Cohesiveness of Robots in Groups Affects the Perception of Social Rejection by Human Observers

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***Abstract*—As robots become increasingly part of human social systems, how humans are psychologically affected by machine behaviors in groups such as ostracism and prejudice become design criteria. Parameters of robot groups can affect robot-robot-human interaction dynamics. The cohesiveness of robot groups, termed entitativity, affects the willingness of humans to engage with the group, and changes the degree of perceived threat and cooperativity. To investigate how group composition affects the extent to which humans perceive negative social intent from robots, we showed subjects videos of different ways humans are socially rejected by robots under conditions of high and low entitativity. Results indicates that for strong types of social rejection, feeling of rejection is greater when robotic groups are less cohesive, suggesting that humans feel greater anxiety over being rejected by more diverse sets of machines. Understanding social impacts of robot group dynamics can help us avoid unintended negative affect from machines.**

***Index Terms*—social rejection, group membership, entitativity, social robotics.**

I. Introduction

Robots are increasingly part of our daily existence serving as personal assistants, tour guides, and hospital nurses. Robots will fill our living spaces as social components rather than working in the factory [1, 2]. As such, our interpretations of social robot actions can critically affect the ability to collaborate successfully. Such robots often function in groups [3]. Negatively interpreted social actions by these robot groups may derail proper utilization of the machines and lead to dissatisfaction and frustration. Hence, we must understand how humans may be affected by robot group behaviors that appear to neglect or negatively impact humans.

Social rejection is a major cause of mental malaise due to its strong link to feelings of being isolated and denigrated [4]. As increasingly social agents, robots can also psychologically harm humans without precaution. For example, playing ball-tossing games with non-humanoid robots in which humans are suddenly excluded from the game could lead to negative feelings of exclusion [5]. Other measures of mental well-being like belonging-ness and self-esteem may be affected by these negative social behaviors as well [6].

What properties of these intentional or unintentional actions of groups of social robots will lead to stronger perceptions of social rejection and negative impact on esteem and belonging? One factor may be the diversity of the group of socially rejecting robots themselves. Perception of the cohesiveness of robots in a group can lead to increased willingness to interact with robots [3], but humans are more likely to be aggressive towards these high entitative robot groups [7]. Are identical robots doing the same thing with the same speed more likely to offend as opposed to robots of different sizes and speeds?

In this study, we examine if humans feel more or less socially rejected by less cohesive (Low Entitativity) or more cohesive (High Entitativity) groups of robots. Answering this question allows us to design robot groups that can reduce negative affect in interaction with humans by only varying movement and appearance that make the group more or less diverse in particular contexts. We showed participants videos of five different social rejection scenarios involving a human walking up to a group of three robots (Expulsion, Group Rejection, Avoidance, Ignore, Recognition) and collected responses to the videos in high and low entitativity conditions. We collected data on how they feel upon viewing the videos in each condition by adapting the previous fundamental needs scale [8] and previous entitativity in robots study [9].

II. Related Works

According to the Computer Are Social Actors (CASA) model, humans tend to treat machines and other media much like human kind [6]. On the positive side, one social context of multi-robot human interaction was tested to show people found the robots to be more likable and warm when they had social aspects in communications [10]. However, We aim to learn about how different social rejection in different entitativity affects humans' feelings and perception. Social rejection had been shown to compromise the quality of people's daily lives[11]. Research has shown that social rejection could cause aggressive behaviors toward others or provoke negative emotional responses (e.g. Hurt Feelings, Jealousy, Sadness, and Anger) [11, 12, 13]. By adapting Psychological theories of social rejection in HRI, scholars studied how ostracism from a human-computer interaction also led participants to decrease belonging and self–esteem [8]. One study found that robot rejection in a social context led to lower self-esteem in the context of letting participants directly play games with a robot in person [14]. In another study of how robotic arms showed favoritism to another human over participants in a tower building task indicated that rejecting by robots lead them to report lower levels of satisfaction [15].

