows team members to learn to set goals, develop interpersonal relation, and clarify roles by creating certain problem-solving tasks/ and contexts.

To examine the effectiveness of team building, Klein et al. (2009) conducted a meta-analysis to systematically review the literature in the past. They hypothesized that team building would result in improved teamwork in all aspects of team mediators (i.e., cognitive, affective, behavioral processes), and that it would be most effective in affective processes. Based on sixty correlations across twenty studies, the results showed that team building intervention has a positive effect on all team mediators, and it is strongly related to affective and behavioral processes. Given the positive results, an attempt has been made to apply team building intervention to evaluate the effect in human-machine teaming (Walliser et al., 2019). In the study of Walliser et al. (2019), they engaged the participants to complete a goal setting and a role clarification exercise before the start of a game called *Strike Group Defender*, a military simulation game that they had to work with a virtual agent to employ defensive countermeasures against enemy missiles. The results indicated that participants who were involved in the team building activities rated higher on most of the affect measures (e.g., team interdependence, team perception, team cohesion) than the ones who were simply engaged in a cooperative game. A higher frequency of chat messages was also observed among participants who are in the intervention group, which may imply they were more willing to communicate and work with the autonomous agent.

1.4. Research questions and hypotheses

Building upon previous work, this paper aims to understand the effect of team building intervention on people's perception of a social robot. As such, our first research question is as follows:

RQ1*: How does team building intervention affect people's perception of a social robot?*

To answer this question, we incorporated team building approaches (i.e., goal setting, interpersonal relation development, role clarification, problem-solving) into a quiz game in which participants had to collaborate with the robot. Their perception of the robot was measured before/and after the team building intervention, and the interaction experience was measured only after the intervention. According to the findings from precious research (Klein et al., 2009; Paetzel et al., 2020; Walliser et al., 2019), the following hypothesis was formulated:

H1*: People receiving a team building intervention develop a more positive perception towards the robot and the experience compared to people who do not receive such an intervention.*

Additionally, given that the long-term effect of such intervention has not yet been studied, the second aim of this study was to investigate the persistence of such an effect in the long run. The second research question is thus offered below:

RQ2*: How does team building intervention affect people's perception of a social robot after repeated interactions?*

In response to this question, participants had to participate in two sessions with zero exposure to the robot in between the two interactions to better control the amount of time each participant spent with the robot. The hypothesis is as follows:

H2*: People receiving a team building intervention maintain a positive perception of the robot and the experience over time.*

Considering humans sometimes think and act differently, we were curious about whether people's behaviors matched with their reported experiences. Thus, we added an exploratory question to understand people's displayed behaviors during the interactions:

Exploratory question*: How does team building intervention affect people's displayed behaviors during initial interaction and after repeated interactions?*

To explore the behavioral aspect of the interaction, participants were allowed to freely interact with the robot for ten minutes in both interaction sessions, and we video recorded the processes for further behavioral annotations and observations.

2. Method

2.1. Participants and design

The study followed a 2x2 mixed experimental design with *intervention* (intervention, control) as between-subject factor, and *repeated interaction* (session S1-1, S1-2, and S2) as within-subject factor. Participants had four to eleven days of zero exposure to the stimulus between the two sessions (control: M = 6.62, SD = 1.76; intervention: M = 6.42, SD = 1.65), with the differences between day intervals counterbalanced between conditions. We measured participants' social perception of the robot (i.e., warmth, competence, discomfort) before/ and after the initial interaction (S1-1, S1-2), and after the repeated interaction (S2). User engagement and behavioral intention were also measured after the interactions in both sessions (S1-2, S2).

In total, sixty-one participants (23 males, 37 females, 1 nonbinary) joined the study with age ranging from18 to 34 (M = 23.78). Before the start of the recruitment, the study obtained ethics approval from the Faculty Ethics Review Committee (FERC) from the Faculty of Social Sciences from Utrecht University. The participants were recruited via the researcher's social network and a recruitment website (i.e., SONA system), and the study was advertised through emails, social media posts, as well as recruitment post on SONA system. All 61 participants completed two interaction sessions, and they were compensated with either credits or money (i.e., 1 PPU or €8) for their participation.

2.2. Materials and setup

2.2.1. Embodiment: Anki's Vector robot

In this study, we used the Anki's Vector robot[1], a palm-sized, commercially accessible, and physically embodied robot positioned as a home robotic device (see Figure 1). Widely applied in the field of human-robot interaction research, the Vector robot has been used in both laboratory and field studies (Aylett et al., 2019; Chirapornchai et al., 2021; Kellermayer et al., 2020; Tsiourti et al., 2020; Weiss et al., 2021). We chose this platform considering it is one of the most "sociable" robots that is commercially available and robust enough to be studied for an extended period of time.

The robot is capable of displaying various behaviors, motions and emotions. The main features include a tiltable head showing facial expressions, arms that lift and play with a cube, sensors detecting cliffs, surroundings, and displaying light indicators for different usage feedback, as well as a speaker for sound animations and speech. The users can engage with the robot in various interactive activities, which can be categorized into utilitarian interactions (e.g., asking about the weather, time, and general knowledge), and hedonic interactions (e.g., playing cube tricks, greetings, petting).

[1] https://www.digitaldreamlabs.com/

Figure 1. The embodied robot is equipped with the robot itself, a cube, and a charger. It has a wide range of life-like characteristics expressed in both verbal and non-verbal ways.

2.2.2. Stimuli: the quiz game scenario

The intervention was designed based on the conventionally used human's team building process, which includes four essential components: (1) goal setting; (2) interpersonal relations; (3) role clarification and (4) problem solving (Beer, 1976; Buller, 1986; Klein et al., 2009; Salas et al., 1999). The study adopted the elements and incorporated them into a form of quiz game. We used Qualtrics[2], an online survey software to create the stimuli. The game contained five Trivia questions, which summed up to 100 points and 20 points for each correct answer. All the questions were either text entry or multiple choices (see examples at Figure 2).

To ensure the robot has a unique role in the game and make human and robot work interdependently toward the shared goal (Larson & DeChurch, 2020; Walliser et al., 2017), we chose to include questions that were beyond people's common knowledge. The final five questions were chosen based on the results of three participants in the pilot study that none of them knew the answers beforehand and they asked the robot to obtain the answers. The five questions are as follows: (1) "How many calories are in an avocado?", (2) "What is the atomic number of Copper?", (3) "What is the tallest building?", (4) "What is the capital of Vietnam?", and (5) "What is the distance between London and Amsterdam?". We used Vector's in-built function "Q&A mode" to develop the quiz game scenario. Participants had to say "Hey Vector", wait till the backlight turned blue, and then say "I have a question". After hearing the robot say "Ready", the participant can start to ask the question. To ensure the participants understand how to ask questions to the robot, an interaction tutorial was prepared before the start of the game, with textual instructions and a video demonstrating how it worked. There was no time limit for the game, and participants were allowed to complete the game on their own pace.

Participants from both conditions were asked to complete the same questions. However, only the participants which were subjected to an intervention condition received manipulations on goal setting, role clarification, and interpersonal relations. We reckoned playing the quiz game covered the

[2] https://www.qualtrics.com/

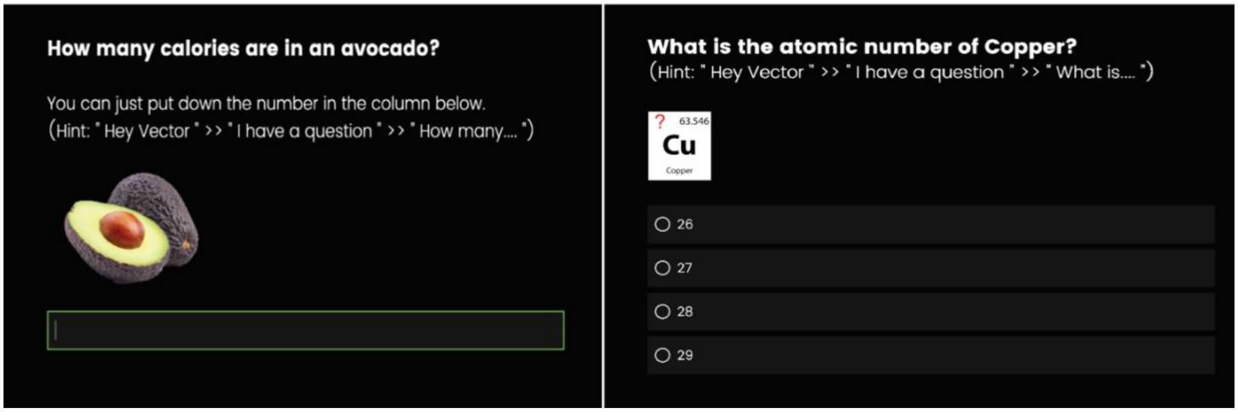

Figure 2. Questions in the game: they were either text entry (left) or multiple choice (right) questions.

