Trick or treat

the effect of pseudo presence of a human operator in bystanders mistreating robot

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Award date:
2020

Eindhoven, 15.MAY.2020

Trick or treat: the effect of pseudo presence of a human operator in bystanders mistreating robot.

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in partial fulfilment of the requirements for the degree of

Master of Science
in Human Technology Interaction
at the Eindhoven University of Technology

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TRICK OR TREAT: THE EFFECT OF PSEUDO PRESENCE OF A HUMAN OPERATOR IN BYSTANDERS MISTREATING ROBOT.

Abstract

When deploying autonomous robots in public environments, people who co-exist in the same environment but do not have direct interaction with the robot are likely to interfere with the robot's task. Those people are referred to as "bystanders". However, field studies found that bystanders mistreat the robot less when a human operator is present. Given the fact that the human perception of the robot shapes and influences humans' behaviour towards the robot, it is possible that people would behave and evaluate the robot differently if they perceive the presence of a human operator, i.e., pseudo presence of a human operator.

The present study investigated the effect of the pseudo presence of a human operator on bystanders mistreating a robot. The pseudo presence was manipulated by framing the descriptions of the robot. Robot task efficiency was taken as the measurement of the mistreatment of the robot. Beyond that, the evaluation of the robot was measured as well to investigate the effect of pseudo presence on people's attitudes towards the robot.

The result showed that pseudo presence was manipulated successfully but it did not decrease the mistreatment significantly. Regarding the evaluation of the robot, the pseudo presence enhanced perceived warmth. A robot perceived to be warm is more likely to experience positive interaction. Moreover, we found that participants indeed mistreated the robot in various ways during the experiment.

The present study paves the way for future research on the mistreatment of robots from bystanders and gives designers inspirations of creating and optimizing the interaction of a social robot in a public scenario.

Keywords: Mistreatment of robot, Bystanders, Pseudo Presence, Human Robot Interaction

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Acknowledgements

The current work is my graduation project for the Msc. program Human-Technology Interaction, as well as a part of the FAST project in the Eindhoven University of Technology. I am grateful for the experience of studying in the HTI department at TU/e. The lectures and projects I followed kept refreshing my answers to the question when I started in this University: 'How can we bring new technologies into human society without hurting the people?', and brought a new question for the future me to think about: 'How can we bring new technologies into human society without hurting the technology?'.

I would like to thank my first supervisor, Peter Ruijten, for his patience and inspiration, without which I would not come out the idea for this thesis. I further thank Margot Neggers for her support and help on the robot, which allowed me to conduct my experiment. I also thank Raymond Cuijpers and all the colleagues from the FAST project for their essential feedback and remarks on my project in my intermediate presentation.

Last, and most importantly, I want to thank my parents and all my friends for their emotional and financial support, inspiration, encouragement, and understandings in the past, present and future, which make me brave every time I face difficulties.

Enjoy the reading and as always, have a good time!

Fanfei Liu

Eindhoven, May 2020

TRICK OR TREAT: THE EFFECT OF PSEUDO PRESENCE OF A HUMAN OPERATOR IN BYSTANDERS MISTREATING ROBOT.

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TRICK OR TREAT: THE EFFECT OF PSEUDO PRESENCE OF A HUMAN OPERATOR IN BYSTANDERS MISTREATING ROBOT.

1. Introduction

At the end of 2019, an outbreak of a new kind of Coronavirus, named 2019-nCoV, occurred in China and quickly swept over the world. It is impressive to see how autonomous robots have been contributing to the fight against the pandemic from multiple perspectives. To minimize physical contact between workers and quarantined people, doctors sent a robot to treat the first known US patient (Chavez, 2020) and hotels in China deployed autonomous robots to deliver food to guests or people who were suspected to be infected (Kent, 2020). Including an autonomous robot in industry or public environments can potentially increase working efficiency and effectiveness and, furthermore, decrease human workload or in the case of a pandemic, lower the risk of medical workers getting infected. In fact, companies and agencies have already started to implement robots to meet their needs. Albert Heijn, a local supermarket in the Netherlands started using autonomous robots to deliver groceries to customers (Solanki, 2019). Online shopping companies like Amazon and Alibaba recruited autonomous robots in their warehouse to sort packages that need to be sent all over the world (Tobe, 2018). It goes without saying that human society benefits more and more from automation and there will be more and more interactions between humans and robots in the upcoming years. Interestingly, as posited by the media equation hypothesis, humans tend to perceive these interactions as social interactions (Bartneck, et al., 2008).

The media equation argues that people tend to treat computers as social actors (Nass, et al., 1996), which could also be relevant in human-robot interaction (Bartneck, et al., 2008). Indeed, people show empathy when seeing a video of a robot being treated violently (Rosenthal, et. al, 2013), help a robot to complete its task (Hiittenrauch, et al., 2003) or are willing to provide help when seeing a video of a robot got stuck on its path (Daly, et al., 2020), and they would intervene both verbally and physically after seeing a robot getting

bullied (Tan, et. al, 2018). Yet, it is not uncommon that robots are treated aggressively by humans in public. People tend to hit, punch, and slap robots (Nomura, et.al, 2017, Salvini, et al., 2010). A worse example is HitchBOT, a robot developed to travel across multiple countries by hitchhiking, which was found dismembered only two weeks after its deployment in the US (Victor, 2015). This leads to the notion that people do not always treat robots with respect.

Although the reason for human's bullying behaviour towards robots is still not clear, previous studies suggested that people's behaviour and attitudes towards robots are influenced by both physical embodiments and perceived intelligence of the robot. Multiple studies found out that physical appearance, such as if the robot is human-like or machinelike and the size of the robot, would indeed make a difference in people's perception and attitudes towards robots. It turned out that people would prefer a more human-like robot for jobs where social competence is required, while a machinelike robot is seen as more applicable to more analytical and rational jobs (Goetz, et al., 2003). Small robots earned more sympathy than the big ones when both were verbally abused (Lucas, et.al, 2016).

Yet, other studies argued that perceived intelligence and mindfulness matters more. For instance, Bartneck and colleagues (2002) found out that people are more aggressive to a "stupid robot" than a "smart robot". In their experiment, participants were required to point flashing light at the robot so that the robot would "react" with the sensors. The robot participants interacted with was either smart (react fast to the flashlight) or stupid (react slow to the flashlight). After a short period of interaction, the participants were asked to destroy the robot with a hammer. Participants hit the stupid robot more than the smart robot i.e, participants behaved less aggressively if they perceived the robot as more intelligent. Keijsers and Bartneck (2018) further showed that robots that are perceived to be less able to think and

feel received more mistreatment, whereas behaving like a human (moving while talking with human voice vs. staying still while talking with a computer-generated voice) did not influence mistreatment of robots significantly. Moreover, they found that human-like behaviour does not always influence perceived mindfulness of a robot. This is in line with the findings from Zlotowski and colleagues (2017) which stated that human likeness does not influence mind attribution.

All in all, it is the human perception of the robot (whether the robot is perceived and treated as a social actor (Lee, 2004)) that shapes and influences human behaviour towards a robot (Thellman, et al., 2016). However, most of the previous lab HRI studies mainly apply to the direct interaction between humans and robots. Unsupervised robots, like HitchBOT, are more likely to get bullied by people who do not have direct interaction with them, which are referred to as bystanders.

1.1 Bystanders' behaviour and mistreatment of robot

In a real-world scenario, robots and users or human operators are not the only actors. Humans who do not have direct interaction with the robot might also coexist in a certain period of time. Scholtz (2003) categorized five types of roles in a human-robot interaction scenario: supervisor, operator, mechanic, teammate, and bystander. More specifically, supervisors take the responsibility of watching over the robot whilst it is doing its tasks and intervene when necessary. Operator refers to people who adjust or modify parameters and mechanisms when the robot behaves autonomously, whereas mechanics take in charge of the hardware of the robot, such as sensors or mechanical components. The teammate exists when humans and robots need to work together to achieve common goals. Bystanders, on the other hand, do not have an explicit interaction with the robot. However, they coexist in the environment for a

certain period of time and do not have a prior understanding of the intention of the robot. For instance, for a cleaning robot in a warehouse, supervisors, and teammates are the "human driver" who sit on the robot and control the steering wheel, while bystanders are the workers that categorize packages between the shelves and normally have no prior knowledge of or experience interacting with the robot. Hence, their behaviour can be unpredictable while they coexist with the robot in the environment. Likely, the behaviour of humans is a response to their understanding of the behaviour of the robot, which depends on prior experiences.

