Social Facilitation with a Social Robot

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***Abstract*— The social facilitation effect describes the phenomenon in which people tend to perform better on easy tasks, and worse on difficult tasks, when in the presence of others. Many theories have been proposed to explain this effect. The theory of evaluation apprehension, states that heightened arousal due to an audience capable of forming evaluations increases the likelihood of dominant responses, corresponding to better performance on easier and more familiar tasks. In this study, we replicate the effects of previous robotics studies to show that robots can also be used to elicit these social facilitation effects. We further investigate the mechanisms behind the social facilitation effect by manipulating the sociality of the robot Jibo, and show that the perceived sociality of the observer mediates the social facilitation effect. Finally, we present initial evidence that supports the view that robots may be attributed with unique social identities that lead to diminished social inhibition effects.**

I. INTRODUCTION

A. The Social Facilitation Effect

The social facilitation effect describes the tendency for people to perform differently when the presence of others than when alone [1]. Specifically, in the presence of others, people tend to perform better on tasks that are simple or well-rehearsed, but worse on those that are complex or unfamiliar (also known as the social inhibition effect). The most well-known example of this was shown by Triplett, who observed that cyclists were faster when racing against other cyclists compared to when they were racing against a clock [2]. This is an example of the co-action effect, in which ones behavior changes in the presence of others engaged in the same activity. The audience effect, in contrast, is a social facilitation effect in which ones behavior changes in the presence of passive spectators.

There have been many theories put forward to explain why the social facilitation effect occurs. One widely held is the theory of activation, which states that heightened arousal increases the likelihood of an organism to do better on well-learned and habitual responses, but worse on unfamiliar ones. This agrees with the Yerkes-Dodson law, which describes bell-shaped relationship between arousal and performance: although moderate levels of arousal can improve performance, for instance by contributing an energizing effect, the relationship reverses after a certain point due to the negative effects of excessive arousal, for instance on attention and stress [3]. In this case, the threshold for the reversal of the effect depends on the difficulty of the task.

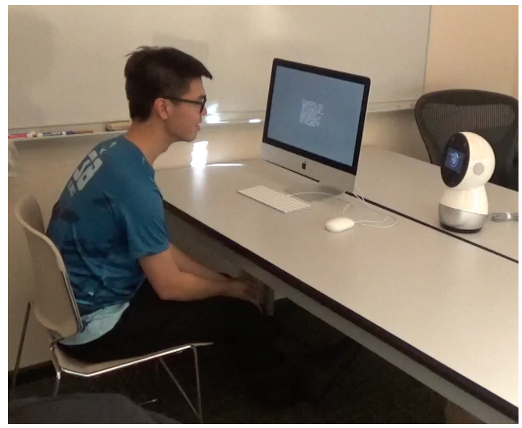

Fig. 1: Participants interacted with Jibo during an introductory phase before carrying out the tasks.

The evaluation apprehension theory expands upon this idea by stating that it is the fear of being evaluated by an audience that impedes performance on difficult tasks, by increasing the probability of a dominant response [4]. For instance, the presence of an evaluative audience can heighten arousal levels, thereby increasing the probability of dominant behaviors, i.e. performing well on familiar or easy tasks, and poorly on unfamiliar or difficult tasks. However, the opposing mere presence theory states that the mere physical presence of others is enough to elicit social facilitation effects [5]. While some studies have found that social facilitation effects can be elicited by the mere presence of a non-evaluative social presence, others have found these effects only in the presence of an observing audience [6, 7].

B. Social Facilitation in Human-Robot Interactions

Given that the presence of others can enhance performance, it is possible to imagine numerous applications in the realm of robotics. Although robots have generally been used to perform tasks independently from humans, the rise of collaborative robots, as well as home and social robots, has put emphasis on the need to study human-robot interactions, such as how the presence of robots can influence human behaviors. For instance, the finding that human performance can be improved by a simple social companion robot would be especially important in fields such as education, where a common and often critical problem is a lack of personalized attention.

Indeed, past literature on human-robot interaction has shown that robots are able to elicit the same social facilitation effects as humans. In one experiment, better performance was observed on easy tasks, and worse performance on difficult tasks, in the condition where a robot periodically glanced at the participant every few minutes, just as was observed in the condition where a human experimenter took place of the robot [8]. Meanwhile, other studies showed that differing levels of anthropomorphism of the robot used may have an effect on the magnitude of the result, such that more anthropomorphic robots elicit the greatest social facilitation effects [9].

