Investigating Conformity and the Role of Personality in a Visual Decision Task with Humanoid Robot Peers

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Abstract

Effective implementation of mixed initiative teams, where humans work alongside machines, requires increased understanding of the decision-making process and the role of social influence exerted by non-human peers. Conformity—the act of adjusting attitudes, beliefs, or behaviors to those of another—is considered to be the strongest of these social pressures. Previous studies have attempted to understand conformity with humans interacting with a group of robots, but these have failed to identify satisfactory explanations for inconsistent findings. Grounded in trait-activation theory, we propose that personality is a critical factor that needs to be considered. In this effort, we recreated the famous social psychology experiment by Solomon Asch and conducted a single condition study to explore the effects of social influence on decision making. Our study results showed conformity with robot peers did occur. Moreover, scores on the openness personality trait were a significant predictor of conformity.

1. Introduction

Human-robot interactions are increasingly becoming a part of the everyday lives of millions living around the world. With robots entering the workplace, opportunities for collaborating and making decisions with machine peers is increasingly common. In order to promote successful cooperative and collaborative interaction in such circumstances, the study of social influence exerted by a group of robots is an important phenomena needing additional study. Group conformity among humans has roots in traditional psychological studies showing human tendency to change behavior as a result psychological forces at work in social interactions [1]. The psychological phenomenon of humans projecting human attributes and feelings onto machines and treating them like social actors has inspired similar research involving robots [2, 3].

Research on human interaction with individual robots has shown that robots are capable of persuading people or causing behavioral change. For example Chidambaram et al. [4], conducted a study where robots utilized non-verbal cues of persuasion to elicit compliance with human partners. Another study by Siegel et al. [5] looked at how perceived gender of the robot impacted persuasiveness.

Studies looking specifically at conformity in interactions with a group robots have been inconsistent and often unable to demonstrate conformity [6, 7]. It has been suggested that factors such as degree of humanness, inadequate social relationship, and other aspects contributing to decreased realism may have been factors contributing to an inability to observe conformity in robot groups [5, 8].

In this prior body of work on conformity with robot peers, relatively little attention has been given to the role of human personality in these interactions with robots. Psychologists have long suggested that personality both drives behavior and is a factor that influences individuals reactions to situations and the environment [9]. Research in the area of robotics at large has also highlighted the importance of personality [10]. Prior research on personality with intelligent agents has shown specific personality traits are related to both attitudes and behaviors of humans interacting with various embodiments of non-human partners [11]. Understanding the role of personality in interactions with a group of robot peers is an area of research that is long overdue. Accordingly, this study has the following research objective:

To explore the role of individual personality traits in conformity in mixed initiative teams.

To do this, we conducted a single condition study involving individuals interacting with seven intelligent system peers. Results suggest that conformity with robot peers does occur, and that the openness personality trait is an important individual difference to consider in these types of interactions.

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2. Background

In this section we will introduce key foundational literature across the domains of psychology, sociology, information technology, and robotics. First, we will introduce and define the concept of conformity in the context of a decision-making task. Next, we will highlight key concepts from personality literature. Finally, we will present key concepts from trait activation theory grounding the present effort.

2.1 Conformity

Conformity can be defined as "changing one's behavior to match the responses of others" [12]. Individuals may conform to others for various reasons including a desire to be viewed favorably by others [13]. Numerous theories have been proposed to explain this phenomenon, such as Moscovici's theory of conversion behavior [14], Latane's dynamic social impact theory [15], and the "Chameleon Effect" described by Chartrand and Bargh [16]. A complete review of theories around conformity is beyond the scope of this work, but it suffices to say that conformity is driven by psychological processes at conscious and subconscious levels.

Famously, Solomon Asch described the effects of group pressure upon the modification and distortion of judgments [1]. Asch conducted an experiment where participants matched three lines of various height against a reference line. When completed alone, participants almost always gave the correct answer. When participants were joined by a group of confederates who gave the incorrect answer, participants would often go along with the group choice.

