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Research Proposal

I, Robot – Mind Perception in The Real World

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1. Introduction

1.1. Perceiving minds

From basic biology we all know what kind of things have brains. Mice have brains; dogs have brains; apes have brains; babies have brains; grandparents have brains. However, the perception of the mind differs from the perception of brains. For instance, who can we hold accountable for their actions? If a mouse steals food in the supermarket multiple times, he will not be held accountable, employees most likely will. These examples hopefully illustrate the difficulties and challenges in perceiving minds. The influential philosopher Kant spent years trying to understand the mind. He proposed the mind as (1) a complex set of abilities or functions, (2) crucial for processing and application of concepts sensory input and (3) synthesis (and consciousness) is central to cognition. And these three ideas are still fundamental to most thinking about cognition. Kant's most important method, the transcendental method, is also still at use in today's cognitive science (Gomes & Stephenson, 2017).

1.2. Dimensions of mind perception

Kant's perception of the mind is one, but there are several ways to look at minds. According to the article of Gray, Gray, & Wegner (2007) there are different dimensions of mind perception. They conducted a survey in which participants had to rate several characters such as a dog, an old lady or a social robot on both agency and experience. So, for example, one such comparison involved rating whether a girl of five years old is more or less likely to be able to feel pain than is a chimpanzee. The dimension of experience is one defined by Gray, Gray and Wegner and involves hunger, fear, pain, pleasure, rage, desire, personality, consciousness, pride, embarrassment, and joy. The other dimension is agency, which involves among other things self-control, morality, memory, emotion recognition, planning, communication, and thought. Agency and experience both correlate for liking a character, wanting to save it from destruction, wanting to make it happy, and perceiving it as having a soul. However, moral judgements show differing correlations with the two dimensions. Agency is linked to moral agency and hence to responsibility. For example, in cases of punishment for wrongdoing (e.g., "A grandma killed someone vs. a toddler stabbed someone, which one do you think would be more deserving of punishment?"). In contrast, experience is linked to moral patiency and hence to rights and privileges. For example, the desire to avoid harming (e.g., "If you were forced to harm a dog or a robot, which one would it be more painful for you to harm?"). These different perceptions of mind thus capture different aspects of morality.

1.3. Perception of Artificial Minds

In the original study of Gray, Gray, & Wegner (2007), mind perception of a social robot Cozmo was mentioned as well. Therefore, the question arises if we humans perceive robots as if they have a mind. In a study by Stafford and colleagues (2013), older people in a retirement village were invited to use a prototype robot with healthcare functions over a two-week period. Residents were told that the robot could take vital signs (e.g., blood pressure), remind about medication, make telephone calls, play some songs, and play memory games. Participants could use the robot as much as they liked in the period of two weeks. The study found that people who chose to use the robot had more computer knowledge, held more positive attitudes towards robots, and attributed less mind agency to robots. The amount of mind agency and mind experience the residents perceived in robots also predicted how much robot-users intended to use the robot again. One possible explanation for the findings is that elderly people who believe that robots are high in agency are afraid to try it. These ideas may originate from exposure to robots in the media, including books, television, film, and news reports, which often exaggerate the capabilities and dangers of robots. Overall, the perception that the residents had of the robot were in line with the study of Gray, Gray, & Wegner (2007): robots have a higher capacity for agency then for experience.

Be that as it may, is it realistic to have a fear for robots? According to Mori (1970) an increasingly humanlike appearance would lead to increased liking up to a certain point. After this point robots that appeared too human became unnerving; he called this dip in liking the ‘‘uncanny valley.’’ A follow up study by Gray and Wegner (2011) tested this idea of the uncanny valley. By using three experiments, they investigated the perception of robots. In the first experiment, mechanic looking robots versus human looking robots were rated and this showed that the humanlike robot was perceived as more uncanny than the mechanical robot. In the second experiment, they tested whether a machine perceived to have experience, but not agency, would induce feelings of unease, even without a human-like appearance and this was indeed the case. And in the third experiment, they examined how people perceive those who have lost significant amounts of mental capacity, almost like a zombie. Participants were presented with a picture of a man described as being either normal, lacking agency, or lacking experience, and then participants had to assess feelings of unnerving-ness. It appears that a person without experience makes people uneasy in a way that someone without agency does not. Therefore, this study sheds a light on the importance of experience ratings. Perception of experience is probably what creates the feeling of uncanniness. The study also suggests that experience, but not agency, is seen as fundamental to humans, and is fundamentally lacking in machines as we saw in earlier studies as well (Gray, Gray, & Wegner, 2007; Stafford et al., 2013).

