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Attitudes towards robots suitability for various jobs as affected robot appearance

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An opinion survey of 878 college students examined attitudes about the suitability of robots for various occupations in society and how these attitudes varied by the robots' appearance. Factor analyses revealed three primary attitudes: Robot-Liking, Robotphobia and Cyber-Dystopianism, and three occupational niches: social-companionship, surveillance and personal assistants. Attitudes varied depending on subjects' gender, religion, perceived competence with technologies and engagement with virtual reality environments and avatars. The analysis of relationships between subjects' attitudes and perception of suitable occupations indicated that Robot-Liking is positively related with social companionship and surveillance occupations, whereas Robotphobia is negatively correlated with the three occupational niches.

Keywords: social robots; attitudes to technology; survey

1. Introduction

Robots have been rapidly proliferating in military and industrial settings and are even appearing in domestic ones. The 2010 annual report of World Robotics found that the number of units sold worldwide almost doubled in that year, most notably in the areas of security, medicine, domestic and mobile robot platforms (IFR Statistical Department 2010). The rapid growth in the use of robots in numerous settings confirms the idea that we are moving towards an era in which 'socially intelligent robots' are entering the realm of human social life, sharing living environments with people, communicating emotionally with them and even learning what people consider right and wrong (Zhao 2006). Robotics researchers are constantly devising new functions for these social machines in diverse areas such as helping the elderly (Heerink *et al.* 2008), therapists for autistic children (Dautenhahn and Billard 2002), home cleaners (Sung *et al.* 2008), museum receptionists (Shiomi *et al.* 2006) and peer tutors in schools (Tanaka *et al.* 2006). However, although robots are becoming increasingly integrated in society, research is unclear as to whether they are creating a comfortable and productive experience for people (Goetz *et al.* 2003).

This paper aims to contribute to a deeper understanding of people's perceptions about robots by analysing how several factors at the individual level affects users' responsiveness to robots appearance and their acceptance to fulfil certain functions and jobs in society. For this purpose, we present an empirical study intended to measure individual's attitudes and emotions towards robot's appearance, and the impact these assumptions may have on occupations for which robots are believed to be qualified based on the following research questions:

- RQ1: For individuals, controlling for robots' appearance, what is the relationship between gender, religiosity, and perceived competence with communication technologies, engagement with virtual reality environments, avatars and attitudes towards robots?
- RQ2: For individuals, controlling for types of robots, what is the relationship between attitudes towards robots and the occupations for which robots are believed to be qualified?

2. Literature review

The concept of 'attitude' is one of the central themes in social psychology. The assumption underlying this centrality is that the development of positive attitudes produces a corresponding change in behaviour (Fazio *et al.* 1989). Commonly viewed as the weighted sum of a series of evaluative beliefs about an object or situation (Ajzen and Fishbein 1980), research suggests that people usually use compensatory attribute based strategies (*e.g.* averaging or additive rules) to make decisions, which make attitudes an indispensable construct for understanding and predicting human judgement and decision-making (Schuman and Johnson 1976). One of the first scholars to study attitudes towards robotic-like communicators was Nass. He and his

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colleagues developed a series of experimental studies to test whether individuals apply social rules and expectations to robot-like technological embodiments. They found that human-like characteristics (*e.g.* facial expressions, voice and emotions) act as cues that lead a person to place the technology agent into the category 'human', changing their attitude and perceptions, and eliciting social responses towards the agent (Reeves and Nass 1996). In different studies, Nass concluded that participants consistently overused human social categories, such as gender and ethnicity, by applying them when referring to computers and many other electronic artifacts (For a review see Nass and Moon 2000).

In similar experiments, Friedman and Millet (1995) explored whether people believed that computer systems could be considered morally accountable for harming humans. They found that more than 80% of participants attributed aspects of agency to computers, and 20% considered machines morally responsible if cancer patients were over-radiated by a computer in error. Although these results corroborate the idea that people interact with computer applications as if they were social agents as demonstrated by Nass and his colleagues, Friedman and Millet's findings went far beyond this, showing for first time how people attributed to technology mental states and even moral standing. Regarding robots, Melson *et al.* (2005) investigated the interactions of children with the Sony's robotic dog AIBO and they found that a surprising majority of children affirmed that AIBO had mental states (56%) and moral standing (76%). Similarly, research by Friedman *et al.* (2003) analysed conversations in the AIBO's online discussion forums, and 47% of the participants spoke about AIBO's biological essences; 42% spoke of AIBO as having intentional behaviour, emphasising the presence of mental life; 38% of the commentators believed AIBO had feelings, and most unexpectedly 39% spoke of AIBO as being capable of being raised, developing and maturing. From these studies, it could be argued that as robots become increasingly integrated in society, people treat them as if they were sentient, social and moral beings, raising robots towards the level of biological others.

Scholars have also explored peoples' opinions towards the possibility of having robots in the job market or working at home. Contrasting preferences with positions occupied by humans, Takayama *et al.* (2008) found that robots were preferred for jobs that required memorisation, keen perceptual skills and service-orientation, whereas the humans were preferred for occupations that required artistry, evaluation, judgement and diplomacy. Regarding the inclination for having robots working at home, Dautenhahn *et al.* (2005) found that people in general prefer having robots vacuuming and doing other roles traditionally associated with a household assistant, while only a small minority prefer robots as assistants for child-care duties, marking a clear division between roles which are considered within the 'human domain' and more impersonal oriented. More specifically, several studies have shown that people systematically prefer robots for occupations when the robot's human-likeness matched the sociability required in those jobs: whereas playful agents are preferred as fellow gamers or dance instructors, more serious-looking robots are preferred for health-related professions (Goetz *et al.* 2003). These scholars explain these differences based on the 'degree' of human-like personality perceived in robots.

