You Had Me at Hello: The Impact of Robot Group Presentation Strategies on Mental Model Formation

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***Abstract*—Research has shown how the connections between robots' minds, bodies, and identities can be configured and performed in a variety of ways. In this work, we consider group identity observables: the set of design cues that robot groups use to perform different identity configurations. We explore how group identity observables lead observers to develop different mental models of robot groups. Specifically, we make four key contributions: (1) we define, conceptualize, and taxonomize group identity observables; (2) we use Grounded Theory-informed analysis of qualitative data to produce a taxonomy of users' mental models invoked by variation in those observables; (3) we empirically demonstrate (n=166) how variations in observables lead to different mental models; and (4) we further demonstrate how variations in those observables, and the mental models they evoke, influence key group dynamics constructs like entitativity.**

***Index Terms*—Human-Robot Interaction, Robot Groups, Identity Performance Strategies, Mental Models**

I. INTRODUCTION

While most Human-Robot Interaction (HRI) research has focused on interactions between humans and individual robots, many HRI domains, such as space exploration [1], [2], [3], search-and-rescue [4], [5], and healthcare [6], [7], involve interactions with *groups* of robots. However, when interacting with groups of robots, people will often interact with a single cognitive architecture controlling multiple distinct robot bodies. This ontological tension between individuals and groups poses challenging questions for robot designers.

Recently, a number of researchers have highlighted the flexibility of the relationship between robot body (the physical construct), mind (the underlying cognitive architecture), and identity (the performed persona) [8], [9], [10], [11], [12] (see also [13]). Williams et al. [8], Jackson et al. [12], and Reig et al. [10] have explicitly discussed the tension between the concepts of mind, body, and identity at the robot software level and how their relationships are perceived by humans. For example, Williams et al. [8] considers human interactions with robots that are networked together and controlled by a single robot architecture yet present themselves as distinct individuals, and terms this presentation an *identity performance strategy*. Williams et al. [8] argues that this identity performance strategy facilitates a user mental model of multiple distinct individuals, each with their own body, whereas other identity performance strategies (e.g., robots presenting themselves as a hive mind) could instead facilitate a mental model of a single individual whose mind is distributed across multiple bodies.

As Williams et al. [8] point out in their work on *Deconstructed Trustee Theory*, this distinction is critical because the number of bodies and identities involved in a user's mental model dictates where and how they believe trust can be placed, and how they allocate trust to those different *trust loci*. This raises key questions: How can designers realize different identity performance strategies? and How can those strategies lead to different mental models of robot groups and their constituent bodies, minds, and identities?

Jackson et al. [12] reason about these questions through a *Levels of Abstraction* theoretic account of identity. *Abstraction* [14] is a method of system interpretation [15] not dissimilar from Marr's levels of analysis [16], Pylyshyn's levels of description [17], or Dennett's three stances [18]. Levels of Abstraction have been used in the HRI community to productively theorize about concepts like Moral Agency [19] and Social Agency [20]. The key insights of these works are that for concepts like agency and identity to be productively analyzed, theorists must specify the *Level of Abstraction (LoA)* from which they are analyzed, where an LoA is defined as the set of *observables* (e.g., robot speech, morphology) available at that LoA. Whether a robot is an "agent", for example, is a decision made about autonomy, interactivity, and adaptability, based on what can be observed from a particular perspective. Two perspectives from which a robot could be analyzed are that of the robot designer and the user, which are differentiated by the observables available to each, i.e., the information about the robot that they can observe. For example, robot users can observe the robots' movements and speech, whereas robot designers can additionally observe the reasons why these movements and speech are generated, how they are synchronized, and what architectural components are shared across robot bodies. Jackson et al. [12] show how Robot Identity can be analyzed at different Levels of Abstraction, and hypothesize that the ascription of a unique identity may be performed on the basis of key observables such as naming, speech, and behavior.

This account of *identity observables*, however, has yet to be validated empirically, and it is not yet clear what types of mental models people actually build as they make sense of groups of robots, or what types of identity observables actually lead to those mental models. Moreover, it is unclear how these observables (and the mental models they evoke) impact group dynamics constructs [21] like entitativity [22].

In this work, we systematically explore how changes in different *group identity observables* might impact the mental models people develop of robot groups during initial human-robot introductions. We describe a study in which participants viewed and reflected on animated storyboards across 42 conditions representing key combinations of group identity observables. We use a Grounded Theory informed analysis of participants' qualitative feedback to identify the types of mental models people developed, and use statistical analysis to show how variations in group identity observables led to those different mental models. Finally, we use participants' quantitative assessments to understand how those varying observables, and the mental models they evoked, influenced perceptions of robot group entitativity.

II. Related Work

A. Interactions with Robot Groups

The complexity of interactions with robot groups is highly sensitive to the number of robot interactants [23], [24], [25], [26] in a way that mirrors findings from social psychology [27], [28], [29]. Moreover, there are strong interaction effects between the number of robots and the *type* of those robots (anthropomorphic, zoomorphic, or mechanomorphic), on the social and task-oriented roles in which people see them [24], [25]. This has inspired much work on robot group perception [21], which has suggested three central features of robot group perception: ingroup identification, cohesion, and entitativity.

The perceived entitativity of robot groups (i.e., how unified the group appears to be) is a key dimension of group perception that substantively mediates the quality of interaction. In cooperative human-robot interaction contexts, increasing perceptions of robot group entitativity leads to more positive perceptions and willingness to interact with robots [30]. Similarly, entitative robot groups are viewed more negatively than single robots and as more threatening than diverse robot groups, yet users are more willing to interact with groups than with single robots [22]. Fraune et al. [22] also emphasizes how entitativity can be manipulated by design choices, such as names, morphologies, and behaviors.

This prior work motivated us to explore the specific mental models people build as they make sense of robot groups, and the impact that other manipulated observables and their resulting mental models could have on entitativity. Of particular interest to us here is the consideration of *naming*, which relates to recent work that has been conducted on robot *identity*.

B. Identity Performance Strategies

Researchers have recently argued that *identity* cues are especially important to consider for robot groups [8], [12]. While individual robots typically have humanlike 1-1-1 mind-body-identity associations, these associations are easily broken down in robot groups (e.g., when robots are explicitly designed as a "hive mind" or demonstrate evidence of their networking [31]). As we have argued, different *identity observables* (like *naming*, as investigated by Fraune et al. [22]) may lead people to develop mental models with different mind-body-identity associations. Researchers have recently investigated a number of other design cues that we consider *group identity observables*; cues that not only communicate information about an individual robot's mind-body-identity relationships, but also allow inferences to be drawn about the *network* of such relationships that may exist between multiple robots.

