

Do the Number of Robots and the Participant's Gender Influence Conformity Effect from Multiple Robots?

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The conformity effect is a critical social phenomenon through which one individual or a particular group influences the thoughts, feelings, or behaviors of another person or group. We focused on two essential factors that influence the power of the conformity effect: the number of people and gender. In this paper, we investigated whether the number of robots and the gender of the interacting partner change the conformity effect. We experimentally compared conformity effects by considering these two factors while participants answered questions after listening to incorrect answers from two, four, or six robots. The conformity ratios were significantly different between the six robots and two/four robots and between female and male participants.

Keywords: Human-Robot Interaction, Conformity Effect

1. Introduction

Human decision-making is generally influenced by the opinions of others. One common social influence from others is the power of the many. For example, Sherif investigated the conformity effect in ambiguous situations and showed that participants followed the choices of others, even though they admitted having objections to them [1]. Asch reported that participants obeyed other people's incorrect choices, and the number of the others strengthened the peer pressure that indicates conforming to the majority [2, 3]. Spencer et al. and Griskevicius et al. investigated the relationships between the power of peer pressure and ambiguity and concluded that more of the latter increased peer pressure [4, 5]. The participant's gender also influences the conformity effect in face-to-face situations. Several research works reported that females conform more than males in face-to-face groups [6, 7], but no such gender effects appeared in situations without face-to-face aspects such as internet-based surveys [8].

In the human-robot interaction research field, researchers have also focused on

the conformity effects caused by multiple robots. For example, Midden et al. investigated the persuasion of a group of virtual agents with Asch's paradigm and found a weaker conformity effect under high task difficulties [9], but they did not focus on physical agents, i.e., robots. Brandstetter et al. investigated the conformity effect from multiple robots [10] and found no significant effects from a group of four robots, even for difficult tasks. Salomons et al. argued that trust relationships between robots and people increased the conformity effects from robots [11]. Recently, Vollmer et al. reported that children conform more than adults to multiple robots [12].

However, even though robotics researchers have broadly investigated such conformity effects, they have less focused on the effects of the number of robots and the participant gender, which are essential factors for conformity in human cases. For instance, past studies used three or four robots to investigate the effects of the number of robots but they did not focus on the effects of that number [10-12], even though it is an essential factor in conformity effects [2, 3]. Moreover, these studies did not focus on the influence of the partner's gender to conformity effects, even though past studies suggested that females conform more than males in face-to-face situations [6, 7].

Due to increased use of multiple robots in real environments, understanding these influences toward conformity effects will contribute to knowledge building in human-robot interaction contexts and how people interact with multiple robots. To investigate the influence on conformity effects, we prepared a multiple-robot controller system and prepared visual judgment tasks that reflect past studies that focused on the conformity effect in both human-human [1-3] and human-robot interactions [10, 12]. In this study, we address the following research questions:

- Does the number of robots influence the ratio of conformity?
- Does the participant's gender influence the ratio of conformity?



Fig. 1 Do multiple robots exert conformity effects?

2. RELATED WORKS

2.1 Conformity Effect in Human-Computer Interaction

A past study reported that people tend to treat computers as social beings [13]. Human decision-making is influenced not only by other people but also by computer systems and computer agents [12]. Based on this context, Midden et al. compared the conformity effect from multiple computer agents on a human experimenter [9]. Their experimental results identified the effects of peer pressure with human experimenters (as in Asch's experiments), but they reported that computer agents only exerted a conformity effect under high task difficulty. Berns et al. also showed such effects with computer agents under the same condition [14]. Rosander et al. concluded that increasing the task difficulty in computer-mediated communication increased the conformity effect [8].

These studies provided rich knowledge about the conformity effect from computer agents. Based on them, we investigated it from multiple robots with high task difficulty.

