robotics

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She's Electric—The Influence of Body Proportions on Perceived Gender of Robots across Cultures †

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† This paper is an extended version of Trovato, G.; Lucho, C.; Eyssel, F.; Bernotat, J. The Influence of Body Proportions on Perceived Gender of Robots in Latin America. In Proceedings of the Third International Conference on Love and Sex with Robots, LSR 2017, London, UK, 19–20 December 2017.

Received: 15 August 2018; Accepted: 3 September 2018; Published: 5 September 2018

Abstract: The assignment of gender to robots is a debatable topic. Subtle aspects related to gender, in a robot's appearance, may create biased expectations of the robot's abilities and influence user acceptance. The present research is a cross-cultural study involving more than 150 participants to investigate the perception of gender in robot design by manipulating body proportions. We are focusing specifically on the contrast between two extremely different cultures: Peruvian and Japanese. From the survey based on stimuli varying in the proportion between chest, waist, and hips, the results indicate the importance of chest-to-hip ratio and waist-to-hip ratio in the attribution of gender to robots.

Keywords: robot design; humanoid robots; gender

1. Introduction

The embodiment of robots, specifically the face in the case of humanoids, is a sensitive issue, since studies on social robots involve complex socio-demographic factors such as age, gender, culture and others [1].

Appearance has an important effect on anthropomorphism, as humans, for instance, commonly have different expectations from mechanical-looking robots and more human-looking robots [2], and attribute different tasks among different kinds of appearances [3]. Acceptance of humanoids can also be influenced by cultural factors between western and Asian countries [4]. Cultural backgrounds has been proven to influence the perception and intention to use a robot as an instrument [5], and preferences about their role in society [6], and the degree of anthropomorphism [7,8] and mind attribution [9].

From the appearance and behaviour, the first impression that we have of a robot matters in the same way as with humans, as depending on time, motivation, and effort in social judgments, mental shortcuts are used when forming an impression of others. People seem to rely on simple rules of thumb and engage in automatic information processing to come to an estimate about a person or a non-human entity [10]. To do so, humans take into account key features that indicate social category membership of a person or entity, relying on visual cues that indicate age, gender, or ethnic background of a person. Similarly, from physical and functional cues humans can infer a robot "personality" which may impact human–robot interaction [11–13].

Subtle visual cues that indicate the gender of a robot may activate peoples' gender stereotypical knowledge structures, which lead to biased expectations regarding the robot's abilities [14].

For instance, the experiment in [11] has documented that indeed, people perceive a long-haired robot as more female than a short-haired counterpart, and accordingly, judgments regarding these "feminine" vs. "masculine" robot prototypes turn out to be more gender-stereotypical, with the robots being differentially rated in their suitability for gender-stereotypical tasks.

Previous research starts from the gender-stereotypic response toward computers: in [15], synthetic voices were investigated and a dominant female voice was found to be perceived more negatively than a male one in a computer, which was also taken more seriously in the case of praise. Another experiment on a gendered voice was performed in [16].

An investigation on children's preferences [17] concluded that, according to the design implications of their research, robots should have a female gender and be brightly coloured for positive behaviours. This is because female gender was associated with positive robot traits such as happiness and friendliness, unlike male gender, which was not distinguishable for positive and negative robot traits.

Similar to human–human interaction, many factors influence the persuasiveness of a robot, including appearance, style and content of communication, and non-verbal behaviour, and gender plays a fundamental role.

Siegel et al. [18] showed that men were more likely to be persuaded to donate money to a female robot, as they felt more trust and engagement. In general, participants tended to rate the robot of the opposite sex as more credible, trustworthy, and engaging. In a recent study about persuasion [19], robot gender was manipulated by changing its voice and name: the results found an influence on preferences in making donations, as the female robot received more donations from the participants. In a study on the robot guard RobotMan [20], its two tasks of security and guidance were associated with gender. The expression of the eyes and the tone of the voice influenced not only the perceived gender-related traits, but also physical attributions like body size as well as likeability.

These results suggest that we should consider manipulating the gender when designing robots for persuasive applications, which can be desireable for specific tasks.

1.1. Female Robots

In science fiction and in the entertainment industry, gendered robots have been portrayed quite often, mirroring the role of females in society. Much discussion has been raised over the risk of de-humanising women as a process of dehumanising female robots, and on the other hand, new terms such as *gynoid* and *fembot* have been created.