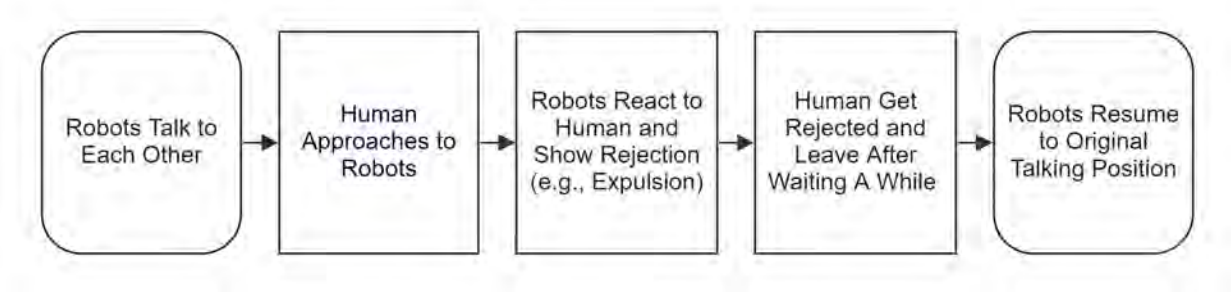
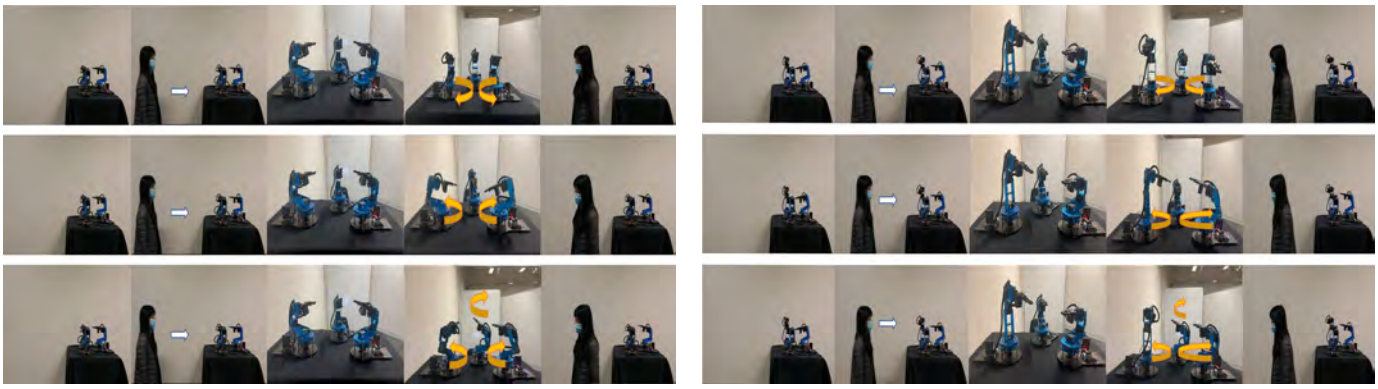


Fig. 1: Process of the Rejection Video



(a) High Entitativity (b) Low Entitativity

Fig. 2: Comparison of High and Low Entitativity Conditions (High Entitativity: Same Turning Speed, Same Height, Synchronous Movement, Low Entitativity:Different Turning speed, Height Difference, and Asynchrous Movement) in Video (The order of rejection types in each condition is; Top: Expulsion, Middle: Group Reject, Bottom: Avoidance).

Multi-robot interaction studies had been done in recent years exploring how multiple robots interact with other robots affected human perceptions [9, 16, 17, 18]. As groups of robots could be automatically categorized by humans, their level of entitativity would be determined the moment humans see them. In HRI, studies had demonstrated that manipulating the entitativity of robots could influence the humans' walking path and perception especially on perceiving threats or friendliness [3, 16]. Humans also reported they felt more trust with a group of anthropomorphic robots (e.g. NAO) versus just one [9]. Therefore, we decided not to use anthropomorphic robots like NAO in our studies because anthropomorphic features allow social advantage to robots by expressing emotional expression and human gestures, which enhances positive social perceptions [19].

However, research has not yet examined if socially rejected by a group of high entitative robots is easier to accept than a group of low entitative robots.