2.1. Anthropomorphism and human-like personality

Research has consistently shown that the use of anthropomorphic pronouns makes human partners more likely to treat humanoid social robots as a real person (Dautenhahn and Billard 2002, Fong *et al.* 2002, Duffy 2003). When autonomous robots, for instance, are capable of natural language interactions and can demonstrate self-directed behaviours, human observers have a strong tendency to attribute human-like qualities since these robots invoke social-psychological processes able to affect human behaviour in ways similar as would the presence of a companion (Schermerhorn *et al.* 2008). Similarly, it has been argued that the judgements of moral accountability increasingly come into play as such systems take on sophisticated humanoid forms (Friedman and Millett 1995). These studies suggest that robots, to be considered effective assistants, should exhibit naturalistic behaviour and appropriate emotions. Since previous studies have shown that the use of more anthropomorphic robots makes human partners more likely to treat them as real people, it is expected that:

- H1a: Subjects exposed to a humanoid designed robot will believe that robots have more human qualities (*e.g.* rights and emotions) than more Android-oriented designs.
- H1b: The humanoid robot will elicit more positive attitudes than Android or pet-like designs, affecting positively their acceptance to fulfil social-oriented jobs.

2.2. Cultural and demographic differences

Research has also identified demographic and cultural differences as predictors of subjects' attitudes towards robots. Scopelliti *et al.* (2004) found that young people have positive feelings towards domestic robots, while adults and elderly are in general more reluctant to have a robot at home. Shibata *et al.* (2003) studied in several countries people's evaluations of Paro, a seal-type robot, and the results showed that participants' opinions differed significantly according to their nationality. The authors explained the results by highlighting the influence that culture has in individuals' perception towards robots and how popular narratives impact people's willingness to interact with robots in real life. In Japan, the authors assert that robots are portrayed in a positive manner and numerous cartoons, such as Astro Boy and Doraemon, depict robots as friendly characters

whereas in Europe and the US robots are often presented as enemies humans. Similarly, it has been theorised that spirituality may also influence people's perception to robots. In the Judeo-Christian tradition, in contrast to other religious and philosophical traditions such as Taoism and Buddhism, a clear division is made between living and dead entities (Woods *et al.* 2007). The Judeo-Christian world enforces a strict division between creatures that have a soul and objects that do not, which is not the case for the Shinto religion in Japanese society and more liberal philosophies in which all things can be deemed as alive and having a soul (Shaw-Garlock 2009). Consequently, since Eastern individuals may see robots with the capability of moral equivalence with humans, whereas in the Judeo-Christian world social robots remain non-human and individuals may perceive them as incapable of ever assuming a 'biological' position (Calverley 2006), it may be expected:

- H2a: Individuals who profess Judeo-Christian religions will show less positive attitudes to robots than individuals who profess Eastern religions.
- H2b: Individuals who profess Judeo-Christian religions and show higher levels of religiosity will have less positive attitudes towards robots than less religious individuals.

Regarding gender differences, Schermerhorn *et al.* (2008) found that males tend to think of robots as more human-like, showing more socially desirable answers in their responses on a survey administered by a robot. In contrast, females saw robots as more machine-like and exhibited less socially desirable answers to the robot's survey. Nomura and colleagues conducted different experiments to investigate relationships between attitudes and anxiety towards robots, and consistently found that female respondents had more pronounced negative attitudes towards situations of interaction with robots than male respondents (Nomura *et al.* 2006, 2009). This implies that attitudes towards robots may be affected by gender, which is also consistent with research in Human Computer Interaction, which has shown that computer anxiety levels are associated with gender differences (Hirata 1990 cited Namura *et al.* 2006). Others instead argue that female' less positive attitudes towards technology are only due to differential experience with technology (Durndell *et al.* 1995, Shashaani 1997, Young 2000, Milto *et al.* 2002). Chen (1986), for example, found that although men in general hold more positive attitudes to computers and have lower anxiety than women, controlling for computer experience these differences disappear. Levin and Gordon (1989) also concluded that females have less positive attitudes towards computers than males, but they suggest that prior computer exposure, such as having a computer at home, has a stronger influence on attitudes than does gender. Consequently, since males are generally more exposed to technology and have more experience with robots, and females have traditionally shown more negative attitudes interacting with robots, we argue that:

- H2c: Female respondents will show less positive attitudes towards robots than male respondents.

2.3. Technology-oriented differences

Research has also noted that previous experiences with technology and robots may influence attitudes and behaviours towards them. In a simulated scenario with a humanised robot of mechanical appearance, Woods *et al.* (2007) found people with a technological background associated their own personality traits to the robots than participants with a non-technology-related background who in fact could not view the robot as having a clearly identifiable personality. Similarly, Nomura *et al.* (2006) conducted several experiments where subjects interacted with Robovie, a social robot, and concluded that previous experiences with robots can affect psychological factors, reducing uncertainty and anxiety towards robots, influencing their interaction positively. Similarly, Bartneck *et al.* (2005) developed a cross-cultural study and concluded that Americans were less negative towards robots than Mexican participants since they are more accustom not. This implies that attitudes towards robots may depend on previous experiences, which is also consistent with classical studies of attitude change. Therefore, it may also be expected that:

- H3a: Respondents with a high sense of competence and comfort using information and communication technologies (ICT) will show a more positive attitude towards robots.

