Designing Social Robots for Interaction at Work: Socio-Cognitive Factors Underlying Intention to Work with Social Robots

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Abstract:
This paper discusses the effects of robot design (machine-like, humanoid, android) and users' gender on the intention to work with social robots in the near future. For that purpose, the theoretical framework afforded by the theory of planned behavior (TPB) is used. Results showed effects for robot design and users' gender. As the robot got more human-like the lower the intention to work with it. Female participants showed lower intention to work with social robots. These effects are mediated by the variables of the TPB. Perceived behavioral control and subjective norm are the main predictors of the intention to work with social robots in the near future.

Keywords: *social robots, intention to work, social robots at work, robots design, gender, theory of planned behavior*

1. Introduction

Late XX and early XXI century society has witnessed a phenomenal increase in the computational power of electronic devices, which was accompanied by a significant production cost reduction [1]. This resulted in a changed outlook on were and how these devices could assist their users.

The field of robotics is no stranger to this change. Robots are no longer "caged" inside factories, growing in autonomy and interaction competence, multiplying in form, and playing an increasingly larger role in daily life [2]. Of particular interest to this paper is the concept of social robot at work.

A social robot can be broadly defined as a robot with high level of autonomy, capable of interacting with people, following contextually correct social norms, attentive to gaze and emotional cues, and able to adapt its responses to user's specific traits and personality (see [2–5] for a more thorough discussion of the definition).

Social robots differ from the lay representation of robot, a high-tech industrial machine [6] in that they are "designed to engage people in an interpersonal manner, often as partners, in order to achieve social or emotional goals" [7]. Despite the diversity of forms, social robots share this focus on interpersonal interactions.

As such, successful deployment of social robots requires a broader focus of analysis, in order to account for future user's attitudes, beliefs and expectations, and how they will impact human-robot interaction [8].

The purpose of this paper is to study the interplay between robot design (machine-like, humanoid and android), users' gender and individual intention to work with a social robot in the near future. The following sections review the state of current research.

1. Robot Design

Social robots are developed under the assumption that people will apply social norms when interacting with them [7]. With this in mind, robot designers have tried to integrate human physical (e.g. eyes, mouth, limbs) and psychological traits (e.g. attention, voice tone) in an attempt to build better interaction metaphors. Below are reviewed some studies dedicated to the subject.

Research by DiSalvo *et al.* [9] on the effects of the robot's physical appearance showed that the presence of nose, eyelids and mouth are the traits that increased the perception of humanness of a robot's head. Blow *et al.* [10] compared various robot smiles, reporting that expressions with a natural transition time where preferred by the participants. Lee *et al.* [11] and Walters *et al.* [12], studied perception of robot's height, concluding respectively that: participants preferred a robot with a height similar to theirs, as this allowed eye contact; and that higher robots where perceived as more human-like and conscientious. Moreover, Walters *et al.* [12] also studied the effect of robot general design (machine-like vs humanoid), concluding that robots with a more human-like design where perceived as more intelligent.

Robot "gender" was also found to affect user behavior. Powers *et al.* [13] had their participants discussing dating preferences with either a male or female version of a robot, and found that participants spent more time talking with the opposite gender robot. Eyssel *et al.* [14] found that participants formed a more positive image of the same gender robot, reporting more psychological closeness. These results however should bear in mind the findings of [15], which suggest that participants, not only prefer the robot that matches their "personality" style, but also tend to attribute to the robot "personality" traits similar to their own.

Research on the effects of the robot's voice shows a preference for robots with human voice [16], and an increased task performance, when participants had a robot whispering cues [17]. As for voice tone, Niculescu *et al.* [18], comparing two robots with female appearance, reports a preference for a robot with a high-pitched voice.

