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International Journal of Social Robotics (2026) 18:49
https://doi.org/10.1007/s12369-026-01385-z

Dictator Game Decisions with Robot Recipients

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Received: 6 March 2024 / Revised: 23 February 2026 / Accepted: 27 February 2026

Abstract

While extensive research has examined human-human interactions in dictator games, studies exploring human-robot dictator games remain scarce. Here, we conducted multiple studies in India and The Netherlands to explore how participants allocate money to robot recipients. Using various versions of the dictator game paradigm with both hypothetical and real stakes, we measured offers toward 18 different robots while also assessing participants' perceptions of these robots. Overall, our findings reveal that participants allocated money to robot recipients in dictator games, with offers varying significantly for hypothetical versus real monetary outcomes, mirroring patterns observed in the existing human-human dictator game literature. Factor analyses identified three key characteristics – perceived likeability, anthropomorphism, and social functionality of the robots – as consistent predictors of offers made in the dictator games. Results were broadly consistent across participants from the two countries. We discuss similarities and differences observed across dictator game variations, key predictors of offers made to robots, and cross-country differences in robot perception, along with study limitations. Our results offer empirical insights into the dynamics of human-robot economic interactions that could inform the design of socially interactive robots.

Keywords Human-robot interaction · Dictator game · Social robotics · Anthropomorphism · Likeability · Social functions

1 Introduction

As robots continue to permeate our lives, a better understanding of human-robot interactions becomes crucial. This recognition has increased the popularity of studying human interactions with robots [1] that can perform specialized tasks or become social actors beyond functional roles [2]. This trend coincides with the prolific growth of the robot industry, presenting both opportunities and challenges for HRI researchers, necessitating further studies that mirror the diversity in commercial robots. Prior studies have investigated social preferences for a small number of robots like NAO, PARO, and iCUB (e.g. [2–4]), which creates a need to explore human preferences toward a more extensive array of robots. On the one hand, it could help the industry better understand our evolving relationships with robots utilizing our social preferences, which serve as a window to our worldviews [5]. On the other hand, these empirical findings about psychological mechanisms and factors that drive social preferences in human-robot interactions can reveal truths about human nature in general [6]. We are yet to completely understand how people engage with machines, including robots, in evolving social interactions and the cognitive processes underpinning such interactions [7]. Therefore, exploring the intricacies of human-robot interactions, particularly the social preferences towards commercial robots, can enrich our comprehension of these novel relationships. One way to advance such understanding is to study human-robot interactions using the lens of human-human interactions for a similar context. In this paper, we focus on human behavior towards robots using dictator games (DGs), a paradigm that has been widely used to measure behavior linked to both prosocial and economic preferences. We first discuss results from dictator games conducted between humans and then lead to our studies on human-robot dictator games. Our results are among the

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Published online: 10 March 2026

first few to have studied dictator games as a window to economic preferences shown to robots.

1.1 Dictator Games as Paradigms for Investigating Human Social Preferences

Paradigms from the field of psychology and behavioral economics have been used successfully to investigate and understand human social preferences. One such class of paradigms is behavioral economic games, where participants allocate money, resources, or tokens. Behavioral economic games are a cornerstone in studying social situations and preferences within controlled laboratory settings [8]. These games serve as valuable tools in examining how individuals make decisions in social settings, often involving trade-offs between one's own self-interest and their concern for others' interests. They allow researchers to study specific aspects of human behavior and measure preferences - like cooperation, trust, altruism, and fairness - that are otherwise difficult to quantify naturalistically. In one particular economic game - the dictator game - participants are offered a certain amount of money that they (as the *dictator*) can share with another participant (the *recipient*). Such a game has typically been seen as an indirect measure of prosocial behavior in humans [9, 10]. This is because it allows the *dictator* to freely decide what proportion of the total received amount they would like to offer to the *recipient*, who must passively accept whatever is offered.

The one-sided nature of the game eliminates strategic considerations, making it viable as a measure of the dictator's willingness to sacrifice their payoffs for the benefit of others. Based on the assumptions of pure self-interest, one would expect the player in the role of the dictator to keep the entire stake for themself, giving nothing to the other player (recipient). However, this is not what we see in experimental settings using a "standard" dictator game with human recipients, where only 40% of participants keep the entire stake for themselves [11]. It is this robust finding, even in the absence of strategic incentives, that challenges the assumptions of purely self-interested behavior and suggests that behavior in the DG may be indicative of prosocial preferences. However, we note that interpretations of the proportion of money offered in the dictator game range from altruism to strategic behavior conforming to social norms (e.g. [12, 13]). While there exists arguments about the interpretability of behavior in the DG [9], for the purpose of this paper, we measure dictator game offers to robot opponents which can potentially serve as a proxy for economic prosocial preferences to a certain extent.

1.2 Potential Moderators of Dictator Game Behavior in Human-Human Interactions

Meta-analyses on dictator game decisions toward other humans show that participants, on average, give about 30% of the total stake (Engel [14] reported an average of 28.35%, and Doñate-Buendía et al. [15] reported 29.56%), and that these decisions can be moderated by demographic factors like gender (women give more than men), age (older adults give more than young), and occupation (non-students tend to give more than students). In terms of country or location of origin, Engel [14] suggests that, if controlled for unobserved heterogeneity, participants from developing countries or indigenous societies are much more likely to give non-zero amounts than those from developed countries. On the other hand, Doñate-Buendía et al. [15] find that European dictators are more likely to offer amounts between 0 and 50% of the stake, while the percentages are between 0 and 40% for Asian dictators. They also suggest that location within the continent also plays a role. For example, North African dictators offer less than South African dictators, and South Asian dictators offer less than North Asian dictators.

Another important moderating factor for dictator game behavior observed in both meta-analyses is the variations in the dictator games across different studies. The type of endowment and incentive structure used, especially whether stakes are real or hypothetical has an effect, with participants much more likely to offer nothing when real money is involved [15]. There is also an effect of the absolute size of stakes, with higher stakes reducing generosity [14]. The number of times dictator games are played has been observed to impact dictator offers as well. Games with multiple rounds with the same or different recipients reduce giving. The type of choice available to the dictator appears to be another moderator. Dictators are less generous if they have a discrete set of values to choose from and if choices are incentivized.

Apart from those mentioned above, there exist other moderators of generosity in dictator games, like social distance and the presence of psychological influence or social cues (see [14, 15] for detailed analyses). However, Engel points out that while all these factors may appear to complicate matters, the dictator game ultimately emerges as a powerful tool for understanding human preferences in dynamically changing social conditions.

1.3 Potential Moderators of Dictator Game Behavior in Human-Robot Interactions

While a substantial amount of work has gone into understanding the dynamics of human-human interactions in the dictator game setup, the same cannot be claimed about human-robot interaction settings. Little is known about how humans behave when playing dictator games against non-human recipients like robots - whether robots would receive amounts similar to what human recipients receive, or what factors moderate the decision to offer money to robots. Dictator games in human-robot interaction are scarce but vital to understanding the social preferences towards robots with only a handful of prior studies [16–20]. There is a general understanding that we tend to look at robots through a human lens, ascribing human traits and our own phenomenological experience to non-human objects [21], a process known as anthropomorphization (see [6] for a review). In several studies involving dictator games in human-robot contexts, artificial agents considered to be higher on an anthropomorphic scale received higher offers in a dictator game (e.g. [22]). Even among human interactions, those perceived as more human (e.g., capable of feeling more complex emotions) are more likely to be helped [17]. A related finding suggests that mind perception plays a role, and offers in the dictator game depend on the extent to which the participant infers cognitive and affective capacity in their opponent [17]. Therefore, according to this perspective, dictator offers should depend on the degree to which proposers assume that robots can possess human-like affective and cognitive skills.

However, some studies have found no effect of anthropomorphic explanations on future monetary donations to a robot (NAO); the prosocial act towards the robot was linked to its functionality instead [23]. Participants were more likely to display prosocial behavior towards their robot counterparts if their ability to complete specific tasks was emphasized. These findings suggest that anthropomorphism may not be sufficient to elicit giving behavior, and there needs to be an additional emphasis on the ability of a robot to complete tasks effectively. This instrumentalist perspective can be reconciled with a transactional view of donations, which regards money as a means to achieve desired outcomes. According to this view, people will only give money to robots if they perceive them to be able to perform a specified function. Note, though, that this instrumentalist view conflates the idea of prosociality but is vital for human-robot interaction.

We suggest that specific characteristics of the robots, especially those related to their likeability (independent from anthropomorphism or functionality), could also play a role in determining prosocial behavior towards them. Although the concept of likeability is somewhat underdefined, it is well known in human-human interactions that people tend to evaluate and make judgments about others based on first impressions, and people are more easily persuaded by likeable than unlikeable opponents [24]. Since the likeability of robots is known to be an important factor in how they are perceived or evaluated [25–27], if robots appear likeable, then people could potentially offer them more money.

While past research has examined different dimensions of robot perceptions individually, systematic analysis of their influence on social or economic preferences towards robots, especially within the context of behavioral economic games like the dictator game, is scarce. Much of the existing work has either focused on specific dimensions, in isolation, or has been constrained to interactions with a very limited number of robot models, often just one or two. This raises the critical issue that findings may be robot model-specific and not generalizable across the vast and growing landscape of robotic designs. The present study was conducted to address some of these limitations. First, we aim to investigate behavior in human-robot dictator games to establish whether offers toward robots mirrors the well-documented findings from games played between humans. And second, we aim to move beyond model-specific results by leveraging a large and diverse set of 18 robots. Additionally, we utilized a wide item pool to sample various dimensions of robot perceptions, rather than relying on pre-existing scales that often focus on specific aspects. This wide-ranging approach allows us to identify which robot characteristics consistently influence dictator game behavior across different robot types, providing insights into how variations in robot design and perceived functionality affect economic preferences towards robots.