On the other hand, in today's digital society, where a growing amount of human activities relies on the incorporation of virtual characters into virtual and augmented reality environments (Holz *et al.* 2009), ever more companies and organisations are using avatars to increase consumer interaction, support students in learning environments (Chittaro *et al.* 2003) and engage users with more personalised services (Belisle and Bodur 2010). In fact, there is a growing body of research on how the use of virtual self-representations affects many factors both within virtual environments and outside of them (Ratan and Hasler 2010). Moreover, similar to Nass and his colleagues, research has found that many of the rules that subjects apply to human–human interaction, are also brought over to human–agent interaction (Pertaub *et al.* 2002). This is why research has hypothesised that despite technical differences between dealing with robotic and virtual domains, today a many issues behind the construction of successful social agents cross the boundaries of virtual agent species as well (Holz *et al.* 2009). Therefore, it is predicted:

- H3b: Respondents who have interacted with others in virtual environment will show a more positive attitude towards robots.

- H3c: Respondents with a high Avatar Engagement will show a more positive attitude towards robots.

3. Method

3.1. Design overview

A between-subjects experiment was conducted with participants from a large US northeastern university who were randomly exposed to different types of robot images (without any textual identification or explication). Participants were 873 undergraduate students (530 females, 313 males and 30 unidentifiable) enrolled in six communications courses, and whose ages ranged from 18 to 30 ($M = 20.1$, SD $= 1.628$). A third of participants ($N = 284$) were exposed to an image of Romeo (a French humanoid robot designed to assist elderly people by Aldebara); another third ($N = 293$) to the AIBO robotic dog designed by Sony, and the remaining third ($N = 296$) to an image with an extreme robotic appearance, characterised as Android herein. Then, participants completed an online questionnaire that measured their attitude towards robots, the degree of human-like characteristics they can perceive in them and occupations for which they believe robots are qualified. Additionally, data were collected on variables such as religiosity, perceived competence with ICT, previous experiences in Second Life, online role games, engagement with avatars and background demographics.

3.2. Stimulus material

The original formatting of the robot images was embedded in the questionnaire (Figure 1). Respondents were asked three questions about the images in order to establish its salience, and only then were asked about their attitudes and the functions that robots should fulfil in society. The questions to prime participants' mental representations and stereotypes of robots were 'I always wanted to have a robot like this one'; 'I would like to have for my use a robot like this one' and 'I think most of my classmates would like to have this robot for their use.' Responses were provided on an 8-point Likert scale that ranges from 1 (strongly disagree) to 8 (strongly agree).

3.3. Measurement

3.3.1. Human-likeness scale

This variable (Cronbach $\alpha = 0.88$) was composed of eight items and measured the recognition of human-like characteristics in robots. Questions such as 'Most robots have emotions of their own', 'robots should have rights just like pets or people' or 'I don't think it is right to mistreat or abuse a robot' were included in an 8-point Likert scale, with anchors 1 = strongly disagree and 8 = strongly agree.

3.3.2. Religiosity

Students were asked about their religion and we differentiated between Judeo-Christian religions (Catholics, Protestants, Jews and Muslims) and others (Hinduism, Jainism, Buddhism, etc.). To measure religiosity, we used the Santa Clara Strength of Religious Faith Questionnaire (Plante and Boccaccini 1997), a 10-items scale designed to measure the strength of spiritual faith regardless of religious affiliation (Cronbach $\alpha = 0.79$). High scores correlate with intrinsic religiosity, higher self-esteem, decreased interpersonal sensitivity and a belief in the availability of God to help with life problems (Plante and Boccaccini 1997). Responses were provided on an 8-point Likert scale that ranges from 1 (strongly disagree) to 8 (strongly agree) (for more details see the appendix).

3.3.3. Perceived competence with information and communication technologies

Drawing from previous research (Campbell and Kwak 2010), four questions were used to measure the extent to which participants were comfortable with the use of technologies to communicate with others. Respondents were asked to state how much they agreed with each of the four statements: 'I enjoy using my mobile phone to communicate with people', 'I feel technology in general is easy to operate', 'I am comfortable with the technical features of my mobile phone' and 'It is easy for me to use my computer to communicate with others'. An eight-point scale, ranging from strongly disagree to strongly agree was used (Cronbach $\alpha = 0.76$).

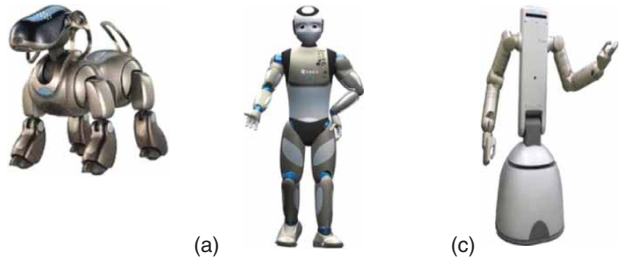

Figure 1. The stimulus used: (a) the humanoid Romeo, (b) the robotic dog AIBO and (c) the Android.

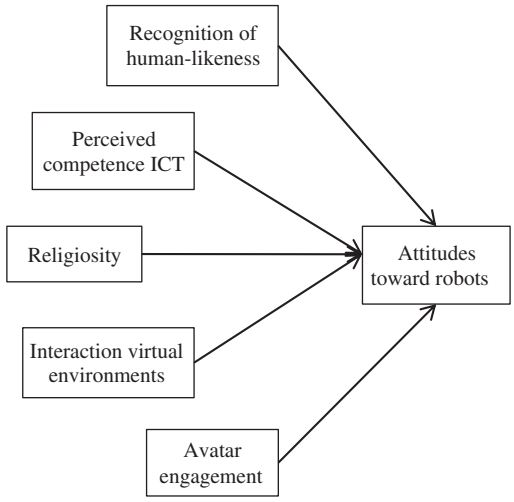

Figure 2. Illustration of the model with the variables considered to affect attitudes toward robots.

