The Impact of Intergroup Bias on Trust and Approach Behaviour Towards a Humanoid Robot

Christopher Deligianis, Christopher Stanton, Craig McGarty, and Catherine J. Stevens
MARCS Institute, Western Sydney University

As robots become commonplace, and for successful human-robot interaction to occur, people will need to trust them. Two experiments were conducted using the “minimal group paradigm” to explore whether social identity theory influences trust formation and impressions of a robot. In Experiment 1, participants were allocated to either a “robot” or “computer” group, and then they played a cooperative visual tracking game with an Aldebaran Nao humanoid robot as a partner. We hypothesised participants in the “robot group” would demonstrate intergroup bias by sitting closer to the robot (proxemics) and trusting the robot’s suggested answers more frequently than their “computer group” counterparts. Experiment 2 used an almost identical procedure with a different set of participants; however, all participants were assigned to the “robot group” and thee different levels of anthropomorphic robot movement were manipulated. Our results suggest that intergroup bias and humanlike movement can significantly affect human-robot approach behaviour. Significant effects were found for trusting the robot’s suggested answers with respect to task difficulty, but not for group membership or robot movement.

Keywords: HRI, social identity theory, intergroup bias, gaze, trust, compliance, proxemics

1. Introduction

Robots are becoming increasingly common, acting as guides at train stations (Hayashi et al., 2007) and museums (Faber et al., 2009), delivering food (Lee et al., 2009), performing rehabilitation therapy (Aisen, Krebs, Hogan, McDowell, & Volpe, 1997), and assisting autistic children to develop social skills (Robins, Dautenhahn, Boekhorst, & Billard, 2005). Robots operating in a high-stress environment, or with populations who have sensitive needs, will need to be trusted as much as a human. For example, a robot working in retirement homes (Broadbent, Stafford, & MacDonald, 2009)may be required to give medication to an elderly patient; if the patient refuses to accept the robot’s advice, then their health could be at serious risk. A disaster survivor, in shock and disoriented, may be hesitant to listen to the directions of a search and rescue robot, thereby placing themselves in jeopardy. In an emergency operation, a surgeon who does not trust a surgical robot’s judgment could detrimentally affect a trauma victim’s chance for survival. Thus, the ability to gen-

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erate and maintain trust is of paramount importance in human-robot interaction (HRI).

1.1 Social Identity Theory

Factors influencing trust formation range from personal characteristics of the trustee, such as their perceived ability, integrity, and credibility, (Briggs, Burford, Angeli, & Lynch, 2002; Mayer, Davis, & Schoorman, 1995; Wood, Boles, Johnston, & Bellenger, 2008) as well as dispositional attributes of the trustor (DeNeve & Cooper, 1998). Trust has also been framed within the context of intergroup relations (Tanis & Postmes, 2005). Intergroup bias, also known as ingroup favouritism, refers to "the systematic tendency to evaluate one's own membership group or its members more favourably than a nonmembership group or its members" (Hewstone, Rubin, & Willis, 2002). Social identity theory postulates that group membership is an important determinant of individual behaviour, where people give preferential treatment to others when they are perceived to be in the same ingroup (Davis, 2014; Tajfel & Turner, 1986).

A collective ingroup is built upon similarities (Brewer, 2001) that include race, religion, skin colour, sex, and sexual orientation. However, trivial or arbitrary differences, such as aesthetic preference (Billig & Tajfel, 1973) and shirt colour (Frank & Gilovich, 1988) are sufficient to generate preferential evaluation. The process of ingroup categorisation is mutually exclusive towards individuals who differ on a given characteristic and results in active antagonism or avoidance (Linville & Jones, 1980). Applied to HRI, a socially interactive robot identified as an ingroup member would be expected to generate positive evaluations and facilitate superior social interactivity.

Brewer (1981) hypothesised that common group membership could serve as a way to evade the necessity for personal knowledge of the trustee. For example, participants rate ingroup strangers as more trustworthy than outgroup strangers (Foddy, Platow, & Yamagishi, 2009; Platow, McClintock, & Liebrand, 1990), indicating intergroup differentiation is sufficient to create "social competition", as long as some basis for discriminating in favour of the ingroup is available (Brewer & Silver, 1978). A study that focused on investment and reciprocity found more trusting behaviour was displayed towards ingroup members than outgroup members, despite participants reporting no differences in perceived trustworthiness (Tanis & Postmes, 2005). Thus, intergroup bias may impact trust formation independently of characteristics specific to the trustor and the trustee (Platow, Foddy, Yamagishi, Lim, & Chow, 2012). If group membership is the only difference between two potential trustees, then an ingroup member will be more likely to be trusted than an outgroup member.

1.2 Trust in HRI

Trust formation in HRI is a product of the inter-relationship between three factors: the human, the robot, and the environment (Hancock et al., 2011). Human-specific features affecting a person's willingness to trust a robot include national or cultural identity (Evers, Maldonado, Brodecki, & Hinds, 2008; Wang, Rau, Evers, Robinson, & Hinds, 2010), age (Heerink, Kröse, Evers, & Wielinga, 2010), expertise (Murphy, Riddle, & Rasmussen, 2004; Tsui & Yanco, 2007), and attentional load (Chen & Terrence, 2009). Environmental factors relate to the situation or task at hand and include task load. For example, Biros, Daly, and Gunsch (2004) demonstrated that participants who incurred a higher task load exhibited an over-reliance on their automated information systems to assist them in their decision-making activities, making them more susceptible to deception. Other factors include task type (Li, Rau, & Li, 2010), proximity to a robot (Kidd, 2003), and setting (Scopelliti, Giuliani, & Fornara, 2005). A meta-analysis identified robotic task performance as the prime influence on trust formation and robotic "attributes" (such as the robot's appearance) as secondary factors (Hancock et al., 2011).