Meanwhile in robotics research, gendered robots are not too common.

In real life, some jobs are more typically associated with female gender, such as the receptionist, which is a role in which robots can be employed. In some countries like Brazil, more than 80% of receptionists are women [21]. In the survey described in [22], 38% of the participants expressed the explicit preference for a female robotic receptionist, compared to 6% who explicitly indicated a male robotic receptionist. A "roboceptionist" was first employed in Carnegie Mellon University, and it featured a conversational agent called Valerie displayed on a screen [23]. More recent works include the android Otonaroid and Saya [24]. In [22], a female agent was used as a receptionist in a hi-tech centre. The research in [25] investigated the effect of voice pitch on the evaluation of a social robot receptionist, showing that a female high-pitched voice was perceived significantly more attractive in terms of behaviour and personality compared to a calm, low-pitched voice.

The guidance robot IOmi [26], although in a stylised design, features a female appearance. Its torso has a yaw twisting motion supported by a cylindrical bearing to distribute the load throughout the skeleton. Such a cylinder is contained in a lower body that resembles a long skirt and that also contains the large-wheeled platform. This is a typical example of matching form with fuction, as the skirt is bigger at the bottom. Similarly, IOmi's head has one degree of freedom in the hair bun. As it is common for women to work having their hair tied, the top knot can symbolise that the robot is on duty and ready to provide services. At the same time, it can move, acting as a communication mean, effectively matching form with function.

The robot Flobi [27] is also worth mentioning, as it is a robotic head that was projected in a modular way, in order to be easily characterised as male or female, through the use of different sets of hair and mouth.

1.2. Anthropometrics

The present research will shed more light on the role of visual gender cues in robots, as these are particularly crucial for product design.

Thus, we aimed to investigate the perception of gender in robot design, focusing specifically on the proportion between chest, waist, and hips to indicate robot gender. By manipulating body proportions, it will be possible to influence user perception of the robot gender, as documented in previous research, and in particular for humanoids, enhance the feeling of intimacy. The novelty in the present paper consists in the manipulation of body proportions, which although extensively studied in anthropometrics, has never been done before on pictures of robot bodies.

We explore the chest–hip ratio and waist–hip ratio as subtle visual cues that are utilised to form gender-based impressions of novel robot prototypes. In anthropometrics, shoulder-to-hip ratio (SHR), chest-to-hip ratio (CHR), and waist-to-hip ratio (WHR) are typical indicators of human body types. We reviewed a number of studies that inspired the stimuli we used which were produced by a professional designer: in our study, a figure of a generic robot was used and adapted to different combinations of CHR and WHR.

In [28], shoulder-to-hip ratio was measured for human models: an average SHR of 1.39 was found for male models and a SHR of 1.23 was obtained for females. In comparison, average males had a SHR of 1.21, while average females had a SHR of 1.08. In their experiment [28], the authors used stimuli that were characterised as having a SHR of 1.2 for males and a SHR of 1.05 for females.

Chest-to-hip ratio represents a similar metric which does not take into account shoulder width. It is used in product design: for example, in the female doll "Bratz", the CHR was 0.82. This CHR score is similar to that of an adolescent female body [29].

Furthermore, the difference between upper and lower body is typically used in symbolism for public toilets: a triangle can be used to represent females because of its resemblance with a skirt. These kinds of symbols are widespread and recorded by institutes such as the American Institute of Graphic Arts (AIGA). Reversed triangle and circle can also be used as symbols for men and women, respectively. They recall broader shoulders of men and rounded bellies of pregnant women [30]. Squares are also typically associated with males and circles with females [31].

Waist-to-hip ratio is also an important measurement related to gender: higher testosterone levels in men stimulate fat deposits in the abdominal region while inhibiting fat deposits on the hips and thighs: healthy adult men generally have higher WHRs than women, with values ranging from between 0.85 and 0.95 [32]. For women, the ideal value is typically 0.70, while for men the ideal is approximately 0.90. In [28], the measurements of WHR resulted in a range of 0.70–0.90 for women and 0.90–1.10 for men.

