Would You Help Me? Linking Robot's Perspective-Taking to Human Prosocial Behavior

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ABSTRACT

Despite the growing literature on human attitudes toward robots, particularly prosocial behavior, little is known about how robots' perspective-taking, the capacity to perceive and understand the world from other viewpoints, could influence such attitudes and perceptions of the robot. To make robots and AI more autonomous and self-aware, more researchers have focused on developing cognitive skills such as perspective-taking and theory of mind in robots and AI. The present study investigated whether a robot's perspective-taking choices could influence the occurrence and extent of exhibiting prosocial behavior toward the robot. We designed an interaction consisting of a perspective-taking task, where we manipulated how the robot instructs the human to find objects by changing its frame of reference and measured the human's exhibition of prosocial behavior toward the robot. In a between-subject study (N=70), we compared the robot's egocentric and addressee-centric instructions against a control condition, where the robot's instructions were object-centric. Participants' prosocial behavior toward the robot was measured using a voluntary data collection session. Our results imply that the occurrence and extent of prosocial behavior toward the robot were significantly influenced by the robot's visuospatial perspective-taking behavior. Furthermore, we observed, through questionnaire responses, that the robot's choice of perspective-taking could potentially influence the humans' perspective choices, were they to reciprocate the instructions to the robot.

CCS CONCEPTS

• **Human-centered computing** → **User studies**; • **Computing methodologies** → *Theory of mind*; **Spatial and physical reasoning**; • **Applied computing** → *Psychology*.

KEYWORDS

Human-Robot Interaction; Perspective-Taking; Prosocial Behavior.

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1 INTRODUCTION

Occasionally in our daily interactions with friends or strangers, we might experience unexpected acts of kindness or less friendly-than-expected interactions. Research has shown that such friendly or helpful acts; defined as *prosocial behavior* in psychology [44], could sometimes be induced by our behaviors and attitudes toward the other person [5, 7]. Engaging in prosocial behavior could be explained by the expectancy of reciprocity from others [51] and it could tacitly mitigate the effects of stress on emotional functioning [39] and mental health [8]. More recently, more studies have investigated the processes that could potentially induce or influence the emergence of prosocial behavior [36, 58] which have led to showing that perspective-taking is one of the processes with a complex relationship with prosocial behavior [43].

Perspective-taking is generally defined as the primary capacity to perceive and infer another's point of view or mental state. What humans perceive in the context of "putting themselves in someone else's shoes" [21] can range from acknowledging what others see differently to computing how things are seen or experienced differently. Our work anchors on studying visuospatial perspective-taking, where the primary focus is placed on understanding other's field of view and spatial relations with the objects in the environment [18]. Regarding the relationship between perspective-taking and prosocial behavior, research has shown a positive correlation between perspective-taking and self-reported prosocial behavior in humans [22, 48]. Evidently, humans who showed increasing levels of perspective-taking in ecological training [7] and mindfulness [5] sessions reported higher levels of prosocial behaviors. Furthermore, self-reported prosocial behavior is also associated with higher levels of social perspective-taking [48].

This line of research in psychology is linked to the field of robotics and AI through an emerging body of research focused on developing self-awareness in robots using perspective-taking and theory of mind. In the field of human-robot interaction (HRI), perspective-taking has been primarily studied in the context of visuospatial communication in collaborative scenarios [11, 50, 55], where the pioneering work by Trafton et al. [50] has shown robots can help resolve ambiguous situations when equipped with perspective-taking abilities. This in turn has contributed to developing computational and cognitive models of perspective-taking to be incorporated in robotic systems [17, 54]. Furthermore, it has been shown that the assumptions humans make about robots are similar to the assumptions they make about their human counterparts [31]. For example, only showing certain nonverbal behaviors from the robot is enough for humans to attribute mental models to robots [59]. As a result, people tend to take the robot's perspective almost as much as they take other people's perspectives. Additionally, past research has shown that tasks with virtual agents stimulate empathy toward stigmatized groups such as the elderly [57], schizophrenics [38], and the homeless [25]. Herrera et al. [26] found a positive relationship between allowing humans to embody and customize their avatar and the measured prosocial behaviors. Furthermore, it has been shown that taking the perspective of a virtual agent by embodying it in a virtual reality scenario leads to helping behaviors [41]. Overall past research shows that robots could stimulate prosocial behaviors in humans [19, 24, 37] in the context of human-robot interaction. For example, humans are "happy to help" robots who show prosocial behavior toward them [19] or others [24], envisioning a broader prosocial computing effort within AI. However, Sassenrath et. al. provides an insight into the boundary conditions that could limit the association between perspective-taking and prosocial behavior, for example in competitive scenarios [42]. In fact, the capacity of taking others' perspectives brings concern for the target and boosts engaging in behaviors that are advantageous to them [3, 58].

