A Minority of One against a Majority of Robots: Robots Cause Normative and Informational Conformity

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Studies have shown that people conform their answers to match those of group members even when they believe the group's answer to be wrong [2]. In this experiment, we test whether people conform to groups of robots and whether the robots cause informational conformity (believing the group to be correct), normative conformity (feeling peer pressure), or both. We conducted an experiment in which participants (N = 63) played a subjective game with three robots. We measured humans' conformity to robots by how many times participants changed their preliminary answers to match the group of robots' in their final answer. Participants in conditions that were given more information about the robots' answers conformed significantly more than those who were given less, indicating that informational conformity is present. Participants in conditions where they were aware they were a minority in their answers conformed more than those who were unaware they were a minority. Additionally, they also report feeling more pressure to change their answers from the robots, and the amount of pressure they reported was correlated to the frequency they conformed, indicating normative conformity. Therefore, we conclude that robots can cause both informational and normative conformity in people.

CCS Concepts: • **Human-centered computing → Empirical studies in HCI**; • **Applied computing →** *Psychology*;

Additional Key Words and Phrases: Human-robot interaction, peer pressure, informational conformity, normative conformity

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1 INTRODUCTION

Conformity is defined as "the act of changing one's behavior to match the responses of others" (page 606) [12]. Several experiments have observed that people conform in a range of tasks, including visual tasks [2], memory tasks [22, 45], and counting tasks [25]. There are different reasons why people conform to others. People have been shown to conform to increase social standing [8] and due to experiencing uncertainty in their own decisions [38]. There have been

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two main identified types of conformity: normative conformity and informational conformity [16], which are detailed below.

Normative conformity is conformity due to feeling pressure to change one's answer or behavior to be equal to the rest of the group. One classic example of normative conformity is shown in Asch's 1950s line task [2]. In his studies, a participant was shown a line and was asked which of three other lines was the same length. When answering alone, only 1% of people chose the wrong answer, but when a group of confederates all stated the wrong answer, the participants conformed to the group, answering incorrectly in 37% of the trials. His experiments were a clear example of conformity due to peer pressure: the answer was obvious, but participants still chose the incorrect answer a significant number of times to not differ from the rest of the group.

Informational conformity is conforming due to believing the other members of the group know the correct answer or behavior. Informational conformity frequently occurs when one decides which product to purchase. For example, Cohen and Golden [13] show that participants were influenced by supposed peer ratings when rating a coffee product. Participants rated the coffee product after tasting it and observing a board with other people's ratings of the product. Participants were more likely to score the product higher when observing others rate it higher than when they had no information about the others' ratings. No significant differences were found in whether the participant was told that their rating would be visible to future raters or not. Their results suggest that participants were incorporating the ratings of others' into their own ratings because they believed them to be accurate.

Several experimenters extended the study of conformity to robots, testing whether participants would also conform to groups of robots. Using Asch's line test, but replacing the human actors with robot actors, prior studies were not able to demonstrate adult conformity [5, 7, 39, 42]. However, children (ages 7–9) were shown to conform to robots in Asch's line task [42]. Williams et al. [43] also show child-robot conformity (ages 4–10) when answering socio-conventional and moral questions with a robotic doll. Using a more subjective test than the line task has been shown to cause adult conformity with robots [24, 36]. Our prior work showed that adults changed their answers to conform to the robot's answers in a subjective card game task and that deciding to conform is related to trust [36]. Additionally, Hertz and Wiese [24] conducted an experiment in which participants were shown videos of robotic hands choosing answers before selecting their own in analytical and social tasks. Their results show that participants conformed to the robots on both tasks, but the authors believe participants are mostly being led by informational conformity.

Although previous studies have shown that robots cause conformity, it is still unclear whether the participants were conforming due to normative or informational influences. This article is the first work that systematically analyzes whether adults conform to robots due to informational influences, normative influences, or both.

2 BACKGROUND

This section presents a literature overview of previous work conducted on conformity in both human groups and mixed human-robot groups.

2.1 Conformity in Human Groups

Conformity is when one changes their own behavior or choices to match the behavior or choices of those surrounding them [12]. Asch's line experiments show that participants will often change their answers to match a group of confederates answers even when the group is clearly incorrect [2]. Asch conducted several further experiments [2] in which he varied the number of trials, the number of human confederates, and the amount of ambiguity of the lines, among other factors. He concluded that in all the different variations, people consistently conformed to the answers of the group. In one of the additional experiments, the participant would write their answer on paper rather than stating the answer, after hearing the confederates verbalize their answer. In this experiment, the conformity rate decreased to only 12.5%. The fact that conformity was much more frequent when giving public answers indicates that participants were acting due to feeling peer pressure from the confederates to give the same answer as the rest of the group.

Research has shown two main reasons people conform to a group: normative conformity and informational conformity [16]. In normative conformity, the person is conforming to the expectations of others, usually because they feel peer pressure to do so. Social impact theory predicts that normative conformity increases due to three factors: group size, immediacy, and social importance [30]. Other factors that increase normative conformity are giving answers publicly rather than privately [16] and having a unanimous group [2]. Asch's study [2] was a clear example of normative conformity: the participants did not think the majority was correct but conformed to the group nonetheless when verbalizing their answer.

Informational conformity is behaving or answering according to the group due to gaining and accepting information from them. Toelch and Dolan [41] define it as "information that is acquired through sampling of the environment with the goal to make adaptive decisions that are optimized for the current context." In informational conformity, people change their answer/behavior to match the group not because they are feeling pressured to do so, but because they are adopting that information as their own. Cialdini [11] stated that the main factors that influence informational conformity are uncertainty in the correct behavior/answer and similarity with the group. Other factors in informational conformity are group size and expertise of the group. An example of informational conformity can be observed in work by Lucas et al. [33], in which they studied conformity in a math task. Their results show that participants were more likely to conform to a group when the math problems were difficult and when their self-efficacy in that particular skill was low.

Normative and Informational conformity are the two main types of conformity. However, they are not always easily distinguishable, as people are frequently influenced by both at the same time [26]. For example, when buying clothes, pre-adolescents are influenced by their friends' opinions on style and what their friends like to wear [34], which are a mix of information and normative reasons. Furthermore, there may be other reasons to conform to a group [27, 32]. In this article, we focus on normative and informational conformity and try to disambiguate between them in a subjective task.

2.2 Conformity with Non-Human Agents

Similar experiments to Asch's conformity experiment were conducted by Beckner et al. [5] and Brandstetter et al. [7], where conformity was tested with both a group of robots and a group of human actors. They administered Asch's conformity line test and also tested a verbal task where participants determined verb tenses. There were four NAO robots present, which all stated the same wrong answer in some of the rounds. Participants conformed to human confederates during the experiment but did not conform to the robots. Rather, the amount of conformity to robots was not significantly different from a baseline condition where participants pressed a button instead of verbalizing their answer. Shiomi and Hagita [39] also tested conformity with robots using Asch's line task. Conformity was tested in 12 out of 18 rounds with two conditions: one where the robots synchronized their actions (by first looking at the previous agents and then the next agent before answering), and one condition where the actions were not synchronized. Neither condition demonstrated conformity compared to a condition where no robots were present.

