Excluded by Robots: Can Robot-Robot-Human Interaction Lead to Ostracism?

Hadas Erel, Yoav Cohen, Klil Shafrir, Sara Daniela Levy, Idan Dov Vidra, Tzachi Shem Tov,
Oren Zuckerman
Media Innovation Lab (milab), Interdisciplinary Center (IDC)
hadas.erel,yoav.cohen,klil.shafrir,sara.levy,idan.vidra,tzachi.shemtov@milab.idc.ac.il
orenz@idc.ac.il

ABSTRACT

Robot-Robot-Human Interaction is an emerging field, holding the potential to reveal social effects involved in human interaction with more than one robot. We tested if an interaction between one participant and two non-humanoid robots can lead to negative feelings related to ostracism, and if it can impact fundamental psychological needs including control, belonging, meaningful existence, and self-esteem. We implemented a physical ball-tossing activity based on the Cyberball paradigm. The robots' ball-tossing ratio towards the participant was manipulated in three conditions: Exclusion (10%), Inclusion (33%), and Over-inclusion (75%). Objective and subjective measures indicated that the Exclusion condition led to an ostracism experience which involved feeling "rejected", "ignored", and "meaningless", with an impact on various needs including control, belonging, and meaningful existence. We conclude that interaction with more than one robot can form a powerful social context with the potential to impact psychological needs, even when the robots have no humanoid features.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in HCI**.

KEYWORDS

Social robots, Ostracism, Exclusion, Robot-Robot-Human Interaction, Non-humanoid robots, Human-Robot Interaction, Cyberball

ACM Reference Format:
Hadas Erel, Yoav Cohen, Klil Shafrir, Sara Daniela Levy, Idan Dov Vidra, Tzachi Shem Tov,, Oren Zuckerman. 2021. Excluded by Robots: Can Robot-Robot-Human Interaction Lead to Ostracism?. In *Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction (HRI '21), March 8–11, 2021, Boulder, CO, USA.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3434073.3444648

1 INTRODUCTION

Human-Robot Interaction (HRI) is commonly perceived as a social experience [4, 9, 18, 19, 54]. The various social effects associated with HRI include core phenomena that are well studied in social psychology such as conflict resolution [50], teamwork [71], bullying [56], and racism [1]. Social interpretations are also attributed to interactions with non-humanoid robots [7, 15, 24, 27, 73], despite their restricted communication modalities (no human-like gestures, no speech capabilities). Even minimal movement of non-humanoid robots (e.g. doors, ottoman, or abstract objects) is consistently perceived as a social experience [3, 27, 51]. A recent study indicated that attributing social interpretation to such interactions is an automatic process that cannot be avoided [15], explained by the human tendency to perceive the world through a social lens [13, 69].

Figure 1: Robot-Robot-Human Interaction. A physical adaptation of the Cyberball paradigm, designed to measure the effect of ostracism by non-humanoid robots.

Most studies evaluating social interaction with robots focus on interactions between one human and one robot [34, 36, 39] or the interaction between a group of humans and one robot [38, 53, 57]. In recent years there is a growing interest in human-interaction with more than one robot, i.e. Robot-Robot-Human Interaction (RRHI). These interactions lead to new social contexts including conformity to a group of robots [48], perception of ingroup vs. outgroup robots [22], and robot-robot social communication [55].

Another core social effect that can be studied in an RRHI context is ostracism, defined as the experience of being socially excluded by others [63, 64, 67]. Ostracism leads to substantial negative effects, including anxiety [6], depression [10], decreased sense of self-worth [43], and even activation of brain areas related to physical pain [14]. These negative effects are attributed to a threat on psychological needs related to well-being. Ostracism received considerable empirical attention [23], and was typically studied using the Cyberball paradigm [61, 62], involving virtual ball-tossing (on the computer) between participants and two computerized co-players, presented as remote human players. The co-players' icons and the participant toss an animated ball between each other (see Figure 2).

In the Cyberball paradigm, the co-players tossing-ratio to the participant is pre-programmed, forming an exclusion or "ostracism" condition (where participants receive only 5%-10% of the tosses),

---

HRI '21, March 8–11, 2021, Boulder, CO, USA

ACM ISBN 978-1-4503-8289-2/21/03…$15.00
https://doi.org/10.1145/3434073.3444648

and an inclusion condition (33% of the tosses) [47, 62, 66]. Some studies also involve an over-inclusion condition (67%-75% of the tosses) [12, 59, 60]. Typical results from Cyberball experiments indicate that the exclusion condition leads to negative effects on mood [64, 72] and on four fundamental psychological needs: control, belonging, meaningful existence, and self-esteem [67]. Similar effects were also found when participants were informed that the co-players are computer generated humanoid characters [72] or virtual humanoid agents [29, 31].

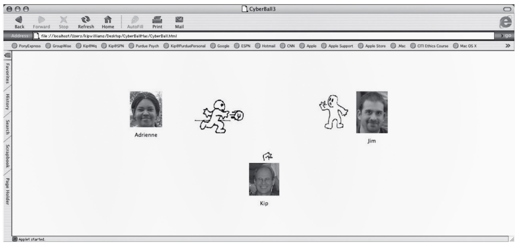

Figure 2: The classic Cyberball paradigm, one participant and two co-players. Figure used with permission [66].

In this study we evaluate if a Robot-Robot-Human Interaction can lead to an experience of ostracism, and to a negative impact on fundamental psychological needs. We implemented a physical adaptation of the Cyberball paradigm with two non-humanoid robots and one participant (unlike classic Cyberball studies which use on-screen representations of two remote humans). Using subjective and objective measures we evaluated participants' experience and the impact on their psychological needs in three conditions with varying tossing ratios towards the participant: *Exclusion*, *Inclusion*, and *Over-inclusion*. We chose non-humanoid robotic objects (see Figure 3), to minimize the influence of human-like features. Both robots are used with permission [3, 25]. Using two different robotic objects allowed to avoid grouping effects due to similar appearance (i.e. gestalt effect) and provided an opportunity to evaluate if there are different responses to the different robots. The specific robots chosen represent two types of robotic objects explored in the non-humanoid robot literature: (1) everyday robotic objects (e.g.[30, 51]), in our study a "desk-lamp" robotic object; and (2) abstract robotic objects that participants do not associate with a consistent metaphor (e.g. [3, 73]), in our study a "ball rolling on a dome".

2 RELATED WORK

Related studies evaluated rejection by robots, the influence of exclusion in the Cyberball paradigm on a following interaction with a robot, and RRHI studies.

2.1 Rejection by robots

A few studies evaluated participants' response to robots that rejected them or preferred another human over them. In a collaborative task with a robotic arm, two participants were asked to build the highest tower possible from single blocks. The robotic arm distributed the blocks either equally or unequally between the participants. Findings indicated that in the non-equal condition (i.e. robot "favored" one of the participants) the participants' performance was negatively influenced (shorter towers) and they reported on lower levels of satisfaction from the teamwork with the human partner [28]. Another example involved an individual human-robot interaction in a “Connect-4” game [40]. The robot verbally stated that it doesn't want to play with the participant again. Participants who were rejected by the robot reported a significant decrease in self-esteem in comparison to participants that were not rejected by the robot (baseline). These studies indicate that an interaction with a robot can lead to a negative impact on participants' performance and self-esteem. We extend this line of work by evaluating the special case of ostracism when interacting with more than one robot and its impact on fundamental psychological needs.