Robot reliability and predictability are the main performance factors that influence trust formation in HRI (Dzindolet, Peterson, Pomranky, Pierce, & Beck, 2003; Grodzinsky, Miller, & Wolf, 2011). If a robot performs differently in identical contexts, breaks down, or fails a task, then it is unlikely to be trusted in the future. However, appearance (Mori, 1970; Syrdal, Dautenhahn, Woods, Walters, & Koay, 2007), behaviour (Walters, Syrdal, Dautenhahn, Boekhorst, & Koay, 2008), and "personality" (Miwa, Takanishi, & Takanobu, 2001) can all affect the quality of HRI. The "matching hypothesis" proposes that humans would prefer to interact with robots whose social behaviour and appearance are appropriate for the task and situation (Powers, Kiesler, & Goetz, 2003). Robots that emulate human movements and eye gaze are more persuasive (Mutlu, Forlizzi, & Hodgins, 2006), have more tasks delegated to them (Hinds, Roberts, & Jones, 2004), and are evaluated more positively (Walters, Syrdal, Dautenhahn, Boekhorst, & Koay, 2008). These findings indicate that HRI may be improved through the introduction of "humanlike" attributes that are not functionally necessary to complete a given task.

1.3 Anthropomorphism and Intergroup Bias in HRI

The propensity to anthropomorphise a robot is based largely upon the robot's similarity to the observer; similarity is thought to be the reason that bipedal movement, eye gaze, emotive gestures, and vocalization improve a user's experience with a social robot and strengthen the social connection (Fong, Nourbakhsh, & Dautenhahn, 2003). Why this phenomenon occurs is not as well understood, yet these characteristics amplify perceived anthropomorphism. One possibility is that in the absence of a sound conceptual model, people automatically apply existing human-human schema when interacting with computers and other media. For example, when interacting with computers, people exhibit politeness in a manner similar to human-human interactions (Reeves & Nass, 1996). Thus, if such behaviours can occur with desktop computers, then when interacting with humanoid robots, people may automatically apply social interaction norms.

An alternate theory proposes that people expect interactive systems to "behave as they do" (Lee, Lau, Kiesler, & Chiu, 2005). This explanation stipulates that an individual's mental model of a robot will be closer to their mental model of other humans as the robot's similarity increases. This theory has been supported through findings that identify anthropomorphic robots as generating more complex mental models than purely mechanical robots (Kiesler & Goetz, 2002) and also provides an explanation for why human responses differ as a function of task type and situation Lee, Lau, Kiesler, and Chiu (2005). For example, people prefer robots for tasks when the robot's human likeness and demeanor matches the sociability required for those tasks (Goetz, Kiesler, & Powers, 2003), and thus anthropomorphic design may also facilitate the production of rich mental models that predicate evaluative and behavioural responses.

Häring, Kuchenbrandt, and André (2014) manipulated a robot's perceived nationality by giving it a German or Egyptian name, a country of origin, and a flag sticker and then asked German participants to play a game with both robots. Task congruency was also altered and participants either competed against or cooperated with their ingroup robot. Independent of task congruency, participants more strongly anthropomorphised the ingroup robot and were far more cooperative than when compared to interactions with the outgroup robot. These findings reinforce the theory that humans form mental models of robots and that these are susceptible to group dynamics.

Research has shown that through the process of anthropomorphism, humans can generate strong affective reactions towards a mechanical construct (Fong, Nourbakhsh, & Dautenhahn, 2003; Ho & K. F. MacDorman, 2010; Mori, MacDorman, & Kageki, 2012). Furthermore, instead of focusing solely on a robot's proficiency and reliability when deciding whether or not to place their trust in a robot, participants have been shown to value humanlike characteristics that are irrelevant to the success of the task at hand (Hancock et al., 2011; Miwa, Takanishi, & Takanobu, 2001; Syrdal, Dautenhahn, Woods, Walters, & Koay, 2007; Walters, Syrdal, Dautenhahn, Boekhorst, & Koay, 2008). These findings, taken together, imply that participant interaction with a robot that possesses humanlike features increases familiarity and therefore elicits more positive evaluations—provided the robot is not eerily or uncannily humanlike (Mori, MacDorman, & Kageki, 2012). Similarity is also a consistent theme of intergroup bias research, with ingroup formation dependent upon shared characteristics. Applying this model to HRI, participants are more likely to engage in positive bias and favouritism towards humanlike robots, in their behaviour and evaluations, because of the robot's perceived anthropomorphism. Anthropomorphic design, therefore, may be conceptualised as a site of discrimination between humans and robots, analogous to, for example, race or religion between humans. If this holds true, when participants are presented with functionally identical robots with differing levels of anthropomorphic design then they should treat the humanlike robot "more favourably", as it is a humanlike ingroup member (Hewstone, Rubin, & Willis, 2002).

