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Don't Stare at Me: The Impact of a Humanoid Robot's Gaze upon Trust During a Cooperative Human–Robot Visual Task

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Abstract Gaze is an important tool for social communication. Gaze can influence trust, likability, and compliance. However, excessive gaze in some contexts can signal threat, dominance and aggression, and hence complex social rules govern the appropriate use of gaze. Using a between-subjects design we investigated the impact of three levels of robot gaze (averted, constant and "situational") upon participants' likelihood of trusting a humanoid robot's opinion in a cooperative visual tracking task. The robot, acting as a confederate, would disagree with participants' responses on certain trials, and suggest a different answer. As constant, staring gaze between strangers is associated with dominance and threat, and averted gaze is associated with lying, we predicted participants would be most likely to be persuaded by a robot which only gazed during disagreements ("situational gaze"). However, gender effects were found, with females least likely to trust a robot which stared at them, and no significant differences between averted gaze and situational gaze. Implications and future work are discussed.

Keywords Trust · Nonverbal communication · Gaze · Human–robot interaction

1 Introduction

In coming years, it is expected that robots will become increasingly common, assisting and collaborating with people in a wide variety of environments such as public spaces, the home, office, school, and health care. For such human–robot collaborations to be successful, social robots must be capable of fostering the trust and confidence of people they interact with. For example, health care robots may need to persuade patients to take their medication, a search and rescue robot will need to be trusted by the survivors it encounters, and a doctor may need to trust the judgment of a surgical robot.

Between people, appearance and nonverbal communication plays a significant role in establishing rapport and influencing others. For example, leaning forward, using eye gaze, nodding, and smiling can all help build rapport [1]. Initial judgments of a political candidate's facial appearance can predict the outcomes of political elections [2], while positive characteristics such as intelligence, competence, leadership, and trustworthiness are attributed to attractive persons [3]. Furthermore, people are more likely to trust someone who is physically similar to themselves [4]. Doctors who sit with uncrossed legs with arms symmetrically side-by-side are rated more highly by patients [5], mirroring another's posture can increase rapport within groups [6], hand shaking has been shown to increase compliance when requesting money [7], and eye gaze has been shown to increase likability, request compliance, and perceptions of truthfulness [8]. When an interviewee maintains a high level of eye contact, interviewers rated that interviewee as being more intelligent [9]. Even the nature of a smile can provide an indication of whether a person is telling the truth [10]. Behaviours such as speech rate, gaze, gesturing, nodding, and upright posture are all correlated with perceptions of intelligence [11]. Thus, it is important to investigate whether nonverbal communication can have similar effects in interactions between robots and people.

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In this study we investigate the impact of a humanoid robot's gaze upon trust. In particular, we ask participants to play a computer game version of the "shell game"[1] with a robot as a partner, under the pretense of testing the robot's vision system. We compare how three levels of robot gaze (averted, constant, and situational) impact the likelihood of participants accepting the robot's advice when the robot and participant have differing opinions as to the true location of the hidden object.

2 Gaze

Eyes are important communicative tools, as we and other species tend to look at things that are of interest to us. Being the recipient of another's gaze could be because you are a potential meal or mate—and the ability to perceive these signals gives considerable evolutionary advantage [12]. Between people, gaze has a number of functions, such as signaling interpersonal attitudes, initiating interaction, and conveying messages of intimacy, attraction, dominance and persuasiveness [13]. During dyadic verbal interactions, gaze serves to provide visual feedback, regulate the flow of conversation, and to communicate emotions [14]. Personality factors also impact gaze, for example introverts tend to gaze less than extroverts during conversation [15].

Gaze can also impact the likelihood of people complying with a request. People on the street are more likely to take a leaflet offered by a person who looks them in the eye [16], hitchhikers have more success in finding a ride when they gaze at drivers [17], and eye gaze can increase the amount of money people are willing to donate to charity [18]. In court rooms, witnesses are viewed as more credible when they employ eye gaze [19].

Gaze can increase cooperation and altruistic behaviour. Simply exposing people to gazing faces has been shown to increase cooperation [20]. For example, Haley and Fessler showed that displaying subtle eye-like stimuli on a computer screen caused participants to behave more generously in an economic game [21]. When using a computer screen displaying an image of eyes, almost twice as many participants gave money to their partners compared with those using screens without eyes. However, while gaze has shown to impact trust, other factors can override it in the longer term. For example, while displaying eyes on a screen can increase altruistic behaviour in a trust game in the short term, in the longer term acquiring a good "honorable" reputation is of far greater benefit [22].