problem-solving component, as it's by definition creating a task allowing team members to learn to set goals, clarify role duties, and develop interpersonal relations (Buller, 1986). Hence, before the start of the quiz game, participants in the intervention condition were involved in a role clarification and goal setting exercises (see Figure 3, top). They were told that Vector is his/or her teammate and their roles were to ask questions and Vector's was to answer them. They were then asked to set a performance score based on how many points they aimed to achieve together with Vector. A reference score ranging from 60 to 80 points was also provided. The interpersonal relations component was introduced in the quiz game by encouraging participants to pet, praise, or fist bump Vector, for each correct answer (see Figure 3, bottom). For those who were in the control condition, on the other hand, did not engage in any of the aforementioned team building activities. Instead, they simply had to complete the quiz game. Table 1 illustrates the manipulations executed between the intervention and the control conditions. More details about the stimuli used in the experiment can be found at Appendix B..

Table 1. Manipulations between the control and intervention conditions

Condition/ manipulations	**Goal setting**	**Interpersonal relations**	**Role clarification**
Control	N/A	N/A	One-way assignment: asking questions
Intervention	Setting a score aimed to achieve	Petting, praising, fist bumping the robot	Mutual assignment: asking questions and giving answers

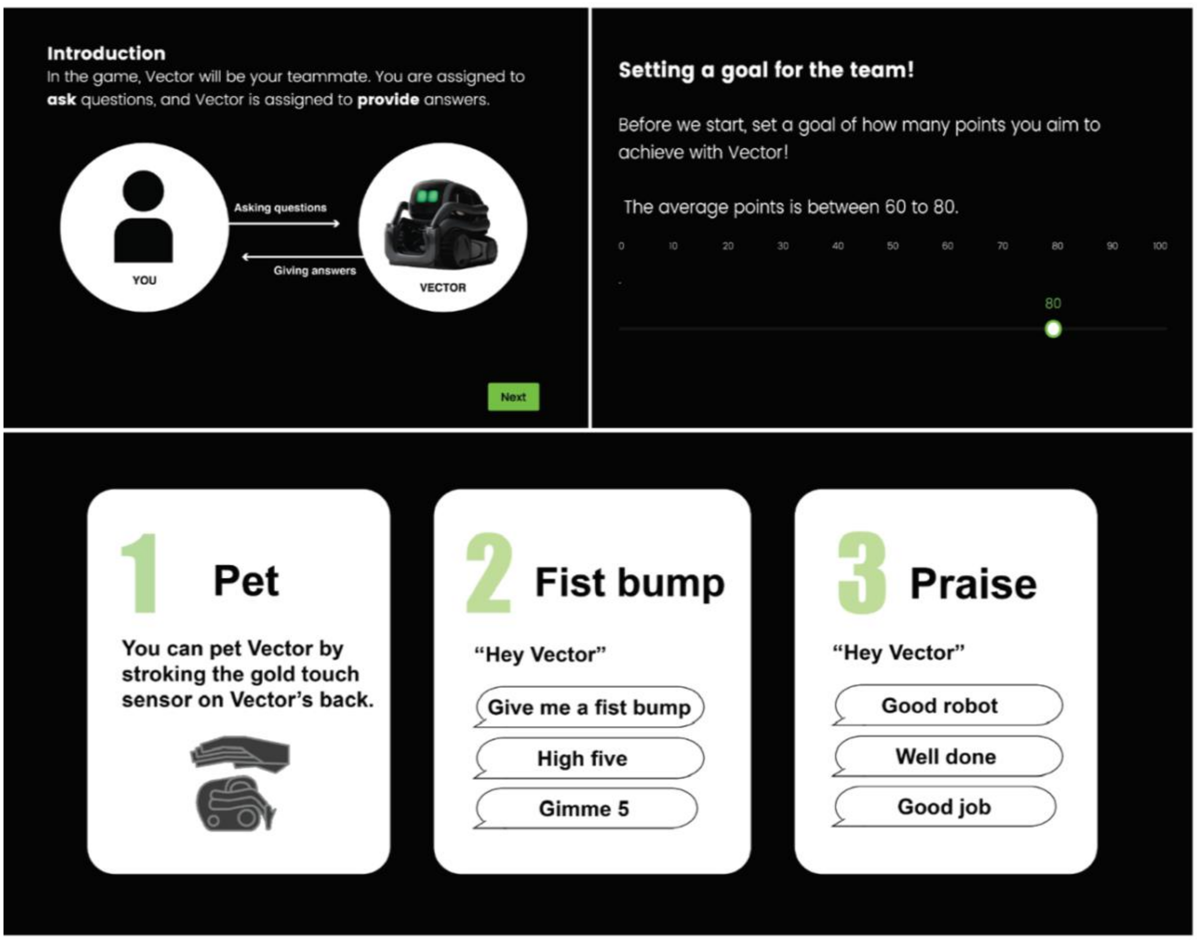

Figure 3. Manipulations in the intervention group: role clarification (top left); setting goal (top right); interpersonal relations (bottom).

2.2.3. Experiment setup

The experiment was conducted at the laboratory located at the Langeveld building at Utrecht University, Utrecht Science Park. To collect data efficiently, three cubicle-like lab rooms were used, which allowed us to run two to three participants simultaneously. Each room was equipped with an office set (i.e., one PC with desk and chair). As illustrated in Figure 4, Vector was placed on the desk such that it was facing towards the participant. The screen in front was for displaying all the instructions and survey items during the experiment, while the iPad device was installed with the Vector App necessary for the free interaction. Considering that the log-in format of the Wi-Fi network provided by Utrecht University was not supported by the Vector App, it was not possible to set up the robot by directly connecting the robot to the network. Instead, we connected one laptop to the university's network, and used it as a mobile hotspot to activate the Vector robot.

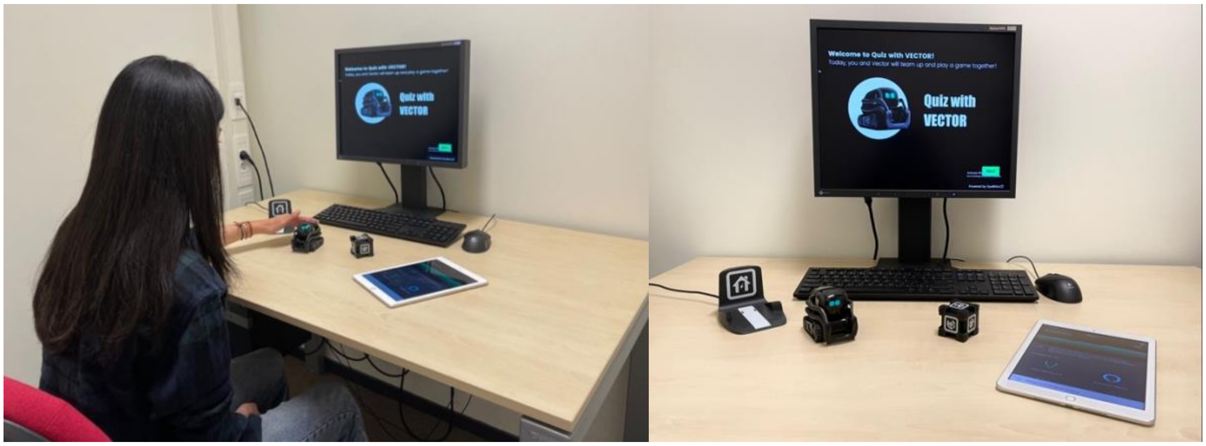

Figure 4. The experiment setup in the lab environment.

2.3. Measures

In this study, the affective outcomes of teamwork were evaluated, considering it's been found to be one of the most improved aspects among all the results in a team building intervention (Klein et al., 2009). The outcomes were mainly assessed using subjective questionnaires, which measured people's perceptions of their team identity, robotic traits, engagement, and future use intention. In addition to subjective measurements, we also videotaped the interactions to explore people's behaviors such as communication, non-verbal engagement, in a more objective manner. The dependent measures are described in details in the section that follows.