While interacting with an autonomous system, people aim to interpret the behaviour of the system based on their prior knowledge or experience (Tanaka, et al., 2016, Lau, et al., 2005). In the case of autonomous vehicles, pedestrians (i.e. bystanders) understand the driving behaviour based on their previous knowledge of the intention of a vehicle, traffic rules, and the driving context, etc. However, different from autonomous vehicles, it might be more challenging for people without previous experience to understand the intentions of the robot while applying an autonomous robot in the real world. Imagine you are in a shopping mall, where a robot is doing a cleaning task alone. You might wonder how it will react if you stop in front of it. It might pause until you leave or make a turn and drive away from you. This results in more difficulties in understanding robot behaviour in human-robot interaction, especially when the supervisor is absent. More explicitly, according to Hüttenrauch and Eklundh (2003), bystanders are people who have no previous knowledge of interacting with a robot but are willing to communicate with the robot. Their unpredictable or improper interacting behaviour might interrupt the automated robot from doing its mission. In a public environment, it is observed that bystanders, for example, kids, bully a robot by constantly blocking the navigation path, approaching the robot violently, and even physically or verbally abuse the robot (e.g. Brscic et al., 2015, Nomura et al, 2015). Children mistreat the robot as

they are curious about the reaction of the robot, are influenced by other people in the environment, or just for fun (Nomura et al, 2015). A similar phenomenon was also found in the field study from Salvini and colleagues (2010), people would touch and test the capability of the robot to "explore the robot" through, for example, blocking its way, covering cameras or sensors, or pressing the button repeatedly to trigger vocal messages.

Seemingly, curiosity triggers bystanders' willingness to interact with a robot and furthermore, leads to improper behaviours, which are categorized as robot mistreatment. Similar to human-human interaction, if people are unfamiliar with the robot, observed physical, verbal, and social contextual cues could help them estimate the intention of the robot (Lau, et al., 2005). Therefore, bystanders might try to gather information to help them to understand the intention of the autonomous robot by exploring its capability. However, this might increase the workload of the robot and furthermore, decrease its working efficiency as it has to stop or change its path to avoid bystanders whilst the navigation path is blocked. This might even cause unnecessary software and hardware damage to the robot (Salvini, et al., 2010). Moreover, in the long run, mistreatment of robots might encourage improper behaviour towards other human-like objects since the robot is perceived as a social actor (Whitby, 2008).

To decrease mistreatment of robots and improve the cooperation between robots and humans, previous research investigated effects of both physical embodiment and the behaviour of the robot in HRI, such as change the robot's size (Lucas, et al., 2016), matching the behaviour of the robot to its task (Goetz, et al, 2003), and changing algorithms of the robot so that it will approach an adult while it detects children in the environment (Brsci & Kanda, 2015). However, most of those changes are expensive and need more complicated mechanisms (Tanaka et al., 2016). Besides, perceived mindfulness influences people's attitudes towards

robots more than the physical embodiment of the robots (e.g. Bartneck, et al., 2007, Keijsers & Bartneck, 2018). Essentially, the idea of optimizing bystander and robot interaction is about changing bystanders' perception of an autonomous robot (Salvini, et al., 2010, Thellman, et al., 2016).

1.2 Presence

From the aspect of social psychology, numerous studies suggest that social presence will indeed influence people's attitudes and evaluation of robots in human-robot interaction (e.g. Lau, et al., 2005, Rea & Young, 2008). A robot's social presence shapes and predicates its social influence (Thellman, et al., 2016) i.e. the human perception of the robot can be modified by the way in which the robot is introduced. People might perceive the robot differently when they are made to believe that it is operated by a human. This is known as pseudo presence. Tanaka and colleagues propose the following definition of pseudo presence in human-robot interaction: " Pseudo presence is the degree to which people feel as if an autonomous robot is actually controlled by a remote operator."(2016, p. 1). It can be beneficial in multiple cases. For example, a communication robot, where the pseudo presence of caregivers is implemented, can improve the cognitive function of elderly people (Tanaka, et al., 2012). Students were more motivated in science class when an android robot with the pseudo presence of a teacher was applied as a teacher (Hashimoto, et al., 2011). However, there are, to our knowledge, no previous studies investigating pseudo presence and mistreatment of robots. Thereby, the question remains whether pseudo presence could make a difference in the mistreatment of robots from bystanders. Hence, our research question is: *what is the effect of the pseudo presence of a human operator on the mistreatment of autonomous robots?*

Human perception of technology shapes the way the technology is applied in society (Rea & Young, 2018) and vice versa. Research in social HRI explores and argues that humans' perception of robots can be influenced by descriptive priming or framing, i.e. the language of introducing a robot (Westlund, et al., 2016, Rea & Young, 2018). For example, Rea & Young (2018) found out that people's perception and evaluation of the robot differ between different descriptions of the same robot while teleoperating it. While interacting with a robot, Lau and colleagues (2005) noticed that people would believe that the robot has the knowledge of local landmarks even when only minimal information about the robot was provided (the language it speaks and the place it was produced).

Thus, it is apparent that framing the introduction of the robot could modify the human perception of it. Therefore, we could assume that if the user focuses on the fact that the robot is controlled by a human operator behind the scenes, they might perceive a pseudo presence of the human operator and furthermore, react socially. This leads to our first hypothesis:

H1: perceived human operation increases pseudo presence.

In a real-world HRI environment, it is found that children often behave well towards the robot when their parents are around (Brsci & Kanda, 2015). It was also found that people tend to treat an autonomous robot aggressively when there were no human operators (Salvini, et al., 2010), i.e. the presence of a human operator decreased robot mistreatment effectively. Hence, if the feeling of an autonomous robot being operated by humans is induced, bystanders might treat them differently. As stated in previous studies, people attempt to mistreat the robot by interfering with its task, which lowers the working efficiency of this robot i.e. the time the robot spent on finishing the task. This leads to our second hypothesis is:

H2: perceived pseudo presence leads to less mistreatment, i.e. higher working efficiency of the robot.

However, in this circumstance, the high working efficiency of the robot might lead to the low working efficiency of the human, as the human might need to avoid interference from the robot while completing their tasks. This leads to our third hypothesis:

H3: robot working efficiency negatively correlates with human working efficiency.

Regarding experience, previous studies argue that curiosity (Nomura, et al., 2015, Salvani, et.al, 2010), perceived intention, and discomfort (Keijsers & Bartneck, 2018) predict negative attitude towards robots. This leads to our fourth set of hypotheses:

H4a: Perceived pseudo presence leads to more perceived intention

H4b: Perceived pseudo presence leads to less curiosity

H4c: Perceived pseudo presence leads to less discomfort

An experiment was conducted to investigate the effect that perceived human operation has on the working efficiency of a robot, while both robot and human do their tasks simultaneously. Meanwhile, the human's experience of the interaction with the robot was also evaluated.

2 Method

2.1 Participants & design:

We recruited 40 participants in total (Male = 27 Female = 13). The average age was 24.18 (SD = 2.37 Min=18 Max=30). The majority of participants were recruited through convenience sampling in Eindhoven since the database server of participants was offline at the time of the experiment. The participants were required to be able to walk independently and have good vision.

The current study was conducted in a lab. It employed a within-subject design. Two conditions were applied: autonomous and teleoperated. The dependent variables were the pseudo presence and working efficiency of the robot, curiosity, perceived intention, and perceived discomfort. The independent variable was the different descriptions of the robot in the two conditions.

In the teleoperated condition, participants were informed that the robot was being teleoperated by the experimenter in another room. The experimenter operated the robot in front of the participant to convince them that the robot was indeed driven and stopped by an operator, thus establishing the pseudo presence of a human operator. The screen of the robot additionally showed the word “teleoperated” (Appendix 8.1.1). In the autonomous condition, participants were informed that the robot was driven autonomously. It was able to perform a cleaning task, detect obstacles, and stop autonomously. The screen of the robot showed the word “autonomous” (Appendix 8.1.2). In both conditions, the robot was actually always driven autonomously, i.e. the same algorithm was applied. Each participant experienced both conditions, which means there were a total of two trials for each participant. The orders of the two conditions and two tasks were both counterbalanced.

2.2 Experimental set-up and materials:

We chose a custom-made robot from the Eindhoven University of Technology, which is known as “FAST-platform” (see Figure1). The size of the robot is L* W * H= 730 mm * 650 mm * 900 mm. The sensor we employed was a Hokuyo 2D laser sensor, which was hanging at the bottom front of the robot. The algorithm allowed the robot to stop when an obstacle was detected in front of it. After several tests, the stopping range of the robot was set at 20 - 70 cm to ensure that the robot would stop at a proper distance from the participants but it would not stop if small obstacles or noise were detected close by. Unfortunately, due to the corona crisis, the final version of the code of the robot is not accessible. The initial version of the code is attached in appendix 8.2.