[1] The "shell game", also known as the "cup game", involves hiding a small object underneath one of three identical cups, and then quickly moving the cups to create uncertainty as to the object's true location.

2.1 Gaze and Trust in Human–Robot Interaction

A meta-analysis of trust in human–robot interaction research found that although reliable and predictable task performance was the most important factor, robot anthropomorphism could also influence trust [23]. Human–robot gaze experiments generally replicate human–human findings. For example, students who receive eye gaze have better recollections of a story told to them by their teacher [24], and a similar effect was found when people were told a story by a robot [25]. Gaze has been shown to increase the persuasiveness of a story-telling robot [26], and people are more likely to comply with a robot's suggestions when it uses nonverbal cues such as gaze and gesture [27]. Furthermore, it has been demonstrated that people respond to a humanoid robot's trust-relevant nonverbal signals (such as crossing the arms and leaning away) in the same manner as they respond to similar signals from people [28].

Using the same human–robot cooperative visual tracking task as this study, Stanton and Stevens [29] asked participants to complete repeated trials with an Aldebaran Nao humanoid robot as a team-mate. Direct and averted robot gaze was randomised over 50% of trials. A significant interaction between gaze and task difficulty was found, with gaze having a positive impact upon participants' likelihood of trusting the robot when they were uncertain on the most difficult tasks, but having a negative impact for less difficult tasks. This finding concurred with previous human interaction research which suggested gaze can have a negative impact upon compliance for illegitimate requests, but a postive impact on legitimate requests [30].

2.2 Constant Gaze

Among many social animals, gaze is used to signal aggression, dominance and submission. For example, in many species mutually sustained direct eye contact is an unambiguously threatening gesture and indicates a struggle for dominance [31–33]. Likewise, among people, prolonged eye contact can be perceived as an aggressive approach signal, leading to an increased galvanic skin response [34] and other physiological responses [35]. Higher levels of gaze are associated with dominant personalities, people who initiate verbal communication in groups, while people with higher status are less likely to be the first to break mutual gaze in face-to-face interaction [36]. For example, Thayer [37] found that a male confederate who engaged in extended looking in an unfocused interaction with a male subject was rated as more dominant than a confederate who engaged in only brief looks. Culture and context also plays a role in governing appropriate eye contact [38]. For example, differences in frequency and timing of gaze between races have been found [15]. Depending upon context and familiarity, the establishment of eye contact can be interpreted as a sign of hostility or anger, or a sign of friendliness or romantic attraction [8,39].

Gaze duration is important—too much or too little can have a negative impact. Moderate amounts of gaze are generally preferred over constant or averted gaze with respect to likability [8]. Too much gaze, i.e. constant, unbroken gaze ("staring"), is commonly interpreted as an assertive gesture in a range of cultures, and several empirical studies have demonstrated the dominating and threatening nature of staring [35]. However, familiarity plays a role in determining how much gaze is appropriate. For example, friends engage in more mutual gaze than strangers [40], and as familiarity increases people become more likely to return gaze that is directed at them [41]. Argyle [42] also found an upper limit to the effect of gaze upon liking, reporting that participants' evaluations of a confederate were reduced when the confederate looked at the participant continuously.

One recent study [43] found that constant gaze can reduce persuasion. Rather than focus on the gaze of the speaker, Chen et al. focused on the gaze of the listener. In their first experiment, Chen et al. asked participants to watch videos of speakers expressing various views about controversial socio-political issues. The amount of time participants spent gazing at the speakers eyes was measured, with greater eye gaze time associated with decreased persuasion. In a second experiment, participants were instructed to look at either the mouth or eyes of the speaker. Intentionally maintaining direct eye contact again led to less persuasion than gazing at the mouth. Thus, given that constant gaze can reduce persuasion, and because in the present study our participants have no experience with robots and therefore constant gaze from the robot may be unnerving [41], we predict constant gaze from the robot will have a negative impact upon the likelihood of participants trusting the robot.