2.2 Conformity Effect in Human-Robot Interaction

Similar to human-computer interaction research fields, robotics researchers have investigated the conformity effect from multiple robots. For example, Brandstetter et al. investigated it from multiple robots [10] (in their reproduction of Asch's experiment) and thoroughly compared the power of conformity effects between robots and humans with both low/high task difficulties. As in Asch's experiment, their experimental results showed peer pressure effects with human confederates in both task difficulties, although in their study the robots did not cause any significant conformity effect in either low or high task difficulties [10].

However, recent related works argued that robots show a significant conformity effect in specific situations. For example, Salomons et al. investigated the effects of trust between robots and adults toward conformity effects and concluded that people conform more to robots when they trust them [11]. Another study investigated conformity effects with children and reported that they conform more than adults to multiple robots [12].

These studies provided valuable knowledge about conformity effects from multiple robots, but several essential factors (i.e., the number of robots and interacting partner's gender) remain insufficiently investigated.

3. Experiment Design

3.1 Task Design

In this study, we prepared visual judgment tasks based on Asch's experiments [2, 3]. However, unlike Asch's task, we considered aspects of Sherif's experiment, i.e., ambiguous situations for conformity effects [1], similar to past studies that focused on the conformity effect from multiple computer agents or robots [9, 10]. Fig. 2 shows an

example of the line tasks in this study, where the participants identified the corresponding line from candidates A to C from a single candidate.

On the left are displayed three lines whose lengths differ from the correct line (labeled “?”) in a range of +/- 1 to 3 mm. Three different choices of correct line lengths are offered: 50, 100, and 150 mm. Note that the difference of the line length was 1 inch (254 mm) in the original experiment. Therefore, since the line differences in our study are more ambiguous, distinguishing among them is often more difficult than in the original settings. The number of total trials was 18, which is identical to the original experiments [2, 3]. We used different line lengths because past studies [9, 10] already showed that using multiple robots and the same line lengths from the original study (as low task difficulties) did not cause conformity effects; using different and ambiguous line lengths (as high task difficulties) might also cause conformity effects. Therefore, to investigate the conformity effects with multiple robots, we used different line lengths than in the original study. Since the past study [10] did not provide any details of its ambiguous line settings, we heuristically adjusted the line lengths to increase the task difficulty.

3.2 System Design

To investigate the conformity effect from multiple robots, we must decide the number of robots for our experiment. In human-human interaction literature, Asch investigated the relationships between conformity and group size [15] and found that the conformity effect increased when a group had three people and did not appreciably increase by adding more people. However, in human-robot interaction literature, Brandstetter et al. argued that four robots did not exert a conformity effect on people, even in high task difficulties [10]. Based on these considerations, we heuristically chose

two, four, and six robots as responders. By considering both task and system design, we developed an experimental system and describe its details in the next section.



Fig. 2 Example of line task

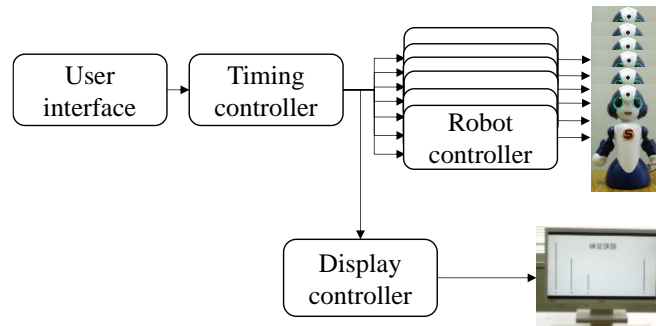


Fig. 3 System overview

3.3 System Configuration

Figure 3 overviews our multiple-robot controller system that consists of the following five components: a user interface to control multiple robots, a timing controller for each robot behavior, a robot controller that manages the robot's motions and utterances, a display controller to show images, and a robot. All of the systems were connected through a wired LAN. To avoid network delays, each system was connected to the same NTP server to synchronize the clocks among the PCs.

For this study, we used Sota, a table-top-sized interactive humanoid robot, which has eight DOFs: three in its head, one for each shoulder and each elbow, and one for its base. It is 28 cm tall and has a voice synthesis. Each robot has a slightly different voice for simpler differentiation; the LED on its mouth blinks to indicate speaking based on the sound level.