However, one question raised by these experiments is whether the robots are truly eliciting social facilitation effects, as opposed to novelty effects, or the effects of distraction caused by increased movement. Furthermore, another unanswered question is: through what mechanism do robots elicit social facilitation effects? The HRI research on the effects of anthropomorphism show that as robots appear more human, they can exert a more human-like influence, but do not explain the original phenomenon itself.

Although the mechanisms behind the effects have yet to be fully explored, evidence does exist that the presence of robot can be used to improve human performance in the real-world setting. In one study, a learning companion robot was used to show that robots can provide long-lasting improvements in reading comprehension and motivation in children [10]. Meanwhile, another study on robot tutoring showed that the physical presence of a robot (as compared to a robotic voice, or a video representation of the robot) solved puzzles faster on average, and improved their puzzle-solving time (i.e. learned) significantly more compared to other conditions [11]. In fact, the effects of robots may even be superior to those elicited by humans in certain situations, such as when working with children with Autism Spectrum Disorder (ASD), perhaps due to the different social status that people attribute to robots [12].

C. The Current Study

In this study, we build upon the existing literature on robots and social facilitation. First, we provide further evidence to show that robots are able to elicit social facilitation effects. We then investigate the mechanisms behind the social facilitation. Robots are especially helpful for this task, due to the difficulty of manipulating single features of human experimenters. Based on previous research, we hypothesize that it is the social presence of others that causes evaluation apprehension, and in turn heightened arousal, which eventually leads to differing performance on easy and difficult tasks. In our experiment, we use two conditions that differ in only the level of sociality of the robot, such that any observed effects can be traced back to the effects of a social (vs. non-social) presence, rather than effects of novelty (caused by the robotic presence) or distraction (caused by movements). We use real-world, learning-based tasks for our experimental measures, as we are particularly interested in exploring how the concept of social facilitation can be utilized in educational robotics.

II. METHODOLOGY

A. Participants

There were 33 participants in this study, recruited in the Yale University area of New Haven, Connecticut through posters and posts on online social networks. Most participants were undergraduate students of Yale University. Participants were randomly assigned to either the experimental (N = 17) or control (N = 16) condition. Of the 33 participants, 22 were female and 11 were male. The mean age of the participants was 20.72 and the standard deviation of the distribution of the ages was 3.53.

Participants were asked to report their experience with programming and robotics. The majority of the participants, 27, had done at least basic programming, while 6 participants had no programming experience at all. While 32 participants reported that they had been exposed to robots in movies and science fiction, only 10 participants reported that they owned toy robots or interacted with a robot in a previous study. Only 2 participants reported that they had previously programmed a robot.

B. Robot Interaction

The robot we used, Jibo, is a small tabletop robot that can be programmed to rotate in all directions, say a given speech input, in addition to various other abilities not used in this study. The Jibo command library consists of an set of ESML (embodied speech) functions that give pre-programmed behaviors, many of which mimic human-like emotions (such as happy, or frustrated). We used these, in addition to Jibos movement abilities, in order to program passive behaviors and passive movements, respectively.

In the introductory phase of the experiment, roughly corresponding to the first 3 minutes, participants were allowed to familiarize themselves with the robot. In the control condition, the participants were given a tablet such that they could control where Jibos movement and speech through their inputs. In the experimental condition, after the experimenter greeted Jibo by asking "Hey Jibo, how are you?", participants were aided by the experimenter to become added to Jibos loop. During this add to loop function, Jibo talked to the participant and gave various interactive instructions to the participant that allowed it to learn how to pronounce the participants name and how to recognize the participants voice and face.

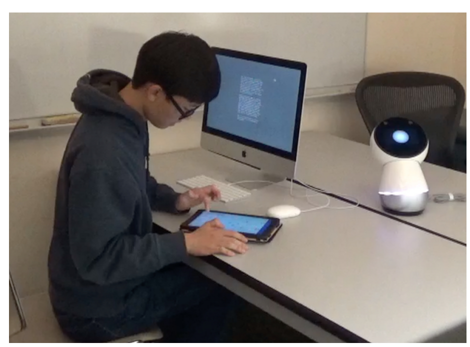

Fig. 2: Participants used an app on a tablet to interact with control Jibo.