On this topic, we could identify a gap in understanding how developing perspective-taking skills in robots could possibly influence the acts of prosocial behavior in collaborative human-robot interaction. Bridging this gap could help to better understand how developing cognitive skills such as perspective-taking should be carefully curated to prevent inducing unexpected behaviors toward the robot or augment the robot's acceptance. As a result, we propose to explore this gap by answering the following research question *"How does the robot's perspective choices influence the human's exhibition of prosocial behavior toward the robot?"*. Our research aims to contribute to the advancement of social robots by bridging the gap on how prosociality can be stimulated by perspective-taking, and if different types of visuospatial perspective-taking of the robot could stimulate different extents of prosociality in humans toward it.

2 BACKGROUND AND RELATED WORK

2.1 Perspective-taking

In general terms, perspective-taking refers to the ability to understand other's points of view commonly known as "putting ourselves in someone else's shoes" [21]. We exercise perspective-taking daily and without explicit awareness of using this skill, still, there is no guarantee that we understand others perfectly and without error. Kurdek and Rodgon [30] suggested three different dimensions of this skill: cognitive, affective, and perceptual. Cognitive perspective-taking is the capacity to estimate the attitudes and opinions of others [27], affective perspective-taking refers to the ability to predict others' emotions and feelings [20, 49], and perceptual perspective-taking is the ability to estimate how another person perceives things through their senses (i.e. visually [18, 47], auditory [14, 28], or tactile [40]). In the perceptual domain, two sub-dimensions of visual and spatial perspective-taking are defined. Visual perspective-taking (VPT) [47] characterizes if and how the self perceives the object seen by the other, and spatial perspective-taking (SPT) [18] corresponds to understanding the object's spatial location and relationship within the environment. When dealing with visuospatial perspective-taking, as in this study, it is important to define the frame of reference, a component of spatial perspective-taking used to decode the spatial information related to the self, other, or the environment [32].

2.1.1 Frame of reference. A frame of reference is the origin of the self's reasoning to address space which in any given context depends on the coordinate system chosen in each situation between the self, the other, or the object [32]. When choosing a frame of reference, the spatial relation between the self/other and the object is weighed. For example, an egocentric perspective uses the self as the reference point, whereas an allocentric perspective requires the self to adopt the other's perspective, with its specific case being the addressee-centric perspective, where the self adopts the addressee's perspective. Furthermore, an object-centric perspective uses the object-intrinsic characteristics (i.e. color, shape, size), or the object-extrinsic characteristics such as a top-down/left-right viewpoint related to the object. The usage of different frames of reference depends both on the environment and the counterpart.

2.1.2 Perspective-taking in HRI. Previously, research in the field of human-robot interaction has focused on understanding the role of perspective-taking in collaborative and learning scenarios with robots [50, 56]. More recently, this research has expanded to understanding the influence of using frames of reference to improve the explainability and responsiveness of the addressee. In a spatial referencing task, Doğan et al. [11] verified that when the robot successfully takes the participant's perspective, they spend less time on the task, commit fewer mistakes, and perceive the task more easily. The study used a previously developed model that is capable of identifying the relation between objects [12]. Another example of collaborative perspective-taking problem-solving in HRI is when participants were asked which perspective should a robot choose when it reaches an ambiguous situation [50]. The results showed that humans prefer the robot to either primarily consider the human perspective or ask for clarifications. Humans make similar assumptions between robots and human counterparts [31], and they tend to use a more egocentric point of view when instructing robots [33]. This topic has also been studied with children, where Yadollahi et al. [56] showed children tend to adapt their perspective to a robot when the robot egocentrism prevents the child and the robot from completing the task.

2.2 Prosocial behavior

Prosocial behavior is defined as "any action that serves to benefit another person" [44] or fulfills their need to support, such as cooperation, helping, and acts of kindness[15]. Humans have the tendency to help out others in various situations, such as helping an elderly to cross a crowded street, volunteering to help friends and colleagues with personal difficulties or illness, or donating blood [23]. Engaging in prosocial behavior includes concerning and feeling empathy for others, varying from high-level actions such as philanthropy and voluntary work to simple activities such as providing comfort or helping someone accomplish a milestone [4]. To research different dimensions of prosocial behavior, four broad dimensions have been covered in the literature: helping, volunteerism, cooperation, and caregiving [52].

2.2.1 Prosocial behavior in HRI. In the field of HRI, a scoping review by Oliveira et al. [35] has shown virtual agents and robots could also stimulate prosocial behavior. For example, a software-based machine (the Tamagochi or Pocket Pikachu) can persuade and stimulate prosociality in humans, where humans had to interact with the pets to keep them alive (e.g. feeding, caring). Furthermore, it was studied that participants that worked with a more helpful computer spent more time helping it later [19]. Another study tested the effects of stimulated prosocial behavior by asking participants to decrease their performance to help the robot avoid a punishment [24]. In the "self-direct" condition, the robot petitioned the participant to reduce their performance to avoid punishment, and in the "externally-directed" condition the robot petitioned on behalf of its programmer. The results showed that the robot in the "externally-directed" condition was significantly more likely to convince participants to follow the robot's request. In a study aimed at making people feel comfortable sharing personal information, it was observed that robots provided higher levels of comfort than humans as they managed to learn slightly more about bullying cases in children [6].