Children are more likely to conform to robots compared to adults. Vollmer et al. [42] tested Asch's study with robots as the confederates on children 7 to 9 years old in addition to adults. Similar to previous studies, adults did not conform to the robots. However, children did demonstrate a significant frequency of conformity to robots, suggesting that children are more susceptible to the influence of robotic agents. Williams et al. [43] also show child-robot conformity (ages 4–10) when answering socio-conventional and moral questions with a robotic doll.

Hertz and Wiese [23] also studied Asch's line task with robots in addition to humans and computers, where they compared high-ambiguity and low-ambiguity lines. Participants observed videos of either one robot, one person, or one computer answering the line task before answering themselves. Ambiguity was introduced by how long participants saw the lines: 1000 ms (low) vs. 400 ms (high). Their results show that there was a low overall conformity rate of 22.3%, but that there were significantly higher differences in conformity with high ambiguity lines compared to low ambiguity lines. Further experiments by Hertz and Wiese analyzed different tasks than Asch's line experiment [24]. They compared conformity towards three different groups of agents: humans, robots, and computers. They tested two different task types; the first was a social task in which participants observed images of people's eyes and selected the emotion they believed the eyes were expressing and a second analytical task in which participants conducted addition and subtraction with a series of dots on the screen. Before participants selected their own answer, they observed either a robot hand, a human hand, or a computer code select an answer, depending on condition. Similar to Asch, in 24 out of 36 rounds, the agents would unanimously select the incorrect answers. Their results show that overall there is no significant difference between conformity rates in the different agents, showing that robots and computers are capable of causing conformity similar to humans. However, there was a difference in conformity for the different types of tasks: participants conformed less to robots and computers in the social task, while in the analytical tasks, the conformity rates were very similar. There are several limitations to the studies conducted by Hertz and Wiese [23, 24]. The robots were not present in person but only shown through videos; there was only one other agent in the videos, but conformity is usually related to groups; the second study [24] only showed videos of hands and not of the whole robot; and there was no feeling of perception that the agents or robots observed the participants' answer, making normative conformity unlikely.

In our previous work, we demonstrated that people conformed to robots when they played a more subjective task [36]. Participants sat at a table with three robots present, and they played a card game. Participants first gave an initial answer, and after observing the group of robots' answers, they were asked to give a final answer. In 6 out of 20 rounds, the robots unanimously chose a different answer than the participant. When this happened, the participants conformed to the robots 29% of the time. Additionally, our previous work showed that there was a link between trust and conformity rates: the higher the trust in the robot, the higher the frequency of conformity.

Previous studies have shown that people conform to robots in subjective or ambiguous tasks [23, 24, 36]. However, it is unclear the reason why they were conforming to the robots. Were they doing so because they were feeling pressured by the robots to give the same answer as the group? Were they conforming because they felt that the robots had the correct answer? Or were both normative and informational conformity at play? In this article, we extend our previous work by systematically examining the motivations behind people's decisions to conform to robots by varying the amount of information given to participants and varying the amount of pressure the robots exert.

3 METHODOLOGY

In this study, our main research question is: **Can robots cause humans to conform, and if so, are they conforming to the robots to have the correct answer (informational conformity) or because they are feeling peer pressure from the robots (normative conformity)?**

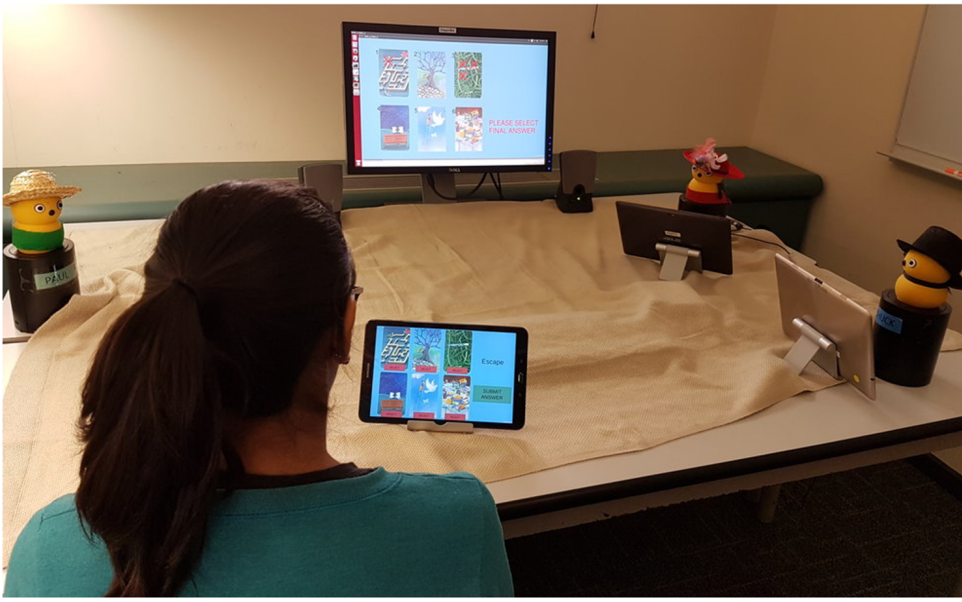


Fig. 1. In this experiment, participants sat around a table playing a game with three myKeepon robots. In certain rounds of the game, the three robots choose a different answer than the one the participant chose. Participants often changed their answers to match the answer of the robots, demonstrating conformity to the group of robots.

We follow the design of our previous work [36]. During the experiment, participants sat around a table with three robots playing a subjective game that did not have a clear, correct answer (Figure 1). A subjective game meant that prior knowledge of the game was not a main factor. Participants played 20 rounds of the game, and each round was composed of two stages. In the first stage, the participant gave a preliminary answer, and in the second stage, they gave their final answer. This mechanic permitted us to measure when they changed their mind directly and allowed us to manipulate the robots' answers depending on the participant's answer in order to maintain consistency across participants. In some of the rounds of the game, which we call *critical rounds*, all of the robots chose a different answer than the participant. It was in these rounds that we tested whether the participant conformed to the robots.

We devised four different experimental conditions to test the reasons people were conforming. In three of these conditions, we varied the amount of information participants received about the robots' answers. People seek information from the environment when uncertain [41]. Therefore, we tested whether participants believed the robots to have the correct answer by varying the visibility of the robots' answers. If participants trust in the answers of the robots, when provided sufficient information about the robots' answers, they will conform to them. However, when provided limited information about the robots' answers, they will not be able to conform. If participants do not trust in the answers of the robots, then they will not conform due to informational reasons independent of the amount of information provided by the robots.

