Preferences and Perceptions of Robot Appearance and Embodiment in Human-Robot Interaction Trials.[1]

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Abstract. Outcomes are presented from experiments on the effect of participants' individual *preferences* for robot appearance and height on their preferences towards and perceptions of live robots. Participants who expressed a preference for a mechanical looking robot, tended to prefer all robot types to stay further away than those participants who expressed a preference for more humanoid robots. A majority group of two thirds (68.5%) preferred a robot which they personally perceived as having an extrovert and agreeable personality and a minority third (31.5%) preferred no strong robot personality factors. Humanoid robots also tended to be perceived as more intelligent than the mechanoid robots, but when combined with short height, were seen as less conscientious and more neurotic. The taller robots overall were also perceived as more human-like and conscientious than the short robots.

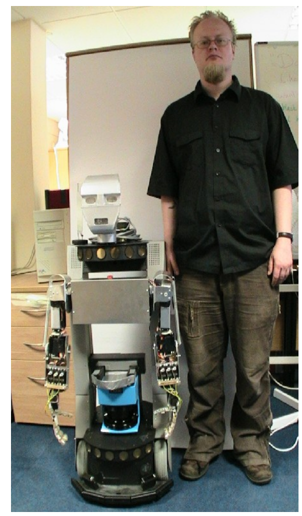
1 INTRODUCTION

Within domestic environments, most current robots have mainly been seen as toys with (often limited) entertainment functions. These robots have usually exhibited a relatively small number of interaction functions and usually outwear their welcome after a relatively short time. In recent years the ongoing development of robot technical capabilities has enabled them to perform some useful functions such as simple cleaning tasks (eg. the ROOMBA vacuum cleaning robot), lawn mowing and basic (remote) security monitoring. However, these limited tasks have been selected for initial domestic robot applications specifically because they actually require little interaction with humans. Domestic robots in particular will exhibit a social aspect in most, if not all, interactions with humans. This is likely to be quantitatively and qualitatively different to that exhibited towards other technical artefacts [1] due to the physical embodiment of robots. We argue that if robots are to become truly useful in a human centered domestic environment they must satisfy two main criteria (cf. Dautenhahn et al. [2] & Syrdal et al. [3]):

1. *It must be able to perform a range of useful tasks or functions.*
2. *It must carry tasks or functions in a manner that is socially acceptable, comfortable and effective for people it shares the environment with and interacts with.*

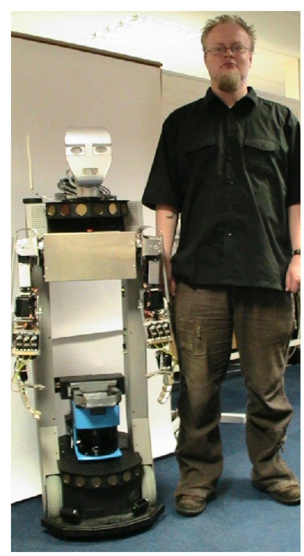
Although many Human-Robot Interactions (HRIs) necessarily involve speech, our research emphasis is on the physical, spatial, visual and audible *non-verbal* social aspects of robots which must interact socially with humans. See Fong et al. [4] for an overview of robots designed to interact with humans in a social way. Peoples' social perceptions of robots may be affected by a number of attributes exhibited by robots including aspects of both robot

Robot A



Robot B

Robot C



Robot D

Figure 1: The PeopleBotTM Robots used for the HRI Studies: A) Short Mechanical, B) Short Humanoid, C) Tall Mechanical and D) Tall Humanoid. +

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appearance and behaviour. With regard to robot appearances investigated here, we define Mechanoid and Humanoid robot appearances based on those for animated agents adopted by Gong & Nass [5] and of Android robots from MacDorman & Ishiguro [6]:

Mechanoid - relatively machine-like in appearance. In live and video based HRI trials described here, a robot described as mechanoid will have no overtly human-like features

Humanoid - a robot which is not realistically human-like in appearance and is readily perceived as a robot by human interactants. However, it will possess some human-like features, which are usually stylized, simplified or cartoon-like versions of the human equivalents, including some or all of the following: a head, facial features, eyes, ears, eyebrows, arms, hands, legs. It may have wheels for locomotion or use legs for walking.