2.3 Averted Gaze

Too little gaze can also have a negative impact upon likability and credibility. People perceive those who avert gaze as more likely to be lying [44]. Even children as young as 6 years old have been shown to associate gaze aversion with lying [45]. However, liars actually increase eye contact [46], a cunning ploy playing on the widespread belief that liars avert eye gaze [47]. Burgoon et al. [13] conducted an experiment in which 140 subjects were asked to act as interviewers for an advertised job position. Confederate interviewees systematically varied three levels of gaze (high, normal, low). Subjects were more likely to hire and rate as credible and attractive interviewees who maintained a normal or high degree of gaze than those who averted gaze. In a courtroom scenario, witness who averted their gaze were perceived to be less credible and, ultimately, the defendant for whom they testified was more likely to be judged guilty [19]. Therefore, in the present study we expect a robot that always averts eye gaze to be deemed less credible and trustworthy than a robot who employs gaze occasionally.

3 The Present Study

The aim of this study is to examine what level of gaze is most successful (averted, constant, or "situational") in convincing participants to change their answer to the robot's suggested answer when the robot offers a differing opinion. As constant gaze between strangers is associated with dominance and threat, and constant gaze has also been demonstrated to hinder persuasion [43], we predict participants will trust a constantly gazing robot less than a robot that gazes occasionally (situational gaze). Furthermore, as averted gaze is associated with lying, participants will also trust a robot that averts gaze less than a robot that gazes occasionally.

Hypothesis 1 As task difficulty increases, and thus participant uncertainty increases, participants will be more likely to trust the robot's suggested answer.

Hypothesis 2 As constant gaze between strangers is associated with dominance and threat, and averted gaze is associated with lying, we predicted participants would be most likely to trust a robot which only gazed during disagreements.

4 Method

4.1 Participants

Fifty-two introductory psychology students from the Western Sydney University participated in the experiment and were recruited through the School of Psychology's research participation system, receiving course credit in exchange for their participation. All participants gave written consent and were informed of the study's ethics approval. Participants reported normal or corrected to normal vision. All participants reported no prior experience with humanoid robots. Thirty-eight participants were female and 14 were male with a mean age of 22.5 years ($SD = 6.9$). There were 17 participants in Averted Gaze (13 female, 4 male), 16 in Constant Gaze (12 female, 4 male), and 19 in Situational Gaze group (13 female, 6 male).

4.2 Equipment

Participants interacted via speech with an Aldebaran Nao[2] humanoid robot. The Nao robot is a small (58 centimetres

[2] For more information about the Nao visit https://www.aldebaran.com.

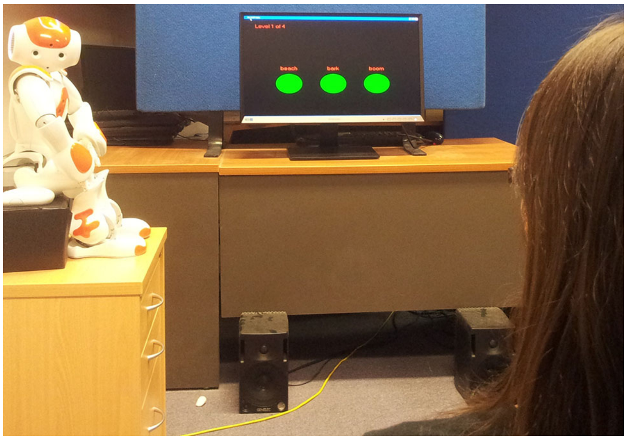

Fig. 1 Experimental setup. The Aldebaran Nao humanoid robot sits on a "chair" between the participant and game stimuli. When the stimuli are in motion, the robot's head, in all gaze conditions, faces the monitor appearing to track the objects. In Averted Gaze, the robot's head never looks away from the monitor. In Situational Gaze, the robot's head would turn to face the participant only if the robot disagreed with the participant's initial answer. In Constant Gaze, after the completion of every shell game trial, the robot's head would immediately turn to face the participant