3 STUDY DESIGN

To evaluate the effects of the robot's different perspective-taking choices on human prosocial behavior toward the robot, we designed a between-subject study with three conditions. We manipulated the *robot's frame of reference* as a between-subject independent variable in a perspective-taking task and evaluated the *participants' prosocial behavior* toward the robot as a dependent variable using a prosocial behavior measure. Building upon the previous research, we developed the human-centered condition as a means to investigate participants' prosocial behavior toward the robot that takes their perspective, e.g. it is addressee-centric. On the other hand, we designed the robot-centered condition to evaluate how participants show prosocial behavior towards a robot that does not take their perspective, e.g. it is egocentric. To ensure that we could isolate the influence of perspective-taking on prosocial behavior, we designed a control condition called an object-centered condition. This condition provided a baseline for interacting with the robot in the task without the consequences of taking someone's perspective; whether self or other. As a result, The experiment consisted of three conditions where the robot addressed objects with an egocentric perspective (e.g. **robot-centered condition**), addressee-centric perspective (e.g. **human-centered condition**), and object-centric perspective (e.g. **object-centered condition**).

3.1 Hypotheses

As denoted by Sassenrath et. al. [43], "the link between perspective-taking and prosocial behavior is not as straightforward or robust as it is often assumed to be". Given the recent surge in the development of self-aware robots by equipping them with perspective-taking and theory of mind (ToM) abilities [34, 53], our goal is to evaluate how incorporating such abilities in robots could potentially stimulate some form of prosocial behaviors in humans [26]. A recent study by Ortiz et al. [36] has shown that inducing people to take others' perspectives could result in behaving more prosocially. Our research takes the concept a bit further by evaluating how prosocial behavior emerges as one perceives their counterpart's choice of perspective toward them. How much our perspective choices could positively elicit or negatively repress prosocial behavior? In this context, we hypothesize that more prosocial actions emerge as one perceives their counterpart is taking the extra effort to take their perspective. On the other hand, we hypothesize as one perceives their counterpart egocentrism, particularly when interacting with them, they tend to become less prosocial toward them [16, 47].

H1a. Participants will show significantly more prosocial behavior toward the robot in the human-centered condition, compared to the object-centered condition.

H1b. Participants will show significantly more prosocial behavior toward the robot in the object-centered condition, compared to the robot-centered condition.

Furthermore, we have exploratory research that aims to investigate the participants' preferences for instructing the robot if they were in the robot's position. To achieve this, we directly asked participants how they would instruct the robot if the roles were switched in the perspective-taking task and we provided them with three instructions derived from each condition. Here, we investigate if and how experimental conditions impact participants' choice of perspectives in addressing an object to the robot. This research direction could advance the research in human-robot collaboration, particularly in adapting instructions to the human and bringing insights into how human preferences could be a function of the robot's behaviors [46]. As we don't have a particular baseline to form a specific hypothesis, we observe and analyze participants' responses and provide future directions to pursue this research direction in the future.

3.2 Perspective-taking task

In this work, we developed a task that requires the human to *1) listen to the robot's description of multiple goal objects* and *2) find the goal objects to complete a task*. We based our task on visuospatial perspective-taking occurrences, where we could minimize the affective and empathic aspects of the interaction as much as possible. This was an important part of our task design as it could provide us with a better understanding of the relationship between perspective-taking and prosocial behavior without the involvement of other processes such as empathy. The perspective-taking task was designed with the overall goal of retrieving a code that opens a box placed in front of the robot. During the task, the participant and the robot were seated in front of each other, with the objects placed between them. As shown in Figure 1, the task included 10 objects composed of 7 different variations of 3 shapes (box, triangular pyramid, and square pyramid), 2 sizes (small and big), and 2 colors (black and blue). The object variations were systematically designed to provide enough diversity in the instructions while providing the potential to create ambiguity using different levels of objects' shape, size, and color. The task included a total of 15 instructions that followed the following structure: *Goal Object (including some details about its shape/color/size) + its Spatial Relation with an anchor object + Anchor Object (including some details about shape/size/color).* An example instruction could be *"Go with the big pyramid, besides the small box"*. The instructions were short and the human would only receive the code after successfully scanning all 15 objects. The instructions across different conditions were using the same goal and anchor objects but differed in the way the spatial