1.4. Self-perception

In this study, we would like to gain insights on how the mind perception of robots can change the perception of our own mind. And investigate how this change in mind perception of the self can lead to changes in behavior. The concepts on which this study will be based are rather complex. Defining the 'self' for instance has an entire research field dedicated to it. According to previous cross-cultural research, the self is most reliably described when a person shows a motivated response to information from the social environment. Motivated responses should thus depend on how the self is defined in a social space (Graupmann, 2018).

In the previous section it was noted that robots are rated as high in agency, therefore they are intentional beings that control their actions. The attribution of intentional agency to others such as other people, animals or robots have an influence over fundamental mechanisms of cognition (e.g., perspective taking or attention) (Zwickel, 2009; Wiese, et al., 2012). It remains unclear whether the attribution of intentional agency to others also affects our own sense of agency. Sense of Agency (SoA) constitutes a crucial aspect of human cognition. The SoA describes the feeling that one is in control over one's actions and their consequences. Ciardo and colleagues (2020) investigated SoA as well. They stated that SoA is influenced by social contexts and thus the presence of other agents like robots. Previous studies found that in the presence of others the SoA is reduced (Beyer, et al., 2018). Moreover, in their study they investigated whether the presence of an embodied robot would reduce SoA in a diffusion of responsibility task. This diffusion of responsibility task consisted of the performance of costly actions (i.e. losing various amounts of points) to stop an inflating balloon from bursting in both individual and joint tasks (i.e. with the Cozmo robot or with an air pump). Participants also had to rate the perceived control they felt over their actions. Ciardo and colleagues (2020) found that in conditions where the robot was able to interact (but did not) participants perceived lower SoA for the social robot only even after a successful trial. Together the results suggest that interacting with social robotic agents affects SoA, similarly to interacting with other humans.

1.5. Aim of this study

The aim of the current study is to investigate if more information about robots will change the perception of our own human self. Moreover, it will be investigated if this change in perception of our own self will be reflected in behavior regarding both agency and experience. Therefore, we will use a dimension of mind perception task both regular and altered with the inclusion of you (as in Hortensius (in preparation)) and an altered diffusion of responsibility task from Ciardo and colleagues (2020) to include a measure of experience besides the measure of sense of agency. The research question that we aim to answer is: "Can changes in robot mind perception change people's own mind perception and control of behavior?”. In order to investigate this research question in a validly scientific manner, we propose the following methods that will be preprocessed and registered in osf.io.

2. Methods

2.1. Participants

The participants in this study will be selected through a convenience sample. In the most fruitful circumstances, the minimal number of participants for this study would be 80 (thus 40 per group). The writers will approach potential participants via various social media platforms. The program SONA will be used to recruit participants from the University of Utrecht. Before taking part in the experiment, the participants will be briefed about the procedure and the duration of the experiment. They will digitally sign an informed consent form, stating that they agree to the terms of participation and are aware that they can drop out at any given moment. After the experiment the participants will be probed for suspicion about the goal of the research. The participants that guessed the aim of the study will be excluded from the data to overcome possible biases in our study.

2.2 Materials

For this study, participants will need access to the internet and need to complete a task on a computer with a screen of 60Hz. The tasks will be programmed in Gorilla and the data analysis performed using SPSS. This study will furthermore use the program SONA to recruit participants as well.

2.3. Social-technological network task

The social-technological network task is used to establish ratings of the dimensions of mind perception agency and experience. This task is originally from Gray, Gray, & Wegner (2007) and also mentioned in the introduction. However, for this study there will be used an altered social-technological network task by Hortesius (in preparation). The alteration is the adding of the categorie you, which will give information about how high people rate themselves in terms of agency and experience. In the task itself there will be mind perceptions ratings of seven categories: animate (humans and animals) and inanimate agents (robots, virtual assistants) and technological objects (tools, appliances, media, transport). Per category there will be six images that have to be rated on dimensions of agency: the ability to plan and act (the scale ranges from no agency to full agency) and experience: the ability to sense and feel (the scale ranges from no experience to full experience). The procedure of the social-technological network task is visualized in figure 1.