Android - a robot which exhibits appearance (and behavior) which is as close to a real human appearance as technically possible.

Previously, both Khan [7] and Dautenhahn et al. [2] have found that people emphatically prefer domestic or service robots that are not realistically human-like in appearance. Therefore the robot appearances investigated here were limited to mechanoid and humanoid. Based on our previous experimental findings (cf. Woods et al. [8]) we speculated that the height of a robot may also affect peoples preferences. Therefore, peoples preferences and perceptions of robot height was also investigated in the current study.

1.1 BACKGROUND

Butler and Agar [9] explored the psychological effects of interactions between humans and mobile personal robots under conditions of different robot speeds, approach distances, and robot body design. Their experimental contexts included the robot approaching and avoiding a human, both while passing by and also performing non-interactive tasks in the same area as a human. Only direct, direct fast and indirect frontal approaches were considered. Two robot appearances were used; a tall humanoid robot (1.7m high with a simple head and arms) and a short mechanoid robot (0.35m high, cylindrical body), both with wheeled bases. Findings indicated that participants preferred closer (comfortable) approach distances by the short (0.35m) mechanoid robot than by the tall humanoid robot. Fast approaches (approx. 1m/s) by the tall humanoid robot in particular caused uncomfortable feelings in the human participants.

In previous human-robot comfortable approach distance experiments we have found most participants approached a mechanoid robot to distances that lie within the closer part of Hall's Personal Zone [10][11], reserved for conversation between friends (cf. Walters et al. [12],[13]). In another experiment (cf. Walters et al. [14]) we investigated comfortable human approach distances to a mechanoid robot which used four different voice styles. There were no significant differences found for comfortable approach distances for humans that had experienced a short previous interaction with a similar robot. However, non-habituated humans tended to approach a robot with a synthesized or female voice to further (comfortable) distances than to a robot with a male or no voice. A possible reason advanced for these initially greater approach distances were that they were due to slight initial uncertainty towards the robot, related to participants' initial expectations for robot appearance and robot voice style.

Our previous HRI proximity trials have also investigated robot to human approach distances for mechanoid (appearance) robots only. Others have investigated the effect of robot appearance on users' perceptions and expectations [15]. Minato et al. [16] and Goetz and Kiesler [17] have stressed the importance of consistency of robot appearance and behaviour with regard to forming and meeting humans expectations of appropriate social cues and technical capabilities. Lee & Kiesler [18] have found that people make very quick initial judgements of robots and their capabilities on very scant evidence or information, and particularly on robot appearance. Hinds et al. [19] also found that people treated machine-like robots in a more subordinate manner than more human-like robots. Walters et al. [20] found that people tended to rate particular robot behaviours or features less favourably when they are not perceived as consistent with the overall appearance of the robot

2 RESEARCH OBJECTIVES

The current study was performed as part of a larger series of HRI trials which took place in the University of Hertfordshire “Robot House”. The HRI trial series ran over five weeks with the main purpose of investigating how a group of long term participants' preferences and responses towards robots changed over that period. The main instrument to assess participants over the period was a controlled set of experiments which measured participants' ratings, responses and comfortable approach distance preferences towards a personal companion robot under a number of experimental conditions. The conditions which were controlled were robot appearance, robot height, task context, notions and perceptions of robot autonomy, and approach direction. A long term group had their responses and preferences tracked over five week period of habituation with the controlled set of trials repeated during the first, second and fifth week of the trial period. A greater number of short term participants underwent a controlled test series initially to establish a firm statistical baseline for comparison with the repeated test observations from the long term participants.