III. Method

A. Design

This study used a between-subject two condition experimental design: we randomly assigned participants to either the high or low entitativity condition such that participants were exposed to the same entitativity condition with different social rejection types using the same format showed in Fig. 1. We used five types of rejection ("Ignore: Robots keep doing what they are doing even when human approach," "Recognition: Robots stop when human approach and return to normal when she leaves," "Group Reject: Robots turn away and form a small group while continue talking to each other then turn back when she leaves," "Avoidance: Robots turn away from where the human is to face the other side and then turn back when the human leaves," "Expulsion: Robots turn toward human and form a invisible wall by directing their gesture at the human when she approaches.") based on the categorization of rejection from previous literature [11]. Fig. 2 showed comparison of Expulsion, Group Reject, and Avoidance in High and Low condition.

B. Procedure

60 participants in total were recruited to respond to online surveys in which they were shown videos of 5 different rejection types in succession (Ignore, Recognition, Group Reject, Avoidance, Expulsion) of high entitativity robot groups (N = 30, Female = 18) or low entitativity robot groups (N = 30, Female = 16). The high entitativity videos consisted of identical robots whose movements were exactly the same speed. The low entitativity videos consisted of the same situation as before but robots of different heights moving at different speed, so

TABLE I: Means and standard deviations (in parentheses) of fundamental needs between different type of rejection

	Type																			
	Group Reject				Avoidance				Expulsion				Ignore				Recognition			
	High		Low		High		Low		High		Low		High		Low		High		Low	
Belonging	4.42*	(1.44)	5.19*	(1.15)	5.59	(1.26)	5.60	(1.48)	4.81	(1.22)	4.62	(1.57)	4.70	(1.21)	4.80	(0.87)	5.11	(1.44)	5.28	(1.25)
Self-Esteem	3.76**	(1.24)	4.73**	(1.22)	4.20	(1.35)	4.96	(1.37)	3.94	(1.28)	4.19	(1.36)	2.98	(1.22)	3.90	(0.94)	4.30	(1.26)	4.68	(1.16)
Meaningful Existence	3.76**	(1.07)	4.57**	(1.15)	4.20	(1.61)	4.79	(1.45)	3.94	(1.53)	4.17	(1.13)	2.98	(1.21)	3.53	(1.14)	4.30	(1.35)	4.43	(1.13)

