The Similarity-Attraction Effect in Human-Robot Interaction

Emily P. Bernier and Brian Scassellati

Abstract— **Constructing valid robotic models of social development requires that we accurately characterize the social learning and interaction that can take place between a robotic agent and a human adult. To that end, this study examined the effect of perceived attitudinal similarity on human-robot interaction. 28 participants rated toys by order of preference and then interacted with a small, socially-expressive robot to determine the robot's preferences for the same toys. The robot displayed either the same preferences as the participant or exactly the opposite preferences. Participants in the Similar-Preferences condition rated the robot as significantly friendlier than did participants in the Dissimilar-Preferences condition. However, there was no difference between conditions in how participants rated their enjoyment of the interaction. These findings have interesting implications for human-robot interaction studies in general, and for work in robotic models of developmental social cognition specifically.**

Index Terms—**Embodied Cognition, Human-Robot Interaction, Social and Emotional Development**

I. Introduction

One of the long-term goals of our social robotics group is to construct and validate models of social development. A significant obstacle to the development of these models, as opposed to models of other developmentally-acquired skills such as hand-eye coordination, is that they require a second, typically more mature agent that serves as the parent/instructor. It follows, then, that we need a mature version of the model in order to create the novice model.

To bypass this contradiction, we instead rely on extant examples of these mature, socially-interactive models (in the form of human adults) as part of the developmental structure. However, this approach requires that a robotic model be able to engage an adult in an interaction that is typical of adult-child interactions between two humans. This assumption (that human adults will treat our robots and computational models as if they were human infants) can be tenuous at best. To support the validity of this supposition, we must demonstrate that the same kinds of effects that dominate human-human interactions, particularly those that are essential for social learning, are present in human-robot interactions. Accordingly, the present experiment attempts to reconstruct one of the most basic social effects that occurs in human-human interactions, the similarity-attraction effect, in interactions involving an adult human and a novice robot.

The principle of similarity-attraction states that people are attracted to others when they perceive those others to be similar to themselves. It has been shown, for instance, that initial interpersonal attraction is positively correlated with the number of similar attitudes that two people hold [1]. The effect has been demonstrated in a wide range of settings and interpersonal situations; similarity on any of a range of dimensions, such as behavior, personality, or background, is often sufficient to spark initial attraction, increase liking, and/or motivate further interactions [2]-[7].

Similarity-attraction is also at work in the interactions of children. Attitudinal similarity has been shown to correlate with interpersonal attraction in both young children and adolescents [8]. In fact, attitudinal similarity in school-age children has been found to be a linear predictor of initial attraction; the linear relationship is identical to that found in adults [9]. Young children have also been shown to form interpersonal preferences based on behavioral similarity, particularly in the realms of social behavior [10]

This strong and pervasive effect, present throughout the developmental cycle, is an obvious candidate for human-robot interaction studies. The simplicity of the effect makes it ideal for such work, as it could potentially provide a basic and dependable way of influencing interactions. Past human-technology interaction work on similarity-attraction has focused primarily on personality similarity, with an emphasis on introversion/extroversion and submissiveness/dominance. Nass and colleagues showed that participants classified as submissive significantly preferred interacting with a computer programmed to behave in a submissive manner, while dominant participants largely preferred interacting with a more dominant computer [11]. Later work with computerized voices showed that extroverted participants were more likely to like, trust, and follow the advice of an extroverted voice, while introverted participants preferred when the computerized voice was more introverted [12]. In terms of embodied agents, it has been shown that people prefer interacting with an assistive robot whose personality matches their own;

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extroverted participants were willing to spend longer interacting with an extroverted robot than with an introverted one [13].

However, with respect to personality, support for the similarity-attraction effect in human-robot interaction has not been unanimous. Lee and colleagues studied interactions between human subjects and a small robotic dog, and found that a *complementary*-attraction effect was the dominant force [14]. Extroverted participants rated the introverted robot as more intelligent and socially attractive than the extroverted robot, while introverted participants preferred the extroverted robot. In another study, Isbister and Nass showed that participants preferred complementary personalities when interacting with animated characters on a computer screen [15].

The authors of these studies discuss embodiment as a possible reason for the discrepancy. Traditional similarity-attraction studies of personality involve pen-and-paper tasks and hypothetical strangers; it is reasonable to suppose that an actual, embodied personality might induce a different reaction than a theoretical one. However, the relationship that this work bears to the assistive robotics study cited above, and to the field in general, remains unclear.