This paper presents outcomes specifically with regard to robot appearance and robot height preferences. Some aspects of the trials outcomes have been reported in Syrdal et al. [21] where findings indicate differences in approach direction preferences based on gender, that participants’ personality traits of extroversion and conscientiousness are associated with closer robot approach distance preference ratings, and differing perceptions and preferences for robot autonomy. Koay et al. [22] found that that preference ratings for robot approach direction and robot appearance changed over time. Participants who became accustomed to the robot tended to prefer to be more ‘in control’ of the situation - in that they appreciated reduced robot autonomy in case of unexpected events. The part of the trials, running between the second and fourth weeks, primarily to habituate the long term participants to the robots, also provided an opportunity to carry out a number of more exploratory experiments into different aspects of human and robot co-habituation. The results and data from this series of HRI mini-trials in weeks 2 to 4 of the trial series is currently being analysed and will be reported elsewhere. In order to investigate which of height, appearance or both factors influenced participants' preferences, ratings of robot behaviour and comfortable approach distances, a 2x2 combination of Tall/Short and Mechanoid/Humanoid robots were used in the trials (see Figure 1). Trial participants experienced interactions with just one out of the four possible robot appearance/height combinations (types). All participants completed post trial questionnaires where they were asked for their preferences and opinions with regard to all four possible robot appearances, height and their suitability for various tasks. For this study we advanced three hypothesis for testing:

1. *Participants' **preferences** for a tall or short robot will affect their robot to human proxemic distances*
2. *Participants' **preferences** for a mechanoid or humanoid robot appearance will affect their robot to human proxemic distances.*
3. *Participants will have a general overall preference for one (subjectively) optimal combination of robot appearance and height, based on their **perception** of robot personality factors and attributes.*

The responses to the post trial questionnaires are the main instruments of this study. The main aim was to investigate Mori's [23][24] observation that increasing the human-likeness of robots (but not to the extent that the "uncanny valley"repulsive effect was invoked) would improve users' interaction experience and effectiveness (cf. Goetz & Kiesler [17] and Minato et al. [16]). As none of the robots used in the study were particularly human-like in appearance, it was expected that the participants would generally prefer one of the more "humanoid" appearance robots. The robot height condition was incorporated in the HRI trials to investigate the notion that a shorter robot would be less intimidating and would therefore be allowed to approach closer than a taller robot. The findings for these trials reported previously in Syrdal et al. [21] indicated a general effect for mechanoid/humanoid robot appearance, whereby participants overall allowed a mechanoid appearance robot to approach more closely than the humanoid appearance robots. These findings also indicated that there were only significant differences in approach distance related to robot appearance, but not robot height. It was anticipated therefore, that robot appearance preferences may have effects on participants' preferred robot approach distances, but their *preferences* for robot height would have none.

3 EXPERIMENTAL METHOD

The HRI trials took place in a standard UK two bedroom rented apartment in order to provide a more ecologically valid setting. This "Robot house" has been used in our previous HRI trials (cf. Dautenhahn et al. [25], Woods et al. [8] and Koay et al. [26]). The territory of the trial is more neutral, home-like and realistic than a simulated environment in a laboratory or institutional setting. It was shown that this encourages participants to feel more at home and less scrutinized or judged, and thus more relaxed.

Twenty four Short Term participants carried out the controlled approach trials once only on a first exposure basis. The 12 Long Term participants carried out the controlled approach trials three times over the five weeks of the HRI trial series. The participants' ages ranged from 21 to 40. They were staff or students from various University of Hertfordshire departments, including Computer Science, Engineering, Psychology, Astronomy and Business Studies and not part of the HRI research team. The final questionnaire response data, which is the focus of this study was gained from participants only after all their live HRI trials were completed. In the case of the long term trial participants, this was after five weeks of exposure to the robot. As their responses will have been affected by the extended exposure, the data from the long term and short term groups of participants are considered separately and differences and comparisons are made between them where appropriate. The participants were drawn from the University population and were mainly postgraduate students, one academic staff member and one undergraduate student. Their ages ranged from 21 to 50 and there were 16 males, 9 females in the short term group, and 8 males, 4 females in the long term group. Participants were paid a modest compensation.

Four robot types were used for the HRI trials and differed only in the combination of the two controlled factors. The robots were carefully designed (using commercially available PeopleBots™ robots as a common robot platform) to be the same in appearance and behaviour apart from the appearance and height factors.