Salem *et al.* [19] focused on multimodal communication, studying the effects of voice and gestures in the perception of human-likeness and likability of a humanoid robot. They concluded that the combined use of gestures and voice increased likability and the future intention to use the robot. Ham *et al.* [20] studied the effects of gestures and gaze, finding that when combining gestures and gaze the robot was perceived as more persuasive. Bartneck *et al.* [21] identified a relation between robots perceived animacy and perceived intelligence.

However, the use of a human-like design does not always facilitate interaction. For instance, people who though that humanoid robots were the more acceptable robot design for house chores, also reported being uncomfortable with the idea of interacting with them [22, 23]. In another study Broadbent *et al.* [24], asked participants to imagine either a robot with human form, or a machine-like robot. Afterwards they had their blood pressure measured by a robot and reported their emotional state. Participants who had imagined the robot with human form, showed greater increases in blood pressure readings and reported more negative emotions.

These feelings of eeriness toward humanoid robots have been described as the Uncanny Valley effect (see [25] for review of concept and theoretical models). That is, as a robot increases in human resemblance so does likeability, until a point where this resemblance induces feelings of eeriness and dread. Research on this subject suggests a link between human appearance and eeriness [26-28] and as identified what seems to be the evolutionary [29] and developmental [30] roots for this dread response.

In short, designing robots with human-like traits can enhance their interactive and social proficiency. Also, different degrees of human likeness seem to impact differently potential user's expectations and behavior. However, this approach should be cautious, since robots with human resemblance may arouse some anxiety in their users.

1.2. User Gender

If technology, *per se*, can be regarded as gender neutral, its use is clearly embedded in social conventions and norms, that prescribe how men and women should think, feel and behave towards technology [31]. Research results have underlined the role played by socio-cognitive factors in the observed gender differences in technology use.

Gefen and Straub [32] compared female and male beliefs about e-mail and e-mail use, using the technology acceptance model (TAM; [33]). They found that female and male participants held different beliefs about e-mail's social presence, usefulness and ease of use. Women reported a higher sense of social presence and usefulness, while men reported a higher sense of ease of use. Interestingly, no differences were found in terms of actual e-mail use. Venkatesh and Morris [34], also using TAM, compared over a period of 5 months, the usage of a software application. After controlling for the effects of income, occupation, education level, and prior experience with computers, they found that, men's use was determined by the perception of usefulness, while women's use was determined by perceived ease of use and subjective norm. Venkatesh *et al.* [35], used the theory of planned behavior (TPB; [36]) to study the introduction of a new software application over a period of 5 months. After controlling for the effects of income, organization position, education and computer self-efficacy, they found that while men's use was predicted by their attitude towards using the software application, women's use was predicted by perceived behavioral control and subjective norm. Long term use was correlated with early use behavior, underlining the importance of early evaluations.

These gender differences are also visible in people's understanding of robots. Piçarra *et al.* [6] found that male and female participants although sharing the social representation of robot as a technological machine, associated it with different contexts (industrial vs. domestic robot). Also, while female participants associated the idea of robot with help at home (domestic robot), male participants associated the idea of help with unemployment. Kuo *et al.* [37] studied people's reaction to health care robots by using a robot to measure blood pressure. They found that male participants had a more positive attitude towards healthcare robots, reporting no differences by age group. Eyssel *et al.* [16] compared two robots with gender neutral look, using either masculine or feminine voice uttered with a human or robotic tone. They identified interaction effects between gender of robot voice and gender of participant. Female participants showed a preference for the robot with female voice, reporting higher levels of psychological closeness and anthropomorphization. Male participants showed the same preference but towards the robot with a male voice. These effects were not noticed with the robot with a "robotic" voice.

In short, the variable gender seems to account for differences in both how technology is used and the perception of its usefulness. These effects seem to extend to human-robot interactions, suggesting that men and women, not only perceive social robots differently, but also interact differently.

1.3. Theory of Planned Behavior (TPB)

Despite its productivity potential, technology is only useful as long as it is used. Some authors estimate that 50% to 75% of the difficulties of implementing technological solutions at work may stem from human factors [38], therefore the importance of understanding users' behaviors.