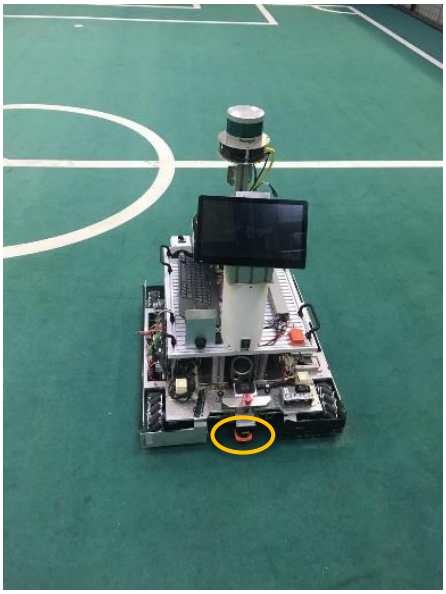

Figure1: Fast-platform. The laser range finder is at the bottom of the robot, which is highlighted with the orange circle.

While the robot was performing a cleaning task in the room, participants were asked to categorize envelopes on two tables according to colour and size. This required that the participants crossed the room from one side to the other. The speed of the robot was set to 0.2

m/s. The size of the available space was 3m*5m. The navigation path of the robot was S-shaped (see Figure 2) in both tasks (categorize the envelopes based on colour and size). It took the robot approximately 3 minutes to navigate from one side of the room to the other side. The robot navigated twice in each condition (forth and back) i.e. 6 minutes in total for each condition. The walking speed of the participant was considered to be 1 m/s. The walking path of participants and the driving path of the robot is shown in Figure 2.

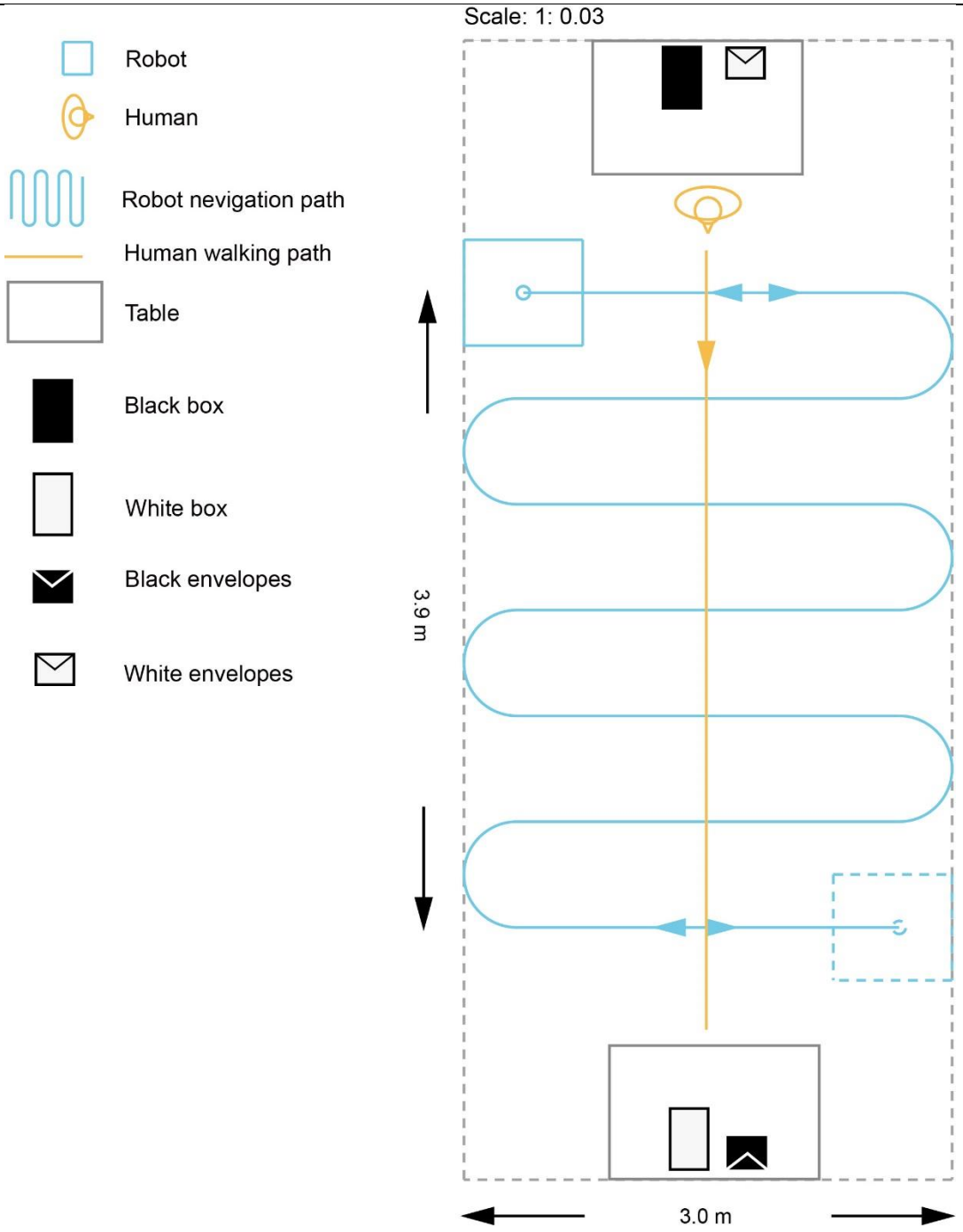

Figure 2: Visualization of the path in categorizing task based on colour. In size categorizing task, envelops and boxes were change to small/big envelops and small/big box and the rest remained the same.

The descriptions of the two algorithms are below:

Algorithm 1: teleoperated

The algorithm is developed for teleoperation. Hence, the robot will be controlled by a human operator behind with a keyboard. The speed of the robot is 0.2 m/s. The robot will be stopped by the human operator when an obstacle (in this case, the participant) is detected in the distance of 70 cm or less. When the obstacle moves out of the range, the operator will start the robot and continue cleaning.

Algorithm 2: autonomous mode

The robot is driven autonomously. The algorithm enables the robot to perform a cleaning task, detect and avoid obstacles autonomously. The speed of the robot is 0.2 m/s. The robot will stop after detecting an obstacle (in this case, the participant) in the distance of 70 cm or less and restart to move in 3 seconds when the obstacle is out of the detect range.

2.3 Measurement:

Working efficiency of the robot was measured by the time the robot spent on finishing the task. While the robot was simulating the cleaning task, participants had to categorize envelops according to colour or size. The amount of categorized envelopes was used as the measurement of working efficiency of participants. Participants were asked to fill in a questionnaire after each condition. The question used to measure pseudo presence was based on the questionnaire used by Tanaka and colleagues (2016).

To check if the manipulation succeeded, we asked the participants if the robot was driven by a human operator and if the robot was stopped by a human operator when it encountered an obstacle. Those two questions were asked as yes / no questions. The scale for manipulation

had $Cronbach's\ \alpha\ =\ 0.83$, which is considered to be with good reliability, so an average score for manipulation was calculated.

Several scales were used to measure people's evaluations of the robot. The perceived intention (referring to the perceived capability of the robot to act intentionally) was measured with 3 items selected from the MAS (mind attribution scale) from Kozak et al (2006) that were answered on a 7-point Likert scale ranging from strongly disagree to strongly agree. The scale contained all three items and had $Cronbach's\ \alpha\ =\ 0.62$, which was considered to be with acceptable reliability.

Curiosity was measured with 3 items created by us that were answered on a 7-point Likert scale ranging from strongly disagree to strongly agree. The scale contained all three items and had $Cronbach's\ \alpha\ =\ 0.70$, which was considered to be with acceptable reliability.

Task priority was also measured with 3 items created by us that were answered on a 7-point Likert scale ranging from strongly disagree to strongly agree. The scale with all three items included had low reliability ($Cronbach's\ \alpha = 0.50$). Therefore, we chose only the third question ('*My task is more important than the robot's task'*) as the measurement for task priority.

Discomfort ($Cronbach's\ \alpha\ = 0.78$)was measured by ROSAS (Carpinella, et al., 2017) where a 7-point Likert scale with unidimensional items ranging from definitely not associated to definitely associated was applied. Beyond that, this scale also comprises of warmth ($Cronbach's\ \alpha = 0.88$) and competence ($Cronbach's\ \alpha = 0.81$). All items have high internal consistency within each factor, respectively.

Moreover, participants' former experience of interacting with robots and contexts in which the interactions took place were measured.

An overview of all questions is attached in appendix 8.3.

2.4 Procedure:

Upon entering the lab, participants were informed about the purpose of the experiment and of the data that would be recorded during the experiment. They then gave informed consent. Next, participants were led to the lab where the experiment took place and given more detailed instruction of their task and information about the robot. The participants were told that the experiment was a pilot test of a cleaning robot that would be introduced to warehouses in the future. Participants were asked to categorize 72 envelopes on the tables according to colour (black envelopes into a black box and white envelopes into a white box) and size (big envelopes into a big box and small envelopes into a small box). Participants were allowed to take only one envelope at a time, while the robot was also performing a cleaning task in the room. To complete the tasks, participants and the robot sometimes interfered with each other, i.e. participants might need to stop to wait for the robot moving away from their walking path and vice versa. In this stage, the working efficiency of the robot and participants, i.e. the time that the robot needed to complete the task and the amount of envelopes participants categorized, were measured.

