Dancing With Myself: The effect of majority group size on perceptions of majority and minority robot group members

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Abstract

While social psychology has identified characteristics of intergroup dynamics, few studies have looked into the perceptions of robot group dynamics. In this experiment, we separate robots into majority and minority groups based solely on their behavior in a simple dance routine. We attempt to understand how people's perceptions of robots within those groups change based on group size and features of behavior. Participants viewed the robot dances and rated one robot from each group on a variety of characteristics. We find that being from the minority versus majority group has a significant impact on perceptions of a robot's creativity, interestingness, anti-sociality, dancing ability, and how much of a team player it is. At the same time, individual behaviors (leading the dance, following the dance, or performing an entirely unique dance) have no statistical effect on participants' ratings of robot characteristics. From these results, we conclude that group size has a larger effect than behavior on subjective evaluations of robots in majority and minority groups.

Keywords: Group dynamics; majority group; minority group; intergroup relations; robotics; human-robot interaction

Introduction

The tendency to categorize people into established groups is an automatic social behavior, and influences much of how we perceive the world. Psychologists have studied the dynamics of intergroup relations, particularly when the group sizes are unequal, for many decades (Tajfel, 2010). Among many other findings, the literature reveals that minority groups—those with fewer members—are susceptible to being influenced by a unanimous majority group (Asch, 1956), even when the majority's assertions are incorrect on a point of fact. Furthermore, people are biased toward perceiving their own group (an in-group) with more positive characteristics than a group of "others" (an out-group) (Tajfel, 1974).

In this paper, we pursue a systematic, empirical analysis of how simple manipulations of group dynamics can affect the perception of group members' personal qualities, some of which are not directly related to the behaviors being demonstrated. To accomplish this, we analyze peoples' judgments of a group of simple robotic agents in terms of characteristics such as interestingness, creativity, and sociality. We vary the agents' behaviors in systematic ways to tease apart which elements of their behavior affect these character judgments. In particular, we compare peoples' perceptions of a majority group robot—one member of a group of robots all exhibiting nearly identical behaviors—to their perceptions of a minority group robot—a single robot exhibiting a distinct set of behaviors different from the majority group.

In the last century, Michotte investigated the appearance of animacy by systematically varying the behavior of simple moving shapes (Michotte, 1963). The current investigation is inspired by this and, in some sense, continues Michotte's work by investigating the characteristics of *groups* of agents by systematically varying the behavior of the group. Through this work, we hope to contribute a greater understanding of social attributions and the dynamics of groups.

Another benefit of this work is a greater understanding of the perception of robot groups. As technology improves, groups of humans are being joined by increasingly agentic technologies such as medicine-delivery robots in hospitals and package-retrieval robots in warehouses. Research in the field of human-robot interaction (HRI) has begun to examine intergroup relations in terms of including or excluding robots from human in-groups. Studies have shown that people respond more favorably to robots in their in-group than one in an out-group (Eyssel & Kuchenbrandt, 2011; Kim, Kwak, & Kim, 2010; Kuchenbrandt, Eyssel, Bobinger, & Neufeld, 2011; Wang, Rau, Evers, Robinson, & Hinds, 2009). However, much of this research investigates a single robot interacting with one or more humans. This paradigm is historically reasonable, because social robots have been typically designed for and deployed in single-robot environments. As robots become less expensive and more socially accepted, however, groups of robots may become more common. In these cases, understanding the dynamics of robot groups will be important for robot designers and users.

Few studies have explored intergroup dynamics for groups comprised exclusively of robots. Most importantly, little research exists that addresses the perception of groups of robots that are distinguished solely based on the *behavior* of the group members. We are interested in how the behavioral categorization of robots into majority and minority groups affects perceptions of group members' characteristics.