Across cultures, a low waist-to-hip ratio represents a predictor of female body attractiveness [29]. Furthermore, the existence of a cross-cultural difference in the preferences regarding body fat and thinness is widely known [33]. In particular, plump females are typically linked with femininity and fertility among many non-western societies. At the same time, in some Asian countries, Confucianism may have an impact on food consumption, thus influencing the thin ideal of female body [34]. However, [33] also indicates that the largest differences in body size ideals are much less present due to modernisation and westernisation.

Since the last century, ideals in the west have been historically oscillating between the desirability of a round, plump body, and sexual attractiveness without maternity [33]. In the nineteenth century, the use of waist training and corsets allowed some women to achieve 0.50 WHR. The Bratz doll is hyper-feminised in such way, featuring a WHR of 0.52 [29]. Designers exploit product proportions and arrangement to evoke associations: a pronounced waist is typically used to indicate female gender [35].

The robot IOmi [26] features a pronounced feminine CHR and WHR in order to increase the perception of a female robot. Although it is not possible to calculate accurately since the exact position of the hip of IOmi is not defined, its CHR is around 0.6 and its WHR is around 0.5.

Pepper [36] features a CHR of approximately 1.30 and WHR of approximately 0.45. The large chest, necessary for the touch screen, contrasts with the small waist, and this may produce a mixed response in terms of visual and social perception.

1.3. The Present Experiment

In order to further study this topic, we conducted a study on the perception of stimuli consisting in robot body shapes, in which we manipulated CHR and WHR.

In the present experiment, our hypothesis is that the two body measurement ratios will impact the perception on gender of robots, namely: a higher CHR suggesting a male gender and a lower CHR a female gender; and a higher value of WHR (close to 1) indicating male gender and a lower WHR, a female gender.

As reported in the Introduction, background culture may play an important role in this kind of studies. For this reason, we performed a cross-cultural comparison between Peru and Japan, also including participants from other countries who were collected in the two countries, for a broader east–west comparison. Peru was the country from where this research originated subsequent to the development of the female robot IOmi [26]. Japan was chosen as a country for the main comparison because while being one of the world leading countries in terms of development of humanoids, it is very distant in terms of culture, and the role of women and gender stereotypes are distinct [37–40]. Due to these differences, we expect to find differences in the attribution of gender-stereotypical traits to the robots.

2. Method

2.1. Robot Body Shapes

In this research we used stimuli consisting in robot stylized body shapes, which were developed by a professional designer. The main goal was to manipulate CHR and WHR, not taking into account SHR. This was done because shoulder width might be a confounding factor: because of this, we decided to keep shoulder design constant.

In our study, the stimuli were manipulated using three levels of CHR: 0.80, 1.00 and 1.20; and two levels of WHR: 0.60 and 1.00. Within this range, the WHR of 0.60 was chosen as it was reported to be the average value of female attractiveness in several countries in Asia, Africa, and South America [41]. The WHR upper bound 1.00 was fixed because, beyond that threshold, WHR may be interpreted as an indicator of obesity in males [42].

The three CHR levels were defined taking into account one body type corresponding to the triangle symbolism in design, one body type for the opposite reversed triangle, and an additional one as middle value, corresponding to the squared shape. All the values were chosen coherently with the values reported in [29], and calculated from anthropometric studies [43]. Finally, and most importantly, the range of variation was kept approximately the same as the variation of WHR, in order to obtain two variables of the same visual importance.

The height of the waist within the body was set to approximately 37%, as calculated from the data reported in [43].

The lower parts of the robot body did not feature any "legs" (which could appear masculine) or a single "block" (which could activate the notion of femininity, looking like a long skirt), as they were represented just by a trunk together with a squared base, as in Figure 1. The robot head was designed to be as iconic and as generic as possible, featuring a slightly round shape.