3.3.4. *Engagement with avatars*

Adapted from Ratan and Hasler (2010), this scale utilises self-presence and social presence factors and provides a measure of how people connect to virtual self-representations on an emotional and identity level (Cronbach $\alpha = 0.95$). It is composed of five statements such as 'When upsetting events happen to my avatar playing a video game, I also feel angry' or 'When disgusting events happen to my avatar playing a video game, I also feel disgusted'. Each item was rated on an 8-point Likert scale, with anchors 1 = strongly disagree and 8 = strongly agree. Figure 2 shows all the variables that may affect attitudes toward robots.

3.3.5. *Interaction in virtual environments*

Participants reported how often they interact with other in Second Life and using Massively Multiplayer Online Role-Playing Games (MMORPG) via an 8-point scale ranging from 1 (do not use it at all) to 8 (almost all the day).

3.4. *Control variables*

All the regression models were controlled by age and gender.

3.5. *Interaction terms*

In order to carry out analyses corresponding to H2b, we created an interaction term between level of religiosity and type of religion.

3.6. *Construction of factors*

3.6.1. *Occupation for robots*

A list of 28 different occupations for robots was taken from three previous studies (Fong *et al.* 2002, Hegel *et al.* 2007, Lohse *et al.* 2007). Participants were asked to look at the robot and think about the needs that people in general have on a regular day. Then, they indicated how interested they would be in having the robot doing the different activities/occupations. Each item was rated on a 5-point Likert scale, with anchors 1 = I would not like it all, and 5 = very interested. The 28 items were subjected to principal components analysis. The analysis shows the presence of four components with eigenvalues over 1, but the screeplot revealed a clear break after the third component, so a three-factor solution was used, which could explained the 25.6%, 17.6% and 16.2% of the variance, respectively. Varimax rotation was performed. As Table 1 shows the first component consisted of nine items, which were occupations related to social and public assistant tasks (Cronbach $\alpha = 0.92$). We called this first factor Robots as Social Companions. Factor two, robots as surveillance beings, consisted of five occupations related to military and security tasks ($\alpha = 0.87$). The third factor, titled Personal Assistance, was composed of five occupations oriented to assisting subjects with different chores and household tasks (Cronbach $\alpha = 0.85$). Nine occupations from the original list were excluded as they failed to reveal any patterns among the responses.

3.6.2. *Attitude towards robots*

Guided by previous studies (Arras and Cerqui 2005, Nomura *et al.* 2006), the negative attitudes toward robots scale (NARS) scale was used as the main measurement to assess attitudes towards robots. The NARS is a 14-item self-report inventory consisting of three sub-scales: (a) attitude towards the interaction with robots (*e.g.* I would feel relaxed talking with robots); (b) attitude towards social influence of robots (*e.g.* I am concerned that robots would have a bad influence on children) and (c) attitude towards emotions in interaction with robots (*e.g.* I would feel uneasy if robots really had emotions). Additionally, 11 items from

Table 1. Factor analysis of occupation for robots items.

	Social companion	Surveillance	Personal assistance
Discuss personal problems	0.87		
Keep company when people travel	0.77		
Companionship for lonely people	0.73		
To replace pets	0.70		
Caregiver, to look after sick, kids and old people	0.65		
To play football or favourite sport	0.64		
Discuss purchases while people are shopping	0.62		
Reception (e.g. welcoming people)	0.57		
Discuss homework with students	0.57		
For military or dangerous tasks		0.74	
For exploratory missions		0.68	
Participate in security missions		0.67	
To watch houses		0.60	
Accompany for protection when people are out at night		0.57	
Helping with chores around the house			0.81
Fetch and carry the newspaper			0.73
An electronic butler			0.72
Personal assistance (*e.g.* for programming VCR or TV)			0.59
Do shopping for people			0.55
Variance	25.6	17.6	16.2
Eigenvalues	5.62	1.81	1.42
Cronbach	0.92	0.87	0.85

Note: Total variance accounted for 59.4%.

Arras and Cerqui (2005) were added. For this study, each item was rated on an 8-point Likert scale, with anchors 1 = strongly disagree and 8 = strongly agree. The 25 items were subjected to principal components analysis. A three-factor solution was used and it was able to explain the 21.2%, 16.7% and 8.4% of the variance, respectively. Varimax rotation was performed, and as given in Table 2, the first component Robot-Liking (Cronbach $\alpha = 0.81$), consisted of eight items, each of which shows a preference for robots. Factor two, Robotphobia (Cronbach $\alpha = 0.79$), was composed of six items that mixed negative attitudes and emotions in the interaction with robots. The third factor titled Cyber-Dystopian (Cronbach $\alpha = 0.71$), consisted of six items related to negative social consequences of the use of robots. Five items of the scale were ultimately excluded.

4. Results

A one-way ANOVA with the Human-likeness scale as the dependent variable showed a statistically significant difference in participants' perceptions of human qualities in robots, $F(2, 744) = 13.53$, $p < 0.001$. In accordance with H1a, participants in the humanoid condition recognised more human qualities in robots ($M = 3.25$, SD = 1.39), than in the Android ($M = 2.93$, SD = 1.43), and the doggy robot conditions ($M = 2.73$, SD = 1.25). *Post hoc* comparisons using one-tailed $T-$tests showed that only the humanoid condition differed significantly from the other two conditions at $p < 0.001$. However, no significant differences were found between the Android and doggy robot conditions. H1b was not supported which means that the humanoid design did not influence the attitude towards robots. To test whether there was a relationship between the variables identified as predictors by previous research in our hypotheses and attitudes towards robots, hierarchical multivariate ordinary-least squares (OLS) regressions were run to account for potential rival explanations and to assess the exact contribution of each block of predictors to the three factors constructed: Robot-Liking, Robotphobia and Cyber-Dystopian.