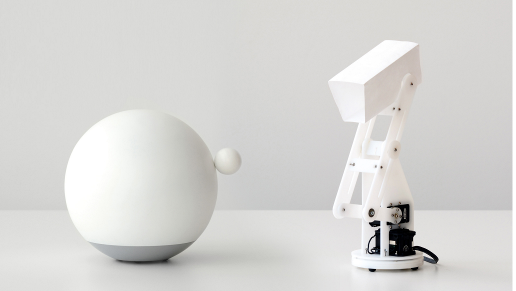

Figure 3: The two non-humanoid robots, used with permission, left [3] and right [25].

2.2 Cyberball experience followed by a human-robot interaction experience

The classic on-screen Cyberball paradigm was used to test if exclusion (by humans) influences robot anthropomorphism in a following interaction with a dinosaur-shaped robot. Findings revealed no increase in anthropomorphism levels associated with the robot. The researcher suggested that the lack of effect may be due to the robot's non-humanoid features [17]. Another study that used the classic Cyberball paradigm evaluated the potential of exclusion mitigation through a following interaction with a zoomorphic pet robot. Findings indicated that the interaction with the robot facilitated coping with the exclusion-related emotions (in comparison to participants who did not interact with the robot). The authors suggested that interacting with the robot is useful for short term emotion regulation [45]. While these studies tested the relation between exclusion and a following interaction with a robot, they did not evaluate exclusion by robots.

2.3 Robot-Robot-Human Interaction: interaction with more than one robot

In recent years, HRI researchers evaluated social experiences in a Robot-Robot-Human Interaction context. Salomons and Scassellati (2018) tested whether humans would change their opinion to comply with robots' opinions. Based on Asch's pioneering work in social psychology, participants interacted with a group of three robots and were asked to match a word to one out of six possible images. In the experimental group, participants first chose a preliminary answer, followed by a presentation of the robots' answers, and were then asked to choose a final answer. The robots' answers were either identical to each other or varied between the robots. In the baseline group, participants were not given information about the robots' choices. Providing the robots' answers and specifically when they were identical, frequently led participants to change their answers to conform to the robots' choices [48]. RRHI was also tested by Tan et al. (2019) who evaluated the communication between two robots in the presence of humans. Participants were asked to request assistance from a stationary robot that summoned a mobile robot to lead the participant to another destination. The stationary robot used verbal cues to communicate with the mobile robot, which could only signal that it is ready with a beeping sound. The findings indicated that when the communication between the robots had social aspects, people found the robots to be more likable and warm. The type of interaction did not affect the perceived functional attributes of the robots [55]. Another social context of RRHI, related to group membership, was tested by Häring et al. (2014) who asked participants to play a card game with two humanoid Nao robots. One of the robots was presented as part of the participant's social ingroup and the other as part of a social out-group. Findings showed that ingroup association (vs. the out-group) increased participants' positive reactions, willingness to cooperate, and tendency for anthropomorphism [22].

We extend these pioneering RRHI studies by testing if an interaction with two robots can lead to intense negative feelings related to ostracism, and if it can further impact fundamental psychological needs. We specifically tested an interaction with non-humanoid robots to evaluate if the effect is evident when interacting with devices that have no human characteristics.

3 TECHNICAL IMPLEMENTATION

We implemented a physical Cyberball experience by adapting the screen-based Cyberball classic paradigm to a physical interaction, using two non-humanoid robots and a hidden robotic arm that controls a physical ball's movement using magnetic force (see Figure 4).

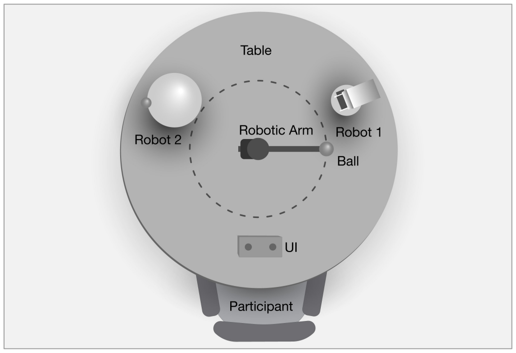

Figure 4: The system consists of a table, two robotic objects, a UI pad with two buttons, a plastic ball with a smaller metal ball inside, and a robotic arm with a magnet at its tip hidden under the table, moving the ball via magnetic force.

The participant clicks a button on a physical UI pad to "toss" the ball towards one of the robots: left or right. The robots react to the ball's movement with carefully triggered physical gestures (e.g. *Follow* ball, *Receive* ball, or *Toss* ball). The perceived experience is of the robots "tossing" the ball towards one another or towards the participant.

3.1 System architecture

The robots are placed at exactly 120 degrees from each other and from the participant. The E-prime software [49] manages the number and order of tosses using the Butter robotics platform [37] which controls the various motors.

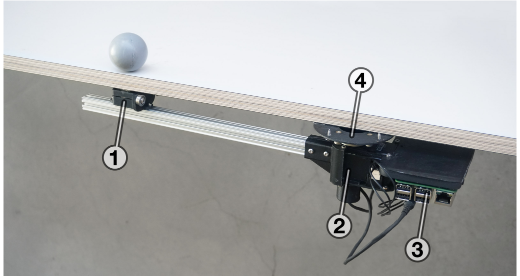

Figure 5: The robotic arm is constructed of a 25 cm metal rod with a magnet at the edge (1), an MX-28 Dynamixel motor (2), a Raspberry Pi controller (3), all mounted under the table (4).

Robotic arm and ball movement. The hidden robotic arm (see Figure 5) leverages magnetic force to move the ball (a 42mm sized ball made of plastic with a smaller metal ball inside) on the table's surface. The arm's movement has pre-defined acceleration and deceleration to simulate natural movement [58].

Robotic objects (see Figure 3). The robots include a Raspberry Pi controller and 2 Dynamixel smart servo motors. Each robot was previously evaluated in separate physical interaction studies, confirming that participants perceive the interaction as a social experience despite the non-humanoid design [3, 15, 25, 46]. Specifically for this study each robot was programmed to perform five gestures, designed by an animator using the Blender animation software: *Toss gesture*, moving from "facing" the ball to "facing" the other robot/participant; *Receive gesture*, moving from "facing" the other robot/participant to the point where the ball stops on the table; *Follow gesture*, moving from "facing" the tossing entity (participant/robot) to "facing" the receiving entity (participant/other robot); *Hello gesture*, turning towards the participant; *Goodbye gesture*, turning away from the participant (see Figure 6, Left).

E-prime. A gold-standard software for experimental (behavioral) studies. We developed a TCP-based communication protocol between E-prime and the robots' control platform, enabling accurate activation and synchronization. The software also controlled the tossing ratio to the participant (10%, 33%, or 75%) and randomized the tosses order.

