Birds of a Feather Flock Together: A study of status homophily in HRI

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Abstract. Homophily, a person's bias for having ties with people who are similar to themselves in social ways, has a vital role in creating a social connection between people. Studying homophily in human-robot interactions can provide valuable insights for improving those interactions. In this paper, we investigate whether similar interests have a positive effect on a human-robot interaction similar to the positive impact it can have on human-human interaction. We explore whether sharing similar interests can affect trust. This experiment consisted of two NAO robots; each gave differing speeches. For each participant, their national origin was asked in the pre-questionnaire, and during the sessions, one of the robot's topics was either personalized or not to their national origin. Since one robot shared a familiar topic, we expected to observe bonding between humans and the robot. We gathered data from a post-questionnaire and analyzed them. The results summarize the hypotheses here. We conclude that homophily plays a significant role in human-robot interaction, affecting trust in a robot partner.

Keywords: HRI · Homophily · Trust

1 Introduction

People tend to connect with others who are similar to themselves [1]. This tendency, referred by social scientists as homophily, manifests itself with similarities due to gender, national origin, social class background, and other socio-demographic, behavioral and interpersonal characteristics [2]. Individuals in homophilic relationships share common characteristics (such as beliefs, values, education) that make communication and relationship formation easier. In HRI, a robot needs to create a smooth interaction with its audience in order to perform well in social settings. We wish to investigate if robots can benefit from the same social tendency and leverage from homophily in their interactions. We proposed an experiment where a social robot acts in such a way that implies homophily

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while another robot does not. Then we observed how the person will react toward the robots. We expected that achieving homophily, or bonding based on a common interest or implying similarity, between a human user and a robot, holds a promise of improvement in trust between them.

The similarity between humans and robots is an essential facilitator of positive attitudes toward robots [3]. For instance, Bernier and Scassellati [4] showed that the more an individual believes that a robot is similar to them, the more they like and prefer to interact with them. Also, research of Bowman et al. [3] found that individuals tend to like and build healthier emotional attachment toward robots that appear to have a similar personality to theirs. Finding homophily between individuals is a useful for human-robot interaction. Therefore, we wanted to investigate if this phenomenon could occur between humans and robots as well.

In this paper, we explore homophily between a person and a robot from a questionnaire by measuring common interest, bonding, and similarity between a person and a robot. The purpose of this work is to determine whether similarities between a robot and a person might improve social connection and trust. If such a link exists, then homophily would be an important physical and behavioral design consideration for effective HRI; this could lead to an improved first impression of a robot, which might eventually help humans communicate and interact with the robot more easily.

2 Background

Homophily in HRI: Homophily is a term familiar in social sciences. In Rhetoric and Nichomachean Ethics, Aristotle noted that people "love those who are like themselves" [5]. It was also observed by Plato that "similarity begets friendship" [6]. Back in 2001, McPherson et al. [2], presented a principle named homophily. It states that "a contract between similar people occurs at a higher rate than among dissimilar people." Overall homophily can be differentiated into two types: 1) value homophily and 2) status homophily. Value homophily is based on attitudes, beliefs, and values. Status homophily is based on national origin, sex, age, and characteristics like religion, education, occupation.

Many research in the robotic world also worked on the common factors that a robot and a human can share. As an example, propensities of preference for Human-Robot Interaction (HRI) according to different personalities and facial expressions of human and robot are presented in A paper of Jung et al.[7]. Two types of personalities: extrovert and introvert were applied to the robot named KMC-EXPR to observe the impact of different personality type in interaction between humans and robots. Also Kahn's work [8], a humanoid robot named Robovie was used to interact with children. After each 15 min session, the experimenter interrupted the session and sent the robot to the closet. Later, it was observed how the children felt towards the robot in many aspects.

The effect of verbal and nonverbal behavior based on personality traits in human-robot interaction has been observed [9]. A NAO robot was used to

validate their model that a person preferred more robots to interact with if they both had the same personality traits. Finally, a study from Heerink [10], shows that age, gender, education, and computer experience had an influence on robot acceptance by older adults. Our prior work showed that establishing common-ground using ice-breaker tasks helped a person identify with a robot team-member [11]. Witnessing verbal mistreatment of a robot also resulted in increased perception of the robot's emotional ability [12].