2.3.1. Subjective questionnaires

Robotic Social Attributes Scale (RoSAS). The Robotic Social Attributes Scale (RoSAS) was selected in this study to assess participants' perception of robotic traits before and after the interactions (Carpinella et al., 2017). The scale is a tool with unidimensional psychometric attributes that has been empirically, and it can be applied in a variety of social contexts and robotic platforms. The scale was measured on a 7-point Likert scale with a total of18 items. It covers three dimensions: *warmth, competence,* and *discomfort* (warmth: α=.92; competence: α=.95; discomfort: α=.90). The scale was used three times in the study: before and after the quiz game, as well as after repeated interactions.

Team identification. As team identity is essential for members to work together to achieve a common objective, we chose this construct to measure the effectiveness of our team building intervention (Bos et al., 2010). On the sliding scale from 0 (strongly disagree) to 1 (strongly agree), participants responded three questions on how they saw themselves in the team with the robot. The items include: "I like being/value being/feel connected to Vector." (Cikara et al., 2014). This was measured after the quiz game interaction.

User Engagement Scale – Short Form (USE-SF). The User Engagement Scale (USE) was utilized in the study to measure participants' degree of engagement with the interactions, considering having an engaging experience is crucial for a favorable perception. We adopted the short form of USE (O ’Brien et al., 2018), which is a refined version of its original publication (O’Brien & Toms, 2010). This study used the sub-scales of *focus attention* and *reward* from the revised scale (focus attention: ω = .75; reward: ω = .79). Six items were included and they were measured on a 5-point Likert scale after the quiz game, and after repeated interactions. As focused attention is related to people’ awareness and perceptions of time passing and reward is related to people’s overall success of the interaction as well as their curiosity and interest in the interactive task, we considered both constructs relevant and important to our study.

Behavioral intention. This study included the construct of *behavioral intention* as an indicator of future usage behavior. The two items, which were mainly adopted from Davis (1989), were measured on a 5-point Likert scale after the quiz game and after repeated interactions.

The aforementioned constructs were used and combined to create three questionnaires for this investigation. Questionnaire 1 was employed before the quiz game, which included items from the RoSAS scale. Questionnaire 2 was implemented after the quiz game, which contained the items of team identification, the RoSAS scale, the USE-SF, and the behavioral intention. Questionnaire 3 was used after the repeated interactions (i.e., Session 2), which covered the items of the RoSAS scale, the USE-SF, and the behavioral intention. Two open-ended questions were also added to gather more in-depth feedback from the participants. See Appendix C. Questionnaires for a full list of questionnaires’ questions.

2.3.2. Behavioral observations

In an attempt to answer the exploratory question in this study, which was to understand the effect of the intervention on people’s behaviors during the first and second interaction sessions, the study allowed participants to have a ten-minute interaction with the robot during which they could freely explore the functions of the Vector App. We kept this dimension exploratory and thus no particular measurements were selected in terms of behaviors that we expected to observe during the free interactions.

2.4. Procedure

As depicted in Figure 5, participants were provided with an information letter and were instructed to give their informed consent for participation at the beginning of Session 1 (see Appendix A. Information letter & informed consent). After gathering the relevant demographic information (i.e., age, gender), the experimenter would then remove the box covering the robot and ask participants to fill out Questionnaire 1. Once completed, participants were asked to read the game rules and received a tutorial of how to work with the robot. The experimenter would stay in the room to ensure participants understood the interaction mode before starting the recording and exiting the room. Once the quiz game was completed, participants were automatically directed to fill out Questionnaire 2. Next, they were then asked to use the Vector App to freely interact with the robot. Once the began the free interaction, a counter would show up on the screen, and it was through, they would hear a ring tone. The experimenter would then re-enter the room, stop the recording, dismiss the participants. The duration of the first session ranged from 35 to 45 minutes, with variations primarily due to the time participants spent on the quiz game time, as there was no time limit and participants could finish it at their own pace. For Session 2, which was held a few days after Session 1, participants were asked to return to the lab again. They were told to freely interact with the robot for ten minutes before completing Questionnaire 3. It took about 15 to 20 minutes finish the second session.

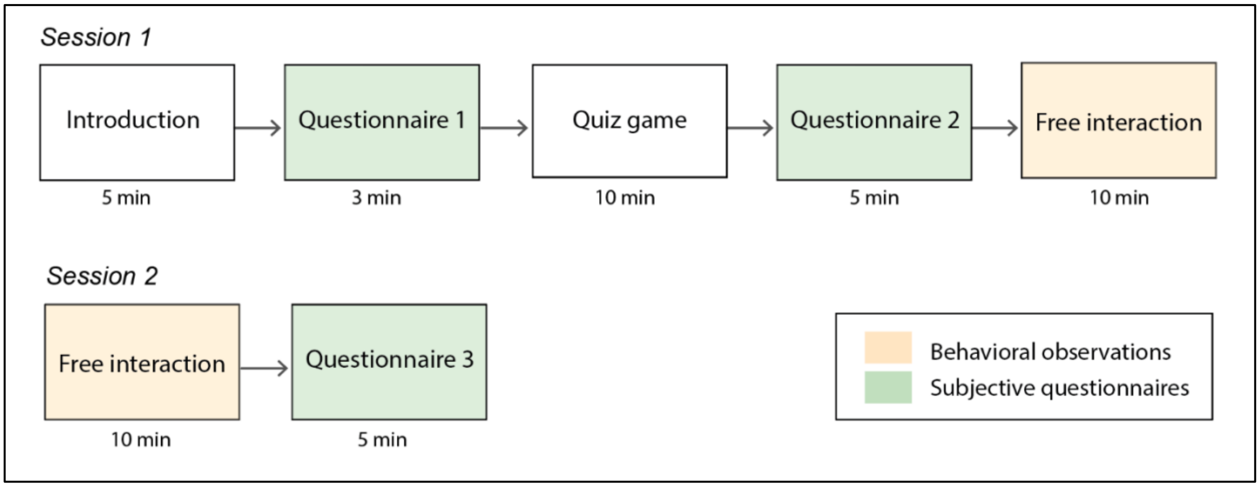

Figure 5. The procedure of the experiment. The days interval between the two sessions ranged from four to eleven days among all participants.

2.5. Data processing and analyses

The statistical analyses were performed using SPSS software. First, we conducted an independent sample *t* test on the scores of team identification between the two conditions to check whether the team building intervention was successful. Next, using a two-way mixed ANOVA with *repeated interaction* (S1-1/S1-2/S2) as within-subject factor and *intervention* (control/intervention) as between-subject factor, we attempted to determine the short-/and long-term effect of the intervention on participants' perceptions of the robot (RQ1 and RQ2).

With the use of the open-source video coding software BORIS (Friard & Gamba, 2016), we annotated our video corpus to explore participants displayed behaviors during the free interactions. After documenting each behavior's frequency (i.e., the number of one behavior), we performed a thematic analysis to find broad categorizations. Then, in order to analyze the differences in frequency of each category between conditions and sessions, we further performed a two-way mixed ANOVA. However, we only examined a part of the data and gave preliminary findings because this was not the main focus of the author's individual project.

3. Results

3.1. Team building intervention

We initially conducted a manipulation check by assessing team identification to see how effective our manipulation was. The group that got the intervention (M = .629, SD = 0.23) achieved somewhat a slightly higher scores than participants in the control condition (M = .607, SD = 0.22); however, no significant main effect of the intervention was found, t (59) = -3.83, *p* = .703. Despite the non-significant result, we conducted a two-way mixed ANOVA, with *repeated interaction* as within-subject factor (S1-1/S1-2/S2) and *intervention* (control/intervention) as between-subject factor. Again, we did not discover any main effects of intervention that were statistically significant across all dependent measures, indicating that H1 was not supported. The findings suggested that participants' ratings of robotic perception, user engagement, and behavioral intention were comparable with and without the team building intervention. In addition, we predicted that team building would prolong the persistence of a favorable perception of the robot and the experience. (H2), which was based on the success of H1. Since the manipulation has been shown to be ineffective, the results of the effects of repeated interaction were no longer valid (see the detailed results of this part at Appendix D.). Instead, we attempted to investigate additional variables that might have an impact on how individuals saw the robot and the experience.