Note, none of the robots used were particularly human-like in appearance. The terms "humanoid" and "mechanoid"are simply used here as labels as a shorthand to distinguish easily the main design features of the four robots (cf. Section 1).

Robot A was 1.2m tall and mechanical looking ("Short Mechanoid"), B was 1.2m tall and had a simple metallic head and two metallic human-like arms ("Short Humanoid"). C and D were both 1.4m tall, with C having mechanical features ("Tall Mechanoid") and D the same human-like features as B ("Tall Humanoid"). The terms "mechanoid" and "humanoid" were **not** used when talking to participants in the HRI trials or in questionnaires; The robots were simply referred to as Robots A, B, C or D (see Figure 1). All participants underwent the same controlled experiment with only one of the four robots types. The robot type actually used was assigned to each participant in sequence, so that approximately the same numbers experienced each robot type. (N=33; A, n=8; B, n=8; C, n=8; D, n=9), The participants used a Comfort Level Device (CLD, cf. Koay et al. [27]) to signal when the robot had approached to a distance which they found comfortable for each trial run, which was recorded from the robot's laser range sensor. The CLD was developed by the team especially to provide a means for participants to indicate uncomfortable situations by means of pressing a button on a wireless device which could be used to directly control the robot or log data as required. If a participant did not operate the CLD, the closest approach distance of the robot was recorded for the particular trial run.

To explore how the level of robot autonomy affected their comfortable approach distances, the CLD had two modes of operation which corresponded to the conditions Human in Control (HiC) and Robot in Control (RiC). Under the HiC condition, a press of the CLD button caused the robot to stop advancing towards the participants. Under the RiC condition, a press of the CLD button did not affect the robot's advance, and it carried on until the robot pre-programmed safety distance was triggered. In both cases the robot recorded the actual distance to the human, using the robot's internal laser range sensing system, when the CLD button was pressed. For each of the two robot autonomy conditions, three different task *context* conditions were studied: *No Interaction* - where the robot approached participants only incidentally while carrying out a task not involving the human. *Verbal Interaction* - where the robot approached participants in order to speak commands to the robot. *Physical Interaction* - where the robot approached the human for a joint task which required physical contact with the human. For each of the Interaction conditions, approaches were made from the front direct, and from the front right side quarter. These two approach directions (front and front side) were identified as most relevant in previous HRI trials (cf. Woods et al. [28] & [8]). Table 1 shows the experimental condition matrix of 2 (Autonomy) x 3 (Interaction Contexts) x 2 (approach Directions).

The main *relevant* findings of these HRI trials are briefly summarized here. Significant effects on comfortable approach distance were found for live robot appearance, but none for robot height. In general, people preferred the humanoid appearance robots (B and D) to keep a further distance away than the mechanical robots (A and C). Participants who rated highly on the Extroversion personality factor were associated with closer approach distance preferences than more introverted individuals, who preferred larger approach distances. In this previous analysis on the live HRI trial data, Syrdal et al. [29] found significant differences in comfortable approach distances for the Interaction context conditions, specifically between the Physical and Verbal Interactions, and the Physical and No Interaction contexts. For the purposes of the present study, a mean comfortable approach distances was aggregated for each participant over all their individual comfortable approach distances for all the experimental conditions. Post trial questionnaires were administered to participants and contained questions relating to participants' overall opinions, perceptions and preferences with regard to all four robot types from static photographs (Figure 1.). The four

Robot Autonomy	**Interaction Context (P, V, and N) x Approach Direction (Front, Front Right)**		
	Physical	**Verbal**	**None**
Robot in Control (RiC)	Front Front Right	Front Front Right	Front Front Right
Human in Control (HiC)	Front Front Right	Front Front Right	Front Front Right

Table 1: The controlled experimental conditions for comfortable approach distance studies

robot types (A, B, C or D) shown also included the one robot type which they had previously encountered in their live trials. The questions considered here were in two groups:

1. ***Personal preference choices as to most and least liked robot types.***
2. ***Subjective ratings of perceived attributes of the four robot types. This included ratings of robot personality factors (Big Five [30]), human-likeness and intelligence.***

The questions required the participants to respond in two possible ways.