Figure 1

Social Technological Network Task

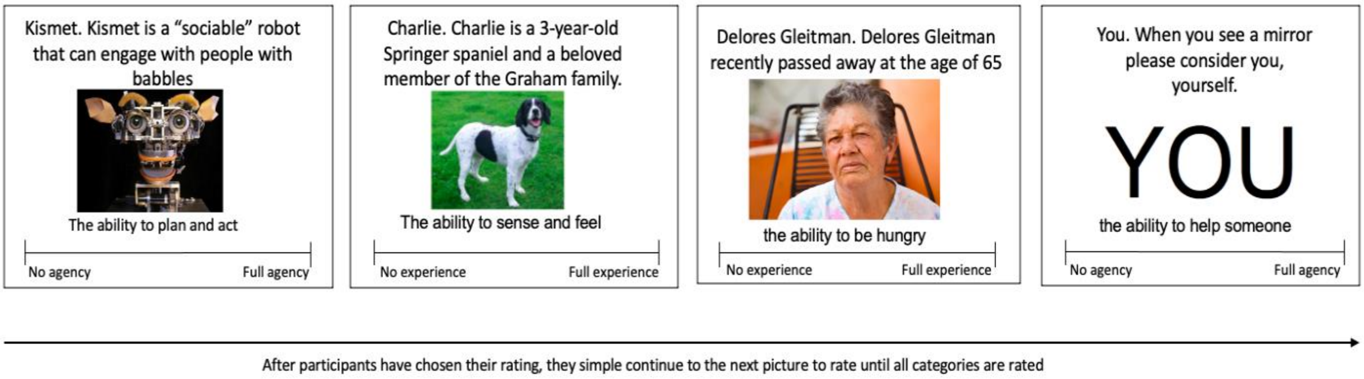

Figure 1. Diagram of the procedure for the social-technological network task with the inclusion of you (self).

2.4. Diffusion of responsibility task

The diffusion of responsibility task is used to measure the behavioral consequences of a change in perceived agency and experience. This task is also used in a study by Ciardo and colleagues (2020) in which they studied the influence of the attribution of intentional agency to a robot on your own SoA. In this experiment, Ciardo and colleagues wanted to see whether human-robot interaction could have the same effect on SoA as human-human interaction has. In order to measure this, they used a diffusion of responsibility task in which the participant worked together with the Cozmo robot in certain trials and worked alone in others. The aim of the diffusion of responsibility task is to stop a visual balloon shown on a screen from bursting by stopping the balloon from reaching a pin (Ciardo et al., 2020). The participant can stop the balloon from inflating any further by tapping a cube but loses a certain number of points depending on the point where they stop the balloon. They were told that they would lose the least number of points if they waited the longest and lose all points if the balloon burst. At the start of the task, they were told that they and Cozmo would receive 2500 points each and could lose up to 100 points per trial.

The diffusion of responsibility task, used in the current study adapted from the task used by Ciardo and colleagues (2020), consists of 6 blocks of 10 trials each. Each trial consists of a few steps, which is made clear in figure 2 and will be explained here as well. At the beginning of each trial, a screen with the number of the trial will be shown for 1000ms and the start of the new trial will be shown for 1500ms. Since in this current study, the participants perform the task alone and do not interact with the robot during the task, there will not be a difference of 'Individual' or 'Joint' blocks and thus there will be 6 instead of 12 blocks. After this, a fixation point will be shown for 800 to 1000ms. This time of the fixation point is varied across trials. Next, the balloon will be shown at its starting size for 500ms and the inflation of the balloon will start. Across trials the speed with which the balloon inflates varies and the point in the sequence at which the balloon will speed up its sequence will also vary. The participant can stop the inflation of the balloon at any time in the sequence by pressing the spacebar. Depending on the time when the participant stops the balloon from bursting, a certain number of points will be lost. After the participant has pressed the spacebar, the stop size of the balloon will be shown for 1000ms. If the participant did not press the spacebar during the trial, the balloon bursts and the word “POP” will be shown on a screen for 1000ms. Then a fixation point is shown again for a time varying between 800 and 1000ms. As a last screen in each trial the number of points lost will be shown for 2000ms, this amount varying between 1 and 100 points. In the current study, the same payoff structure as in the study by Ciardo and colleagues will be used and is shown in table 1. After each trial within the blocks, participants receive two questions on the amount of control they feel and the amount of anxiety they feel on a visual analog scale. The control scale goes from “No control” on the one side to “Full control” on the other and the anxiety scale from “No anxiety” on the one side to “Only anxiety” on the other.