Recent work investigated if a human user would help a robot being bullied by other humans when social bonding has been applied in human-robot's interactions [13]. Similar to our study, they used favourite food to contextualize a human and robot conversation so the person finds a similarity with the robot. Their results did not prove their hypothesis, on the other hand our findings suggest that a shared similarity can improve the sympathy in human and robot interaction.

Trust in HRI: It is observed that people tend to trust more easily those people who appear similar to themselves. By similarity, it may include common values, membership in a defined group (such as manufacturing departments, a local church, gender), shared personality traits, etc.[14]. In that research, when people evaluate others' trustworthiness, cues such as gender [15], age [16], race, and nationality influence the initial assessment.

Salem et al. [17], conducted an experiment in which participants interacted with a home companion robot in one of two experimental conditions named correct mode and faulty mode while tapping different dimensions of trust based on a variety of unusual collaborative tasks. It was observed that the robot's performance did not influence participants' decisions to comply with its request. Hancock et al., evaluated the effects of the human, robot, and environmental factors on perceived trust in human-robot interaction [18]. Human-related factors depend on ability-based characteristics, robot-related factors are based on performance and attributes, and environmental factors include team collaboration and tasking. In this study [19], whether a robot's vulnerable behavior can create ripple effects on a team and increase team physiological safety and human-human trust-related behavior were explored. It was seen that the 'ripples' of the robot's vulnerable behavior influences not only team member's interaction with the robot but also team members' human-human-trust-related interaction with each other.

3 Study Design

In this user study, we aimed to measure the perceived similarities between a person and a robot when they shared a common interest. As our second interest, we were looking into the effect of homophily on trust human-robot trust. We proposed two hypotheses on similarity and trust:

– **H1**: A person will feel a similarity (homophily) to the robot in a human-robot interaction when they share a common interest

– **H2**: There is a correlation between homophily and trust in human-robot interaction

Our two hypothesis would be tested by making two experimental conditions and analysing data.

3.1 Experiment Conditions

In this section, we explain how we developed two conditions for testing out the hypothesis. Each participant experiences condition one in which the person finds similarity to the robot and condition two where it is the opposite. There can be different homophily categorizations based on age, gender, national origin, socioeconomic state, ethnicity, attitude, etc. However, we chose 'National Origin' as our divider for different groups. Since we wanted to find a food known by the person, we considered national origin which means the nation where a person was born, or the country of origin that person's ancestors came from. And, they may know food associated with that area directly or by their family. The correlation between national origin and homophily is also higher than gender [20] for instance. For this study, to more tightly control potential participant differences, we chose only one age range (18-35) and one education level (university students).

The experiment was conducted in a room in one of the libraries on the University of Nevada, Reno campus. For the experiment, we used two NAO robots. We distinguished the robots to the participants as Red NAO and Blue NAO based on their color. Here, the Blue and the Red NAO were the Homophilic Condition Robot and the Non-Homophilic Condition Robot respectively. Fig. 1a shows the set up of the robots during the user study. In the pre-questionnaire form (Table 2), general information such as age, gender, major, and national origin information were asked of the participant.

3.2 Experiment Task

At first, before staring our experiment we explained our experiment in brief to each participant. We let them know that all collected data would remain anonymous. If the participant agreed to take part in the experiment then we continued with the rest of the experiment.

Our proposed method was divided into 3 major steps. These are: 1) Pre Questionnaire, 2) Speech Presentation, 3) Post Questionnaire

– **Pre Questionnaire** At first, the participant was given a pre questionnaire form (Table 2) which included demographic questions such as age, gender, major, and national origin information. We used the national origin information to categorize participants.
We categorized the participants into one of 12 broad national origins: European, Middle East, North African, African, North American, South American, Central American, Southeast Asia, East Asian, West Asian, South Asian, and Other. The name of the national origin category in the U.S. was collected from the United States Census Bureau data [21].