The robots behavior while the participant was carrying out the tasks was very similar between both conditions, such that the total expected amount of movement was equal. Jibo exhibited the same probability of passive movement and behaviors in both conditions. Both conditions also contained a glancing behavior. In the experimental condition, Jibo faced towards the direction of the participant, and the glancing behavior involved looking at the participant, the desktop, and the participant again. The experimental condition also included an additional screen component that allowed Jibo to appear to have an expression (e.g. changing eye shapes to signal emotions), using ESML commands, as shown in Fig. 3 below. In the control condition, Jibo faced away (to the right) of the participant, and the glancing behavior was not targeted.

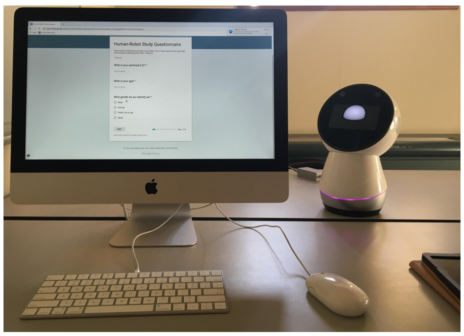

Fig. 3: An ESML expression in the experimental Jibo.

C. Performance Tasks

We measured participants performance on easy and difficult versions of three task types: paired association, word association, and reading comprehension, given in the stated order. In all task types, the difficult version was always given first in order to prevent experience from the easy version of the task from causing the difficult version to become easier.

1) Paired Association Task: In the paired association task, participants were given the goal of learning cue-response pairs. In each session of the training phase, participants were presented with 8 cue-response pairs, ordered randomly such that each pair was displayed 4 times in total, for 1 second at a time. In the testing phase, participants were presented with 8 cue-response pairs that may be correctly or incorrectly matched, and were asked to determine if the pair was a correct match. The cues in both versions were Japanese hiragana characters. In the difficult version, responses were English romanizations of the characters, whereas English meanings were used for the easy version. In total, there were 3 sessions each for the difficult and easy version, such that participants performed 6 training-testing sessions total.

Fig. 3: Examples of the difficult (left) and easy (right) cue-response pairs displayed during the training phase.

2) Word Association Task: In the word association task, participants were given a stimulus word and asked to type as many single-word verbs related to that word in 30 seconds. In total, participants were given 3 difficult words (Kite, Projector, and Scissor) and 3 easy words (Rope, Ball, and Wheel). Responses were later manually checked such that any response that was not a single-word verb was not accepted.

Fig. 4: An example of a displayed stimulus word and some possible participant responses.

3) Reading Comprehension Task: In the reading comprehension task, the participants were 2 articles to read, and were asked to complete 4 multiple-choice questions about each article. In the hard version of this task, the participants were given an excerpt of a conference paper from a robotics journal [11], and each of the multiple-choice questions had 5 possible answers. In the easy version, participants were given an excerpt from a more accessible science news website [12], and the multiple-choice questions had 4 possible answers.

D. Procedure

After obtaining informed consent from the participant, an experimenter led the participant into the experiment room. The participant was seated at the table in front of the computer. Next to the computer, to the right, on the table was a Jibo robot. At this point, the procedure differed between the two conditions.

In the control condition, an experimenter explained that the instructions for the experiment would be given on the computer screen before exiting the room.The participant was asked to use the tablet to interact with the robot for 3 minutes. After the 3 minutes, the participant was instructed to press a button on the tablet (which initiated the robots during-task behaviors), and then they began the tasks on the computer.

In the experimental condition, an experimenter first greeted the robot and asked the robot how it was doing. The experimenter then initiated the add to loop function and exited the room for the duration of the interaction. After the participant was added to Jibos loop, the experimenter used the tablet to initiate the robots during-task behaviors and the participants began the task on the computer.

After the tasks were completed, the experimenter entered the room, and directed the participants to complete the post-experiment survey. After the participants completed the post-experiment survey, they received a cash payment and were debriefed on the forms of deception used in the experiment and the overall purpose of the experiment.

III. MEASURES

To help answer our research questions, we used both task performance measures and survey measures. Survey measures were obtained during the post-experiment questionnaire, while task performance measures were calculated based on data from participant performance on the given tasks.