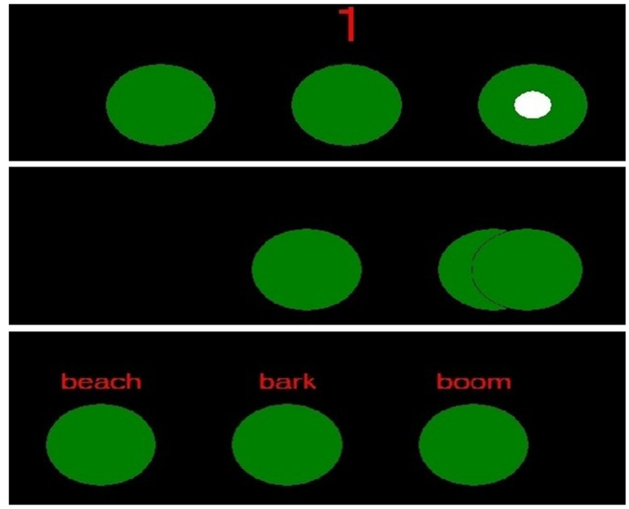

Fig. 2 Screen shots of the shell game stimuli. *Top* the game would initiate with a "3, 2, 1" countdown (countdown at time "1" is displayed), with the object of interest identified by a *white circle*. *Middle* when the game begins the *white circle* disappears, and the cups are shuffled horizontally with overlap, occlusion and changes of direction creating doubt as to the object's true location. *Bottom* when the cups stop moving after 4 s words appear above each cup to identify the different cups

tall) programmable robot commonly used for research. The Nao robot was chosen as it has a face with two "eyes" (although the eyes are not cameras), and is easily programmed. Participants were told the robot was operating autonomously; however, in truth the robot was operated using a Wizard-of-Oz setup (the cover story and procedure is described in Sect. 4.4). The robot spoke using the Nao's default text-to-speech settings. The robot, seated on a black box (see Fig. 1), was programmed to move its head to face either the monitor displaying the task or the participant. The robot was also programmed to use its arm to press a mouse button after each shell game trial, in order to facilitate the illusion of the robot operating autonomously.

4.3 Shell Game Task

With the robot as a partner, participants played a graphical computerised version of the classic "shell game" or "cup game", in which an object is hidden under one of three cups, and those cups are quickly shuffled to create doubt and uncertainty as to the true location of the object (see Fig. 2). Game trials comprised 3 levels of difficulty (Easy, Medium and Hard), with difficulty determined by the speed of cup movement and the number of cup "shuffles" per trial (see Table 1). A total of 48 trials (16 trials of each level of difficulty) were presented to each participant, randomised for difficulty. No feedback was given to the participant regarding whether their answers (or the robot's) were correct or incorrect after each trial, but a true score update was displayed after every 12 trials for the purpose of keeping the participant engaged and vigilant. On 8 trials of Medium difficulty and 8 trials of Hard difficulty the robot was programmed to disagree with the participant's initial answer (regardless of whether the participant's initial answer was correct or incorrect) and offer an alternative response.

Table 1 Task difficulty

Difficulty	Cup shuffles per trial	Movement speed (pixels per second)	Degree of occlusion (%)
Easy	10–15	800	70–80
Medium	20–30	1200	74–88
Hard	40–60	1600	78–96

For each trial, the cup shuffling process took 4 s, after which a word appeared above each cup. The robot would ask the participant "What is your answer?", and participants would identify their answer to the robot using the word that appeared above the cup they believed to be hiding the object. If the robot agreed with the participant's answer, the robot would say "I agree. Answer recorded" and press the mouse button to start the next trial. If the robot disagreed with the participant's answer the robot would say "I disagree. I think it is <*different answer*>. What is your final answer?". Upon receiving the participant's final answer the robot would say "Answer recorded" and press the mouse button to start the next trial.

4.4 Procedure

Upon arrival, all participants were given an information sheet detailing general information about the study and the study's ethics approval. After consenting to the experiment, participants completed a questionnaire which captured demographic information such as their age, gender, and experience with robots. Participants who had vision impairments or previous experience with robots were excluded from the study.

A cover story was told, in which participants were told the purpose of the experiment was to test new research designed to allow the robot to track moving objects, and to compare the robot's ability to human performance. Participants were informed that the shell game was a game of skill, and that the robot's vision system was "good, but not perfect". Furthermore, participants were told that because the game is difficult there are likely to be trials in which the participant is correct and the robot is incorrect, but also trials where the robot is correct and the participant is incorrect. In circumstances in which the participant and robot disagree, it is up to participant to choose a final answer that they believe most likely to be correct. After explaining the cover story, the experimenter stayed in the room for 3 practice trials with the participant to ensure the instructions were understood. After the practice trials, the experimenter left the room and the participant completed 48 trials with the robot alone. Upon completion of the 48 shell game trials, the experimenter reentered the room and debriefed the participant.