Table 1: Homophilic Condition for Each National Origin Category

1.	What is your age?
2	What is your gender? 1.Male 2.Female 3.Other
3.	What is your major and degree?
4.	Are you familiar with robots?
5.	Choose which national origin best represents you: 1. Europe 2. Middle East 3. North African 4. African 5. North American 6. South American 7. Central American 8. Southeast Asia 9. East Asian 10. West Asian 11. Indian 12. Other

Table 2: Pre Questionnaire

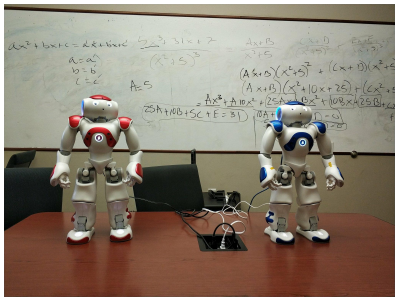
National Origin	**Homophilic Condition**
Europe	Pirozhki
Middle East	Kebab
North African	Coucous
African	Bobotie
North American	Cheese Steak
South American	Ceviche
Central American	Pupusa
Southeast Asia	Nasi Campur
East Asia	Sichuan Cuisine
West Asia	Kebab
South Asia	Biriyani
Others	Ice Cream

– **Speech Presentation** We designed an interaction between human and robot where two NAO humanoid robots gave speech presentations in front of the participant individually (Fig. 1b) where the robots were tele-operated by the experimenter from the other room. The participants did not know about the existence of the robot's operator. During each session, one robot gave a presentation on the homophilic condition related to the participant's national origin shown in Table 1. After that, the remaining robot gave a presentation on a non-homophilic condition.

The topic of the homophilic condition of the presentation for each participant was selected based on the national origin information given by the specific participant in the pre-questionnaire. The famous food dishes from each region of the national origin was chosen as the homophilic condition for each national origin group (Table 1). The robot gave a speech presentation on bread as the non-homophilic condition which is familiar to every national origin category.

Samples of the speeches by the homophilic condition robot and the non-homophilic condition robot are given below respectively, where the homophilic condition robot's speech is about 'Kebab' towards the participants categorized into the 'Middle East' and the non-homophilic condition robot's speech is about 'Bread.'

- Homophilic Condition Robot: *'Hi, I am Blue NAO. I am going to talk about a dish named Kebab. Kebab is a very popular dish all around the world. Shish Kebab or doner Kebab can be two familiar names of Kebab.*



(a) Red and Blue NAOs used for the experiment

(b) The participant listening to the robot's speech

Fig. 1: Experimental Setup

It is often served during special occasions. It can be made with ground meat or seafood, even sometimes with fruits and vegetables. Traditional meat of Kebab is most often mutton or lamb, but regional recipes may include beef. Sometimes Onions are often added with Kebab to enhance the taste. Kebab is served with various dishes according to each recipe. Kebab with naan is very popular in some regions. Yogurt drink is often served with Kebab. It is also served with rice, grilled tomatoes, tabbouleh salad, or bread. There are many restaurants in Reno where we can find Kebab, and they are delicious. Well, I hope you enjoyed my speech.'

- Non-Homophilic Condition Robot: *'Bread is a staple food prepared from a dough of flour and water, usually by baking. Throughout recorded history, it has been popular around the world and is one of the oldest artificial foods, having been of importance since the dawn of agriculture. Proportions of types of flour and other ingredients vary widely, as do modes of preparation. As a result, types, shapes, sizes, and textures of bread differ around the world. Bread may be leavened by processes such as reliance on naturally occurring sourdough microbes, chemicals, industrially produced yeast, or high-pressure aeration. Some bread is cooked before it can leaven, including for traditional or religious reasons. Non-cereal ingredients such as fruits, nuts and fats may be included. Commercial bread commonly contains additives to improve flavor, texture, color, shelf life, nutrition, and ease of manufacturing. Also, bread has a social and emotional significance beyond its importance as nourishment. It plays an essential role in religious rituals and secular culture. Well, I hope you enjoyed my speech.'*

– **Post Questionnaire**
Each speech took less than 3 minutes. After listening to these presentations one after another, the participant filled out a post-questionnaire form. There were questions regarding homophily, trust, and provided speeches. The questionnaire was divided into two parts. First part was observing the effect of