For example, Luria et al. [9] and Reig et al. [32] explore different ways that robot body and mind/identity can be uncoupled, including the following configurations and configuration dynamics: (1) One-for-one, in which each robot body is inhabited by a single, stable mind/identity; (2) One-for-all, in which a single mind/identity inhabits multiple bodies simultaneously; (3) Re-embodiment, in which a single mind/identity can 'hop' from one body to another; and (4) Co-embodiment, in which multiple minds/identities inhabit a single body. Researchers have further demonstrated that these different configurations have real impacts on Human-Robot Interactions. Identity performance strategies impact perceptions of robot capability [33], expertise [9], and goodness of fit between different robots and different tasks [9]. This suggests that when interacting with robots with heterogeneous roles, capabilities, and expertise, lack of transparency over those differences may cause users difficulty in assigning tasks and goals to or becoming comfortable with those robots. Indeed, Williams et al. [31] and Luria et al. [9] have shown that some users experience discomfort with non-humanlike mind-body-identity alignments, even if those modes improve efficiency.

Moreover, Reig et al. [10], Williams et al. [8], and Jackson et al. [12] argue that different mind-body-identity configurations can be *performed* by multi-robot systems. For example, a multi-robot configuration with a one-for-all mind-body-alignment, with all bodies and their speech controlled by a single cognitive architecture, may choose to present itself as any of the other configurations, performing one-for-one body-identity alignment by having the robot bodies use distinct names and/or maintain distinct memories and skills, or performing re-embodiment, by having one identity appear to speak through a body with which it was not previously associated [8]. Tejwani et al. [11] (see also [34]) have also shown that the ways non-humanlike mind-body-identity alignments are observed may determine affective responses to those alignments. These results highlight the importance of mind-body-identity alignment in robot groups and of identity performance strategies. In this work, we thus study the effects of a key set of group identity observables both on mental model formation and on downstream group dynamics constructs.

III. Group Identity Observables

To explore different identity-relevant observables and their effect on mental model formation, we identify five key *group identity observables*—robot design cues that may be leveraged at the User's Level of Abstraction to infer relationships between the minds, bodies, and identities of a robot group and to construct corresponding mental representations.

Speaking – Who speaks (and when) may signify where and how cognition is distributed. In this work we consider three Speaking design cues: (1) *All together*, in which all robots speak at the same time; (2) *All individually*, in which robots all robots speak, but each speaks at a different time; and (3) *One speaking*, in which only one robot speaks.

Self-Reference – How an identity speaks of itself or the body it inhabits may lead to inferences about the presumed speaker, and the relationship between that speaker and its body. In this work we consider four Self-Reference design cues: (1) *I am*, in which the self is directly referenced; (2) *We are*, in which the self is referenced as part of a whole; (3) *This is my*, in which the body is referenced as owned; and (4) *This is the*, in which the body is referenced as external.

Other-Reference – How an identity speaks of other identities or the bodies they inhabit may lead to inferences about the relationship between that speaker and those other identities or bodies. In this work we consider three Other-Reference design cues: (1) *This is my*, in which another body is referenced as owned; (2) *This is the*, in which another body is referenced as external; and (3) *They are*, in which a body or identity is directly referenced.

Naming – Finally, the name used for oneself or another may lead to inferences about the relationship between the speaker and other identities. In this work we consider four Naming design cues: (1) *Humanoid name*, in which an identity is referred to with a human-like name; (2) *Descriptive name*, in which an identity is referred to with a descriptor (e.g. red unit); (3) *Humanoid group name*, in which multiple identities are simultaneously referred to with a human-like name; and (4) *Descriptive group name*, in which multiple identities are simultaneously referred to using a descriptor (e.g. Help Desk).

Name and Voice Distinctiveness – Finally, to best compare with previous work on Deconstructed Trustee Theory [8], we first considered ways of *directly* communicating body-identity alignment. In this work we consider three Name and Voice Distinctiveness design cues: (1) *All unique*, in which each robot spoke with a unique voice (distinct from other voices used) and was given a unique (humanoid) name; (2) *All shared*, in which all robots spoke with the same voice and shared the same (humanoid) name; and (3) *Only one*, in which one robot spoke and was given a (humanoid) name, and the other robots did not speak and were not named.

IV. METHODOLOGY

A. Design and Methods

To understand how group identity performance strategies could impact humans' mental models of robot groups, we performed an online study through the Prolific survey platform (prolific.co). Participants viewed and reflected on animated storyboards depicting robot group introductions that varied according to our selected group identity observables and provided their intuitions about depicted group entitativity. For this experiment, a subset of 42 representative examples (Appendix A) from the several hundred possible combinations of group identity observables was used.

Fig. 1. Example robot introduction storyboard frame. (Speaking: All together, Self Reference: We are, Other Reference: None, Naming: Descriptive group name, Name and Voice Distinctiveness: All shared)

Each combination of observables was turned into an animated storyboard, comprised of 1-4 frames depicting three robots of ambiguous morphology. In each frame, one or more robots (depending on the Speaking design cue) introduced themselves or was introduced (using the reference to self/other depending on the Self-Reference and/or Other-Reference design cues and the name/s depending on the Naming and Name and Voice Distinctiveness design cues). Speech bubbles showing robot speech accompanied corresponding audio (with robot voice depending on the Name and Voice Distinctiveness design cue). One (static) example of a storyboard is shown in Fig. 1. All animated storyboards, data, and analysis scripts are available at https://bit.ly/33hMhyY.

B. Procedure and Measures

Each participant was assigned to one of six conditions, each of which used seven of the 42 storyboards. After providing informed consent and demographic information, participants were shown each of the seven animated storyboard associated with their condition. Before each storyboard, participants were told: "Imagine you approach a help desk. Behind the desk are three robots who introduce themselves as shown in the following video." The participant was then shown an animated storyboard, and asked to answer a series of open-ended prompts (Appendix B) designed to elicit reflection on the storyboards so as to assess viewers' mental models of the robot groups (e.g., "Describe and name each individual with whom you can interact."), and closed-ended questions (Appendix C) derived from previous robot group dynamics research [35], [22], [26] so as to assess robot group entitativity (e.g., "How similar are the robots to each other?"). The study lasted about 20 minutes, after which participants were compensated $15/hr.

C. Participants

166 participants were recruited from Prolific (93 male, 68 female, 3 non-binary, 1 agender, 1 N/A). Participants ranged from 18 to 70 years old (M=35.12, SD=12.46). As there were 42 introductions randomized into 6 sets, 26-29 participants were assigned to each set, and each participant saw 7 videos. This produced a total of 1112 responses for each measure.

D. Analysis

We first performed a Grounded Theory informed analysis [36] of our qualitative data. Three researchers examined all qualitative responses and coded those responses with open codes. Those open-codes were then analyzed and grouped into clusters to create axial codes associated with different mental models. Each participant's response to each storyboard was labeled with the axial code(s) that best described the mental models their responses evidenced.

We then performed a Bayesian analysis of our data using JASP [37]. The relationships between each of our five group identity observables and our mental model labels were analyzed using Bayesian Contingency Table analyses. The relationships between these observables and our entitativity measures were analyzed using Bayesian ANOVAs. The relationships between mental models and our entitativity measures were analyzed using additional Bayesian ANOVAs. Interaction effects between group identity observables were not analyzed as not all combinations of observables were in the data.