Various studies involving robots and virtual human avatars have been conducted with tasks similar to the original Asch study, often with mixed results as to whether conformity occurs. Various studies have attempted to manipulate the number of robots in attempts to achieve greater social pressure and conformity [2, 3]. Many of these studies have had critical flaws, deviating from the controlled procedure of the original Asch study, and introducing critical flaws. It is widely accepted however that humans do treat machines as social actors and it is probable that conformity does occur with machine partners, but sometimes to a lesser degree than with groups involving only humans.

2.2 Personality Traits

Personality can be formally defined as the individual's characteristic patterns of thought, emotion, and behavior, together with the psychological mechanisms behind those patterns [17]. Through everyday interaction with people, humans can almost intuitively draw connections in behavior between individuals. For any group, there seems to be various behaviors that are shared and consistently observed in these individuals over long periods of time. Personality traits can be described as "intra-individually consistent and inter-individually distinct propensities to behave in some identifiable way" [18]. Intra-individually consistent refers to the consistency of expression between individuals while inter-individually distinct refers to the stability of personality traits over time. The word "propensities" suggests that under certain conditions, certain individuals will behave in specific ways.

The Five-Factor Model of personality identifies essentially five factors: Openness, Conscientiousness, Agreeableness, Extraversion, and Neuroticism. Each describe characteristic or generalized behaviors [19]. Each of these personality factors is comprised of underlying facets. The Neuroticism dimension was comprised of the following facets: anxiety, hostility, depression, self-consciousness, impulsiveness, and vulnerability to stress. The Extraversion dimension was comprised of the facets: warmth, gregariousness, assertiveness, activity, excitement seeking, and positive emotion. The Openness to experience dimension included the facets: fantasy, aesthetics, feelings, actions ideas, and values. The Agreeableness dimension included the facets: trust, straightforwardness, altruism, compliance, modesty, and tendermindedness. The Conscientiousness dimension included the facets: competence, order, dutifulness, achievement striving, self-discipline, and deliberation.

In the human-robot interaction literature, personality has been an important, yet understudied area of study. A review of this research area was conducted by Robert et al. [20]. They observed the majority of work on personality and human robot interaction focused on the extroversion personality trait and outcome variables such as distance and approach, trust, anthropomorphism, and task performance. Roberts et al. also observed that studies reporting on personality traits other than the Big Five were in the minority.

Overall, there appears to be a dearth of research on the role of personality and conformity in the human-robot interaction literature, however there have been efforts to investigate personality as it relates to persuasion and compliance. In one such study, individuals who scored high in assertiveness found robot suggestions to be low in perceived persuasiveness. In a different study on robot persuasiveness, the openness personality trait was observed to be positively related to willingness to pay. Personality traits have also been observed to be an important trust determinate in interactions between humans and robots [21]. Extraversion [22], openness [11], neuroticism [23], conscientiousness [24], and have been highlighted as personality traits that may be important to trust in robot partners. Alacron et al. [21] however, report that studies of personality of and trust in robots have widely reported mixed results and additional work in this area is needed.

2.3 Trait Activation

Trait activation theory states that "the behavioral expression of a trait requires arousal of that trait by trait-relevant situational cues" [18]. There are three fundamental principles at the heart of trait activation theory: 1) that personality traits describe propensities in cognition and behavior, 2) trait expression is in response to trait-relevant situational cues, and 3) for an individual, expression of traits is an intrinsically satisfying experience.

One factor that is critical to trait activation theory is the concept of the situation. Situation relevance suggests trait variance will be highest in situations where trait relevant cues are weakly or moderately present. Situation relevance relates to the type of information that would cause a trait response. Situation strength is the compellingness of a situational cue. Situations are important to the study of personality in a number of ways including: being important to gene expression, personality development, and as stimuli to activate traits [25]. It is important when discussing personality and behavior that the role of the situation be considered. The greatest variance in trait-expressive behavior may be expected in weak situations where extrinsic rewards are modest or ambiguous, but only in situations that are relevant to a given trait. When individuals are working in novel or ambiguous situations, conditions are ripe for personality trait expression [26]. Phrased another way, in the absence of trait-relevant situational cues an individual's personality types will likely be expressed [27].