Before the start of the teleoperated condition, the experimenter first changed the interface to "tele-operated mode". Then the robot was introduced as tele-operated by a human operator. To make participants believe that the robot was actually tele-operated, the experimenter drove the robot back to the initial place in front of the participant through a laptop. On the other hand, before the start of autonomous condition, the experimenter changed the interface

to “autonomous mode” and pushed the robot back to the initial place. Then the experimenter introduced the robot as autonomously driven and showed the sensor that was employed in the task.

Participants were asked to briefly repeat the task they were going to perform to ensure that they understood the procedure of the experiment. Then the experimenter left the room. Once the robot started moving, participants started doing their task as well.

After each task, participants filled in a questionnaire, where pseudo presence, curiosity, perceived intention, task priority, warmth, competence, and discomfort were measured. After the first task, the participants’ former experience of interacting with robots was also measured. To gain more objective insight, their behaviour was recorded by the two cameras in the lab.

At the end of the experiment, participants were debriefed. Participants from Eindhoven University of Technology received either 5 euro or study credits, while participants outside the University received 7 euro as compensation. The experiment took in total approximately 30 minutes.

3 Results

Firstly, we checked the participants' former experience in encountering robots. Then, we checked if our manipulation succeeded. Thirdly, we conducted a set of analyses to test our hypotheses. Lastly, we included several extra factors from the questionnaires in further exploratory analyses.

3.1 Former experience

In the questionnaire, former experience with robots was evaluated. We asked about the frequency with which participants encountered robots (daily, weekly, monthly, yearly, or never). 35 out of 40 participants had previously encountered robots (Figure 3). More specifically, 11 out of 35 participants encounter a robot yearly, 16 out 35 encounter a robot monthly, 6 out of 35 encounter robots weekly, and 2 out of 35 encounter robots daily.

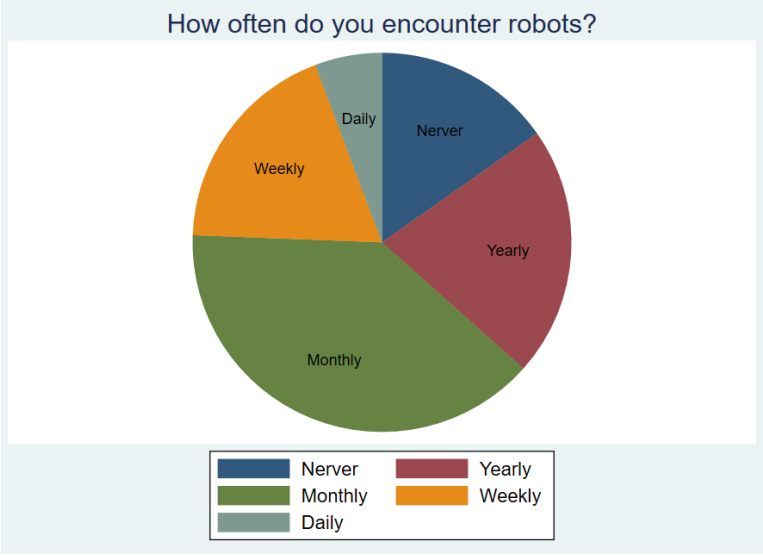

Figure 3: frequency of encountering robots

Moreover, the way participants interacted with robots were taken into concern as well (see Figure 4), where participants were allowed to choose multiple experiences. 4 out of 40 participants have a robot at home, 8 out of 40 have the experience of designing code for

robots, 15 out of 40 have seen robots in public environment, 23 out of 40 have the experience of participating in experiments with robots, 1 out of 40 have other kinds of related experience ("A friend has a robot").

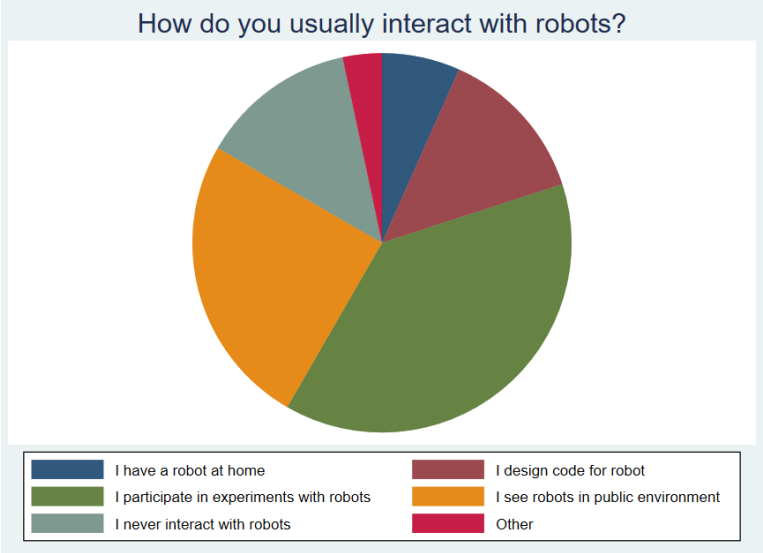

Figure 4: Interaction between participants and robots

To check the influence of former experience of participating in experiments with robots on perceived intention and curiosity, a set of simple t-tests were performed on responses of the respective variables on the questionnaire. The result showed that for participants with the experience of participating in experiments with robots, the difference of perceived intention between autonomous condition and tele-operated condition was insignificant. Regarding participants with no experience of participating in experiments with robots, the difference of curiosity and discomfort between autonomous condition and tele-operated condition was insignificant ($all\ t < 1.5,\ \ p > 0.13$). In other words, former experience did not have statistically significant influence on perceived intention, curiosity, and discomfort in the two conditions.

3.2 Manipulation check

We noticed that although participants had doubts on whether the robot was truly tele-operated in the tele-operated condition, they still chose to believe that there was a human operator

behind the robot. This was also reflected on the manipulation check: several participants indicated that they believed the robot was either only driven by a human operator or only stopped by the human operator (see Figure 5). To check the manipulation of a human operator, data on the question of whether the robot was driven or stopped by a human operator were submitted to a Fisher's exact analysis since the values were considerably unevenly distributed. Primary results indicated a significant enhancement of our manipulation on perceived human operator in the tele-operated condition with a proportion of 70% (28/40), compared to 5% (5/40) autonomous condition ($p < 0.01$), which means that the manipulation succeeded.

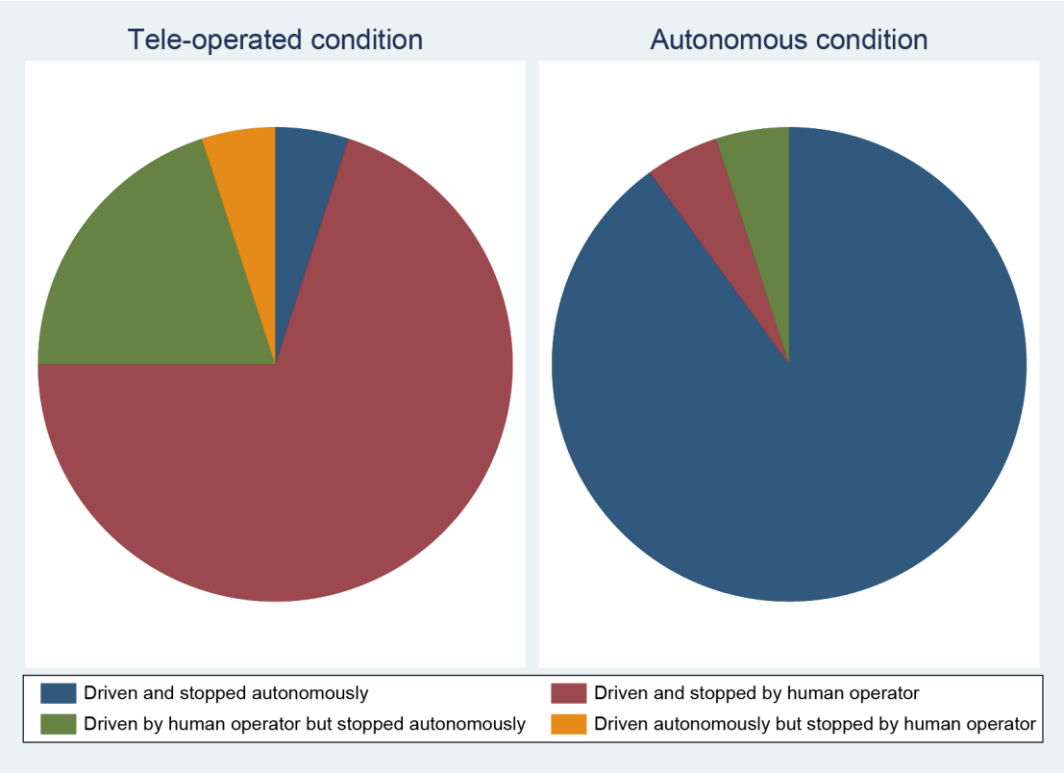

Figure 5: Pie chart with response to whether the robot was driven or stopped by a human operator in tele-operated condition (a) and autonomous condition (b)