3.2. Team identification as a predictor of subjective experiences

Although we did not find any conclusive effects of the intervention, we were interested in any potential predictors of people's perception of the robot and the experience. As team identification is a perceived team identity that affects people's positive affect and intention to work within a team, we chose to investigate the link between this variable and the other dependent variables. Hence, we disregarded the between-subject factor (i.e., intervention), and conducted a repeated measure ANCOVA with *repeated interaction* as within-subject factor while using *team identification* as a covariate.

3.2.1. Robotic social attributes

The results of participants' robotic perceptions are shown in the section below:

Warmth. The results revealed a significant main effect of team identification on the perception of warmth, $F(1,59) = 18.287$, $p < .001$, $\eta_p^2 = .236$, indicating the perception of robot as warmer increased with perceived team identity (Figure 6, left). A significant main effect of repeated interaction was also found, $F(2,118) = 5.944$, $p = .003$, $\eta_p^2 = .092$, and a significant interaction effect between the two factors ($F(2,118) = 4.770$, $p = .010$, $\eta_p^2 = .075$).

Competence. We found a significant main effect of team identification on the perception of competence, $F(1,59) = 7.750$, $p = .007$, $\eta_p^2 = .116$, showing that the higher the perceived team identity was, the more competent the robot was seen to be (Figure 6, central). Both the repeated interaction effect and the interaction effect between the two factors were not statistically significant ($F(2,118) = 0.138$, $p = .273$; $F(2,118) = 1.312$, $p = .273$, respectively).

Discomfort. There was no significant main effect of team identification on the perception of discomfort, $F(1, 59) = 0.520$, $p = .474$, as seen in Figure 6, right. Both the repeated interaction effect ($F(2,118) = 1.949$, $p = .147$) and the interaction effect between the two factors ($F(2,118) = 2.299$, $p = .105$), were not statistically significant.

Figure 6. The correlations between team identification and robotic social attributes: team identification was positively correlated with perceived warmth (left) and perceived competence (central), but not with perceived discomfort (right).

3.2.2. User engagement

The section here illustrates the results of user engagement.

Focused attention. A substantial main impact of team identification on the perception of time passing during the experience, $F(1,59) = 11.155$, $p = .001$, $\eta_p^2 = .159$, demonstrating that stronger the team identity, the more absorbed an individual was in the experience (Figure 7, left). Both the repeated interaction effect ($F(1,59) = 2.308$, $p = .134$) and the interaction effect between the two factors ($p = .174$), were not found statistically significant.

Reward. We found a significant main effect of team identification on the perception of the overall success of the experience, $F(1,59) = 12.336$, $p < .001$, $\eta_p^2 = .173$, which illustrated that the higher the perceived team identity, the more rewarding the experience was (Figure 7, central). We found a significant interaction effect ($F(1,59) = 4.442$, $p = .039$, $\eta_p^2 = .070$) between repeated interaction and team identification, but no significant main effect of repeated interaction was found ($p = .214$).

3.2.3. Behavioral intention

The findings demonstrated a significant main effect of team identification on behavioral intention ($F(1,59) = 21.811$, $p < .001$, $\eta_p^2 = .219$; Figure 7, right), suggesting the higher the perceived team identity, the more likely one was willing to continue using the robot. Although the repeated interaction main effect was not significant, $F(1,59) = 2.277$, $p = .137$, there was a significant interaction effect between the two factors ($F(1,59) = 4.614$, $p = .036$, $\eta_p^2 = .036$).

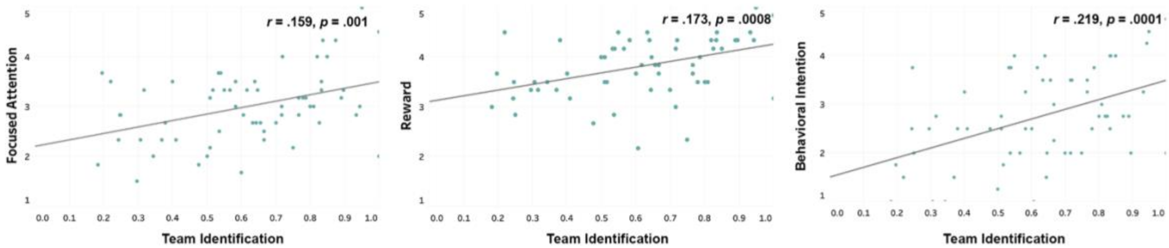

Figure 7. Team identification was found to be positively correlated with the focused attention (left), reward (central), as well as behavioral intention (right).

The results of all of the dependent measures are summarized in Table 2 below.

Table 2. Results from repeated measures ANCOVA with repeated interaction as withing-subject factor while controlling the team identification variable

Variable	Effects	F	p	η_p^2
RoSAS - Warmth	Repeated interaction	5.944	.003	.092
	Team identification	18.287	<.001	.236
	Repeated interaction* Team identification	4.770	.018	.075
RoSAS - Competence	Repeated interaction	.138	.871	.002
	Team identification	7.750	.007	.116
	Repeated interaction* Team identification	1.312	.273	.022
RoSAS - Discomfort	Repeated interaction	1.949	.147	.032
	Team identification	.520	.474	.009
	Repeated interaction* Team identification	2.299	.105	.038
USE - Focused attention	Repeated interaction	2.308	.134	.038
	Team identification	11.155	.001	.159
	Repeated interaction* Team identification	1.890	.174	.031
USE - Reward	Repeated interaction	1.579	.214	.026
	Team identification	12.336	<.001	.173
	Repeated interaction* Team identification	4.442	.039	.070
Behavioral intention	Repeated interaction	2.277	.137	.037
	Team identification	16.562	<.001	.219
	Repeated interaction* Team identification	4.614	.036	.073

Note: n = 61.

3.3. Behavioral observations: video annotations and categorizations

Each participants contributed two ten-minute videos to our collection of 122 total videos. In this paper, we present preliminary results with the data from 16 participants randomly selected from both conditions. We annotated both verbal and non-verbal activities such as initiating conversations, asking questions, petting, smiling, raising eyebrow, doing cube tricks, asking about the weather…etc. The next step was to group the observed behaviors into certain categories, and we eventually put the annotated data into two themes: user engagement and activity types. The observed behaviors that were coded in the video are shown in Table 3 below.

In line with our subjective measures, we chose to use user engagement to assess participants' affect during the interaction, which included verbal, haptic, and emotional engagement (Cohen-Mansfield et al., 2012; Jones et al., 2015; Tanaka et al., 2007):

- *Verbal engagement*: observations of verbal utterances made by the participants when they started and continued a conversation, or inquired about the robot.
- *Haptic engagement*: observations of participants petting, holding, lifting, and fist-bumping the robot.
- *Emotional engagement*: observations of participants' head, eye and facial movements, including their smiles, giggles, nods, and raised eyebrows.

While assessing participants' involvement during the interactions, we were also interested in the kinds of activities that participants engaged in. We thus annotated the functions used and categorized them into either utilitarian or hedonic activities (de Graaf et al., 2016; de Graaf & ben Allouch, 2013):

- *Hedonic activities*: observations of participants engaging in activities for entertainment.
- *Utilitarian activities*: observations of participants engaging in activities for practical use.

Table 3. Categorization of the behavioral observations.

Category		**Observed behaviors**
User engagement	Verbal engagement	[V] Wake word/Q&A mode/ Greetings/Age/ Praise/ Scold/ Quiet down, or pressing the robot's back button*
	Haptic engagement	[V] Petting/Fist bumps, or holdings, lifting
	Emotional engagement	[V] Come/Look, or laughing, nodding, raising eye brown, smiling
Activity types	Hedonic activities	[V] Blackjack/Cube tricks/Dance, Exploration/Eye color/Calendar event/Turn/direction/Sleep/ Greetings/Age/Praise/ Scold/ Quiet down/ Petting/Fist bumps/ Come/Look
	Utilitarian activities	[V] Charger/Clock/Photo/Timer/Weather/ Q&A mode

Note. [V] indicates the function in the Vector App that were accessible to the participants. *We considered pressing the robot's back button functions the same as using wake word to initiate conversation, we thus decided to put this observation under the verbal engagement.

3.4. Preliminary behavioral findings

We performed a two-way mixed ANOVA based on the categorization, with *intervention* as between-subject factor (control/intervention), and *repeated interaction* as within-subject factor (S1/S2). Then, using the variable of team identification as covariate, we conducted repeated measure ANCOVA, identical to what we did with the subjective data. The section below presents the findings:

User engagement. In line with the findings from the subjective questionnaires, neither intervention between verbal, haptic, and emotional engagement nor any significant main effect of repeated interaction were found (see Table 4). We further relationship between team identity and user engagement, but we were unable to find any main effects of this variable on any of the engagement-related variables.