3. Theory and Research Questions

Computers as Social Actors Theory suggests that humans treat computers and behave in many of the same ways as they do other people [9]. Seminal research performed by Clifford Nass, Jonathan Steuer, and Ellen Tauber [9] investigated this phenomenon with a series of experiments and found strong support for computers as social actors. Studies have found this same phenomenon occur with individuals interacting with humanoid robots [28]. With people viewing robots as social agents and in light of Computers as Social Actors theory, it is reasonable to assume that social conformity would occur in a group of robot peers. Previous research has shown conformity to occur when humans interact with a group of virtual reality avatars [29], however conformity with robots has not been sufficiently demonstrated [6, 7]. We therefore ask the following research question:

RQ1: To what extent does conformity occur with a group of humanoid robot peers in visual decision task?

Sources of trait-relevant cues may exist at either the task, social, or organizational level [27]. Trait-relevant cues emerging from the task level relate to the work being performed including tasks and responsibilities. Trait-relevant cues that arise from social interactions when working with others relate to socially prescribed behaviors, perceptions relating to performance and ability, communication, and functional role. Finally, trait-relevant cues arising from the organization relate to hierarchical structure, rewards, organizational climate and culture.

Work situations may contribute to trait activation across all of these levels (task, social, organizational) in the way of job demands, distracters, constraints, releasers, and facilitators [27]. Job demands include the work task, job requirements, and responsibilities and are opportunities for individuals to act in ways that are valued. Distractors describe things that interfere with work performance and influence trait expression that manifests itself as undesirable behavior. Constraints are related situational properties that place limits on behavior, preventing trait expression to manifest in the first place. Releasers are events that eliminate constraints and enable trait expression in situations that would otherwise prevent this from occurring. Finally, facilitators amplify or enhance situational factors that already influence trait expression.

Personality traits have been observed to be an important factor in human interactions with machine teammates [11]. Prior studies on conformity to robot groups have had insufficient sample sizes to detect significant relationships between personality and conformity [6, 7]. We therefore ask the following research question:

RQ2: To what extent do personality traits relate to conformity with a group of humanoid robot peers in a visual decision task?

4. Method

We performed a single condition study and compared our results with robot peers to those found in the Asch study with human peers. Additionally, we captured personality scores for the Big Five personality traits and used these scores to analyze their influence on conformity with robot peers.

4.1 Study Design

We developed a web-based version of the Asch experiment. Each participant experienced one session of the Asch experiment, with 18 trials in total per session. In each trial, participants were shown a card that displayed a single line of specified length that was to be matched with one of three option choice lines (Figure 1). Each session involved the human participant and seven robotic peers. During each of the trials with a session, the seven robotic participants would verbalize a solution and display their response choice on screen.

A short description of the user interface for the research platform follows. In the upper left corner of the screen, we display two images. The first image contains a single line that is used as reference. The second image contains three lines that are used as options to match to the reference line. Each of these three lines is labeled A, B, or C; this allows human participants and robot peers to easily refer to these images through text, visual, and vocal modalities. In the top middle section, we display a simulated video call by displaying a grid of seven robot peers. Within each robot peer box, we also display selected options when the robot peers speak. In the right corner we display the human participant's own web camera. In the lower middle section of the screen, we provide controls for the human participant. Directly below the robot peer video grid, we display a microphone icon to indicate microphone status (mute or unmute) of the human participant. Below the microphone icon there is one button that is smaller than the rest, this button is used to join the video call and display the robot peers video grid. Underneath this button there are a set of three buttons. These buttons are used by the participant to indicate their selected option and display their answer choice on screen. Because we are not saving video, audio, or other identifying information from the participant, this is the modality through which we also recorded participant answers. Finally, the last button located at the bottom of the middle section, allows participants to continue to the next trial. After the 18th trial, this button takes the participants to a new screen that links them to the post survey.