3.3 Hypotheses tests

3.3.1 Pseudo presence

To test the hypothesis that perceiving a human operator to control the robot increases pseudo presence, data on the question of pseudo presence were submitted to a Fisher's exact analysis since the values were considerably unevenly distributed. Results showed that participants in the tele-operated condition ($M = 3.83,\ SD = 1.89$) perceived more pseudo presence than those in the autonomous condition ($M = 1.9,\ SD = 1.46$), $Cramér's\ V = 0.5882,\ p < 0.001$. Therefore, H1 was supported. Perceived human operation indeed enhances pseudo presence of a human operator.

3.3.2 Working efficiency

The behaviour of participants was recorded through the two cameras in the lab. The videos showed evidence of mistreatment of the robot from the participants. In general, the mistreatment of the robot can be categorized into 3types. In the first category, participants were focusing on their own task. They walked past the robot from the front or the back depending on how close the robot was to them. Therefore, the robot got mistreated since participants might be focusing on their own task more than on the robot (49 out of 80). In the second category, participants were trying to explore the capability of the robot by walking past or stopping in front of it on purpose, jumping into the navigation path in front of it, touching it, and trying to stop it from different directions with their feet or hands while doing the task. In this case, the robot might have gotten mistreated since the participants were curious about it while doing their task (18 out of 80). In the third category, participants were exploring the capability of the robot by interfering with its task by standing in front of it and using envelopes to block it from different directions instead of focusing on their tasks. In this case, the robot might be mistreated since the participants got distracted by the robot (8 out of

80). Moreover, there were 5 cases where participants did not show any mistreating behaviour. Hence, those cases did not fall into any categories.

As a result of the mistreatment, the robot went off the path in several cases either as a direct effect of the mistreatment or too much inference from the participant making it unable to finish its task. In those cases, the experiment had to be interrupted. The working efficiency of the robot in those cases was marked as missing value (10 out of 80 cases). More specifically, 6 out of these 10 cases were caused by mistreatment or too much interference from the participants, where 3 cases happened in the tele-operated condition and 3 cases happened in the autonomous condition. In addition, there were 2 cases where participants showed contrasting behaviour. In one case, the participant stopped the robot by putting an envelope in front of it in both conditions. After he finished his task, he removed the envelope and started observing and interfering with the robot. Eventually, he figured out that the robot was autonomously driven in both conditions. This led to an extremely low robot working efficiency. In the other case, the participant was observing and interfering with the robot in both conditions whilst doing little of his task. Consequently, the human working efficiency was extremely low (2 out of 72 envelopes were categorized in both conditions). This leads to the notion that mistreatment might affect both humans and robots when applying a robot in public. People might lower the working efficiency of the robot by mistreating it, while their own working efficiency might be lowered by getting distracted by the robot as well. Including all the cases above, in total 12 cases were labelled as outliers and excluded while analysing working efficiency of robot and human.

To test the hypothesis that perceived pseudo presence leads to less mistreatment, data on the time the robot took to finish the task in the tele-operated condition and the autonomous condition were submitted to a rank sum test since the data was not normally distributed in

both conditions. Figure 6 illustrates the time the robot spent on finishing the task in both conditions, where the line on the graph represents the trend if the robot was to spend the same amount of time on finishing its task in both conditions. As we can see from the plot, the robot spent more time on finishing the task in the autonomous condition than in the tele-operated condition, which means that the robot had higher working efficiency in tele-operated condition than autonomous condition. This was also reflected in the mean value of robot working efficiency in the two conditions (see Figure 7). However, the result of the rank sum test showed that the difference of robot working efficiency between the tele-operated condition ($N = 32,\ M = 199.74,\ SD = 4.13$) and the autonomous condition ($N = 34,\ M = 202.60,\ SD = 8.16$) was insignificant ($z = 1.32,\ p = 0.19$). H2 was rejected. Our results showed that pseudo presence had no significant impact on mistreatment of robots.

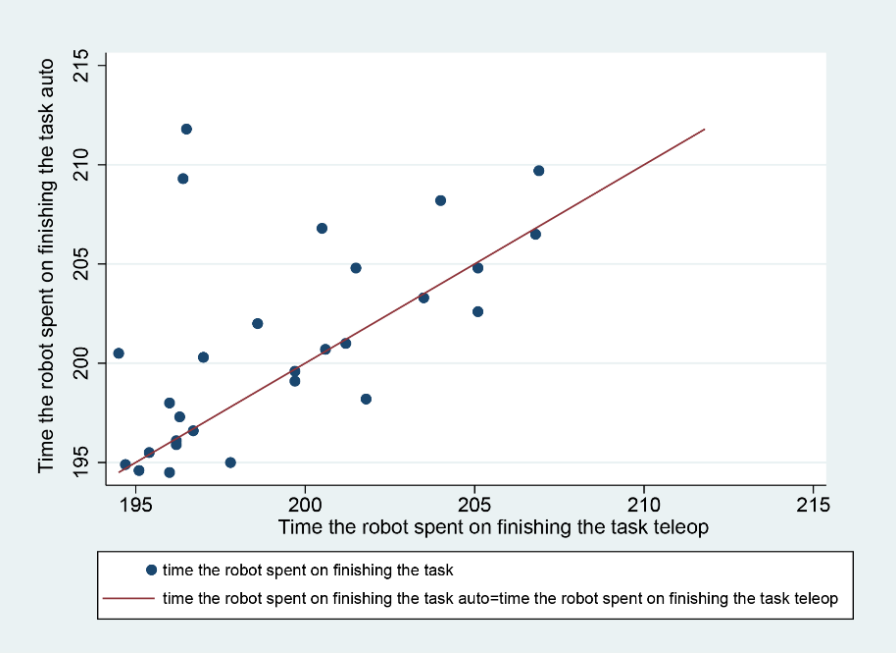

Figure 6: visualization of the time robot spent on finishing the task in autonomous and tele-operated condition

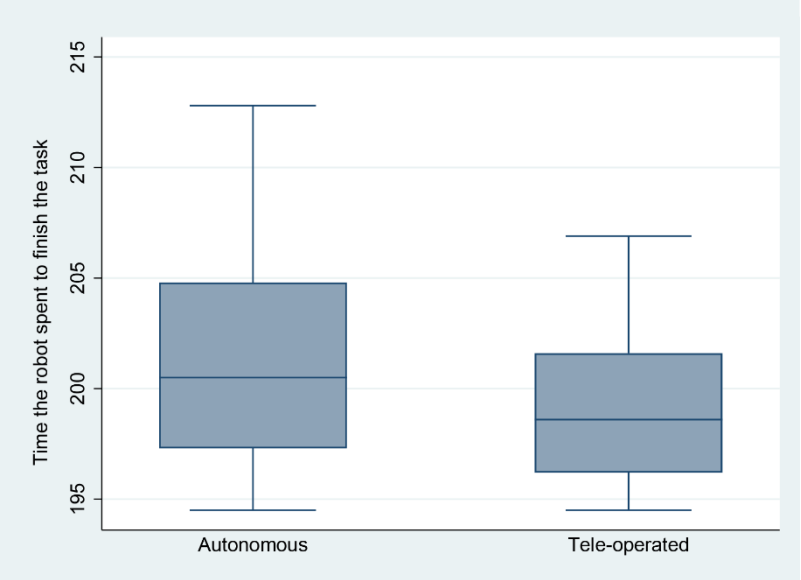

Figure 7: robot working efficiency box plot

To seek an explanation for the insignificant result, a set of correlation analyses were conducted between robot working efficiency and the other variables we evaluated through the questionnaire (perceived intention, task priority, curiosity, warmth, competence, and discomfort). We found a positive correlation between the time the robot spent on finishing the task and task priority ($Spearman's\ \rho\ =\ 0.48, p\ =\ 0.0052$) in the tele-operated condition but not in the autonomous condition ($Spearman's\ \rho\ =\ 0.17, p\ =\ 0.33$). This means in tele-operated condition, participants who valued their task more were more likely to mistreat the robot, which leads to the notion that the difference in robot working efficiency between the two conditions might be neutralized by the negative correlation between task priority and robot working efficiency.