4.5 Experimental Design

A mixed design (3×3) was employed, with the between-subjects variable Eye Gaze (3 levels: Averted, Constant, and Situational) and the within-subjects variable Task Difficulty (3 levels: Easy, Medium and Hard). The dependent variable was the frequency with which participants would change their initial answer to the robot's suggested answer when the robot disagreed with the participant.

4.6 Independent Variables

4.6.1 Eye Gaze

In the Averted Gaze condition, the robot never looks at the participant, and gaze is always directed towards the monitor displaying the shell game stimuli. In the Averted Gaze condition the participant is never face-to-face with the robot during the entire experiment.

In the Constant Gaze condition, the robot would gaze at the monitor when the shell game stimuli is being presented. However, at the completion of each and every trial the robot would turn its head to gaze at the participant. Once the robot's head was facing the participant, the robot would then ask "What is your answer?". After interacting with the participant to determine the agreed upon answer (see Sect. 4.3), the robot would turn its head back to face the monitor for the next shell game trial.

In the Situational Gaze condition, the robot always faces the monitor displaying the shell game stimuli, with the exception of only turning its head to face the participant when the robot disagrees with the participant's initial answer. In particular, the robot would be facing the monitor when the robot asks the participant "What is your answer?", and if the robot disagreed with the participant's response, the robot would then turn its head to face the participant. Once the robot's head has finished moving to face the participant the robot would then say "I disagree. I think it is *<different answer>*. What is your final answer?". After interacting with the participant to determine the final answer, the robot would turn its head back to face the monitor for the next shell game trial. On trials where the robot agrees with the participant's initial answer, the Situational Gaze robot behaviour is identical to Averted Gaze.

4.6.2 Task Difficulty

Task Difficulty (three levels, ranging from easy to hard) were manipulated to prevent ceiling and floor effects, and to aid in participant vigilance. On Easy level trials the robot always offers the correct answer to add credibility and believability to the robot's behaviour. On 50% of Medium and Hard trials the robot would disagree with the participant's answer.

4.7 Dependent Variable

Participants played 48 trials of the shell game (see Sect. 4.3). On 16 of these trials (8 Medium and 8 Hard trials) the robot was programmed to disagree with the participant's initial answer, and the robot would offer an alternative answer. The dependent variable was the frequency with which each participant would change their initial answer to the robot's suggested answer.

5 Results

A 3×2 mixed analysis of variance (ANOVA) was conducted with Gaze (Averted, Constant, and Situational) and Task Difficulty (Hard vs Medium)[3] as independent variables, and mean answer change as the dependent variable. The first

[3] As the robot was programmed to always provide the correct answer on Easy trials, Easy trials are not considered in the analysis. Furthermore, participants gave the correct answer on 93.9% percent of Easy trials, and therefore the robot rarely disagreed with participants on Easy trials.

hypothesis predicted that harder trials would produce more frequent answer change. The second hypothesis stated that as constant gaze can signal dominance and threat, and averted gaze is associated with lying, participants would be most likely to be persuaded by a robot which only gazed during disagreements ("situational gaze").

There was a significant main effect of Difficulty, $F(1, 49) = 16.827$, $p = .0002$, with participants more likely to trust the robot on Hard trials ($M = 0.558$, $SD = 0.268$) than Medium trials ($M = 0.416$, $SD = 0.26$). Thus, the first hypothesis was supported. However, there were no significant effects or interactions related to Gaze. Given the large percentage of female participants (38 of 52), when only females are considered the effect of Gaze approaches significance, $F(2, 35) = 2.583$, $p = .0899$, with Constant gaze eliciting the lowest frequency of answer change ($M = 0.385$, $SD = 0.268$), while Averted gaze ($M = 0.543$, $SD = 0.29$) and Situational gaze had similar rates of answer change ($M = 0.582$, $SD = 0.237$). The second hypothesis was not supported.

While task difficulty was intended to manipulate participants' uncertainty as to the correct answer, and this is reflected by the accuracy of participants' responses (for example, participants gave the correct answer on 93.9% percent of Easy trials, 73.8% of Medium trials, and 50.3% of Hard trials), task difficulty was not a perfect measure of a participant's confidence that their answer was correct. Furthermore, due the strong main effect of Difficulty, $F(1, 49) = 16.827$, $p = .0002$, it appears that when participants were uncertain of the correct response (irrespective of whether the trial was categorised as Medium or Hard) they were likely to defer to the robot's suggested answer, regardless of the gaze condition. This was confirmed by comparing trials in which the participants' initial answers were correct versus incorrect. Participants were significantly more likely to trust the robot, $F(1, 49) = 10.56$, $p = .002$, if their initial answer was incorrect ($M = 0.572$, $SD = 0.263$) as opposed to correct ($M = 0.47$, $SD = 0.27$). Thus it appears participants were capable of evaluating their likelihood of being correct on invidual trials, and on trials in which their uncertainty was high, trusted the robot regardless of gaze condition.