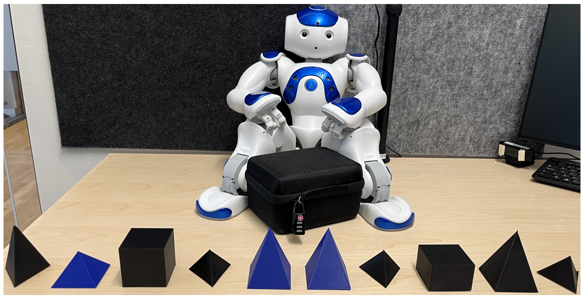

Figure 1: Participant's point of view during the experiment.

relations were expressed. Therefore, the experiment was carried out using three conditions in which the robot's specifications of the spatial relation between the goal and anchor object were adapted according to the frame of references used in that condition. An example of an instruction used in the **object-centered condition** was *"Go with the big pyramid, beside the small box"*. In this case, the participant could select the correct pyramid by just understanding its spatial relations with the small box. An example of an egocentric instruction used in **robot-centered condition** was *"Go with the pyramid that I see on the left of the small box"*, in which the participant needed to understand the "left" of the small box from the robot's perspective. Finally, an instruction in **human-centered condition** with an addressee-centric perspective was: *"Go with the pyramid that you see on the right of the small box"*, which did not require a change of perspective for the participant. The correct object to pick according to the above instructions would be the 9th object from the left in figure 1.

3.2.1 Implementation details. In this study, we opted for using the NAO robot, a robot extensively used in HRI domains [2] and programmed it using python and NAOqi API [45]. The in-built camera module was used to track the participants' faces and to detect the landmarks placed underneath each object as shown in Figure 2. The robot moved its upper body with pre-defined movements synchronously with the speech. The speaker was used to instruct the participants and to give feedback alongside the LEDs around the eyes. Overall, the system ran autonomously, with an experimenter intervening to use a wizard-of-oz interface to input the undetected speech in cases where speech detection failed.

3.3 Voluntary data collection session

To measure prosocial behavior, three options are commonly presented in the literature: self-reported questionnaires [26, 48], third-party observations [5], and direct observations [19, 24, 29]. However, in psychological research, it is recommended not to solely rely on self-reported data as they might be biased [1]. As a result, we developed a voluntary data collection session to evaluate participants' prosocial behavior toward the robot. The participants were not aware of this session prior to starting the experiment. We had two criteria for designing the session itself: 1) being a meaningful data collection session that could help improve robot functions and 2) providing us not only with a dichotomous variable (help vs. not help) but also continuous variables (duration) or discrete variables (number of times doing something) to have a better measure of prosocial behavior toward the robot. As a result, inspired by [29], we created an endless task where participants were directed to read aloud sentences with specified emotions in order to help collect data for a speech corpus. The sentences in the task were directly taken from [29] and the participants were instructed to read aloud each sentence with the specified emotion. An example of this task is reading aloud the sentence *"Tom beats that farmer"* with *sadness*.

3.4 Study procedure

The interaction was divided into the following steps: 1) initial briefing, 2) perspective-taking task that led to retrieving a code for opening a box, 3) opening the box that contained a voucher for participation plus a ReadMe letter that informed the participant about their next step, 4) voluntary data collection session and 5) two sets of questionnaires. The perspective-taking task let participants interact with the robot in the context of finding the password to a box, where per design, all participants were successful. The robot described each object based on the details provided in the section 3.2. After hearing the robot's description of an object, the participants could either proceed with picking the object or ask the robot to repeat its instructions. In the cases where the participants needed to verbally interact with the robot and the speech recognition failed, we had the experimenter on standby, in another room, to wizard that part [9]. When participants picked the object, they showed the landmark placed under it to the robot as shown in Figure 2. After scanning, the robot informed the participant if they picked the correct object or not, and in case of an incorrect object, participants could scan another object until the correct object was detected. The task continued in the same manner until all 15 objects were scanned successfully. After finishing the perspective-taking task, participants received a code to open the box placed in front of the robot. The box contained a voucher, as compensation for participating in the experiment, and a ReadMe letter. The letter informed the participant that they could either move to fill out the questionnaires and conclude the experiment or stay and participate in a voluntary data collection session. If participants decided to take part in the data collection, the session was initialized, otherwise, they moved on to fill out the questionnaires. To ensure that participants perceived the data collection session as completely

Figure 2: Participant scanning the landmark underneath the object to the camera placed on the robot's forehead.

voluntary, we made sure: 1) they receive their voucher after completing the first task, which is generally a sign of completing the experiment, and 2) we designed the data collection task unrelated to the perspective-taking task and collected the type of data that could be used by other researchers in the field. In the end, both groups of participants, the ones who decided to help with the data collection and the ones who decided to move on, filled out the questionnaires and concluded the experiment.