To test the hypothesis that robot working efficiency correlates to human working efficiency negatively, data on the time the robot spent finishing its task and the amount of envelopes the participant categorized were submitted to a correlation analysis. With all outliers excluded, no significant correlation was found ($r = -0{,}03, p = 0.79$). The third hypothesis was

rejected. Thus, there was no correlation between human task efficiency and robot task efficiency according to our results.

3.3.3 Evaluations of the robot

To investigate the relationship between pseudo presence and intention, curiosity, and discomfort, a set of linear regression analyses were conducted with pseudo presence as a categorical predictor, other variables as dependent variables. To test the hypothesis that pseudo presence leads to more perceived intention, data on the evaluation of pseudo presence and perceived intention from the questionnaire were submitted to a linear regression. The assumptions of normality, linearity and homoscedasticity were met and no outliers that had strong influence were found. The results showed that pseudo presence did not significantly predict perceived intention ($F\ (6, 73)\ = 1.75, R2 = 0.11, p = 0.12$). H4a was rejected. As can be seen in figure 8(a), there is indeed a wide spread of the evaluation of perceived intention in the autonomous and tele-operated conditions. This revealed that participants perceived the intention of the robot differently; some participants perceived more intention in the autonomous condition, whereas other participants perceived more intention in the tele-operated condition.

To test the hypothesis that pseudo presence leads to less curiosity, data on the evaluation of pseudo presence and curiosity from the questionnaire were submitted to a linear regression. The assumptions of normality, linearity and homoscedasticity were met and no outliers that had strong influence were found. As can be seen in figure 8 (b), participants seemed to be more curious in autonomous condition than in tele-operated condition. However, the result showed that pseudo presence predicted curiosity insignificantly ($F\ (6, 73)\ = 1.01, R2\ = 0.08, p = 0.43$). H4b was rejected. One explanation could be that former experience might

influence the evaluation of curiosity. This was reflected by the remarks from some participants after the experiment. For instance, one participant said he was more curious about the robot in the tele-operated condition than in the autonomous condition since he had experience and knowledge in programming a robot, whereas other participants with knowledge in programming robots showed more exploring behaviour in the autonomous condition.

To test the hypothesis that pseudo presence leads to less discomfort, the assumptions for linear regression were checked, where the normality was rejected. Hence, the data on the evaluation of pseudo presence and discomfort from the questionnaire were submitted to a robust regression. The result showed that pseudo presence predicted discomfort insignificantly ($F\ (6, 73)\ = 1.74\ R2 = 0.12\ p = 0.12$). H4c was rejected. As can be seen in figure 8 (c), participants seemed to evaluate low discomfort in both conditions. The spread of the responses stayed close to the line which represented that the evaluations of discomfort were same in autonomous and tele-operated condition.

To sum up, inclusion of the pseudo presence did not lead to more perceived intention, less curiosity, and less discomfort

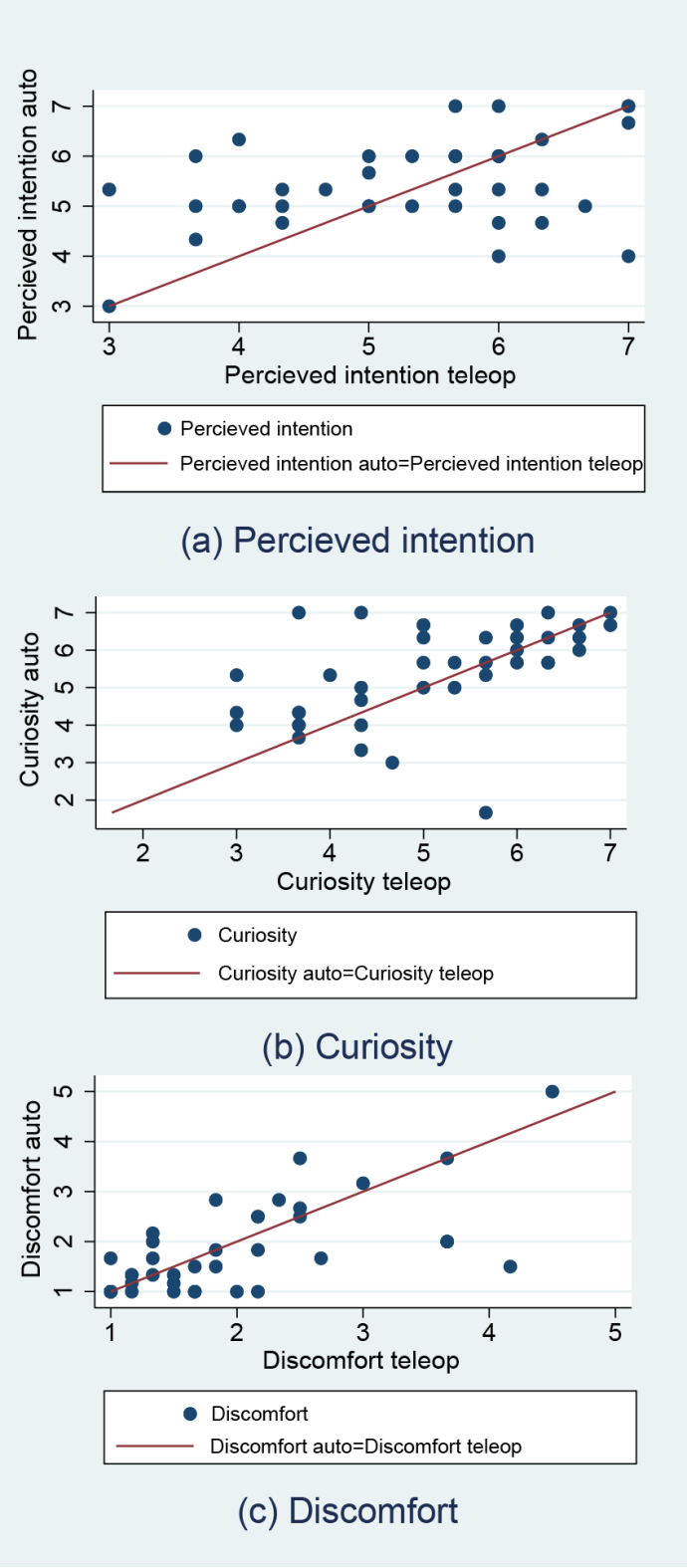

Figure 8: visualization of the evaluation of perceived intention (a), Curiosity (b), and discomfort (c) in autonomous and tele-operated condition.

3.4 Exploratory analyses

Aside from the hypotheses, we also included task priority, warmth, and competence in the questionnaire as exploratory factors. We conducted linear regressions with each factor as dependent variable and pseudo presence as the categorical predictor. The assumptions were checked, where normality, linearity and homoscedasticity were accepted. No outliers had strong influence on the result. The results showed that pseudo presence only predicted warmth significantly ($F\ 6,73 = 2.26, R2 = 0.16, p = 0.046$). The graph (see Figure 9) revealed that warmth and pseudo presence correlated positively, i.e. the more pseudo presence participants perceived, the more warmth they associated with the robot.

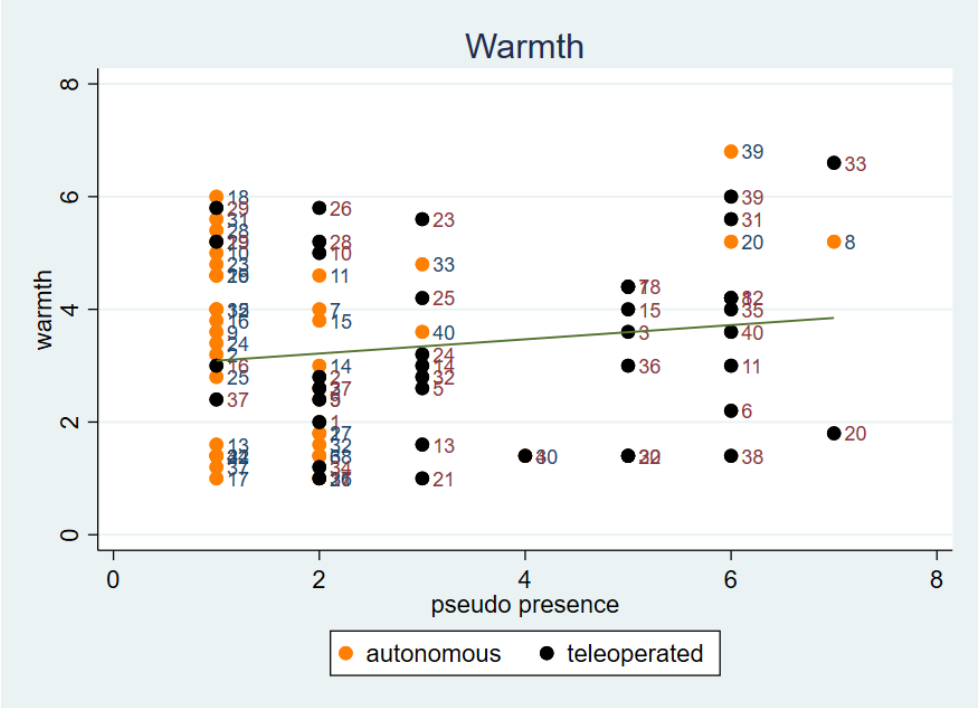

Figure 9: Warmth and pseudo presence

4 Discussion

It is an inevitable trend that autonomous robots will be applied more and more in public. Therefore, the issue of robots being mistreated by bystanders becomes more necessary to investigate. The present study proposed pseudo presence of a human operator as a potential factor that might influence bystanders mistreating robots and investigated this in a lab. We created a scenario where participants and a robot had to coexist in the environment by assigning the participants tasks of categorizing envelopes, while a robot was simulating a cleaning task.