In this paper, we describe an experiment that attempts to identify the effect of majority group size on people's characterizations of majority group and minority group robots. We use a basic robot behavior—a simple dance—as the distinguishing feature between groups. In our experimental manipulation, we vary both majority group size (one, three, or seven robots in the majority group versus a single-robot minority group) and the type of dance performed by the minority group robot (same as or different from the majority group dance). We ask participants to rate the robots on a number of characteristics both related to and unrelated to dancing, in an attempt to understand how groups distinguished only by behavior are perceived. Our hypotheses are:

H1 *The minority group robot will be rated more highly in in-*

dividualistic characteristics (such as "creative" and "anti-social") than a majority group robot. Because its behavior will set it apart from the majority group, we expect the single minority robot to appear more independent than the group of similiarly-behaving majority group robots. We expect to see these characterizations with both positive and negative connotations.

H2 *As the majority group size increases, the differences between minority and majority group members will increase.* Research has demonstrated a positive correlation between group size and conformity (Tanford & Penrod, 1984). Although participants in this study are not conforming themselves, they are making a character judgment about the conformity (and conversely, the individuality) of the minority group agent, so we expect this trend to hold.

H3 *Dance type will affect how the minority robot is perceived relative to the majority.* For instance, a dance in which the minority robot performs the motions one second before the majority group robots will lead to perceptions of the minority robot as the leader.

Related Work

In this paper, we ask participants to make judgments of majority and minority group members from an outside perspective; the participant is not a member of either group. In contrast, in-group and out-group studies typically involve the participant being a member of one of the groups. Though we are analyzing majority versus minority groups in this paper, we are still influenced by research about in-group and out-group dynamics, and we briefly summarize the literature here.

Intergroup relations among human groups have been studied for over four decades, and there is a well-established body of literature describing the effects of in- and out-group membership on perception and behavior of people (e.g., (Tajfel, 1982; Turner, Hogg, Oakes, Reicher, & Wetherell, 1987; Brewer & Brown, 1998)). People exhibit positive responses to conformity with in-group norms, and they tend to be protective of the in-group stereotype (Castano, Paladino, Coull, & Yzerbyt, 2002; Christensen, Rothgerber, Wood, & Matz, 2004). People also tend to view an out-group as having less variety than their in-group (Boldry, Gaertner, & Quinn, 2007). Similarly, members of a group of size one tend to be stereotyped by their distinguishing characteristic, such as gender (Wolman & Frank, 1975).

Studies of group pressure between minority and majority groups have found that both groups can be swayed by the other, but that minority groups are particularly susceptible to being overridden by majority opinion (Asch, 1956). The amount of influence exerted by either a majority or a minority group is mostly affected by the size of the competing groups, and is less affected by the task or group characteristics (Tanford & Penrod, 1984).

While human groups have been studied extensively, less research exists on peoples' perceptions of robot groups. Studies have shown that robots perceived as in-group members appear more compelling, familiar, reliable, and anthropomorphic (Kim et al., 2010; Kuchenbrandt et al., 2011; Wang et al., 2009). Participants report more positive interactions with an in-group robot than an out-group robot, even when that grouping was established only implicitly by changing the robot's name and country of origin (Eyssel & Kuchenbrandt, 2011). Participants exhibit greater perception of secondary emotions to in-group virtual agents (Besmann & Rios, 2012). Responses to in-group membership may depend on culture: one study found that Chinese participants (i.e., from a more collectivist culture) were more comfortable with a robot than US participants (i.e., from a more individualistic culture) when that robot was presented as a strong in-group member (Evers, Maldonado, Brodecki, & Hinds, 2008).

Experiment Design

We used survey responses to videos of groups of dancing robots to investigate how in-group size and out-group behavior affected perceptions of group members. Surveys were completed using an interactive web page provided by SocialSci, an online social science research utility. Respondents were recruited from the SocialSci survey pool, a vetted collection of survey takers similar to Amazon's Mechanical Turk. Respondents were rewarded for their time with SocialSci credits which can be exchanged for gift cards and other rewards (*SocialSci*, 2012).

In all, 89 respondents were recruited. All survey respondents were over 18 years of age, with a mean age of 29 years (SD 10 years). About half (54%) of the respondents were male. Sixty-two percent of respondents identified themselves as white, 6% were African-American, 12% Hispanic, 10% Asian, 2% Pacific Islander, and 6% identified as "Other."