1) Performance Measures: For the paired association task, we calculated the average correctness of the participants responses, as well as the amount of time they spent on each tested pair. For the word association task, we measured the number of valid responses the participants gave for each word, and the time taken to come up with each response. For the reading comprehension task, we measured the accuracy of the participants responses for the multiple choice questions and recorded the amount of time they spent reading the articles.

2) Controls: In order to capture individual factors that could influence participants behavior on the tasks in the presence of a robot in addition to the manipulation, we used surveys used in previous literature to collect measures of empathy [15], self-efficacy [16], as well as extraversion [17], using a standard likert scale of 1 (strongly disagree) to 7 (strongly agree) for the provided statements. We believed that participant empathy and extraversion can influence how participants perceive Jibo, whereas self-efficacy may influence how much effort participants gave in completing the tasks. We additionally asked participants about their previous experience with computer science and robotics, as this type of experience may negatively affect perceptions of robot sociality. Specifically, we used items such as I have never programmed before to assess past exposure to computer science, coding each item as a categorical variable. We used items such as I have participated in a study where I have interacted with a robot to assess experience with robotics, and calculated an overall score by summing up the items checked due to the lack of obvious ordering in the responses. Finally, we also used age and gender as controls.

To summarize, the covariates used in our ANOVA tests of the main effect of the experimental condition were: age, gender, exposure to computer science, exposure to robotics, and scores of extraversion, self efficacy, and empathy.

3) Manipulation Checks: We collected survey measures of participants perceptions of Jibo as a manipulation check for the experiment. Participants were asked whether Jibo was distracting during the experiment and whether they were conscious of Jibos presence during the experiment, on a scale from 1 (strongly disagree) to 7 (strongly agree). In addition, participants were asked several questions about their perceptions of Jibos warmth, competence, and discomfort. The items on this survey were based on previous literature [18] and were rated on a likert scale from 1 (definitely not associated) to 9 (definitely associated).

IV. RESULTS

A. Experimental Manipulation Check

We conducted an independent-samples t-test to assess whether participant ratings of Jibos sociality significantly differed between the two conditions. Though participants in the experimental condition did tend to rate Jibo as more social ($M = 5.88$, $SD = 2.45$) compared to the control group ($M = 4.75$, $SD = 2.41$), this effect was not significant, $t(31) = 1.34$, $p = .19$.

B. Paired Association Results

To check that the difficult condition was indeed harder for participants, we conducted a paired-samples t-test between average accuracy scores in the difficult ($M = .75$, $SD = .16$) and easy ($M = .80$, $SD = .14$) versions of the paired association task. Scores on the difficult version were marginally lower than those in the easy version, $t(32) = -1.99$, $p = .05$.

A 1-way ANOVA of the experimental condition, with the aforementioned covariates and an addition covariate for knowledge of Japanese, on scores on the hard paired association task revealed a significant effect of the condition, $F(1, 31) = 6.33$, $p = .02$. On average, the experimental group ($M = .80$, $SD = .16$) performed better than the control group ($M = .70$, $SD = .16$). The same pattern appeared in the easy task, such that the experimental group ($M = .83$, $SD = .14$) was more accurate on average ($M = .78$, $SD = .13$). However, this was not a significant effect, $F(1, 31) = 1.76$, $p = .20$.

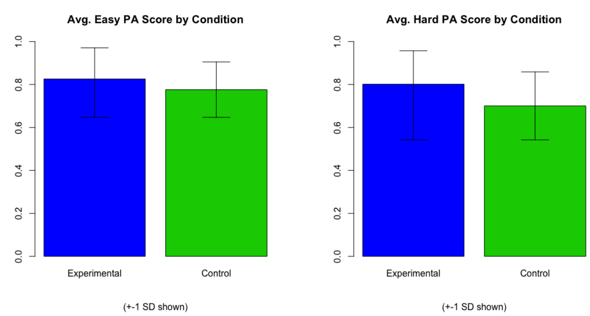

Fig. 5: Average scores for the paired association task.

C. Word Association Results

A paired-samples t-test showed that scores on the difficult version of the word association task ($M = 22.55$, $SD = 6.32$), were marginally lower than those on the easy version of the word association task ($M = 24.45$, $SD = 6.32$), $t(32) = 1.79$, $p = .08$.