3.2 Technical validation

We performed two technical validations to verify the system's reliability with regards to automated response time, circular movement accuracy, and possible time variations caused by the mechanical components. Completion time of full system operation was tested

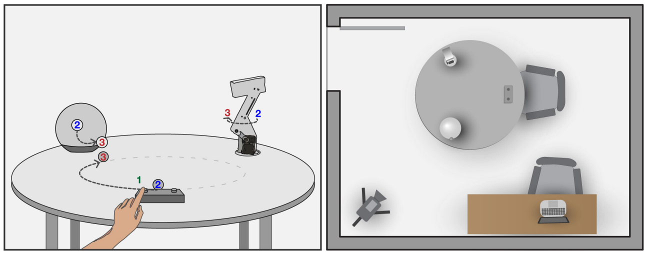

Figure 6: *Left* - Participant click on the left button (1), the hidden robotic arm moves the ball (2-3); Left robot performs a Receive gesture (2-3); Right robot performs a Follow gesture (2-3). All motors are synchronized using E-prime; *Right* - Experimental setting. A table (106cm diameter, 1.8cm thick, 71cm high), UI buttons pad, robotic objects, table for post-experience evaluation.

in 39 tosses, mean completion time was 4:27.31 minutes, with a standard deviation of 0:1.42, indicating low variance. Circular movement was tested with 10 sets of 12 tosses, mean position difference was 2.9 degrees (SD=0.11) indicating low variance between start and end points.

4 METHOD

The study was approved by the ethics committee of the research institute and conducted under strict COVID-19 safety regulations. The UI buttons pad, robots, and the experimental room were sanitized after each experiment.

4.1 Participants

36 young adults participated in the study (15 females, 21 males; Mean=25.3, SD=2.8). The participants received a double coupon for a coffee and pastry in a local coffee shop chain, signed a consent form, and were informed that all recorded materials will be erased after the data analysis.

4.2 Experimental setting

The experiment took place in a dedicated room. The robotic objects were placed 3 cm from the edge of the table equidistant from each other and from the UI buttons pad. The robots' height was the height of a human's shoulder when seated. The robots' control hardware was attached to the underside of the table. The ball moved in accordance with the robotic arm's movement, in a 51cm diameter circle. (see Figure 6, Right).

4.3 Experimental design

A between-participant experimental design included three conditions (12 participants in each condition), with varying ball-tossing ratio from the robots to the participant in each condition: (1) *Exclusion* condition, only ~10% (4/39) of the tosses were passed to the participant and the rest were passed between the robots. (2) *Inclusion* condition, 33% (13/39) of the tosses were passed to the participant, making it an equal number of tosses between the participant and the robots. (3) *Over-inclusion* condition, ~75% (29/39) of the tosses were passed to the participant. The robots' tossing-ratio was determined based on previous classic Cyberball studies with similar conditions that used approximately 40 tosses [12, 47, 62, 66]. We chose specifically 39 tosses (the multiple of three closest to 40), in order to design an unbiased *Inclusion* condition were participants receive exactly one third of the tosses (half of the tosses from each robot). This number of tosses (39) was validated in a pilot study verifying that participants had the opportunity to fully experience the interaction, while avoiding negative consequences of a drawn-out experiment (due to the physical nature of the study and the time required for each physical toss). Participants were *randomly* assigned to one of the three conditions using a matching technique that balanced relevant variables across conditions (gender, need to belong [33], self-esteem [32], and attitudes towards robots [11]), decreasing the possibility that the random assignment would result in biased groups.

4.4 Dependent Measures

We used both quantitative and qualitative measures. *Quantitative* measures included questionnaires assessing fundamental psychological needs [72], mood [68], and the participants' perception of robots [5]. We also performed an objective evaluation using the Lexical Decision task [16] to measure the implicit effect of the RRHI experience. *Qualitative* measures included semi-structured interviews.

4.4.1 Quantitative measures.

Subjective measures.

Needs Threat Scale (NTS) [20, 72]. The questionnaire consists of 12 questions designed to assess the costs of ostracism and the benefits of inclusion. It includes questions concerning four needs: (1) Control (e.g. "I feel that I am able to do what I want"); (2) Belonging (e.g. "I feel poorly accepted"); (3) Meaningful existence (e.g. "I feel non-existent"); (4) Self-esteem (e.g. "I feel good about myself"). All questions were rated on a 5-point Likert scale (1-not at all, 5-extremely). Cronbach's Alpha 0.83.

Mood questionnaire [68]. The questionnaire consists of 8 questions designed to assess mood. Participants are asked to report to what extent they feel *friendly, unfriendly, angry, pleasant, happy, sad, good, and bad.* Participants rated their mood on a 5-point Likert scale (1-not at all, 5-extremely). Cronbach's Alpha 0.85.

Godspeed questionnaire [5]. Although not the focus of this work, we also evaluated the influence of the robot's tossing-ratio on participants' perception of the robots. We used three relevant sub-scales from the godspeed questionnaire: Likability (Cronbach's Alpha 0.88), Animacy (Cronbach's Alpha 0.86), and Perceived Intelligence (Cronbach's Alpha 0.83).

Objective measure.

Lexical Decision is a Reaction-Time (RT) task used for implicit evaluation of participants' experience [16, 70]. In the computerized task participants judged if a string of letters represents a word (e.g. "asked") or a non-word (e.g. "ekads"). The non-words are composed of the same letters and same length as the words (e.g. word: "Accepted"; non-word:"Cacteped"). 15 strings composed a word and 15 a non-word. Each letter-string was presented twice during the experiment in a randomized order (a total of 60 trials). In each trial,

Table 1: Results of the ANOVA analysis showing significant impact on all four subscales composing the Needs Threat Scale [72]. Scheffe post hoc analyses indicated a similar pattern for the control, belonging, and meaningful existence needs.

Need	F(2,33)	P value	P value Scheffe Inclusion vs. Exclusion	P value Scheffe Exclusion vs. Overinclusion	P value Scheffe Inclusion vs. Overinclusion
Self-esteem	5.97	0.006	n.s.	0.008	0.05
Belonging	17.35	<0.001	<0.001	<0.001	n.s.
Control	65.9	<0.001	<0.001	<0.001	n.s.
Meaningful existence	20.64	<0.001	<0.001	<0.001	n.s.

a single letter-string was presented at the center of the screen. Participants classified the string by pressing on 'A' for a word and 'L' for a non-word.

Previous Lexical Decision studies, indicated that humans have a general tendency to respond slower to negative words, due to an inherent defense mechanism [2]. Participants' RTs for negative words were found to be longer in comparison to RTs for neutral or positive words ("slowing effect") [16, 70]. The "slowing effect" is eliminated when the negative words are relevant for the participant's current context (e.g. classifying sad words after watching a sad movie). In these cases RTs for negative words become similar to those of neutral and positive words [16].

This objective measurement technique was leveraged for evaluating the effect of ostracism immediately after the interaction with the robots. We used 5 exclusion-related words (e.g. Invisible), 5 inclusion-related words (e.g. Accepted), and 5 neutral words (e.g. Taught). Participants were asked to respond as quickly and accurately as possible. Exclusion effects were calculated by the difference (in RT) between exclusion-related words and neutral words. If the *Exclusion* condition indeed leads to an ostracism experience, the exclusion-related words should become "relevant for the current context" and the RTs should be similar to those of neutral and positive words, eliminating the "slowing effect". In the *Inclusion* and *Over-inclusion* conditions, exclusion-related words should not become "relevant for the current context" and the "slowing effect" should not be eliminated.