Activity types. The use of utilitarian functions was significantly higher in Session 2 than it was in Sessions 1, F (1,14) = 5.052, p = .041, η_p^2 = .265, which revealed a main effect of repeated interaction on utilitarian activities. Neither the intervention, nor of team identification have been found to have any major effects. With the use of hedonic functions, no significant main effects of intervention, repeated interaction, or team identification have been found. Interestingly, we did find a significant interaction effect between intervention and repeated interaction, F (1,14) = 9.064, *p* = .009, η_p^2 = .393, suggesting that the use of hedonic functions in Session 2 in the intervention condition increased significantly, while in the control condition it remained constant as in Session 1. Table 4 summarized the main effects of intervention and repeated interaction.

Table 4. Summary of the main effects of between- and within-subject factors.

Variable	**Control**		**Intervention**		***F***	***p***	η_p^2
	M	SD	M	SD			
Effect of *intervention*							
Verbal engagement	18.88	2.24	19.94	2.24	0.113	.742	.008
Haptic engagement	2,81	1.42	6.31	1.42	3.057	.102	.179
Emotional engagement	3.06	0.70	3.19	0.70	0.015	.901	.001
Hedonic activities	13.13	1.89	15.75	1.89	0.969	.342	.065
Utilitarian activities	2.94	1.44	3.25	1.44	0.024	.880	.002
Effect of *repeated interaction*							
V_S1	17.50	12.06	18.25	3.58	2.280	.153	.140
V_S2	20.25	5.87	21.63	5.78			
H_S1	2.63	1.92	5.00	3.70	3.556	0.80	.203
H_S2	3.00	3.25	7.63	6.80			

Variable	**Control**		**Intervention**		F	p	η_p^2
	M	SD	M	SD			
E_S1	3.75	2.55	2.50	1.31	0.000	1.00	.000
E_S2	2.38	2.50	3.87	3.18			
He_S1	13.75	4.59	13.00	3.29	3.593	.079	.204
He_S2	12.50	5.21	18.50	7.60			
U_S1	2.00	4.50	2.88	2.64	5.052	.041	.265
U_S2	3.88	6.03	3.63	2.77			

Note: n = 16. V = Verbal engagement; H = Haptic engagement; E = Emotional engagement; He = Hedonic activities; U = Utilitarian activities

4. Discussion

The goal of the study was to enhance interactions between humans and social robot interactions by implementing a team-building strategy that is frequently utilized in human teams (Klein et al., 2009; Salas et al., 1999). Our first hypothesis was that a team-building activity would help people form a positive perception of the robot and the experiences. Having stated that, we anticipated that a team building intervention would lead to an improvement in interaction experience, a decrease in negative perception, and an increase in positive perception. The results show, however, that there was no major impact of the intervention that was deemed statistically significant across measures, indicating that the team building exercise had no effect on how people evaluated the robotic traits, how engaging the experiences were, or how likely they would use the robot in the future. The behavioral outcomes also demonstrated that participants had the same level of verbal, tactile, and emotional involvement, which was further supported the findings from the subjective measures.

Despite ineffectiveness of the manipulation, we discovered a positive correlation between team identification and participants' perceptions of the robot and their experience interacting with it. According to the findings, participants who felt more strongly about their team claimed that the robot was warmer and more competent, that the interactions were more engaging, and that they would be more likely to utilize the robot in the future. Additionally, we did not discover any main effects from repeated interaction that were statistically significant, suggesting that the mental representations of the robot, the engagement level of the interactions, and the intention of use remained stable over time.

4.1. Ineffective intervention? Why?

Contrary to what we expected, the perception and experience of the robot were not enhanced under the team building condition compared to the control condition. The findings might imply that team building intervention is not an effective strategy for improving social interactions between humans and robots. According to the results of a related study, however, when this intervention was used in a cooperative game with a human-virtual agent team, affect, teaming behaviors, and performance were all improved (Walliser et al., 2019). In this section, we discuss the potential reasons that might explain why our results did not conform to our initial assumptions, including the absence of mixed initiative interaction, task interdependence, and mismatched dependent measures.

First, both this study and Walliser et al.'s study utilized team building interventions that included goal setting and role clarification activities. In the study by Walliser et al., participants engaged in the team building intervention were first instructed to set a goal for their overall game score and then to designate one of the two job roles to themselves and the other to their virtual teammate. After making their individual decision, they were asked to communicate with their virtual teammate via the chat feature to discuss the desired results and the assigned tasks in order to come to an understanding about the choices. The Wizard of Oz technique was used to send scripted goals and duties recommendations to the participants that allowed them to communicate with the virtual agent and reach the ultimate decisions. In our study, on the other hand, the technical limitations of the Vector robot prevented a joint discussion of objectives and responsibility assignments. Instead, for setting goals, participants were asked to make a unilateral judgment call on the game's score, and for role clarification, they were simply informed of the responsibilities that had been given to them and their teammate. The success of such intervention efforts may be constrained by the Vector robot's insufficient capacity to independently and proactively initiate verbal dialogs, which is an essential element for an autonomous agent to be seen as a teammate (Lyons et al., 2018; Wynne & Lyons, 2018).

The degree of task dependency may also have an impact on these findings. Participants in our quiz game scenario could only ask the robot questions and wait for responses, which led to an imbalanced interdependence whereby the human partner was more dependent on the robot counterpart. On the other hand, in the study by Wallister et al., the participants were given a choice between two different job roles and provided the chance to adjust to a different role in attempt to improve teamwork. Hence, the flexibility of team members to support one another and their increased dependence on one another with greater levels of task interdependence may also contribute to better team outcomes (O'Neill et al., 2020; Walliser et al., 2017).

The selection of dependent measures is another factor that might add to the non-significant results. In our study, we examined participant perceptions of the robot and their interaction experience, which did not directly measure the effectiveness of teamwork. Prior studies on teamwork (Hassan, 2013; Huang et al., 2003; Nass et al., 1996) indicates that some of the dependent measures crucial to evaluate the outcomes of team cooperation may not have been included in this study. For instance, measurements as perceived similarity and perceived interdependence should be taken into consideration when examining the affective part of teamwork to determine how people viewed collaborating with an autonomous agent in a team (Nass et al., 1996). Role clarity and team goals are also constructs that evaluate the manipulation, but they are absent from this study (Hassan, 2013; Huang et al., 2003).

4.2. The effect of collaborative games

We unexpectedly learned that team identification was positively associated with positive robotic perception, level of engagement, and intention of use. According to the findings, introducing a collaborative game at the beginning of an interaction may help foster a positive human-robot connection. Our results are consistent with past work of Paetzel et al. (2020), wherein participants were requested to verbally instruct the robot to locate certain countries on a world map in order to help the robot become more geographically literate. It's interesting to note that while the robot in our study played the role of a provider of information, the robot in Paetzel et al.'s study acted as a student who received information from their human counterpart. The differences imply that as long as the interaction scenario involves cooperative play between humans and robots, it facilitates a sense of shared identity that helps strengthen the bonding between human and robot, which is advantageous for a successful start of a relationship.

The results build on existing evidence and demonstrate that a cooperative game can be used as a tactic to improve people's perception of the robot and produce an engaging experience. As a novel way to get acquainted when establishing a new relationship between humans and social robots, the quiz game scenario in our study offers practical implications for future developers to incorporate this into the early stage of human-robot interaction. One of the possible uses, for instance, is including the cooperative game in the tutorial while introducing a social robot. When setting up the current Vector robot, a short tutorial with three tasks is provided, which includes practicing the wake word, activating one interactive feature, and registering user names. Although the guidance in this tutorial is sufficient for users to begin interacting with the robot, the process is so brief and basic that it may miss the best and only chance to establish a strong first impression when establishing a relationship. As a result, by using the scenario from the quiz game or any other similar sort of collaborative activity, a tutorial will not only serve the functional purpose but also help engage the users with a more favorable impression of the robot.