Stimuli

We employed a 3×4 within-respondents design. The two factors in this design are group size (one majority versus one minority robot, three majority robots versus one minority robot, and seven majority robots versus one minority robot) and dance type (similar, unique, follower, and leader). The condition with a single majority robot was used as a control. Participants saw one video from each combination of group size and dance type for a total of twelve videos. We randomized presentation order of these twelve videos. To add to the perception of dancing, each video had an audio track containing one of five songs taken from a current top-40 pop music list. The robots' dance rates were altered with video processing to match the tempo of the current song. Song presentation order was also randomized.

Each video clip was 30 seconds long. Videos were created by stitching together multiple videos of the same robot (for majority-group members) or a different robot (the minority-group member) side-by-side (see Figure 1 for a still image from one video). The position of the minority-group robot was randomized across trials. In order to elicit a sense of realism, small delays were added to some majority-group members' videos at random; these delays were 10 frames

(about 160 milliseconds) at maximum, and simply served to strengthen the illusion that the video presented to participants showed several individual robots instead of one robot replicated several times.

To test how behavior affects characterizations of majority and minority group members, we created four distinct dance types. Figure 2 shows these four conditions. Dance types are described as a comparison of the minority robot's dance to the majority group's dance, and they can vary across two dimensions. First, the minority robot's dance can have the same available dance moves (repertoire) or a disjoint set of dance moves than the majority group's dance. Second, the minority robot's dance can have the same sequence of dance moves or a different sequence of dance moves than the majority group's dance. In the *similar* condition, the minority robot's dance has the same repertoire but a different sequence of moves. In the *unique* condition, the minority robot's dance has a completely disjoint repertoire. In the *follower* condition, the minority robot's dance has the same repertoire and the same sequence of moves, but the minority robot's sequence is one second behind that of the majority group members, eliciting the appearance that the minority robot is following the majority robots and struggling to catch up. Finally, in the *leader* condition, the minority robot's dance again has the same repertoire and sequence as the majority group's dance, but this time it is the minority robot that performs its sequence ahead of the majority robots by one second, in an attempt to simulate a single leader that is being followed by the other robots. These dances were designed to span the range of possible group dynamics, to identify how a robot's behavior with respect to other robots affects peoples' perceptions of it.

Survey

The survey consisted of one page for each of the twelve videos and a final page to collect demographic information. Each video page contained a video that was 140 pixels tall and either 222 pixels wide (in the control, one-versus-one condition), 444 pixels wide (in the three-versus-one condition), or 888 pixels wide (in the seven-versus-one condition). Each robot was numbered with an overlay on the video which did not obstruct a view of the robot's motions (see Figure 1).

Following the video stimulus, respondents were asked to rate two of the robots (a random member of the majority group and the sole minority group member) on nine attributes using a seven-point scale:

- How well did robot x dance?
- How entertaining is robot x?
- How likable is robot x?
- How lifelike is robot x?
- How interesting is robot x?
- How much is robot x a team player?
- How mindless is robot x?
- How creative is robot x?
- How anti-social is robot x?

Four survey questions were carefully selected for their positive and negative connotations of conformity or non-conformity. "Team player" and "mindless" represent positive and negative conformist words, respectively. Similarly, "creative" and "anti-social" have positive and negative connotations for non-conformity, respectively. Other survey questions address a range of attributes, including those having to do with the relevant behavior of dancing ("good dancer," "entertaining") and those not specifically related to dancing ("likable," "lifelike," "interesting").

Results

In order to investigate our three hypotheses, we conducted within-subjects ANOVAs with group size (one-versus-one, three-versus-one, or seven-versus-one), dance type (similar, unique, follower, or leader), group affiliation (majority or minority), and their interactions as fixed factors, participant as a random factor and each of the nine ratings of the robot as dependent variables.

Dance type showed no statistically significant effect on ratings between minority and majority robots for any of the group size conditions, disproving hypothesis H3. Song type also showed no statistically significant effect, so in our subsequent analysis we combine all trials of a single group size together, regardless of dance type or song.