The three conditions with varying amounts of information could also lead to a change in normative conformity, with more information leading to more conformity as the participant would be aware they were a minority in their answer. In the conditions with more information, if the participant does not conform, it would be visible to the whole group that they chose a different answer. Thus, having increased information may lead to feeling more peer pressure. The increase

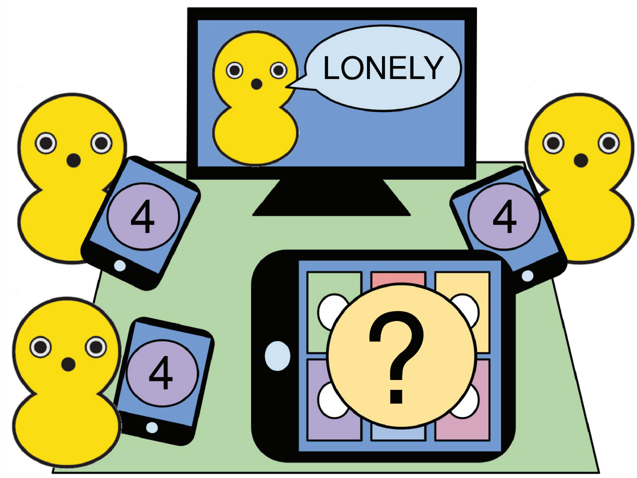


Fig. 2. Participants were given a word by a robot on a screen and then chose out of six pictures the one they best believed corresponded to the word. In certain rounds, the three robots would select an opposing answer, and the participant had to decide whether to conform to the robots or to continue with their initial answer.

of information about the robots' answers influences both normative and informational conformity. Completely separating informational and normative conformity is difficult as they are both frequently present [26, 41].

The fourth condition was similar to the condition with the highest amount of information, but a peer pressure behavior was included in the form of staring. Eye gaze is a tactic often adopted when trying to persuade [28] and has been shown to increase compliance [37]. Therefore, we tested whether staring increased the frequency of normative conformity.

To further disambiguate between normative and informational conformity, participants completed post-experiment questionnaires assessing the reasons they conformed and whether they felt pressure to change their answers because of the robots.

3.1 Procedure

Participants were seated around a table with three myKeepon robots [29]. MyKeepon robots are small yellow robots, which were dressed in colored hats to give each robot a unique personality. The robots were present in the same room as the participant, as it has been shown that being physically close to the group increases conformity [30]. Additionally, the number of robots was chosen to be three because previous studies have shown that conformity increases with the number of agents but that there are no significant differences after having more than three agents [2]. Each of the robots and the participant were given a personal tablet, and there was a shared screen that all the agents could observe.

Participants played a game with the robots in which, in each round, they were shown a set of six cards with drawings. Along with the six cards, a fourth robot (called the "game master") gave the group a word for the six cards, such as "Irony" or "Leader" (as seen in Figure 2). They were asked to select the card they believed the game master had selected as the correct answer. The cards used were digitalized images from a commercial board game called Dixit manufactured by Libellud [31].[1] They contain detailed drawings, which often did not have one singular interpretation. After

[1]Participants might have been familiar with the cards because of the board game; however, the task they did with the robots was novel to them.

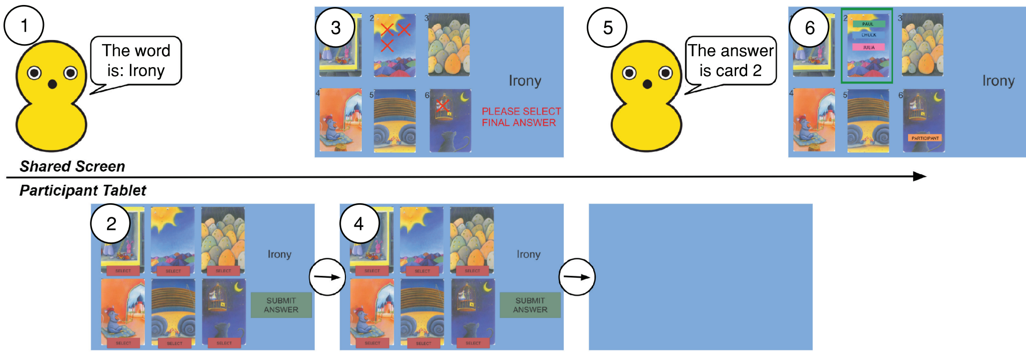


Fig. 3. The sequence of each round. (1) A "game master" robot gave a word on the shared screen. (2) The participants chose the card that they believed best corresponded to the word on their tablets. (3) Information about the robots' answers was given. In this case, the quantitative condition is shown where red "X's" were shown for the chosen cards on the shared screen. (4) The participant chose their final answers on their tablets. (5) The game master gave the correct answer on the shared screen. (6) Each agents' final answer was shown by displaying their name on top of the card they chose on the shared screen.

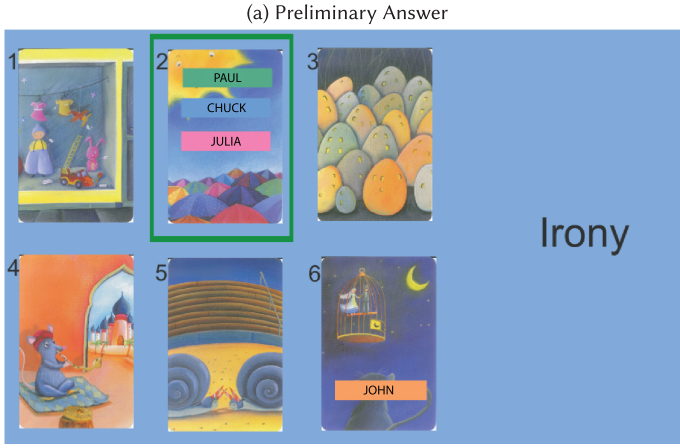
having chosen a preliminary answer on a personal tablet, the participant was given some information about the robots' answers on a shared screen. In sequence, the participant selected the final answer, and then the game master robot gave the group the "correct" answer. As the game is subjective, there is no absolute correct answer, so it was defined as the one the game master thought was the correct answer. Participants played a total of 20 rounds of the game with the robots, in which the word, the specific cards, and the answers for the round were chosen beforehand.

3.1.1 The Sequence of the Task. After completion of the consent form, the experimenter led the participant into the testing room and greeted the robots and the participant. The experimenter explained the game, and then the participants and the robots completed a practice round. After the practice round, the experimenter gave the robots and the participants a chance to ask questions. One of the robots was pre-programmed to ask whether it was OK to change their answer, and the experimenter said that they could all change their answers as many times as they wished. If the participants had any further questions, they were answered. Afterward, the experimenter left the room, and the participant played 20 rounds of the game with the group of robots (the sequence of what happened in each round can be seen in Figure 3). Each round proceeded as follows:

(1) A word was announced by a video of a fourth robot (the "game master") on the shared screen.
(2) The participant and the three robots individually chose one of the six cards that they felt best represented the word out of six cards on their personal tablets.
(3) Participants were given full, partial, or no information on the robots' answers depending on the condition they were in. Robots directed their gaze as determined by the experimental condition.
(4) The participant and the robots were given the opportunity to change their answer to one of the other cards (for the same word).
(5) The correct answer was given by a video of the "game master" robot on the shared screen.
(6) The robots' and participant's answers were shown publicly to everyone by displaying their names on top of the cards they chose for their final answer.

After the participant had played 20 rounds with the robots, they completed a post-experiment questionnaire, which is detailed in Section 3.5.