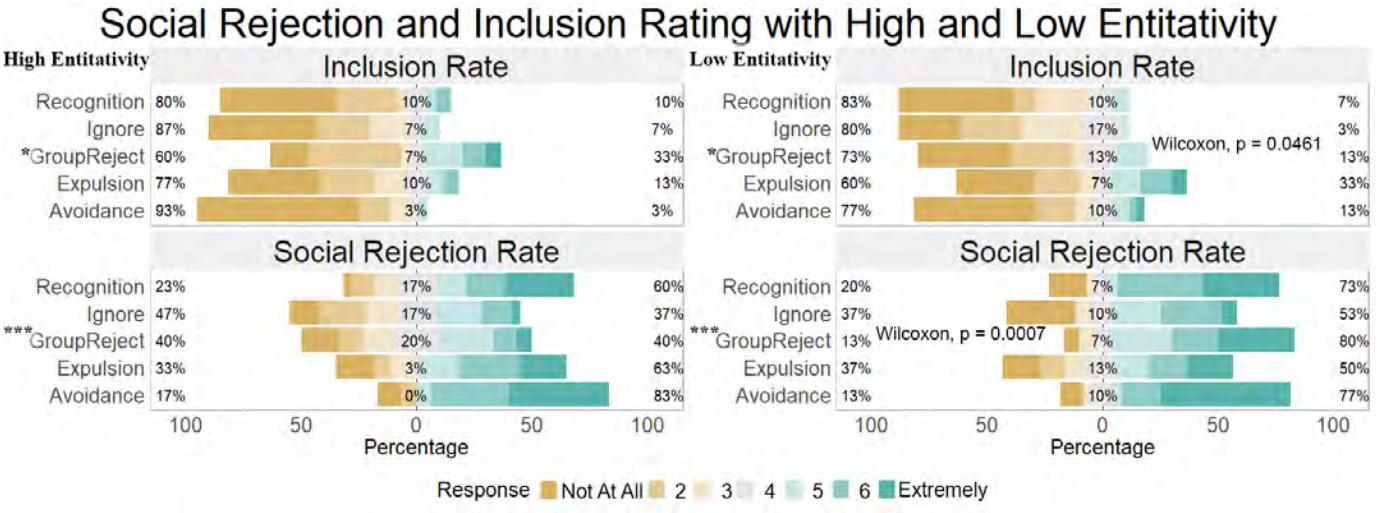


Fig. 3: Comparison of Social Rejection and Inclusion Rating on each type between High and Low Entitativity Setting (From Not At All (1) to Extremely (7)). Significance was marked with the format * P $\leq 0.05, **P \leq 0.01, ***P \leq 0.001$.

that in turning away, for example, they are not synchronized, but rather move one after another (with about a 0.5 second delay). The low entitativity group contained robots of different heights looking at several directions. Participants were either college students recruited from an unrelated course (N = 20) or through Prolific (N = 40). Participants were randomly assigned to each of the low and high entitativity group regardless of the source of their recruitment. All participants provided informed consent prior to participation.

After watching a video for a particular rejection type, the participant answered questionnaires focusing on perceived entitativity of the robot group, Belonging, Self-Esteem, Meaningful Existence, feeling of Inclusion, and feeling of Social Rejection Rate for that particular type of rejection. The next video after a short break (30 seconds) then examined a different rejection type and led to another survey involving the same questions. Participants in both conditions were presented with same order of the rejection video.

C. Measures

The Survey included open-ended questions and scales adapted from previous research. The open-ended items (e.g., "Please use three phrases to describe what is happening in the video") aimed to identify if participants recognized the plot being told in each video. Another question (e.g. "Describe how you feel emotionally after watching the interaction.") was used to collect emotional response from participants. The third open-ended question (e.g. "Write a 2-3 sentence descriptive story about what the viewer's experience is in experiencing this interaction.") was to get more information regarding their experience watching the interaction. The entitativity scale was adapted from a previous study that found that entitativity of robot-to-robot behavior positively influences participants' willingness to interact with robots in social context [18]. The Fundamental Need Scale was adapted based on the context of this study [8]. The questionnaire we adapted contained a number of questions that asked the participants to assess their level of three needs that they felt toward the interaction. Control was taken out from the original scale because there was no actual interaction in this study. These needs were after adapted: belonging ("I felt poorly accepted by the group of robots," "I felt as thought I had made connection or bonded with robots," "I felt like an outsider during the interaction"), Self-esteem ("During the interaction, I felt good about myself," "I felt that the other robots failed to perceive me as a worthy person," "I felt inadequate during the experience"), Meaningful Existence ("I felt that my attempt to approach had some effect on the way those robots respond," "I felt unworthy during the interaction," "I felt as though my existence was meaningless during the interaction"). Participants rated from a 7 point Likert scale (From "Strongly Disagree," to "Strongly Agree").

At the end of each survey, participants would be also asked the following questions to assess their Inclusion ("To what extent do you feel included by the robots?") and Social Rejection ("To what extent do you feel included by the robots?") using a 7 point Likert rating (from "Not at All (1)"

to "Extremely (7)") [9].

IV. Results

Because the data were non-parametric, we performed Wilcoxon signed-rank test on each rejection analyzing each of the needs (belonging, meaningful existence, and self-esteem), inclusion rate, and social rejection rate between two conditions. On the other hand, We ran a one-way Kruskal-Wallis test to see if type had effect on Inclusion and Social Rejection rate. The social rejection score in Fig. 3 was lower in the Group Reject type in high entitatity condition. This implies that people felt more comfortable when rejected by higher entitative group of robots, indicating that robots which were more diverse and less cohesive caused greater distress for the human than groups that contained more similar robots (Wilcoxon, p = 0.0007). We also found that Belonging (Wilcoxon, p = 0.031), Self-Esteem (Wilcoxon, p = 0.0069), and Meaningful Existence (Wilcoxon, p = 0.006512) were also significant different in group reject between high and low entitative condition. We found that entitativity between condition (Kruskal p = 0.47) was not significantly different as we expected with our design. However, significant difference were found between type of rejection (Kruskal, p = 4.02e-07). The other type of rejection were not found significant different between high and low condition. As we could see in Table I, except Belonging on Expulsion, all rejection type in low condition showed higher rating than those in high condition. It was partially supporting our expectation on rejecting by less cohesive robots groups resulted with less negative feelings.