4. Experiment

4.1 Hypotheses and Predictions

Human decision-making is often influenced by a conformity effect that is exerted by others [2, 16]. To investigate whether multiple robots can exert it, we used a different number of robots compared to a past study [10] to investigate whether additional robots might intensify the conformity effect and create conformity to the answers from the robots.

Moreover, in face-to-face situations, participant gender is an essential factor in conformity effects. Past studies reported that females conform more than males in face-to-face situations [7] [8]. Interaction with robots in the same physical environment might cause similar reactions from female. Based on these considerations, we made the following predictions:

Prediction 1: The ratio of conformity will increase based on the number of robots.

Prediction 2: Female participants will conform more to the robots than male participants.

4.2 Environment

We conducted our experiment in a laboratory room (Fig. 4). A maximum of seven robots (one facilitator robot and six respondent robots) and a display were placed on a desk in room A. The facilitator robot is on the display's right, and the placement of the six respondent robots is shown in the figure. From room B, the operator sends start signals to the robots. The participants sat 180 cm in front of the display. We managed the experiment through the facilitator robot and recorded all of the experiment's data with two cameras and two microphones.

4.3 Conditions

We prepared three conditions to evaluate and compare the effects of multiple robots: *two-*, *four-* and *six-*robot conditions. In all the conditions, we replicated Asch's experiment with multiple robots. In the beginning, the facilitator robot requested that a participant answer a question after an answer was given by the robot to the participant's right. After responding to the question, each robot looked at the next respondent (Fig. 5, left, where the fifth robot is answering and the fourth is looking at it in the *six-*robot condition). The second to the last robot answered the question, and then the participant answered (Fig. 5, right, where the participant is answering and the fifth robot is looking at the participant in the *six-*robot condition), and finally the last robot answered, too. After all the robots have answered, the facilitator robot asked the next question. The answers of all the robots were identical, but they provided incorrect answers in 12 of 18 trials.

Note that in the *two-*robot condition we only used the 5th and 6th robots as respondents in Fig. 4, and in the *four-*robot condition we only used the 1st, 3rd, 5th, and 6th robots as respondents. We removed the rest of robots in the *two-* and *four-*robot conditions.

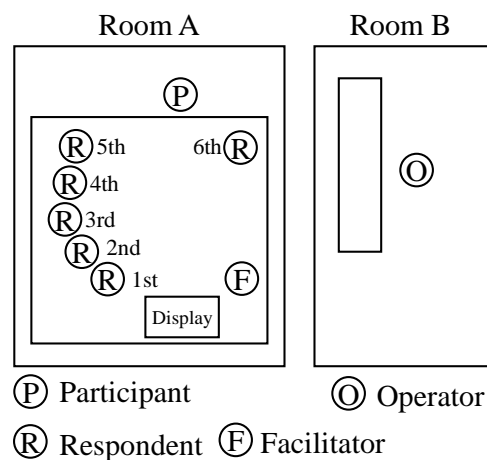


Fig. 4 Experimental environment in *six-*robot condition



Fig. 5 Experiment scenes in *six*-robot condition

4.4 Participants

Fifty-four people (27 female and 27 male whose average age was 31.39, S.D 9.82) participated in the experiment. None had previously interacted with our robots.

4.5 Procedure

Before the experiment, the participants were given a brief description of its procedure. Since this experiment had a between-participant design, the participants were assigned to one of the three robot situations: *two*-, *four*- or *six*-robot conditions. The participants filled out questionnaires after the task. This research was approved by our institution's ethics committee for studies with human participants. Written, informed consent was obtained from all of them.

4.6 Measurements

In this experiment, we calculated both the objective and subjective measurements. For the former, we measured the conformity ratio when their answers were incorrect. We also measured two items for the subjective measurements as additional evaluations: the degree of their confidence in their own answers and the degree of influence exerted on their choices by the robot answers. For these subjective measurements, we used a questionnaire with a 1-to-7 point scale.