4.4.2 Qualitative measure.

A semi-structured interview was conducted to better understand participants' experience, thoughts, and attitudes (e.g. "Please describe the experience"; "What did you think about the robotic objects?"). In addition, participants were asked to estimate the number of tosses they received from the robots as a manipulation check.

4.5 Procedure

A week prior to the experiment, participants received (by email) pretest questionnaires evaluating the need to belong [33], self-esteem [32], and attitudes towards robots [11].

On the day of the experiment, the participant arrived at the lab, signed an informed consent form, and completed a demographic questionnaire. The participant was informed that the purpose of the study is to have an introductory experience with two robotic objects that will serve as a basis for following interactions with these robots. The participant was then invited to the experiment room and sat next to the table (see Figure 1). The researcher explained that ball-tosses are initiated using the buttons, with the left button initiating a toss to the left robotic object, and right button to the right robotic object. The participant was also reminded that the experiment is recorded for later analysis and that it is possible to quit without consequences. The researcher left the room, started the experiment protocol using E-prime, and the robotic objects were triggered to perform the *Hello* gesture. The participant began the interaction by pressing on one of the buttons which initiated the ball's movement (executed by the robotic arm). At the same time the robots' *Follow* or *Receive* gestures were triggered. As the ball reached one of the robots and stopped, that robot performed its turn, directing a *Toss* gesture towards either the other robot or the participant, with the ball moving accordingly. When the ball was tossed towards the participant, the non-tossing robot followed the ball movement with a *Follow* gesture. When the ball was tossed towards the other robotic object, that robot performed a *Receive* gesture.

The overall experience lasted approximately 5 minutes and included 39 tosses with varying tossing ratios towards the participant based on the condition (*10% Exclusion*, *33% Inclusion*, *75% Over-inclusion*). At the end of the interaction, the robots performed a *Goodbye* gesture and returned to their base position. The researcher re-entered the room and the participant was asked to perform the Lexical Decision task, to complete the questionnaires, and was then interviewed. As in previous Cyberball studies [47, 72], the experiment ended with an extensive debriefing and participants were invited to experience the other conditions. The researcher verified that participants left with an overall positive experience and provided them with an e-mail address for any further questions.

5 FINDINGS

Quantitative and qualitative analyses were applied to assess participants' experience. An ANOVA analysis confirmed that the groups were balanced in all pretest measures (Need to belong, Self-esteem, and Attitudes towards robots). These ANOVA null effects were further verified using Bayesian effects analysis [35] which revealed that all effects yielded Bayes factors lower than 0.3, viewed as compelling support for the null model [26, 52].

In addition, the manipulation check confirmed that participants in all conditions provided close estimations for the number of tosses they received throughout the experiment.

5.1 Quantitative analysis

The quantitative analysis included a one-way ANOVA comparing the three conditions for the following dependent measures: Needs

Threat Scale (NTS); Mood questionnaire; Godspeed questionnaire (3 subscales), and the Lexical Decision task.

5.1.1 Subjective measures.

Needs Threat Scale. A separate one-way ANOVA analysis was performed for each of the four psychological needs (control, belonging, meaningful existence, and self-esteem; see Table 1), revealing that the robots' tossing-ratio in the different conditions had a significant effect on each of the subscales (see Figure 7).

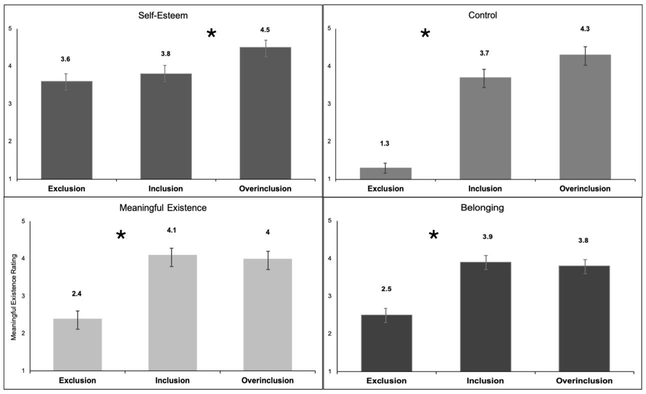

Figure 7: Impact of the robots' tossing-ratio on the four needs, showing significant negative impact of *Exclusion* on Control (top-right), Belonging (bottom-right), and Meaningful existence (bottom-left), and positive impact of *Over-inclusion* on Self-esteem (top-left).

Post-hoc multiple comparisons using Scheffe's method indicated a similar pattern for the control, belonging, and meaningful existence needs. The *Inclusion* and *Over-inclusion* conditions resulted in higher ratings than the *Exclusion* condition, indicating that participants in the *Exclusion* condition felt less sense of control, less sense of belonging, and less sense of meaningful existence. The difference between the *Inclusion* and *Over-inclusion* conditions was not significant. A different pattern was revealed for the self-esteem subscale, with higher ratings in the *Over-inclusion* condition than the *Inclusion* and *Exclusion* conditions, indicating that *Over-inclusion* increased participants' self-esteem. The difference between the *Inclusion* and *Exclusion* conditions was not significant.

Mood questionnaire. The robots' tossing-ratio had a significant effect on participants' mood, F(2,33) = 11.28, $p = 0.01$ (see Figure 8, Left). Post-hoc multiple comparisons using Scheffe's method indicated that the *Inclusion* ($p < 0.001$) and *Over-inclusion* ($p < 0.001$) conditions resulted in higher mood ratings than the *Exclusion* condition. The difference between the *Inclusion* and the *Over-inclusion* conditions was not significant.

Godspeed questionnaire. A separate one-way ANOVA analysis was performed for each of the three subscales of the 'Godspeed questionnaire' (Likability, Animacy, and Perceived Intelligence). We first compared the ratings of the two robots and as no difference was found between them (F<1) we grouped the ratings into a single measure of robots' perception.

The only subscale that was significantly influenced by the robots' tossing-ratio was the Likability subscale, F(2,33) = 8.88, $p < 0.001$ (see Figure 8, Right). Post-hoc multiple comparisons using Scheffe's method indicated that the *Inclusion* ($p = 0.04$) and *Over-inclusion* ($p < 0.001$) conditions resulted in higher Likability ratings than the *Exclusion* condition. The difference between the *Inclusion* and the *Over-inclusion* conditions was not significant.

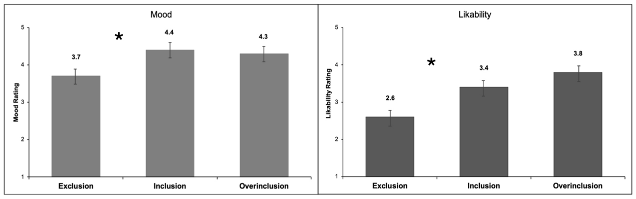

Figure 8: Analysis of Mood and Robots' Likeability questionnaires, indicating a significant decrease in mood (left) and Robots' likability (right), in the *Exclusion* condition.