Figure 2

Adjusted Balloon Task

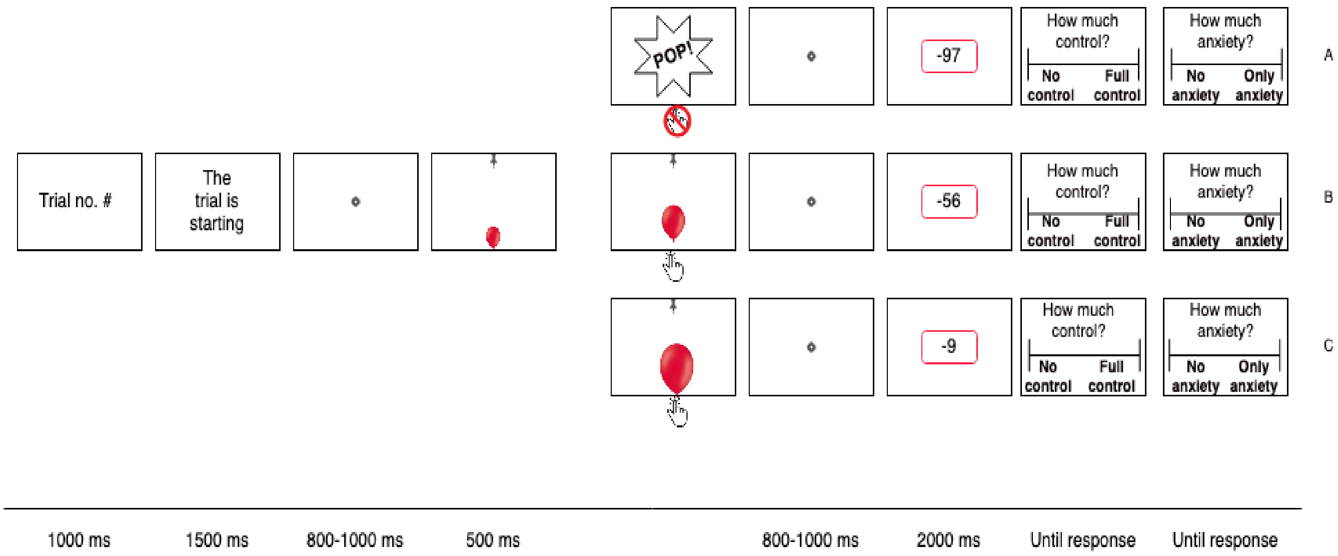

Figure 2. Diagram of adjusted task procedure with A: missed trial; B: low-risk taking trial ; C: high-risk taking trial.

Table 1

Payoff Structure

Table 1
Payoff structure of the task for trials in which the balloon was stopped or burst. The table shows the payoff sections in which the inflating sequence was divided, the corresponding balloon size, and the amount of points lost for each payoff section. Within each payoff section, the actual number of points lost was varied randomly from trial to trial.