As given in Table 3, the total variance in Robot-Liking explained by the regression model was 27.1%. The block of technological variables had a higher explanatory power compared to the demographic block, due to the strong relationship between Avatar Engagement and Robot-Liking. It is also interesting to note that recognition of human-likeness in robots was positively related to Robot-Liking ($\beta = 0.317$, $p < 0.001$), which means that even controlled by the type of robots to which participants were exposed, subjects who recognised more human qualities in robots still like them much more than those who recognise less human qualities. Remarkably, recognition of human-likeness in robots was negatively related to the second factor, Robotphobia ($\beta = -0.148$, $p < 0.001$), which is consistent with the idea that individuals who can perceive human qualities in robots are less likely to have negative attitudes and emotions in their interaction with them. It is also important to understand that although the variance explained for this second factor by the regression model was lower than in Robot-Liking (only 8.5%), recognition of human-likeness and gender within the demographic block in Robotphobia had the biggest explanatory power. However, unlikely Robot-Liking, recognition of human qualities in robots was related negatively and gender positively to Robotphobia.

Table 2. Factor analysis of attitudes towards robots.

	Robot-Liking	Robotphobia	Cyber-Dystopian
If robots had emotions, I would be able to make friends with them	0.75		
I would feel relaxed talking with robots	0.71		
Robots can contribute to my personal happiness	0.69		
I would like to live with robots	0.68		
I would prefer a robot to help me instead of a human helper	0.66		
I would like robots to handle my physically laborious tasks for me	0.62		
I would feel more 'autonomous' if assistance comes from a robot rather than a human	0.60		
I would prefer to interact with a machine with robot appearance than one with humanoid appearance (head, arms, etc.)	0.57		
Something bad will happen if robots developed into living beings		0.78	
I would feel very nervous just being around a robot		0.68	
I would feel uneasy if robots really had emotions		0.69	
Robots should never make decisions concerning people		0.59	
Robots would be a bad influence on children		0.59	
I would feel worried talking with a robot		0.55	
Robots could become a serious competitors with people			0.75
If I depend on robots too much, something bad might happen			0.65
In the future society will be dominated by robots			0.61
I would feel uneasy if I was given a job where I had to use robots			0.60
Robots are used by the military to attack people			0.57
Robots are replacing people at work			0.59
Variance	23.2	18.7	9.2
Eigenvalues	3.96	1.54	1.07
Cronbach α	0.81	0.71	0.79

Note: Total variance accounted for 51.1%.

Table 3. OLS regression predicting attitudes to robots ($N = 748$).

	Robot-Liking	Robotphobia	Cyber-Dystopian
Doggy condition	0.057 (0.109)	0.007 (0.122)	0.158 (0.126)
Android condition	−0.03 (0.105)	−0.043 (0.118)	−0.02 (0.121)
Human-likeness	0.317*** (0.033)	−0.148*** (0.037)	0.06 0.028
R^2 (%)	15.8	2.3	0.6
Religiosity	−0.006 (0.02)	0.061** (0.022)	0.027 (0.023)
Judeo-Christian Religions (1 = yes)	−0.176† (0.106)	0.023 (0.012)	−0.186 (0.124)
R^2 change (%)	0.5	1.7	0.2
Perceived competence ICT	0.064 (0.043)	0.073 (0.049)	−0.104* (0.05)
Avatar Engagement	0.152*** (0.025)	−0.012 (0.028)	0.083** (0.028)
Experience in second life (1 = yes)	−0.3* (0.139)	−0.07 (0.156)	−0.081 (0.161)
Experience playing MMORPG (1 = yes)	0.233 (0.147)	−0.145(0.166)	−0.314† (0.031)
R^2 change (%)	6.8	1	1.7
Age	0.029 (0.024)	−0.028 (0.027)	−0.004 (0.028)
Gender (1 = female)	−0.569*** (0.091)	0.555*** (0.101)	−0.149 (0.105)
R^2 change (%)	4.1	3.8	0.02
Constant	1.914	4.84	4.24
Adjusted R^2 (%)	27.1	8.5	2.7

Notes: b = unstandardised regression coefficients with standard error in parentheses are presented. R^2 change refers to the unique contribution of each block of variables controlling for the previous variables entered in the regression.
*$p \leq 0.05$.
**$p \leq 0.01$.
*** ≤ 0.001.
$^{\dagger}p \leq 0.10$.

Concerning the third factor, Cyber-Dystopian, the regression model was able to explain only 2.7% of the variance, which may be due to the absence of a relationship between the dependent variable and gender and recognition of human-likeness.

Concerning the second couple of hypotheses, partial support was found for the predicted relationship between religiosity and attitude to robots: whereas Judeo-Christian religion was negatively related to Robot-Liking ($\beta = -0.176, p < 0.1$), religiosity did not have a significant

Table 4. Interactive relationship between type and level of religiosity in accounting for Robot-Liking and Robotphobia.