Overall preference - a multiple choice selection response was presented (E.g. : "Which was your most preferred robot? Choose answer from: A, B , C or D:"). These nominal answers were used as grouping factors for a GLM (General Linear Model) Univariate ANOVA for significant differences between groups for mean comfortable approach distances (scale data).

Quantitative ordinal ratings - Used a five point Likert scale to obtain ratings (E.g. "How much did you like robot A?" Response from: 1 = Not at all, 2 = Not much, 3 = Neutral, 4 = A bit, 5 = A lot). These were compared with each other by non-parametric tests to obtain significant differences and correlations. Friedman ANOVA tests were used to test for significant differences between Likert [30] scale answers and Spearman Rho tests for significant correlations. Details of the particular questions relevant to this study are given in the appropriate part of the results section below:

4 RESULTS

4.1 MOST PREFERRED ROBOT TYPE

Although most of the 24 short term (single exposure) participants preferred either the tall humanoid (Robot D, n=7, 36.8%) and short mechanoid robot types (Robot A, n=6, 31.6%), with smaller minorities preferring C (n =4, 21.1%) and B (n = 2, 10.5%). However, these numbers were not statistically significant ($\chi^2 = 3.105$, df = 3, $p = 0.376$). The 12 long term participants, who had experienced five weeks of habituation before completing the questionnaires, showed similar proportions with robot D (n = 5, 42%) most preferred, with A and B (n = 3, 25%) joint second and C (n = 1, 8%), but again these were not statistically significant ($\chi^2 = 4.484$, df = 3, $p = 0.214$). See Figure 2 for details.

Chi-square tests on the participants' preferred robot height ($\chi^2 = 0.290$, df =1, $p = 0.590$) and appearance ($\chi^2 = 0.290$, df =1, $p=0.590$) also indicated no overall significance. It must be therefore assumed that the reasons for a particular robot type (A, B, C or D) being preferred was based on participants' individual or internal preference factors.

Non-parametric tests also indicated there were no correlations (Spearman's Rho < 0.497, $p > 0.190$) between the robot types which short-term participants encountered in their HRI trials and their preferred robot types. No long term participant experienced actual interaction with their preferred robot type so similar tests could not be performed for this group. It seems therefore, that

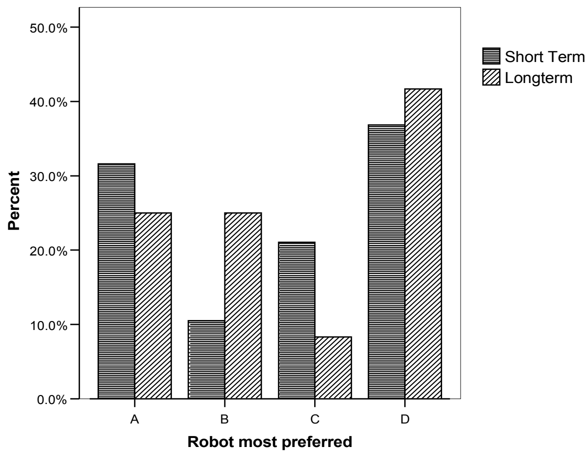

Figure 2: Robot types most preferred by first exposure (short term) and long term exposure participants. Robot A = Short Mechanoid, B = Short Humanoid, C = Tall mechanoid and D = Tall Humanoid

previous trial exposure to a particular robot type did not affect participants' preference for a particular robot type in any direct ways. Alternatively, participants might have chosen an appearance other than the one they encountered in live long-term studies since they might have hoped for a better performance of a 'new robot companion'. Given the current data, this explanation cannot be ruled out and requires further investigation. Note, ideally all long-term participants would have encountered twice a week each of the 4 robot types, but this was not possible for logistical reasons (i.e. entailing 96 HRI trials per week).