Participants have been shown to preferentially evaluate robots based upon anthropomorphic features; however, this paradigm has not been explicitly applied to trust formation. Gaze behaviour and emotive gestures have been explored as potential determinants of a robot's persuasive capacity. Eye gaze has been implicated as a powerful anthropomorphic trait that can significantly impact HRI (Garau, Slater, Bee, & Sasse, 2001; Mutlu, Forlizzi, & Hodgins, 2006). For example, Ham, Bokhorst, Cuijpers, Pol, and Cabibihan (2011) found that eye gaze was necessary to convey the moral agenda of Aesop's "The boy who cried wolf", and that gesture could enhance the effect of gaze. Importantly, gaze is not a functional necessity for communication between a human and a robot; a robot that does not maintain direct gaze is equally capable of observing, listening and responding to a human as one that does. If there are other humanlike behaviours that a robot can emulate, even if those behaviours are not a functional necessity for the task at hand, then there may be a cumulative benefit to integrating these routines into future robotic design.

2. Overview

2.1 The Present Study

The aim of this study is to test whether participants treat physically and functionally identical robots more favourably when the robot is perceived as an ingroup member. Furthermore, if a robot can be accepted as an ingroup member by a human participant, it then follows that increasing levels of anthropomorphic movement will strengthen ingroup favouritism due to the robot being perceived as more humanlike.

In the present study, two experiments were conducted using near identical procedures, with a different set of participants in each experiment. The experiments differed in two ways: group membership and robot movement. The first experiment sought to establish the presence of intergroup bias upon trust and approach behaviour, and thus in Experiment 1, only participants' group membership was manipulated (while robot movement was identical for all participants in Experiment 1). The aim of the second experiment was to explore the impact of different levels of anthropomorphic robot movement upon participants' interactions with an ingroup robot. To achieve this, three different levels of robot movement were manipulated. It was hypothesised that increased anthropomorphic robot behaviours would strengthen ingroup favouritism.

2.2 The Minimal Group Paradigm

Both experiments employed the "minimal group paradigm", which is a proven technique for inducing intergroup bias among people. The minimal group paradigm is an experimental manipulation in which participants are assigned to different groups or categories of a trivial nature (Diehl, 1990). Experiments using the minimal group paradigm have demonstrated that arbitrary group assignments, even apparently meaningless in nature such as a preference for a particular painting artist (Tajfel, Billig, Bundy, & Flament, 1971), can lead to ingroup favouritism and discrimination against the outgroup. The minimal group paradigm has been previously used in human-robot interaction, with group assignment based upon colour (Kuchenbrandt, Eyssel, Bobinger, & Neufeld, 2013). Kuchenbrandt et al. introduced Nao robots to participants as members of the "blue group" and then arbitrarily assigned participants to either the "blue group" or the "green group". Ingroup membership with the robot generated greater anthropomorphic inferences, and participants were more willing to interact with an ingroup robot.

2.3 Proxemics

Both experiments used an unobtrusive proxemics measure (interpersonal spacing) between the participant and the robot as a dependent variable, as a measure of comfort and intimacy with the robot. Proxemics, or "personal space", refers to physical boundaries into which others are permitted based upon psychological intimacy, with interpersonal distances decreasing as intimacy increases (Hall, 1966; Hayduk, 1983). Thus, how people position themselves in proximity to others is informative, providing a behavioural measure of comfort, attraction, and psychological closeness (Cook, 1970). For example, Ickinger (1982) found that strangers who conversed freely later exhibited closer interpersonal distancing than those participants who did not converse easily. People distance themselves further away from strangers who have a facial disfigurement (Rumsey, Bull, & Gahagan, 1982). When interacting with robots, participants with prior experience with robots positioned themselves more closely to a robot than those without prior robot experience (Takayama & Pantofaru, 2009).

3. Experiment 1: Intergroup Bias

3.1 Cover Story

A cover story was told to participants. Upon arrival, each participant was told by the experimenter that the purpose of the experiment was twofold: 1) to test the robot's ability to track moving objects; 2) to track the eye movements of participants for aiding future improvements to the robot's vision system. To add believability, a stereo depth camera was placed facing the participant, and participants were told the camera was tracking their eye movements (however, the camera was never operational). The experimenter informed the participant that they would be allocated to one of two groups, either the "computer group" or the "robot group". Participants were told they would complete two tasks during the experiment, and that all participants would complete the first task with the robot. For the second task participants who were assigned to the "computer group" would interact with a desktop computer, while those in the "robot group" would interact with the robot. However, in truth, there was no second task to the experiment. Furthermore, participants were told their group allocation would be determined based upon their responses to a brief four-item multiple-choice questionnaire[1] regarding their experience and attitudes towards computing technology and robots. However, in accordance with the minimal group paradigm, group assignment was arbitrary. When the participant completed the questionnaire, the experimenter exited the room under the pretense of determining their group allocation. After a brief period, the experimenter returned to the room with a laminated ID card that had a photo of either the computer or the robot, depending on the participant's group allocation. Participants were instructed to keep the card on them at all times under the pretense that another experimenter would be leading them through the second part of the experiment, and the ID card would be used to identify their group membership.