	Robot-Liking	Robotphobia
Prior blocks R^2 (%)	27.1	8.5
Judeo-Christian religions × religiosity	$0.094^{\dagger}$ (0.054)	$0.084^{\dagger}$ (048)
Adjusted R^2 (%)	27.4	8.8

Notes: Prior blocks include age, gender, perceive competence with ICT, experience with MMORPG, Second Life, Engagement with Avatars, religion, religiosity, recognition of human-likeness, and doggy and Android experiment conditions. b = unstandardised regression coefficients with standard error in parentheses are presented. R^2 change refers to the unique contribution of each block of variables controlling for the previous variables entered in the regression.
$^{*}p \leq 0.05$.
$^{**}p \leq 0.01$.
$^{***} \leq 0.001$.
$^{\dagger}p \leq 0.10$.

impact on it. However, religiosity was positively related to the second factor, Robotphobia ($\beta = 0.061$, $p < 0.01$), which means that more religious individuals have a more fearful attitude towards robots. In order to test H2b, we created interaction terms between religiosity and type of religion. As given in Table 4, the interaction term between type of religion and religiosity level was found to be marginally significant for Robot-Liking ($\beta = 0.084$, $p = 0.082$) and for Robotphobia ($\beta = 0.094$, $p = 0.08$). The interaction results indicated that the negative relationship between those who profess Judeo-Christian religions and Robot-Liking, and the positive relationship between Judeo-Christians and Robotphobia, tend to be greater among those who are more religious. Regarding demographic factors, we predicted that females will show less positive attitudes towards robots than male respondents, and in fact gender was a significant predictor for attitudes towards robots: females were negatively related to Robot-Liking ($\beta = -0.569$, $p < 0.001$) and positively associated with Robotphobia ($\beta = 0.555, p < 0.001$), supporting H2c.

H3a hypothesised that subjects with a high sense of competence interacting with ICT will show a more positive attitude towards robots. However, the results were contrary to H3a, and as Table 3 illustrates, individuals with a high sense of competence interacting with ICT showed a positive relation with Cyber-Dystopian ($\beta = 0.104, p < 0.05$), a negative attitude towards robots. H3b and H3c showed mixed results. Individuals who have interacted with others in MMORPG showed a marginally significant negative relationship with Cyber-Dystopian ($\beta = -0.314$, $p = 0.07$), which supports the idea that those who interact in virtual environments will show a more positive attitude towards robots. However, concerning individuals highly engaged with avatars, on the one hand, these individuals were positively related to Robot-Liking ($\beta = 0.152, p < 0.001$), but on the other hand, also positively related to Cyber-Dystopian ($\beta = 0.084, p < 0.05$), which means they have a positive attitude towards robots since they like them more as was predicted by H3c, but they also show higher concerns about the negative consequences in the use of robots by human beings.

Our second research question asked whether there is a relationship between attitudes towards robots and the occupations for which robots are believed to be qualified. To answer this question, hierarchical multivariate OLS regressions were run with the three factors constructed for occupations for robots as dependent variables, and the constructed factors for attitudes towards robots as independent variables. The models were also controlled by the variables recognised as significant predictors, and they were entered in separate blocks. Table 5 shows that in the three models the attitudes towards robots are able to explain more than 17% of the variance. In the occupations related to Social Companion, the three attitudinal factors are significantly associated, and unsurprisingly, the factor that reflects positive attitude, Robot-Liking, is the only one that it is positively associated ($\beta = 0.307, p < 0.001$), whereas Robotphobia ($\beta = -0.101, p < 0.001$) and Cyber-Dystopian ($\beta = -0.05$, $p < 0.01$) are negatively related, which means that individuals who have a positive attitude towards robots want them to be engaged in social occupations. Consistent with the findings related to attitudes towards robots, human-likeness ($\beta = 0.13, p < 0.001$) and Avatar Engagement ($\beta = 0.047, p < 0.01$) were also positively related.

In the second factor for robots occupations, surveillance, it is interesting to note that the block of attitudes towards robots had a higher explanatory power compared to the variables identified as predictors in previous studies (17.3% vs. 11.6%). Robot-Liking was positively associated ($\beta = 0.324$, $p < 0.001$) with this factor, while Robotphobia ($\beta = -0.131$, $p < 0.001$) was negatively associated, meaning that subjects who like robots would prefer to be protected by them, whereas individuals with Robotphobia would prefer that robots not fulfil surveillance occupations in society. However, to our surprise, results also showed that Cyber-Dystopian ($\beta = 0.097, p < 0.01$) was positively related to surveillance occupations. Within the predictors, perceived competence with ICT, gender and experience playing MMORPG were significantly associated with the surveillance factor. Finally, regarding the personal assistance factor, which was composed of occupations oriented to serve and help subjects with different chores, the block of attitudes towards robots has a higher explanatory power compared to the variables identified as predictors (18.5% vs. 7.8%). This high explanatory power deserves attention because although Robotphobia was the only factor significantly related to personal assistance ($\beta = -0.109$, $p < 0.001$), it shows how relevant the attitudes towards

Table 5. OLS regression predicting occupations for robots ($N = 748$).