Although the common belief that someone's predisposition towards something is a sure indicator of future behavior, scientific research has shown attitudes to be poor predictors of specific behaviors [36]. To deal with this problem, Ajzen and Fishbein [39] proposed that the proximal cause of behavior is behavioral intention (BI), being attitudes a distal cause. Intention is then an indication of the effort a person is willing to put in order to perform a certain behavior. Intentions imply some forms of planning, and temporal framing, and they are associated with a reasonable level of confidence in the capacity of performing the action [40]. The stronger the intention, the more likely the performance of a certain behavior. Intention is then the central element of the TPB, but is not the only one, since performing a behavior also depends on the availability of resources (personal and/or material). This evaluation of available resources is labelled perceived behavioral control (PBC). PBC is the perception of how easy or difficult it will be to perform a particular behavior, and includes not only perceived obstacles and strengths, but also past experiences [36]. PBC can have a direct effect on behavior, but can also have an indirect effect on behavior *via* intentions. The other two elements of the TPB are attitudes and subjective norms. As mentioned, attitudes *per se* have proven to be unreliable predictors of behavior. Nonetheless they play a role in behavior. Ajzen [36, p. 191] puts it this way: "In the case of attitudes toward a behavior, each belief links the behavior to a certain outcome, or to some other attribute such as the cost incurred by performing the behavior. Since the attributes that come to be linked to the behavior are already valued positively or negatively, we automatically and simultaneously acquire an attitude toward the behavior." Subjective norms assess the person's beliefs about significant other's opinions and judgments. That is, if they think a person should or should not perform a given action. It is a measure of social compliance [36]. Figure 1 shows a diagram of the TPB.

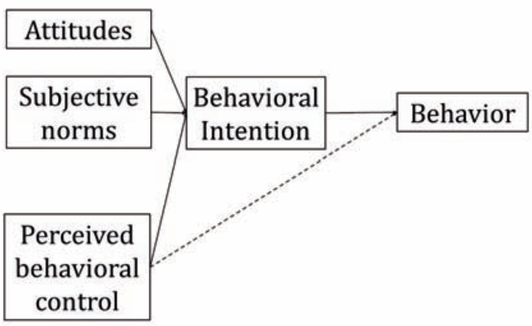

Fig. 1. The theory of planned behavior

The TPB has received ample empirical confirmation of its usefulness, both in theoretical and applied fields of research. Ajzen [36] reviews empirical evidence for the prediction of behavior using BI, PBC and the TPB. Ajzen [41–43], reports on recent theoretical and empirical progresses, while responding to some criticisms to the model. The TPB has been found useful in the prediction of among other behaviors, exercise (see [44] and [45] for reviews), health related behaviors (see [46] for a meta-analysis), buying behavior [47] and consumer adoption intentions [48]. The TPB has also been applied to behavior related to the use of technology, namely, intention to use information systems [49], online shopping [50, 51], e-commerce adoption [52], and digital piracy [53–57].

In short, according to the TPB, behavior is a function of intention, which is the combined expression of attitude, perceived behavioral control and subjective norms. None of these variables have fixed effects, being their weights dependent of the context and behavior.

The intention to work with social robots, according to TPB, is the result of the interplay of attitudes, subjective norms and perceived behavioral control. All other factors, like socio-demographic status, gender, personality traits, should have their effects on behavioral intention mediated by attitudes, subjective norms and perceived behavioral control [36].

1.4. Summary and Overview of the Study

The previous sections presented examples of research about the effects of robot design on user's perception, gender differences in technology use and the role of socio-cognitive factors, namely those defined by the TPB, in the prediction of technology use. Based on those results, this study tests the following hypotheses:

1) The level of human-likeness of the social robot will have an effect on participants' intention, attitude, perceived behavioral control and subjective norm.
2) Male and female participants will have different levels of intention attitude, perceived behavioral control and subjective norm.
3) The components of the TPB (attitude, perceived behavioral control and subjective norm) will predict the intention to work with a social robot.
4) The effects of robot design and participant gender on intention to work with the social robot are mediated by the components of the TPB.