Given that participants were likely to choose the robot's suggested answer if they were unsure of the correct response, a second analysis was conducted which only considered trials in which the participant has initially chosen the correct answer and is thus likely to have a higher degree of confidence. The first hypothesis was again supported, with a significant main effect of Difficulty, $F(1, 49) = 9.925$, $p = .00278$, as participants were more likely to trust the robot on Hard trials ($M = 0.539$, $SD = 0.348$) than Medium trials ($M = 0.39$, $SD = 0.289$). There is a trend related to Gaze but it is not significant $F(2, 49) = 2.261$, $p = .115$. When only females are considered there is significant main

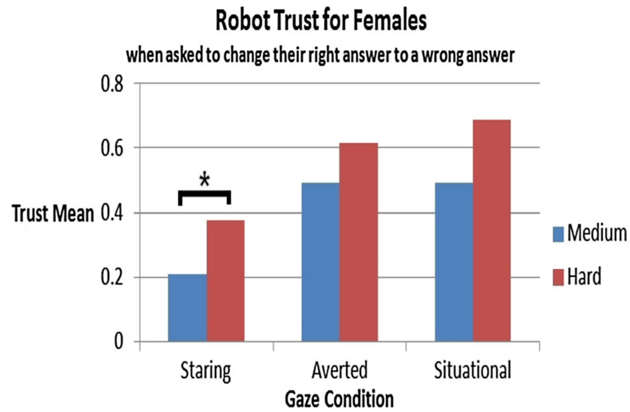

Fig. 3 Results for trials in which female participants were asked by the robot to change their correct answer to an incorrect answer. Means for both Medium and Hard trials are displayed. There was a significant main effect of Gaze, $F(2, 35) = 5.306$, $p = .00972$, with women least likely to be persuaded to change their correct answer to an incorrect answer by a staring robot. There was no significant difference between Averted gaze and Situational gaze

effect of Gaze, $F(2, 35) = 5.306$, $p = .00972$, with women least likely to be persuaded to change their correct answer to an incorrect answer by a staring robot ($M = 0.292$, $SD = 0.287$), as compared to Averted gaze ($M = 0.555$, $SD = 0.340$) and Situational gaze ($M = 0.591$, $SD = 0.301$). There was no significant difference between Averted gaze and Situational gaze. These results are displayed in Fig. 3. For females, the second hypothesis is partially supported in that constant gaze has a negative impact upon trust—however averted gaze did not have a negative impact.

Unexpected gender effects were found. Due to the small number of male participants ($N = 14$) these results must be treated with a very high degree of caution, but the males who participated in this study responded to the robot's gaze very differently to the female participants, especially with respect to "staring". For example, the Constant Gaze condition resulted in the lowest levels of trust towards the robot for females ($M = 0.385$, $SD = 0.268$), but for males the opposite was true ($M = 0.591$, $SD = 0.329$). Furthermore, while the Situational Gaze condition resulted in the highest trust for females ($M = 0.582$, $SD = 0.237$), again the opposite was true for males ($M = 0.362$, $SD = 0.283$). The Averted Gaze condition had the smallest difference between the genders with women ($M = 0.543$, $SD = 0.290$) recording a marginally higher trust rate towards the robot than males ($M = .504$, $SD = 0.395$).

6 Discussion

We investigated the effect of gaze upon the likelihood of participants trusting a robot. Trust was measured by the frequency with which participants, when presented with a robot which disagreed with them, would change their original answer to the robot's suggested answer. We hypothesised that participants would trust the robot more often on Hard trials than Medium trials, and this was supported. This demonstrates that as participants become increasingly uncertain, they become more willing to rely on a robot's judgment, regardless of gaze condition.

