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, becomes criteria for design. Parameters of Robot group can have an effect on the dynamics of robot-robot-human interaction. The cohesiveness of robot groups, termed entitativity, affects humans' willingness to engage with the group and alters their perception of threat and cooperativity. To investigate how group composition affects how people perceive negative social intent from robots, we showed subjects videos of various ways humans are socially rejected by robots under high and low entitativity conditions. The results reveal that when robotic groups are less cohesive, the sense of rejection is greater, implying that humans experience increased anxiety over being rejected by more diverse sets of machines. Understanding the social consequences of robot group dynamics can assist us in avoiding unanticipated negative affects caused by machines.**

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

I. Introduction

Robots are becoming an increasingly integral part of our daily lives, performing functions such as personal assistants, tour guides, and hospital nurses. Rather than working in factories, robots will populate our living spaces as social components [1, 2]. As such, our interpretations of social robot behavior can impact our perception and our ability to collaborate successfully. Robots increasingly operate socially in groups [3]. Negatively interpreted social actions by these robot groups have the potential to derail proper machine utilization, resulting in dissatisfaction and frustration. Thus we must understand how humans may be affected by robot group behaviors that appear to neglect or reject humans.

Social rejection is a major cause of mental malaise, as it is strongly associated with feelings of isolation and denigration [4]. Without caution, robots can also cause psychological harm to humans as they become increasingly social agents. For instance, playing ball-tossing games with non-humanoid robots in which humans are suddenly excluded from the game may elicit negative feelings of exclusion [5]. Other indicators of mental well-being, such as sense of belonging and self-esteem, may also be affected by these negative social behaviors [6].

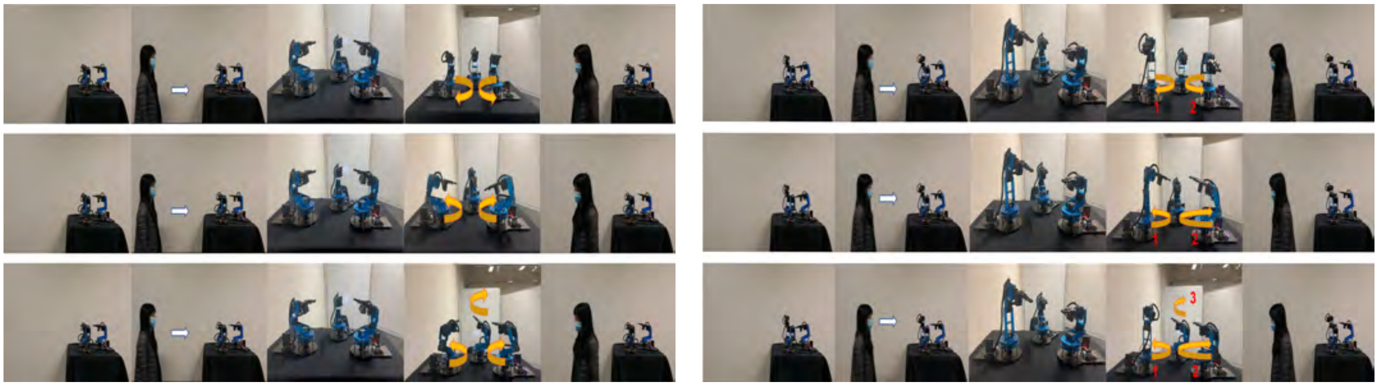
What characteristics of these intentional or unintentional actions by groups of social robots contribute to increased perceptions of social rejection and have a detrimental effect on self-esteem and belongingness? One possible factor that could play a role is the diversity of the group of socially rejecting robots. Although humans' perceptions of the cohesiveness of robots in a group can increase their willingness to interact with them [3], humans are more likely to be aggressive toward these highly entitative robot groups [7]. Is it more likely that identical robots performing the same task at the same speed will offend than robots of varying sizes and speeds?

The purpose of this study is to determine whether humans feel more or less socially rejected by groups of robots that are less cohesive (low entitativity) or more cohesive (high entitativity). By addressing this question, we can create robot groups capable of reducing negative affects in interactions with humans simply by varying the group's movement and appearance in specific contexts. We showed participants videos depicting five social rejection scenarios (Expulsion, Group Rejection, Avoidance, Ignore, and Recognition) involving a human approaching a group of three robots, and collected responses to the videos in both high and low entitativity conditions. We collected data on how they feel upon viewing the videos in each condition by adapting the fundamental needs scale [8] and the scale from an entitativity in robots study [9].