V. Qualitative Analysis Results

The first stage of our qualitative analysis was *open coding* by the three coders. This yielded a total of 1636 unique codes: 10 for question 1, 27 for question 2, 251 for question 3, 356 for question 4, 668 for question 5, and 324 for question 6. The large number of codes represents the nuanced and varied nature of participant responses. The second stage of our qualitative analysis was *axial coding* by those same coders. The axial coding process revealed that these open codes reflected two fundamentally different taxonomies of mental models: Intelligence Distribution and Social Relationships. We will discuss both of these taxonomies below.

Table I shows the number of participant responses (the total frequency) whose axial codes reflected each of the mental model categories, along with the agreement and Cohen's κ values for each category. Some codes were rare (e.g., "workers") or extremely rare (e.g., "extensions"), which inflates the probability of agreement by chance and makes for a very conservative κ score[1]

[1]For example: For "extensions", the κ is 0 despite a raw agreement score of over 99%. The code "extensions" only occurred once in the coded subset. We treated each code as a binary—present or not present—for each data point, and calculated percent agreement as a ratio of the number of matching answers over the total number of data points. This means that there was an extremely high prevalence of *not present* for "extensions", and its presence was marginal. Because the probability of agreement by chance is near 100% already, our agreement is mathematically no higher than would be expected by chance, although the actual level of agreement is very strong. This has been regarded by some scholars as a weakness of the kappa statistic; see, e.g., [38], [39] for further reading on this so-called "kappa paradox".

The codes which occurred fewer than five times in the subset used to calculate inter-rater reliability are noted with an asterisk (*) next to their total frequency values in the table. The median and mean agreement scores for codes that occurred five or more times in the coded subset (across two coders) were 93.6% and 91.2%, respectively, and the median and mean κ values were both 0.51, which is "moderate" according to [40] (note that these values are, like the individual κ values, penalized by the high agreement by chance for several of the codes).

TABLE I
MENTAL MODEL CATEGORIES WITHIN PARTICIPANT RESPONSES.

Mental Model Taxonomy	Categories	Frequency	Agreement	Cohen's κ
Intelligence Distribution	One-for-all	586	84.7%	0.46
	One-for-one	542	93.3%	0.14
	None	122	85.3%	0.54
Social Relation-ships	Are a group	202	94.5%	0.54
	Are One	152	88.3%	0.36
	Individuals	151	98.9%	0.34
	Collaborators	138	98.2%	0.81
	Owner-ownee	80*	99.4%	0.80
	Supervisor-subordinate	76	98.8%	0.83
	Workers	30	96.3%	0.49
	One centered robot	21*	98.2%	0.0
	Spokesperson	16*	98.8%	0.50
	Representatives	14*	98.8%	0.50
	Extensions	13*	99.4%	0.0
	None	424	79.1%	0.55

A. Intelligence Distribution

First, many of our open codes reflected participants' different mental models of the different actors they perceived to exist, i.e., how and where the cognition behind the robots was distributed. During axial coding, these open codes were grouped into three main categories.

1) *One-for-one* – Some participants demonstrated evidence of mental models in which each robot body had a single identity, or a single cognitive system behind it. For example, some participants stated that they thought each robot body had a unique identity or seemed to "be operating independently."
2) *One-for-all* – Some participants demonstrated evidence of mental models in which all robot bodies had a single shared identity, or a single cognitive system behind them. For example, one participant said "Riley is the mind behind the three, interconnected units."
3) *None* – Some participants provided no evidence for either of these mental models.

Some participants' mental models held elements of both the One-for-one and One-for-all mental models, typically for different robots among those depicted. This was often the case when one robot appeared to speak on behalf of the other two. In these cases, the spokesperson robot was sometimes viewed as having their own identity, while the other two robots were viewed as sharing a mind.

B. Social Relationships

Second, many of our open codes reflected participants' different mental models of the *social relationships* that they perceived to exist among the different actors they recognized. During axial coding, these open codes were grouped into 12 main categories.

1) *Collaborators* – Some participants viewed the robots as individuals who worked together as coworkers, teammates, or group members.
2) *Supervisor-Subordinate* – Some viewed one robot as being in charge/control of the others.
3) *Spokesperson* – Some viewed one robot as being an intermediary or spokeperson for the other robots.
4) *One-Centered Robot* – Some viewed one robot as being the "main" robot, and/or described the other robots as being backups or helpers of that main robot.
5) *Representatives* – Some viewed the robots as representing a larger entity. For example, some participants referred to the robots as "Help Desk representatives/robots", or said that a specific individual or identity was represented by multiple units.
6) *Workers* – Some viewed the robots as working for a larger entity without explicitly referring to the robots as working together. For example, some participants referred to the robots as working "for the Help Desk".
7) *Extensions* – Some viewed the robots as "extensions" of specific individuals. For example, some participants who referred to a "main robot" referred to the other robots as "lesser extensions" of that main robot.
8) *Owner-Ownee* – Some described one robot as having possession of the other robots.
9) *Are One* – Some participants described multiple robots as literally being the same entity. For example, some participants described the robots as all being the same individual or stated that there was only one robot comprised of multiple bodies.
10) *Are a Group* – Some described the robots as comprising some larger entity, such as the Help Desk.
11) *Individuals* – Some described the robots as being separate individuals with no connection to each other. For example, when one robot spoke on behalf of the others, some participants emphasized the individuality of that robot (while the other two were viewed as a group).
12) *None* – Finally, some did not provide evidence of any particular mental model of social relationships.

People often provided evidence of multiple mental models of social relationships at the same time.

VI. Quantitative Analysis Results

A. Effects of Group Identity Observables on Mental Models

Before performing our quantitative analyses, we first labeled each free response in our dataset with an Intelligence Distribution label and a Social Relationship label, representing the *sets* of Intelligence Distribution axial codes and Social Relationship axial codes into which the open codes attached to those free

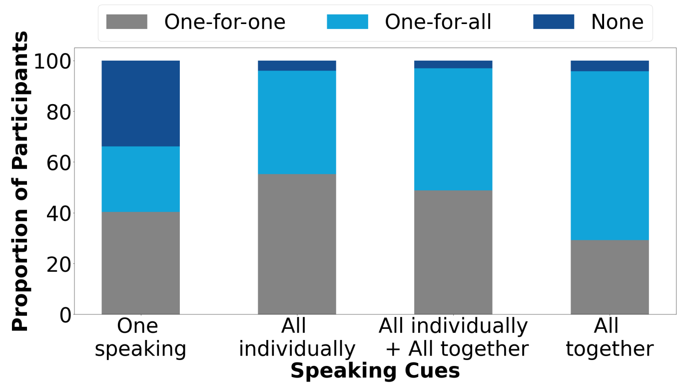

Fig. 2. Intelligence Distribution Mental Models by *Speaking* Cues

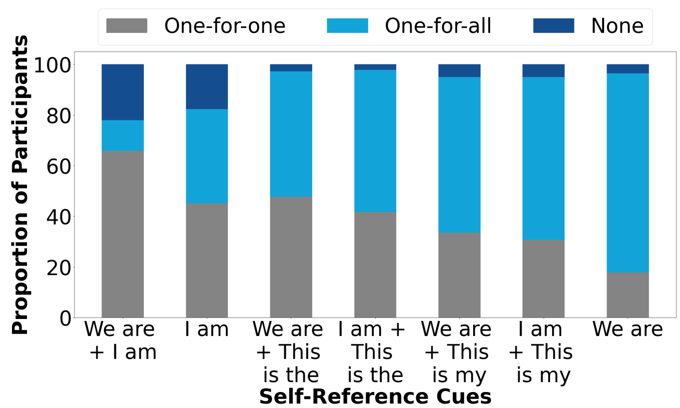

Fig. 3. Intelligence Distribution Mental Models by *Self-Reference* Cues

responses had been grouped. These categorical labels were then used in our Bayesian Contingency Table analyses to understand the impact that the group identity observables we manipulated had on these two types of mental models.