3.5 Participants

A total of 70 participants were recruited for the experiment. Participants were recruited through announcements in the university and a user study email list and were compensated for their participation. The recruitment fliers contained data about the duration of the experiment and the amount of compensation in the form of vouchers. Before starting the experiment, participants signed a consent form agreeing to the collection of their images and demographic data. Participants' age ranged between 19 and 39 (M=24.8, SD=4.12) with 39 identifying as male and 31 identifying as female. Participants were required to have an advanced level of English to participate in the experiment, which took 30 minutes on average. They were assigned randomly to each condition resulting in 23 participants in object-centered and robot-centered conditions and 24 participants in human-centered conditions.

3.6 Experimental measures

We collected a few measures when participants were interacting with the robot, in the context of the perspective-taking task and the data collection session, as well as additional measures using the post-experiment questionnaires

3.6.1 Task-related measures. As part of the study design, in the perspective-taking task, we manipulated the robot's choice of frame of reference in different conditions. To observe the influence of the robot's perspective-taking on task performance, we collected the following data during the perspective-taking task.

Completion time - During the task, we measured the time it took for the participants to correctly scan each object from the time the robot's instruction ended. The data for all the instructions were used to calculate the total completion time.

To reflect the influence of the robot's perspective taking on the exhibition of prosocial behavior, we collected the following data during the data collection session.

Occurrence of prosocial behavior - We collected a dichotomous variable based on the number of participants that decided to join the voluntary data collection versus the ones who decided not to. Furthermore, we noted down the number of participants that initialized the voluntary data collection session but decided not to read any sentence versus the ones who initialized the session and started reading sentences.

Extent of prosocial behavior - We collected this discrete variable based on the number of sentences read to the robot.

3.6.2 Questionnaire measures. In this study, we tackle how participants perceive the robot's perspective-taking and how they decide to help the robot. To ensure that the results are robust and not due to individual differences in perspective-taking or empathic concern, we decided to use the Interpersonal Reactivity Index (IRI) questionnaire to ensure that participants were distributed equally between conditions given their skills in perspective-taking and empathic concern, the two skills that could impact their understanding and behavior in the experiment.

Interpersonal Reactivity Index is a questionnaire developed by Davis et al. [10] and it includes 7 questions in four dimensions: Perspective Taking (PT), Fantasy (FS), Empathic Concern (EC), Personal Distress (PD). In our experiment, we only used **fantasy**, **perspective-taking**, and **empathic concern** scales on a five-point Likert scale as used in the original questionnaire [10]. We used the responses to evaluate if the participants were distributed equally between the conditions with respect to their IRI scores.

Task-related questionnaire was created to evaluate the participant's perception of the robot and the task and to provide us with some quantitative measures of the participant's experience in the experiment. Generally, the questions focused on how participants rated the difficulty of following the instructions, and how they rated the **robot's communication skills**, **likability**, and **empathy toward them**. They also rated their perception of the **robot's need for collecting speech data** and how much **they cared for the robot**. Most of the responses were collected using a 7-point Likert scale and the questions are available as supplemental material.

3.6.3 Exploratory research measure. As a measure of knowing if and how the robot's perspective-taking choices influenced participants' hypothetical instruction toward the robot, we asked them *"If you were to tell the robot to pick up the objects, how would you do it?"*. To respond they were provided with three options that each corresponded to an instruction taken from each experimental condition. The responses to these questions were used to evaluate and analyze our exploratory research question.

4 RESULTS

Of the 70 participants, the data from one participant was excluded from the analysis due to technical failure during the perspective-taking task. This resulted in 23 participants per condition. To test the distribution of participants between conditions, first, we ran a normality test on the participant's responses to the IRI questions per condition, which showed the responses were normal for each subscale in each condition. Then, we used Kruskal-Wallis H-test for the scores of the IRI questionnaire grouped by the conditions. The results for the perspective-taking scale $H(2) = 1.146,\ P = .56$, empathic concern scale $H(2) = 1.063,\ P = .59$, and fantasy scale $H(2) = 1.188,\ P = .55$ showed that participants were equally distributed between conditions.

4.1 Occurrence and extent of prosocial behavior

The hypothesis *H1a* states that participants who interacted with the human-centered robot would be more prosocial compared to the condition where the robot was using an object-centered frame of reference. Whereas, *H1b* hypothesizes that participants were going to be less prosocial toward the robot when the robot is egocentric (robot-centered) compared to the control condition. To evaluate the impact of our manipulation on prosocial behavior, we looked at two main variables, the *occurrence of prosocial behavior* as in the percentages of participants choosing to participate in the second task

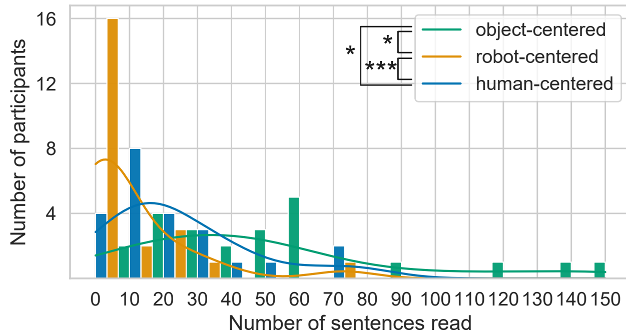

Figure 3: Distribution of participants based on the number of sentences read in each condition, discretized into batches of 10 sentences. x-axis: batches of 10 for total sentences read, y-axis: number of participants in each batch.