[1] Question 1 asked participants whether they believed robots would become increasingly common in everyday life. Question 2 asked how many examples of robots in movies and popular culture the participant could think of. Question 3 asked how often participants used computing devices in daily life, while Question 4 asked participants how many hours a week they spent playing computer games. Participant responses were irrelevant, as in accordance with the minimal group paradigm, group allocation was random.

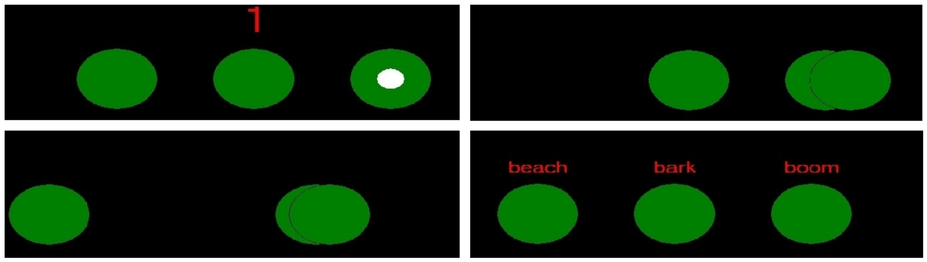

Figure 1. Screen shots of the shell game stimuli. *Top left*: the game would initiate with a "3, 2, 1" countdown (countdown at time "1" is displayed), with the object of interest identified by a white circle. *Top right and bottom left*: When the game begins the white circle disappears, and the cups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

3.2 Shell Game Task

The first (and only) task involved participants playing a cooperative version of the "shell game" with the robot as a partner (see Fig. 1). The "shell" game (or "cup" game) involves hiding an object under one of the three cups, then quickly shuffling and moving the cups to create doubt and uncertainty as to the true location of the hidden object. The shell game was constructed and implemented, as it offers a reliable method to induce participant doubt and a behavioural measure of trust. The robot, effectively a confederate, was controlled by a "Wizard-of-Oz" setup. On particular trials, the robot would disagree with the participant's answer and suggest an alternative answer. The frequency with which participants would change their original answer to the robot's suggested answer constituted the experiment's measure of trust.

Game trials comprised three difficulty levels (Easy, Medium, and Hard), with difficulty determined by the speed of cup movement, the number of cup "shuffles" per trial, and the degree to which the cups overlapped when being shuffled (see Table 1). A total of 48 trials (16 trials of each difficultly level) were presented to each participant, randomised for difficulty. No feedback was given to the participant regarding whether their answers 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.

Table 1: Task Difficulty

Difficulty	Cup Shuffles Per Trial	Movement Speed	Degree of Occlusion
Easy	10-15	800 pixels per second	70-80%
Medium	20-30	1200 pixels per second	74-88%
Hard	40-60	1600 pixels per second	78-96%

Participants interacted with the robot using speech. The robot's speech was produced using the Nao's text-to-speech engine (using the default pitch and speed settings). For each trial, the cup shuffling process took four seconds, after which a word appeared above each cup. The robot would ask the participant "What is your answer?" and participants would relay their answer to the robot

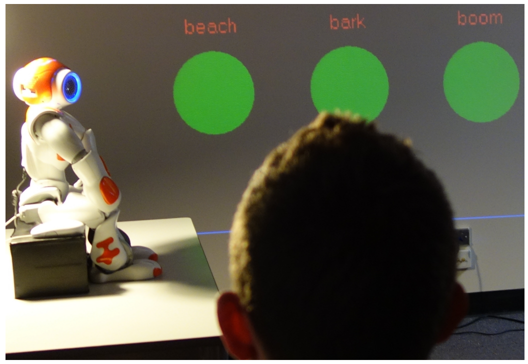

Figure 2. Experimental setup. The Aldebaran Nao humanoid robot sits on a “chair” between the participant and game stimuli. A mouse button is located on the “chair” to the robot’s right.

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”, and the next trial would begin. 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?”. On Difficult and Medium trials the robot was programmed to pseudo-randomly disagree on 50% of trials, regardless of whether the participant was correct or incorrect with their initial response. However, on Easy trials, the robot was programmed to only disagree if the participant’s initial response was incorrect, and if so the robot’s suggestion would be the correct answer. The robot’s behaviour on Easy trials was intended to add believability and credibility to the robot.

3.3 Robot Movement

In Experiment 1, all participants experienced a Nao that would move its head to appear to be tracking the moving objects on the screen, turn to look at participants when speaking to them, and press down on a mouse button with its hand to initiate each shell game trial in order to facilitate anthropomorphic inferences.

3.4 Procedure

Upon arrival, the participant was told the cover story (Section 3.1). As described in Section 3.1, participants completed the four-item multiple choice questionnaire, and were told that their answers would determine whether they would be placed in the “robot group” or the “computer group”. Irrespective of their responses, participants were randomly allocated to one of the two conditions and then informed of their group membership. The participant was then given instructions regarding how to play the shell game with the robot. The experimenter then left the room, allowing participants to play the digital shell game with the Nao robot alone, with the robot disagreeing on particular trials with each participant’s answers (as described in Section 3.2). Following completion of all the shell game trials, the experimenter re-entered the room and asked the participant to move their chair and sit in front of the Nao, and while the participant did this, the experimenter again left the room. After 60 seconds, the experimenter would then re-enter the room, and inform the participant the experiment was in fact completed and there were no further tasks (except for a questionnaire). The distance between the position of the participant’s chair (as it is located when the experimenter re-enters the room) and the robot formed the proxemic measure. Finally, participants were asked to complete the Godspeed questionnaire (Bartneck, Kulic, Croft, & Zoghbi, 2009). After completing the questionnaire, participants were informed that the experiment was complete and then debriefed[2].