5 Results

5.1 Verification of Predictions

Figure 6 shows the conformity ratios when the robot answers were incorrect. We conducted a two-factor ANOVA with two between-subject factors: the number of robots (*two*, *four*, or *six*) and the participant's gender (*male* or *female*). There were significant differences in the number factor ($F(2, 48)=6.906, p=.002, \text{partial } \eta^2=.223$) and the gender factor ($F(2, 48)=7.754, p=.008, \text{partial } \eta^2=.139$). There were no significant differences in their interaction ($F(2, 48)=1.451, p=.244, \text{partial } \eta^2=.057$). Multiple comparisons of the number factor with the Bonferroni method showed significant differences between the *six*- and *four*-robot conditions ($p=.003$) and the *six*- and *two*-robot conditions ($p=.020$). We identified no significant difference between the *two* and *four* conditions ($p=1.000$).

Moreover, we investigated the correlation between the number of robots and the conformity ratios when the robot answers were incorrect. There was a positive correlation between them ($r=0.334, p=.014$), which showed a weak positive correlation.

Thus, prediction 1 was partially supported; i.e., the conformity ratio from six robots was significantly larger than two or four robots. But the ratios between two and four robots were not significantly different, even though the results showed a weak positive correlation between the number of robots and the conformity ratios when the robot answers were incorrect. Prediction 2 was supported; females conformed to the robots more than males.

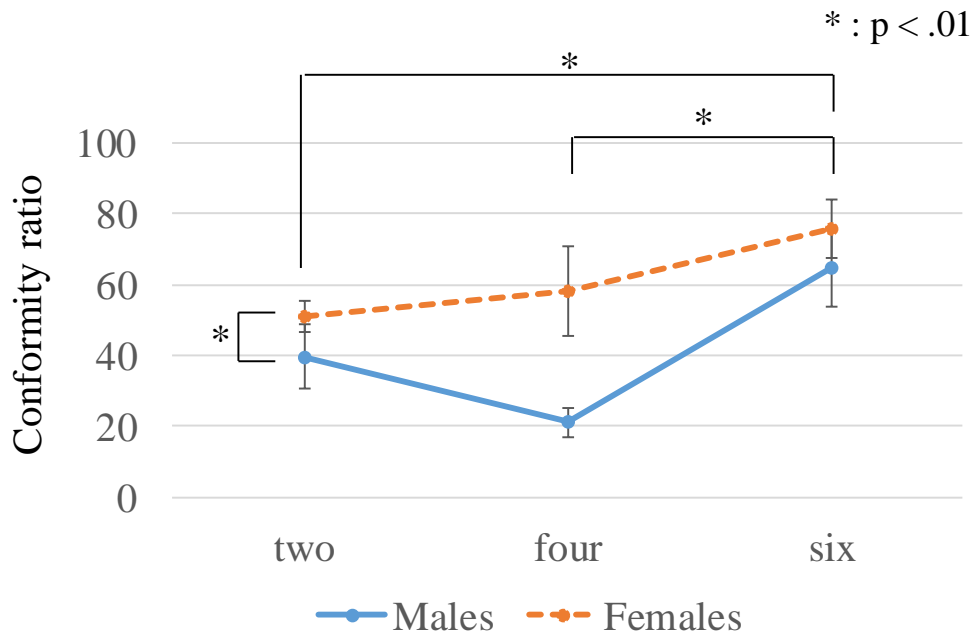


Fig. 6 Conformity ratio when robot answers were incorrect

5.2 Additional Evaluation: Questionnaire Results

Figure 7 shows the degree of the confidence of the participants in their own answers. We conducted a two-factor ANOVA with two between-subject factors: the number of robots (*two*, *four*, or *six*) and gender (*male* or *female*). There was a significant difference in the gender factor ($F(1, 48)=6.673, p=.013, \text{partial } \eta^2=.122$). There were no significant differences in the number factor ($F(2, 48)=.027, p=.973, \text{partial } \eta^2=.001$) or their interaction ($F(2, 48)=1.016, p=.370, \text{partial } \eta^2=.041$).