Payoff section	Stop Balloon size	Outcome
4	The balloon was stopped over the 50% of the maximum size.	15-1
3	Participant stopped the balloon at a size between the 49% and 33% of the maximum size.	29-16
2	Balloon stop size was between the 33% and the 17% of the maximum size.	45-31
1	Participant stopped the balloon at a size lower or equal to < the 17% of the maximum size.	60-46
0	The balloon burst.	100-80

Table 1. Payoff structure of the origional balloon task (Ciardo et al., 2020)

2.5. Knowledge manipulation

After the first social-technological network task and the first diffusion of responsibility task, participants observe a video that provides further information on the basic functionality (e.g., movement and face recognition) of the Cozmo robot. The video either discusses the basic functionality from a mechanistic point-of-view ("the robot is rigid with a limited behavioural repertoire") or from an intentional point-of-view ("the robot is flexible and learns new behaviours continuously"). Participants will be divided into two groups, of which one will watch the intentional and the other the mechanical video. From earlier research by Hortensius (in preparation) it is known that the intentional description will increase both the ratings for agency and experience of a robot and that the mechanical description will decrease both the ratings for agency and experience of a robot (i.e. a difference of +6.8 for agency and +16.1 for experience, and -4.8 for agency and -4.3 for experience respectively). This double dissociation in the social-technological network rating task is expected in this study as well.

2.6. Procedure

The experiment starts with informed consent and thanking the participants for participation in this study. They will be informed about the duration of the study as well as a general overview about the procedure. Then participants will have to perform the social-technological network task for the first time to establish a baseline rating for agency and experience. After this, the participants do the first diffusion of responsibility task to establish a baseline rating for sense of control and anxiety. Next, the knowledge manipulation will occur and participants will see a video of Cozmo from a mechanistic point-of-view or an intentional point-of-view as described above. Besides the knowledge manipulation everything in this experiment is the same for all participants.

After the knowledge manipulation participants do both the social-technological network task and the diffusion of responsibility task again in order to measure the influence of the knowledge manipulation. After the experiment the participants will be probed for their suspicion of what the research was about, debriefed and thanked.

Figure 3

Experimental Procedure

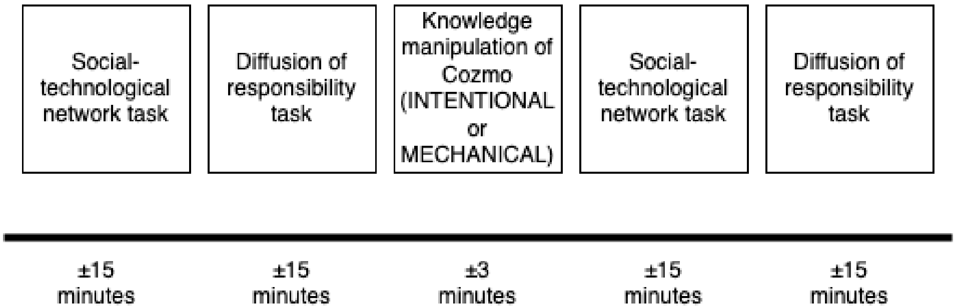

Figure 3. Visualization of the order and duration of the experimental procedure

2.7. Hypotheses

Based on the procedure of this experiment, different hypotheses will be tested. The knowledge manipulation will serve as the independent variable throughout the experiment. The first three hypotheses are based on expected changes within subjects, the other two on changes between subjects.

Hypothesis 1: The knowledge manipulation will change agency and experience ratings to the Cozmo robot, with the intentional manipulation increasing agency and experience ratings and the mechanistic manipulation decreasing agency and experience ratings.

Hypothesis 2: The knowledge manipulation will change agency and experience ratings to self with the intentional manipulation increasing agency and experience ratings and the mechanistic manipulation decreasing agency and experience ratings.

Hypothesis 3: The knowledge manipulation will change the sense of agency and the sense of experience, with the intentional manipulation increasing sense of agency and experience and the mechanistic manipulation decreasing sense of agency and experience.

Hypothesis 4: The rating of the self's experience/agency will differ between the two manipulations.

Hypothesis 5: the sense of agency/sense of experience will differ between the two manipulations.

2.8. Data analysis

Data analysis for this study will be complex since it involves two tasks that are both performed before and after the manipulation in order to understand mind perception. For this study the two dimensions used for mind perception are agency and experience, both measured in a rating task and a behavioral task. In the latter task, agency and experience will be measured by proxies: sense of control as a proxy for agency and anxiety as a proxy for experience. In order to study the effect of the manipulation, the data from before the manipulation and after the manipulation will be subtracted. In short, positive values indicate an increase, negative values a decrease and zero values no change due to the knowledge manipulation. The extensive analysis used for the independent t-test is described in Appendix 1. for the agency measures and Appendix 2. for the experience measures, including which value will (not) support which hypotheses 1,2 and 3. In Appendix 3. it can be found which data will be used in the factorial ANOVA to confirm hypotheses 4 and 5.