Table 3: Post-Questionnaire

Category	**Question**	**Type**
Homophily	The Robot was similar to me	(1-5)
	The Robot thinks like me	(1-5)
	The Robot behaves like me	(1-5)
	The Robot and I had a common interest	(1-5)
	I felt a bond with the Robot while it was speaking	(1-5)
Being Suspicious	The Robot is deceptive	(1-5)
	The Robot behaves in the underhanded manner	(1-5)
	I am suspicious of the Robot's intent,action or outputs	(1-5)
	I am wary of the Robot	(1-5)
	The Robot's actions will have a harmful or injurious outcomes	(1-5)
Security	I am confident in the Robot	(1-5)
	The Robot provides security	(1-5)
Trust	The Robot is dependable	(1-5)
	The Robot is reliable	(1-5)
	I can trust the Robot	(1-5)
Familiarity	I am familiar with the Robot	(1-5)
Topic	Are you familiar with the blue Robot talked about?	(1-5)
	Which speech did you find more interesting?	(1-5)

Table 4: One-Sample Test (Test Value = 3)

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval	
					Lower	Upper
Common Interest	4.858	15	0.000	0.938	0.53	1.35
Felt Bonding	2.551	15	0.022	0.688	0.11	1.26
Similarity	3.162	15	0.006	0.500	0.16	0.84

the speech on the trust by asking each participant to choose one of the robots to pick one snack for themselves from the other room.
The other part consisted of questions to measure the degree of both homophily and trust (see Table 3). This questionnaire was adapted from [22] and Jian et al.[23] to measure homophily and trust respectively. We also added some extra questions related to this experiment that would help us to analyze the answers. All the questions in the questionnaire are based on five-point Likert scale.

4 Results and Analysis

Details of experiment results and analysis are presented in this section. We analyzed data from questionnaires in order to support or refute our hypotheses presented above.

Participants were gathered from the University of Nevada, Reno campus area. Most of the participants' age ranged from 18 to 35. We initially recruited 19 participants, discard three participants' data due to robot malfunctions. We used the remaining 16 participants in our analysis, 6 male, ten female. Among the participants, there were 4 participants from Southeast Asia, 4 participants from Middle East, 3 participants from South Asia, 2 participants from East Asia, 2 participants from North America, and 1 participant from Europe.

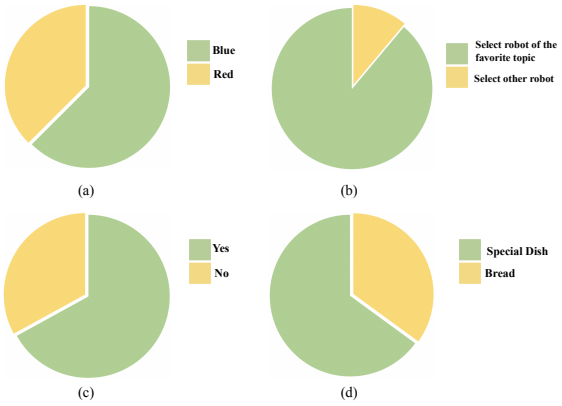


Fig. 2: (a) Chosen Robot, (b) Familiarity with topics, (c) Chosen robot is the one with dish topic, (d) More interesting topic

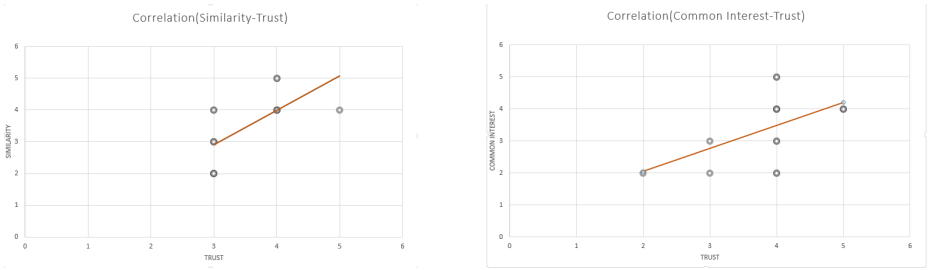
We explored results related to our hypothesis: first, homophily among participants (two groups of the ones who chose the Blue NAO and those who chose the Red NAO); second, correlation between homophily and trust categories in data.