2 Overview

In a series of four studies (total $N=451$), we measured single-shot dictator game offers [14, 15] to robot recipients. Across studies, participants allocated money to each of 18 different robot opponents that are currently available for purchase and use in various fields, as listed on the IEEE website ("https://robotsguide.com/robots". Our primary goal was to investigate dictator game behavior toward a heterogeneous set of robot recipients and to explore which robot characteristics predict the behavior.

2.1 Robot Stimuli Selection

To maximize heterogeneity, we sampled robots spanning different categories – like education, consumer, medical, entertainment, industrial, humanoid (see Table S1 in Supplementary Materials for a full list and categorization of each robot). It was ensured that the robots varied greatly, differing in terms of size, functionality, and appearance. Our final set comprised 5 humanoid, 5 consumer, 3 industrial/military & security, 3 medical/research, and 2 education robots.

These categories are not mutually exclusive, and some robots can fit into multiple categories. Therefore, in addition to sampling across broad categories, we attempted to ensure diversity within them. For instance, the 'Humanoid' category was intentionally varied to include not only highly anthropomorphic robots like Sophia, but also semi-humanoid research robots and more mechanical-looking robots designed for different social and functional purposes.

2.2 Perceived Robot Characteristics: An Exploratory Item Pool

To examine whether robot characteristics predict dictator game offers, participants responded to twelve questions about the perceived characteristics of each robot. These items were chosen to maximize heterogeneity and included both the experiential and agency-related perceptions attributed to robots [28]. Some of the items were also inspired by the robot rating items on the IEEE website.

We intentionally refrained from using existing scales measuring human perceptions of robots to avoid targeting only certain specific dimensions or aspects of HRI. Existing HRI scales often focus on specific aspects of human-robot interaction, such as trust, acceptance, or usability [25, 29], and are often tailored for robots with substantial social presence or anthropomorphic design. Given the heterogeneity of our robot set - which included non-anthropomorphic industrial arms, functional appliances, and toy-like robots alongside more social companions - we determined that an existing scale might fail to capture the diversity of perceptions relevant to our context.

Anthropomorphism provides a useful illustration. While robust and widely used anthropomorphism scales exist (for e.g. [25]), many of these focus predominantly on the physical likeness of robots to humans, often lacking items assessing perceived emotional capacity or other non-physical attributes. Our research aimed to capture a broader spectrum of robot perceptions, across dimensions, that could potentially influence behavior in the dictator game context. Hence, we compiled a list of twelve items spanning perceptions such as friendliness/creepiness, interest in touching or owning the robot, perceived ability of the robot to think or feel like humans, willingness to allow the robot to perform various tasks, among others (complete list of items in Supplementary Materials). This approach was better suited for the exploratory goals of our research, allowing the most salient perceptual dimensions to emerge directly from the data rather than assuming their structure beforehand.

2.3 Research Questions

This research was primarily exploratory in nature, aimed at investigating dictator game behavior as a measure of economic social preferences, and often (arguably) linked to prosocial preferences, in the context of human-robot interactions. Therefore, no a priori hypothesis was framed and no power analyses were conducted. Given the different moderators in both human-human and human-robot dictator games, we intended to examine variations in both the game characteristics and the robot recipients. The main objectives were to determine : (RQ1) whether participants would offer money to robots in a dictator game; (RQ2) how these offers to robots compare to typical offers made to human recipients in previous studies; (RQ3) whether established variations of the dictator game would influence offers to robots in a manner similar to human-human interactions; and (RQ4) if specific characteristics of the robots themselves (e.g., the perceived friendliness/creepiness, or the perceived ability to think/feel) would impact the offers made to them.

2.4 Study Roadmap

Study 1 measured hypothetical dictator game offers to the robots and asked participants from India to rate the robot characteristics. These ratings were later factored into three dimensions – anthropomorphism, social functionality, and likeability – to examine whether these factors predict dictator game offers. The order of rating robot characteristics first versus playing the dictator game first was observed to have no effect.

In subsequent studies, participants first rated the characteristics of the robots and then played the dictator game for each of the 18 robots, presented in random order. Given the established effects of culture on the perception of robots and human-robot interaction [30], our studies were conducted in two countries - India and the Netherlands. Study 2 replicated the effect and confirmed the findings across participant samples drawn from both India and the Netherlands, Study 3 used real money in the dictator game to test whether the results converge for real stakes. Study 4 used a two-step dictator game with real money to find potential differences between variations of the game and to further the generalizability of our findings. Cleaned data for all the four studies are available on OSF at https://osf.io/b5uta/?view_only=33adf2bb7ecf4758b84f2b1bfa742e4a (See Table 1).

Table 1 Overview of studies - all dictator game (DG) decisions with robot recipients

	Brief Aim	RQ Addressed	Data Collected	Key Statistical Analyses	Results
Study 1	Establish a baseline for giving and identify predictors in a hypothetical context.	RQs 1, 2, 4	• Hypothetical one-step DG offers in an Indian sample. • Robot perception ratings (slider scale).	• Descriptive statistics • Exploratory Factor Analysis (EFA) • Principal Component Analysis (PCA) • Linear mixed effects analyses	• Robots receive ~48% of the stake. • 3 factors – likeability, anthropomorphism, social functionality – from perceived robot characteristics.
Study 2	Test the cross-cultural generalizability of the initial findings.	RQs 1, 2, 4	• Hypothetical one-step DG offers in Indian and Dutch samples. • Robot perception ratings (slider scale).	• Descriptive statistics, correlation analysis • Principal Component Analysis (PCA) • Linear mixed effects analyses • Logistic mixed model analysis	• Robots receive similar offers from both countries ~48%. • All three robot characteristics predict DG offers.
Study 3	Test the validity of findings with real money and examine a key DG variation.	RQs 1, 2, 3, 4	• Real one-step DG offers in Indian and Dutch samples. • Robot perception ratings (slider scale).	• Descriptive statistics, correlation analysis • Principal Component Analysis (PCA) • Linear mixed effects analyses • Independent samples t-test	• Robots receive lower offers when money is real ~35% • All three robot characteristics predict DG offers
Study 4	Test the effect of a structural DG variation (two-step model) on giving.	RQs 1, 2, 3, 4	• Real two-step DG offers in Indian and Dutch samples. • Robot perception ratings (slider scale).	• Descriptive statistics, correlation analysis • Principal Component Analysis (PCA) • Linear mixed effects analyses • Independent samples t-test • Logistic mixed model analysis	• Robots receive much lower offers in a two-step DG ~18% • All three robot characteristics predict DG offers.

3 Study 1: Hypothetical DG Offers to Robots and Perceived Robot Characteristics

The first study serves to provide initial answers to our core research questions. Specifically, it aimed to determine (RQ1) whether participants would offer money to robots, (RQ2) how these offers compare to human benchmarks, and (RQ4) if specific perceived robot characteristics could predict these offers. We examined dictator game offers (participant as dictator) to a variety of robots (as recipient) and also measured perception of different characteristics of the robots. Additionally, we compared the impact of first responding to questions about robot characteristics versus first playing the dictator game to probe if dictator game offers are subject to order effects.

3.1 Methods

3.1.1 Participants

The sample consisted of participants from India ($N=222$), all undergraduate students from an engineering institution (*complete age and gender information not available*) who participated as part of a class activity.

3.1.2 Procedure

The study was designed using Qualtrics software and was conducted in a laboratory setting. Participants were seated on individual desktops in a large lab. It followed a mixed-design, with robot type as a within-subject factor (all participants evaluated all 18 robots) and task order as a between-subject factor.

Upon starting the experiment, participants were randomly assigned to one of two conditions to counterbalance the task order:

- Perception-first Condition ($n=110$) - For each robot, participants first rated it on 12 items assessing perceived characteristics using continuous slider scales (anchored ‘Not at all’/‘Definitely not’ and ‘Very much’/‘Definitely’), and then immediately played a one-shot hypothetical dictator game.
- DG-first Condition ($n=112$) - For each robot, participants first played the one-shot, hypothetical dictator game and then immediately rated it on the 12-item perception questions using the same slider scales.

The dictator game prompt was: “If you were given ₹250, how much would you give this robot? Please enter a value between 0 and 250.”

This two-part procedure (perception questions and DG) constituted a single trial. Each participant completed 18 such trials (see Table S1 in the Supplementary Materials), one for each robot stimulus. The presentation order of the 18 robot trials was fully randomized for each participant to prevent order effects.

Table 2 Factor loadings for study 1

	RC1	RC2	RC3	Uniqueness
Feel emotions	0.940			0.285
Think like human	0.841			0.243
Plan independently	0.826			0.340
Friendly	0.481	0.540		0.358
Physical Similarity	0.418		0.487	0.435
Creepy		−0.903		0.405
Want to Touch		0.731		0.377
Like		0.694		0.332
Want to Have		0.674		0.284
Cook			0.870	0.268
Vacuum			0.864	0.350
Care for Family			0.419	0.519

Note: Applied rotation method is promax

3.2 Analysis and Results

On average, participants offered about 48% (SD = 0.33, median = 0.48) of the total stake to the robot opponents. The average proportion of money offered appeared to be similar for the group that responded to questions about robots first and then played the dictator game (M = 0.469, SD = 0.32) and the other group that played the dictator game first and then responded to questions about robots (M = 0.496, SD = 0.34). A linear mixed effects analysis with order of playing the DG as the fixed effect, and the participant ID as a random effect showed there was no significant effect of dictator game order on the amount of money offered to the robots ($beta$ = 0.013, SE = 0.016, t = 0.828, p = 0.408). Hence, to remain consistent in all the later experiments, we first asked questions about the robot characteristics, followed by the dictator game for each robot on a separate page.