3. Expected results

3.1. Results

This study aims to answer the main research question "Can changes in robot mind perception change people's own mind perception and control of behavior?''. The five hypotheses can all provide different parts of the answer to this question. Based on the study by Hortensius (in preparation), the knowledge manipulation has an effect on the agency and experience ratings of the Cozmo robot. This study will likely find the same effect, confirming hypothesis 1. This will serve as a manipulation check for the independent variable. The change in experience and agency ratings found by Hortensius (in preparation) will likely occur to the perception of the self as well. This experiment will show how the two different knowledge manipulations affect the mind perception of the self.

The manipulation will likely change the perception of the self, either increasing or decreasing agency and experience ratings. In their study on SoA, Ciardo and colleagues (2020) found that the attribution of intentional agency to other agents has an effect on peoples' SoA. Namely that interaction with a robot can reduce people's SoA (2020). We expect to find a similar result, in the intentional manipulation condition. When receiving intentional information on Cozmo, even though there is no interaction, participants will likely experience a decrease in SoA. We expect this effect to occur for SoA as well as for SoE. It is expected that the participants in the mechanistic condition will experience the opposite effect of a higher SoA and SoE. The results that will follow from the between group analysis will show how the different manipulations, intentional and mechanistic, affect the mind perception of the self and the SoA and SoE. In figure 4 and 5 a simplified visualization of an example of the results can be found.

Figure 4

Expected Results Social Network task

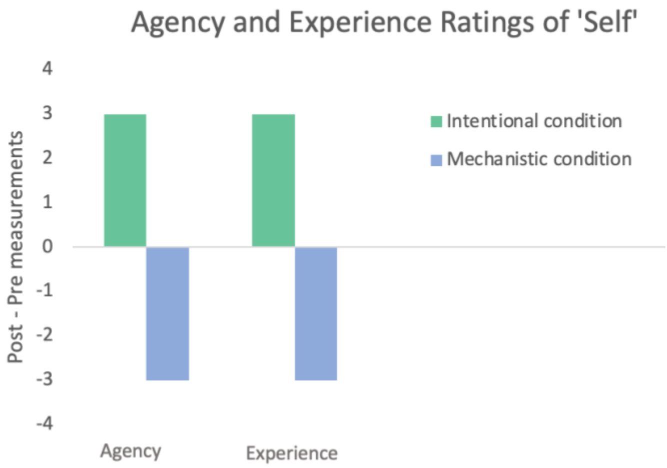

Figure 4: Visualization of an example of the expected results. In this situation the intentional manipulation causes an increase in agency and experience, while the mechanistic manipulation causes a decrease in both agency and experience. The single bars can be seen as the within subjects measures, the differences between the coloured bars is the between subjects measure. The values in this graph are purely for illustrational purposes.

Figure 5

Expected Results diffusion of Responsibility Task

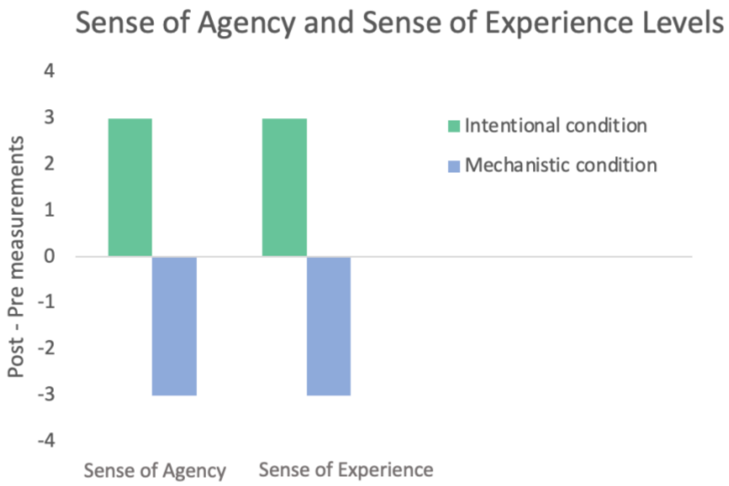

Figure 5: Visualization of an example of the expected results. In this situation the intentional manipulation causes an increase in SoA ans SoE, while the mechanistic manipulation causes a decrease in both SoA and SoE. The single bars can be seen as the within subjects measures, the differences between the coloured bars is the between subjects measure. The values in this graph are purely for illustrational purposes.