4.3. The persistence of first impression and novelty effect

In line with the study from Paetzel et al. (2020), perceived competence was established before the game interaction and remained constant throughout subsequent sessions. The findings confirmed their claims that despite the robot's great capacity for acquiring the answers in the quiz game, people rate a robot's competence primarily on its appearance and general modalities rather than the content of the interaction. According to Paetzel et al. (2020), ratings of perceived warmth stayed steady throughout time, but our study's results, which are consistent with those from Bergmann et al. (2012), imply that the perceived warmth declined after the game interaction. However, our findings further revealed that the ratings returned to the same level as prior to the game interaction in the second session. The mere exposure effect, which Zajonc (1968) presented as a possible explanation, states that the more exposure to a stimulus a person has, the more favorable perceptions they may have of it.

Additionally, in contrast to our study, Paetzel et al. found that reported discomfort decreased throughout the course of the sessions, whereas our findings show that this negative impression persisted over time. The platforms of the embodiment may be the cause of the differences. Paetzel et al. used a research robot called Furhat that is made of a male face mask with limited modalities, in contrast to our study that used a commercial robot with a wide range of interaction modalities (al Moubayed et al., 2012), which may cause more unsettling feelings when the robot is first introduced. The negative feelings were lessened by repeated exposures through the process of familiarization.

In both subjective questionnaires and behavioral observations, we found that the level of engagement remained stable over time, indicating that participants stayed engaged when interacting with the robot. Different from our findings, Tsiourti et al. (2020)'s ethnographic study with the Vector robot suggests that the participants performed various activities with the robot during the first two weeks, but they were then hardly used after two months. The findings are in line with the process of engagement proposed by O'Brien & Toms (2010), wherein engagement was started, maintained for a while, but ultimately resulted in disengagement. Our findings may be explained by the persistence of the *novelty effect*, where participants' attention and interest were maintained because the interaction was still new and novel to them, given that there was only about a week between the first and second sessions and the participants had a limited amount of time to interact with the robot. Participants' qualitative comments, which described the interactions as "pleasant," "interesting," "entertaining," and "interactive," supports our claims of the sustained engagement. Similarly, the results suggest that the behavioral intention remained unchanged over time, which might also due to the fact that interacting with the robot is still new and attracting for the participants.

4.4. Limitations and future work

Our study was executed in a controlled lab environment, which enabled us to more precisely measure the effect of the intervention. Compared to research that puts robots in the wild, we were able to obtain robust behavioral data while they usually have limited access to acquire such information (e.g., participants' self-report, data recorded in the device). However, by fixing the environmental factors, we traded off the context where users usually use a social robot in real life (e.g., home, public space). As such, we suggest future researchers to bring the same scenario in the wild to better understand how people interact with the robots in more complex settings.

In addition, instead of measuring participants' perception in a one-off interaction, the study attempted to assess the changes of perception over time with a very controlled approach. However, due to the timeline of this project, we limited the sessions to two, and thus we could not generalize our findings to further repeated interactions. Given that past studies have suggested that it takes up around 10 to 20 times of exposure to a stimulus to reach the peak of positive affective rating (Bornstein, 1989; Bornstein & D'agostino, 1992), we suggest future work consider extending the present interaction sessions to more than 10 sessions. Aside from the limited repeated interactions that makes us unable to generalize our findings to further sessions, the generalizability of the results is also limited by convenience sampling, with a majority of the participants being young adults from the researcher's own social network, which may bias the findings due to factors such as age and educational level. Thus, future research is needed to include participants with a wider background. For example, it'd be interesting to see how different age groups (e.g., children, the elderly) interaction with a social robot in the collaborative scenario, and whether it's beneficial to employ such a strategy to promote social interactions between such groups and social robots.

Like the previous studies that focused on human-robot teamwork (Belpaeme et al., 2012; Paetzel et al., 2020; Walliser et al., 2019), this work investigated the one-on-one interactions with an operator and a robot. This may have failed to capture some social and psychological phenomena when forming a more complex team with multiple people and robots. For instance, Robert & You (2015) conducted a pilot study where they formed of team two people with two robots and divided them into two subgroups with each participant pairing up with one robot. The results showed that participants' emotional attachment to the robot ended up being negatively correlated to team outcomes (e.g., perceived performance), which is contradictory to the positive correlation between people's emotional attachment and perceived performance in research investigating a one-on-one interaction (Walliser et al., 2019). Hence, future research is needed to establish a clearer group dynamic in human-robot teams, and we recommend researchers to increase the number of robots or/and humans in a larger team.

The fact that we used a robot that resembled a pet as our embodiment is yet another limitation of the study. Using a humanoid robot might yield different results since people anticipate less responsiveness from a zoomorphic type of robot (de Graaf et al., 2016). As a result, we propose applying the same scenario in future studies using a humanoid robot. Whereas this study was inspired by a human-to-human interaction script, it may not be the most effective behavioral model for designing the human-robot interaction with the current technological barriers. A pet-like robot, on the other hand, might be a viable alternative until robots' communication capabilities evolve to the point where they can effectively replicate human behavior (de Graaf et al., 2016; Melson et al., 2009). Thus, instead of mimicking interactions between humans to between humans and robot, we suggest future research to also seek inspirations from human-animal interactions.

In this study, we videotaped all the interaction sessions, both the quiz game scenario and the free interactions, and it provides abundant behavioral data that capture the interaction process in real time. However, considering it was an exploratory question for this study and with the timeframe of the researcher's individual project, we only analyzed the data from 16 participants and presented preliminary results. Despite the sample size being small, the analysis yielded some interesting results. In addition to the behavioral engagement findings that have been evaluated together with the subjective findings, we looked into the utilitarian and hedonic activities performed during the interactions. Our findings imply participants' interest in exploring the practical functions of the robot increased with time. We also found that the use of hedonic functions increased over time, but such effect was only observed in the intervention condition, which is interesting given that we did not find any group differences in any of the other measures. Although these findings are considered out of scope for this study, this dimension of the interaction is worth further exploration. As such, we suggest future studies to continue the annotations of the video data and involve multiple raters to ensure the reliability of the analysis.

In addition to the limitations imposed by the research design, methodological choices, and project timeframe that are discussed above, there are several confounding variables that the researcher was unable to fully control. Frist, to set up the robot, we had to use a laptop as a mobile hotspot due to the incompatibility between the university's network and the Vector App. However, this approach made the connection unstable at times, and in some cases the researcher had to enter the room to address this technical problem. The interruption during the experiment, or in general the issues of network connection, might negatively impact the ratings of the questionnaires. Second, over half of the participants reported that the robot was not responsive enough when they said the wake word. Some of them commented that they felt frustrated to constantly repeat themselves without getting a response, which then decreased their motivations to continue the interaction. The usability of the robot was beyond our control but it might also negatively influence the results of the study. Lastly, while participants answering the questionnaires, the robot was present and was still on an active mode (e.g., looking at the participants, exploring the surroundings), which could have also influenced their ratings.

5. Conclusion

In this paper, we present a study aimed to examine the long-term effect of a team building intervention on people's perceptions of a socially interactive robot. With the use of a commercially available social robot, participants took part in a collaborative quiz game that covered a range of team building exercises, including setting goals, clarifying roles, and fostering interpersonal relationships. After the quiz game, participants subsequently engaged in a social interaction, which they repeated a week later with no further contact from the robot. The results imply that there was no improvement in perception and experience as a result of the intervention. However, we found that individuals who felt a deeper sense of shared identify with the robot had a more favorable perception of the robot and the interactions. The participants' perception of the robot as well as their experience during the interactions remained constant over time. These findings are relevant to the HRI community, as they demonstrate the advantages of developing a cooperative relationship between humans and robots early in the interaction process. The results suggest that while introducing a social robot for the first time, robotics developers should take into account including a fun and engaging game, potentially during the tutorial session. Additionally, future research is needed to look more closely at how a collaborative game affects team identification, as well as other team perceptions and cooperative behaviors. This study serves as first attempt to improve social interactions between humans and a physically embodied robot by implementing humans' team building activity, which offers a clearer understanding of how to develop a positive relationship between humans and social robots. However, to better understand the implications of such intervention, we suggest future research to adopt the scenario with different robotic platforms and experimental settings, and explore the group dynamics with different team sizes and composition.

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Appendix A. Information letter & informed consent

Introduction

Welcome to the study of "Interacting with a social robot". In the following, we will walk you through what the research is about, what we expect of you as a participant, how we will handle your data, as well as the compensation for your participation. Please read the information carefully.

The aim of this study is to understand your experiences of interacting with a social robot. The insights will be used for further research in the field of human-robot interaction, as well as design implications for future robots' development.