2. Participants and Procedure

In order to conduct this experiment, the participants were randomly assigned to one of three conditions, machine-like robot (video of Snackbot), humanoid robot (video of Asimo) and android robot (video of Actroid DER). The use of indirect methods, like video, to study human-robot interaction (HRI) is quite common [58–61] and proved to be a valid method [62].

The sample used in this research is composed of 90 students from the University of the Algarve, Portugal. From these 51 are woman (M_{age} = 21.78; SD_{age} = 4.87) and 39 are man (M_{age} = 21.87; SD_{age} = 4.86). Sixty-five are humanities students, 25 are science students. Forty-five had already seen presented type of robot, 45 had never seen it.

Thirty participants were assigned to each condition. After being informed about the conditions of participation and confidentiality of the data collected, the participants were shown the video. The video lasted about 1 minute and 50 seconds and was projected on the wall facing the subjects using a ceiling projector. Before viewing the videos, participants received the following instructions: "In the future it will be common to interact with robots. This will happen in public spaces (factories, offices, museums) and in our houses. We are going to show you a video with one of these social robots. Your task is to imagine yourself working with this robot in the future and forming an opinion about it". During the video a female voice narrated the following: "Hello, my name is Snackbot (or Asimo, or Actroid) and I'm a social robot. A social robot is a robot created to interact with people in a natural fashion. In order to do that, my creators included in my design human characteristics like eyes, mouth, language and the capacity to understand and perform social behaviors. In the future I will be performing such jobs as hotel receptionist, personal trainer or office clerk. Some even say that in the future I will be responsible for caring for the elders. Goodbye and see you in the future." Both the instructions and the video dialogue, underlined how working with a social robot will be different from working with a current day industrial robots, by focusing on the socio-affective aspects of these interactions.

After watching the video, participants were asked to complete a questionnaire. At the end of the experiment they were debriefed about the research project. The measures used are presented in the next section.

2.1. Material

In order to assess the effects of different robot designs, videos of the following robots were used, Snackbot, Asimo and Actroid DER (see figure 2).

Fig. 2. Robot design, from left to right: Snackbot (machine-like design), Asimo (humanoid design), Actroid DER (android design)

Snackbot (machine-like design), is an assistive social robot developed at Carnegie Mellon University. The wheels set on its base allow the robot to move autonomously. The robot is about 142 cm high, with a round shaped head that served as housing for the visual and verbal hardware. A led display was used to simulate the mouth. The robot is able to produce simple verbal interactions. Although its arms are not fully functional, they carry a tray that allows Snackbot to transport objects from one place to another. (Lee *et al.* [11]).

Asimo (humanoid design), is a humanoid bipedal social robot developed by Honda Corporation[1]. With a height of 130 cm, Asimo can move autonomously and use its hands to pick up and use objects.

Actroid DER (android design), is a full body human-like female social robot with a corporate look (i.e., make-up, black blazer, crème trousers, white shirt, and collar)[2]. During its speech, the Actroid displayed nonverbal behaviors (e.g. arm movements, blinks), was shown in different angles (e.g., ¾) and looking straightforward at the participant.

In order to measure the intention to work with the social robot in the near future, the measures proposed by the TPB were used. Scale items were based on [63].

Behavioral Intention (BI). Measures the effort a person is willing to invest in order to work with the social robot presented in the video in the near future (e.g. I'm willing to try hard to work with this robot in the future: disagree/agree). It is composed of 5 items, measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate a stronger intention to work with the social robot presented in the video.