II. Related Works

According to the Computer Are Social Actors (CASA) model, humans treat machines and other media in a manner similar to how humans treat one another[10]. Robots, as one form of machines, were interpreted as social actors naturally[11]. On the plus side, one social context of multi-robot human interaction was tested, and it was discovered that when robots communicated socially, people found them more likable and warm [12]. However, we aim to learn about how different social rejection in different entitativity affects humans' feelings and perception.

Social rejection degrades the quality of people's daily lives [13]. 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) [13, 14]. By adapting psychological theories of social rejection to HRI, researchers investigated how ostracism from a human-computer interaction also decreased participants'



(a) High Entitativity

(b) Low Entitativity

Fig. 1: 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). Rotating order was marked using numbers (0.5 second apart). For further video references see https://youtube.com/playlist?list=PLV7NZQ34qpRi1Hg-GftU96gx-AJ2nnb1S.

sense of belonging and self-esteem. One study discovered that participants reported lower self-esteem when they experienced rejection by a robot after playing a game of connect-4 against it [15]. Another study found that when robotic arms favored another human over participants in a tower building task, they reported lower levels of satisfaction [16].

Recent studies on multi-robot interaction have examined how interactions between multiple robots affect human perceptions [9, 17, 18, 19, 20, 21]. As groups of robots could be automatically categorized by humans, their level of entitativity would be determined the moment humans see them. Research has demonstrated that manipulating the entitativity of robots can influence humans' walking patterns and perceptions, particularly when it comes to perceived threats or friendliness [3, 17]. Additionally, humans reported feeling more trust in a group of anthropomorphic robots (e.g. NAO) than in a single robot alone [3]. Therefore, we decided not to use anthropomorphic robots like NAO in our studies because anthropomorphic features provide social advantage to robots by expressing emotional nuances and human gestures, which enhances positive social perceptions [22]. However, research has not yet examined how socially rejected by a group of high entitative robots compares to rejection by a group of low entitative robots.

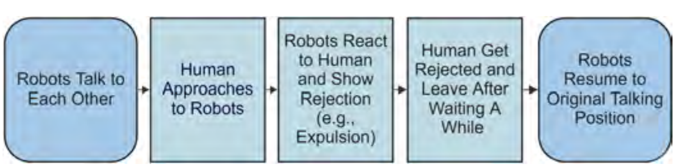


Fig. 2: Progress of the videos for each type of social rejection

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 shown in Fig. 2. 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 an invisible wall by directing their gesture at the human when she approaches.") based on the categorization of rejection from previous literature [13]. The High Entitativity condition featured videos of identical robots moving at the exact same speed. The Low Entitativity videos depicted the same robots of varying heights moving at varying speeds, such that when they turn away, for example, they do not move in unison, but rather one after the other (with about a 0.5 second delay). Height and facing direction of robots in Low Entitativity condition were varied to create dissonance among them. Fig. 1 showed the comparison of Expulsion, Group Reject, and Avoidance between High Entitativity and Low Entitativity conditions. This exploratory study used video-based format, reasoning that videotaped scenarios can produce similar results as live trials in HRI[23, 24].

B. Procedure

A total of 60 participants were recruited to complete online surveys in which they were shown videos of five distinct types of rejection in succession (Ignore, Recognition, Group

TABLE I: Means and standard deviations (in parentheses) of Belonging, Self-Esteem, and Mingful Existence on rejection types across High Entitativity and Low Entitativity

	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)