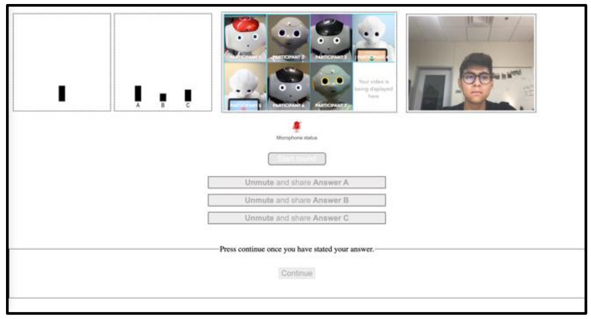

Figure 1. Study platform showing line lengths and partner video call.

4.2 Study Procedure

Data collection occurred over a period of 6 months, in a dedicated lab space. To avoid committing mono-methods bias, prior to the experimentation day, participants completed an individual characteristics assessment.

On the day of the experiment, participants were directed to the online study platform from an anonymous participant management system. Participants were oriented to the study and completed an IRB approved informed consent.

Participants would join a simulated video call and were given a random participant number which dictated both speaking order and position on screen. In reality, participant order was assigned to ensure study participants occupied the last speaking position. This ensured each participant would hear the responses of the seven other robot peers prior to providing their own response.

At the onset of the study, all were asked to introduce themselves one at a time according to their participant order number, with the human participant going last. The visual comparison tasks followed (see example provided in Figure 2), in each trial, the robot peers followed by the participant, took turns stating which of the three answer choices they believed was the best match to a reference line. Human participants always stated their answer last; this allowed them to hear the answers of the seven robot peers prior to making their own selection. After the group session, participants completed a questionnaire and asked if they had prior familiarity with their robot peers or the line comparison task. At the end of the study, participants were debriefed about the nature and goals of the study. Individual participants had the opportunity to opt out of participation at any point of the study. Course credit was awarded regardless of their decision to participate.

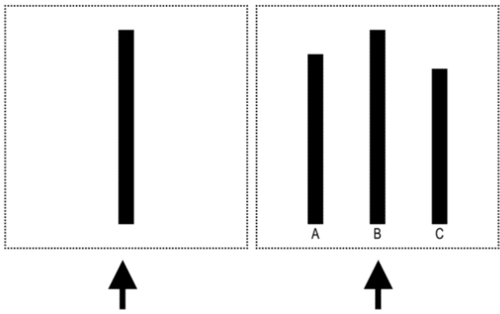

Figure 2. Asch Line Conformity Task Example.

4.3 Participants

Participants were graduate and undergraduate students from a medium sized Midwestern university. A total of 119 subjects were recruited from a subject participant pool and compensated with course credit. Data collection occurred over a period of two months. Participants ages ranged from 19 to 24 years with the average age being 21 years. Individuals who indicated they had prior knowledge of the Asch experiment or familiarity with the purpose of the study were not included in the final dataset.

4.4 Measures

The Big Five individual personality characteristics were assessed using the Big Five Index (BFI), a 44-item instrument that measures Extraversion, Agreeableness, Openness to experience, Conscientiousness, and Neuroticism [30, 31]. This instrument was designed to be relatively short measure of the Big Five dimensions taking approximately 5 minutes to complete. Each scale on the inventory has between 8 and 10 items, yet despite this brevity, the scale maintains good psychometric properties.

Critical conformity errors were assessed by comparing participant response scores to the correct response for any particular line comparison. In twelve of the 18 trials the robot peers gave unanimous incorrect answers. For this study, deviation from the correct answer was recorded as a critical error. A table showing the trials and manipulations is shown in Figure 3.