5.1.2 Objective measure.

Analysis of the Lexical Decision Reaction-Time task revealed a significant influence on participants' implicit exclusion experience. The difference (in RTs) between exclusion-related words and neutral words was compared between the experimental conditions, revealing a significant effect F(2,33) = 4.03, $p = 0.03$ (see Figure 9). In the *Inclusion* and *Over-inclusion* conditions, the Reaction-Time to the exclusion-related words was longer than the Reaction-Time to neutral words (i.e. "slowing effect"). In the *Exclusion* condition, the "slowing effect" was eliminated and the Reaction-Time to exclusion-related words was similar to the Reaction-Time to neutral words, indicating that the exclusion-related words were relevant for the participant's current context [16].

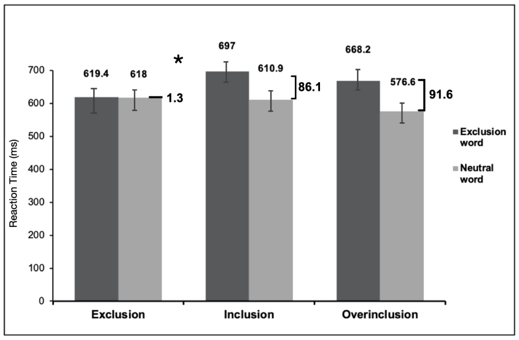

Figure 9: Objective measurement of participants' experience. The RT difference between exclusion-related words and neutral words revealed the expected "slowing effect" in the *Inclusion* and *Over-inclusion* conditions, but not in the *Exclusion* condition. The effect is eliminated due to the words relevancy to the context.

5.2 Qualitative analysis

The interviews were transcribed and analyzed using Thematic Coding, a qualitative analysis methodology commonly used in HCI and HRI [8, 21]. The analysis included five stages: (1) A collection of interview transcriptions from each condition were read several times to develop a general understanding of the data; (2) Three researchers identified initial themes (individually), and discussed them with a fourth researcher in-depth until inconsistencies were resolved; (3) A list of mutually-agreed themes was defined; (4) All three researchers used the mutually-agreed themes to analyze a selection of the interviews independently (four interviews from each condition), and inter-rater reliability was verified (Kappa=85%); (5) Following inter-rater reliability confirmation, the three raters analyzed the rest of the data. In total, 540 quotes were analyzed, leading to four main themes: Involvement in the Interaction, Belonging, Sense of Control, and Robots' Animacy.

5.2.1 Theme 1: Involvement in the Interaction.

Participants in all conditions explicitly mentioned their level of involvement in the interaction, and reflected on how it made them feel. Their responses varied between the conditions.

Exclusion condition. 11/12 of the participants in this condition reported an experience of exclusion: *"They didn't let me play, they ignored me, left me out"* (P.28, M) and described their feelings: *"It was quite frustrating I have to admit, I felt helpless"* (P.25, M); *"I experienced feelings of loneliness and alienation"* (P.26, M), and even *"I was meaningless"* (P.27, M). Most participants associated the experience with the robots' behavior and intent: *"It's like playing with another person who decides to toss only to another player"* (P.16, F). Others were concerned that it is related to their own behavior: *"They did not include me, maybe something is wrong with me, maybe I did something wrong"* (P.15, F). Participants consistently reported a need to be included: *"I kept waiting for them to toss me the ball"* (P.1, F); *"I wanted to participate, I wanted them to care about me"* (P.3, M).

Inclusion & Over-inclusion conditions. Most participants in these conditions reported feeling included in the interaction (10/12 *Inclusion*, 9/12 *Over-inclusion*). They were satisfied with their level of involvement in the interaction: *"I felt it was fair, they included me in the game"* (P.19, F) and reported that it was a positive experience: *"It was very nice. It brought a smile to my face"* (P.35, M). They attributed the inclusion experience to the robots' willingness to interact with them: *"I felt as though I arrived as a stranger and they let me feel part of the group"* (P.29, F). In some cases participants did not report on an emotional experience and were impartial: *"I just tossed the ball, it had no meaning"* (P.20,M).

5.2.2 Theme 2: Belonging.

Most participants in the *Exclusion* condition and a few in the *Inclusion* condition reported a low sense of belonging.

Exclusion condition. 8/12 participants stated that they felt like outsiders: *"I was the third wheel, outsider"* (P.3, M). They explicitly stated that they were not a part of the group: *"They had their own language that I do not understand, so I was left-out, not part of the group"* (P.14, M), and that it bothered them: *"They continuously treated me as a stranger, it hurt a little"* (P.4, M).

Inclusion condition. Despite taking an equal part in the interaction, some participants (3/12) reported that they felt somewhat like outsiders: *"They have some kind of bond of their own, I tried to join the gang"* (P.18, F). In some cases this feeling led to interpreting the interaction as a competition: *"I thought they felt like I'm a stranger, I'm one against two"* (P.32, F).

5.2.3 Theme 3: Sense of Control.

Most participants discussed their sense of control in the interaction. Their responses varied between the conditions.

Exclusion condition. 9/12 participants reported a low sense of control: *"The robots decided when I got to participate, I was sitting and waiting for their decision"* (P.14, M). They were frustrated: *"I told them, enough with that, I am here, I am supposed to play with you"* (P.28, M) and some participants tried to take control of the interaction by communicating with the robots: *"I tried to wave my hands to teach them that it is better to take turns, but it didn't work"* (P.15, F).

Inclusion & Over-inclusion condition. Unlike the *Exclusion* condition, most participants in the *Inclusion* (9/12) and *Over-inclusion* (11/12) conditions reported a high sense of control. In some cases they stated that they shared control with the robots: *"My role wasn't more meaningful than theirs, we had the same position in the game"* (P.9, M). In other cases participants felt that they controlled the interaction: *"I was the leader of the game I guess"* (P.6, M) and controlled the robots: *"I was the puppets' master"* (P.23, M). Despite not being excluded, a small number of participants (2/12 *Inclusion*, 1/12 *Over-inclusion*) reported a need for increased control: *"I couldn't control their choices, I wanted to control them"* (P.30, F).

5.2.4 Theme 4: Robots' Animacy.

Most participants in all conditions described the robots using both animated descriptions: *"It felt as if they are alive, I wanted to please them"* (P.4, M) and mechanical descriptions: *"I liked it's mechanics, the magnet and sensors"* (P.4, M). However, an interesting duality emerged, regarding the robots being "mechanical" yet evoking feelings and emotions. The duality was expressed mostly in the *Exclusion* condition (7/12 *Exclusion*, 4/12 *Inclusion*, 2/12 *Over-inclusion*). Participants were surprised by the emotions they experienced when interacting with a machine: *"I felt something very odd, when they passed the ball to me I was like "yes! finally", but then I think to myself, what's going on… these are robots"* (P.2, F). Participants described their attempts to think of the robots as machines: *"After not receiving the ball I started convincing myself that they are robots and everything here is rational, but I noticed that I was feeling things"* (P.1, F) and explicitly mentioned the duality associated with the interaction: *"It's just something, a machine, but it makes you feel things"* (P.9, M).