3.5 Experimental Design

A 2x2 mixed factorial design with "group" (robot or computer) as a between-subjects variable and task difficulty (Medium or Hard) as a within-subjects variable were utilised.

3.5.1 Dependent Variables. Dependent variables were the frequency of participants' answer changes to the robot's suggested answer during the shell game (trust), the distance with which the participant positioned themselves from the robot when asked to by the experimenter at conclusion of the shell game task (proxemics), and lastly, participants completed the Godspeed questionnaire (Bartneck, Kulic, Croft, & Zoghbi, 2009) after both the shell game and proxemics measures were completed.

3.5.2 Hypotheses. It was hypothesised that participants would change their answers more often on Hard trials than Medium trials, as they would be under greater attentional load (Biros, Daly, & Gunsch, 2004) and their increased doubt prompts a reliance on the Nao. The second hypothesis was that members of the "robot group" would change their answers more than members of the "computer group" due to ingroup bias. The third hypothesis was that ingroup members would subjectively evaluate and engage with the Nao more positively than outgroup members as measured by the Godspeed questionnaire and proxemics.

3.5.3 Participants. Thirty-nine introductory psychology students from the Western Sydney University participated in the experiment and were recruited through the School of Psychology's research participation system "SONA", 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. Participants were comprised of 28 females and 11 males with a mean age of 22 (SD = 4.99). There were 20 participants in the "robot group" and 19 in the "computer group".

3.6 Experiment 1: Results

3.6.1 Participant Skill. "Easy" trials were designed so that participants would achieve near perfect scores for this difficulty level, thus building and facilitating the illusion that the robot is also playing the game. As agreement and disagreement rates were central to the construction of the experiment, exceptionally poor skill could severely compromise the reliability and validity of the experiment; participants who make mistakes on Easy trials will experience a robot that disagrees with them more frequently than participants who do not. The mean participant score for Easy trials was 14.9 out of 16 (SD = 1.3). Three participants were removed from the dataset for scoring at near chance levels (7 or less) on Easy trials.

3.6.2 Trusting the Robot's Opinion. A 2x2 mixed analysis of variance (ANOVA) was conducted with group membership and task difficulty as independent variables, and mean answer change as the dependent variable. The first hypothesis predicted that harder trials would produce more frequent answer change. This was supported with participants changing their answer more often on Hard trials (M = .51, SD = .23) than Medium trials (M = .41, SD = .21), $F(1,37) = 7.24$, $p = .011$, $\eta^2 = .16$. The second hypothesis, that "robot group" participants would change their answer more frequently than "computer group" participants was not supported, $F(1,37) = 0.06$, $p = .807$, $\eta^2 < .01$.

[2] Participants were fully debriefed and made aware of deception. This research was approved by Western Sydney University's Human Ethics Committee (approval number H10313).

3.6.3 Proxemics. Members of the "robot group" were hypothesised to sit closer to the Nao than the "computer group". Proxemics was analysed with an independent samples *t* test and a significant difference was observed $t(37) = 5.15$, $p = <.001$. On average members of the robot group sat at a distance of 93.85cm ($SD = 18.76$) away from the Nao while participants in the computer group chose to sit at a mean distance of 128.95cm ($SD = 23.66$), consistent with the hypothesis. This mean difference of 35.1cm, 95% CI [48.91, 21.28], indicates a large effect size ($r = .65$).

3.6.4 Godspeed Questionnaire. No significant differences were observed for the Godspeed measures of Animacy $t(37) = 0.39$, $p = .696$, Anthropomorphism $t(37) = 1.12$, $p = .269$, Intelligence $t(37) = 1.45$, $p = .155$, Liking $t(37) = 0.014$, $p = .989$ and Safety (equal variances not assumed) $t(37) = 1.31$, $p = .202$.

3.7 Experiment 1: Discussion

Experiment 1 investigated the effect of group membership upon trust, approach distance, and ratings of a humanoid robot. Trust was measured by the frequency with which participants, when presented with a robot that disagreed with them, would change their original answer to the robot's suggested answer. Our first hypothesis was that participants would trust the robot more often on Hard trials than Medium trials, and this was supported. The second hypothesis was that group membership would have an impact upon trust, with ingroup members being more likely to trust the robot than outgroup members. The second hypothesis was not supported. The third hypothesis was that ingroup members would have a more positive response to the robot than outgroup members, as measured by approach distance and the Godspeed questionnaire. The third hypothesis was supported for approach distance, with ingroup members positioning themselves much closer to the robot after the shell game than outgroup members. However, no significant findings were found for questionnaire ratings.