Attitude towards working with the social robot (ATW). Measures a person's attitude towards working with the social robot presented in the video (e.g., working with this robot will be useless/useful). It is composed of 10 items, measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate a more positive attitude towards working with the social robot presented in the video.

Subjective norms (SN). Measures the person's beliefs about significant others attitude towards him working with the social robot presented in the video in the future (e.g. people close to me, would approve/disapprove that I work with robots in the future). It is composed of 3 items, measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate more favorable subjective norms towards working with the social robot presented in the video.

Perceived behavioral control (PBC). Measures the extent that a person sees himself as capable of operating the social robot presented in the video (e.g. It would be easy to work with this robot: disagree/agree). It is composed of 7 items measured on a 7-point Likert type scale (1 = minimum to 7 = maximum). Higher scores indicate a higher level of perceived behavioral control in operating the social robot presented in the video.

In order to control for the effects of video presentation and previous familiarity with social robots, the following measures were used:

Animacy (ANI). This measure is adapted from the Godspeed scale, developed by Bartneck, Kulic, Croft and Zoghbi [64], and is comprised of 5 items each. Items (e.g. inert/ interactive) are rated from 1 (strongly disagree) to 7 (strongly agree) in a Likert type scale.

Familiarity with robots. In order to control for the effects of previous familiarity with robots, participants were asked if they were knowledgeable of the type of robot presented in the video.

3. Results

Analysis of the data indicates that it meets the assumptions of normality, skewness (Skew.) and kurtosis (Kurt.). Data was also analyzed for missing values and outliers. No variable had more than 2% of missing values and all were missing at random. These values were replaced using the expectation-maximization method. No outliers were identified. The analysis was performed using IBM SPSS Statistics (Version 20). Table 1 shows the descriptive statistics and re-

1 http://asimo.honda.com/
2 http://www.kokoro-dreams.co.jp/

liability for the scales used. All measures presented a Cronbach α above the recommended .70 value.

Table 1. Descriptive statistics and scales reliability

	Range	Mean	Std. Dev.	α	Skew.	Kurt.
BI	1-7	3.14	1.36	.88	0.05	-0.71
ATW	1-7	4.26	1.46	.95	-0.30	-0.50
PBC	1-7	4.44	1.33	.89	-0.62	-0.11
SN	1-7	3.71	1.39	.79	0.07	-0.40

Notes: * p <.05; ** p <.01; *** p < .001. BI = Intention; ATW = Attitude towards working; PBC = Perceived behavioral control; SN = Subjective norm.

3.1. Effects of Robot Design and Participant Gender

In order to measure the effects of robot design and participant gender (hypotheses 1 and 2), a multiple analysis of variance (MANOVA) was conducted on the variables, VOL, ATW, PBC, and SN. MANOVA is a generalized form of univariate analysis of variance (ANOVA) that uses the covariance between outcome variables for comparing the means of two or more dependent variables at the same time [65].

Although results of Box's test indicate that the assumption of equality of covariance matrices is met, results of the Levene's test suggests that the assumption of equality of covariances is not met for PBC. A post hoc analysis with Games-Howell procedure was used for this variable. All experimental groups meet the assumptions of normality, skewness and kurtosis. Figures 3 and 4 show the scales means by robot type and participant gender, respectively.

Because the assumption of homogeneity of variance-covariance was violated, an analysis of Pillai's trace was conducted. Results indicated statistically significant effects for robot design (V = 0.18, F(8,164) = 2.09, p = .039). Analysis of the univariate tests suggest that there are statistically significant differences for the variables: BI (F (2, 84) = 3.53, p= .034) and PBC (F (2, 84) = 5.90, p = .004). Robot design had no