4.2 ROBOT TYPE PREFERENCES AND COMFORTABLE APPROACH DISTANCES

The four robots used for the live HRI trial runs, and in the still images shown to participants for the final questionnaires, were identical apart from the two factors of appearance and height. These factors were used as grouping factors for GLM (General Linear Model) Univariate ANOVA tests which examined the effects of participants' preferences on their comfortable approach distances from the live HRI trials with an actual robot. Syrdal et al. [29] found previously that the participants overall allowed the mechanoid robots to approach more closely than the humanoid robots. It was hypothesized that participants' preferences for robot appearance and height would also have an effect on comfortable robot approach distances overall (by any robot). The short term participants were considered separately from the long term sample, as the longer exposure of the long term sample to a particular robot may have caused systematic differences between the two sample sets. Table 2 summarizes the results obtained. The equivalent results for the long term participants are not directly comparable due to the smaller participant base and the repeated exposures to the robot over the five week period, but are given in Table 3. It can be seen that, as reported in Syrdal et al. [29] previously, the (live HRI trial) interacting robot's appearance has a significant effect on participants' approach distance preferences. When live robots are encountered, overall the participants preferred the humanoid robots to remain at further approach distances (mean = 0.645m, SD = 20.43) than the mechanoid robots (mean = 0.490m, SD = 20.43). The height of the live interacting robot had no significant effect.

However, for the short-term participants, there are significant effects related to their stated *preferences* for robots, both for preferred robot appearance ($p = 0.044$) and preferred robot height ($p = 0.003$), with the live interacting robot approach distances. There is also a significant interaction effect between most preferred robot appearance and actual robot appearance ($p = 0.002$). Participants who expressed a preference for humanoid and/or short robots, generally tolerated closer approaches by whichever robot they actually interacted with in the live HRI trials. In fact, the effect of the *preferred* height factor (variance = 31.5% of total) of the robot is slightly greater than that for the actual appearance of the interacting robot (variance = 25.5% of total). See Table 3 for a summary of these results.

The same UNANOVA with respect to the long-term participants must be treated with more caution (Table 3) due to the smaller sample set and the very different HRI trial and habituation procedures experienced. However, some broadly similar general trends can be tentatively identified. Although actual robot appearance is the only factor which is actually significant ($p = 0.038$), it can be seen proxemic effects related to preferred robot appearance and preferred robot height are both approaching significance at $p < 0.1$, and due to the small sample size (12) cannot be discounted as a possible real effect.

4.3 PARTICIPANT RATINGS OF ROBOT ATTRIBUTES AND PERSONALITY

The post trial questionnaires also asked participants to rate attributes of each of the robot types using five point Likert scales. Each robot was rated for degree of liking or disliking (Figure 3), and for attributes based on personality factors from the big five personality model, used commonly to rate human (cf. Goldberg

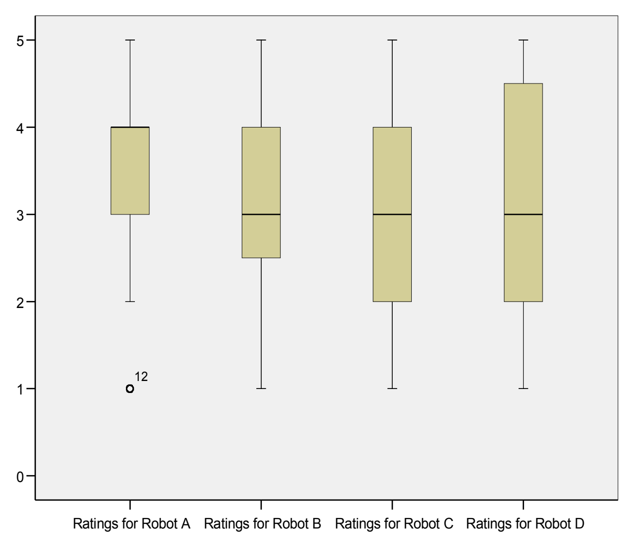

Figure 3: Mean participants' ratings of robot types (A, B, C, and D) on a five point Likert Scale (1 = Like not at all , 5 = Like very much).