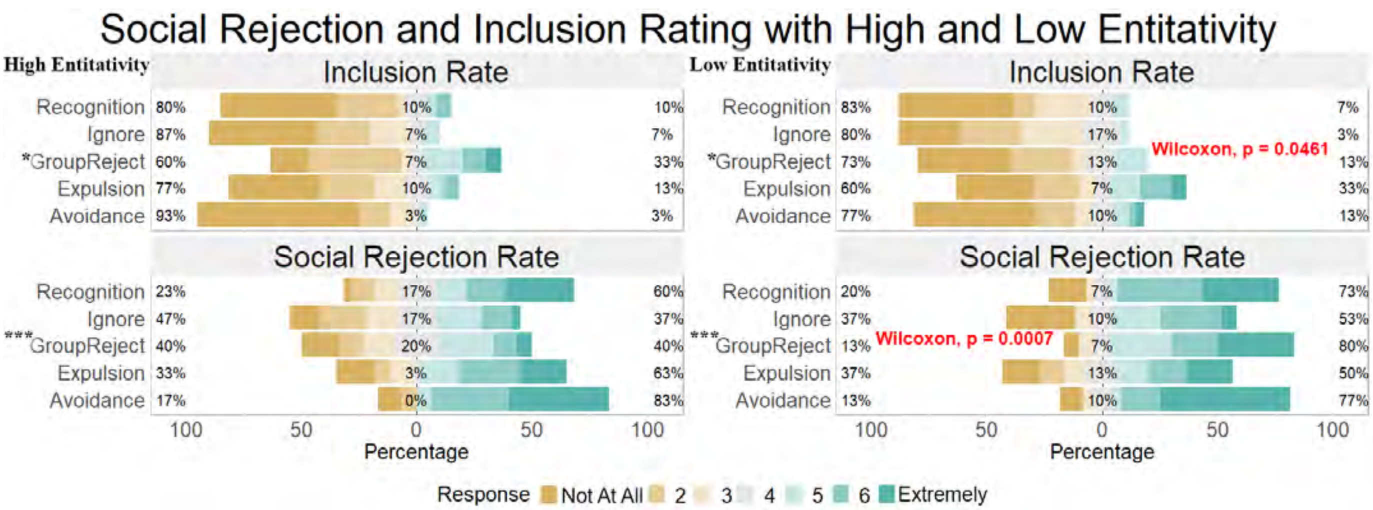


Fig. 3: Comparison of Social Rejection and Inclusion Rating of each rejection type between High and Low Entitativity Setting (From Not At All (1) to Extremely (7)). Significance was marked with the format $*P \leq 0.05$, $**P \leq 0.01$, $***P \leq 0.001$.

Reject, Avoidance, and Expulsion) in High Entitativity ($N = 30, Female = 18$) or Low Entitativity ($N = 30, Female = 16$) condition. Participants were either college students recruited through Prolific ($N = 40$) or through an undergraduate course ($N = 20$). Participants were randomly assigned to either one of two conditions (high or low entitativity), and all participants provided informed consent. Procedures followed all IRB regulations at the university.

After watching a video for a particular rejection type, the participant answered questions focusing on perceived entitativity of the robot group, Belonging, Self-Esteem, Meaningful Existence, feeling of Inclusion, and feeling of Social Rejection for that particular type of rejection. Following a brief (30 second) break, the following video examined a different type of rejection and led to another survey with the same set of questions.

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 responses 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 entitativity of robot-to-robot behavior positively influences participants' willingness to interact with robots in social context [19]. 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 though 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 also be 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 a Wilcoxon signed-rank test on each rejection, analyzing 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 rejection types had a impact on Inclusion and Social Rejection rate. The social rejection score in Fig. 3 was lower in the Group Reject in High Entitativity condition. On Group Reject, it implies that people felt more comfortable when rejected by a high entitative group of robots, indicating that robots that 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 significantly different in Group Reject across two conditions. We found that entitativity between conditions (Kruskal, p = 0.47) was not significantly different as we expected with our design. However, significant differences were found among types of rejection (Kruskal, p = 4.02e-07). As we could see in Table I, except Belonging on Expulsion, all rejection types in Low Entitativity showed higher ratings than those in High Entitativity. It partially supported our expectation that rejection by less cohesive robots groups resulted in less negative feelings.

Ignore and Recognition rejections appeared 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 faster movements that participants might not feel anything. Group Reject was the only rejection type among those five rejections in which robots still talked to each other after they turned away trying to reject the participant. However, we still found significance between types 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.

TABLE II: Comparison of reported "Rejection" or "Exclusion" between High Entitativity and Low Entitativity

	High Entitativity (N=30)	Low Entitativity (N=30)
Group Reject	7	15
Avoidance	16	18
Expulsion	0	4
Ignore	5	7
Recognition	7	11

On qualitative responses, rejection or exclusion were reported more in Low Entitativity than High Entitativity as shown in Table II. Expulsion was found the most interesting because participants on both conditions reported "*Threatened*" more than feeling rejected or excluded. It could be explained by Expulsion showing direct rejection to participants unlike other four mild rejections.

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 relationships should consider the negative interpersonal impact of robot groups on humans to avoid unnecessarily harmful emotions caused by social rejection based on context [3, 8, 9, 25]. In particular, robots in the future are embedded in human social environments, making it critical to communicate subtle gestures correctly. For example, different cultures interpret robot gestures in a group differently [19], 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 [26] and group composition. Although only one specific type of social rejection was found connecting to the cohesiveness of the robot group in this study, other parameters such as perceived affiliation, different interaction functionality, and inter-group dynamics may have an effect on perceived rejection.

The implication for the 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 not to 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 the human perception of them in social situations where they are embedded. Designs of future social robot groups must take into account the effect of group parameters such as appearance and entitativity on the way humans perceive their social action.

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