As we expected, most participants believed the fact that the robot was driven by a human operator after being told so. Hence, our manipulation succeeded. Interestingly, a few participants believed in our manipulation only partially: they believed that the robot was either driven by the human or stopped by the human. One potential explanation for this could be how participants might distinguish human operation of the robot compared to autonomous behaviour. This was reflected in the comments some participants made after being debriefed. A few participants believed that the robot stopped autonomously in the tele-operated condition since they thought the human operator would not be able to stop the robot with precision as soon as it detected an obstacle. In contrast, some participants speculated that the human operator would not be able to drive the robot with precision, and thought that the main job of the human operator was only to stop the robot when it met an obstacle. This might, furthermore, influence their behaviour in the tele-operated condition since they might be curious to see how the robot, or more explicitly, the “human behind the robot” would react.

In line with our expectation, participants perceived more pseudo presence of a human operator in the tele-operated condition. Therefore, our first hypothesis, that perceived human

operation would increase the pseudo presence of a human operator, was supported. This was in line with previous studies that show that pseudo presence can also be produced by framing the introduction of the robot in a scenario (Tanak et al., 2015), and additionally confirms this effect where no direct interaction between human and robot was applied.

Contrary to our expectation, no differences in robot working efficiency were found between the tele-operated and autonomous conditions, i.e., pseudo presence did not influence mistreatment. Our second hypothesis that pseudo presence lead to less mistreatment of the robot was rejected. One explanation could be that in some cases, the robot went off the path and stopped in the middle of the experiment due to the mistreatment from the participants. This resulted in some missing values in both conditions, which were excluded in the analysis afterwards. If the robot had not gone off the path, there could be a different result. Moreover, a negative correlation was found between robot working efficiency and task priority in the tele-operated condition, not in the autonomous condition. In the tele-operated condition, for participants who evaluated their task with higher priority, the robot spent longer time to finish its task, i.e. participants were more likely to mistreat the robot. The correlation between the two might neutralize the difference between the tele-operated and the autonomous conditions, which led to an insignificant result. This suggests that when introducing autonomous robots in daily life, the integration of pseudo presence of a human operator should be context dependent. It might lead to more mistreatment when humans' task is seen to be more important than robots', for example when applying a cleaning robot in hospitals. However, the present study does not have enough data to test this assumption.

In terms of the correlation between robot working efficiency and human working efficiency, no significant correlation was found. The third hypothesis was rejected. Although no clear patterns were found regarding participants' behaviour, one explanation could be that we chose

the amount of envelopes that got categorized in each condition as the measurement of human working efficiency. But the difference between the amount of categorized envelopes was small. It could be influenced by the walking pace, step size of the participants in each condition i.e. the interference from the robot did not have much influence on participants categorizing the envelopes.

Regarding the fourth hypotheses, perceived pseudo presence did not predict perceived intention, curiosity or discomfort significantly. In terms of perceived intention, the result found that some participants perceived more intention from the robot in the autonomous condition, whereas some participants perceived more intention from the robot in the tele-operated condition. This suggested that there might be other factors that influenced how participants perceived the intention of the robot, which would be valuable for further investigation. On the one hand, a robot is perceived as human-like because of its independence and autonomy (Keijsers & Bartneck, 2018), which could be the reason that participants perceived more intention in the autonomous condition. On the other hand, the behaviour of a robot is perceived to be intentional when the behaviour is believed to be created by humans (Wiese, et al., 2012), which might explain why participants perceived more intention in the tele-operated condition. Regarding curiosity, participants seemed to be more curious about the robot in the autonomous condition than in the tele-operated condition. Nonetheless, pseudo presence did not predict curiosity significantly. An explanation could be that previous experience of the participants might influence their evaluation of the robot. For instance, some participants claimed that they were more curious about the robot in the tele-operated condition as they have the knowledge of robotics, whereas some participants showed more curious behaviour in the autonomous condition by exploring the capability of the robot. Besides, curiosity can also be regarded as a personality trait, which leads to the

notion that participants who are in general curious might evaluate more curiosity than those who are not.

Except for the above analysis, we performed several exploratory analyses. The result suggested that pseudo presence predicted warmth positively and significantly, i.e., pseudo presence of a human operator increased perceived warmth. Warmth was applied as a measurement of the impression of a human, as well as a dimension of perception of a robot (Capenilla, et.al, 2017). A robot that is perceived to be warm is more likely to experience positive interaction (Capenilla, et.al, 2017). Hence, the pseudo presence of a human operator might bring a positive impression and interaction between the robot and human. Although no significant correlation between robot working efficiency and warmth was found, this might be a valuable factor to further investigate the mistreatment of robots. However, that is not to say that pseudo presence of a human operator should be a default in the design of robots. Given that we found a negative correlation between human task priority and robot working efficiency, the inclusion of pseudo presence would be more relevant for contexts in which humans' tasks are less important than robots' tasks, such as shopping malls.

Moreover, similar to the field study conducted previously (Brsci & Kanda, 2015), the videos showed strong evidence of mistreatment behaviour of the robot from bystanders during the experiment such as approaching the robot from different directions aggressively or stopping in front of the robot for a few seconds on purpose. We categorized three types of robot mistreatment from the participants, which could be identified as the following: mistreatment caused by participants doing their task, mistreatment caused by participants exploring the capability of the robot while doing their task, mistreatment caused by distraction from the robot. Some mistreatment caused the robot to go off the path and stop in the middle of the experiment, which, eventually, affected the final experimental outcome of robot working

efficiency. However, when applying a robot in public, the mistreatment can be on both sides: the unpredictable behaviour from bystanders may lower the working efficiency of the robot, while human working efficiency may also be affected since they may get distracted by the robot. Lastly, previous studies suggested that social influence is one of the reasons for mistreatment of robots (e.g. Nomura et al, 2015). Although the present study did not take that into account, a pattern was still found in the remarks of participants. One participant commented that he wanted to touch the robot before and after the experiment, while he was not sure if he was allowed to do so. The other participant remarked that the questionnaire after the first task sparked the idea of touching or stopping in front of the robot. Although they did not strongly mistreat the robot, they might be socially influenced to mistreat the robot while seeing other people doing so in public.

Last but not the least, former experience influenced participants' attitudes and behaviour towards the robot (Tanaka, et al., 2016, Lau, et al., 2005). This was reflected in the behaviour of the participants: those who had knowledge of robotics showed more curiosity and exploring behaviour. Compared to participants with less knowledge of robotics or experience of designing code for robots, they might take a different perspective as an expert to explore the capability of the robot, which led to more mistreatment. They showed curiosity towards both the software (the code and platform of the algorithm) and the hardware (the mechanical settings) of the robot by asking relevant questions before and after the experiment and exploring the capability of the robot whilst doing their task. One participant with experience of a robot battle competition treated the robot more aggressively. He did not intend to avoid or give the way to the robot, even when the robot got really close to him. As a consequence, the robot went off the path in the second study. In spite of the fact that they have certain knowledge of autonomous robots and were exploring the capability of the robot, they still

believed that there was a human operator behind the robot, which might have influenced their evaluation towards the robot and the degree of mistreating the robot.

5 Limitations & future research

One major limitation was that since the experiment was conducted in a lab where the space was limited, the robot stopped in the middle of the experiment when it went off the designed path due to mistreatment and detected the wall. Moreover, the overloaded use of the robot led to several instances of malfunction. As a consequence, there were several missing values for robot working efficiency, which got excluded while conducting the quantitative analysis.

The current study analysed human behaviour through the video recording with the two cameras in the lab. Although participants mistreated the robot while they were focusing on their task, the behaviours were different. Some participants chose to wait or walk behind the robot while the robot was approaching, while other participants would walk in front of the robot as long as the robot was close to them. Hence, in future studies, location tracking could be employed to investigate humans' decisions on the walking path while a robot is approaching them.