Ignore and Recognition conditions appear to have a smaller emotional affect, so participants did not feel strong enough affected by these rejection types to be treated differently by high and low entitative robot groups. Expulsion and Avoidance showed stronger movements to reject participant right away in which could shorten the uncomfortable feeling. Among those five rejections, Group Reject was the only rejection type that robots still talked to each other after they turned away trying to reject the participant. However, we still found significance between type overall on Belonging (Kruskal, p = 0.0002117), Self-Esteem (Kruskal, p = 0.0007285), and Meaningful Existence (Kruskal, p = 2.638e-05). Based on this finding, we hypothesize that to see greater effect of the high vs. low entitativity result, we would need to present a more perceptible design of the rejection types of Ignore, Expulsion, Avoidance, and Recognition akin to the strong social rejection engendered by Group Reject. It is also possible that the other rejection types are not affected by group cohesion, but more data is needed to test the latter hypothesis.

On qualitative data asking participants to describe their feelings, rejection or exclusion feelings were reported more in low entitativity than high entitativity condition. In Ignore, 7/30 of the participants in low condition reported they felt rejected or excluded than 5/30 of the participants in high condition. In Recognition, 11/30 of the participants in low over 7/30 in high condition. Group Reject had 15/30 in low over only 5/30 in high. Avoidance showed similarity between two conditions(18/30 low, 16/30 high). Expulsion was found the most interesting because participants on both conditions reported "*Threatened*" more than feeling rejected or excluded. In Expulsion, 4/30 of the participants reported rejection or exclusion while high condition had none. Since Expulsion is such as strong gesture, we hypothesize that group entitativity effects may be different for Expulsion than from the other social rejection types, which contain machine gestures that are passive rather than actively acting on the participant.

V. Discussion and Future Research

We found that in the Group Reject social rejection type (robots turn away and talk amongst themselves), participant's perception of being rejected is higher when the cohesiveness of the group of robots is lower, i.e. when they are of different heights, looking at different directions, and move with different speed in the video.

This result suggests that studies investigating the role of multi-robot human relationship should consider how negative interpersonal impact of robot groups on human to avoid unnecessary harmful emotions caused by social rejection based on context [3, 8, 9, 20]. In particular, robots in the future are embedded in human social environments, making it critical to correctly communicate subtle gestures. For example, different cultures interpret robot gestures in a group differently [18], making it easy to misinterpret particular movements negatively. These potentially unintentional negative group social actions may be avoided by changing the parameters of the robot appearance [21] and group composition. Although this study showed that only a particularly strong type of social rejection may be affected by the cohesiveness of the robot group, other parameters like perceived affiliation, different interaction functionality, inter-group dynamics, etc, may affect perceived rejection.

The implication for design of robot group composition is that for particular social applications in which humans must not be made to feel neglected, ostracized, emotionally bullied, etc, it will be critical to produce robots not only of particular types but to carefully design their relationship with other robots in the group. In our study, we take the example akin to a human trying to get into a conversation with a group of strangers. If the strangers are all of a particular gender or race that is different from the participant, then it may be okay to not feel rejected, because this other group must have some shared identity. But if the strangers are ethnically diverse of different gender and age, then the fact they reject you may lead you to a greater sense of being neglected and maltreated. Thus in designing robot systems in different contexts, especially social ones in which subtle robot behaviors can drive success and failure in the interaction, it's important to put the best foot forward to make the robots be, for example, of the same type, to avoid causing undue perceptions of perceived rejection.

We envision a future whereby such subtler aspects of group composition in robot groups can determine human perception of them in social situations where they are embedded.

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