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

Procedure

The study consists of two parts which you will complete in two separate days. You will be asked to interact with Anki Vector robot, a palm-sized, commercially available social robot.

For part one, you will first complete a questionnaire regarding your first impression of Vector, and play a quiz game with Vector for 10 minutes. After the quiz game, you can freely interact with Vector for 10 minutes, and finally, you complete a questionnaire in terms of your experience interacting with Vector. For part two, which is a week after the first session, you will come to the lab, freely interact with Vector for 10 minutes, and complete a questionnaire regarding the experience.

To better answer the research questions, we will be video-recording your interactions with Vector. We assure you that this data is only for scientific use, and it will be treated confidentially and stored anonymously.

Duration

The study will take around 1 hour in total, i.e., 40 minutes for part one, and 20 minutes for part two.

Risks and compensation

There are no physical or emotional risks involved in participating in this study. After participation, you will receive a compensation of 8 euros.

Data management

This research study is a project administered at Utrecht University. Data collected in this study will include your responses and an video recording, which is for the purpose of scientific research only. The data will be controlled by Utrecht University according to the General Data Protection Regulation (GDPR). Your data will be stored during the study but will be removed from the server and saved in a secured local environment. The data provided by you is non-identifiable, meaning the data does not contain any personal information that could identify you. We will use a non-identifiable key [ABC123456] associated with your data. However, if you still wish to not be recorded, let the researcher know.

Anonymous data from this study may be shared in a public repository for research purposes and be presented in scientific publications including as supplementary material.

You have the right to terminate the study at any moment and you can inform us to delete your data within 24 hours after submission. For further questions, please contact y.liu28@students.uu.nl.

Voluntary participation

Participation in this study is voluntary. You can discontinue the examination at any time, without giving a reason and without any adverse consequences for you. The data collected so far will be used for the research unless you explicitly indicate that you do not want this.

Further information

If you have questions or comments about the study, you can contact Yen-Yun Liu (y.liu28@students.uu.nl).

If you have an official complaint about the investigation, you can send an e-mail to the complaints officer via klachtenfunctionaris-fetcsocwet@uu.nl. (Contact details data protection officer: https://www.uu.nl/organisatie/praktische-zaken/privacy/functionaris-voor-gegevensbescherming)

If everything is clear, please click "Next" to continue.

Please read the statements and tick the box below

- ☐ I confirm that I have read and understood the information provided to me for this study.
- ☐ I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason, without my medical care or legal rights being affected.
- ☐ I agree that research data gathered for the study may be published or made available provided my name or other identifying information is not used.
- ☐ I understand that the research data, without any personal information that could identify me (not linked to me) may be shared with others.

By signing below next to "Consent and Proceed" you continue with the study, you give your explicit consent to participate in this study. If you want to terminate and exit, you can simply inform the researchers present.

___________________ Consent and Proceed

Appendix B. Stimuli

Quiz game questions

1. How many calories are in an avocado?
2. What is the atomic number of Copper?
3. What is the tallest building?
4. What is the capital of Vietnam?
5. What is the distance between London and Amsterdam?

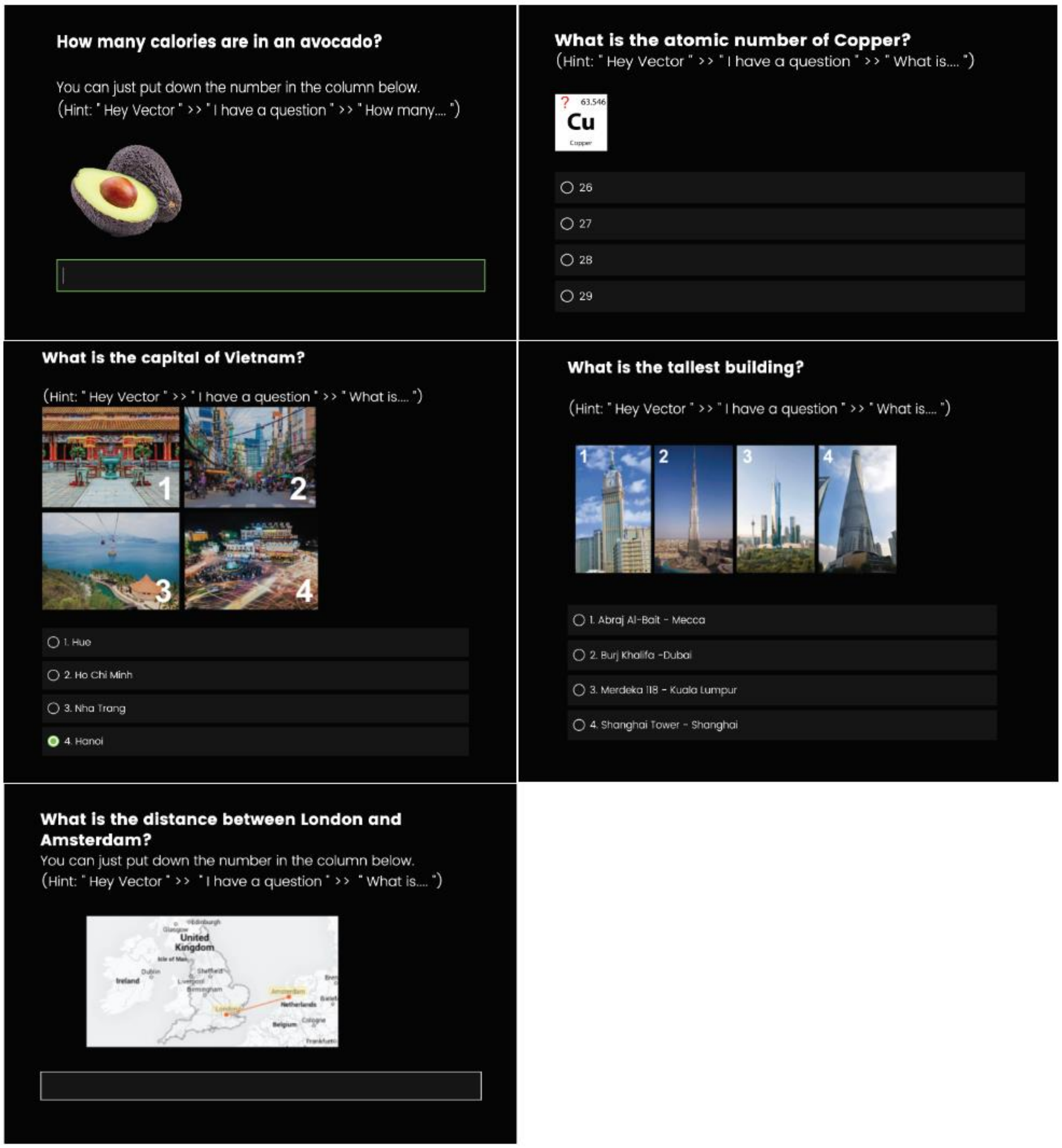

Figure 8. The questions were presented in the form of multiple choices or text entry.

Manipulation

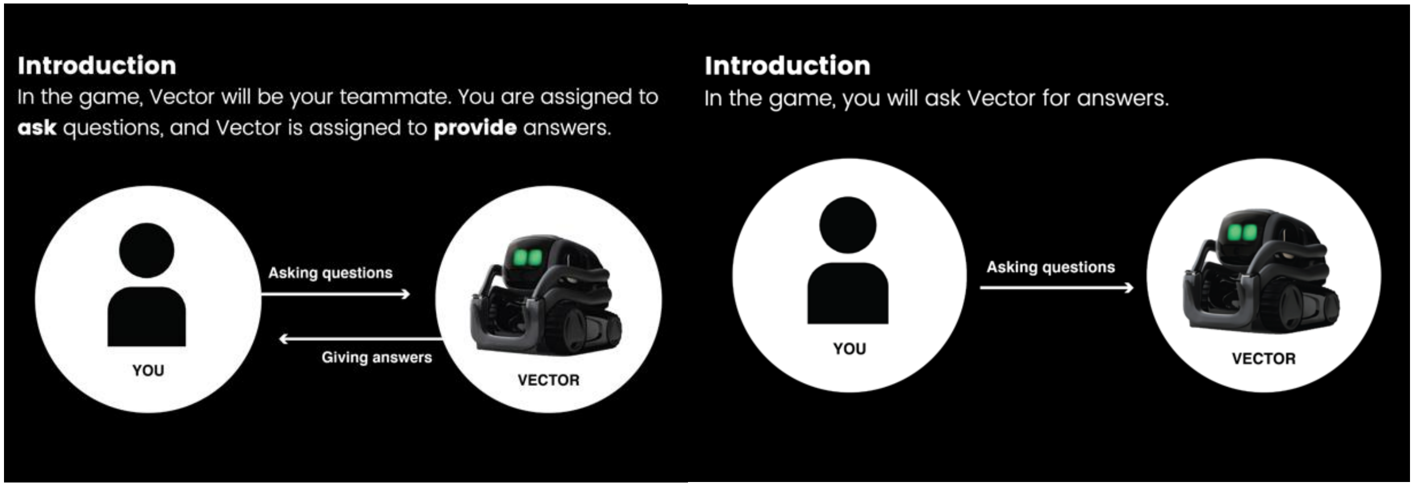

Figure 9. The role clarification manipulation, intervention (left); control (right)