Using the same 1-way ANOVA described above with the difficult word association task did not reveal significant effects of the experimental condition, $F(1, 31) = 0.19$, $p = .67$, though the experimental group scored higher on average ($M = 23.00$, $SD = 6.96$) than the control group ($M = 22.06$, $SD = 5.76$). There was also no significant effect between the experimental ($M = 23.88$, $SD = 6.17$) and control ($M = 23.06$, $SD = 6.62$) groups in the easy task version, $F(1, 31) = 0.39$, $p = .54$.

Table 1

	Hard Version			Easy Version		
	r	$t(31)$	p	r	$t(31)$	p
PA accuracy	.28	1.69	.10	**.39**	**2.34**	**.03**
WA scores	.03	0.16	.88	**-.37**	**-2.19**	**.04**
WA time per response	.17	0.97	.34	**.42**	**2.61**	**.01**
RC accuracy	.17	0.98	.33	**.43**	**2.63**	**.01**
RC time per response	.34	1.99	.05	-.01	-0.07	.94
RC time reading article	.17	0.95	.35	.28	1.62	.12

Correlations (r) with Jibo Sociality

D. Reading Comprehension Results

Average accuracy on the difficult reading comprehension task ($M = 0.35$, $SD = 0.25$) was significantly lower than accuracy on the easy version ($M = 0.67$, $SD = .16$), $t(32) = -7.04$, $p < .001$. Likewise, average time spent reading the hard article ($M = 137.50$, $SD = 74.90$) was significantly higher than the average time spent reading the easy article ($M = 85.82$, $SD = 42.05$), $t(32) = 4.95$, $p < .001$.

A 1-way ANOVA showed no significant effect of the experimental condition, $F(1, 31) = 0.06$, $p = .80$, on accuracy of the experimental ($M = 0.34$, $SD = 0.26$) and control ($M = 0.36$, $SD = 0.24$) groups in the hard task. Likewise, no significant differences were seen between the accuracies of the experimental ($M = 0.67$, $SD = 0.15$) and control ($M = 0.66$, $SD = 0.18$) groups in the easy version of the task, $F(1, 31) = 0.11$, $p = .75$.

There was likewise no significant effect of the experimental condition on time spent reading the hard article, $F(1, 31) = 0.24$, $p = .63$, though the experimental group ($M = 131.28$, $SD = 77.05$) than the control group ($M = 144.11$, $SD = 74.47$) on average. The same pattern of a non-significant difference between the experimental group ($M = 75.43$, $SD = 33.08$) and the control group ($M = 96.86$, $SD = 48.51$) was seen for the easy article, $F(1, 31) = 2.53$, $p = .13$.

E. Correlation Measures

We conducted additional correlation tests of several measures and participant ratings of Jibo sociality. Results are shown above in Table 1.

V. DISCUSSION

Our results provide further support for previous robotics studies that have shown that like humans, robots can elicit social facilitation effects. In particular, we believe that our results show that the perceived sociality of a robot observer mediates the social facilitation effect, such that the effect is greater when the robot observer is perceived to be more social. However, as the difference in ratings of robot sociality was not significant between groups, it is plausible that some other hidden factor was responsible for these effects. This is highly unlikely, however, due to the controlled nature of our manipulation of robot sociality. Rather, we believe that the fact that we are able to observe significant effects despite the weak manipulation demonstrates the robustness of the social facilitation effect, even in robots. A stronger manipulation of robot sociality may show larger results, such as for the word association and reading comprehension tasks, in which we were not able to find significant results for either task.

The results shown in the paired association task are particularly promising because it is a learning-based task: participants were required to learn pairings of Japanese hiragana characters and their English meanings and their romanizations for the easy and difficult versions of the task, respectively, in order to accurately classify test pairs as correct or incorrect. Thus, not only is the social facilitation effect possible with robots, it is effective in the domain of learning. Further research should be conducted to investigate how we can employ these effects in real-life applications. Similar to how students work more efficiently at libraries, perhaps companion robots such as, but not limited to, desktop robots like Jibo, can be used to improve performance (for instance, by promoting attention and learning). This could help alleviate some obstacles to learning caused by accessibility problems (i.e. lack of human resources), such as for students living in isolated areas, or attending schools with problems of overcrowding. We believe that the finding that even simple domain-general robots can enhance performance is especially promising for research in the development of robot tutors, which further take advantage of more domain-specific knowledge, and are not prone to fatigue, frustration, boredom, or other emotions that may have negative effects on the effectiveness of a human tutor.