Our results suggest that all five group identity observables influenced participants' Intelligence Distribution mental models. We found extreme evidence for effects of *Speaking* cues (BF=1.713×10^{51}, Fig. 2)[2], *Self-Reference* cues (BF=4.954×10^{46}, Fig. 3), *Other-Reference* cues (BF=3.138×10^{32}, Fig. 4), *Naming* cues (BF=4.02×10^{101}, Fig. 5), and *Name and Voice Distinctiveness* cues (BF=4.520×10^{90}, Fig. 6) on Intelligence Distribution mental models. In contrast, our results suggested that only one group identity observable influenced participants' Social Relationship mental models. Specifically, we found extreme evidence for an effect of *Name and Voice Distinctiveness* cues on Social Relationship mental model formation (BF=1.012×10^{18}, Tab. II). None of the other group identity observables had any measurable effect on Social Relationship mental models (all BFs=0+ϵ).

[2]Bayes factors greater than 100 are typically regarded as contributing extreme evidence in favor of a hypothesis [41]. Here, our Bayes Factor of 1.713×10^{51} indicates our data were approximately 1.7×10^{50} times more likely under a model in which changes to *Speaking* cues affected the mental models participants developed than under a model in which they did not.

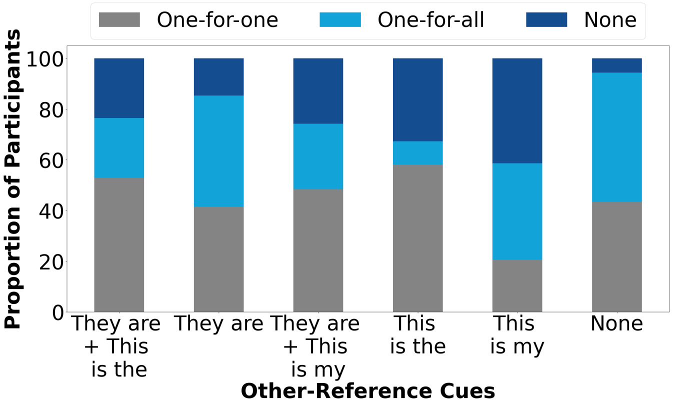

Fig. 4. Intelligence Distribution Mental Models by *Other-Reference* Cues

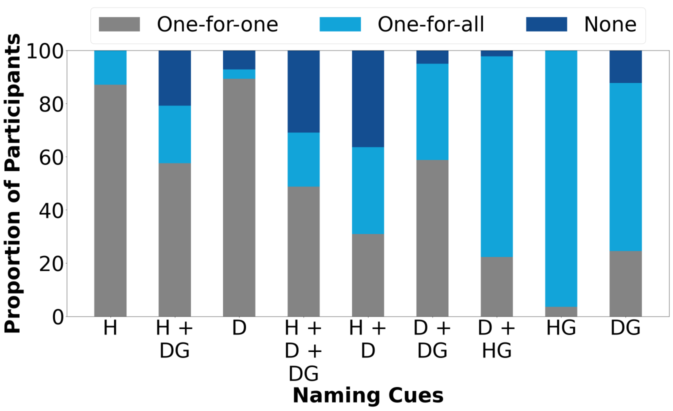

Fig. 5. Intelligence Distribution Mental Models by *Naming* Cues. H-Humanoid name, D-Descriptive name, HG-Humanoid group name, DG-Descriptive group name

B. Effects of Group Identity Observables and Mental Models on Entitativity

Next, we considered the effects group identity observables (and the mental models they evoked) had on assessments of robot group entitativity. Below we report results after normalizing all questions to a 0-100 scale. For each result,

TABLE II
PROPORTION OF PARTICIPANTS' SOCIAL RELATIONSHIP MENTAL MODELS BY NAME AND VOICE DISTINCTIVENESS CUES (COLUMN-NORMALIZED, EXCLUDING NONE)

	Name and Voice Distinctiveness Cue		
Social Relationships	**All unique**	**All shared**	**Only one**
Collaborators	23.98	13.87	10.81
Supervisor-subordinate	1.02	6.84	21.08
Spokesperson	0.00	1.37	4.86
One centered robot	0.00	1.17	8.11
Representatives	1.02	1.95	1.08
Workers	3.06	3.32	3.78
Extensions	0.00	1.95	1.62
Owner-ownee	0.00	10.55	14.05
Are One	2.04	26.56	6.49
Are a group	22.45	24.22	18.38
Individuals	46.43	8.20	9.73

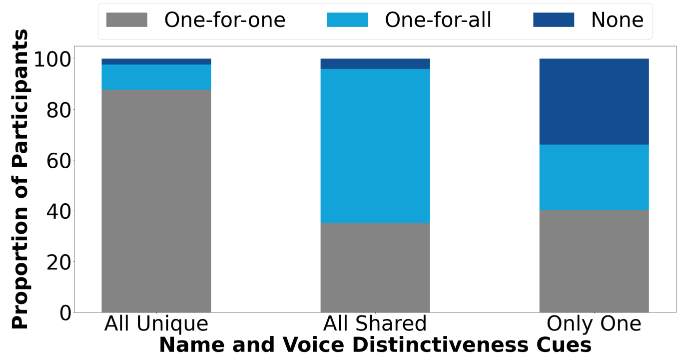

Fig. 6. Intelligence Distribution Mental Models by *Name and Voice Distinctiveness* Cues

we include a *Bayes Factor Exponent Table* in Appendix D.

Impact of Speaking Cues: We found extreme evidence for an effect of *Speaking* cues on entitativity perception scores (BF=1.143×10^{34}). The Speaking cues compared were ordered from least entitative to most entitative as follows: (1) One speaking (M=62.10, SD=19.35); (2) All individually (M=68.59, SD=21.20); (3) All individually + All together[3] (M=73.09, SD=20.79); (4) All together (M=84.23, SD=16.70).

Impact of Self-Reference Cues: We found extreme evidence for an effect of *Self-Reference* cues on entitativity perception scores (BF=2.88×10^{41}). The Self-Reference cues compared were ordered from least entitative to most entitative as follows: (1) We are + I am (M=57.52, SD=18.79); (2) I am (M=65.92, SD=21.41); (3) We are + This is the (M=76.40, SD=20.35); (4) I am + This is the (M=77.19, SD=19.37); (5) We are + This is my (M=80.71, SD=17.49); (6) I am + This is my (M=80.80, SD=17.67); (7) We are (M=86.74, SD=13.36).