Despite previous intergroup bias research suggesting that participants are more likely to trust ingroup members (Foddy, Platow, & Yamagishi, 2009; Platow, Foddy, Yamagishi, Lim, & Chow, 2012; Platow, McClintock, & Liebrand, 1990; Tanis & Postmes, 2005), no evidence was found using the shell game task that group membership would impact the likelihood of participants trusting a robot. Previous research has identified that tasks with high cognitive or attentional demand can lead participants to an over-reliance on automated information systems (Biros, Daly, & Gunsch, 2004), and the main effect of task difficulty supports this finding. Thus, it is possible that the high attentional demand of the shell game (especially on Hard difficult trials) led participants to trust the robot regardless of group membership, and therefore, task difficulty may have superseded any effects related to group membership.

Proxemics produced results in the hypothesised direction; participants sat closer to the robot when they were an ingroup member as opposed to an outgroup member. These results demon- strate parity with existing human-human intergroup bias research (Dovidio, Hebl, Richeson, & Shelton, 2006; Ryen & Kahn, 1975) as humans have been shown to demonstrate a proximal preference towards ingroup members. However, results from the Godspeed questionnaire did not reveal any effects related to group membership. A possible explanation is the proxemic measurement, unlike the questionnaire, was unobtrusive. Furthermore, questionnaire ratings were generally extremely positive, and thus a ceiling effect may have occurred. For example, with regards to likability, participants in both the computer group ($M = 4.21$, $SD = 0.76$) and robot group ($M = 4.20$, $SD = 0.61$) rated the robot near the maximum positive score of 5.

4. Experiment 2: Humanlike Movement

Having established evidence of ingroup bias for approach behaviour using the minimal group paradigm in Experiment 1, the aim of Experiment 2 was to investigate the effect of "humanlike" movement on trust formation and approach behaviour with an ingroup robot. It was hypothesised that increasing levels of anthropomorphic robot movements would strengthen ingroup favouritism.

4.1 Procedure

The procedure (Section 3.4), task (Section 3.2) and cover story (Section 3.1) were identical to Experiment 1, with the exception that all participants, after completing the four-item questionnaire and irrespective of their responses, were told that they had been placed in the "robot group" (in contrast to Experiment 1 in which participants were randomly allocated to either the "computer group" or "robot group"). Furthermore, in contrast to Experiment 1, in which all participants experienced a robot with one level of movement (Section 3.3), participants were randomly allocated to one of three conditions (described below in Section 4.2).

4.2 Robot Movement

In Experiment 2, participants were randomly allocated to one of three movement conditions, namely:

1. The "no movement" condition, in which the Nao remained motionless (the robot's head was always facing the monitor and away from the participant);
2. The "gazing" condition, in which the Nao's only movement was turning its head to gaze at the participant when speaking to the participant;
3. The "gaze and movement" condition, in which the Nao used not only gaze, but also other movements such as head nodding (for agreement) or head shaking (for disagreement), a head tracking behaviour to simulate movement of the robot's camera to track a moving object, and use of the robot's arm to press the mouse button to initiate each shell game trial.

4.3 Experimental Design

Experiment 2 was a 3x2 mixed factorial design with "robot movement" as a between-subjects variable and shell game task difficulty (Medium and Hard) a within-subjects variable. The dependent variables were identical to those in Experiment 1 (Section 3.5.1).

4.4 Hypotheses

It was hypothesised that the "Hard" trials would result in a higher frequency of answer change than "Medium" trials. The second hypothesis was for each level of increasing humanlike movement, participants would change their answers with increasing frequency to the robot's suggested answer. Our third hypothesis predicted an increasingly positive response to be observed on the Godspeed questionnaire and proxemic measures in response to increasing levels of humanlike movement, i.e. a gazing robot will be rated more positively than a robot without movement, and a robot with gaze and other movements will be rated more positively than a robot whose only movement is gaze.

4.5 Participants

Forty-eight students from Western Sydney University participated in the experiment. Thirty-three participants were introductory psychology students who received course credit in exchange for their participation. Fifteen participants were recruited via advertisements placed on university noticeboards, and these participants received $15 for their participation. Participants were comprised of 36 females and 12 males, and the mean age was 22 (*SD* = 5.95). There were 17 participants in the "no movement" condition, 16 in the "gaze" condition, and 15 in the "gaze and movement" condition.

4.6 Experiment 2: Results

4.6.1 Participant Skill. Seven participants were removed from the dataset for scoring at near-chance levels (7 or less) on Easy trials. Four of these were in the "no movement" condition and

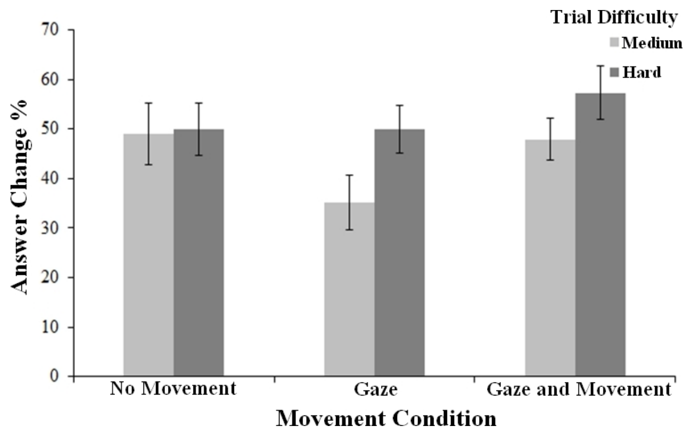

Figure 3. Experiment 2 results for the shell game. A significant main effect of task difficulty was observed, with participants more likely to choose the robot's suggested answer during Hard trials than Medium trials, F (1, 38) = 5.79, p = .021, η^2 = .13

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three were in the "gaze and movement" condition. With these outliers removed, the lowest score was 12, with a mean of 14.88 (SD = 1.12) and a median of 15. Thirteen participants remained in the "no movement" condition, 16 in the "gaze" condition, and 12 in the "gaze and movement" condition.