3.2. Limits and implications

As mentioned by Ciardo et al (2020), embodiment plays a crucial role when studying SoA during social interactions. The robots in this study will not be embodied due to it being online. This might have an effect on the results. Furthermore, the fact that the study was taken online means that there was less control on participant concentration. There is no one or nothing that encourages them to focus or to keep being focused. This might have an effect on the results as well. A bigger sample could have made the effect of the study stronger, this was not possible due to limited time. The convenience sample in general might not be ideal for a generalization to the general population, which might mean the results do not reflect those of the general population. The participants in this study might have previous knowledge on robots which is not known beforehand, and thus might affect their perceived mind perception of robots. The findings in this study will have implications for the way we view human-robot interactions. Providing insights in human cognition and the underlying mechanisms of social interaction will be better understood.

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Appendix 1. Data analysis for agency

Social-technological Network Test

1a	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of agency for self from social-technological network task after knowledge manipulation for the intentional point-of-view minus rating of agency from social-technological network task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that agency for self was increased by the knowledge manipulation	Supporting hypothesis 2
Negative Value (-)	Negative value indicates that agency for self was decreased by the knowledge manipulation	Rejecting hypothesis 2
Zero Value (0)	Zero value indicates that agency for self was not changed by the the knowledge manipulation	Rejecting hypothesis 2

2a	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of agency for Cozmo J from social-technological network task after knowledge manipulation for the intentional point-of-view minus rating of agency from social-technological network task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that agency for Cozmo J was increased by the knowledge manipulation	Supporting hypothesis 1
Negative Value (-)	Negative value indicates that agency for Cozmo J was decreased by the knowledge manipulation	Rejecting hypothesis 1
Zero Value (0)	Zero value indicates that agency for Cozmo J was not changed by the knowledge manipulation	Rejecting hypothesis 1

3a	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of agency for self from social-technological network task after knowledge manipulation for the mechanical point-of-view minus rating of agency from social-technological network task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that agency for self was increased by the knowledge manipulation	Rejecting hypothesis 2
Negative Value (-)	Negative value indicates that agency for self was decreased by the knowledge manipulation	Supporting hypothesis 2
Zero Value (0)	Zero value indicates that agency for self was not changed by the knowledge manipulation	Rejecting hypothesis 2

4a	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of agency for Cozmo J from social-technological network task after knowledge manipulation for the mechanical point-of-view minus rating of agency from social-technological network task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that agency for Cozmo J was increased by the knowledge manipulation	Rejecting hypothesis 1
Negative Value (-)	Negative value indicates that agency for Cozmo J was decreased by the knowledge manipulation	Supporting hypothesis 1
Zero Value (0)	Zero value indicates that agency for Cozmo J was not changed by the knowledge manipulation	Rejecting hypothesis 1

Diffusion of responsibility task

5a	Factorial ANOVA for 5a/6a and 5b/6b Hypothesis 5	
Processing of data	Sense of control rating from diffusion of responsibility task after knowledge manipulation for the intentional point-of-view minus sense of control rating from diffusion of responsibility task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that sense of control was increased by the knowledge manipulation	Supporting hypothesis 3
Negative Value (-)	Negative value indicates that sense of control was decreased by the knowledge manipulation	Rejecting hypothesis 3
Zero Value (0)	Zero value indicates that sense of control was not changed by the knowledge manipulation	Rejecting hypothesis 3

6a	Factorial ANOVA for 5a/6a and 5b/6b Hypothesis 5	
Processing of data	Sense of control rating from diffusion of responsibility task after knowledge manipulation for the mechanical point-of-view minus sense of control rating from diffusion of responsibility task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that sense of control was increased	Rejecting hypothesis 3

	by the knowledge manipulation	
Negative Value (-)	Negative value indicates that sense of control was decreased by the knowledge manipulation	Supporting hypothesis 3
Zero Value (0)	Zero value indicates that sense of control was not changed by the knowledge manipulation	Rejecting hypothesis 3