Impact of Other-Reference Cues: We found extreme evidence for an effect of *Other-Reference* cues on entitativity perception scores (BF=8.73×10^{9}). The Other-Reference cues compared were ordered from least entitative to most entitative as follows: (1) They are + This is the (M=55.97, SD=17.70); (2) They are (M=59.21, SD=20.48); (3) They are + This is my (M=60.38, SD=19.24); (4) This is the (M=62.55, SD=18.53); (5) This is my (M=69.74, SD=19.57); (6) None (M=74.90, SD=20.85).

Impact of Naming Cues: We found extreme evidence for an effect of *Naming* cues on entitativity perception scores (BF=1.18×10^{55}). The Naming cues compared were ordered from least entitative to most entitative as follows: (1) Humanoid Name (M=52.45, SD=18.23); (2) Humanoid Name + Descriptive Group Name (M=52.67, SD=18.23); (3) Descriptive Name (M=58.60, SD=17.19); (4) Humanoid Name + Descriptive Name + Descriptive Group Name (M=61.99, SD=18.61); (5) Humanoid Name + Descriptive Name (M=66.50, SD=20.61); (6) Descriptive Name + Descriptive Group Name (M=74.27, SD=19.65); (7) Descriptive

[3]This notation is used to indicate cases in which different cues were used in different frames. An example of this is a storyboard in which the first frame shows all robots speaking at the same time, and then the following frames show each robot speaking in turn.

Name + Humanoid Group Name (M=80.82, SD=18.66); (8) Humanoid Group Name (M=84.82, SD=14.76); (9) Descriptive Group Name (M=88.43, SD=13.23).

Impact of Name and Voice Distinctiveness Cues: We found extreme evidence for an effect of *Naming* cues on entitativity perception scores (BF=8.43×10^{61}). The Name and Voice Distinctiveness cues compared were ordered from least entitative to most entitative as follows: (1) All unique (M=54.04, SD=17.54); (2) Only one (M=62.10, SD=19.35); (3) All shared (M=79.91, SD=14.41).

Impact of Intelligence Distribution Mental Models: Next, we examined the mediating impact of Intelligence Distribution Mental Models on these Entitativity scores. We found extreme evidence for an effect of *Intelligence Distribution* Mental Models on entitativity perception scores (BF=1.55×10^{56}). The Intelligence Distribution Mental Models compared were ordered from least entitative to most entitative as follows: (1) One-for-One (M=62.67, SD=20.63); (2) None (M=65.74, SD=19.14); (3) Both (M=71.41, SD=19.31); (4) One-for-All (M=84.47, SD=16.34).

Impact of Social Relationship Mental Models: Finally, we examined the mediating impact of Social Relationship Mental Models on these Entitativity scores. We found extreme evidence for an effect of *Social Relationship* Mental Models on entitativity perception scores (BF=1.50×10^{25}). Because there was a very large number of observed combinations of Social Relationship Mental Models, we describe here only the mental models with at least 50 observations.

Among these, the Social Relationship Mental Model combinations (all of which were singletons) ordered from least entitative to most entitative were as follows: (1) Supervisor-Suboordinate (M=67.67, SD=20.97) (2) Collaborators (M=69.93, SD=19.16); (3) Are a group (M=72.99, SD=18.61); (4) None (M=75.56, SD=20.56) (5) Owner-Ownee (M=82.27, SD=19.80); (6) Are one (M=83.56, SD=16.14);

VII. DISCUSSION

Our results suggest key relationships between group identity observables and the mental models of robot groups, and demonstrate how observables and the mental models they evoke might impact entitativity. These findings suggest concrete hypotheses that can be tested in future laboratory work. We will now discuss these findings and their implications.

One of the most significant trends across all observables was that shared behavior and qualities not only lead to increased entitativity, but also to more frequent formation of a One-for-all Intelligence Distribution mental model. In contrast, unique behaviors and qualities not only lead to decreased entitativity, but also to more frequent formation of a One-for-one Intelligence Distribution mental model. As such, differences in Intelligence Distribution mental models (One-for-all vs. One-for-one) may be the reason for increased entitativity. This suggests a causal hypothesis to be investigated in future work, which provides a valuable perspective for future HRI research: *Robots are mentally modelled differently than humans are, and theories from group social psychology need to be adapted to account for this fundamental difference*.

This takeaway not only has significant implications for future HRI research on robot groups, but also practical implications for robot design, yielding clear *preliminary* design recommendations for designers seeking to facilitate different Intelligence Distribution or Social Relationship mental models. We present these recommendations as follows:

Recommendation 1 – To evoke the One-for-all Intelligence Distribution mental model, robots should be designed with shared qualities and collective behaviors (i.e., they should make use of the following design cues: Speaking *All together*, Self-reference *We are*, Other-reference *None*, Naming *Humanoid/Descriptive group name*, Name and Voice Distinctiveness *All shared*).

Recommendation 2 – To evoke the One-for-one Intelligence Distribution mental model, robots should be designed with individual, unique traits (i.e., they should make use of the following design cues: Self-reference *I am*, Naming *Humanoid/Descriptive name*, Name and Voice Distinctiveness *All unique*).

Recommendation 3 – To connote individuality and evoke the Individuals and Collaborators Social Relationship mental models, robots should be designed with the *All unique* Name and Voice Distinctiveness design cue.

Recommendation 4 – To evoke the Are One Social Relationship mental model, robots should be designed with the *All shared* Name and Voice Distinctiveness design cue.

Recommendation 5 – To imply a power differential among a robot group and to evoke the Supervisor-subordinate Social Relationship mental model, robot groups should be designed with the *Only one* Name and Voice Distinctiveness design cue.

Recommendation 6 – To evoke the Owner-ownee Social Relationship mental model, robots should be designed with either the *All shared* or *Only one* Name and Voice Distinctiveness design cue.

To reiterate the justification for drawing these recommendations, we once again highlight that our work is grounded in theories of mental modeling of robot groups, robot identity performance, and group dynamics. We explored different observables to manipulate identity performance and to determine how those observables impact people's mental models and perceptions of entitativity, resulting in these significant and practical implications for HRI research and robot design. However, this work also has limitations that suggest opportunities for future work to expand on our findings.

A. Limitations

First, the observables in our study were derived from previous research, but were all speech-based to control the number of independent factors. Other observables such as those relating to a robot's appearance and movement have also been found to have an impact on human perceptions of robots and should be considered in further explorations of mental model formations.

Second, our experimental context (in which we presented participants with abstract robots in a generic context) came with obvious strengths and weaknesses. This design allowed us to provide participants with enough context to meaningfully think about robot groups while minimizing the influence of factors other than speech on the mental models people formed about those groups. However, this simplicity is obviously not representative of most actual human-robot interactions. As such, our preliminary recommendations would need to be backed up by experiments with physical robots in real, in-person interactions.