6 DISCUSSION

In this work we tested if a Robot-Robot-Human Interaction (RRHI) can lead to a social exclusion experience as strong as ostracism, and impact fundamental psychological needs. We implemented an RRHI system with two non-humanoid robots and a moving ball operated by a hidden robotic arm. The system was used as a physical adaptation of the Cyberball experimental paradigm that was previously studied as a virtual interaction using VR and standard computers. The robots' tossing-ratio, manipulated based on previous Cyberball studies, resulted in different social experiences. The *Exclusion* condition led to a negative experience related to ostracism, while the *Inclusion* and *Over-inclusion* conditions led to an experience associated with social inclusion. The ostracism experience in the *Exclusion* condition had a significant negative influence on participants' mood and three out of four psychological needs: control, belonging, and meaningful existence. We made sure to debrief participants at the end of the experiment and to alleviate any negative feelings. These effects are aligned with prior ostracism studies (conducted with the classic screen-based Cyberball paradigm), and are commonly explained by exclusion posing a threat to psychological well-being [64, 65]. The fourth need, self-esteem, was not negatively affected in the *Exclusion* condition, however, it was positively impacted in the *Over-inclusion* condition.

Participants' experience of ostracism in the *Exclusion* condition was indicated by both objective and subjective measures. The Lexical Decision measure revealed that the "slowing effect" related to the processing time of negative words [16, 70] was replicated in the *Inclusion* and *Over-inclusion* conditions. In the *Exclusion* condition, the effect was eliminated, indicating the relevancy of the exclusion-related words and providing an objective indication for the exclusion experience. The subjective measures indicated the same pattern. Participants in the *Exclusion* condition described their experience using a variety of words related to ostracism, including being *"ignored", "left-out", "unnoticed", "rejected", and "excluded"*. They reported that the interaction made them feel *"weak", "irrelevant", "meaningless", "helpless", and "lonely"*. These intense negative emotions sometimes surprised the participants themselves, who were fully aware of the robots' mechanical aspects and perceived them as mechanical devices. Most participants associated the exclusion experience with the robots' unwillingness to interact with them, attributing agency and intent to the non-humanoid robots. Consistent social interpretations were also attributed to the robots in the *Inclusion* and *Over-inclusion* conditions, where participants reported positive feelings of being *"a part of the game", "involved", and "included"*. They stated that the robots *"made sure" and "made an effort"* to include them in the interaction. These strong social experiences further contribute to the current body of work in RRHI, showing conformity [48] and ingroup-outgroup effects [22].

Experience in the *Exclusion* condition (in contrast to the *Inclusion* and *Over-inclusion* conditions) had a significant impact on participants' mood, and on three fundamental psychological needs: control, belonging, and meaningful existence, all associated with psychological well-being. These results are aligned with previous ostracism studies [72], and are further supported by the qualitative findings. Participants described feeling a lack of control: *"I couldn't do anything, they had all the power"* (P.25, M), and a lack of belonging: *"I was an outsider, a stranger"* (P.27, M). A few participants even mentioned a decreased sense of meaningful existence: *"Nobody cared about me, I could leave and no one would notice"* (P.5, M).

Self-esteem was the only psychological need (out of the four needs tested) that was not negatively affected in the *Exclusion* condition. Interestingly, this was also the only need that was positively influenced by *Over-inclusion*, and was the only need in which there was a significant difference between the *Over-inclusion* and *Inclusion* conditions. This increase in self-esteem implies that RRHI has the capacity to positively influence participants' psychological well-being. Future research should test the extent and scope of this positive influence.

Another finding that should be further tested is the lack of observed differences between the *Inclusion* and *Over-inclusion* conditions in most measures. Previous classic cyberball literature indicates inconsistent over-inclusion effects [42]. Specifically in the case of exclusion by robotic objects, it is possible that the lack of effect is due to humans' expectations that technology will be responsive to them and serve them [72].

Taken together, our findings indicate that human interaction with two non-humanoid robots can lead to an experience of ostracism and have a significant effect on mood and fundamental psychological needs. Together with previous work that showed conformity to robots [48] and ingroup-outgroup effects [22], our findings indicate that an interaction with more than one robot forms a social context that can have a powerful impact on human participants. More broadly, with the expected growth in autonomous devices and robotic objects in our daily lives, the likelihood of interacting with more than one robot increases. We suggest that further RRHI research should be conducted to better understand the risks and the potential of human interaction with more than one robot.

7 LIMITATIONS

This study has several limitations. Subjective measures may be influenced by the "good subject effect" [41], with participants providing pleasing responses. To limit this effect, participants were reassured that anything said is helpful and valuable. Additionally, it is possible that the interviewer influenced interviewees' responses [44]. Therefore, we followed a strict interview protocol, and verified the interviewer's awareness of this effect. We also verified that the interviewer uses neutral language. Another limitation relates to a possible order effect. To minimize such effect, participants first completed the Lexical Decision task, followed by the questionnaires, and finally the interviews. This order was constant across all conditions. In addition, the participants number was limited due to the challenge of running a physical interaction lab study during the COVID-19 pandemic. Power analyses using the actual effect sizes revealed the following power estimations for the dependent measures: Belonging, 0.89; Control, 0.92; Self-esteem, 0.71; Meaningful existence, 0.91; Mood, 0.83; Likability, 0.75; Lexical decision, 0.81. Lastly, the ball-tossing context may have influenced the results, as in every Cyberball study. We suggest that ostracism should be further studied in various RRHI contexts and with different populations (e.g. older adults).

8 CONCLUSION

In this study we showed that a Robot-Robot-Human Interaction can lead to a negative experience of ostracism, even when the robots have no humanoid features. The social context associated with the RRHI experience impacted fundamental human needs known to mediate psychological well-being. The parallels between being excluded by robots and being excluded by humans (in classic Cyberball studies), suggests that RRHI experiences have the potential to form a powerful social context that impacts humans' emotions and behavior. We believe that additional research, mapping negative and positive social effects of Robot-Robot-Human Interaction, is needed to better understand this emerging field.

ACKNOWLEDGMENTS

We wish to thank the following people for their valuable help and advice: Benny Megidish, Paz Roz, Andrey Grishko, Ron Gissin, Iddo Wald, Nadav Viduchinsky.

REFERENCES

[1] Arifah Addison, Christoph Bartneck, and Kumar Yogeeswaran. 2019. Robots can be more than Black and White: Examining racial bias towards robots. In *Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society*. 493–498.

[2] Daniel Algom, Eran Chajut, and Shlomo Lev. 2004. A rational look at the emotional stroop phenomenon: a generic slowdown, not a stroop effect. *Journal of experimental psychology: General* 133, 3 (2004), 323.

[3] Lucy Anderson-Bashan, Benny Megidish, Hadas Erel, Iddo Wald, Guy Hoffman, Oren Zuckerman, and Andrey Grishko. 2018. The greeting machine: an abstract robotic object for opening encounters. In *2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 595–602.

[4] Christoph Bartneck and Jodi Forlizzi. 2004. A design-centred framework for social human-robot interaction. In *RO-MAN 2004. 13th IEEE international workshop on robot and human interactive communication (IEEE Catalog No. 04TH8759)*. IEEE, 591–594.

[5] Christoph Bartneck, Dana Kulić, Elizabeth Croft, and Susana Zoghbi. 2009. Measurement instruments for the anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety of robots. *International journal of social robotics* 1, 1 (2009), 71–81.

[6] Roy F Baumeister and Mark R Leary. 1995. The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological bulletin* 117, 3 (1995), 497.