4.6.2 Trusting the Robot's Opinion. A 3x2 mixed measures ANOVA was performed with movement condition and task difficulty as independent variables and mean answer change rate as the dependent variable. Harder trials were hypothesised to increase answer change rate. A mean difference was observed with an answer change mean of .43 (SD = .21) for Medium trials and .52 (SD = .52) for Hard trials. This difference was statistically significant, $F(1, 38) = 5.79$, p = .021, η^2=.13, supporting the hypothesis. The second hypothesis, that greater levels of humanlike movement would increase frequency of answer change, was not supported F (2, 38) = 1.38, p = .263, η^2=.07.

4.6.3 Proxemics. It was hypothesised that participants who experienced a robot with "gaze and movement" would sit closest to the robot, with participants in the "no movement" condition sitting furthest away. Participants in the "gaze and movement" condition sat, on average, closest to the robot (M = 88.75, SD = 27.7), followed by the "gaze" condition (M = 90.5, SD = 16.65), while participants in the "no movement" condition sat the furthest away from the robot (M = 119.85, SD = 32.7). A Kruskal-Wallis nonparametric test produced a significant result, $\chi^2(2, N = 41) = 8.28$, p = .016, η^2 = .21. Using the Mann-Whitney test, three post hoc comparisons between pairwise means were conducted with a Bonferroni adjusted alpha of .0167. Only the "gaze and movement" and "no movement" conditions were significantly different from each other, z (N = 25) = 2.39, p = .0159, τ^2 = .23. There was little difference between the two conditions in which the Nao did move; however, the "no movement" and "gaze" comparison fell just outside the critical adjusted alpha, z (N = 29) = 2.35, p = .0172, τ^2 = .19.

4.6.4 Godspeed Questionnaire. No significant differences were found. However, there was a mean difference in the hypothesised direction for Anthropomorphism between the "no movement" (M = 13.15, SD = 3.31), "gaze" (M = 15.44, SD = 4.16) and "gaze and movement" (M = 15.83, SD = 1.85) conditions. This result fell just short of significance $\chi^2(2, N = 41) = 5.76$, p = .056.

4.7 Experiment 2: Discussion

Experiment 2 investigated the effect of an ingroup robot's movement upon trust, approach distance, and ratings of an ingroup humanoid robot. Our first hypothesis was that participants would trust the robot more often on Hard trials than Medium trials, and this was supported, replicating the results of Experiment 1 (this result will be discussed in more detail in the context of both experiments in Section 5).

The second hypothesis was that robot movement would have a positive impact upon trust, as measured by the frequency with which participants would change their original answer to the robot's suggested answer, with increasing levels of robot movement having an increasing impact upon trust. The second hypothesis was not supported. As per Experiment 1, a possible explanation for this result lies with the high attentional demands of the shell game task; as stated earlier, tasks with high cognitive load and attentional demands can lead to an over-reliance on automated information systems (Biros, Daly, & Gunsch, 2004). Thus, the main effect of task difficulty again may be superseding any effects related to robot movement. Another possible explanation concerns the nature of the robot's movement, as the Nao's precise, repeated movements may not be reflective of true human movements. Even though the Nao demonstrated a range of behaviours modelled on human behaviours, the robot's actions were identical on each trial and thus the robot's movement patterns became quickly predictable and "machine-like". People demonstrate variation in their movements (such as fidgeting and shifting posture) and the robot's repetition of the same behaviours over repeated trials could reinforce the impression of the Nao as a pre-programmed artificial construct, and therefore not a convincing humanlike ingroup partner. If similarity is the primary driving force behind anthropomorphism (Fink, 2012; Fong, Nourbakhsh, & Dautenhahn, 2003) then a robot that shows a variation in movements and a degree of randomness would be more similar to a human than a robot whose movements are set to a precise pattern. Replicating the present study with a Nao that only occasionally repeats movements, has variation between similar movements, or is able to change its posture and positioning as people would naturally, may increase anthropomorphic inferences and tangibly impact trust formation as the robot would appear to be more "humanlike".

The third hypothesis was that robot movement would generate a positive response, as measured by approach distance and the Godspeed questionnaire. The third hypothesis was supported for approach distance; participants who experienced a robot with "gaze and movement" would sit closest to the robot, with participants in the "no movement" condition sitting furthest away. Only the "gaze and movement" and "no movement" conditions were significantly different from each other, with no significant difference between "gaze" and the other conditions. These results suggest people expect humanoid robots to exhibit some degree of movement, as there was little difference between the conditions featuring movement, while participants who interacted with a motionless robot positioned themselves the furthest away. These findings suggest that a humanoid robot, simply through its familiar physical form, creates expectations of movement. This provides empirical support for the importance of "similarity" in generating positive human-robot interactions (Fong, Nourbakhsh, & Dautenhahn, 2003; Mori, MacDorman, & Kageki, 2012). With regards to the Godspeed questionnaire, the third hypothesis was not supported. However, there was a mean difference in the hypothesised direction for Anthropomorphism between the "no movement", "gaze", and "gaze and movement" conditions.