(a) Preliminary Answer



(b) Final Answer

Fig. 4. In this example of the quantitative condition, the preliminary answer (a) of all of the robots and the participant was publicly shown on the shared screen. After having chosen their final answer, each of the answers of the agents was shown on the shared screen. The names of each of the robots (Paul, Chuck, and Julia) were shown on top of their chosen cards, and the participants' answer (John in this case) was also marked with their name.

3.1.2 User Interfaces: Tablet and Shared Screen. There were two different user interfaces used in the study: the tablet user interface and the shared screen. Each of the agents (the participant and the three robots) had their own tablet through which they gave their preliminary and their final answers. The tablet showed a blue screen when the participant was not selecting an answer. A tablet was used instead of physical cards, as the robots did not have the dexterity to manipulate cards. The tablets also provided a mechanism for each agent to provide their answer without it being visible to the other agents.

There was a shared interface that was visible to the participant and to all the robots, called the shared screen. The shared screen showed videos of a fourth robot called the "game master" which gave the word at the start of each round and also provided the correct answers at the end of each round. Additionally, the shared screen showed the preliminary answers (Figure 4(a)) and the final answers publicly (Figure 4(b)).

The shared screen facilitated social pressure on the participant as the participant, and the robots all looked at the same screen. The participant felt as if the robots clearly could see when the participant chose a different answer than them; thus, they may have felt peer pressure from the group.

3.2 Conditions

In this article, we present a between-subjects study in which 63 participants were spread across four different conditions.[2]

- *Blind Condition.* Participants were given no information about the robots' preliminary answers. Instead, they were just shown a screen with the cards again (Figure 5(A)). During each round, the robots looked at the screen when the screen showed the cards again.
- *Selected Condition.* Participants could see which preliminary answers were selected by at least one robot but not how many robots chose each card. Figure 5(B) shows that both the first and second cards were chosen by at least one person/robot, but no information was given about how many chose each of the answers. The robots looked at the screen when the preliminary answers were shown.
- *Quantitative Condition.* Participants were shown an "X" on top of each card chosen by a robot. An example can be seen in Figure 5(C), where three players chose the first card, one player chose the second card, and none chose the last card, but no information was given about which red "X" corresponded to whom. The robots looked at the screen when the preliminary answers were shown.
- *Staring Condition.* Participants also saw the robots' answers in the form of red "X"s on the screen (identical to the quantitative condition). However, whenever the robots all chose a different preliminary answer than the participant in the critical rounds, they all first looked at the screen briefly and then stared at the participant for several seconds (Figure 5(D)). If the participant continued choosing a different answer than the robots for their final answer, the robots would stare again at the participant after the final answers were revealed. During all the non-critical rounds, the robots did not exhibit the staring behavior.

We only created the condition that included the staring behavior in the case where the red X's appeared for each answer. In the other two cases, the robots would not have sufficient information to know there was a minority present, and therefore the staring behavior would not make sense.

3.3 Rounds

Participants played 20 rounds of the game with the robots. For each round, the cards that were shown and the word were chosen beforehand. There was a variety in the types of rounds to make the game feel more realistic. For example, there were rounds where the correct answer was very clear, and all three robots chose the same card. There were rounds where all their answers diverged. Furthermore, there were rounds where one or more of the robots changed their answers, and there were rounds where they did not change their answers. This showed that it was permissible to either change or keep your original answer. The "correct" answers for the rounds were also chosen beforehand. For the easier rounds, the most plausible answer was usually correct. For some of the rounds, the answer that the participant chose was correct, and for others, the answer that the robots chose was correct.

The different rounds were based on Table 1. Because the robots adapted to the choices of the participant, the robots' choices did not always perfectly follow the pre-planned rounds.

[2]Two of the four conditions overlap with the conditions presented in [36] - the blind condition and the quantitative condition.

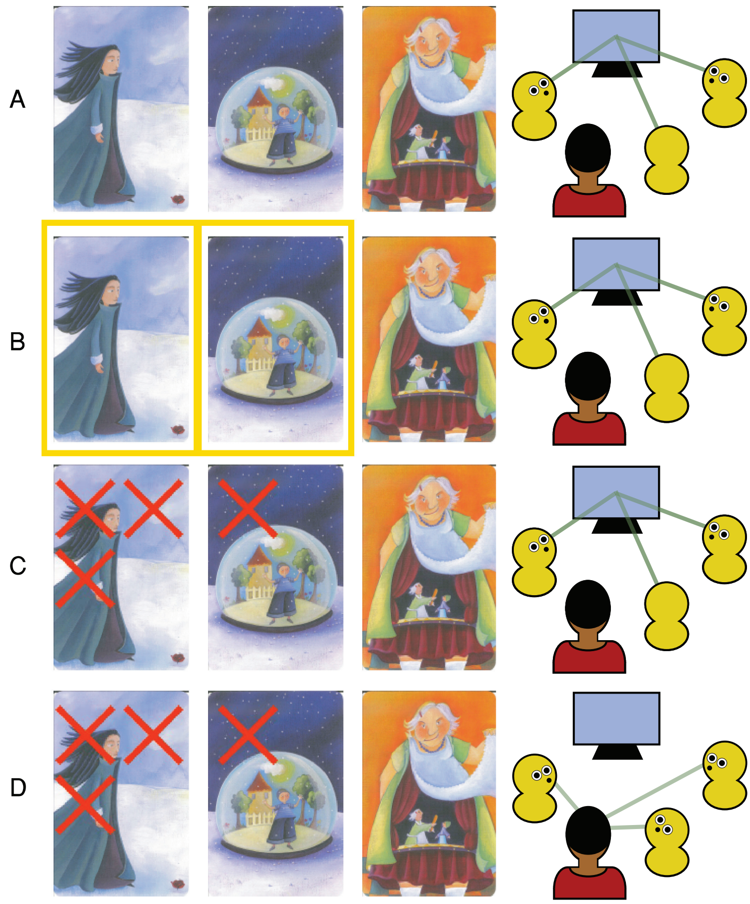


Fig. 5. Examples of the preliminary answers of the robots in the four conditions. In the **blind condition** (A), no information was shown about the robots' preliminary answers, and the robots looked at the shared screen after the participant had selected his/her answer. In the **selected condition** (B), the selected cards (that were chosen by at least one robot or the participant) were shown with yellow squares around them, and the robots looked at the screen after the participant had selected his/her answer. In the **quantitative condition** (C), each robot's answer and the participant's answer were represented with a red X on top of their chosen cards, and the robots looked at the screen after the participant had selected his/her answer. In the **staring condition** (D), the robots' and participant's answers were represented with a red X on top of the chosen card. During critical rounds, all three robots first looked at the screen briefly and then turned around and stared at the participant for several seconds. During non-critical rounds, the robots looked at the screen after the participant had selected his/her answer.

- *Unanimous Rounds.* There was one picture that seemed more correct than the others. All three of the robots chose the same preliminary answer and did not change their answer for their final answer. The participant was also expected to choose this answer.
- *One Robot Converges.* During the preliminary round, two robots chose one answer, and one chose a different answer. The robot with the different answer converged to match the group for its final answer.
- *Two Robots Converge.* During the preliminary round, one robot chose the same answer as the participant, and the other two robots chose a different answer. The two differing robots changed their answer to be the same as the participant.