As constant gaze can be associated with dominance and threat, and averted gaze is associated with lying, we predicted participants would be most likely to be persuaded by a robot which only gazed during disagreements ("situational gaze"). However, gender effects were found, with females least likely to trust a robot which stared at them, and no significant differences between averted gaze and situational gaze. Furthermore, this effect was only significant on trials where female participants had initially chosen the correct answer. When trials in which the participant is initially incorrect are included, the effect is weakened (and is no longer significant $F(2, 35) = 2.583$, $p = .0899$), further evidence that as participants become increasingly unsure of the correct response, they become more willing to rely on the robot's judgment, regardless of gaze condition.

Gaze only had a significant impact upon trust when female participants who had chosen the correct answer were faced with a robot that disagreed with them. The negative impact of constant gaze upon trust concurs with our previous findings [29] which, using four levels of difficulty, found an interaction between gaze and task difficulty, with gaze having a negative impact upon trust for all but the most difficult of trials. Thus, it appears the use of gaze, in this task context, is of no benefit in gaining participants' trust, and instead hinders it. It has been shown that gaze hinders compliance for illegitimate requests [30], and a request by the robot to a confident participant to change their correct response may be considered "illegitimate" and unreasonable by the participant, thus explaining the current phenomenon. Furthermore, recent research has found constant gaze hinders persuasion [43].

Unexpected gender effects were found in this study. However, due to the small number of male participants ($N = 14$) these results must be treated with caution. While eye contact may be a sign of connection or trust in friendly situations, for young women who have no experience with robots and find themselves in a novel experimental situation, a staring robot may create perceptions of an adversarial relationship and intimidation. Conversely, it appears males respond differently to the Nao in this task context, and the robot's constant gaze may be interpreted as a sign of the robot's willingness to interact with them. In any case, given the small number of male participants in this study, further investigation is required.

Gender effects have been found previously in human–robot interaction. For example, robot gaze has been shown to increase the minimum comfortable proxemic distance between female participants and a "PR2" robot, but robot gaze decreases this distance for men [48]. However, a study in which participants were asked to approach a "Wakamaru" robot with either mutual or averted gaze [49] this was contradicted, with males distancing themselves further away from the Wakamaru than females. Furthermore, gaze had no effect on female distancing, but for males gaze resulted in participants increasing their interpersonal distance. It is worth nothing the vastly different appearances of the PR2 and Wakamaru—the PR2 appeared mechanical with exposed silver metal, while the Wakamaru exterior was yellow plastic. Thus, it appears complex interactions between social rules, task, culture, and anthropomorphism are impacting participant behaviour.

A limitation of this study relates to the task difficulty and low-stakes nature of the shell game. Firstly, task difficulty was not a perfect measure of a participant's level of confidence that their answer was correct, as demonstrated by the fact that participants were significantly more likely to choose the robot's suggested answer if they had initially chosen an incorrect answer as opposed to a correct answer. Secondly, it appears that the nature of the task, combined with the cover story, resulted in many participants choosing the robot's suggested answer whenever their uncertainty was high as this would be better than "guessing". Thus, due to the low-stakes nature of the task, with no substantial consequences for incorrect responses, participants would readily trust the robot on difficult trials because they were told the robot's vision system was designed specifically for this task. Furthermore, when task difficulty and participant uncertainty was high, the willingness of participants to defer to the robot's answer overwhelmed any effects of gaze. This is supported by the fact that the only effects of gaze were found when participants were asked by the robot to change correct answers to incorrect answers.

Future work could address some of the limitations of this study. Gender effects could be explored by recruiting a larger sample of participants, balanced for gender. Task difficulty could be reduced, as the negative effects of constant gaze upon trust towards the robot only appeared to be present when participants had a higher degree of confidence that their responses were correct. Furthermore, the stakes of the task could be increased (for example, offering a financial reward for choosing the correct answer or answers), so that the decision whether to trust or not trust the robot is more important to the participant. Lastly, personality factors, such as extraversion and agreeableness, may play a role in how trusting each individual is towards the robot. Measuring the personality traits of participants with an inventory could be valuable.

In conclusion, this study has shown participants, regardless of gender, are willing to trust a robot's judgment for low-stakes decisions when they are uncertain of their own judgment. However, constant robot gaze can have a negative impact upon females trusting a robot's opinion, especially when they have confidence in their own judgment. This finding concurs with previous research using the shell game that gaze can hinder trust for all but the most difficult of trials [29]. The practical implication of these findings is that robot gaze can be used excessively, having negative consequences upon trust towards robots when females interact with robots. This may be especially the case when robots are interacting with people who have little familiarity with robots, as for these people a robot seeking to establish mutual gaze may be unnerving [41].

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