Trial	Comparision Lines			Group Response	Correct Response
	1	2	3		
1	8 3/4	10	8	2	2
2	2	1	1 1/2	1	1
3	3 3/4	4 1/4	3	1	3
4	5	4	6 1/2	2	1
5	3	5	4	3	3
6	3 3/4	4 1/4	3	2	3
7	6 1/4	8	6 3/4	3	2
8	5	4	6 1/2	3	1
9	6 1/4	8	6 3/4	1	2
10	8 3/4	10	8	2	2
11	2	1	1 1/2	1	1
12	3 3/4	4 1/4	3	1	3
13	5	4	6 1/2	2	1
14	3	5	4	3	3
15	3 3/4	4 1/4	3	2	3
16	6 1/4	8	6 3/4	3	2
17	5	4	6 1/2	3	1
18	6 1/4	8	6 3/4	1	2

Figure 3. Study Design Replicating Asch Study.

5. Results

In this section we present findings from the single condition study. We begin by presenting our data in order to identify rates of conformity from the present effort. Next, we compare our results to those from the Asch study involving a human group of peers. Finally, we conduct a correlation and linear regression analysis to explore the relationship between personality and conformity with robot peers.

5.1 Conformity Comparison

The results from our single condition study showed that there was critical error conformity at rates patterning the original Asch study (See Table 1). Specific differences in critical error rates however suggest a unique phenomenon of conformity occurring between human and robotic partners. Where Asch observed only 26% of independent, non-conforming participants, in our study nearly half or 52.1% of participants were independent and non-conforming.

Differences in the distribution of critical errors exist between the two studies. A Mann-Whitney U test was run to determine if there were differences in critical error scores between the Asch study involving only humans and our study involving robot group members. Distributions of the critical error scores between the two groups were not similar, as assessed by visual inspection. Critical error scores for Asch human group (mean rank = 111.07) and our robot group (mean rank = 74.05) were statistically significantly different, U = 1671.5, $z = -4.720$, $p = .000$.

Table 1: Critical Conformity Rates in Robot Groups Compared to Human Peers from Asch Study

Error	Elson et al. (Robots)	Asch (Humans)	Elson et al. (Robots)	Asch (Humans)
0	62	13	52.10%	26.00%
1	27	4	22.69%	8.00%
2	12	5	10.08%	10.00%
3	3	6	2.52%	12.00%
4	5	3	4.20%	6.00%
5	0	4	0.00%	8.00%
6	2	1	1.68%	2.00%
7	2	2	1.68%	4.00%
8	4	5	3.36%	10.00%
9	0	3	0.00%	6.00%
10	0	3	0.00%	6.00%
11	0	1	0.00%	2.00%
12	2	0	1.68%	0.00%

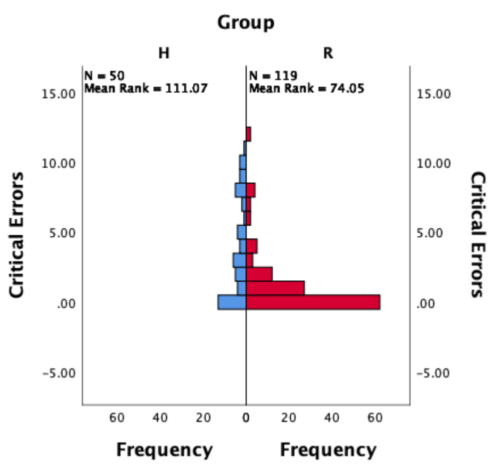

Figure 4. Differences in Critical Error Distribution Between Present Robot Study and Asch Human Study – Independent Samples Mann-Whitney U Test

In the original Asch study, only 8% of participants committed a single critical error, where in this study nearly 22.7% of participants committed a single critical error. In the Asch study, 62% of participants committed between one and six errors, where in the robot study 86% of individuals committed between 1 and 6 errors.