Table 1. The Round Number with Their Type of Round

Round Numbers	Type of Rounds
1, 3, 6, 8, 18	Unanimous Round
2, 4	One Robot converges
11, 19	Two Robots Converge
12	One robot different
7, 14, 15, 17	All different
5, 9, 10, 13, 16, 20	Critical Round

- *One Robot Different.* One robot was different from the other robots. The participant could have aligned his/her answer with the two robots or with the one robot. The different robot did not change its answer.
- *All Different.* All the robots chose a different answer from each other. In some of the rounds, one of the robots' answer might overlap with the participant's answer. In some of these rounds, one of the robots changes their answer to either match a participant or to match another robot.
- *Critical Rounds.* All the robots chose the same opposing answer from the participant. These are the rounds in which we were testing conformity.

The answers of the robots were adjusted to the answers of the participant to make the experience of the participants as similar as possible. For example, in the 'Two Robots Converge" case, when the robot chose a particular answer, one of the other robots also chose it. The two remaining robots chose a separate reasonable answer. And in the "One Robot Different" case, two of the robots were assigned the same answer that the participant chose, and the third robot was assigned a different answer. By adjusting the behavior of the robots, participants experienced the same scenarios independent of their own preliminary answers, and they observed the robots get the answers right/wrong the same amount of times and on the same rounds. The exception to this was on the unanimous rounds where the answer was very apparent, and the robots consistently chose the correct answer as a clear wrong answer might make the participants question the robots' capabilities.

3.3.1 Critical Rounds. Out of the 20 rounds, six were *critical rounds* In these rounds, the three robots were programmed to unanimously choose a different plausible answer opposing the participant's answer. For example, in one of the rounds, the word was "Immense," and one of the options was a large landscape with a night sky above it, and another option was a monster with its mouth open. When the participant chose the landscape, then all three robots would choose the monster and vice-versa. The six critical rounds where the robots unanimously diverged their answers were the rounds in which we observed whether participants conformed to the robots. In three of the six rounds, the participants' initial guess was right, and in the other three rounds, the robots' preliminary guess was correct. This was kept balanced to prevent participants from believing that the robots were always correct or always incorrect. Examples of some of the critical rounds are shown in Figure 6.

3.4 MyKeepon Robots

During the experiment, three myKeepon robots were used. MyKeepon robots have four degrees of freedom and are commercialized versions derived from a research robot called Keepon Pro [29]. The robot is a 15 cm tall robot composed of two spheres giving it a snowman-like appearance with a soft yellow exterior foam. The three robots used are shown in Figure 7. Each robot was capable

Fig. 6. Examples of several of the critical rounds, with their words and images. The pictures highlighted in yellow were the two most reasonable answers. Whichever of the two that the participant chose for their preliminary answer, the three robots unanimously selected the other one. When a participant chose neither of the two, the robots had a predetermined one of the two that they chose.

Fig. 7. In this human subjects study, a human participant interacted with a group of MyKeepon robots. Each of the robots was dressed uniquely and had a different voice.

of moving to look at the different robots and also to look at the different screens. Additionally, the robot was programmed to sway side-to-side when an audio file played to simulate talking. Each of the robots had a unique name, a different recorded voice, was dressed differently, and had different styles of utterances (for example, one made some jokes, and one was a bit shy), so they appeared to have different personalities. Previous studies have shown that diverse human groups are attributed more agency [35] and that diverse robots are perceived as more intelligent [20] than entitative robots. Therefore, we chose to have the robots look and behave slightly different from each other. They performed utterances during the game such as "I am not sure about this one," "Hmmm," or "This one I think I know." During the critical rounds, the robots did not say anything to avoid confounds created by verbal persuasion.

We chose to have three robots in the experiment, as three robots are the minimum necessary for them to be considered a group [46]. In Asch's studies, he founds that more confederates present increased conformity, but few differences were found when the group was larger than three confederates [2]. Two of the robots were assigned to be male, and one of the robots was assigned to be female. The game master robot was also assigned to be female to keep the genders balanced during the interaction. The three robots were on the table around the participant, and each had a tablet in front of it to play the game with the participant.

3.5 Measures

During the interaction, we collected both behavioral (mainly what participants chose as their final answer during critical and non-critical rounds) and questionnaire data.

3.5.1 Answer Changes. Our primary measurement was whether or not participants changed their answers to the answer of the group of robots in the six critical rounds. We also measured how frequently participants changed their answers to match at least one of the robots in the rounds that were not critical rounds. Additionally, we measured how frequently participants conformed in the round following the critical round. We did this to test whether participants in the selected and blind conditions who did not know they were in the minority in the current critical round would attempt to be similar to the robots in the following round.

3.5.2 Questionnaire. After playing 20 rounds of the game with the robots, the participants completed a post-experiment survey. The survey included the godspeed questionnaire with questions on the perceived animacy, likeability, and intelligence of the robots [4]. The survey asked the participants to rate the following questions on a Likert scale from 1 (disagree) to 5 (agree): "I felt pressure to change my answers because of the robots" and "The robots were better at playing the game than me." The last question was an open-ended question: "Did you ever change your answer because of the robots and why?".

3.6 Participants

A total of 66 participants were recruited, out of which three participants were excluded due to technical problems. Of the remaining 63, 27 were male and 37 were female, with an average age of 26.3 years old (SD = 8.8). Most of the participants were students from a local university and people from its surrounding community. There were no significant differences in age and gender between conditions. Participants were randomly assigned to conditions: 15 participants (6 male) were in the staring condition, 17 participants (6 male) were in the quantitative condition, 16 participants (9 male) were in the selected condition, and 15 participants (6 male) were in the blind condition. The University Institutional Review Board approved this study. Participants signed a consent form agreeing to participate in the study and received 5 dollars compensation for their time. The game with the robots and the questionnaire took approximately 30 minutes.

4 RESULTS

In this section, the findings on the conformity rates for the different conditions and post-experiment questionnaire results are presented.

4.1 Behavioral Results

First, we tested whether there was a difference in the conditions for the number of times people changed their answers to be the same as at least one of the robots throughout all the rounds. A logistic regression was conducted with condition (quantitative+staring,[3] selected and blind) and whether it was a critical round as independent variables; the independent variable was whether they conformed during that round. The logistic regression showed that there was an effect on the amount of information about the robots' answers shown to the participants ($logodds : 0.61, SE : 0.16, Z : 3.84, p < 0.001$). It also showed that there was a significant difference for the conditions in the conformity rate depending on if it was a critical trial or a neutral trial ($logodds : 0.60, SE : 0.16, Z : 3.84, p < 0.001$), indicating that people were changing their answers more frequently to match the robots in the critical trials than in the neutral trials. Last, a logistic regression with staring as an independent variable shows that the staring behavior had no significant influence on the interaction ($logodds : 0.19, SE : 0.20, Z : 0.95, p = 0.340$).