Each of the aforementioned studies investigated the effects of *personality* similarity; that is, they involved the complete alteration of a mechanical agent's behavior to match or contrast with that of a participant. Our work examines whether perceived similarity can be manipulated in a more basic manner. Much of the social psychology literature on similarity-attraction has focused on *attitude* similarity; in line with this work, we chose to hold constant our robot's behaviors and "personality," and to alter only the robot's demonstrated preferences to match or contrast with those of each participant. We expected that when attitude similarity was manipulated, the similarity-attraction effect would be observed.

II. Methodology

A. *Participants*

We recruited 30 participants from the Yale community; the majority were undergraduates. Only two participants had significant experience in computer science and/or robotics. All participants were at least 18 years of age.

B. *Interaction Protocol*

Testing sessions took place in the Yale Social Robotics Lab facility. After consenting to participate, the participant was presented with a box of seven bright-colored toys and a toy-ranking worksheet. Each toy was labeled with a single, unique uppercase letter between A and G, inclusive; the worksheet referred to the toys by letter only. The experimenter instructed the participant to examine the toys, rank them by order of preference, and record the ranking on the worksheet.

When the participant finished ranking the toys, the experimenter collected the worksheet and toy box and asked the participant to wait while the toys were set up in the next room. In the adjoining room, the experimenter set up the box of toys in front of Keepon, our robot. The experimenter then programmed Keepon's toy preferences based on the participant's preference worksheet.

Participants were placed randomly into either a Similar Preferences or Dissimilar Preferences condition. In the Similar Preferences condition, the experimenter set Keepon's preferences to exactly match those of the participant. In the Dissimilar Preferences condition, the experimenter set Keepon's preferences to be the exact opposite of the participant's.

After entering the appropriate preferences into the control computer, the experimenter invited the participant to enter the room containing the robot. To minimize error in the color detection algorithms, the participant was asked to don either a gray or white jacket. The experimenter then led the participant to a cubicle in the corner of the lab, and introduced him to Keepon. The participant sat facing the robot.

The participant was instructed to show toys to Keepon one at a time, determine Keepon's toy preferences, and record the preferences on a ranking worksheet. Any questions about the procedure were answered with rephrasings of the original instructions; the experimenter explained that the participant was free to interact with Keepon however he chose, as long as he only took out one toy at a time. The participant was then left alone with Keepon. The experimenter monitored the interaction via video feed; all participants abided by the interaction guidelines.

Keepon was programmed with seven different response behaviors, ranging from highly interested (#1) to neutral (#4) to afraid/sad (#7). Keepon responded to the presentation of each toy with the pre-programmed behavior corresponding to the toy's calculated preference level. With the exception of two behaviors that involved active ignoring (#5 and #6), all behaviors involved Keepon orienting its face toward the toy, giving the illusion of attention. When no toy was present in the visual field, Keepon displayed an idling behavior.

The participant was allowed to take as much time as needed to finish the ranking worksheet. (All participants took between four and eight minutes.) The experimenter waited outside the cubicle until the participant announced that he had finished.

The experimenter then invited the participant to sit at a table outside the cubicle and complete a post-interaction questionnaire. Finally, the experimenter debriefed the participant by explaining the purpose of the study, revealing the experimental manipulation, and answering any questions.

C. *Setup*

Keepon is a small robot with a silicone-rubber body, resembling a yellow snowman. Keepon was created by Marek Michalowski and Hideki Kozima, and is sold commercially by BeatBots LLC. The robot is equipped with two wide-angle color CCD cameras in its eyes and a microphone in its nose. Keepon sits atop a black cylinder containing four motors and two circuit boards, via which its movements can be

Keepon Behaviors	
Preference Ranking	Behavior
1	Gaze follows toy constantly; frequent bouncing. (High interest.)
2	Gaze follows toy constantly; moderate bouncing. (Moderate interest.)
3	Gaze follows toy constantly. (Some interest.)
4	Gaze follows toy intermittently. (Neutral.)
5	Gaze rarely directed toward toy. (Partial ignoring.)
6	Gaze never directed toward toy. (Complete ignoring.)
7	Jerky bounce. Gaze then follows toy constantly, head hanging. (Fear/sadness.)
- Idling -	Gaze moves about the room, fixating on random points.

Fig. 1. When each toy was presented, Keepon displayed the behavior associated with the toy's preference ranking. When no toy was visible, Keepon displayed the idling behavior.

manipulated with four degrees of freedom. All software is run off-board.

Keepon's original control software was designed in a Max/MSP architecture. Our lab uses a control structure written in Processing, an open source programming language and development environment. A simple Java library allows Processing to send Keepon commands to the Max/MSP software.