As we found in our manipulation, participants' perception of the robot differed between different states (driving, turning, or pausing) of the robot. For instance, a few participants believed that the robot was driving autonomously but stopped by the human operator, while several participants thought that the robot was driven by a human operator but stopped autonomously. Present study only included one item while measuring pseudo presence. Thus, future studies could include more items according to the different states of the robot to evaluate the extent of the pseudo presence of a human operator.

Almost half of the participants have the knowledge of robotics or designing code for the robot, which may not accurately reflect society. This helped us gain many essential insights from both the videos and the remarks they made after the experiment. However, this might

also neutralize some of the effects we were trying to investigate, such as perceived intention, curiosity, and discomfort. The attitudes of those with less experience of robots might be valuable to further investigate in a future study. Hypothetically, for people with less experience, pseudo presence of a human operator may decrease their perceived intention of an autonomous robot as they might see the robot as a puppet controlled by a human behind instead of an intelligent object that is capable to complete a task independently. People are more likely to have had prior experience seeing a human-operated robot (e.g. a cleaning robot is driven by a human in supermarkets). These previous experiences can be referred to whilst understanding the behaviour of a "tele-operated robot", which may lead to less curiosity and discomfort towards the robot.

However, the present study is the first study that investigated the relationship between pseudo presence and mistreatment of the robot from bystanders. The study shed light on the possibility of investigating an issue that was widely discussed in field studies in a lab study. Although some limitations might have led to the insignificant results, the pattern we found in the videos still provided evidence of bystanders mistreating the robot. It can be insinuated that this effect would be more pronounced in a real environment, where the role of a human operator absent. Moreover, current study succeeded in creating the pseudo presence of a human operator in the scenario where an indirect interaction between human and robot took place, which draws attention to the possibility for further studies. Last but not least, we found a positive correlation between warmth and pseudo presence which is beneficial for future research and design on social robots.

6 Conclusion

Mistreatment behaviour towards robots had been observed and researched in both field studies and lab studies. Previous lab studies mostly investigated mistreatment of robots when a direct interaction between human and robot is applied. Meanwhile, field studies found that the mistreatment of robots are mainly from bystanders, who are the major actors coexisting in the public environment that do not necessarily interact with the robot. They tend to approach the robot to explore its capabilities, which results in a mistreatment of the robot. Yet, it was found that the present of a human operator would decrease those mistreatments. The current study investigated this issue by applying the pseudo presence of a human operator in the lab, which is to our knowledge, the first study investigating this. It paves the way for future research on mistreatment of robots from bystanders and gives designers inspiration of creating and optimizing the interaction of a social robot in a public scenario.

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TRICK OR TREAT: THE EFFECT OF PSEUDO PRESENCE OF A HUMAN OPERATOR IN BYSTANDERS MISTREATING ROBOT.

8 Appendix

8.1 Interface of autonomous condition and tele-operated condition

CSS file:

```
html {
    height: 100%
    font-family: 'Montserrat';

    display: grid;
    align-items: center;
    justify -items: center;

}
```

8.1.1 HTML file for tele-operated condition

```
<!DOCTYPE html>
<html lang="en" >
<head>
  <meta charset="utf-8">
  <meta name="viewport" content="width=device-width,initial-scale=1.0">
  <meta http-equiv="X-UA-Compatible" content="ie=edge">
  <title>Document</title>
  <link rel="stylesheet" href="main.css">
</head>
<body>
  <div class="container">
    <h1>Tele-operated</h1>
  </div>
</body>
</html>
```

Interface of the robot in tele-operated condition

8.1.2 HTML file for autonomous condition

```
<!DOCTYPE html>
<html lang="en" >
<head>
  <meta charset="utf-8">
  <meta name="viewport" content="width=device-width,initial-scale=1.0">
  <meta http-equiv="X-UA-Compatible" content="ie=edge">
  <title>Document</title>
  <link rel="stylesheet" href="main.css">
</head>
<body>
  <div class="container">
    <h1>Autonomous</h1>
  </div>
</body>
</html>
```

Interface of the robot in autonomous condition:

8.2 Robot driving code

```
import rospy
import time
import numpy as np
from geometry_msgs.msg import Twist
from nav_msgs.msg import Odometry
from sensor_msgs.msg import LaserScan
from time import sleep
rospy.init_node('robot_cleaner', anonymous=True)

laser = False
counter = 0
t = Twist()
t.linear.x = 0.2
t.angular.z = 1
start_time = 0
is_running = False
full_round = 0

pub = rospy.Publisher('/cmd_vel', Twist, queue_size=10)

def callbacklaser(data):
    #print(rospy.get_caller_id() + " Laserdata: ", data.ranges)
    global laser
    #print(" Laserdata: ", data.ranges)
    count = 0
    for i in data.ranges:
        if i < 1:
            count = count + 1
    if count >= 10:
        laser = True
    else:
        laser = False
    #print "Volgens de callback is Laser = ", laser

def callback(data):
   # print(rospy.get_caller_id() + " X pose odom: ", data.pose.pose.position.x)
    #print(" X pose odom: ", data.pose.pose.position.x)
    d = data.pose.pose.position.x


def vel_callback(data):
    global start_time
    global is_running
    global laser
    global counter
    global full_round

    t.linear.x = 0
    t.angular.z = 0

    #print "Function is called: ", counter

    print "Laser = ", laser

    if not is_running:
```

```
        #start_time = time.time()
        start_time = 0
        is_running = True
    elif not laser:
        start_time = start_time + 0.1
        dif = start_time
        #dif = time.time()-start_time
        if dif < 10:
            t.linear.x = 0.2
            t.angular.z = 0
        elif dif < 10 + np.pi/2:
            t.linear.x = 0.2
            t.angular.z = 1
        elif dif < 20 + np.pi:
            t.linear.x = 0.2
            t.angular.z = 0
        elif dif < 20 + 2*np.pi:
            t.linear.x = 0.2
            t.angular.z = -1
        elif full_round < 4:
            #start_time = time.time()
            start_time = 0
            full_round = full_round + 1
        else:
            t.linear.x = 0
            t.angular.x = 0
            pub.publish(t)
            exit()
    else:
        t.linear.x = 0
        t.angular.z = 0

    pub.publish(t)

    print "Function finished: ", counter
    counter = counter + 1


rospy.Subscriber("/odom", Odometry, callback)
rospy.Subscriber("/hokuyo/scan", LaserScan, callbacklaser)

timer = rospy.Timer(rospy.Duration(0.1), vel_callback)

rospy.spin()
```

8.3 Questionnaire

Manipulation check:

In the last experiment, the robot is driven by a human operator to complete its task

Yes/no

In the last experiment, the robot is stopped by a human operator when there is an obstacle.

Yes/no

Hypothesis check:

Please choose how much you agree with the following statements:

Pseudo presence:

I felt the presence of a human operator.

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

Perceived intention:

Intention:

This robot is capable of doing things on purpose.

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

This robot is capable of planned actions.

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

This robot is capable of having goals.

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

Curiosity

I was curious of what the robot would do.

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

I was curious what would happen if I interfered

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

I was curious what would happen if i touch the robot

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

Task priority

My task is important

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

The robot's task is important

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

My task is more important than the robot

Strongly disagree						*Strongly agree*
1	*2*	*3*	*4*	*5*	*6*	*7*

RoSAS

Using the scale provided, what is your impression of this robot?

warmth

Happy

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Feeling

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Social

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Organic

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Compassionate

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

competence

Emotional

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Capable

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Responsive

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Interaction

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Reliable

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Competent

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Knowledgeable

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

discomfort

Scary

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Strange

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Awkward

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Dangerous

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Awful

Definitely not associated						*Definitely associated.*

1	*2*	*3*	*4*	*5*	*6*	*7*

Aggressive

Definitely not associated						*Definitely associated.*
1	*2*	*3*	*4*	*5*	*6*	*7*

Former experience:

How often do you encounter robots?

Daily

Weekly

Monthly

Yearly

Never

How do you usually interact with robots? Choose all options that apply.

I have a robot at home

I design code for robot

I participate in experiments with robots

I see robots in public environment

I never interact with robots

Other___

If you interact with robots, with what kind of robot do you interact?

_____

Please fill in your personal information:

Your age:

Please select your gender:

Male

Female

Other

Prefer not to say

8.4 Task Instruction

Colour categorize

In this task, you need to categorize the envelopes into the boxes according to colour match, which means, you need to put white envelopes into the white box and black envelopes into the black box. Please note that you can only take one envelope at a time.

Size categorize

In this task, you need to categorize the envelopes into the boxes according to size match, which means, you need to put the big envelopes into the big box and the small envelopes into the small box. Please note that you can only take one envelope at a time.