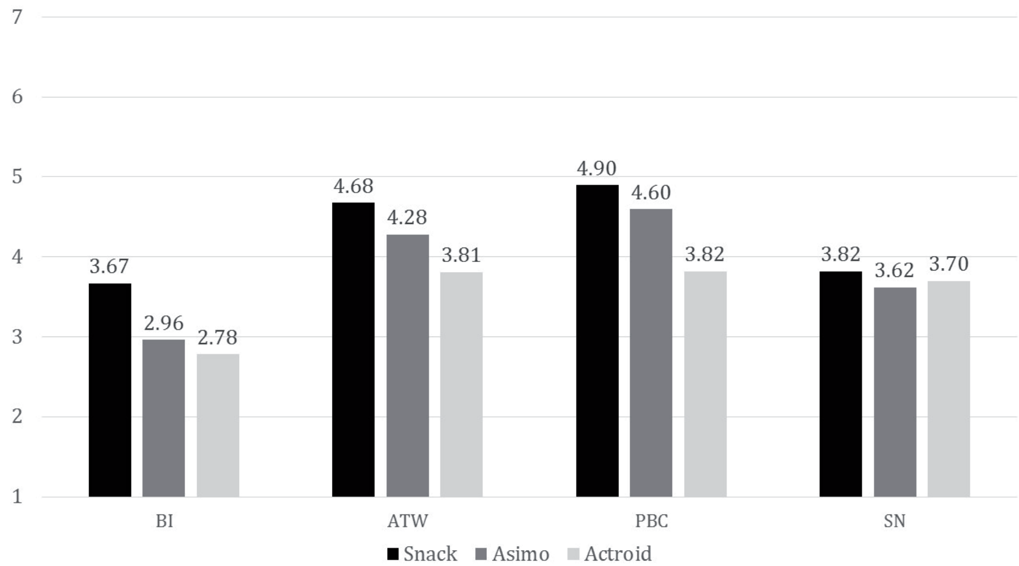

Fig. 3. Scale means by robot design

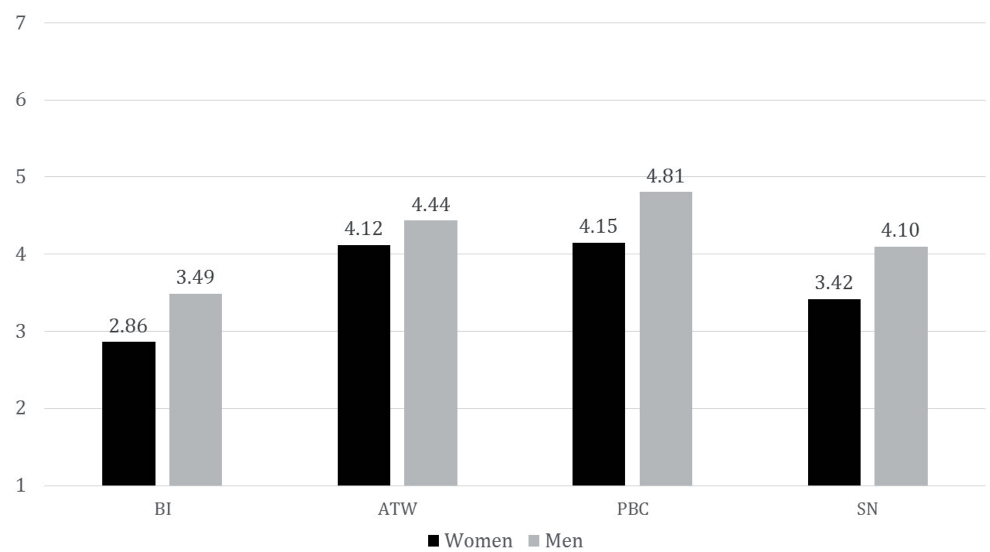

Fig. 4. Scale means by participant gender

effect on the variables ATW (F (2, 84) = 2.55, p = .084) and SN (F (2, 84) = 0.17, p = .847). That is, robot design seems to affect both the intention to work with the social robot and the perceived ability to do it. There is a statistically significant difference (p< .05) for the means of BI and PBC between Snackbot and Actroid, with the first presenting higher means for the two variables.