Figure 8 shows the degree of influence from the robot answers on the participant choices. We conducted a two-factor ANOVA as a dependent variable, with the number of robots (*two*, *four*, or *six*) and participant gender (*male* or *female*) as a between-subject factor. There was a significant difference in the gender factor ($F(1, 48)=4.574, p=.038, \text{partial } \eta^2=.087$). There were no significant differences in the number factor ($F(2, 48)=.595, p=.556, \text{partial } \eta^2=.024$) or their interaction ($F(2, 48)=.015, p=.985, \text{partial } \eta^2=.001$).

Therefore, in this experiment, the participant gender significantly influenced their subjective feelings about their confidence in their own answers and their impressions of the robots. The male showed higher confidence and less influence than the female in this study.

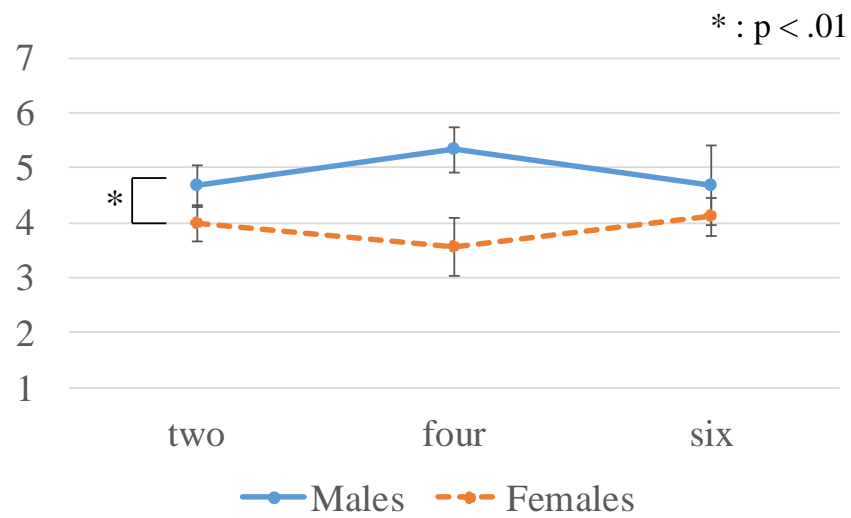


Fig. 7 Degree of confidence

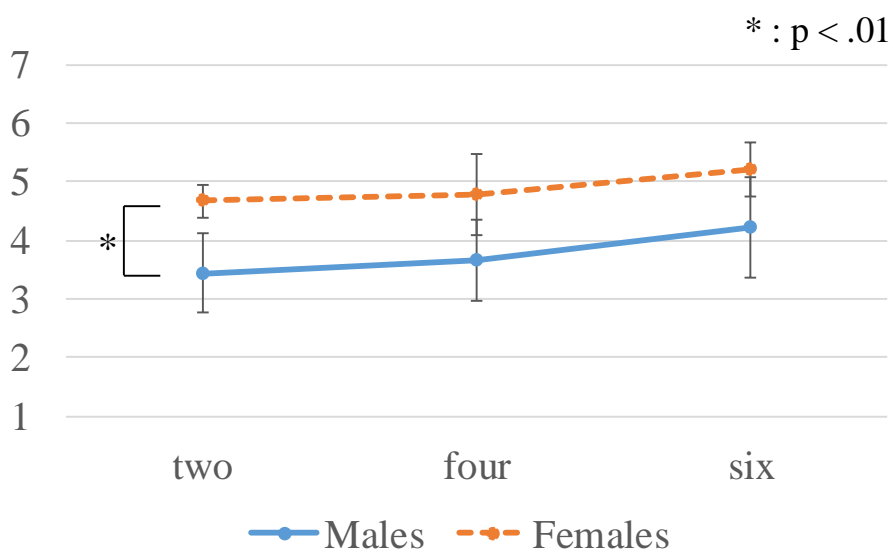


Fig. 8 Degree of influence from robot

6 Discussion

6.1 Implication

Our results suggest that people's choices are indeed affected by the number of robots. Similar to a past study [10], using four robots (or two) did not show any significant conformity effects, but the participants in our study conformed more to the choices of six robots than of two or four robots. Males showed the lowest conformity to four robots, and we found a positive weak correlation between the number of robots and the conformity ratio. But our statistical results between two and four robots did not show any significant difference in multiple comparisons.