Since there was a significant difference in the conditions on the conformity rate during the critical trials, we further investigated how the varying amounts of information given to the participants influenced their conformity rates. On average, participants conformed to the robots less in the blind condition ($M = 0.33, SD = 0.72$) and the selected condition ($M = 1.00, SD = 0.89$) compared to the quantitative condition ($M = 1.94, SD = 1.48$). An ANOVA test with the conditions as the independent variable and number of changes as the dependent variable showed that there was a significant difference in conformity between conditions during the critical rounds [$F(2, 48) = 8.70, p < 0.001$]. A post-hoc Tukey HSD test showed that there was a significant difference between the quantitative and selected conditions ($p = 0.046$), a significant difference between the quantitative and blind conditions ($p = 0.001$), but no significant difference between the selected and blind conditions ($p = 0.221$). These results showed that participants conformed significantly more to the robots when they were aware they were a minority in their answer. These results are presented in Figure 8(a). In the quantitative conditions, the robot would either stare at the participant or not when their answers differed. However, the staring behavior did not cause a significant increase in frequency of conformity in the critical trials [$F(1, 30) = 0.22, p = 0.640$]. These results are presented in Figure 8(b).

Participants changed their answers (on critical and non-critical rounds) to match at least one robot a similar number of times on average in the three conditions where information was provided: staring ($M = 4.2, SD = 2.018$), quantitative ($M = 3.53, SD = 2.29$), and selected ($M = 3.94, SD = 3.21$). However, in the staring and quantitative condition, participants were making a large number of these changes in critical rounds (52.8% and 55.0%, respectively), whereas most of the changes in the selected condition were not in critical rounds (25.40% in critical rounds). Using Chi-Squared with Bonferroni corrections, we compared the number of critical and non-critical round changes in the three conditions: the difference was significant between the staring and selected conditions X^2 $(2, N = 126) = 9.6512, p = 0.006$, the difference was also significant between the quantitative and the selected conditions X^2 $(2, N = 123) = 11.24, p = 0.002$. There was no significant difference between the staring and quantitative conditions. These results are presented in Figure 9(a).

[3]quantitative+staring encompassed both the pure quantitative and the staring conditions as they both provide the same amount of information of the robots' answers.

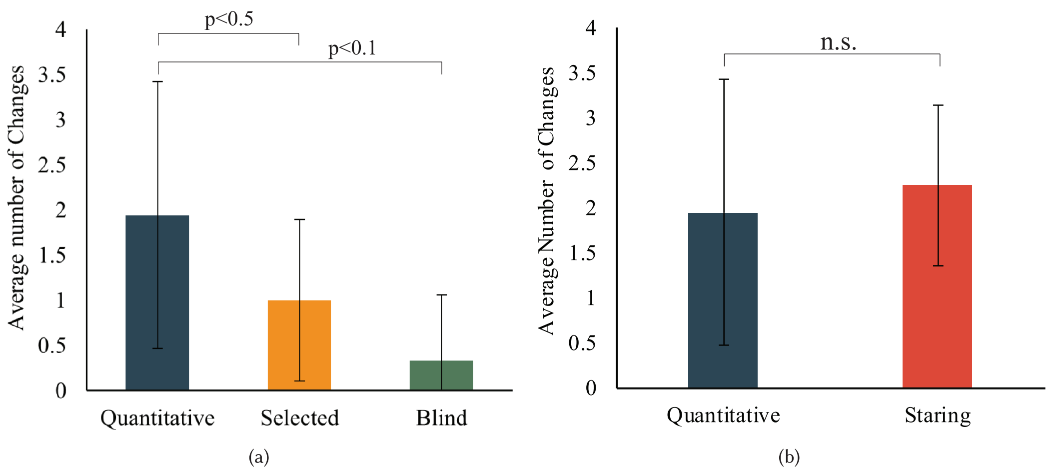


Fig. 8. (a) Participants were significantly more likely to conform to the robots' answers when they were aware they were a minority compared to when they only knew at least one robot had chosen a different answer than they did. They were also significantly more likely to conform than the participants who had no information about the robots' answers. (b) Adding the staring behavior to the quantitative condition did not significantly increase conformity in the critical rounds.

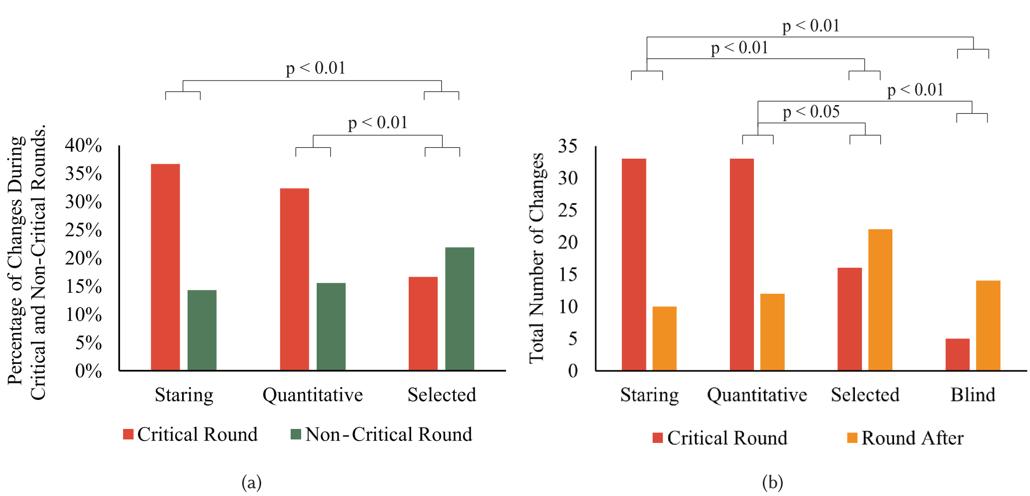


Fig. 9. (a) Despite participants having changed their answers a similar number of times to match the robots in the three conditions with information, participants in the selected condition significantly changed their answers more in non-critical rounds than in critical rounds compared to the staring and quantitative conditions. (b) Participants in the selected and blind conditions significantly more frequently changed their answers in the round right after the critical round than in the critical rounds, compared to the staring and quantitative conditions.

Further investigation of which rounds participants in the selected and blind conditions changed their answers to match at least one of the robots showed that they were frequently changing their answers in the rounds immediately after the critical rounds.[4] A logistic regression showed that

[4]One subsequent round was excluded because it was both a critical round and the round after the critical round.

there was a difference in conformity between the round immediately after the critical round and the remaining neutral rounds ($logodds : 0.50428, SE : 0.17, Z : 2.90, p = 0.004$). Participants in the selected and blind conditions were frequently making changes in the round immediately after the critical round, compared to the quantitative and staring conditions: 34.4% of the time in the selected condition, 23.3% of the time in the blind condition, 19.1% in the quantitative condition, and 16.7% in the staring condition. Performing a chi-squared analysis with Bonferroni corrections showed that participants were significantly more likely to change their answer in the critical round than in the round immediately after the critical round in the quantitative condition compared to the selected condition X^2 $(2, N = 83) = 8.31, p = 0.024$ and compared to the blind condition X^2 $(2, N = 64) = 12.24, p = 0.003$. They were also significantly more likely to change in the critical round rather than in the round after the critical round in the staring condition compared to the selected condition X^2 $(2, N = 81) = 10.13, p = 0.009$, and the blind condition X^2 $(2, N = 62) = 14.12, p = 0.001$. In summary, participants in the blind and selected conditions were frequently changing their answers to match at least one of the robots in the round immediately after the critical round, while in the quantitative and staring conditions, they were more frequently changing their answers in the critical round. These results can be seen in Figure 9(b). Whether the robot achieved the right or wrong answer did not appear to play a significant role in the participant's deciding to change his/her answer in following rounds (12 and 10 times, respectively, after observing the robots' answers were right and wrong in the selected condition, and 8 and 6, respectively, in the blind condition).