Although no statistically significant differences were found for the means of BI and PBC for Snackbot vs. Asimo, and Asimo vs. Actroid, trend analysis indicates there is a significant linear trend in the effect of robot type for BI (F (1, 87) = 6.75, p = .011) and PBC (F (1, 87) = 10.79, p = .001). That is, as the robot gets more human-like in appearance, the lower the participant's perceived behavioral control and intention to work with the social robot in the near future. Participants state both a stronger intention and a perceived behavioral control towards working with Snackbot.

Although analysis of Pillai's trace suggests no statistically significant differences between genders (V = 0.10, F(4, 81) = 2.15, p = .082), the univariate tests show statistically significant differences for the variables: BI (F (1, 84) = 5.03, p = .028), PBC (F (1, 84) = 5.60, p = .020) and SN (F (1, 84) = 5.84, p = .018). No effects were detected on ATW (F (1, 84) = 0.96, p = .330). That is, although participants share a positive attitude towards working with social robots in the near future, female participants have a lower intention to work with social robots in the near future, perceive themselves has less able to do it, and think that working with social robots is less sociably acceptable than men do.

No interaction effects were found between robot design and gender (V = 0.12, F (8, 164) = 1.34, p = .226).

3.2. Predicting Intention to Work with Social Robots

The third research hypothesis was about the effectiveness of the TPB model to predict the intention to work with a social robot in the near future. Table 2 shows the correlations between the studied variables.

Table 2. Correlations for the variables of the TPB

	1	2	3	4
1-BI	–			
2-ATW	.45***	–		
3-PBC	.65***	.54***	–	
4-SN	.40***	.14	.35**	–

Notes: * p <.01; ** p <.001; *** p <.001.

Table 3. Predictors of intention to work with a social robot in the near future

	B	Std. Error	Beta	*t*	*Sig.*	*CI*
Model 1						
Constant	3.67	.24		15.19	.000	[3.19, 4.15]
Snack *vs.* Asimo	-.71	.34	-.25	-2.07	.041	[-1.38, -0.03]
Snack *vs.* Actroid	-.89	.34	-.31	-2.60	.011	[-1.56, -0.21]
Model 2						
Constant	3.40	.26		12.86	.000	[2.87, 3.92]
Snack *vs.* Asimo	-.73	.33	-.25	-2.18	.032	[-1.39, -0.06]
Snack *vs.* Actroid	-.87	.33	-.30	-2.59	.011	[-1.53, 0.20]
Female *vs.* Male	.62	.27	.23	2.26	.026	[0.08, 1.17]
Model 3						
Constant	-.17	.51		-.33	.744	[-1.18, 0.84]
Snack *vs.* Asimo	-.47	.26	-.16	-1.81	.074	[-0.99, 0.05]
Snack *vs.* Actroid	-.20	.28	-.07	-.74	.458	[-0.75, 0.34]
Female *vs.* Male	.14	.22	.05	.64	.521	[-0.30, 0.59]
ATW	.13	.09	.14	1.54	.126	[-0.04, 0.30]
PBC	.50	.10	.49	4.76	.000	[0.29, 0.71]
SN	.18	.08	.19	2.21	.030	[0.02, 0.35]

Notes: * p <.05; ** p <.01; *** p < .001.
Model 1: F(2,87) = 3.77, p = .027, $R2$ = .08, Adjusted $R2$ = .06.
Model 2: F(3,86) = 4.34, p = .007, $R2$ = .13, Adjusted $R2$ = .10.
Model 3: F(6,83) = 13.78, p < .001, $R2$ = .50, Adjusted $R2$ = .46.

All variables have positive significant correlations with the intention to work with social robots in the near future. Moreover, ATW and PBC are positively correlated and PBC and SN are positively correlated.