An unanswered question concerns the role of gaze. In Experiment 2, participants in the "no movement" condition experienced a robot with averted gaze, as opposed to the "gaze" and "gaze and movement" conditions. Previous research using the shell game paradigm has shown that gaze can have a negative impact upon trust for 'easy' trials in which the participant is confident of the correct answer (Stanton & Stevens, 2014), and as demonstrated by Fig. 3 (which displays mimimal impact of task difficulty on trust for the "no movement" averted gaze condition); a similar effect may be occurring in these experiments. Furthermore, averted gaze may be impacting upon proxemics, as the means for "gaze" (M = 90.5, SD = 16.7) and "gaze and movement" (M= 88.8, SD= 27.7) conditions were very similar in comparison to the "no movement" condition (M = 119.85, SD = 32.7), thus suggesting that gaze, and not movement, is the important factor in determining approach distance. To test this, future work could involve a movement condition in which the robot performed bodily movements but averted gaze.

5. Discussion and Conclusion

Both experiments failed to find any significant impacts of either group membership or robot movement on trust, as measured by the frequency with which participants changed their answers to the robot's suggested answer during the shell game task. A possible confounding factor influencing participant behaviour may have been the score updates provided to participants after each block of 12 trials (in both experiments). The score update, included to help participants remain focused and competitive, may have inadvertently offered participants the ability to 'test' the robot's task performance, comparing it with their own ability. For example, a participant could agree with the robot frequently in the first block, receive a score update, disagree frequently in the second block and compare their results. Participants who likely had never encountered a Nao before, may have been employing strategies to evaluate the robot's performance and inform their decision-making process that could have diminished any effect of group membership; indeed research suggests a robot's task performance is the primary determinant of trust in HRI (Hancock et al., 2011).

Another possible factor impacting trust is the "low-stakes" nature of the shell game task. Johansson-Stenman, Mahmud, and Martinsson (2005) demonstrated using a financial trust game that trust toward others decreases significantly as stake size increases. For participants playing the shell game, there was no significant financial, emotional or social cost to incorrectly trusting the robot. If doubt is present in the participant regarding the correct answer, then the Nao's suggestion may be sufficient to swing a response, regardless of group membership or the robot's movement. In this low-stakes context, answer change may even simply be a form of compliance, rather than trust. In future, a clearer picture of the relationship between group membership, robot movement, and trust could be gleamed through a replication of the shell game without score updates and by providing incentives to raise the stakes (for example, a financial reward for achieving a high score).

Proxemics produced differences in the hypothesised direction for both experiments; participants sat closer to the robot when they were an ingroup member and when the robot demonstrated human-like movements. Proxemics was an unobtrusive measure; at no point were participants made aware during the experiment that their physical proximity to the robot was being recorded, and because the experimenter left the room during this process, the experimenter was unable to give physical cues to a participant, providing a measure with strong internal validity. The results for proxemics for intergroup bias conform with existing human-human intergroup bias research (Dovidio, Hebl, Richeson, & Shelton, 2006; Ryen & Kahn, 1975), indicating that HRI is susceptible to social dynamics. The proxemic results of Experiment 2 provide empirical support for the importance of 'similarity' in generating positive human-robot interactions (Fong, Nourbakhsh, & Dautenhahn, 2003; Mori, MacDorman, & Kageki, 2012). Furthermore, Experiment 2 demonstrated that when these norms are violated by a motionless humanoid robot, participants will distance themselves further away from the robot. Note, however, that cultural factors can impact proxemics (Sorokowska, Sorokowski, Hilper, Cantarero, & Frackowiak, 2017), and the only demographic information collected from participants in this study was their age and gender.

Both experiments found significant main effects for task difficulty, with participants more likely to trust the robot as task difficulty increased. These results support previous findings that as cognitive load and attentional demands increase, people are more likely to rely on automated information systems (Biros, Daly, & Gunsch, 2004). Furthermore, other factors such as the low-stakes, low-risk nature of the task, and the participant's confidence in their own answer may be accentuating the impact of task difficulty (Parasuraman & Riley, 1997).

Finally, an important finding of this study was that participants, when told they were better suited to working with a robot than a desktop computer (Experiment 1), interacted differently with the robot, as demonstrated by closer interpersonal spacing between themselves and the robot. This result, a demonstration of greater comfort and willingness to interact with the robot, has implications for how to best introduce robots to people interacting with a robot for the first time, as simply telling a person they are well suited to working with a robot can induce positive attitudinal change.

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Authors names and contact information: Christopher Deligianis, Western Sydney University (WSU), Australia. Email: 17811297@student.uws.edu.au; Christopher Stanton, MARCS Institute, WSU, Australia. Email: c.stanton@westernsydney.edu.au; Craig McGarty, School of Psychology, WSU, Australia. Email: c.mcgarty@westernsydney.edu.au; Catherine J. Stevens, MARCS Institute, WSU, Australia. Email: kj.stevens@westernsydney.edu.au