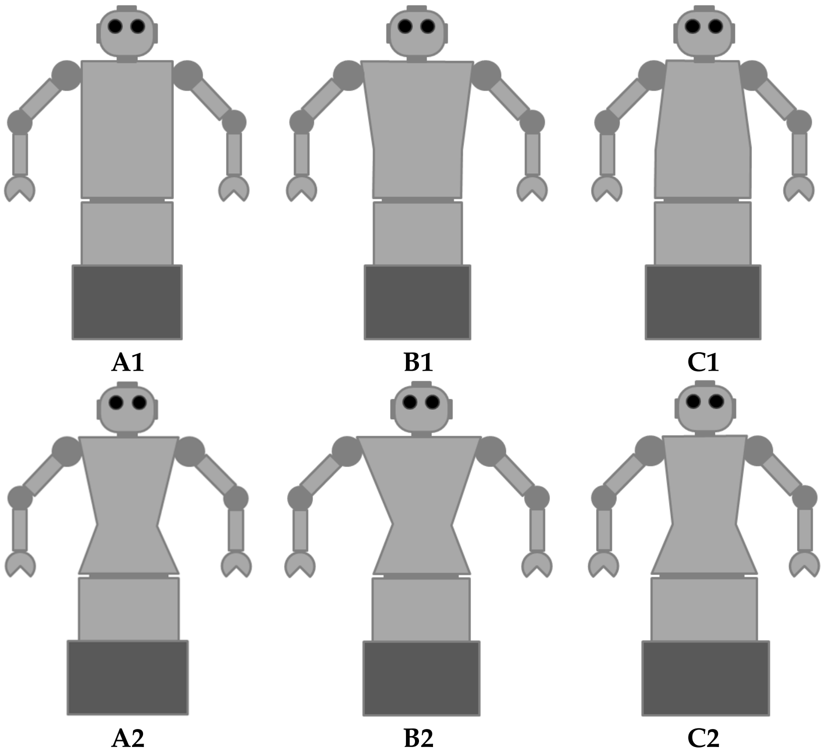

Figure 1. The six stimuli used in the questionnaire: in each row three different variations of chest-hip ratio; in each column two different variations of waist–hip ratio.

Figure 1 shows all the stimuli used in this research that correspond to the 2 × 3 combinations of WHR and CHR. They were drawn first by calculating waist and chest while keeping the hip size constant, and later resizing the width of the whole body. For resizing, the volume of the whole body (included lower body) was calculated and normalised. This was done in order to ensure the same perception in terms of body mass, and in order to avoid any of the stimuli being perceived as fat or slim.

2.2. Procedure

The participants filled an online survey. Firstly, participants were asked to provide demographic data (gender, age, nationality, familiarity with robots, familiarity with product design).

As a within-subjects design, participants rated each of the six stimuli that were presented in a randomised order. For each stimulus, participants completed a fill-in-the-blank task to measure attribution of gender to the prototypes. The text comprised an introduction such as "This robot is called ZX-A1".

The fill-in the-blank test consisted of a space in which participants had to insert the personal pronouns "he" or "she", to fit into the running text and complete the following sentence. While the gender-neutral pronoun "it" was not an option, participants could still choose to leave the field blank, or could alternately write a comment in a box below. This approach served to address the choice between male or female pronoun excluding a priori the most obvious choice "it", but without forcing the participants, effectively exploring their spontaneous initial impression of the robot.

The robot name was composed of random consonants and one of the suffixes A1 ... C2 as in Figure 1. This was done to avoid any undesired effects of a robot's name that might indicate gender.

Subsequently, we measured the effect of robot gender indirectly: by using a 5-point Likert scale ranging from 1 ("not at all"), to 5 ("very"), participants reported the extent to which gender-stereotypical attributes would apply to the robot prototypes, by using the Bem Sex Role Inventory [44].

Bem inventory traits are indicative of prototypically male "agency" and female "communion". Participants provided insights into the cues on which basis they came to their judgments using an open-ended response.

We believe that this way of understanding the perceived gender through the completion of a sentence and the choice of the pronoun corresponds to how spontaneously a user could perceive at first sight, compared to a semantic differential scale. For instance, in the recent interaction experiment in [26], it was observed that the robot, allegedly female, was referred to by using the pronoun "it" rather than "she", proving that participants spontaneously felt the robot to be asexual.

The questionnaire was available in three languages. For the Spanish version, the translation from [45] was used. Regarding the Japanese version, previous research in [46,47] employed, according to the authors, some incorrect and inconsistent translations. For this reason, we borrowed from those papers only the adjectives that seemed consistent, and manually translated the rest. Table 1 shows the employed adjectives.

Table 1. Translation in three language of the Bem sex-role inventory items.