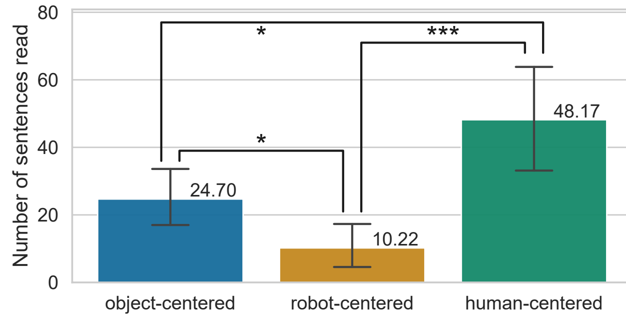

Figure 4: Mean of the number of sentences read in the prosocial behavior task per condition. Error bars represent the standard error of the mean. x-axis: experimental conditions, y-axis: mean of the number of sentences read.

and the *extent of prosocial behavior* as in the number of sentences they read.

As mentioned before participants could choose to know more about the helping task or directly move to the questionnaire. Table 1 shows the percentage of the ones who "wanted to know more" versus the ones who "did not want to know more". The data presented in the table also shows a measure of taking part in the task after wanting to know more as in a sub-percentage of the participants who "wanted to know more but did not read any sentence" and moved on to the questionnaire versus "wanted to know more and read some sentences". In the analyses, we concatenated the first and second columns e.g. "did not read any sentence" and compared it to the ones who "read sentences". Table 1 shows that all participants in the human-centered condition participated in the prosocial behavior task, as opposed to only 57% of the participants in the robot-centered condition. Furthermore, 87% of participants in the object-centered condition decided to help the robot. An overall chi-square test was performed to verify a significant global difference between all conditions, testing the participants who helped the robot by reading sentences ($\chi^2 = 14.975,\ P < .001,\ df = 2$). A post-hoc chi-square indicated that this difference was statistically significant between the robot-centered and the object-centered conditions ($\chi^2 = 3.860\ P = .049\ df = 1$), but not statistically significant between the human-centered and object-centered conditions ($\chi^2 = 1.426\ P = .23\ df = 1$).

Table 1: Participants taking part in data collection session.

	Prosocial Behavior Task		
	Showed interest in helping the robot?		
	No	Yes	
		Helped the robot by reading sentences?	
Condition		No	Yes
Object-centered	9%	4%	87%
Robot-centered	30%	13%	57%
Human-centered	0%	0%	100%

As for the analyses regarding the *extent of prosocial behavior*, we used the number of sentences read as the dependent variable. We discretized this variable into batches of ten sentences and presented the distribution of the number of sentences read by participants in each condition in Figure 3. We first ran a one-way ANOVA test, $F(2, 66) = 9.900,\ P < .001$, which showed there was a significant difference between at least two conditions. A post hoc t-test between conditions showed that robot-centered and human-centered are both significantly different from the object-centered condition at $P = .02$ and $P = .019$, respectively. Furthermore, robot-centered and human-centered conditions are significantly different from each other at $P < .001$. Based on the analyses of the occurrence and extent of prosocial behavior both *H1a* and *H1b* are accepted. The result showed that participants expressed significantly more prosocial behavior toward the robot that took their perspective compared to when it did not and were significantly less prosocial toward the egocentric robot. Figure 4 shows on average participants in the human-centered condition read 48.17 ($SD = 39.37$) sentences to the robot which is significantly more than the object-centered condition with 24.70 ($SD = 21.23$) sentences, and participants in the object-centered condition read significantly more sentences than the robot-centered condition with 10.22 ($SD = 17.17$).

Additionally, we analyzed the influence of the robot's perspective-taking on the participant's perception of the robot. The analyses of the questions about how the participants found the robot likable and empathetic did not yield significant results between conditions. However, for the question regarding how much participants cared for the robot, one-way ANOVA revealed that there was a statistically significant overall difference between conditions $F(66, 2) = 3.320,\ P = .04$. Tukey's HSD test for multiple comparisons found that participants in the human-centered condition significantly cared more for the robot compared to the robot-centered condition, $P = .047$, 95% $C.I. = [-2.3362, -0.016]$ with no statistically significant difference between human-centered and object-centered conditions, $P = .90$. Looking at the results of the participant's perception of the robot's need for collecting speech data, we could observe no significant difference between the three conditions. This result shows that participants equally perceived that the robot needed the speech data — which was what we aimed