To explore the underlying structure of the perceived characteristics of a robot collected from 12 questions, we initially conducted an exploratory factor analysis. Parallel analysis based on principal components suggested a two-factor solution (Fig S1 in Supplementary Materials). However, due to low factor loadings and the scree plot indicating a potential three-factor structure, we decided to further investigate this possibility. A Principal Component Analysis (PCA), with oblique rotation method promax, was then conducted to fit the data into a three-factor model. The resulting solution provided a more interpretable structure, with the analysis and scree plot supporting the retention of three factors (Table 2). Based on the thematic content of the items loading most strongly onto each factor (see Table 3), we assigned descriptive labels. We interpreted our items as capturing the dimensions of the likeability of the robots, their perceived similarity – both physical and cognitive – to humans, as well as the acceptability to allow them to perform certain functions. The first factor was labeled as the Likeability Index, as it primarily captured items related to positive affective responses toward the robots and their perceived approachability. and would prefer to interact with them. The second factor was labeled Anthropomorphism index, as it captured items concerning the attribution of human-like qualities, and closely people think a robot resembles a human in both physical and cognitive aspects. Finally, the third factor was labeled as the Social Functionality Index, as it captured items that were related to the robots' perceived utility and functional roles, particularly in tasks involving assisting humans. Using weighted averages, we aggregated the items under each factor into three indices - Likeability Index (LI), Anthropomorphism Index (ANI), and Social Function Index (SFI), respectively, in line with [31]. Two items - physical similarity and friendliness - cross-loaded on two factors. For the purpose of analysis, we included them in the factors with higher factor loading.

Next, we investigated whether the indices we created could predict dictator game offers. We used a linear mixed effects model, fitted using restricted maximum likelihood, with the proportion of dictator offers as the dependent variable and the three indices as the fixed effects. As random effects, by-participant random intercepts, by-participant random slopes, and the correlation among the by-participant random effects were added. Main effects were observed for all three factors, suggesting that each factor independently predicted dictator game offers toward robots (Supplementary Materials, Table S2).

4 Study 2: Cross-Cultural Replication of Hypothetical Dictator Game Offers

Much human-robot interaction research has been limited to Western European and North American participants, yet evidence suggests that culture can significantly impact the perception and likeability of robots [30]. Therefore, Study

Table 3 Thematic composition of the three emergent perceptual factors

Likeability Index	Anthropomorphism Index	Social Functionality Index
• How much do you like this robot? • How friendly is this robot? • How creepy is this robot? • Would you like to touch this robot? • Would you want to have this robot?	• How physically similar is this robot to a human? • Can this robot plan its own actions independently? • Can this robot feel emotions?	• Would you let this robot vacuum your house? • Would you let this robot cook for you? • Would you let this robot take care of your family?

Table 4 Factor loadings for study 2

	RC1	RC2	RC3	Uniqueness
Want to Touch	0.829			0.311
Like	0.820			0.240
Creepy	−0.812			0.412
Want to Have	0.803			0.223
Friendly	0.567			0.375
Feel Emotions		0.874		0.337
Plan Independently		0.873		0.304
Think like Human		0.835		0.212
Physical Similarity		0.474	0.449	0.452
Cook			0.985	0.154
Vacuum			0.779	0.311
Care for Family			0.647	0.327

Note: Applied rotation method is promax

2 was designed to test the robustness and cross-cultural generalizability of our initial findings. We replicated our experiment with participant samples from both India and the Netherlands. This allowed us to confirm our initial findings for RQ1 (whether participants give) and RQ2 (how it compares to offers made to human counterparts) across two distinct populations. Additionally, it enabled us to directly test RQ4 by investigating whether the same robot characteristics could predict dictator offers in a similar manner in these samples.

4.1 Methods

4.1.1 Participants

The sample consisted of participants from both India and the Netherlands ($N=84$; n(India) = 42, n(Netherlands) = 42), all students from various universities (*age and gender information not available*) in India and the Netherlands.

4.1.2 Procedure

The experiment was designed on Qualtrics and was conducted online. Upon beginning the study, participants first indicated their country of participation, which determined the currency and stake of the hypothetical dictator game task. The procedure was then consistent for all participants with 18 trials like in Study 1. Within each trial, participants first rated the presented robot on the 12 perception items using the continuous slider scales. Immediately following the ratings, they played one round of a hypothetical dictator game.

The allocation amount was framed depending on the country (€10 for the Netherlands, ₹250 for India) adjusting for purchase power parity between the countries. As in Study 1, the presentation order of the 18 robot trials was randomized for each participant.

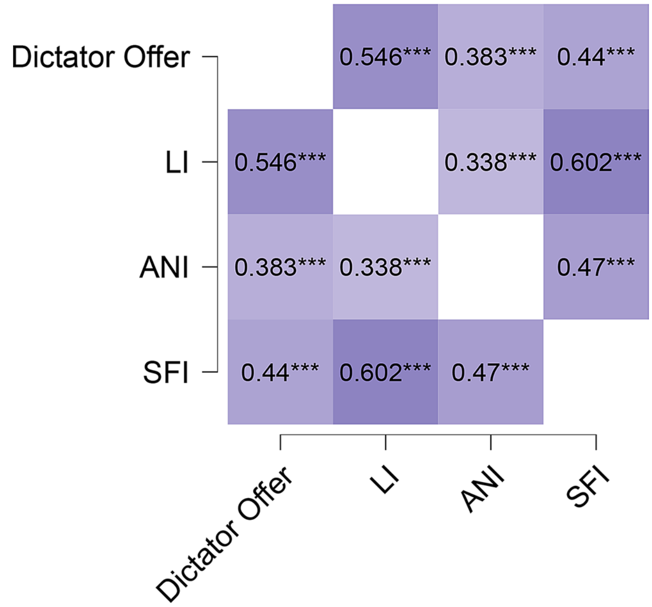


Fig. 1 Correlations between the three factors and dictator offers

4.2 Analysis and Results

On average, the mean proportion of dictator offers was 0.48 ($SD=0.35$, median = 0.50). Indian participants offered about 52% of the stake ($M=0.52$, $SD=0.27$), while the Dutch participants offered about 44% of the total amount ($M=0.44$, $SD=0.24$). Of note, such offers for hypothetical money among student participants align with prior findings on human-human dictator games [15].

To determine if the underlying structure of this new data also had three factors, as in Study 1, we again performed a PCA and found similar results and an almost identical factor structure. The analysis and scree plot again supported the retention of a three-factor structure (Table 4 and Supplementary Materials, Fig S3). Using the same method of weighted averages, we created the three indices - Likeability Index (LI), Anthropomorphism Index (ANI), and Social Function Index (SFI), respectively. One item - physical similarity - cross-loaded onto two factors. For the purpose of analysis, we included them in the factor with higher factor loading (ANI).

We first performed Pearson's correlation analyses to explore the relationship between the three indices and dictator game offers, as well as the inter-relationships among the factors themselves. Correlational analysis (see Fig. 1) revealed that dictator offers had the strongest correlation with LI (r [82] = 0.55, $p<0.001$), followed by SFI (r [82] = 0.44, $p<0.001$) and ANI (r [82] = 0.38, $p<0.001$).

A linear mixed effects analysis was conducted to test the relationship between the three indices, country, and dictator game offers. The three indices and the country from which the participants belonged were added as the fixed effects in the model. As random effects, the participant ID was added to control for by-participant random intercepts and slopes. This analysis revealed main effects of all three factors on the proportion of money offered in the dictator game ($ps < 0.001$), reinforcing the importance of robot characteristics in driving economic preferences. However, no effect of country was observed on the dictator game offers ($beta = -0.017$, $SE = 0.024$, $t = -0.703$, $p = 0.484$).

To compare the proportion of participants giving away non-zero amounts between countries, we fitted a logistic mixed model to predict the probability of giving away a non-zero amount using country as a fixed factor. As random effects, we had intercepts for participants and robots. The coefficients are displayed in log odds. No effect of country was observed on the odds of giving away non-zero amounts ($beta = -3.15$, 95% CI [−6.33, 0.03], $p = 0.052$; Std. beta = −3.15, 95% CI [−6.33, 0.03]) showing results were largely similar across participants from the two countries.

5 Study 3: Incentivized Dictator Games with Real Money

Our prior studies utilized hypothetical money in dictator games. However, a critical question in behavioral economics is whether behavior in economic games differs when real money is at stake. While some early evidence has suggested a decrease in generosity with real money, other work, such as that by Ben-Ner et al. [32], found no significant difference on average. To address this ambiguity within human-robot interactions, Study 3 used real monetary stakes. This allowed us to directly address RQ3, investigating whether this variation in the dictator game would also impact offers made to robot opponents. Simultaneously, this study also served as a crucial validity check for our other core findings (RQ1, 2, and 4).