Furthermore, we found that while the effect in the easy version of the paired association task was only marginally significant, effects in both versions were such that the experimental group performed better than the control group. In fact, notably, the fact that the effect in the hard version of the task was significant and positively contributed to performance is in direct contrast with the prediction that the social facilitation effect should have a negative effect on unfamiliar or more difficult tasks. We believe that this may be due to an unique social identity attributed to robots, such that they do not elicit the same social inhibition effects as a human normally would, a hypothesis that is supported by previous work in the use of social robots for children with ASD. However, it is also possible that both versions of the paired association task can be considered easy tasks. Or, as the social facilitation effect occurs on a spectrum, a future direction would be to investigate if the social inhibition effect appears later on the spectrum (i.e. for more difficult tasks) for effects elicited by robots compared to those elicited by humans.

One reason for the difference between the observed effects in the paired association task and the lack thereof in the two other tasks may be the order of the experiment. Following completion of the experiment, many participants mentioned that they did not pay attention to Jibo as they were concentrating on the computer tasks. This is interesting on the one hand because despite this lack of conscious attention to Jibo, we noticed significant differences in the performances between the two conditions. On the other hand, this means that it is also possible that the already-weak initial differences between participant perceptions of robot sociality were further weakened throughout the time course of the experiment, particularly as our social manipulation was primarily concentrated during the pre-task phase of the experiment in which participants in the experimental group were added to Jibos loop. Moreover, a surprisingly prevalent problem of Jibo suddenly disconnecting and reverting back to its default out-of-box behavior occurred in several cases, further weakening the experimental manipulation. While Jibo did generally remain facing the same direction and was quiet unless directly called by name, this further diminished the differences between the two conditions. Alternatively, or perhaps additionally, it is also possible that the paired association task as a whole could be considered an easy task, and the latter two difficult tasks.

There may also have been potential issues with the task designs of the two latter performance tasks. In particular, evaluations of performance in the word association task was dependent on what was considered a valid participant response. To prevent bias, we simply decided to accept all responses that were single-word verbs. However, this means our results are vulnerable to cheating behaviors such as typing non-relevant verbs. In addition, participant boredom may have been a large factor in the word association task. Participants may have experienced fatigue from generating a large amount of words from previous words. This may have contributed to the lack of significant effects in the manipulation of difficulty. Further analysis on this point did reveal that the last word presented in this task had the fewest total responses, though this may also have been a result of a misclassification of the word as an easy stimulus.

In addition to possible problems with fatigue, a similar issue of performance evaluation existed for the reading comprehension task. Many of our questions tested recall of specific details from the article, as we found it difficult to formulate conceptual questions that would not suffer from ceiling effects (for example, nearly every participant - 32 and 30, specifically - correctly answered two questions in the easy article). As a result of these detail recall questions, our findings may have been based on luck of what parts participants happened to focus their attention on. An improvement for a future design is to use more conceptual readings, in order to actually be able to test for reading comprehension. Meanwhile, whereas the detail recall questions may have been too difficult, the readings themselves may not have been difficult enough, and importantly, the difference in difficulty too small. This brings to attention the composition of our participant pool.

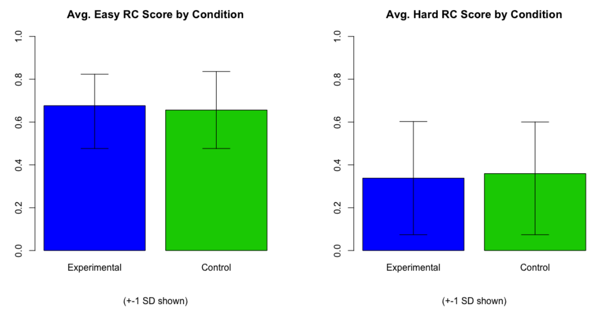

Fig. 6: Average scores for the reading comprehension task.

As previously mentioned, our participants were recruited through social media and posters around the Yale University campus. Thus, in addition to self-selection issues, our participant pool was highly biased towards university students with a high level of understanding and experience with computer science and robotics. In several of our ANOVA analyses, we found that effects of previous exposure to computer science was significant. It is likely that more exposure is associated with lower effects of the main manipulation (due to low pre-existing perceptions of robot sociality and capability), as well as further weakening the difficulty manipulation in the reading comprehension. We observed similar significant effects for empathy, which may have heightened perceptions of robot sociality in the control group. Moreover, although not a significant effect ($p = .11$), it is notable that we found a higher average self-efficacy of 4.68 in our control group, compared to an 4.19 average in our experimental group.