Our results also showed that females conformed to the robots more than males, which resembles past studies [7, 8]. Questionnaire results also suggested that female felt more pressure from multiple robots than male regardless of the number of robots.

These results provide one clear implication. For a behavior design with multiple social robots, scrutiny is required because the behaviors of multiple robots might increase human susceptibility to deceptive advertising practices. Understanding other effects of the behaviors of multiple robots on human decision-making is also needed to reduce incorrect human judgments.

6.2 Effects of Number of Robots

Does increasing the number of robots also linearly strengthen the conformity effect? In human science literature, an increase over three persons does not largely promote conformity. In human-robot interaction situations, however, our study showed that six robots did exert an conformity effect, even though a past study reported that four did not [10]. Therefore, investigating the effects of different numbers of robots (e.g., eight or ten) is another future work of this study. Using more robots might increase the intensity of the conformity effect because our results identified a weak

positive correlation between the number of robots and the conformity ratio; but of course, the conformity effects caused by the robots will eventually reach saturation. One intriguing future work is to identify the saturation number in the robot case, which was not covered in this study.

Related to the effects of the number of robots, another future work will investigate whether the number of computer agents causes a conformity effect. A past study concluded that four computer agents exerted a conformity effect under high task difficulties [9]. Increasing the number of computers might increase the conformity effect's power.

6.3 Appearance and Voice Effects

In this study, we used identical robots with slightly different voices. However, a robot's appearance and its voice are other factors related to the conformity effect. For example, a past study showed that a large robot creates more anxiety in people than a small robot [17]. Another study concluded that more humanlike robots might exert a different conformity effect since groups of humanlike robots are perceived more positively than groups of machine-like robots [18]. Moreover, a robot's gender, including appearance and voice differences, also changes the impression of the interacting partners [19]. Siegel et al. reported that people tended to rate a robot of the opposite sex as more credible, trustworthy, and engaging. These studies suggest that using a different appearance and voice matching a robot's appearance might differently affect human decision-making.

6.4 Personal and Group Relationship Effects

Another factor is the relationship between robots and participants, including previous familiarity, personal and group relationships. Even if people perceive robots

differently and don't treat them as human beings [20, 21], several studies successfully constructed friendly relationships between humans and social robots through long-term interaction [22, 23]. If a robot established a rapport or a social relationship with people, their responses might be different even if the robot's answers are incorrect.

Investigating the effects of such personal/group relationships on the conformity effect is another future approach.

6.5 Limitations

Since this study investigated the conformity effect from multiple robots, our predictions cannot be generalized. Even though we showed pressure effects from multiple robots, our work was conducted within the framework of an academic study with an artificial task with relatively few participants.

The participants had limited interaction with our desktop-sized robots. Thus, the effect shown in our experiment might be moderated if they interacted with a robot with a different appearance or size. Of course, the number of interacting robots also influences the experiment results as described in the section 6.2. Moreover, we did not investigate the previous familiarity of the participants with robots, it also has influences to their responses as described in the section 6.3.

7 Conclusion

We reported the influence of the conformity effect by multiple robots by focusing on the number of robots and the participants' gender. To investigate such effects from multiple robots, we conducted an experiment in which multiple robots (two/four/six) provided correct or incorrect answers under an ambiguous situation. Our experimental results indicated that the participants conformed more to the choices of six robots than two or four. Moreover, females conformed to the robots' choices more than

males regardless of the number of robots.

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