Hypothesis H1 predicts that the minority group robot will be rated more highly than the majority group robot in individualistic characteristics and less highly than the majority group robot in conformist characteristics. The survey attributes dealing with individualism and conformism are: creative, anti-social, mindless, and team player.

For perceptions of how creative the robot was, the majority group robot was rated lower than the minority group robot ($F(1,2128) = 9.148, p < 0.01$). The interaction was also significant ($F(2,2128) = 6.973, p < 0.01$). Individual group comparisons using Tukey HSD confirm significant differences between the minority and majority robots in the three-versus-one and seven-versus-one conditions (Figure 3a).

For perceptions of how anti-social the robot was, the majority group robot was rated lower than the minority group robot ($F(1,2128) = 26.146, p < 0.001$). The interaction was significant as well ($F(2,2128) = 8.706, p < 0.01$). Individual group comparisons using Tukey HSD confirm significant differences between minority and majority robots in the three-versus-one and seven-versus-one conditions (Figure 3b).

For perceptions of the robot as a team-player, the majority group robot was rated higher than the minority group robot ($F(1,2128) = 158.06, p < 0.001$). The interaction was significant as well ($F(2,2128) = 39.67, p < 0.001$). Individual group comparisons using Tukey HSD confirm significant differences between minority and majority robots in the three-versus-one and seven-versus-one conditions (Figure 3c).

No statistical differences were found for mindlessness. Analysis therefore shows significant differences for three of the four attributes dealing with individualism (creative, anti-

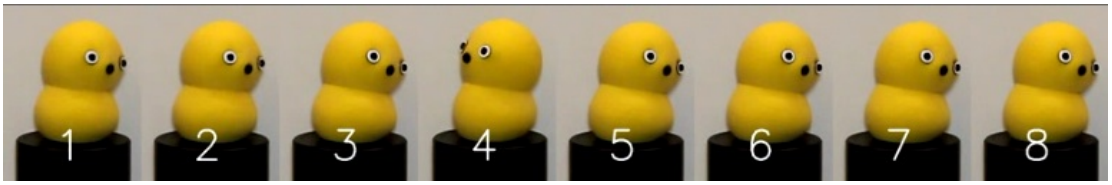


Figure 1: A still image from video of the seven-versus-one group size condition, showing the minority group robot (number 4) performing a different dance than the seven majority group robots.

Condition Name	Available Repertoire: majority	Available Repertoire: minority	Sample Sequence (time)	Explanation
similar			maj: / min:	Same repertoire, different sequence
unique			maj: / min:	Different repertoire
follower			maj: / min:	Same repertoire, minority sequence is one second behind
leader			maj: / min:	Same repertoire, minority sequence is one second ahead

Figure 2: A comparison of the four dance types used for the dance manipulation. Each row represents one dance type. The "available repertoire" column shows a graphical representation of the repertoire for majority and minority groups, where each shape is a distinct move (e.g., rocking back and forth). The "sample sequence" column shows example dances for each group.

social, and team player), partly confirming H1.

Hypothesis H2 predicts that an increase in group size will increase the impact of being a minority. There were significant differences between the group size conditions on ratings of the team player attribute, positively correlated with group size ($F(1,2128) = 14.64, p < 0.001$). Individual comparisons with Tukey HSD confirm significant differences in the minority robot's ratings between the three-versus-one and the seven-versus-one conditions. No other differences were observed across group sizes. Therefore, H2 is only upheld for the team player attribute.