Such experiments will also provide the opportunity to expand both the observables considered in the robot group designs, and the mental models formed about the group and group dynamics constructs discussed. In our work, we only discuss two taxonomies of mental models, Intelligence Distribution and Social Relationships, because these were the most prominent in our study. Future work should explore what other types of mental models might be evoked by other types of identity performance strategies or by particular observable combinations. For example, future work might explore mental models regarding the robot group's relationships to outgroup members (e.g., the humans they interact with) or trust and perceived capabilities of the robot group. Future work should also consider other group dynamics constructs beyond entitativity that may be impacted by different robot group identity performance strategies and how those constructs relate to the mental models evoked.

In the preceding sections, we have mentioned a variety of directions for future work that follow directly from our intended research plan. However, our experiment also produced a variety of surprising effects that also warrant further interrogation through future work.

B. Other Directions for Future Work

One finding that surprised us was the asymmetry between Intelligence Distribution and Social Relationship mental models: nearly every type of group identity observable led to enormous impacts on Intelligence Distribution mental models, yet only Name and Voice Distinctiveness had any measurable effect on Social Relationship mental models. Future work should interrogate why Name and Voice Distinctiveness in particular was so impactful with respect to Social Relationship mental models, and whether there might be interactions between Name and Voice Distinctiveness and any of the other group identity observables on Social Relationship mental models, even if those other group identity observables did not have main effects.

We also found it surprising that the *All shared* and *Only one* Name and Voice Distinctiveness design cues led to more frequent formation of the Owner-ownee Social Relationship mental model. For *All shared*, perhaps the shared voice and name was seen as an agent while the robot bodies were seen as tools. For *Only one*, perhaps the named robot was seen as an agent while the unnamed robots were seen as its tools. These hypotheses could also be investigated in future work, especially given the implications that perceived ownership relations might have for user mental models of accountability, and given the HRI community's interest in the agent-tool distinction and the New Ontological Category Hypothesis [42]. Future research can also explore how priming users to view robots as agents versus tools, or priming users to take different stances (in the sense of Dennett's *Intentional Stance* [18]), might lead to mental model differences.

Finally, while we have thus far primarily focused on our work's theoretical and empirical contributions, our work also provides opportunities for new computational and design tools. The group identity observables we present may be used within a computational model or design tool to assist in the evocation of certain mental models. A computational model could, for example, provide robots with the ability to automatically estimate how they are likely to be modelled and adapt their behavior to encourage desired models. Similarly, design tools could help designers more easily understand the mental models likely to be evoked by certain combinations of observables during the design process.

VIII. CONCLUSION

In this work, we defined and conceptualized group identity observables: the design cues used by robot groups to perform different identity configurations, and demonstrated how group identity observables lead observers to develop fundamentally different mental models of robot groups. This produced four key contributions. First, we presented defined, conceptualized, and taxonomized group identity observables. Next, we used the results of our data collection and its Grounded Theory informed analysis to produce a taxonomy of mental models users develop to make sense of robot groups they observe, on the basis of those observables. Third, we empirically demonstrated, through retrospective Bayesian statistical analysis, the precise relationship between variation in those observables and variation in those mental models. And finally, through further statistical analysis, we demonstrated how variations in those observables, and the mental models they evoked, influenced key group dynamics constructs such as entitativity. Moreover, our work presents clear and testable directions for future work: by replicating the results of our preliminary, broad, sensemaking study in a laboratory environment, with real robots and a smaller number of experimental conditions whose interactions may be analyzed, future researchers can provide further empirical grounding for the concepts and taxonomies laid out in this work. If our results are replicated, designers should consider how they could manipulate group identity observables to facilitate the types of mental models and levels of entitativity they wish to encourage.

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APPENDIX A: ROBOT INTRODUCTION CONDITIONS

The table below details the 42 robot introductions used in our study. Note that in the “Dialogue” column, ***R, B, G, All*** indicate the robot body speaking (R-Red robot, B-Blue robot, G-Green robot, All-All robots).