Although we were not able to find significant results for the word association and reading comprehension tasks, however, we did observe some interesting findings. Firstly, the participants consistently spent less time reading the articles in the reading comprehension task compared to those in the control group. This hints at a potential effect of the condition that can be revealed with an improved experimental design. Furthermore, we conducted correlational tests of Jibo sociality ratings and our various performance measures. Although they cannot be interpreted as causational effects due to problems with confounding, it is promising to observe a general trend towards positive associations of performance and perceptions of robot sociality, some of which are significant. The exception to this trend was for the easy word association task. However, probing into this finding revealed that not only was the effect small (one standard deviation increase in ratings of Jibo sociality predicted a score, i.e. word, decrease of less than one), but in addition because the positive difference in performance between the experimental and control groups in the word association task was larger, though not significant, for the first half of the word prompts (the difficult words), it is possible that an increased social facilitation effect of robot sociality for the first few words led to a more dramatic effect of fatigue in the later words. Moreover, we observe significant and marginally significant positive associations of ratings of Jibo sociality and the average time spent on a response for both the easy version of the word association task, and the hard version of the reading comprehension task, that indicates that robot sociality is associated with an increased motivation to do well. (In the word association task, a higher average response time usually meant that participants continued to try coming up with words after having exhausted the store of words they initially came up with, i.e. the words they entered quickly).

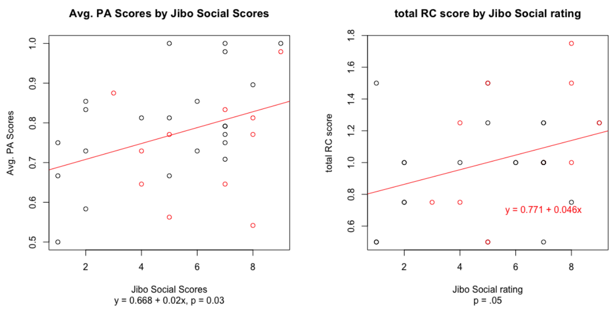

Fig. 7: Correlation between Jibo's social scores and performance on paired association and reading comprehension tasks.

Thus, in general, we believe that our effects support our original hypotheses that robots are capable of eliciting social facilitation effects in humans, and that the effect is mediated by perceptions of the sociality of the observer. Though we used a robot, which allowed us to minimize confounding effects of additional differences in behavior that would inevitably occur by using a human experimenter, we believe that our results show that perceived sociality is also an important mediating factor for human observers as well. It is interesting to think about the possible implications of this, as well as what it means to perceive one person to have more of a social identity than another. These results are supportive of the evaluation apprehension theory of social facilitation, as evaluation apprehension is caused by the fear of being judged by another, a risk factor in the social reputation of a person.

Finally, we suggest additional avenues to explore in the context of robots and social facilitation. Given that robots can elicit social facilitation effects, it would be interesting to compare these effects with those elicited by human observers, as well as performance with no observers. However, in order to do this, it will be necessary to pay special attention to problems due to novelty and distraction. In addition, current studies focus on the social facilitation effect in the context of the audience effect. A possible future direction would be to investigate if, and to what extent, the social facilitation co-action effect exists for robots.

VI. CONCLUSION

In this study, we investigated the ability of a robot to elicit the social facilitation effect. We programmed a robot, Jibo, that was used to interact with participants in an introductory pre-task phase, and to exhibit passive movements and behaviors in the task phase of our experiment. We manipulated the sociality of the robot in the introductory phase by adding an additional greeting from the experimenter to Jibo in the experimental phase, as well as by having Jibo get to know the participants by learning their names, faces, and voices. In the task phase, we adjusted the direction and type of robot looking behaviors while keeping total movement constant. We found that the robot was able to elicit social facilitation effects, and that the perceived sociality of the robot mediated this effect, such that the experimental group performed significantly better than the control group in the paired association task. We also present some initial evidence that while robots can elicit the social facilitation effect, they may elicit diminished social inhibition effects, as participants showed improved performance in both the easy and hard versions of the task. This supports the view that robots may occupy a unique social role that differs from those occupied by humans. We hope that our results can promote further research in the applications of social robots, particularly in the field of education.

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