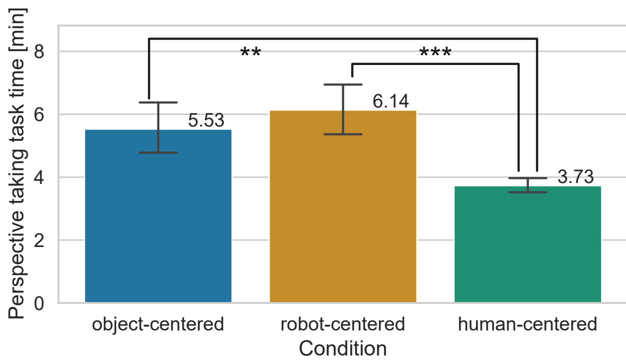

Figure 5: Mean minutes spent in the perspective-taking task per condition with error bars representing the standard error of the mean. x-axis: experimental conditions, y-axis: time spent in the perspective-taking task.

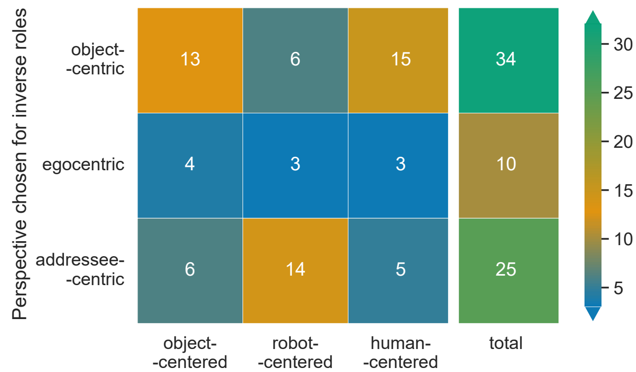

Figure 6: Participants' responses to the question "If you were to tell the robot to pick up the objects how would you do it?" with choices coded into *object-centric*, *egocentric*, and *addressee-centric* responses. x-axis: experimental conditions, y-axis: responses to the question.

for, and their decision to help the robot significantly differently was influenced by other variables.

4.1.1 Time as a mediating factor. One of the consequences of taking the other person's perspective compared to being egocentric is the time it takes to understand the other perspective, which could consequently influence the time it takes to finish the task. Figure 5 shows the time participants in each condition spent on the perspective-taking task. To compare the means, we ran a one-way ANOVA test, $F(2, 66) = 12.848,\ P < .001$, which showed that there was a significant difference between the conditions. The post-hoc Tukey analysis showed that participants spent significantly less time in the human-centered condition compared to robot-centered $P < .001$ and control conditions $P = .0015$. We performed an ANCOVA and examined the effects of *condition* and *time spent in the perspective-taking task* on the *extent of prosocial behavior*. The result yielded a main effect of condition, $F(2, 66) = 3.613,\ P < .001$, however, the time to complete the perspective-taking task did not significantly influence the extent of exhibiting prosocial behavior, $F(2, 56) = 0.425,\ P = 0.51$.

4.2 Exploratory research question

Figure 6 presents participants' hypothetical instructions to the robot on the y-axis based on the condition they were on the x-axis. We performed the Freeman-Halton extension of the Fisher exact probability test for a three-rows by three-columns contingency table which was selected as a result of having three cells with counts below 5. The analysis confirmed a significant association between the participants' choice of instruction and the experimental condition they were in ($P = 0.039$, Fisher's exact test). As shown in Figure 6, the egocentric instruction was selected the least regardless of the participant's condition. On the other hand, some trends could be observed in the selection of object-centric and addressee-centric instructions. The majority of the participants in the human-centered and object-centered conditions selected object-centered instruction. However, the participants in the robot-centered condition mostly selected an addressee-centric instruction, which was the opposite of the condition they were in.

5 DISCUSSION

The goal of this research was to evaluate whether a robot's choice of perspective and particularly the frame of reference could influence humans' exhibition of prosocial behavior toward the robot.

5.1 Prosocial behavior toward the robot

The results support both hypotheses investigating our overarching research question. In **H1a**, we observed that when the robot takes the human perspective in the first task, participants are significantly more prosocial toward the robot in the context of participating in the data collection session. We speculate that this happened because, when the robot takes the human's perspective, it reduces the perspective-taking processes involved for the human to understand the instructions, which consequently leads to a more fluid interaction and reduced time in completing the task [11]. As per previous perspective-taking literature in HRI, human performance in an object identification task is better when the robot takes the human's perspective [11]. The results presented in Figure 5 support the same argument that participants finished the perspective-taking task significantly faster in the human-centered condition in comparison to the robot-centered and object-centered conditions. Furthermore, our results supported that participants in the human-centered condition cared significantly more about the robot than those in the robot-centered condition. As noted by Sassenrath et al. [43] other processes potentially stimulated by perspective-taking, such as emotional empathy or empathic concern, intertwine with evaluating the path from perspective-taking to prosocial behavior. As a result, and as previously mentioned, we based our interaction on a visuospatial perspective-taking task to mitigate the emergence of these processes from the task itself, however, we could not prevent the emergence of empathy-related processes as a consequence of the interaction, particularly in the way humans perceive the robot. Overall, we managed to show that even by using a visuospatial perspective-taking, to collaborate on tasks that do not involve empathy, a robot could still elicit prosocial behavior in humans.