Table 5 Factor loadings for study 3

	RC1	RC2	RC3	Uniqueness
Creepy	−0.891			0.362
Like	0.841			0.228
Want to Touch	0.708			0.380
Friendly	0.693			0.293
Want to Have	0.640			0.275
Think like Human		0.881		0.225
Plan Independently		0.824		0.399
Feel Emotions		0.816		0.329
Physical Similarity		0.623		0.404
Cook			0.893	0.213
Vacuum			0.833	0.277
Care for Family			0.535	0.326

Note: Applied rotation method is promax

5.1 Methods

5.1.1 Participants

The sample consisted of participants from both India and the Netherlands ($N = 70$; n(India) = 36, n(Netherlands) = 34), all university students. Participants were in the age range of 18 - 30 years (*M = 24 years, SD = 6.25; 67% female*).

5.1.2 Procedure

The study was designed on Qualtrics and was conducted online. It employed a within-subjects design where all participants rated all 18 robots. The core procedure for each trial was identical to Study 2 - participants first rated a presented robot on the 12-item perception questionnaire using slider scales, then immediately made a dictator game decision for that robot.

The key manipulation in this study was the introduction of real monetary stakes (€10 for the Netherlands, ₹250 for India). Participants were informed that one of their 18 allocation decisions would be randomly selected at the end of the experiment to be paid out for real. For that single, randomly selected trial, the amount they chose to keep (total stake minus their offer to the recipient) would be paid to them. Participants were also required to provide their payment details to facilitate the transfer. As in the previous studies, the presentation order of the 18 robot trials was randomized for each participant.

5.2 Analysis and Results

The average dictator game offers in this study was about 35% ($SD = 0.34$, median = 0.30), where participants from India offered about 37% ($M = 0.37$, $SD = 0.34$) and participants from the Netherlands offered about 34% of the stake ($M = 0.34$, $SD = 0.34$). These results again mirror the behavior observed in human-human DG offers for real stakes where approximately 30% is offered [14].

PCA was conducted to determine if the data from this study fit the three-factor structure. As with Study 2, we found the same factor structure for this dataset with real money (Table 5 and Fig S4 in Supplementary Materials). The same items loaded onto the same three factors. Similarly, weighted aggregates were formed based on the factor loadings of each item under each factor to create the three indices - Likeability Index, Anthropomorphism Index, and Social Function Index. The relationship between the proportion of dictator offers given to robots and the three indices showed a similar pattern to Study 2. All three indices showed significant correlations with the proportion of money offered. However, dictator offers were most strongly correlated with the LI (r [68] = 0.46, $p < 0.001$), followed by SFI (r [68] = 0.44, $p < 0.001$), and were least correlated with the ANI (r [68] = 0.34, $p < 0.001$). Again, we ran a linear mixed effects model to determine what best predicts dictator game behavior towards robots. The three indices and the country were added as fixed effects, while the participant ID was added as a random effect to control for the by-participant random intercepts and slopes. Main effects were observed for all three factors on the dictator offers (ps < 0.001). Results reveal no effect of country on dictator game behavior (*beta* = −0.017, *SE* = 0.028, $t = -0.615$, $p = 0.541$).

We also fitted a logistic mixed model to predict the probability of giving away a non-zero amount using country and the three indices as fixed factors. As random effects, we had intercepts for participants and robots. The coefficients are displayed in log odds. No effect of country was observed on the odds of giving away non-zero amounts (*beta* = −2.02, 95% CI [−5.06, 1.03], $p = 0.195$; Std. beta = −2.02, 95% CI [−5.07, 1.03]) showing results were largely similar across participants from the two countries. The effect of ANI was statistically non-significant (*beta* = 7.93e-03, 95% CI [−0.01, 0.03], $p = 0.433$; Std. beta = 0.15, 95% CI [−0.22, 0.52]). The effect of LI was statistically significant and positive (beta = 0.09, 95% CI [0.06, 0.12], $p < 0.001$; Std. beta = 1.80, 95% CI [1.28, 2.33]). The effect of SFI was statistically significant and positive (*beta* = 0.05, 95% CI [0.03, 0.08], $p < 0.001$; Std. beta = 1.22, 95% CI [0.68, 1.75]).

Additionally, we decided to analyze if offers made in this study differ significantly from the offers made in the previous study with hypothetical money. We find that when participants played for hypothetical money in Study 2, the mean proportion of money offered in the dictator game was 0.48 (*SD* = 0.26). On the other hand, in this study, where participants played for real money, the dictator offers to robots reduced to a mean of 0.37 (*SD* = 0.26). Using an independent samples t-test, this difference was found to be significant, $t(146) = 2.65$, $p = 0.009$, $d = 0.44$ (Fig. 2), showing that even in human-robot dictator games people give less for real money compared to hypothetical money, which contradicts some previous findings [32]. Additionally, Fig. 3 (below) illustrates how the proportion of offers vary across the different robots for hypothetical versus real monetary tasks.

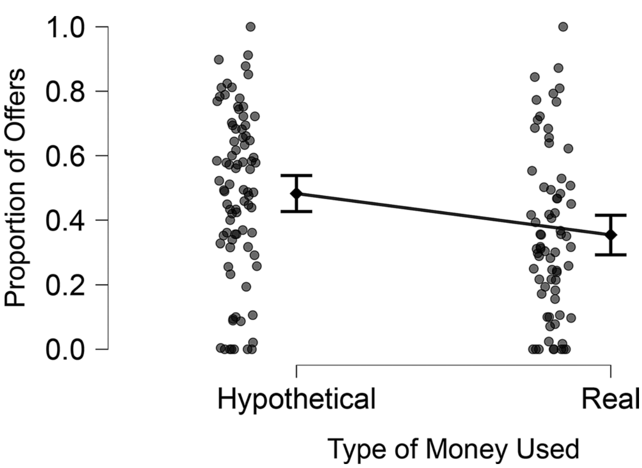


Fig. 2 Difference in the proportion of stake offered in the dictator games with hypothetical vs. real money ($p = 0.009$, data from studies 2 and 3). Error bars indicate 95% *CI*

6 Study 4: Two-Step Dictator Game with Real Money

To reduce potential demand characteristics in the DG, we built on prior work in the context of donation decisions which has argued that the decision to give away money is a two-step process [33]. First an individual decides whether to give or not, and second, those who do choose to give, decide how much to give. Based on such a two-step model of decision making, Study 4 was designed to specifically address RQ3 by introducing a key structural variation to the dictator game. We modified the original one-shot game by splitting it into two distinct steps to mirror this process - a binary decision to give (yes/no), followed by a decision on the amount for those who chose to give. We continued the use of real monetary stakes in this study, which also helped us confirm our previous findings in a new sample.

6.1 Methods

6.1.1 Participants

The sample consisted of participants from both India and the Netherlands ($N = 75$; n(India) = 31, n(Netherlands) = 44), all university students. Participants belonged to the age range of 18 - 30 years (*M = 23 years, SD = 3.87; 70% female*).

6.1.2 Procedure

The study was designed on Qualtrics and was conducted online. For each of the 18 randomized trials, participants first rated the presented robot on the 12-item perception questionnaire. Following the ratings, they proceeded to the two-step DG:

- The decision to give: Participants were first presented with a binary choice (“Would you like to give money to this robot?” Yes/No).
- The allocation amount: If a participant selected ‘Yes,’ they were then directed to a new screen where they could enter the specific amount they wished to give. If they selected ‘No,’ the trial concluded for that robot.