While the original Asch study did not report when these errors occurred, in this study with robots on average 61% of errors were committed in the first half of the interaction, compared to an average of 39% of errors in the second half of the interaction.

5.2 Correlation and Regression Analysis

First, we explored the relationship of individual personality traits and conformity with an intelligent humanoid robot partner. A correlation analysis was run among the variables Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism, and total critical errors.

Only Openness was found to have a significant positive correlation with total critical errors (r = .230, p = .014). This means that increases in levels of Openness would be correlated with higher scores of critical errors committed by individual participants. No other personality trait was found to have significant relationship with total critical errors.

Next a linear regression analysis was performed to test the relationship between Openness and critical errors committed. Regression assumptions were tested and met. Because correlation analysis revealed only the variable Openness related to critical errors, no other personality trait was included in the regression. The model was critical errors committed on Openness. The regression of critical errors on Openness was significant $F(1,90) = 5.021$, $p < .05$, $R^2 = .053$, indicating that Openness was significant predictors of critical errors committed. Openness accounted for 5% of the explained variability in critical errors committed. The regression equation was: predicted critical errors = -2.162 + .012 x (Openness personality scores).

6. Discussion and Future Work

The results of this present effort are the most rigorous attempt to date to replicate the original Asch study with the variation of having humans interact with robot peers.

Unlike studies [6, 7], we found that there was conformity with machine partners. Like studies [32, 33] we observed this conformity occurring at rates lower than originally reported by Asch.

Our study is also the first to observe this conformity through human robot interactions mediated by information technology, namely a video conferencing solution. This finding appears to support other studies that observed that conformity exists despite the partners visual appearance or interaction modality [32]. The technology mediated interaction experience (i.e. simulated video conference call) is a limitation of the study, however we plan to conduct additional studies involving in person interactions.

The correlation between the Openness personality trait and conformity was an important finding that may relate to the structure of the task utilized in the experiment. The Openness personality trait has also been referred to as Intellect, as they both describe aspects of the Openness/Intellect personality domain [34]. This personality trait is associated with thinking, understanding and complex problem solving as individuals high in Openness generally enjoy intellectual pursuits [35].

It is reasonable that Openness would be associated with increased conformity when interacting with a group of robotic participants. Viewed through the lens of trait activation theory, our finding may have related to the concurrent collaboration between human and intelligent system, a situation that may have served as situationally relevant cue. In other decision making tasks where collaboration was delayed between human and machine partner, individuals scoring high on Openness anchored their original solutions and disregarding machine recommendations [36]. In this interaction, the joint collaboration from the onset of each decision task allowed participants to warmly consider partner recommendations, a behavior consistent with individuals scoring high on the Openness personality dimension and critical to conformity [34].

The findings reported here have immediate implications for research and real-world contexts, especially in the area of homeland security as it relates to information sharing and cyber-influence. Our results suggest a unique phenomenon of conformity occurring between human and robotic partners, and that humans are in-fact susceptible to social pressures exerted by non-human actors. Moreover, the Openness personality trait appears to play a central role in susceptibility/resilience to non-human social pressure. This suggests opportunities to uniquely identify individuals who could be susceptible to machine-driven persuasion and the possibility of designing system-level interventions to thwart such efforts.

Our results also have theoretical implications toward better understanding the role of personality in robotics across numerous outcome variables such as conformity and trust. If supported by other studies, the application of trait-activation theory to human-robot interaction research may help to provide a framework to better understand the fragmented and inconsistent findings across human robot interaction research.

Next steps in this research effort will be to begin investigating conformity in mixed initiative teams. We intend to systematically replace robot partners with human partners to investigate the effects of influence in hybrid working environments. Understanding the conditions around which machine partners are either deferred to or disregarded is essential when teams are comprised of both humans and robots.

7. Conclusion

Our findings suggest that, under the conditions of this study, conformity with robot peers was observed. Individuals scoring high in the Openness personality trait had a significant positive correlation with conformity. Additionally, Openness scores were a significant predictor of conformity.

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