Another element to consider is how the round number influenced the number of times participants changed their answers. There was not a significant correlation between the round number and the number of changes for all rounds ($R = -0.02, N = 20, p = 0.93$). Neither was there a significant correlation between the round number and the number of changes during critical rounds ($R = -0.48, N = 6, p = 0.34$). Therefore, the round's number did not play a strong role in the number of changes during the interaction.

4.2 Questionnaire Results

In the post-experimental questionnaire, participants reported on a scale from 1-5 on how much pressure they felt to change their answers because of the robots. In the staring condition, participants reported feeling the highest amount of pressure to change ($M = 3.53, SD = 1.25$), followed by participants in the quantitative condition ($M = 2.82, SD = 1.29$), then participants in the selected condition ($M = 2.16, SD = 1.18$), and lastly participants in the blind condition ($M = 1.6, SD = 0.83$). Performing an ANOVA with condition as the independent variable showed that there were differences between conditions in the amount of pressure they felt from the robots [$F(4, 63) = 7.94, p < 0.001$]. Post-hoc Tukey tests showed that participants in the staring conditions felt a significantly higher amount of pressure to change compared to the blind ($p = 0.001$) and selected conditions ($p = 0.008$). Participants in the quantitative condition also felt a significantly higher amount of pressure compared to the blind condition ($p = 0.021$). There were no significant differences between the remaining conditions. These results are presented in Figure 10(a). There was a correlation in the staring condition and the quantitative condition between reporting pressure to change and critical round changes. Using Pearson correlation, in the staring condition, there was a moderately positive correlation between critical round changes and pressure to change ($R = 0.52, N = 15, p = 0.048$), and also, in the quantitative condition, there was a positive correlation ($R = 0.65, N = 17, p = 0.005$). There were no significant correlations between feeling pressure and critical round changes for the selected and blind conditions.

Lastly, participants were asked whether the robots were better at playing the game than they were on a 5-point Likert scale. On average, participants across the three conditions responded similarly that the robots were on par with them at the game (staring: $M = 2.73, SD = 1.28$; quantitative: $M = 2.94, SD = 1.20$; selected : $M = 3.2, SD = 1.26$; blind: $M = 3.27, SD = 0.88$). An

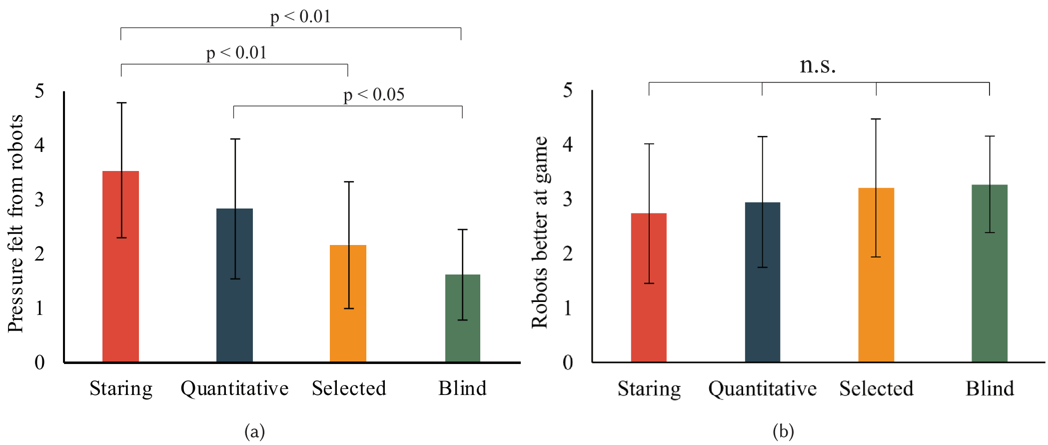


Fig. 10. (a) Participants felt significantly more pressure to change their answers because of the robots in the staring conditions than they did in the selected and blind conditions. Additionally, participants in the quantitative condition felt more pressure than the blind condition. (b) Participants in all four conditions viewed robots similarly in terms of if they were better at the game than they were.

ANOVA showed no differences between all four conditions in how participants rated the robots in if they were better at the game than they were [$F(4, 63) = 0.81, p = 0.495$]. These results are shown in Figure 10(b).

Although prior work has shown females to conform more than males [6, 17], in our study there were no significant differences in gender for the number of times participants conformed. Additionally, prior work has shown that people are more influenced by those they perceive as more likeable and intelligent [10]; however, in our study, there were no significant correlations between conformity and the perceived animacy, intelligence, or likeability of the robots.

5 DISCUSSION

Previous results have shown that robots are capable of causing adult conformity [24, 36]. In this section, we discuss how robots in our study were causing normative conformity in addition to informational conformity. We also discuss how different tasks affected the conformity rates in human-robot interaction. Last, we discuss some potential future directions.

5.1 Informational Conformity

We believe robots were causing informational conformity due to three main reasons. First, when participants were given more information about the robots' answers, they conformed significantly more. Second, participants viewed the robots as being capable of this task, which is an element that enables informational conformity. And third, the subjective nature of the task increases the willingness to accept information from the robots, which was confirmed by many participants in the open-ended question.

To measure whether robots were causing informational conformity, the current analysis focused on the quantitative, selected, and blind conditions, where the amount of information given to the participant varied. Participants conformed significantly more in the quantitative conditions than they did in the blind and selected conditions. Even though participants in the selected condition did conform a higher number of times on average than the blind condition, this difference was not significant, implying that being aware that at least one robot chose a different answer was not sufficient to sway the participant to change their answer. However, when the participants were aware that all the robots chose a different answer than they did, they more frequently conformed to the robots. The results suggest that having the information that one was in the minority in his/her answer increased the likelihood of accepting information from the majority as the participants had more information from the environment to make decisions [41].

One of the factors that is believed to influence informational conformity is the expertise of the group [10, 44]. Participants viewed the robots as performing well at this particular task: in the questionnaire, participants rated the robots as being similar to themselves at how good the robots were at the game. These results are surprising, considering robots do not usually perform well at high-level tasks such as understanding the meanings of images. Additionally, participants gave similar scores to the robots' capabilities across the conditions, indicating that they are not viewing the robots as better at the game in one condition compared to another. However, participants conformed more in the quantitative condition compared to the selected and blind conditions. Once participants were given more information (such as how many robots chose each answer), they utilized this information and conformed to the robots. This indicated that participants believed the robots to have the correct answer but only had sufficient information to conform in the conditions with more information.