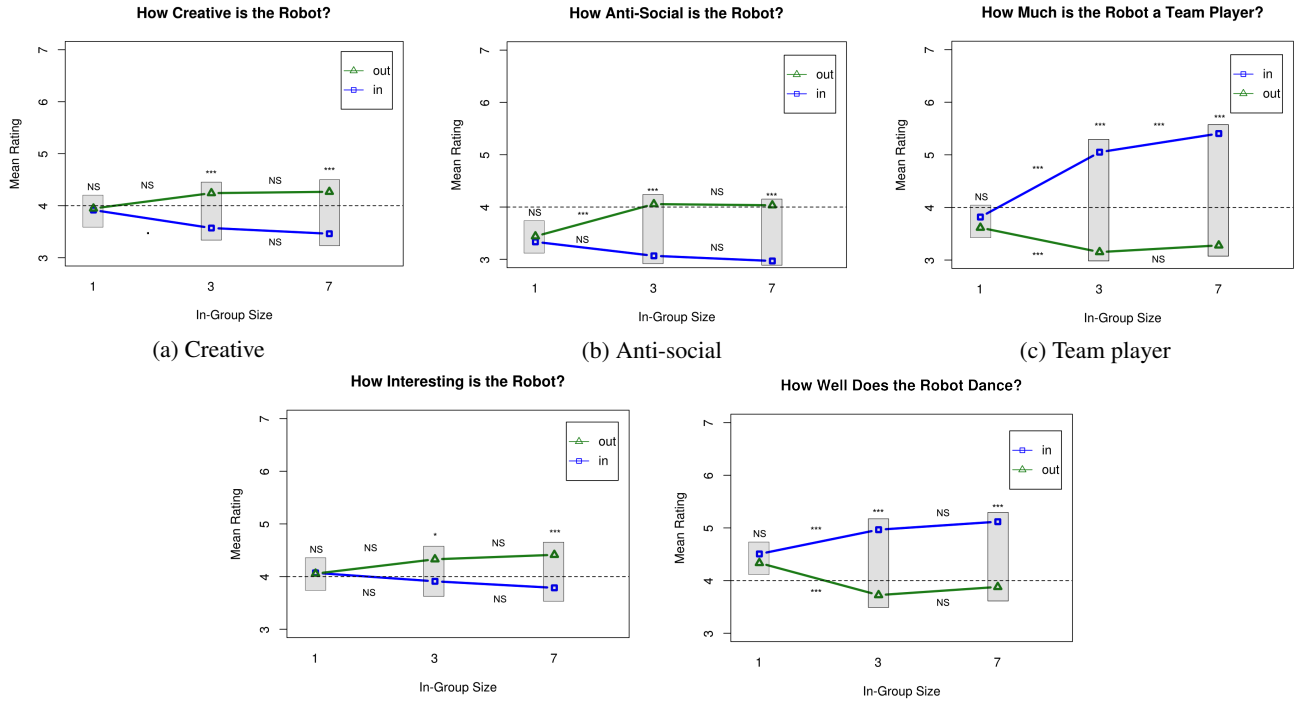
Analysis of the additional attributes reveals statistical differences between majority and minority robot ratings for interestingness and dance ability as well. For perceptions of how interesting the robot was, the majority group robot was rated lower than the minority group robot ($F(1,2128) = 4.128, p < 0.05$). The interaction was marginally significant as well ($F(2,2128) = 3.611, p = 0.058$). Individual group comparisons using Tukey HSD confirm significant differences between minority and majority robots in the three-versus-one and seven-versus-one conditions (Figure 3d). For perceptions of how well the robot danced, the majority group robot was rated higher than the minority group robot ($F(1,2128) = 30.35, p < 0.01$). The interaction was significant as well ($F(2,2128) = 6.22, p < 0.05$). Individual group comparisons using Tukey HSD confirm significant differences between minority and majority robots in the three-versus-one and seven-versus-one conditions (Figure 3e).

We also found a weak but highly significant correlation between positive and negative conformist words, "team player" and "mindless" (Pearson's $r = 0.165, p < 0.001$), as well as between the positive and negative non-conformist words, "creative" and "anti-social" (Pearson's $r = 0.235, p < 0.001$).

There were no significant differences in ratings of how mindless, lifelike, likeable, or entertaining the robots were. There was also no significant influence of demographic information such as age, gender, or ethnic background.