As for **H1b**, we observed that the robot's egocentric instructions in the robot-centered condition resulted in significantly less prosocial behavior exhibited by the participants toward the robot compared to the object-centered and human-centered conditions. The mere act of having to understand where an object is located with respect to another person's right or left; even if it only requires mirroring left and right, is an extra cognitive effort for humans. Having this extra effort could potentially influence the way humans perceive the robot and as presented in this study increase the average time to finish the task, which consequently resulted in reducing human's willingness to help the robot. Figure 5 shows that participants spent significantly more time finishing the task in both object-centered and robot-centered conditions in comparison to the human-centered condition. Since no significant difference between object-centered and robot-centered conditions is observed in terms of completion time, if time was the decisive factor in helping the robot, participants should have shown similar prosocial behavior in both conditions. However, as shown in Figure 3, participants showed significantly different degrees of prosocial behavior both in the occurrence and extent measures. The comparison between object-centered and robot-centered conditions shows that participants were impacted by the robot's perspective choice, i.e. similar time spent on the task but exhibited different degrees of prosocial behavior. Overall, the results presented in this section indicate that the implementation of perspective-taking in robots should be closely evaluated for the way it might influence human's implicit and explicit attitudes toward robots and more studies can be done on this topic in the future.

5.2 Implications of robot's perspective-taking

The interaction in the perspective-taking task was designed to be one-sided, the robot described an object, and the human tried to pick up the correct object. Using this design, we could fully focus on how participants perceived the robot's choice of perspective. However, we were also curious to know how each condition would impact the participant's choice of perspective if they were to instruct the robot. We could have extended the task, similar to what was done by previous studies with children [56] or we could directly ask the participant as we did in this experiment. Our choice of asking the participant rather than measuring it through interaction was driven by our main goal which was to measure prosocial behavior, and we did not want a second session where the human instructing the robot potentially influence the result. As shown in Figure 6 and the analyses, participants' choice of instruction was influenced by the condition they were in. Overall, among 69 participants almost half of them preferred to instruct the robot with object-centered instruction, this result implies that humans preferred a neutral perspective like a baseline. On the other hand, this result highlighted that participants in the robot-centered condition were particularly impacted by the robot's egocentricity. Their choice of how they would instruct the robot was significantly different than the other two conditions and could be only adequately explained through further studies. However, we consider two possibilities for this behavior, either, due to the robot's egocentric instructions in this condition, the participants perceived the robot as egocentric and incapable of understanding other perspectives, hence they adapted their choice to the robot's perspective [56]. Or, having to repeatedly change their perspective to the robot's, they selected a perspective closer to what they would have preferred the robot to have, hence selecting the addressee-centric perspective more than other conditions. Overall, participants in the robot-centered condition showed the lowest measure of prosocial behavior toward the robot and in the case of reciprocating the instruction to the robot, they deviated the most from the behavior shown in other conditions.

5.3 Limitations

Our manipulation of the robot's choice of frame of reference impacted the time it took to complete the perspective-taking task and its difficulty. To mitigate the impact of the task completion, we made sure regardless of the condition the participants were in, they finished the task with enough spare time for the data collection session if they decided to do so. Furthermore, we made sure to account for possible mediation effects of time in our analyses. There are methodological concerns in evaluating prosocial behavior using self-reported measures in psychological research [42, 43]. We put serious effort into designing our prosocial behavior measure, particularly by collecting different types of data, to investigate if our manipulation triggered prosocial behavior in the participants or not. Nevertheless, our prosocial behavior measure does not correspond to all different types of prosocial behaviors in the literature [13] and it is a specific case of helping the robot.

6 CONCLUSION

Prior research has shown that robots could stimulate acts of prosocial behavior in humans. We extended the research by investigating how developing cognitive skills such as perspective-taking could influence the acts of prosocial behavior toward the robot. We developed a user study where in different conditions the robot opted for addressing objects using different frames of reference (human-centered, robot-centered, and object-centered). We then evaluated the occurrence and extent of prosocial behavior toward the robot using a voluntary data collection session, where after completing the perspective-taking task participants could decide whether to join or not. We observed that, compared to the object-centered condition, participants showed significantly more prosocial behavior toward the robot when the robot took their perspective (human-centered) and significantly less prosocial behavior when the robot was egocentric (robot-centered). Furthermore, the perspective the robot took during the task, particularly when the robot was egocentric, significantly influenced how the participants would reciprocate if they were to instruct the robot to pick up an object. Our results could highlight how the development of perspective-taking skills in robots should be carefully curated to prevent inducing unintended consequences on humans' attitudes toward robots.

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