One of the main factors that influences informational conformity is uncertainty in the answer [11]. Individuals are more likely to copy others when they are uncertain [40]. Therefore, it was likely that the subjective nature of the game increased the participants' likelihood of accepting information from the robots. Our results are in line with how participants responded to the open-ended question, where they frequently stated they were using the robots' answers to decide their own final answer. For example, one participant in the quantitative condition wrote: "Yes, from life experiences, majority is usually correct." Another participant in the quantitative condition wrote: "Yes, because I thought the way they decided was going to be right." There were also participants in the selected condition who responded that they changed their answer due to information of the robots' answers: 'When they highlighted a different option, and then I felt that it was more apt than the one I chose."

5.2 Normative Conformity

Our results show that normative conformity was playing a role in the participants' decisions to conform to the robots in the staring and quantitative conditions: participants conformed significantly more in critical rounds in the staring and quantitative conditions compared to the other rounds. Participants reported feeling pressure to change because of the robots and acted upon it. Additionally, participants in the selected and blind conditions that did not have the information to conform during critical rounds changed their answers frequently to the answer of at least one of the robots in the next round.

To measure whether robots were causing normative conformity, this analysis was focused on the comparison of the staring, quantitative, and selected conditions (as in the blind condition, participants had no information on the robots' answers, and therefore normative conformity was highly unlikely). In the quantitative condition, there were significantly more changes in participant answers during critical rounds than in the selected condition, demonstrating that being aware of the number of robots choosing certain answers influenced participant's decisions to conform. Therefore, being aware that one was in the minority in a group of robots increased the likelihood of conforming to them, compared to only knowing that at least one robot chose a different answer.

Participants in the staring, quantitative, and selected conditions were making, on average, a similar number of changes across all the rounds (critical and non-critical). However, participants in the staring and quantitative conditions were making many more of these changes in critical rounds. Providing participants with the information of how many robots chose each card did not increase overall changes but specifically increased the number of changes to the robots in the rounds where they were the minority. This is in line with previous research showing that having a unanimous group increases normative conformity [2].

There were no significant differences in the frequency of conformity between the staring and quantitative conditions. Therefore, adding the staring behavior did not significantly increase conformity. There are multiple possible interpretations of this. The first being that participants did not feel additional peer pressure because of the staring behavior either because it was not very observable or because they did not perceive it as a persuasive behavior. Another interpretation is that the quantitative behavior alone was already causing a large amount of peer pressure, and adding the staring behavior did not increase the frequency of conformity significantly. A previous study has shown that eye contact can actually create resistance to the person who is trying to persuade [9]; therefore, the staring behavior might have caused some participants to conform less. An additional possibility is that the staring behavior is causing psychological reactance in some of the participants towards the robots. Studies have shown that very apparent persuasive behaviors can decrease the amount of compliance [21]. Additional studies should be conducted to determine which social behaviors of robots cause increased peer pressure.

Participants in the staring and quantitative conditions were making most of their changes in critical rounds, whereas participants in the selected and blind conditions were frequently changing their answers in the round right after the critical round. Participants in the selected and blind conditions did not have the necessary information to see they were a minority in the critical rounds in time for them to change their answers. However, when the final answer was shown, the participants observed that all the robots had chosen a different answer than they did. We believe this caused the participants in these conditions to change their answers in the following round, attempting to choose the same answer as the robots. Additionally, the robots getting the answer right or wrong in the critical rounds did not appear to play a role in deciding to change their answer in the subsequent round. Therefore, the main reason they were changing their answer was not necessarily because they thought accuracy would be increased. Instead, we believe this was an indication of normative conformity where participants wanted to be in-group with the robots.

Participants in the staring and quantitative conditions reported higher pressure to change their answers because of the robots than the selected and blind conditions. Additionally, the amount of pressure to change was correlated with the number of critical round changes. This was an indication of normative conformity, where participants were feeling pressure to change and acting upon that pressure. Participants in the staring and quantitative conditions also mentioned feeling peer pressure in the open-ended question. Several participants commented that they changed their answers to match the robots' answers when they were part of the minority, indicating that participants were changing to become part of the majority. For example, one participant in the staring condition wrote: "Yes, because they'd look at me judgmentally when I had a different answer, so it made me doubt myself." Another participant in the staring condition commented: "Sometimes when they all chose the rose field, I felt dumb for picking the ballet shoes." A participant in the quantitative condition wrote: "Yes (I changed) if they outnumbered me on one particular picture."

5.3 Influence of Task in Conformity

Several studies have been conducted attempting conformity with robots, of which some observed conformity [24, 36, 43] and some did not [5, 7, 39]. The main difference between the experiments which observed conformity and those which did not was the task being tested. It is necessary to have a task where the participant is not certain of the correct answer. The robotic studies which failed to show conformity mostly tested Asch's line task, which has a clear, correct answer, whereas the studies which did show conformity with robots had a task in which the answer was not as clear. Our study used a subjective word-card matching task. Hertz and Weise [24] presented the questions to the participants for only 2.5 seconds and the accuracy rate of responding solely was 63% for the analytical task and 68% for the social task. Similarly, the tasks of Williams et al. [43] used socio-conventional and moral questions. Therefore, we believe it is necessary to have a more subjective task to cause conformity. This is in line with human psychology, where more difficult and subjective tasks have higher rates of conformity [3].

Other characteristics of our task that could have influenced the number of times participants conformed were that they were all sat at the same table close together [30] and that the answers were publicly shown on a shared screen [16]. Additionally, the answers of the robots were highlighted on the screen, focusing the participants' attention on those answers, which could have influenced conformity [10].

5.4 Future Work

There are several different areas of potential future work, following our results. The robots used in the study were very simple, but despite their size and simplicity, they caused both informational and normative conformity. Factors that increase informational conformity are the similarity with the group [11] and the expertise of the group [44]. Future studies should analyze whether having robots with increased similarity to humans or with higher appearance of capabilities will also lead to more informational conformity.

Factors that increase normative conformity are group size, the immediacy of the group, and their social importance [30]. Future studies could analyze how changing the perceived social importance of the group, changing the number of robots, and changing how close the robots are will influence the frequency of normative conformity. Another factor that influences normative conformity is whether the other members are considered in-group or out-group [1]. Several studies have shown that in-group robots are rated more anthropomorphic and are favored over out-group members [18, 19]. Therefore it should be studied how group membership and anthropomorphism influence conformity.

Our results indicate that conformity is directly linked with the type of task being tested. Future work could analyze how conformity changes depending on the type of task and to further investigate if conformity to robots can be used in pro-social ways [14]. Last, conformity is influenced by individual characteristics [40]. Culture [6], age [15], gender [6, 17], and other personal factors have been shown to influence the decision to conform in human groups. More studies on different personal factors should be studied to see how they influence conformity to robot groups.

6 CONCLUSIONS

In this article, we showed that robots can cause people to conform to them in a subjective task. Participants played a card game with three robots in which they were given varying amounts about the robots' answers, and in one condition, the robots stared at them to cause peer pressure. Informational conformity was shown to be at play because participants conformed more when they were given more information about the robots' answers, and they considered the robots on par with them at the game. Normative conformity was shown to be at play because participants conformed significantly more when they were aware they were a minority and because they reported feeling pressure by the robots in the questionnaire. We conclude that adults conform to robots due to both informational conformity and normative conformity.

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