	Social companion	Surveillance	Personal assistance
Doggy condition	0.012 (0.068)	0.1 (0.09)	0.047 (0.084)
Android condition	0.003 (0.066)	0.012 (0.086)	−0.006(0.081)
Human-likeness	0.13*** (0.022)	0.002 (0.029)	−0.004(0.027)
Religiosity	0.012 (0.012)	0.001 (0.017)	0.024 (0.015)
Judeo-Christian religion (1 = yes)	−0.087 (0.066)	−0.016 (0.088)	−0.036 (0.082)
Perceived competence ICT	−0.023 (0.027)	0.076** (0.036)	0.126*** (0.033)
Avatar Engagement	0.047** (0.016)	0.028 (0.021)	0.012 (0.019)
Experience in Second Life (1 = yes)	0.118 (0.089)	−0.166 (0.177)	−0.062 (0.109)
Experience playing MMORPG (1 = *yes*)	0.019 (0.092)	−0.243**0.122	−0.13 (0.113)
Age	0.005 (0.023)	0.007 (0.020)	−0.002 (0.018)
Gender (1 = female)	−0.094 (0.059)	−0.197** (0.078)	0.027 (0.073)
R^2 change (%)	25.2 (0.024)	11.6 (0.027)	7.8 (0.028)
Robot-Liking	0.307*** (0.026)	0.324*** (0.034)	0.331*** (0.032)
Robotphobia	−0.101*** (0.025)	−0.131*** (0.032)	−0.109*** (0.03)
Cyber-Dystopian	−0.05** (0.024)	0.097** (0.031)	0.003 (0.029)
R^2 change (%)	17.7	17.3	18.5
Constant	1.517	1.76	1.777
Adjusted R^2 (%)	43.9	28.9	26.3

Notes: b = unstandardised regression coefficients with standard error in parentheses are presented. R^2 change refers to the unique contribution of each block of variables controlling for the previous variables entered in the regression. The humanoid condition was excluded in order to consider it as the reference and compare the other two conditions.
*$p \leq 0.05$.
**$p \leq 0.01$.
*** ≤ 0.001.
†$p \leq 0.10$.

robots are in explaining the occupations for which are believed to be qualified.

5. Discussion

This study examined which factors at individual level affect users' attitudes to robots appearance, and the impact these assumptions have on occupations for which robots are believed to be qualified. Overall it yielded five major findings. First, as was expected, results revealed a positive relationship between the use of humanoid robots and recognition of human-likeness attributes, which is consistent with previous findings that the use of more anthropomorphic robots makes human partners more likely to treat them as real people (Schermerhorn *et al.* 2008). Similarly, we also expected that exposure to humanoid designs would elicit a more positive attitude towards robots; however, we found that only recognition of human characteristics in robots was associated with positive attitudes, which suggests that it is not the exposure to a particular type of robot but rather the recognition of human attributes what affected subjects' attitudes towards them. This positive relationship can be explained through the concept of social presence, the sense that other intelligent being coexist and interact with the user in the same environment (Biocca 1997). Research has shown that users' attitudes, evaluations and social responses towards robots are mediated by their feelings of social presence during their interaction with robots (Lee *et al.* 2006), which means that individuals react based on how much they feel that there are other person interacting with them.

Second, in contrast to our initial belief that participants who feel more comfortable with the use of technologies to communicate with others will have a better attitude towards robots, our results indicated that those individuals are more concerned of the impact that robots might have on society, showing a higher Cyber-Dystopianism than other participants. One plausible explanation could be related to their higher exposure to technology and maybe robots in real life, which could make them more aware of the abilities represented by technology but also of their shortcomings. Bartneck *et al.* (2005) gave a similar reason to explain why Japanese participants with a high degree of comfort and experience using technology were more concerned emotionally than participants less savvy technologically in their interaction with robots. This argument might also explain why in our study individuals who engage more with avatars and have more experience interacting in virtual environments, on the one hand, liked much more robots and showed a higher preference for them than participants with less sense of competence and comfort using ICT, but on the other hand, presented a higher Cyber-Dystopianism, showing much more concerns about negative social consequences as robots become increasingly integrated in society.

Third, our results also showed a negative relationship between individuals who profess a Judeo-Christian religion and Robot-Liking, suggesting that subjects with an

Eastern religious background like robots more, which offers comparable demonstration of how philosophical elements embedded in each culture–religion may influence attitudes towards technology. MacDorman *et al.* (2009) explain that Judeo-Christian religions have an explicit prohibition of idols: Islam bans all icons from mosques, Puritans prohibit icons in their churches and Amish do not even take photographs. Thus, building robots in man's image, with human qualities, may be considered a usurpation of God's role, which could be evaluated negatively by believers. MacDorman *et al.* (2009) contrast this outlook with the idea expressed by Makoto Nishimura, a Japanese robotics pioneer, who stated that if in the Eastern cultures humans are considered as the children of nature, artificial humans created by the hand of man should be regarded as nature's grandchildren. Consequently, the difference in how Eastern and Judeo-Christian religions perceive robots reported in our study may be explained by how these two different cultures have historically considered human-like machines.

And fourth, this study found that individual's attitudes towards robots are strongly related to their acceptance of having robots fulfil certain occupations in society. Individuals who like robots, for example, prefer them to do activities related to social companionship and surveillance functions, which is consistent with previous findings that individuals systematically preferred robots for jobs when the robot's Human-likeness matched the sociability required in those jobs (Goetz *et al.* 2003). However, robot likers did not show a significant preference to having them as personal assistants, which is also consistent with Goetz *et al.*'s findings, who suggest that robotic assistants, to be effective, should exhibit naturalistic behaviour and appropriate emotions, and require little or no learning effort on the user's part to be used satisfactorily. Neither of these characteristics and features was embedded in the robots presented in our study, so it is possible to argue that more realistically designed robots would have elicited from participants stronger preferences to use them as personal assistants. Similarly, subjects with Robotphobia showed a significantly lower preference to having robots fulfilling these three types of occupations, which reinforces the idea that individual's attitudes towards robots are strongly related to their acceptance of occupations they could fulfil in society. Noteworthy too is that those with a Cyber-Dystopian attitude did not want robots as social companion, but preferred them for surveillance functions. Although this relationship may not be obvious, it may be interpreted as a self-defence mechanism, in the sense that individuals who fears negative consequences using robots, may prefer to have the negative consequences imposed on those who might threaten them. Or it may be that they believe that if they function in a security capacity, *i.e.* protecting themselves and their possessions rather than doing any other function, they may feel that robots are more likely to remain under human control.