Discussion

Hypothesis H1 was confirmed in the three-versus-one and seven-versus-one case for creative, anti-social, and team-player attributes. Furthermore, we found statistical differences between majority and minority robots for interestingness and how well the robot danced. In the control case—that is, in the one-versus-one condition—there was no statistical difference in ratings for either robot in these five traits, suggesting that the appearance of majority and minority groups elicited these differences in evaluation.



(a) Creative (b) Anti-social (c) Team player

(d) Interesting (e) Dancing ability

Figure 3: Graphs of participant ratings of minority and majority group robots for each of the group size conditions. The dotted line indicates an average rating on the seven-point scale. For brevity, we only show ratings that achieved statistically significant results (.: $p < 0.1$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; NS: not significant).

We also predicted that majority group size would have an effect on the magnitude of differences between minority and majority robots (H2). For the team-player condition, as the group size increased, the differences between the majority and minority group robots also increased. Therefore, H2 was confirmed for one of the attributes. This result is interesting because it shows that group size can affect the intensity of "otherness" exhibited by the out-group member. Our finding is in line with other psychology research, which reports that group size affects the intensity of pressure to conform to group behavior (Tanford & Penrod, 1984). This result also suggests that teams are identified not just by coordination of action but by size of population, because a larger majority group increased the difference in team-player ratings between the majority and minority robots. It would be interesting to identify whether there is an upper bound in majority group size for this effect. Future work might also analyze minority group sizes greater than one, to see if the effect of group size on the intensity of "otherness" is mitigated when the minority group grows proportionally to the majority group.

The dance types used in this experiment were carefully designed to account for many possible group interactions: one group leading another, one group following another, the groups having completely different behaviors, or the groups having the same behaviors but in a different pattern. Regardless, we found no significant differences due to dance type, disproving hypothesis H3. This suggests that it may not matter what the minority group robot is doing, as long as it is not doing exactly what the majority robot does. This supports Asch's majority effect (Asch, 1956), and is an interesting and novel finding in multi-robot interactions.

We chose the phrases "team player" and "mindless" as terms that have positive and negative connotations of conformity, respectively. Similarly, we chose "creative" and "anti-social" for their positive and negative connotations with non-conformity. Results indicate that the out-group robot was perceived as less conformist (team-player) and more non-conformist (creative, anti-social) overall. When comparing positive and negative connotations of those categories, we see weak but highly significant correlations between the two conformist words and between the two non-conformist words. Thus, if participants saw a robot as conformist, they were more likely to rate it highly for both positive and negative conformist words (and similarly with non-conformist words).

In this study, we measured participants' subjective evaluations, but they were not part of either group. The lack of situatedness of the robots, coupled with the fact that respondents did not participate in the task, make it unlikely that participants identified with either the majority or minority groups. Assigning participants to one of the groups might reveal further perceptions relating to group membership, and would allow comparisons to existing research on intergroup dynamics.

This paper investigates a social phenomenon—group dynamics—using controlled, precise stimuli and quantitative

metrics for evaluation. The general methods presented here, such as using recorded stimuli to manipulate a single social behavior within a group, can be useful for exploring many other social phenomena as well. The use of robots as stimuli further benefits researchers by allowing them to leverage the flexibility, precise control, and repeatability of movements, facial expressions, and other socially relevant behaviors, which may be impractical to achieve with human actors.

Conclusion

Social psychologists have long known that group membership and size affect characterizations of group members, but there is a dearth of studies on this topic within the field of human-robot interaction. In this paper, we analyze the dynamics of robot groups: how are members of robot majority and minority groups perceived, and how does this perception change with differences in group size? We created majority and minority robot groups based on robot behaviors, by having robots perform simple dances which varied between the two groups in either timing (the minority group led or followed the majority group) or content (the minority group performed a different set of behaviors from the majority group). The minority group always contained one robot, while the majority group size varied from one robot (a control condition) to three robots to seven robots. We found a significant effect of group size on five characteristics: how creative, interesting, anti-social, much of a team player, and good a dancer the robot was. In contrast to this group size effect, there was no significant influence of behavior on any character attributions. This research suggests that group size has a strong effect on the evaluation of robot characteristics.

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