[7] Cindy L Bethel and Robin R Murphy. 2007. Survey of non-facial/non-verbal affective expressions for appearance-constrained robots. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews)* 38, 1 (2007), 83–92.

[8] Richard E Boyatzis. 1998. *Transforming qualitative information: Thematic analysis and code development.* sage.

[9] Cynthia Breazeal. 2002. Designing sociable machines. In *Socially intelligent agents*. Springer, 149–156.

[10] Nicki R Crick, Nicole E Werner, Juan F Casas, Kathryn M O'Brien, David A Nelson, Jennifer K Grotpeter, and Kristian Markon. 1999. Childhood aggression and gender: A new look at an old problem. (1999).

[11] Malene Flensborg Damholdt, Christina Vestergaard, Marco Nørskov, Raul Hakli, Stefan Larsen, and Johanna Seibt. 2020. Towards a new scale for assessing attitudes towards social robots: The attitudes towards social robots scale (ASOR). *Interaction Studies* 21, 1 (2020), 24–56.

[12] Wendy De Waal-Andrews and Ilja Van Beest. 2020. Reactions to claimed and granted overinclusion: Extending research on the effects of claimball versus cyberball. *The Journal of Social Psychology* 160, 1 (2020), 105–116.

[13] Brian R Duffy. 2003. Anthropomorphism and the social robot. *Robotics and autonomous systems* 42, 3 (2003), 177–190.

[14] Naomi I Eisenberger, Matthew D Lieberman, and Kipling D Williams. 2003. Does rejection hurt? An fMRI study of social exclusion. *Science* 302, 5643 (2003), 290–292.

[15] Hadas Erel, Tzachi Shem Tov, Yoav Kessler, and Oren Zuckerman. 2019. Robots are Always Social: Robotic Movements are Automatically Interpreted as Social Cues. In *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–6.

[16] Zachary Estes and Michelle Verges. 2008. Freeze or flee? Negative stimuli elicit selective responding. *Cognition* 108, 2 (2008), 557–565.

[17] Friederike A Eyssel and Michaela Pfundmair. 2015. Predictors of psychological anthropomorphization, mind perception, and the fulfillment of social needs: A case study with a zoomorphic robot. In *2015 24th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 827–832.

[18] Terrence Fong, Illah Nourbakhsh, and Kerstin Dautenhahn. 2003. A survey of socially interactive robots. *Robotics and autonomous systems* 42, 3-4 (2003), 143–166.

[19] Jodi Forlizzi. 2007. How robotic products become social products: an ethnographic study of cleaning in the home. In *2007 2nd ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 129–136.

[20] JP Gerber, Si-Hua Chang, and Hannah Reimel. 2017. Construct validity of Williams' ostracism needs threat scale. *Personality and Individual Differences* 115 (2017), 50–53.

[21] G Gibbs. 2008. Analysing qualitative data (Qualitative research kit). *Retrieved from* (2008).

[22] Markus Häring, Dieta Kuchenbrandt, and Elisabeth André. 2014. Would You Like to Play with Me? How Robots' Group Membership and Task Features Influence Human–Robot Interaction. In *2014 9th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 9–16.

[23] Chris HJ Hartgerink, Ilja Van Beest, Jelte M Wicherts, and Kipling D Williams. 2015. The ordinal effects of ostracism: A meta-analysis of 120 Cyberball studies. *PloS one* 10, 5 (2015), e0127002.

[24] Guy Hoffman and Wendy Ju. 2014. Designing robots with movement in mind. *Journal of Human-Robot Interaction* 3, 1 (2014), 91–122.

[25] Guy Hoffman, Oren Zuckerman, Gilad Hirschberger, Michal Luria, and Tal Shani-Sherman. 2015. Design and evaluation of a peripheral robotic conversation companion. In *2015 10th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 3–10.

[26] Harold Jeffreys. 1998. *The theory of probability*. OUP Oxford.

[27] Wendy Ju and Larry Leifer. 2008. The design of implicit interactions: Making interactive systems less obnoxious. *Design Issues* 24, 3 (2008), 72–84.

[28] Malte F Jung, Dominic DiFranzo, Brett Stoll, Solace Shen, Austin Lawrence, and Houston Claure. 2018. Robot Assisted Tower Construction-A Resource Distribution Task to Study Human-Robot Collaboration and Interaction with Groups of People. *arXiv preprint arXiv:1812.09548* (2018).

[29] Matthew P Kassner, Eric D Wesselmann, Alvin Ty Law, and Kipling D Williams. 2012. Virtually ostracized: Studying ostracism in immersive virtual environments. *Cyberpsychology, Behavior, and Social Networking* 15, 8 (2012), 399–403.

[30] Heather Knight, Timothy Lee, Brittany Hallawell, and Wendy Ju. 2017. I get it already! the influence of chairbot motion gestures on bystander response. In *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 443–448.

[31] Oswald D Kothgassner, Mirjam Griesinger, Kathrin Kettner, Katja Wayan, Sabine Völkl-Kernstock, Helmut Hlavacs, Leon Beutl, and Anna Felnhofer. 2017. Real-life prosocial behavior decreases after being socially excluded by avatars, not agents. *Computers in human behavior* 70 (2017), 261–269.

[32] Mark R Leary and Roy F Baumeister. 2000. The nature and function of self-esteem: Sociometer theory. In *Advances in experimental social psychology*. Vol. 32. Elsevier, 1–62.

[33] Mark R Leary, Kristine M Kelly, Catherine A Cottrell, and Lisa S Schreindorfer. 2013. Construct validity of the need to belong scale: Mapping the nomological network. *Journal of personality assessment* 95, 6 (2013), 610–624.

[34] Jamy Li, Andrea Cuadra, Brian Mok, Byron Reeves, Jofish Kaye, and Wendy Ju. 2019. Communicating dominance in a nonanthropomorphic robot using locomotion. *ACM Transactions on Human-Robot Interaction (THRI)* 8, 1 (2019), 1–14.

[35] J Love, R Selker, M Marsman, T Jamil, AJ Verhagen, A Ly, and EJ Wagenmakers. [n.d.]. JASP (Version 0.6. 5) 2015 https://jasp-stats. org. *Retrieved from* ([n. d.]).

[36] Michal Luria, Guy Hoffman, and Oren Zuckerman. 2017. Comparing social robot, screen and voice interfaces for smart-home control. In *Proceedings of the 2017 CHI conference on human factors in computing systems*. 580–628.

[37] Benny Megidish. 2017. *Butter*. https://butter-robotics.web.app/

[38] Bilge Mutlu, Toshiyuki Shiwa, Takayuki Kanda, Hiroshi Ishiguro, and Norihiro Hagita. 2009. Footing in human-robot conversations: how robots might shape participant roles using gaze cues. In *Proceedings of the 4th ACM/IEEE international conference on Human robot interaction*. 61–68.

[39] Eunice Njeri Mwangi, Emilia I Barakova, Marta Diaz, Andreu Català Mallofré, and Matthias Rauterberg. 2017. Who is a Better Tutor? Gaze Hints with a Human or Humanoid Tutor in Game Play. In *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*. 219–220.

[40] Kyle Nash, Johanna M Lea, Thomas Davies, and Kumar Yogeeswaran. 2018. The bionic blues: Robot rejection lowers self-esteem. *Computers in human behavior* 78 (2018), 59–63.