[31]) and robot personality (cf. Syrdal et al. [21]). These factors were Extroversion, Agreeableness, Conscientiousness, Neurotism and Intelligence. An additional rating for perceived human-likeness of each robot type was included. The ratings for personality factors and human-likeness were tested using Spearman's Rho non-parametric tests for significant correlations with the overall participants' liking ratings for each robot type. These findings are discussed in detail below:

4.3.1 Overall Ratings of Robot.

Spearman's Rho tests found significant positive correlations between liking robot A and liking robot C (r = .532, p=.002), also between liking robot B and liking D (r = .609, p<.001). There was also a negative correlation between a liking for robot A and a disliking of robot D (r = -.392, p = .018). The common factor to these correlations is robot appearance. Individuals tend to like both the robots (B and D) with humanoid appearance, or like both the robots with mechanoid appearance (A and C). There were no significant correlations between the robot overall ratings and robot height, indicating that robot height did not have a major effect on participants' preferences for a particular robot type.

Factor	**Mean Square**	**Variance (%)**	**df**	**F**	**Sig.**
Most Preferred Robot Appearance	18365	8.5%	1	5.720	**0.044**
Most Preferred Robot Height	67832	31.5%	1	21.129	**0.002**
Live HRI Robot Appearance	54833	25.5%	1	17.080	**0.003**
Live HRI Robot Height	3799	1.7%	1	1.183	0.308
Most Preferred Robot Appearance + Live HRI Robot Appearance	69602	32.3%	1	21.680	**0.002**
Total Variance	215208	(99.5%)	11		

Table 2: GLM UANOVA test results for between subjects effects of *Short-Term* participants' preferences for robot appearance and height factors on comfortable robot approach distances.

Factor	**Mean Square**	**Variance (%)**	**df**	**F**	**Sig.**
Most Preferred Robot Appearance	8564	20%	1	15.418	0.059
Most Preferred Robot Height	6896	16.1%	1	12.415	0.072
Live HRI Robot Appearance	13713	32%	1	24.689	**0.038**
Live HRI Robot Height	1638	3.8%	1	2.950	0.228
Total Variance	42867	(79.1%)	11		

Table 3: GLM UANOVA test results for between subjects effects of *Long-Term* participants' preferences for robot appearance and height factors on comfortable robot approach distances.

4.3.2 Participants' Perceptions of Robot Types.

Robot A: Participants who liked short mechanoid robot A rated it as relaxed and contented (low neurotism) (r = -.445, p = .014) and also preferred mechanoid robot appearance (r = .517, p = .043).

Robot B: Participants who liked short humanoid robot B, preferred a humanoid robot appearance, perceived both humanoid robots B (r = -.420, p = .021) and D (r = -.517, p = .003,) as more extrovert, and perceived mechanoid robot A (r = .445, p = . 001) as less extrovert. They tended to rate both humanoid robots B (r = -.552, p = .002) and D (r = -.364, p = .048) as more agreeable, and tall mechanoid robot C (r = .508, p = .004) as less agreeable. They also rated short mechanoid robot B as being more intelligent and (surprisingly!) rated tall mechanoid robot C as more human-like (r = -.382, p = .037).

Robot C: Participants who liked mechanoid robot C, tended to perceive both mechanoid robots A (r = -.390, p = .033) and C (r = -606, p < .001) as more extrovert, robot C as more agreeable (r = -.398, p = .029) and low in neurotism (r = -.443, p = .014).

Robot D: Participants who liked tall humanoid robot D, especially preferred humanoid robots overall (r = .678, p < .001), saw robot D as more extrovert (r = -.605, p < .001), agreeable (r = -.393, p = .032), conscientious (r = -.433, p = .017), intelligent (r = -.513, p = .004) and human-like (r = -.449, p = .013). They also perceived mechanoid robot C as less agreeable (r = .589, p = .001) and humanoid robot B as more intelligent (r = -.430, p = .018), but did not rate B significantly for extroversion, agreeableness and conscientiousness.