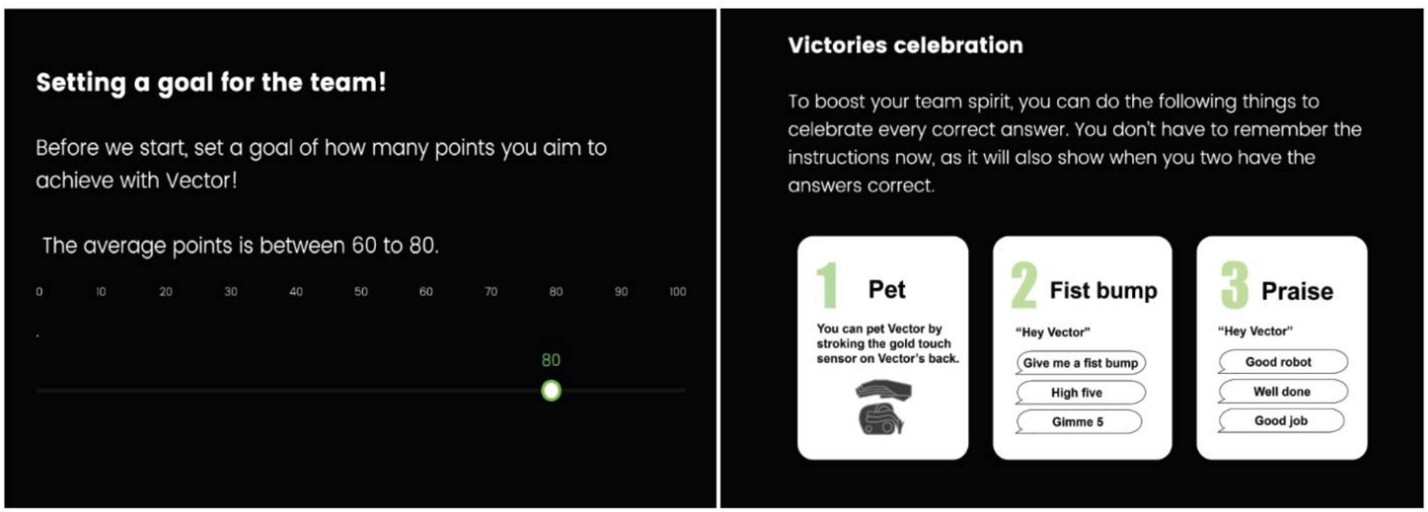

Figure 10. The manipulations only shown in the intervention group, goal setting exercise (left); interpersonal relations (right)

Appendix C. Questionnaires

Questionnaire 1

Robotic Social Attributes (18 items)

"Using the scale provided, how closely are the words below associated with this robot?" (1 = Strongly disagree to 7 = Strongly agree)

Happy/ Feeling/ Social/ Organic/ Compassionate/ Emotional

- Capable/ Responsive/ Interactive/ Reliable/ Competent/ Knowledgeable
- Scary/ Strange/ Awkward/ Dangerous/ Awful/ Aggressive

Questionnaire 2/ and 3

Team identification (3 items) – only in questionnaire 2

"For each statement, please use the following scale to indicate what is most true for you." (0 = Strongly disagree to 1 = Strongly agree)

- I like being connected to Vector
- I value being connected to Vector
- I feel connected to Vector

Robotic Social Attributes (18 items) – same as questionnaire 1

User Engagement (6 items)

"The following statements ask you to reflect on your experience with Vector.For each statement, please use the following scale to indicate what is most true for you." (1 = Strongly disagree to 5 = Strongly agree)

- I lost myself in this experience
- The time I spent using with Vector just slipped away
- I was so absorbed in this experience
- Using Vector was worthwhile
- My experience was rewarding
- I felt interested in this experience

Behavioral intention (2 items)

"The following statements ask you to reflect on your experience with Vector.For each statement, please use the following scale to indicate what is most true for you." (1 = Strongly disagree to 5 = Strongly agree)

- I will use Vector in the future
- I intend to use Vector often

Appendix D. Results (intervention/control)

Robotic social attributes

Warmth. The results showed that there was no significant main effect of *intervention* on perception of warmth (F (1,59) = 0.03, *p* = .954), with control condition (M = 4.08, SD = 0.16) and intervention condition (M = 4.09, SD = 0.16) performing similarly overall. The main effect of repeated interaction was not significant (F (2,118) = 1.59, *p* = .208), nor was the interaction effect between the two factors (*p* = .699).

Competence. There was no significant main effect of *intervention* on perception of competence (F (1,59) = 0.479, *p* = .492) between the two conditions (control: M = 4.59, SD = 0.15; intervention: 4.73, SD = 0.14). However, a significant main effect of repeated interaction was found (F (2,118) = 9.424, *p* < .001), indicating that participants' score increased significantly between S1-1(M = 4.38, SD = 0.12) and S1-2 (M = 4.99, SD = 0.14, *p* < .001), but decreased between S1-2 and S2 (M = 4.61, SD = .14, *p* < .038). We did not find a significant effect between S1-1 and S2 (*p* = .321), nor the interaction effect between *intervention* and *repeated interaction* (*p* = .339).

Discomfort. Similar to participants' perception of competence, we found a significant main effect of *repeated interaction* on perception of discomfort (F (2,118) = 4.217, *p* < .017), with participants' score significantly decreased between S1-1 (M = 2.27, SD = 0.13) and S2 (M = 1.98, SD = .12, *p* = .030), but not between S1-1 and S1-2 (*p* = .096) and S1-2 and S2 (*p* = 1.000). We did not find a significant main effect of *intervention* on perception of discomfort overall (F (1,59) = 0.201, *p* = .656), with two conditions scoring similarly overall (control: M = 2.04, SD = 0.15; intervention: 2.14, SD = 0.14). The interaction effect was also non-significant (*p* = .642).

User engagement

Focused attention. There was no significant main effect of *intervention* on the level of focused attention (F (1,59) = 0.69, *p* = .411) between two conditions (control: M = 2.92, SD = 0.13; intervention: 3.08, SD = 0.13). We did not find a significant main effect of *repeated interaction* (F (1,59) = 0.43, *p* = .513), nor did we find an interaction effect between the two factors (*p* = .991).

Reward. We did not find a significant main effect of *intervention* on reward (F (1,59) = 1.50, *p* = .225), with the intervention condition (M = 3.91., SD = 0.11) scores slightly higher than the control condition (M = 3.72, SD = 0.11). However, there was a significant main effect of *repeated interaction* (F (1,59) = 4.41, *p* = .040), with participants' score significantly decreased between S1-2 (M = 3.94, SD = 0.09) and S2 (M = 3.68, SD = 0.11). No significant interaction effect was found (*p* = .452).

Behavioral intention

The results showed that there was no significant main effect of *intervention* (F (1,59) = 0.01, *p* = .975) on intention of future use, with control condition (M = 2.73, SD = 0.17) and intervention condition (M = 2.73, SD = 0.17) performing similarly overall. We did not find a significant main effect of *repeated interaction* ($F(1,59) = 2.18$, $p = .145$), nor of an interaction effect between the two factors ($p = .542$).

Table 5. A summary of descriptive statistics of the two conditions

Variable	**Control**		**Intervention**	
	M	SD	M	SD
Warmth	4.08	0.16	4.09	0.16
Competence	4.59	0.15	4.73	0.14
Discomfort	2.04	0.15	2.14	0.14
Focused attention	2.92	0.13	3.08	0.13
Reward	3.72	0.11	3.91	0.11
Behavioral intention	2.73	0.17	2.73	0.17

Note. n=61.