English Attribute	Spanish Attribute	Japanese Attribute
affectionate	cariñoso/a	愛情深い
sensitive to others' needs	sensible a las necesidades de los otros	気が利く
dominant	dominante	支配的な
aggressive	agresivo/a	攻撃的な
warm	cálido/a	温かい
tender	tierno/a	繊細な
forceful	fuerte	力強い
loves children	amante de los niños	子ども好きな
strong personality	personalidad fuerte	強靭な心をもつ
acts as a leader	actua como líder	統率力のある

3. Results

3.1. Participants

A total of 161 participants took part in the online survey on volunteer basis, after giving consent. Data were collected in Peru and Japan, through social networks and within students of the Pontifical Catholic University of Peru and of Waseda University.

This number does not include all the respondents who filled in the survey incompletely, and duplicates. All those cases were excluded from the count.

Among the 161 (72 males, 89 females), the mean age was 25.9 (standard deviation (SD) = 8.49), ranging from 17 to 61. They were divided into 4 groups according to their nationality. One outlier was left out of this classification as her nationality was US/Taiwan and did not fit in any group; two more were left out because they stated in the comments that they answered randomly to the questions.

- **Japanese:** male = 22; female = 34; total = 56; age mean = 25.17; age SD = 7.86
- **Other Asians:** male = 12; female = 15; total = 27; age mean = 21.93; age SD = 3.74. Specifically: Chinese = 5; Taiwanese = 2; Indonesians = 3; Myanma = 1; South Koreans = 9; Mongolian = 1; Singaporeans = 3; Vietnamese = 2; Thai = 1.
- **Peruvians:** male = 27; female = 27; total = 54; age mean = 27.95; age SD = 9.59
- **Other Westerners:** male = 11; female = 10; total = 21; age mean = 28.33; age SD = 10.01. Specifically: Spanish = 3; Argentine = 1; Uruguayan = 1; Mexican = 3; Americans = 9; Italian = 1; German = 1; Finnish = 1; French = 1.

The analysis in the following sections is mainly based on Japan v Peru, with additional data on Asians v westerners.

3.2. Reliability

The dimensions of agency and communion of Bem items were verified to be reliable. Internal consistencies (Cronbach's alpha) were for agency: A1:0.79; A2:0.70; B1:0.80; B2:0.80; C1:0.75; C2:0.79. For communion: A1:0.87; A2:0.90; B1:0.89; B2:0.88; C1:0.91; C2:0.89.

3.3. Gender in Language Use

Figures 2 and 3 reveal the percentage scores regarding the use of personal pronouns "he" or "she" in the text passage for each of the robot body type. Participants referred to the robots most of the time using a male pronoun: only for the case of Peruvians and in general westerners, A2 and C2 were referred as "she". Only a small number of participants appeared undecided.

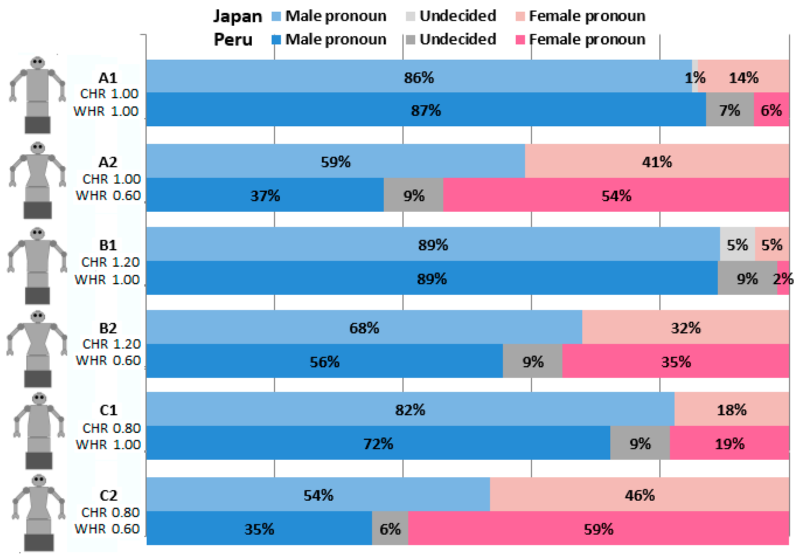

Figure 2. Declared gender ("he"/"she") for each of the six stimuli—Japan vs. Peru.