Robot Height Overall: There were significant correlations for robot height preferences for the humanoid robots B (r =.367, p = .046) and D (r = -378, p = .040) which suggested that the taller humanoid robot was seen as conscientious, whereas the shorter humanoid robot B was rated as less conscientious.

Summary: It seems that most participants (68.5%) tended to perceive their preferred robot (B, C, and D) as having both extrovert and agreeable personalities. The minority of participants who preferred robot A (31.5%) seem to have perceived it as particularly lacking in any strong personality factors, apart from being relaxed and content (low neurotism personality factor rating). Participants who tended to prefer the more humanoid appearance robots, B and D (56.8%), seem to appreciate the generally stronger personality and intelligence factors which they are perceived as exhibiting. Robot D in particular also seems to be perceived as being more human-like, more conscientious and less stressful (low in neuroticism) than the shorter humanoid robot B.

5 DISCUSSION AND CONCLUSIONS

We have shown that peoples *preferences* for robot appearance and height are powerful indicators as to their likely responses to actual robots overall. This has implications for designers of domestic robots, as it implies that people who choose taller or humanoid type robots for their own domestic use, will tend to prefer closer approaches than those who choose a smaller mechanoid type robot design. These findings also suggest that a smaller more mechanoid robot appearance, with correspondingly less close approaches may be more acceptable for robots which must act within a public area. Although less obtrusive robots may be not be actively preferred by a majority of people, they may however be perceived as potentially less annoying or unsettling, and thus more acceptable by most people.

Although the tall humanoid robot was preferred overall, there was no significant overall preference for any particular one of the four robot types. Also, there was no overall preference for either of the factors for appearance (humanoid or mechanoid) or height (short or tall). There was some general tendencies for participants to prefer either the tall humanoid robot or the short mechanoid robot for both short and long term participants. It seems that individual participants had definite personal preferences, mainly based on their individual perceptions of the robot types however. These individual perceptions can be categorized into two main groups, a majority of roughly two thirds (68.5%) who preferred a robot which they personally perceived as having an extrovert and agreeable personality (primarily robot types B, C and D), and a minority third (31.5%) who actually preferred a small robot with no strongly perceived robot personality factors (robot type A). One might consider that robot type A may have been preferred by those participants who just wanted an unobtrusive, emotionally undemanding servant or smart machine. Syrdal et al. [21] found a possible relationship between peoples personalities and their preferences. More introverted individuals tended to prefer mechanoid robot appearance and extroverts prefered more humanoid robots. This suggests that peoples' preferences for robot appearance and behaviour may also be related to aspects of their personalities. However, more specific focussed research would be needed to confirm and investigate this aspect further.

The humanoid robots (B and D) also tended to be perceived as more intelligent with richer personalities than the mechanoid robots. However, When humanoid appearance was combined with short height (B), the robot also tended to be perceived as less conscientious and more neurotic. Interestingly, these are traits that are typical of human children and therefore possibly it may have been perceived as requiring more close attention and supervision, and be less responsible. The tall robots (even mechanoid robot C) overall also tended to be perceived overall as more human-like and conscientious than the short robots. It may be that the participants perceived the small stature of the humanoid robot as more childlike, while seeing the taller humanoid as more adult. Therefore the overall popularity of the tall humanoid robot D may be due to the participants' perceptions that it looked like it could actually carry out tasks responsibly and cheerfully. The low overall preference rating of short humanoid robot B may be due to participants perception that it may be childlike and would therefore not be capable of carrying out useful work effectively.

The tall mechanoid robot C was rated by some participants as human-like, and it may have been most preferred by some participants as they personally perceived it as exhibiting extrovert and agreeable personality factors.

The suggested explanations we have provided above regarding people's choices and preferences need to be investigated further in future work. These results have provided some insights into how humans perceive and rate robots on initial acquaintance. More data from this study still awaits analysis. How participants own personality factors influences their preferences and perceptions of the four robots, and analysis of the participants views on task domains, capabilities and suitabilities of the four robots are left for presentation in future papers.

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