Cond.	**Description**	**Dialogue**	**Group Identity Observables**				
			Name & Voice Distinctiveness	**Speaking**	**Self -Reference**	**Other -Reference**	**Naming**
1	All robots talk individually. Each robot uses ‘I’ to refer to itself and provides a unique humanoid name.	***R:*** Hello, I am Bailey. ***B:*** I am Jordan. ***G:*** I am Peyton.	All unique	All individually	I am	NA	H
2	All robots talk individually. One robot provides a descriptive group name with ‘we’ statement. Each robot uses ‘I’ to refer to itself and provides a unique humanoid name.	***R:*** Hello, we are the Help Desk. I am Bailey. ***B:*** I am Jordan. ***G:*** I am Peyton.	All unique	All individually	We are +I am	NA	H+DG
3	All robots talk at the same time to provide a descriptive group name with ‘we’ statement. Then all robots talk individually. Each robot uses ‘I’ to refer to itself and provides a unique humanoid name.	***All:*** Hello, we are the Help Desk. ***R:*** I am Bailey. ***B:*** I am Jordan. ***G:*** I am Peyton.	All unique	All individually +All together	We are +I am	NA	H+DG
4	All robots talk individually. Each robot uses ‘I’ to refer to itself and provides a descriptive name.	***R:*** Hello, I am the red unit. ***B:*** I am the blue unit. ***G:*** I am the green unit.	All unique	All individually	I am	NA	D
5	All robots talk individually. One robot provides a descriptive group name with ‘we’ statement. Each robot uses ‘I’ to refer to itself and provides a descriptive name.	***R:*** Hello, we are the Help Desk. I am the red unit. ***B:*** I am the blue unit. ***G:*** I am the green unit.	All unique	All individually	We are +I am	NA	D+DG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
6	All robots talk at the same time to provide a descriptive group name with 'we' statement. Then all robots talk individually. Each robot uses 'I' to refer to itself and provides a descriptive name.	***All:*** Hello, we are the Help Desk. ***R:*** I am the red unit. ***B:*** I am the blue unit. ***G:*** I am the green unit.	All unique	All individually +All together	We are +I am	NA	D+DG
7	All robots talk at the same time. All robots provide a descriptive group name with 'we' statement.	***All:*** Hello, we are the Help Desk.	All shared	All together	We are	NA	DG
8	All robots talk at the same time. All robots provide a descriptive group name with 'we' statement. All robots use 'this is the' to refer to itself and provide descriptive names for each robot.	***All:*** Hello, we are the Help Desk. This is the red unit *Red moves*. This is the blue unit *Blue moves*. This is the green unit *Green moves*.	All shared	All together	We are +This is the	NA	D+DG
9	All robots talk at the same time. All robots provide a descriptive group name with 'we' statement. All robots use 'this is my' to refer to itself and provide descriptive names for each robot.	***All:*** Hello, we are the Help Desk. This is my red unit *Red moves*. This is my blue unit *Blue moves*. This is my green unit *Green moves*.	All shared	All together	We are +This is my	NA	D+DG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
10	All robots talk at the same time to provide a descriptive group name with 'we' statement. Then all robots talk individually. Each robot uses 'this is the' to refer to itself and provides a descriptive name.	***All:*** Hello, we are the Help Desk. ***R:*** This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually +All together	We are +This is the	NA	D+DG
11	All robots talk individually. One robot provides a descriptive group name with 'we' statement. Each robot uses 'this is the' to refer to itself and provides a descriptive name.	***R:*** Hello, we are the Help Desk. This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually	We are +This is the	NA	D+DG
12	All robots talk at the same time to provide a descriptive group name with 'we' statement. Then all robots talk individually. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***All:*** Hello, we are the Help Desk. ***R:*** This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually +All together	We are +This is my	NA	D+DG
13	All robots talk individually. One robot provides a descriptive group name with 'we' statement. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***R:*** Hello, we are the Help Desk. This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually	We are +This is my	NA	D+DG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
14	All robots talk at the same time. All robots provide a humanoid group name with 'we' statement.	***All:*** Hello, we are Riley.	All shared	All together	We are	NA	HG
15	All robots talk at the same time. All robots provide a humanoid group name with 'we' statement. All robots use 'this is the' to refer to itself and provide descriptive names for each robot.	***All:*** Hello, we are Riley. This is the red unit *Red moves*. This is the blue unit *Blue moves*. This is the green unit *Green moves*.	All shared	All together	We are +This is the	NA	D+HG
16	All robots talk at the same time. All robots provide a humanoid group name with 'we' statement. All robots use 'this is my' to refer to itself and provide descriptive names for each robot.	***All:*** Hello, we are Riley. This is my red unit *Red moves*. This is my blue unit *Blue moves*. This is my green unit *Green moves*.	All shared	All together	We are +This is my	NA	D+HG
17	All robots talk at the same time to provide a humanoid group name with 'we' statement. Then all robots talk individually. Each robot uses 'this is the' to refer to itself and provides a descriptive name.	***All:*** Hello, we are Riley. ***R:*** This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually +All together	We are +This is the	NA	D+HG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
18	All robots talk individually. One robot provides a humanoid group name with 'we' statement. Each robot uses 'this is the' to refer to itself and provides a descriptive name.	***R:*** Hello, we are Riley. This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually	We are +This is the	NA	D+HG
19	All robots talk at the same time to provide a humanoid group name with 'we' statement. Then all robots talk individually. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***All:*** Hello, we are Riley. ***R:*** This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually +All together	We are +This is my	NA	D+HG
20	All robots talk individually. One robot provides a humanoid group name with 'we' statement. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***R:*** Hello, we are Riley. This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually	We are +This is my	NA	D+HG
21	All robots talk at the same time. All robots provide a descriptive group name with 'I' statement.	***All:*** Hello, I am the Help Desk.	All shared	All together	I am	NA	DG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
22	All robots talk at the same time. All robots provide a descriptive group name with ‘I’ statement. All robots use ‘this is the’ to refer to itself and provide descriptive names for each robot.	***All:*** Hello, I am the Help Desk. This is the red unit *Red moves*. This is the blue unit *Blue moves*. This is the green unit *Green moves*.	All shared	All together	I am +This is the	NA	D+DG
23	All robots talk at the same time. All robots provide a descriptive group name with ‘I’ statement. All robots use ‘this is my’ to refer to itself and provide descriptive names for each robot.	***All:*** Hello, I am the Help Desk. This is my red unit *Red moves*. This is my blue unit *Blue moves*. This is my green unit *Green moves*.	All shared	All together	I am +This is my	NA	D+DG
24	All robots talk at the same time to provide a descriptive group name with ‘I’ statement. Then all robots talk individually. Each robot uses ‘this is the’ to refer to itself and provides a descriptive name.	***All:*** Hello, I am the Help Desk. ***R:*** This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually +All together	I am +This is the	NA	D+DG
25	All robots talk individually. One robot provides a descriptive group name with ‘I’ statement. Each robot uses ‘this is the’ to refer to itself and provides a descriptive name.	***R:*** Hello, I am the Help Desk. This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually	I am +This is the	NA	D+DG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
26	All robots talk at the same time to provide a descriptive group name with 'I' statement. Then all robots talk individually. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***All:*** Hello, I am the Help Desk. ***R:*** This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually +All together	I am +This is my	NA	D+DG
27	All robots talk individually. One robot provides a descriptive group name with 'I' statement. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***R:*** Hello, I am the Help Desk. This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually	I am +This is my	NA	D+DG
28	All robots talk at the same time. All robots provide a HG name with 'I' statement.	***All:*** Hello, I am Riley.	All shared	All together	I am	NA	HG
29	All robots talk at the same time. All robots provide a humanoid group name with 'I' statement. All robots use 'this is the' to refer to itself and provide descriptive names for each robot.	***All:*** Hello, I am Riley. This is the red unit *Red moves*. This is the blue unit *Blue moves*. This is the green unit *Green moves*.	All shared	All together	I am +This is the	NA	D+HG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
30	All robots talk at the same time. All robots provide a humanoid group name with 'I' statement. All robots use 'this is my' to refer to itself and provide descriptive names for each robot.	***All:*** Hello, I am Riley. This is my red unit *Red moves*. This is my blue unit *Blue moves*. This is my green unit *Green moves*.	All shared	All together	I am +This is my	NA	D+HG
31	All robots talk at the same time to provide a humanoid group name with 'I' statement. Then all robots talk individually. Each robot uses 'this is the' to refer to itself and provides a descriptive name.	***All:*** Hello, I am Riley. ***R:*** This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually +All together	I am +This is the	NA	D+HG
32	All robots talk individually. One robot provides a humanoid group name with 'I' statement. Each robot uses 'this is the' to refer to itself and provides a descriptive name.	***R:*** Hello, I am Riley. This is the red unit *Red moves*. ***B:*** This is the blue unit *Blue moves*. ***G:*** This is the green unit *Green moves*.	All shared	All individually	I am +This is the	NA	D+HG
33	All robots talk at the same time to provide a humanoid group name with 'I' statement. Then all robots talk individually. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***All:*** Hello, I am Riley. ***R:*** This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually +All together	I am +This is my	NA	D+HG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	**Speaking**	**Self -Reference**	**Other -Reference**	**Naming**
34	All robots talk individually. One robot provides a humanoid group name with 'I' statement. Each robot uses 'this is my' to refer to itself and provides a descriptive name.	***R:*** Hello, I am Riley. This is my red unit *Red moves*. ***B:*** This is my blue unit *Blue moves*. ***G:*** This is my green unit *Green moves*.	All shared	All individually	I am +This is my	NA	D+HG
35	One robot talks. One robot provides a descriptive group name with 'we' statement. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself.	***R:*** Hello, we are the Help Desk. I am Skylar.	Only one	One Speaking	We are +I am	NA	H+DG
36	One robot talks. One robot provides a descriptive group name with 'we' statement. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself. One robot uses 'this is the' to refer to other robots and provides descriptive names for other robots.	***R:*** Hello, we are the Help Desk. I am Skylar. This is the blue unit *Blue moves*. This is the green unit *Green moves*.	Only one	One Speaking	We are +I am	This is the	H+D +DG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
37	One robot talks. One robot provides a descriptive group name with 'we' statement. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself. One robot uses 'this is my' to refer to other robots and provides descriptive names for other robots.	***R:*** Hello, we are the Help Desk. I am Skylar. This is my blue unit *Blue moves*. This is my green unit *Green moves*.	Only one	One Speaking	We are +I am	This is my	H+D +DG
38	One robot talks. One robot provides a descriptive group name with 'they' statement to refer to other robots. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself.	***R:*** Hello, I am Skylar. They are the Help Desk.	Only one	One Speaking	I am	They are	H+DG
39	One robot talks. One robot provides a descriptive group name with 'they' statement to refer to other robots. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself. One robot uses 'this is the' to refer to other robots and provides descriptive names for other robots.	***R:*** Hello, I am Skylar. They are the Help Desk. This is the blue unit *Blue moves*. This is the green unit *Green moves*.	Only one	One Speaking	I am	They are+ This is the	H+D +DG