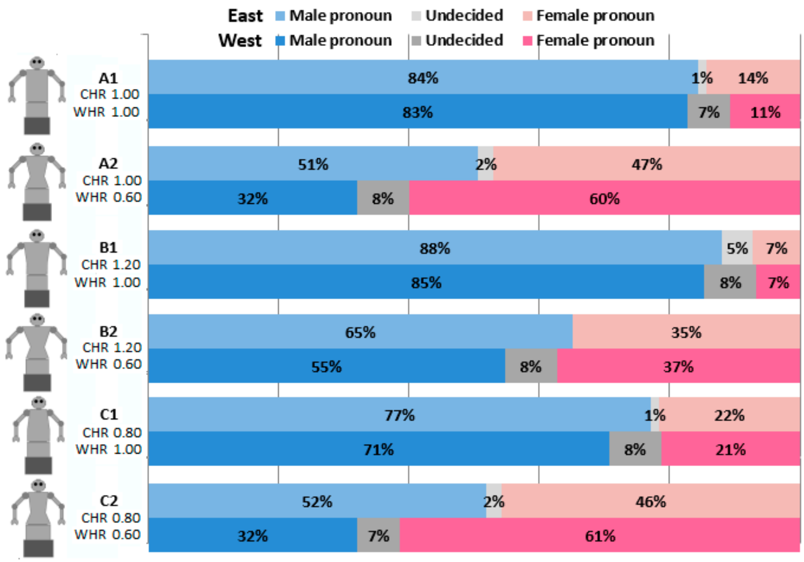

Figure 3. Declared gender ("he"/"she") for each of the six stimuli—east vs. west.

A generalized estimating equations (GEE) model was built to ascertain the effects of CHR (Type A/Type B/Type C), WHR (1/2) and cultural group (East/West) on the robot's sex identification made by participants (Male/Female). The GEE model displayed a QIC statistic (goodness of fit) value of 980.24. In such model, it was found that CHR (Wald's X^2 = 25.81, $p < 0.001$) and WHR (Wald's X^2 = 78.86, $p < 0.001$) significantly predicted the sex that participants attributed to the robots, and that cultural group did not exert an influence on participants' responses (Wald's X^2 = 3.60, $p = 0.058$). Similarly, the same GEE model was built considering only Peruvian and Japanese participants, and the findings remained constant, QIC = 647.20, CHR Wald's X^2 = 17.06 ($p < 0.001$), WHR Wald's X^2 = 65.93 ($p < 0.001$), Cultural Group Wald's X^2 = 2.08 (p = 0.149).

3.4. Stereotypical Attributes

Hereafter, we report the result on the investigation of the attribution of gender-stereotypical traits to the robot body types.

Regarding masculine traits, a 3 × 2 × 2 mixed factorial analysis of variance (ANOVA) revealed the main effects of the within subjects factors CHR, F(1.869) = 29.634, $p < 0.001$, $np^2 = 0.16$; and WHR, F(1) = 4.995, $p = 0.027$, $np^2 = 0.03$. No effect was found for the between subjects factor cultural group (East/West), F(1) = 0.048, $p = 0.827$, $np^2 < 0.01$. All interactions were non-significant and considered irrelevant for further analysis, all F $\leq$ 0.1.995, $p \geq 0.14$, $\eta p^2 \leq 0.01$. Regarding the CHR found effect, three Bonferroni corrected pairwise comparisons indicated that CHR type B (M = 1.67, SD = 0.95) scored higher in masculine traits than CHR type A (M = 1.34, SD = 0.83), $p < 0.001$, d = 0.37; and CHR type C (M = 1.30, SD = 0.87), $p < 0.001$, d = 0.43. Analogously, a 3 × 2 × 2 mixed factorial ANOVA was computed to ascertain the effects of CHR, WHR and cultural group considering only Peruvian and Japanese participants. The within subjects findings remained constant and no effect was found for cultural group (Peru/Japan), F(1) = 0.054, $p = 0.816$, $np^2 = 0.001$.