Finally, the relevant role of gender should be noted although females showed higher levels of Robotphobia and liked robots less, they did not show a higher Cyber-Dystopianism. This seemingly lack of consistency may be explained by the fact that this factor was constructed principally by social–functional consequences in the use of robots, such as 'robots may replace people at work', which introduces the notion of competition. And in comparison to males, females, as research shows, tend to prefer cooperative modes of relationships rather than competitive ones (Schermerhorn *et al.* 2008). Therefore, it is possible to argue that females may not feel threatened by robots.

6. Conclusion

This study is valuable for several reasons. In the first instance, it identifies empirically factors that differentially affect individuals' attitudes to robots, including gender, religion, perceived competence with ICT, engagement with virtual reality environments and avatars. The results of this study showed that when individuals are exposed to humanoid robots, participants recognise more human-like characteristics in robots than when they are exposed to doggy or Android designs. By comparison, gender, religion, perceived competence with communication technologies, engagement with virtual reality environments and avatars differentially affects individuals' attitudes to robots more generally. Furthermore, based on the idea that changes in attitudes produce a corresponding change in behaviour, results also imply that if people interact with robots their attitudes and emotions may affect their behaviour. Therefore, we believe it is important to continue investigating the influences of these attitudes and emotions on human–robot interaction, especially because popular sentiment and previous perceptions shape technology's assimilation (Frambach and Schillewaert 2002). Technologies may become far more usable if people's expectations are taken into account.

In the second instance, we found individual's attitudes towards robots are strongly related to their views about the acceptability of having robots fulfil certain occupations in society. This has important implications. (1) If robots are introduced in settings such as homes, there may be differences in attitudes among family members, for example, depending on their gender. (2) If interaction with avatars can reduce negative attitudes towards robots, it may be advisable to introduce them virtually first, making explicit all their functionalities and affordances, before companies actually use them. (3) We found that culture may moderate certain attitude towards robots; however, more research is needed in order to understand which specific aspects have a higher influence.

In the third instance, we highlighted the role of verisimilitude to humans in assessing the roles deemed suitable for robots. Attention has been paid to the question of the uncanny valley in which people become quite uncomfortable if robots seem too human. Yet, our findings, while not directly engaging this issue, do suggest that among young people there is unlikely to be the same discomfort levels

that have been reported in other studies. That is to say, the human-like qualities of the robot can be a definite plus in terms of their acceptability in certain roles. This is certainly a worthwhile question to be explored, especially in terms of the interests people have in finding companionship for the sick or elderly.

Finally, the point that people tend to treat their devices that communicate with human-like qualities, uncovered by Nass and expanded by Katz and colleagues (see, for example, Katz 2003), is germane here. While human-like appearance modulates people's assumed reactions to robots, it is also the case that they are willing to ascribe human qualities – willingness to carry out tasks that require intelligence and social interaction skills – to robots even if they do not have human-like appearance. Nonetheless, as Nass and Katz among others have pointed out, having our machines evince social cues (including saying 'thank you') help people to see machines as sentient beings, or at least entities requiring a modicum of social interaction. Whether this continues, or humans begin to treat robots like wallpaper (cognitively invisible after a few exposures) is an open question. We would expect that to the degree robots act in social ways humans will respond in kind.

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Appendix. Scales and measurement

Perceived competence with ICT	Mean	Std. dev.	
I enjoy using my mobile phone to communicate with people	6.55	1.301	
I feel technology in general is easy to operate	6.58	1.422	
I am comfortable with the technical features of my mobile phone	6.54	1.523	
It is easy for me to use my computer to communicate with others	6.74	1.273	
Human-likeness scale	Mean	Std. dev.	
Robots are autonomous, self-contained beings, not like puppets who need to have someone pulling their strings	3.96	2.024	
Robots are able to recognise human emotions	2.83	1.800	
I do not think it is right to mistreat or abuse a robot	3.93	2.249	
Robots should have rights just like pets or people	2.45	1.820	
Most of robots are capable to understand what humans say	3.58	1.959	
Robots have their own personalities	2.55	1.749	
Robots can have feelings	2.18	1.605	
Most of robots can have emotions of their own	2.14	1.606	
Religiosity (Santa Clara Strength of Religious Faith Questionnaire)	Mean	Std. dev	
My faith is an important part of who I am as a person	4.50	2.654	
My relationship with God is very important to me	4.52	2.640	
My religious faith is very important to me	4.32	2.628	
I pray daily	3.40	2.553	
I look to my faith as a source of inspiration	4.08	2.609	
I look to my faith as providing meaning and purpose in my life	4.09	2.627	
I enjoy being around others who share my faith	4.21	2.527	
I look to my faith as a source of comfort	4.22	2.600	
My faith impacts many of my decisions	4.01	2.556	
I consider myself active in my faith or church	3.32	2.454	
Avatar Engagement Scale	Mean	Std. dev	N
When upsetting events happen to my avatar playing a video game, I also feel angry	2.60	2.105	762
When disgusting events happen to my avatar playing a video game, I also feel disgusted	2.44	1.921	762
When arousing events happen to my avatar playing a video game, I also feel aroused	2.31	1.914	762
When surprising events happen to my avatar playing a video game, I also feel surprised	2.72	2.131	762
When scary events happen to my avatar playing a video game, I also feel afraid	2.59	2.058	762