Appendix 2. Data analysis for experience

Social-technological network task

1b	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of experience for self from social-technological network task after knowledge manipulation for the intentional point-of-view minus rating of experience from social-technological network task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that experience for self was increased by the knowledge manipulation	Supporting hypothesis 2
Negative Value (-)	Positive value indicates that experience for self was increased by the knowledge manipulation	Rejecting hypothesis 2
Zero Value (0)	Zero value indicates that experience for self was not changed by the knowledge manipulation	Rejecting hypothesis 2

2b	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of experience for Cozmo J from social-technological network task after knowledge manipulation for the intentional point-of-view minus rating of experience from social-technological network task before the knowledge manipulation	
		Hypothesis Indication

Positive Value (+)	Positive value indicates that experience for Cozmo J was increased by the knowledge manipulation	Supporting hypothesis 1
Negative Value (-)	Negative value indicates that experience for Cozmo J was decreased by the knowledge manipulation	Rejecting hypothesis 1
Zero Value (0)	Zero value indicates that experience for Cozmo J was not changed by the knowledge manipulation	Rejecting hypothesis 1

3b	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of experience for self from social-technological network task after knowledge manipulation for the mechanical point-of-view minus rating of experience from social-technological network task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that experience for self was increased by the knowledge manipulation	Rejecting hypothesis 2
Negative Value (-)	Negative value indicates that experience for self was decreased by the knowledge manipulation	Supporting hypothesis 2

Zero Value (0)	Zero value indicates that experience for self was not changed by the knowledge manipulation	Rejecting hypothesis 2

4b	Factorial ANOVA for 1-4a and 1-4b Hypothesis 4	
Processing of data	Rating of experience for Cozmo J from social-technological network task after knowledge manipulation for the mechanical point-of-view minus rating of experience from social-technological network task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that experience for Cozmo J was increased by the knowledge manipulation	Rejecting hypothesis 1
Negative Value (-)	Negative value indicates that experience for Cozmo J was decreased by the knowledge manipulation	Supporting hypothesis 1
Zero Value (0)	Zero value indicates that experience for Cozmo J was not changed by the knowledge manipulation	Rejecting hypothesis 1

Diffusion of responsibility task

5b	Factorial ANOVA for 5a/6a and 5b/6b Hypothesis 5	
Processing of data	Anxiety rating from diffusion of responsibility task after knowledge manipulation for the intentional point-of-view minus anxiety rating from diffusion of responsibility task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that anxiety was increased by the knowledge manipulation	Supporting hypothesis 3
Negative Value (-)	Negative value indicates that anxiety was decreased by the knowledge manipulation	Rejecting hypothesis 3
Zero Value (0)	Zero value indicates that anxiety was not changed by the knowledge manipulation	Rejecting hypothesis 3

6b	Factorial ANOVA for 5a/6a and 5b/6b Hypothesis 5	
Processing of data	Anxiety rating from diffusion of responsibility task after knowledge manipulation for the mechanical point-of-view minus anxiety rating from diffusion of responsibility task before the knowledge manipulation	
		Hypothesis Indication
Positive Value (+)	Positive value indicates that anxiety was increased by the knowledge manipulation	Supporting hypothesis 3
Negative Value (-)	Negative value indicates that anxiety was decreased by the knowledge manipulation	Rejecting hypothesis 3
Zero Value (0)	Zero value indicates that anxiety was not changed by the knowledge manipulation	Rejecting hypothesis 3

Appendix 3. Factorial ANOVA tests

Factorial ANOVA for 1-4a and 1-4b   Hypothesis 4

Compare	Hypothesis 4 is supported if…
1a + 1b with 3a + 3b	1a and 1b are higher than 3a and 3b
2a + 2b with 4a + 4b	2a and 2b are higher than 4a and 4b

Factorial ANOVA for 5/6a and 5/6a   Hypothesis 4

Compare	Hypothesis 5 is supported if…
5a + 5b with 6a + 6b	5a and 5b are higher than 6a and 6b