Regarding feminine traits, a 3 × 2 × 2 mixed factorial ANOVA revealed the main effects of the within subjects factors CHR, F(2) = 8.441, $p < 0.001$, $np^2 = 0.05$; and WHR, F(1) = 5.792, $p = 0.017$, $np^2 = 0.04$. No effect was found for the between subjects factor cultural group east/west, F(1) = 0.711, $p = 0.400$, np2 < 0.01. All interactions were non-significant and considered irrelevant for further analysis, all F $\leq$ 0.2.662, $p \geq 0.07$, $\eta p^2 \leq 0.01$. Regarding the CHR found effect, three Bonferroni corrected pairwise comparisons revealed an absence of significant differences among CHR types, all $p \geq 0.113$, $d \leq 0.07$. Figures 4 and 5 illustrate the breakdown of culture group-wise results. Similarly, a 3 × 2 × 2 mixed factorial ANOVA was computed to ascertain the effects of CHR, WHR and cultural group considering only Peruvian and Japanese participants. The within subjects findings remained constant for CHR, but not for WHR, F(1) = 3.631, $p = 0.059$, $np^2 = 0.033$. In addition, no effect was found for cultural group (Peru/Japan), F(1) = 0.479, $p = 0.491$, $np^2 = 0.004$.

3.5. Correlations

In order to further explore the statistical relationship regarding the attribution of traits, we conducted Spearman correlation analyses. The degree of attribution of female communion traits was negatively correlated both with familiarity with product design ($r(155) = -0.24$; $p = 0.003$), and with familiarity with robots ($r(156) = -0.19$; $p = 0.019$). Nothing significant was found between familiarity with products design and agency ($r(155) = -0.05$; $p = 0.5$), and familiarity with robots and agency ($r(156) = -0.12$; $p = 0.12$). Age of participant was also not correlated with either communion ($r(154) = -0.12$; $p = 0.12$) or agency ($r(154) = -0.11$; $p = 0.16$).

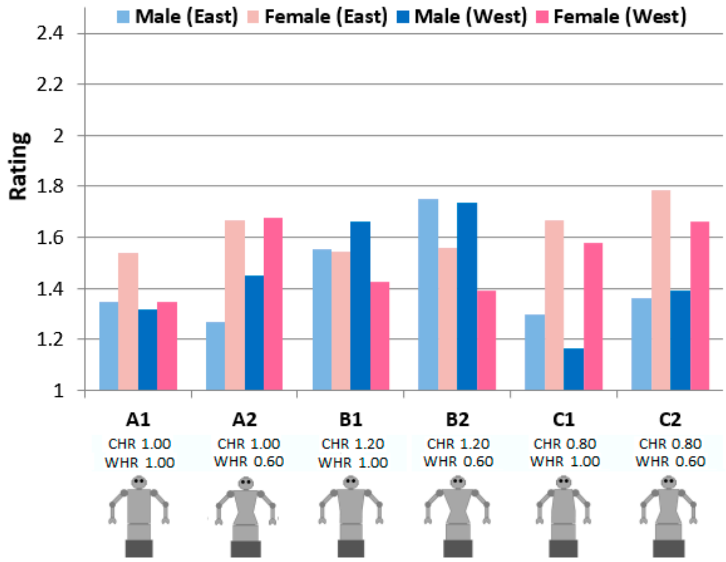

Figure 4. Rating of stereotypically male (agency) and female (communion)—Japan vs. Peru.

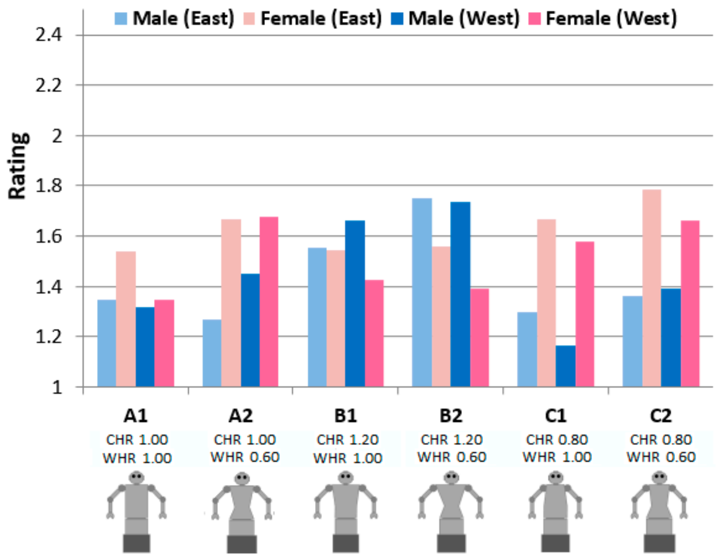

Figure 5. Rating of stereotypically male (agency) and female (communion)—east vs. west.