To enable Keepon to detect the presence of toys in its visual field, we adapted part of the OpenCV Processing and Java Library. OpenCV is an open source computer vision library originally developed by Intel; the Processing and Java library is a partial port of the OpenCV library to the Java/Processing languages. This library contains a comprehensive blob detection module, which locates regions in the visual field that are brighter or darker than the surrounding areas. Our software runs these detected regions through a specialized color filter, allowing us to identify our seven toys with a high degree of accuracy.

Although Keepon is outfitted with two internal cameras, we decided that a physically stable source of visual input would better suit our purposes. All visual input in this experiment was obtained using an external webcam wired to the control computer.

The toys used in the experiment were small, inexpensive, commercially-available items. Each toy was a different solid color. The toys consisted of a red box, an orange stuffed fish, a yellow stuffed lion, a green ball, a tennis ball, a blue stuffed bear, and a purple stuffed turtle. Over the course of the experiment, two toys were damaged and/or lost. In later trials, the red box was replaced by a red hat, and the purple stuffed

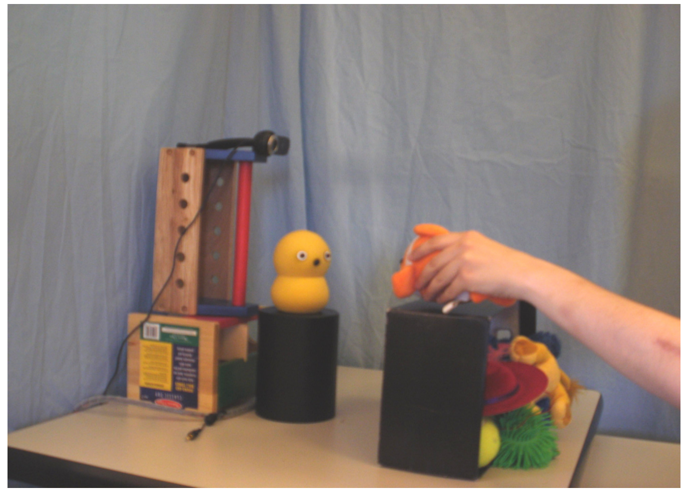

Fig. 2. The experimental setup. A participant shows Keepon a toy.

Fig. 3. Left: Keepon responding to the presentation of a toy. Right: The box of toys.

turtle was replaced by a purple stuffed bear. The toys were always presented in a plain, black cardboard box.

The first part of each testing session took place at a table outside of a main laboratory room. The robot interaction then took place in a small testing cubicle inside the laboratory space. The testing cubicle was formed by two freestanding curtains placed in the corner of a room. Keepon was placed on a table inside the cubicle, facing the chair where the participant was asked to sit. Behind Keepon, a small but clearly visible camera was placed on top of a construction of multicolored toy blocks. In front of Keepon, the box of toys was turned on its side, with the opening facing the participant's chair, so that the box formed a barrier between Keepon and the toys.

D. Measures

The post-interaction survey consisted of twenty-two statements concerning participants' perceptions of Keepon and of the interaction overall. Participants rated their agreement with each statement on a seven-point Likert scale (1 = "Strongly Agree", 7 = "Strongly Disagree").

Two of the questionnaire items ("Keepon's toy preferences were similar to mine" and "Keepon felt very differently about the toys than I did") acted as a manipulation check. The remaining twenty items were designed to assess five different

Sample Post-Interaction Questionnaire Items

Category	Sample Items
Friendliness	Keepon was very friendly. Keepon wasn't that sociable.
Attractiveness	I though Keepon was cute. Keepon is an ugly robot.
Intelligence	Keepon behaved quite intelligently. I don't think Keepon is very smart.
Preference Similarity	Keepon's toy preferences were similar to mine. Keepon felt very differently about the toys than I did.
Overall Similarity	Keepon behaved very differently than I did. Keepon's personality seemed similar to mine.
Enjoyment	I enjoyed spending time with Keepon. I would not want to interact with Keepon again.

Fig. 4. A partial list of statements from the post-interaction questionnaire.

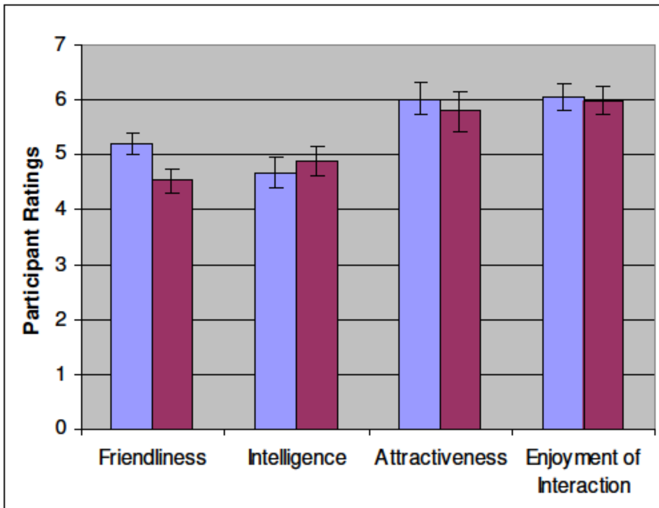

Fig. 5. Results from the post-interaction questionnaire, by participant condition.