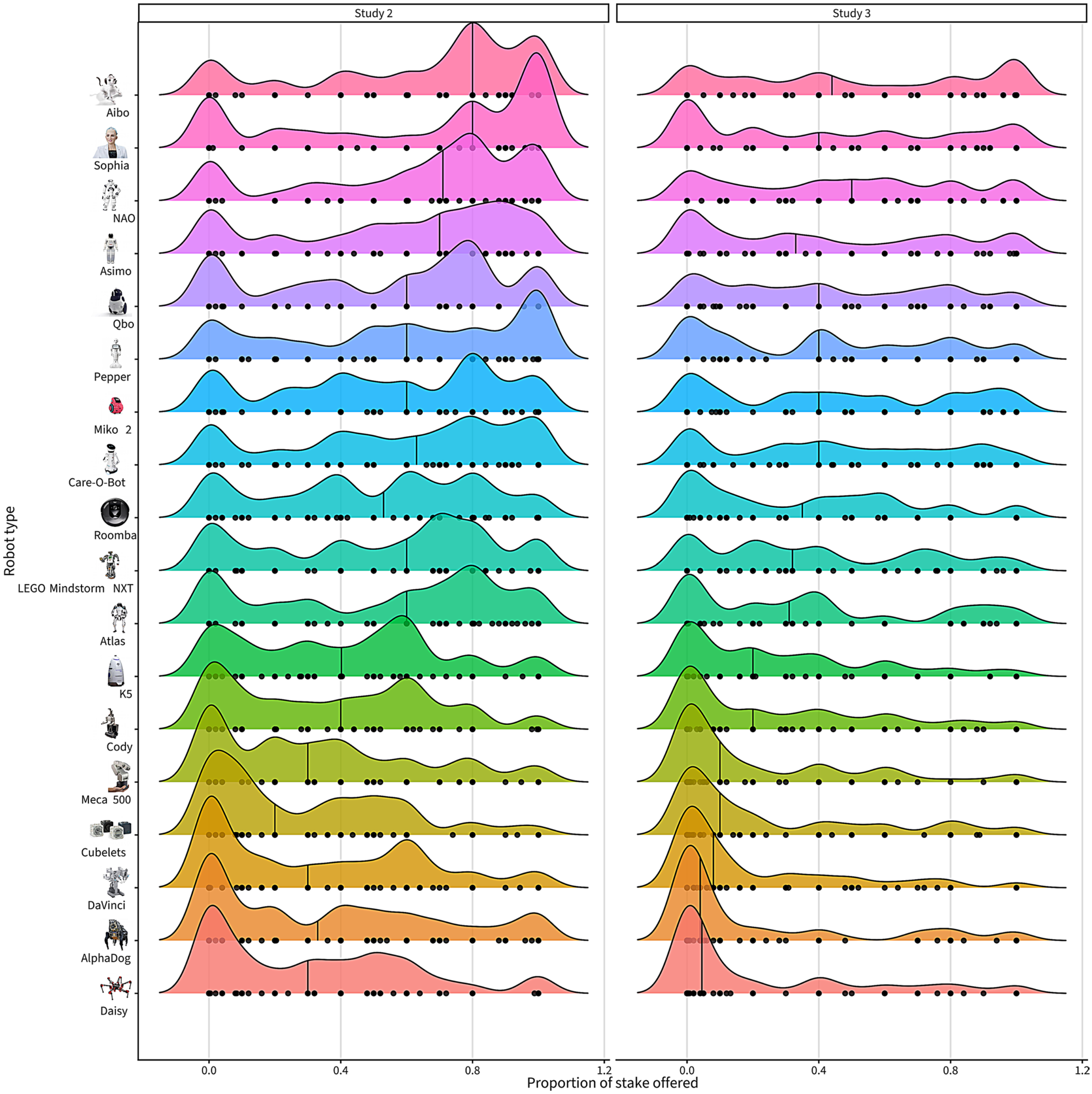


Fig. 3 Offer distributions across robots in dictator games with hypothetical (study 2) versus real (study 3) monetary stakes

As in Study 3, decisions involved real monetary stakes. The endowment was set at €10 (Netherlands) or ₹250 (India). Participants were informed that one of their 18 decisions would be randomly selected for real payment, and at the end of the experiment, they provided payment details.

6.2 Analysis and Results

When participants played the two-step dictator game, the average offers among those who chose to share were observed to be about 18% ($SD = 0.29$, median = 0; M(India) = 0.245, M(Netherlands) = 0.134). Since in this version of the game, participants were first given the option to decide whether or not they want to make offers to the robots, we first look at the trials in which they accepted. We find that across all trials, participants chose to make offers to their opponents in only 38.8% of the trials. Indian participants opted to make offers in about 46% of the total trials, while Dutch participants opted to make offers in about 32% of the total trials.

Table 6 Factor loadings for study 4

	RC1	RC2	RC3	Uniqueness
Think like Human	0.886			0.240
Feel Emotions	0.820			0.330
Physical Similarity	0.769			0.429
Plan Independently	0.755			0.462
Creepy		−0.951		0.324
Like		0.825		0.220
Friendly		0.692		0.266
Want to Have		0.614		0.254
Want to Touch		0.526		0.362
Vacuum			0.938	0.199
Cook			0.914	0.176
Care for Family			0.472	0.366

Note: Applied rotation method is promax

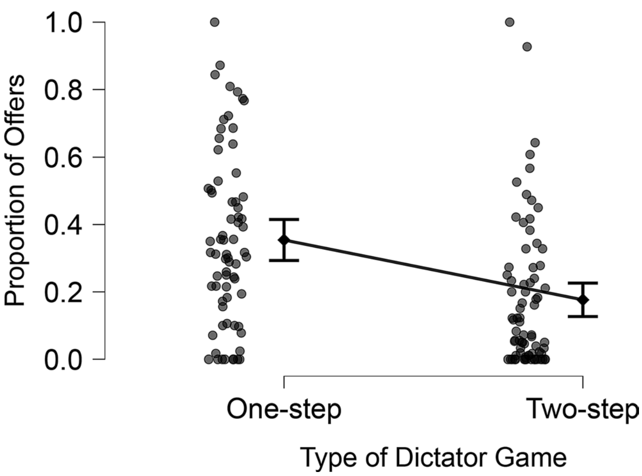


Fig. 4 Difference in the proportion of stake offered in the one-step vs. two-step dictator games ($p<0.001$, data from across studies 3 and 4). Error bars indicate 95% *CI*

The same factor structure was observed through PCA, resulting in the three indices with weighted aggregates as before (Table 6 and Supplementary Material, Fig S5). Following a similar pattern, the Likeability Index had the strongest relationship with dictator offers ($r[73]=0.49, p<0.001$), followed by the Social Function Index ($r[73]=0.40$, $p<0.001$), and finally by the Anthropomorphism Index ($r[73]=0.34, p<0.001$), which had the weakest relationship with dictator offers. Linear mixed effects analysis showed main effects for all three indices in predicting the proportion of dictator offers (ps<0.005). The three indices and the country were added as fixed effects, while the participant ID was added as a random effect to control for the by-participant random intercepts and slopes. Again, the country had no effect on the dictator offers in the two-step dictator game with real money (*beta*$=0.027$, *SE*$=0.014$, $t=1.909$, $p=0.064$).

We then analyzed how the dictator offers differ in this study when compared to the previous one. We found a stark difference between dictator game behavior in a one-step dictator game versus a two-step dictator game (Fig. 4). When participants played the two-step dictator game, the observed mean proportion of dictator offers was considerably reduced to 0.18 (*SD*$=0.29$). When we compare this, using an independent samples *t*-test, to the mean proportion of dictator offers in Study 3, where participants played a one-step dictator game, the difference was statistically significant, $t(143)=4.53$, $p<0.001$, $d=0.75$.

To compare the proportion of participants giving away non-zero amounts between one-step and two-step dictator games, we fitted a logistic mixed effects model to predict the probability of giving away a non-zero amount using the dictator game type as a fixed factor. As random effects, we had intercepts for participants and robots. The coefficients are displayed in log odds. The model's intercept, corresponding to one-step dictator games in India, is at 3.50 (95% CI [2.14, 4.86], $p<0.001$). The effect of dictator game type was statistically significant and negative for a two-step dictator game (beta=−4.01, 95% CI [−5.39, −2.64], $p<0.001$; Std. beta=−4.01, 95% CI [−5.39, −2.64]). Playing a two-step dictator game reduces the odds of a non-zero offer by 98%, underscoring the important role of task characteristics in DG beyond social preferences, and potentially highlights demand characteristics for heightened giving in previous versions. Interestingly for us, robot characteristics consistently predict dictator game offers irrespective of the nature of the game.

7 Aggregate Analysis

7.1 Predictors of Dictator Game Offers

We analyzed the complete set of collected data from Studies 2, 3, and 4 consisting of 4122 observations in a linear mixed effects model to predict the proportion of the stake given away. 95% confidence intervals (CIs) and *p*-values were computed using a Wald *t*-distribution approximation. As fixed effects, we included country, real/hypothetical stake, dictator game type, and the LI, ANI, and SFI indices. As random effects, we had intercepts for participants and robots. The model's total explanatory power is substantial (conditional $R2=0.77$) and the part related to the fixed effects alone (marginal R2) is 0.38. The model's intercept, corresponding to a one-step, hypothetical dictator game in India with the three indices at 0 is at 0.23 (95% CI [0.17, 0.29], $t(4112)=7.69$, $p<0.001$). Within this model:

- The effect of country [Netherlands] is statistically non-significant and positive (beta=2.13e-03, 95% CI [−0.06, 0.06], $t(4112)=0.07$, $p=0.943$; Std. beta=6.09e-03, 95% CI [−0.16, 0.17]).

- The effect of real/hypothetical stake [real] is statistically significant and negative (beta=−0.11, 95% CI [−0.18, −0.04], $t(4112)=-3.10$, $p=0.002$; Std. beta=−0.32, 95% CI [−0.52, −0.12]).
- The effect of one/two-step dictator game [two-step] is statistically significant and negative (beta=−0.19, 95% CI [−0.26, −0.11], $t(4112)=-5.01$, $p<0.001$; Std. beta=−0.53, 95% CI [−0.74, −0.33]).
- The effect of LI is statistically significant and positive (beta=5.97e-03, 95% CI [5.53e-03, 6.42e-03], $t(4112)=26.44$, $p<0.001$; Std. beta=0.34, 95% CI [0.31, 0.36]).
- The effect of ANI is statistically significant and positive (beta=2.37e-03, 95% CI [1.89e-03, 2.85e-03], $t(4112)=9.63$, $p<0.001$; Std. beta=0.13, 95% CI [0.10, 0.15]).
- The effect of SFI is statistically significant and positive (beta=1.86e-03, 95% CI [1.46e-03, 2.26e-03], $t(4112)=9.14$, $p<0.001$; Std. beta=0.13, 95% CI [0.10, 0.16]).

In conclusion, there is a significant effect for real/hypothetical dictator games, with dictator games that are played for real money leading to a decrease in offered stake of 0.11 compared to a hypothetical stake. There is also a significant effect for dictator game type, with two-step dictator games leading to a decrease in offered stake of 0.19. Additionally, the three indices showed significant effects. Because gender information was only available for Studies 3 and 4, it was not included as a predictor in this analysis. Subsequent analyses on this subset showed no differences in gender. These results are displayed Fig 5 and in Table S7 in the Supplementary Materials.