4. Discussion

4.1. Summary

In this manuscript we present the results of an investigation on the perception of gender in robot design, focusing specifically on the proportion between chest, waist and hips to indicate robot gender. Our goal was test whether the manipulation of chest-to-hip ratio and waist-to-hip ratio in robots would orientate the perception of robot gender and elicit gender-stereotypical trait attributions (agency and communion). We performed this experiment with a total number of participants of 158, from different countries.

Our hypotheses regarding body proportions were confirmed by the statistical analysis, and both WHR and CHR appear to influence the participants' choices of the pronoun. The two factors also play a role in influencing the more subtle choice of stereotypically male or female traits.

This pattern happens regardless of the cultural group east/west, contrary to our expectations. The more specific comparison Japan/Peru follow approximately the same pattern.

Perceived communion trait of robots was also found to be negatively correlated with familiarity with product design and with robots. The latter result was expected, as familiarity with robots and design exposes, respectively, how the robots and their pictures are made. A degree of habituation to robots may make them seen more as machines and reduce the degree of anthropomorphism. Similarly, a familiarity with product design may make the participant aware that the gender is characterised following some design rules, and this might specifically reduce the subtle attribution of traits.

One last thing to remark is the generally low scores of communion and agency, always below half of the scale (which is made of 5 points). This result suggests the need for further design cues to characterise the gender of robots.

4.2. Findings for Robot Design

Let us analyse the results with the concrete purpose of finding design advices for making gender-characterised robots.

From the statistical finding we can determine that, specifically, a CHR visibly greater than 1 suggests a male gender, whereas visibly less than 1 suggests a female gender. Body types A and C are considered more feminine, in an equivalent way differing from B.

WHR can also indicate female when visibly less than 1, whereas values close to 1 indicate male. Body type 2 is considered more feminine than 1.

Therefore, A2 and C2 are the most feminine, and B1 the most masculine.

Additionally, it seems that WHR is stronger than CHR to influence in participants choices.

The three other body types A1, B2 and C1 indeed convey mixed visual signals, which may end up in contradictory perception. This is confirmed by the mismatch visible from a qualitative analysis: A1 and C1 are seen mostly male, judging from the choice of pronoun, while having a high degree of attribution of feminine traits; conversely, B2 is attributed masculine traits, while a relevant share of participants (32 to 37%) choose a female pronoun for it.

These kinds of mismatches should be avoided in robot design, especially the case of humanoids and androids, in which misalignment of visual cues can be critical in the characterization of gender, unless specifically aimed for.

4.3. Confounds

While analyzing the results and the participants' comments, we realised of the presence of some confounds, which were unavoidable because of language.

In the Spanish language, the introduction sentence "This robot is ... (robot name) ..." reads "Este robot es ...". The demonstrative pronoun *este* is male even though commonly applied to any case when gender is not specified. The absence of a neutral form may have slightly biased the answers towards male gender. The same happens in other language such as French, and may have indirectly biased French speaking participants, even though filling the English questionnaire.

A few participants expressed a priori that the word 'robot' would be inherently male, and were also biased in that direction.

Additional minor confounds were found in colour, shape and naming of the stimuli. One subject opted for a male pronoun because according to him, "grey colour is male". Another participant was distracted by the shape of the head, despite it being made as neutral as possible.

A few other participants stated that the consonants Z, X, V, N, C, B and K were either suggesting a male or female name, and were influenced in their choice according to their own perceptions.

4.4. Limitations and Future Work

Besides the confounds, the main limitations of this study were that it was performed by using drawn figures rather than photos of a robot. While on the one hand this choice was made in order to use the most possible generic stimuli, on the other the external validity was limited, as the realistic photo of a robot can give a different impression.

Nevertheless, given the findings of the present research, we can highlight some additional developments. The present study showed the effectiveness of body size manipulation, however limited regarding the extent of subtle attribution of stereotypical traits. This fact prompts the need to stress gender through additional design cues: as stated in [12], it is important for robot designers to consider a combination of physical characteristics rather than focusing specifically on certain features in isolation. We can find new ideas from the detected confounds of our study. Naming, shape and colour could be manipulated and influence gender perception in a subtle way. Further research should focus on these aspects without resorting to trival means of characterisation.

Author Contributions: G.T. and C.L. ideated the experiment and prepared the stimuli; R.P. analysed the data and reported the results; G.T. wrote the rest of the paper.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

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