elements: perceived similarity to Keepon ("Keepon's personality seemed similar to mine"), enjoyment of the interaction ("I enjoyed spending time with Keepon"), and opinions of Keepon's intelligence ("I don't think Keepon is very smart"), attractiveness ("Keepon is an ugly robot"), and friendliness ("Keepon was very friendly"). Each aspect was tested by four questions; two questions on each topic were reverse-coded. The responses to each group of four questions were averaged, creating five composite scores. The responses to the two manipulation check items were also averaged, creating a sixth composite.

Note: To permit a more intuitive analysis, each composite score was inverted on the 1-7 scale, such that higher scores corresponded to more favorable ratings.

III. Results

Thirty people participated in the experiment. Data from two participants was excluded from post-experiment analysis due to mechanical failures that occurred during testing. All data was analyzed using independent-sampling t-tests.

As expected, participants in the Similar-Preferences condition rated Keepon as significantly more friendly (M = 5.19, SD = .73) than did participants in the Dissimilar-Preferences condition (M = 4.52, SD = .81), $t(26) = 2.31$, $p < .05$ (one-tailed). However, participants in the Similar-Preferences condition did not enjoy their interactions with Keepon significantly more (M = 6.04, SD = .87) than did participants in the Dissimilar-Preferences condition (M = 5.98, SD = .968), $t(26) = .154$, *n.s.* They also did not rate Keepon as significantly more attractive or intelligent than did participants in the Dissimilar-Preferences condition.

The manipulation of perceived preferences proved to be successful. Participants in the Similar-Preferences condition rated Keepon's preferences as being very similar to their own (M = 5.87, SD = .829), while participants in the Dissimilar-Preferences condition rated Keepon's preferences did not (M = 2.41, SD = 1.22), $t(26) = 9.41$, $p < .001$ (one-tailed).

Finally, ratings of overall similarity showed a strong trend towards statistical significance, with with participants in the Similar-Preferences condition seeing themselves as more similar to Keepon overall (M = 4.00, SD = 1.30) than did participants in the Dissimilar Preferences condition (M = 3.21, SD = 1.10), $t(26) = 1.72$, $p < .10$ (one-tailed).

IV. Discussion

As predicted by the similarity-attraction literature, participants rated a robot more highly when it displayed preferences similar to their own. Participants accurately perceived the similarity or dissimilarity between Keepon's preferences and their own, and accordingly perceived Keepon as being more or less friendly.

There was no difference between conditions in participant's ratings of their enjoyment of the interaction. However, a simple explanation is available: given that the average rating in both conditions was approximately a 6 on a 7-point scale, a ceiling effect is likely responsible for the lack of differentiation. A slightly different experimental design – perhaps a longer interaction, or a more complicated task – might reveal differences in overall enjoyment. A ceiling effect is also likely at work in the ratings of Keepon's attractiveness, where the average rating in both conditions approached a 6.

Our work supports the theory that the similarity-attraction effect, and not the complementary-attraction effect, is the dominant force in human-robot interaction. Again, however, our work focused on attitudinal similarity, while previous studies have examined the effects of similarity of personality. It is possible, for instance, that people prefer a robot with similar attitudes but a complementary personality. Future work in this domain could shed light on the precise types of similarities and dissimilarities that most affect the experience of human-robot interaction.

Such work will be vitally important to the task of constructing valid robotic models of social development, as we continue to investigate whether adult partners will behave sufficiently naturally towards an infant-like robot to permit a reasonable simulation of social learning. Characterizing the social psychology of human-robot interaction is important in that it permits us both to judge the validity of social input our computational models will receive, and to better manipulate such interactions. The results of this study, for instance, suggest that we can influence people's general opinions of a robot simply by having the robot agree or disagree with them, or by having the robot match or oppose them on some attitudinal dimension. Our results also suggest that on at least one basic level, people respond to and form opinions of robots in the same manner that they do with other people. The developmental literature reminds us that similarity-attraction is a crucial effect at play throughout life, beginning with young children's selections of and interactions with social partners, and continuing through the interpersonal interactions of adulthood. Future studies of such an effect in human-robot interaction will assist in developing both more effective robotic agents and better models of social development as a whole.

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