We also ran an analysis on the complete dataset to predict whether or not there would be a non-zero offer to a robot (Fig. 6). It should be noted that the between-participant variance in giving away non-zero amounts is large: participants tend to either give non-zero amounts to all robots or give only zero amounts to all robots. We fitted a logistic mixed effects model using the same fixed and random effects as above. The model's total explanatory power is substantial (conditional $R^2=0.93$) and the part related to the fixed effects alone (marginal R^2) were of 0.47. The model's intercept, corresponding to a one-step, hypothetical dictator game in India with the three indices at 0 is at 3.09 (95% CI [1.51, 4.67], $p<0.001$). The coefficients are displayed in log odds. Within this model:

- The effect of country [Netherlands] is statistically non-significant and negative (beta=−1.27, 95% CI [−2.71, 0.18], $p=0.085$; Std. beta=−1.30, 95% CI [−2.68, 0.08]).
- The effect of real/hypothetical stake [real] is statistically significant and negative (beta=−1.88, 95% CI [−3.66, −0.11], $p=0.038$; Std. beta=−1.95, 95% CI [−3.65, −0.25]).
- The effect of one/two-step dictator game [two-step] is statistically significant and negative (beta=−6.25, 95% CI [−8.12, −4.39], $p<0.001$; Std. beta=−5.85, 95% CI [−7.59, −4.11]).

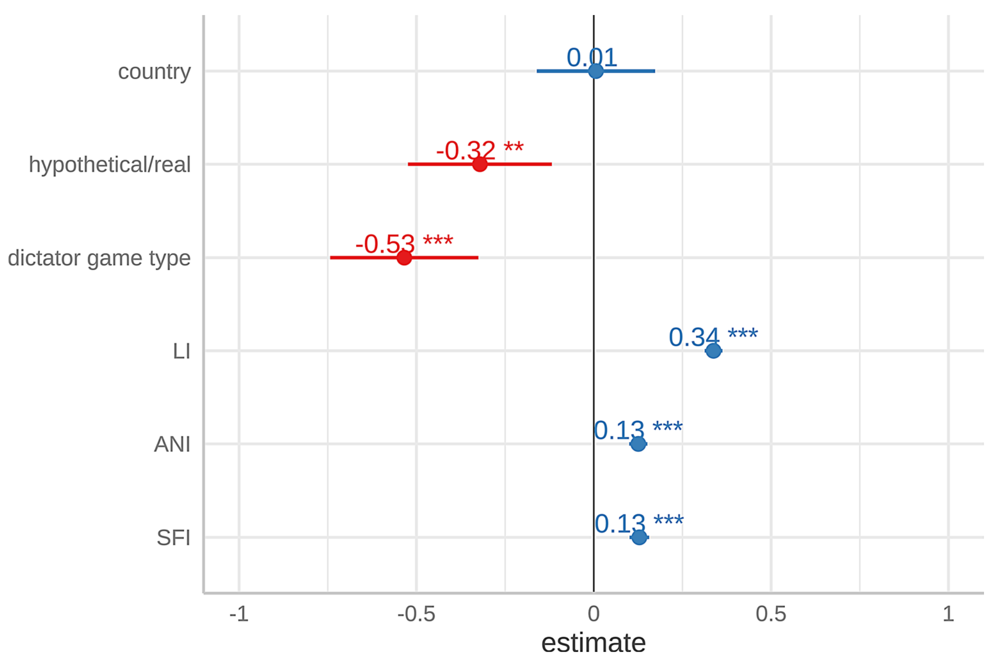


Fig. 5 Linear mixed effects model standardized coefficient estimates with 95% CI (data from across studies 2, 3, and 4). *Note: ** $p<0.01$, *** $p<0.001$*

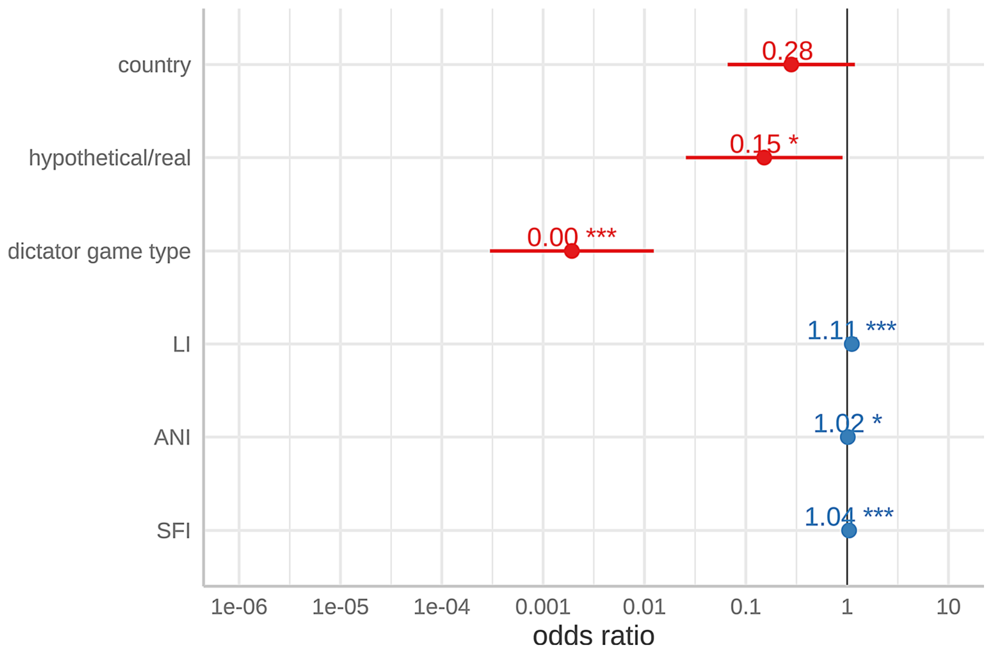


Fig. 6 Logistic linear mixed effects model coefficient estimates with 95% CI. *Note:* * $p<0.05$, *** $p<0.001$

- The effect of LI is statistically significant and positive (beta = 0.11, 95% CI [0.09, 0.12], $p<0.001$; Std. beta = 2.04, 95% CI [1.77, 2.32]).
- The effect of ANI is statistically significant and positive (beta = 0.01, 95% CI [3.41e-03, 0.03], $p=0.011$; Std. beta = 0.26, 95% CI [0.06, 0.47]).
- The effect of SFI is statistically significant and positive (beta = 0.04, 95% CI [0.03, 0.06], $p<0.001$; Std. beta = 1.03, 95% CI [0.76, 1.31]).

In conclusion, there is a significant effect of real/hypothetical stake, with playing for real money reducing the odds of a non-zero offer by 85%. There is also a significant effect of dictator game type, with playing a two-step dictator game reducing the odds of a non-zero offer by 99%. Figure 5 shows coefficient estimates in odds ratios.

7.2 Varying Perceptions of Robot Characteristics

We analyzed how perceptions about the diverse robots used across the four studies differed on the key factors observed. While the nature of the dictator game was subject to change based on the different studies, the questions about robot characteristics remained the same. Additionally, the PCA revealed a consistent factor structure from our initial question pool, which we aggregated to create the indices of Likeability, Anthropomorphism, and Social Functionality. Hence, it is important to observe how the different robots differ on these three factors.

When we look at averaged responses for the Likeability Index (LI), we observe a distinct preference for robots like Aibo and Miko 2, which receive the highest ratings (Fig. 7). The cute and playful appearance of these robots may have contributed to them being most likeable. The humanoid robots also fare reasonably well, suggesting that there could be an inherent appeal in the human form. On the other hand, robots like AlphaDog, DaVinci, and Daisy were observed to be least likeable for participants. This could be due to the pronounced mechanical appearance of these robots, which might have been perceived as scary.

A distinct gradient of human likeness can be observed when we look at the robots' Anthropomorphism Index (ANI) ratings (Fig. 8). Sophia, with its strikingly human features, was considered by participants to resemble humans the most. Other humanoid robots follow closely but with a discernible difference from Sophia. Robots resembling other forms of life, like Aibo (which resembles a dog) and Daisy (which resembles a spider), lie somewhere in the middle of the anthropomorphism scale. Unsurprisingly, all the other robots that bear little or no resemblance to human or organic forms were rated lowest on anthropomorphism.

When we consider the Social Functionality Index (SFI) ratings of the different robots, we observe humanoids like NAO, Asimo, and Pepper as the most preferred candidates for social roles (Fig. 9). However, quite interestingly, Sophia (the most advanced-looking humanoid) ranks only fifth in this category, suggesting that participants do not seem to find its human likeness important for social roles. It is also possible that the uncanny valley effect plays a role here [34]. Semi-humanoid and dome-shaped robots find themselves in the middle of this scale, demonstrating a degree of suitability for social functions. The lowest rated in terms of preference for social roles are robots like DaVinci, AlphaDog, Cubelets, and Daisy. These robots were also rated low in