[41] Austin Lee Nichols and Jon K Maner. 2008. The good-subject effect: Investigating participant demand characteristics. *The Journal of general psychology* 135, 2 (2008), 151–166.

[42] Michael Niedeggen, Natia Sarauli, Santi Cacciola, and Sarah Weschke. 2014. Are there benefits of social overinclusion? Behavioral and ERP effects in the Cyberball paradigm. *Frontiers in Human Neuroscience* 8 (2014), 935.

[43] Susan F O'Brien and Karen Linn Bierman. 1988. Conceptions and perceived influence of peer groups: Interviews with preadolescents and adolescents. *Child development* (1988), 1360–1365.

[44] Raymond Opdenakker. 2006. Advantages and disadvantages of four interview techniques in qualitative research. In *Forum qualitative sozialforschung/forum: Qualitative social research*, Vol. 7.

[45] Michaela Pfundmair, Friederike Eyssel, Verena Graupmann, Dieter Frey, and Nilüfer Aydin. 2015. Wanna play? The role of self-construal when using gadgets to cope with ostracism. *Social Influence* 10, 4 (2015), 221–235.

[46] Danielle Rifinski, Hadas Erel, Adi Feiner, Guy Hoffman, and Oren Zuckerman. 2020. Human-human-robot interaction: robotic object's responsive gestures improve interpersonal evaluation in human interaction. *Human–Computer Interaction* (2020), 1–27.

[47] Sabrina Ruggieri, Mons Bendixen, Ute Gabriel, and Françoise Alsaker. 2013. Cyberball. *Swiss Journal of Psychology* (2013).

[48] Nicole Salomons and Brian Scassellati. 2018. Trust and conformity when interacting with a group of robots. In *Companion of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. 315–316.

[49] Walter Schneider, Amy Eschman, and Anthony Zuccolotto. 2002. *E-Prime: User's guide*. Psychology Software Incorporated.

[50] Solace Shen, Petr Slovak, and Malte F Jung. 2018. " Stop. I See a Conflict Happening." A Robot Mediator for Young Children's Interpersonal Conflict Resolution. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. 69–77.

[51] David Sirkin, Brian Mok, Stephen Yang, and Wendy Ju. 2015. Mechanical ottoman: how robotic furniture offers and withdraws support. In *Proceedings of the Tenth Annual ACM/IEEE International Conference on Human-Robot Interaction*. 11–18.

[52] Jan Sprenger. 2013. Testing a precise null hypothesis: The case of Lindley's paradox. *Philosophy of Science* 80, 5 (2013), 733–744.

[53] Sarah Strohkorb Sebo, Margaret Traeger, Malte Jung, and Brian Scassellati. 2018. The ripple effects of vulnerability: The effects of a robot's vulnerable behavior on trust in human-robot teams. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. 178–186.

[54] Leila Takayama, Doug Dooley, and Wendy Ju. 2011. Expressing thought: improving robot readability with animation principles. In *Proceedings of the 6th international conference on Human-robot interaction*. 69–76.

[55] Xiang Zhi Tan, Samantha Reig, Elizabeth J Carter, and Aaron Steinfeld. 2019. From one to another: how robot-robot interaction affects users' perceptions following a transition between robots. In *2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 114–122.

[56] Xiang Zhi Tan, Marynel Vázquez, Elizabeth J Carter, Cecilia G Morales, and Aaron Steinfeld. 2018. Inducing bystander interventions during robot abuse with social mechanisms. In *Proceedings of the 2018 ACM/IEEE International Conference on Human-Robot Interaction*. 169–177.

[57] Hamish Tennent, Solace Shen, and Malte Jung. 2019. Micbot: A peripheral robotic object to shape conversational dynamics and team performance. In *2019 14th ACM/IEEE International Conference on Human-Robot Interaction (HRI)*. IEEE, 133–142.

[58] Frank Thomas, Ollie Johnston, and Frank Thomas. 1995. *The illusion of life: Disney animation*. Hyperion New York.

[59] Ilja Van Beest and Kipling D Williams. 2006. When inclusion costs and ostracism pays, ostracism still hurts. *Journal of personality and social psychology* 91, 5 (2006), 918.

[60] Ilja Van Beest, Kipling D Williams, and Eric Van Dijk. 2011. Cyberbomb: Effects of being ostracized from a death game. *Group Processes & Intergroup Relations* 14, 4 (2011), 581–596.

[61] Kipling D Williams. 1997. Social ostracism. In *Aversive interpersonal behaviors*. Springer, 133–170.

[62] Kipling D Williams. 2002. *Ostracism: The power of silence*. Guilford Press.

[63] Kipling D Williams. 2007. Ostracism. *Annual review of psychology* 58 (2007).

[64] Kipling D Williams. 2009. Ostracism: A temporal need-threat model. *Advances in experimental social psychology* 41 (2009), 275–314.

[65] Kipling D Williams, Christopher KT Cheung, and Wilma Choi. 2000. Cyberostracism: effects of being ignored over the Internet. *Journal of personality and social psychology* 79, 5 (2000), 748.

[66] Kipling D Williams and Blair Jarvis. 2006. Cyberball: A program for use in research on interpersonal ostracism and acceptance. *Behavior research methods* 38, 1 (2006), 174–180.

[67] Kipling D Williams and Lisa Zadro. 2001. Ostracism: On being ignored, excluded, and rejected. (2001).

[68] Wouter Wolf, Ana Levordashka, Johanna R Ruff, Steven Kraaijeveld, Jan-Matthis Lueckmann, and Kipling D Williams. 2015. Ostracism Online: A social media ostracism paradigm. *Behavior Research Methods* 47, 2 (2015), 361–373.

[69] Robert H Wortham, Andreas Theodorou, and Joanna J Bryson. 2016. What does the robot think? Transparency as a fundamental design requirement for intelligent systems. (2016).

[70] Zhao Yao, Deshui Yu, Lili Wang, Xiangru Zhu, Jingjing Guo, and Zhenhong Wang. 2016. Effects of valence and arousal on emotional word processing are modulated by concreteness: Behavioral and ERP evidence from a lexical decision task. *International Journal of Psychophysiology* 110 (2016), 231–242.

[71] Sangseok You and Lionel Robert. 2018. Trusting robots in teams: Examining the impacts of trusting robots on team performance and satisfaction. In *You, S. and Robert, LP (2019). Trusting Robots in Teams: Examining the Impacts of Trusting Robots on Team Performance and Satisfaction, Proceedings of the 52th Hawaii International Conference on System Sciences, Jan*. 8–11.

[72] Lisa Zadro, Kipling D Williams, and Rick Richardson. 2004. How low can you go? Ostracism by a computer is sufficient to lower self-reported levels of belonging, control, self-esteem, and meaningful existence. *Journal of Experimental Social Psychology* 40, 4 (2004), 560–567.

[73] Oren Zuckerman, Dina Walker, Andrey Grishko, Tal Moran, Chen Levy, Barak Lisak, Iddo Yehoshua Wald, and Hadas Erel. 2020. Companionship Is Not a Function: The Effect of a Novel Robotic Object on Healthy Older Adults' Feelings of" Being-Seen". In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. 1–14.