A multiple regression analysis was conducted, using BI as the dependent variable. In order to check for the effects of robot design and participant gender, variables were entered using the hierarchical method. Robot design was entered in the first block, gender in the second block, and the variables of the TPB on the third block. Table 3 shows the results of the multiple regression analysis.

Results of the multiple regression analysis indicate that robot design is a statistically significant negative predictor of the intention to work with social robots, accounting for 6% of the explained variance. That is, as the robot design gets more human-like the lower the intention to work with it.

Analysis of model 2 shows that participant gender is also a predictor of the intention to work with social robots, with the model predicting 10% of the variance. Male participants have a stronger intention to work with social robots than female participants.

Model 3 accounts for 46% of the observed variance. Analysis of the individual contributions of these variables show that PBC (β= .49) and SN (β= .19) are statistically significant predictors of intention to work with social robots. That is, the more people rate themselves as capable of working with social robots, and think that working with social robots is viewed as an acceptable task by their significant ones, the more they intend to work with a social robot.

Adding the variables of the TPB to the regression model reduced the effects of robot design and participant gender, which supports hypothesis 4, that is, all factors external to the model, have their contribution to behavioral intention mediated by the model's dependent variables.

4. Discussion

In this paper the authors set out to study the interplay between robot design (machine-like, humanoid and android), user gender and the socio-cognitive factors defined by the TPB in the building of a person's intention to work with a social robot in the near future.

Like it was hypothesized, the level of human-likeness of the social robot design, affects participant's intention to work with a social robot in the near future (BI), and their perceived capacity of doing it (PBC). These results partly support hypothesis 1, since no effects were found for attitude towards working with a social robot and subjective norm. Results suggest that participants, not only, would prefer to work with a less human-like social robot, but also, would feel more confident of their capability of working with a social robot, if the robot is less human-like. Although the results seem in line with the Uncanny Valley hypothesis, two aspects must be noted. First, the Uncanny Valley hypothesis suggests an acceptance curve that drops abruptly when the robot looks too human. Given this, it would be reasonable to expect Asimo to have higher means for BI and PBC than Snackbot, and to see a drop in the means' values as we move from Asimo to Actroid. However, the trend analysis result suggests a steady decrease in the means, as we move from Snackbot, to Asimo, to Actroid. Second, this effect is limited to BI and PBC, with no effects found in ATW and SN. Given the evaluative character of attitudes and the social-normative character of subjective norm, it would be reasonable to expect that these variables were sensible to robot design. Although these results generally confirm that the use of human traits in the design of social robots is useful (Snackbot presents a head, with what resembles a pair of eyes and a mouth). They also underline the need for further research on the interplay between social robot design and the socio-cognitive factors.

Hypothesis 2 was partly confirmed, with participant gender affecting BI, PBC and SN. Male participants presented significantly higher means for these variables, while no differences were found for ATW. Unlike other studies reviewed previously, the differences found between female and male participants are quantitative not qualitative. That is, female participants present lower means than male participants for the three variables.

Hypothesis 3 was confirmed, with the TPB explaining a considerable amount of the variance of the intention to work with a social robot in the near future. Like posited by the model, the components contribute differently to the intention to work with social robots in the near future, with PBC and SN, showing the larger effects. These results are of particular interest, because more than the personal evaluation of the value of working with robots, it is the perception of the ability to do it, and the social norms surrounding the idea of working with robots that supports the intention to work with it. Thus, the deployment of human-robot solutions in the work environment should account not only for individual factor, like competence, but also for socio-normative factors, like work colleagues' acceptance of social robots.

Finally, hypothesis 4 was also confirmed. The effects of robot design and participants gender is mediated by the variables of the TPB. This means that these effects will be mediated by a set of personal representations and beliefs about the value of robots, how capable a person is to use them, and the social norms regarding their role. As such, objective changes in robot design are bound to produce variable effects in user perceptions of the robot's qualities.

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