Fig. 7 Ratings for LI across robots

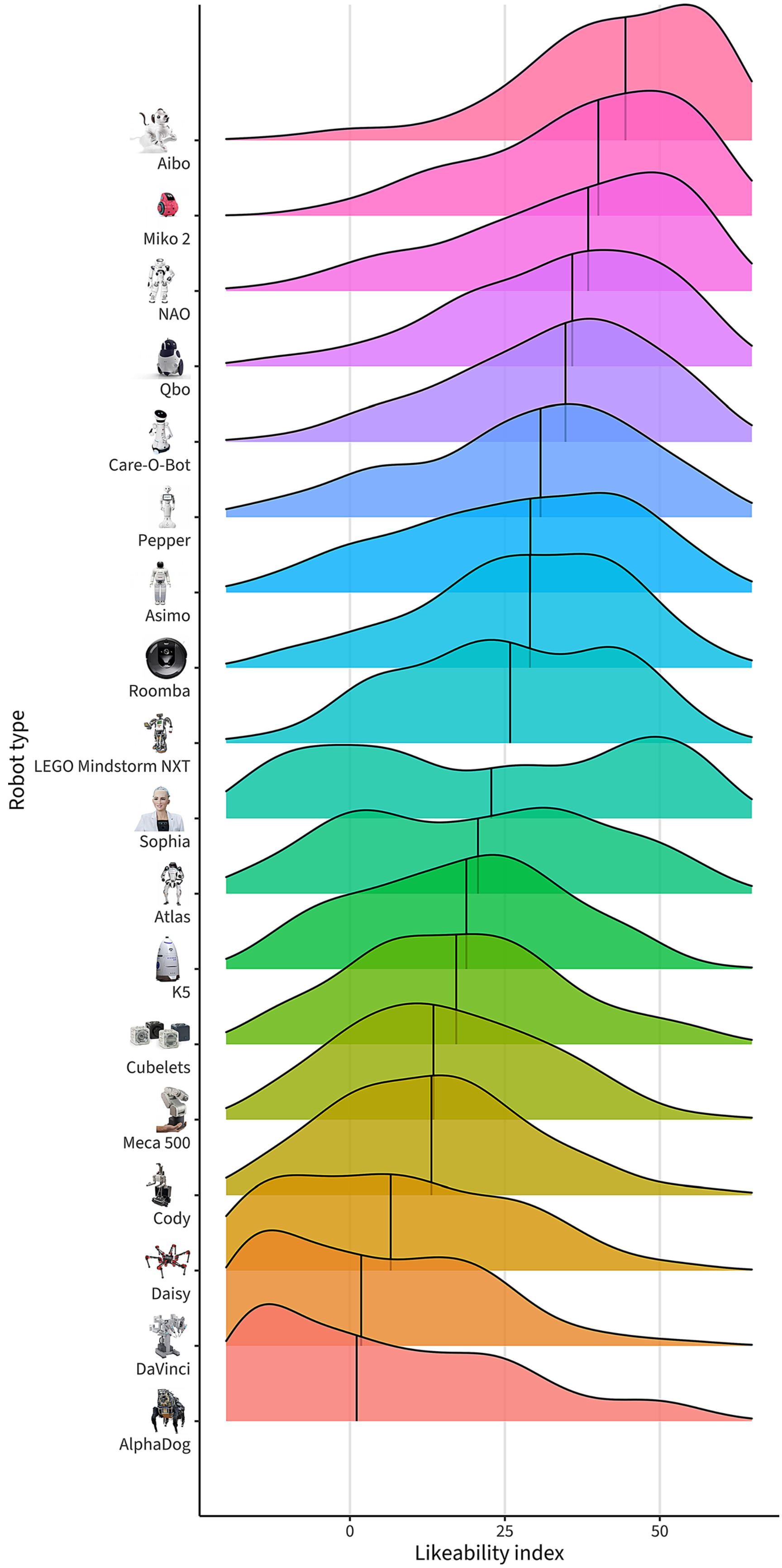


Fig. 8 Ratings for ANI across robots

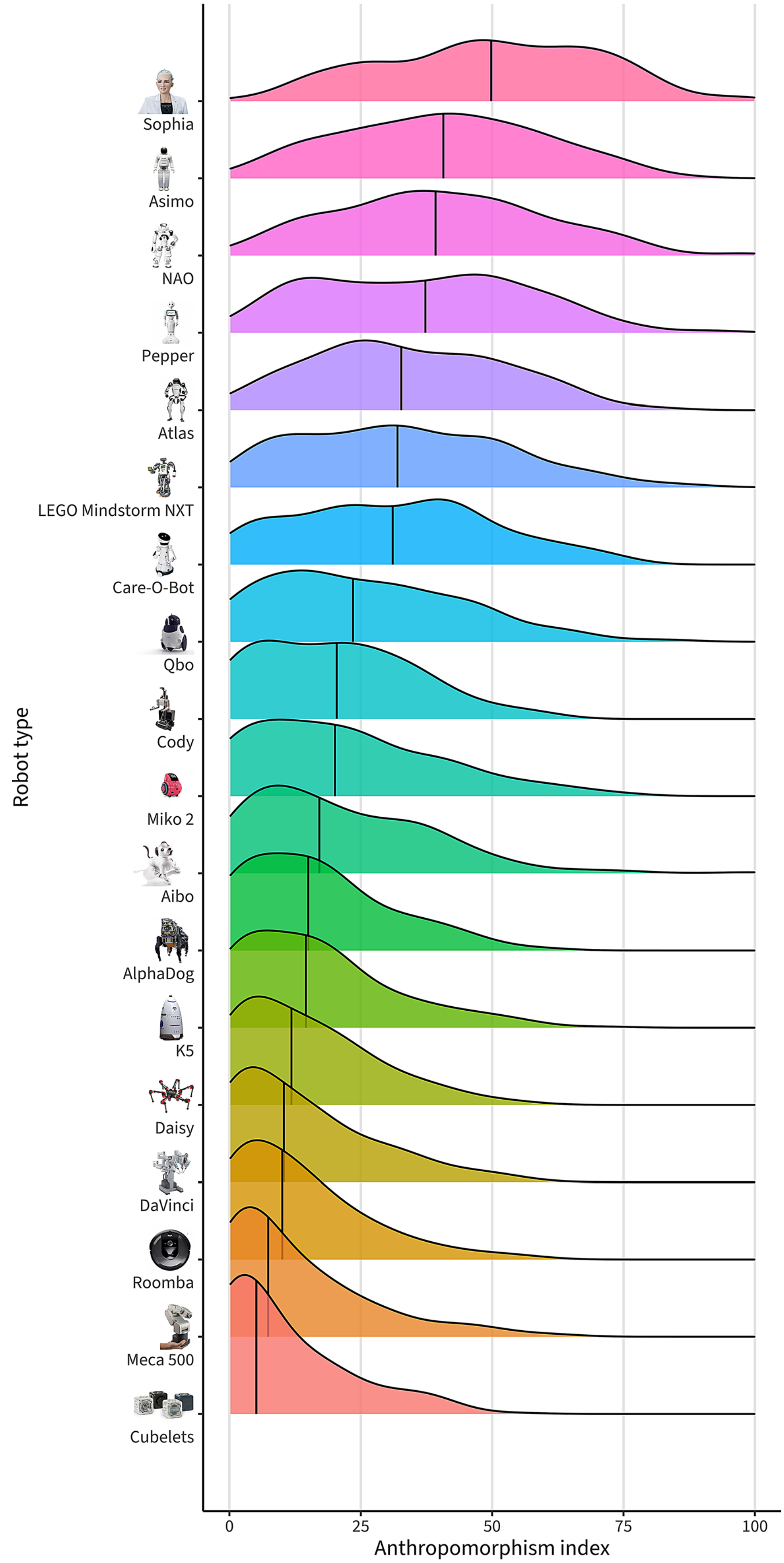
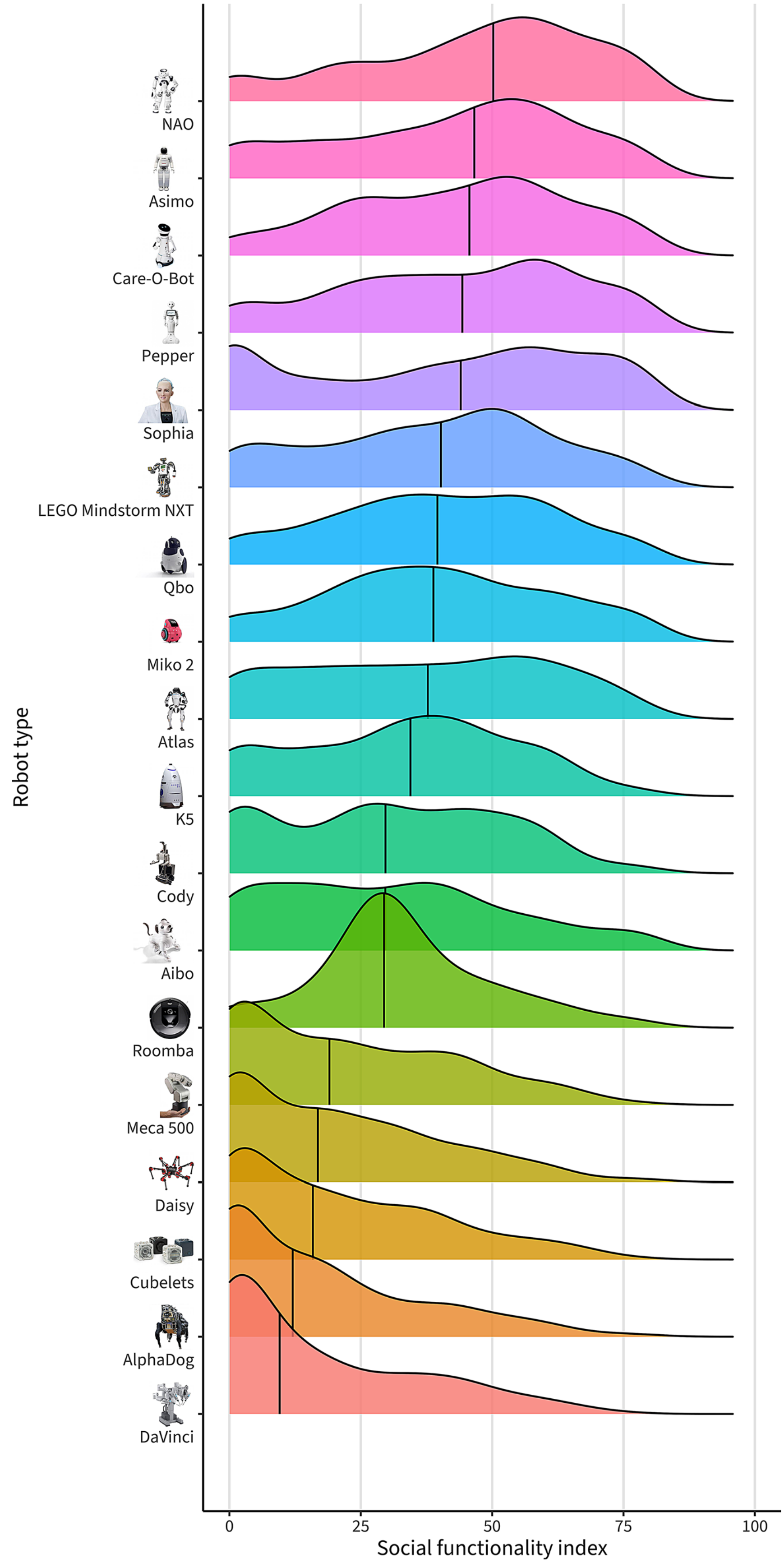


Fig. 9 Ratings for SFI across robots



likeability, suggesting a close relationship between robots we like and those we allow to perform social roles.