To have a better understanding of our data, we used pie charts. The data shown in figures 2(a)-(d) relate to our experiment hypotheses. The majority of the participants (62.5%) chose the blue robot (homophily condition) in the first part of post-questionnaire which we mentioned in Section 3.2.

We further investigated why some participants preferred the red NAO. Many countries share one origin, but there is a possibility that people of one origin may not be familiar with exceptional food. For those participants with no idea about the unique food, the general topic of 'bread' the familiar topic. Fortunately, The last two questions in the 'topic' category of post-questionnaire shown in TABLE 3 define this issue and clear if the person is familiar with the blue NAO topic or not, and which topic was more interesting for him/her. So, we used the favorite topic question to compare 'chosen robot' and 'favorite topic' to have a new query, which is 'the participants whose choice was in line with their favorite topic. If choosing (Red NAO-homophily condition) and (Blue NAO-homophily condition), the person gets a 1 and otherwise gets a 0. We observed this group

Table 5: Correlation

		Reliability	**Trust**	**Similarity**	**Common Interest**
Reliability	Pearson Correlation	1	.631**	0/316	-0/022
	Sig. (2-tailed)		0/009	0/233	0/937
	N	16	16	16	16
Trust	Pearson Correlation	.631**	1	.665**	.539*
	Sig. (2-tailed)	0/009		0/005	0/031
	N	16	16	16	16
Similarity	Pearson Correlation	0/316	.665**	1	0/205
	Sig. (2-tailed)	0/233	0/005		0/447
	N	16	16	16	16
Common Interest	Pearson Correlation	-0/022	.539*	0/205	1
	Sig. (2-tailed)	0/937	0/031	0/447	
	N	16	16	16	16



(a) Similarity-Trust (b) Common Interest-Trust

Fig. 3: Correlation

owned 80% of the population (see Figure 2(c)). We conclude that participants mostly chose the robot that was talking about a familiar topic.

To investigate our first hypothesis for each independent variable, we analyzed the results using one sample t-test, knowing that the experiment has one sample group with two variables. As seen in Table 4 a one-sample t-test showed that there is a significant difference in mean 'common interest' between the homophilic and non homophilic conditions ($p < .001$). There was a significant difference in mean 'felt bonding' between the the homophilic and non homophilic conditions ($p < .001$). There was also a significant difference in mean 'similarity' between the homophilic and non homophilic conditions ($p < .001$) (see Table 4).

To explore our second hypothesis, we used Pearson correlation test results (see Table 5). We found that there is a moderate positive correlation between 'similarity' and 'trust' variables ($r = 0.665, n = 16, p = 0.005$) (see Figure 3a). There was also a moderate positive correlation between 'Common Interest' and 'Trust' ($r = 0.539, n = 16, p = 0.03$) (see Figure 3b).

5 Conclusion and Future Work

In this paper, we explored the effect of national origin as homophilic condition in case of Human-Robot interaction because among all of these 'national origin' is a significant social divider today [24].

Our two hypotheses were supported by our results shown in the prior section. Our first hypothesis, H1: **"A person will feel a similarity (homophily) to the robot in a human-robot interaction when they share a common interest"** was supported via the significant result in the similarity comparison shown in Table 4. H2: **"There is a correlation between homophily and trust in human-robot interaction"** was supported by showing that there is a correlation between homophily and trust in human-robot interaction in Table 5. The responses to question one show the preference for the homophily condition with a correlation for preference in the robot with familiar topic (see Figure 2). This question gave participants a forced choice between robots to pick their prize (snack), which reflects trust in a social situation. We also asked our participants to explain their reasoning after choosing a robot, and most of the comments showed that they were trusting the robot that shares the interest or the topic robot was talking about was more familiar to them. This 'trust' can be contextualized with two comments: "If he were talking about bombs, I would have not to trust him, but he was talking about Biryani! I love spicy food."; "I chose the blue one because I love kebab, and I miss it."

There is room for more investigation on our proposed hypotheses by having more participants. We can have more accurate homophily categories and related speech for each category. That will profoundly affect our results because the more robot's speech is close to a person's homophily group; our results can reflect the more accurate result.

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