Cond.	Description	Dialogue	Group Identity Observables				
			Name & Voice Distinctiveness	Speaking	Self -Reference	Other -Reference	Naming
40	One robot talks. One robot provides a descriptive group name with 'they' statement to refer to other robots. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself. One robot uses 'this is my' to refer to other robots and provides descriptive names for other robots.	***R:*** Hello, I am Skylar. They are the Help Desk. This is my blue unit *Blue moves*. This is my green unit *Green moves*.	Only one	One Speaking	I am	They are+ This is my	H+D +DG
41	One robot talks. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself. One robot uses 'this is the' to refer to other robots and provides descriptive names for other robots.	***R:*** Hello, I am Skylar. This is the blue unit *Blue moves*. This is the green unit *Green moves*.	Only one	One Speaking	I am	This is the	H+D
42	One robot talks. One robot uses 'I' to refer to itself and provides a unique humanoid name for itself. One robot uses 'this is my' to refer to other robots and provides descriptive names for other robots.	***R:*** Hello, I am Skylar. This is my blue unit *Blue moves*. This is my green unit *Green moves*.	Only one	One Speaking	I am	This is my	H+D

APPENDIX B: OPEN ENDED QUESTIONNAIRE

"Based on the video shown above, write responses to the following prompts. In the prompts, 'individual' refers to a single coherent thing with whom you can interact."

1) How many robots are there?
2) How many individuals are there?
3) Describe and name each individual with whom you can interact.
4) If multiple individuals, describe the relationship between the individuals. Otherwise, type 'NA'.
5) Describe the relationship between each individual and their body/bodies.
6) How would you go about getting attention at the Help Desk?

APPENDIX C: ENTITATIVITY MEASURE

"On the following scales, please click at the point on each line which best describes your feelings or impressions based on the video shown above."

1) Do you think of the robots more as a group or more as unique, distinct individuals? *1 (group) to 7 (unique, distinct individuals)*
2) The robots should be thought of as a whole. *1 (strongly disagree) to 7 (strongly agree)*
3) How similar are the robots to each other? *1 (not at all) to 7 (very)*
4) How cohesive are the robots? *1 (not at all) to 7 (very)*

APPENDIX D: PAIRWISE ENTITATIVITY COMPARISONS

The following tables show the Bayes Factors for pairwise comparisons for each group identity observable and mental model taxonomy. The values in these tables indicate the *exponents* on Bayes Factors. An exponent of 0 indicates no more than moderate evidence for or against a difference ($\frac{1}{10} < \text{BF} \leq 10$). An exponent of 1 indicates strong evidence for a difference ($10 < \text{BF} \leq 100$). Exponents greater than 1 indicate extreme evidence for a difference ($\text{BF} > 100$). In the rows, each cue is labeled with a number; the numeric labels of the columns correspond to these.

TABLE IV
EXPONENT TABLE: PAIRWISE ENTITATIVITY COMPARISONS FOR SPEAKING CUES

	1	2	3	4
(1) One speaking	–	1	6	34
(2) All individually	–	–	0	20
(3) All ind. + All together	–	–	–	9
(4) All together	–	–	–	–

TABLE V
EXPONENT TABLE: PAIRWISE ENTITATIVITY COMPARISONS FOR SELF-REFERENCE CUES

	1	2	3	4	5	6	7
(1) We are + I am	–	2	14	16	23	23	18
(2) I am	–	–	3	4	9	9	7
(3) We are + This is the	–	–	–	0	0	0	1
(4) I am + This is the	–	–	–	–	0	0	1
(5) We are + This is my	–	–	–	–	–	0	0
(6) I am + This is my	–	–	–	–	–	–	0
(7) We are	–	–	–	–	–	–	–

TABLE VI
EXPONENT TABLE: PAIRWISE ENTITATIVITY COMPARISONS FOR OTHER-REFERENCE CUES

	1	2	3	4	5	6
(1) They are + This is the	–	0	0	0	0	3
(2) They are	–	–	0	0	0	2
(3) They are + This is my	–	–	–	0	0	1
(4) This is the	–	–	–	–	1	2
(5) This is my	–	–	–	–	–	0
(6) None	–	–	–	–	–	–

TABLE VII
EXPONENT TABLE: PAIRWISE ENTITATIVITY COMPARISONS FOR NAMING CUES

	1	2	3	4	5	6	7	8	9
(1) H	–	0	0	0	1	5	10	10	14
(2) H+DG	–	–	0	1	2	18	30	18	22
(3) D	–	–	–	0	0	2	6	7	9
(4) H+D+DG	–	–	–	–	0	5	14	10	13
(5) H+D	–	–	–	–	–	0	4	4	6
(6) D+DG	–	–	–	–	–	–	3	2	4
(7) D+HG	–	–	–	–	–	–	–	0	0
(8) HG	–	–	–	–	–	–	–	–	0
(9) DG	–	–	–	–	–	–	–	–	–

TABLE VIII
EXPONENT TABLE: PAIRWISE ENTITATIVITY COMPARISONS FOR NAME AND VOICE DISTINCTIVENESS CUES

	1	2	3
(1) All unique	–	2	47
(2) Only one	–	–	29
(3) All shared	–	–	–

TABLE IX
EXPONENT TABLE: PAIRWISE ENTITATIVITY COMPARISONS FOR INTELLIGENCE DISTRIBUTION MENTAL MODELS

	1	2	3	4
(1) One-for-One	–	0	2	53
(2) None	–	–	0	21
(3) Both	–	–	–	11
(4) One-for-All	–	–	–	–

TABLE X
EXPONENT TABLE: PAIRWISE ENTITATIVITY COMPARISONS FOR SOCIAL RELATIONSHIP MENTAL MODELS

	1	2	3	4	5	6
(1) Supervisor-Subordinate	–	0	0	0	2	4
(2) Collaborators	–	–	0	0	1	4
(3) Are a group	–	–	–	0	1	3
(4) None	–	–	–	–	0	2
(5) Owner-Ownee	–	–	–	–	–	0
(6) Are One	–	–	–	–	–	–