8 Discussion and Conclusion

As suggested by some research, humans engage with computers and robots as social actors, often applying social norms and expectations to interactions with these machines [35, 36]. Building upon this idea, the current research investigated whether this also extends to economic prosocial preferences. The well-established dictator game paradigm, extensively employed in human-human interactions but scarce in human-robot contexts, allowed us to measure how participants might offer money to robot recipients. By employing this method, we aimed to compare the extent to which this behavior is similar to their interactions with human counterparts. Our findings provide clear and consistent answers to our four primary research questions. Our first two research questions asked whether participants would allocate money to robots and if this behavior compares to established human-human benchmarks. The answer, across multiple contexts, is a definitive yes. Our third research question explored how variations in the dictator game paradigm itself would influence offers. Here, we find that behavior toward robots is not immune to some of the same contextual and structural factors known to influence human-human prosociality. Finally, our fourth research question was about identifying which robot characteristics predict giving to robots. Rather than assuming which traits matter, our data-driven approach allowed three core perceptual dimensions to emerge - likeability, anthropomorphism, and social functionality. Overall, we demonstrate that giving to robot recipients in a dictator game is a robust and predictable phenomenon, analogous in some ways to giving in human-human interactions and is driven by the perceived characteristics of the robots.

Prior research has mainly attributed prosociality towards robots to anthropomorphism [37], positing that people mimic prosocial behavior towards humans to a certain extent with robots. Following such a view, one would predict that prosocial behavior would only be displayed toward robots that resemble humans. While there is a definite relationship between how human-like people perceive a robot to be and how much money is offered in dictator games [16], it has also been observed that people give away money to avatars that look like animals [38]. This suggests that anthropomorphism may be important but insufficient in explaining generosity towards robots. Across all four studies, our results suggest that dictator game offers toward robots can be explained by all the three robot attributes we measured - likeability, anthropomorphism, and the perceived social function of the robots. These attributes independently predict offers in dictator games. A noteworthy pattern across the three studies was that the likeability of robots was a better predictor of the offers than the perceived social function and anthropomorphism of the robots. This can be explained using a likeability heuristic in human-robot interaction, where people quickly decide whether or not they find a robot likeable based on a few sampled characteristics, like the perceived friendliness or creepiness of the robot. This heuristic processing possibly reduces the effort required in evaluation using all the available information [39]. This behavior is comparable to the literature on impression formation in human-human interactions. A significantly large area of research suggests that people tend to quickly create first impressions of others, inferring characteristics from appearances, and these impressions tend to impact various social judgments (e.g. [24, 40]).

When participants played the one-step dictator game for hypothetical money, they offered almost 50% of the total stake. However, when participants played the one-step dictator game for real money, they offered significantly lower proportions of the stake to the robots. This observation was found to be true for participants from both countries. Our results appear to contradict some of the work that suggests there is no difference in dictator game generosity when playing for hypothetical versus real money (e.g. [14, 32]). In fact, the meta-analysis by Engel [14], with dictator games involving human recipients, reported that if dictators decide to share, they offer more when handling real money. However, we provide supporting evidence for a more recent meta-analysis, which shows dictator game behavior (with human recipients) differs when participants play for hypothetical versus real money and that when playing a hypothetical game, participants are more likely to offer either nothing or about 50% of the stake [15].

Further, the type of dictator game played significantly impacted the amount of money offered. Participants offered much less money in a two-step dictator game with real money than in a one-step dictator game with real money. The same pattern was observed in participants from both countries, which can be explained from a dual-systems perspective [33], built upon some social heuristics [41]. Regarding cultural differences, we do not find significant variations in dictator game behavior between Indian and Dutch participants across the latter three studies when considering the proportion of stake offered. This is in contrast with most of the literature around dictator games in human-human interactions. For example, Engel [14] finds that a dictator might offer more money if they belong to a developing country. However, while we do find a difference between the countries overall, this seems to be explained by differences in robot perception between the two countries.

Our results suggest that humans do allocate money to robots in DGs, which may potentially reflect some prosocial economic preferences along with the attribution of social characteristics in the robots. There is an assumption that offers made in a dictator game serve as a proxy for prosocial behavior. And there is an intuitive sense in this assumption, considering the fact that the *dictator* can make a decision that has no consequence, and they can get away with not sharing without facing any rebuttal from the *receiver*. However, as List [9] points out, it might be important to review our interpretations of giving away money in dictator game set-ups. Moreover, giving in dictator games may be driven by a desire to comply with perceived social norms rather than purely altruistic motives. Factors such as anonymity, entitlement, and framing can substantially impact giving behavior, emphasizing the importance of context. Some researchers have also argued that dictator game giving may be partly an artifact of the experimental setting rather than a true reflection of prosocial preferences [42]. The set-up itself might create an expectation for the *dictator* to share. The difference between the proportion of money offered in Studies 3 and 4 lends support to this proposition. When participants were given an explicit choice of not sharing their money, a lot more decided against it. Beyond variations in game structure, the broader implications of making such offers to robots warrant further investigation.

There are accordingly some limitations of our study that must be considered when interpreting the results. First, we need to better control demand characteristics and investigate why participants allocate money to robots that, unlike humans, have no material needs. Second, there are design and participant aspects of the study that we note. Our use of static images to represent various robots, while allowing for controlled and consistent presentation across participants, may not fully capture the dynamic nature of human-robot interactions. Videos or real physical interactions might elicit different behavior and can be explored in future research. Another potential limitation of our study design is that we presented the perception questions and dictator game offers within the same trial. This approach may have inadvertently cued participants to judge the robots along these specific dimensions, influencing their subsequent offer decisions. Additionally, our sample consists entirely of a student population. While student samples provide a homogenous group that helps control for the effects of known moderators and facilitates comparisons with much of the DG literature, it limits the generalizability of our findings to broader populations. Another notable limitation of this research concerns the collection of participant demographics. The initial choice of convenience sampling led to an oversight in collecting demographic data, including age and gender, for Studies 1 and 2. This oversight was rectified for Studies 3 and 4, where we find no significant effect of participant gender on allocation behavior toward robots. However, the absence of this data from our first two studies prevents a full analysis of potential demographic influences. Future studies should aim to replicate these findings with non-student samples, including more diverse participants across age groups and socioeconomic backgrounds. Thirdly, our robot perception scale was exploratory. It is important to consider that the primary goal of this research was not to develop and validate a new psychometric scale, but rather to use a data-driven, exploratory approach to identify key dimensions relevant to economic games in HRI. Consequently, while the three-factor structure proved robust across our samples, we did not engage in extensive item selection to minimize potential cross-loadings between factors. Future research could refine this item set and formally test it, using Confirmatory Factor Analysis (CFA) for instance, providing a validated instrument. Finally, all our recipients were robots and hence there was no way to compare behavior to other agents or human recipients. It might be possible that when the recipient pool is heterogenous, different patterns of behavior unfold. These limitations present opportunities for future researchers to build upon our findings and further explore the nuances of human-robot dictator game interactions.

This study is among the first few to demonstrate economic social preferences to a range of commercially available robots. Our findings show that people can perceive robots as social actors, ascribing different levels of intentionality and personality traits to them, and that these perceptions have downstream effects on economic interactions with these robots. We find considerable similarities between dictator game behavior with robot recipients and existing literature about dictator game behavior with human recipients. We also find that monetary offers to robots are not random and can depend on specific factors like the perceived likeability, social functionality, and anthropomorphism. While this is unlikely to be an exhaustive list, these factors may prove crucial in shaping social and economic interactions with robots given their increasing presence in the public sphere.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12369-026-01385-z.

Acknowledgements The authors would like to thank Carmen Rueda Lindemann for her help in collecting data and writing up parts of an earlier draft of this research project. The authors would also like to acknowledge the feedback and suggestions by the reviewers which helped improve the paper.

Data Availability All the cleaned data files are available on OSF via a view-only link at https://osf.io/b5uta/?view_only=33adf2bb7ecf4758b84f2b1bfa742e4a

Declarations

Ethical Approval The current study was approved by the Psychology Research Ethics Committee, Social and Behavioral Sciences, Leiden University under code 2021–07-06-V2-3336.

Informed Consent and Confidentiality Informed consent was obtained from all individual participants who participated in the study. No identifying information was recorded.

Conflicts of Interest The authors declare that they have no conflict of interest.

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Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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