How Human Likeness, Gender and Ethnicity affect Elders'Acceptance of Assistive Robots

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***Abstract*—The present study investigates the extent to which robots' 1) degree of human likeness, 2) gender and 3) ethnicity affect elders' attitude towards using robots as healthcare assistants. To this aim 2 groups of 45 seniors, aged 65 + years, were asked to watch video clips showing three speaking female and male robots, respectively. Each set of stimuli consisted in 2 androids, one with Caucasian and one with Asian aspect, and 1 humanoid robot. After each video clip elders were asked to assess, through the Robot Acceptance Questionnaire (RAQ) their willingness to interact with them, as well as robots' Pragmatic, Hedonic and Attractive qualities. Through this investigation it was found that male seniors were more proactive than female ones in their attitude toward robots showing more willingness to interact with them and attributing more positive scores to robots' qualities. It was also observed that androids were clearly more preferred than humanoid robots no matter their gender. Finally, seniors' preferences were for female android robots with Asian traits and male android with Caucasian traits suggesting that both gender and ethnical features are intermingled in defining robot's appearance that generate seniors' acceptance.**

Keywords*—*robot's acceptance, elder users, humanoid/android robots, robots' gender, robots' ethnicity.

I. INTRODUCTION

Robots are already accessible and commercially available to consumers, assuming an integral role in the current and future society. Being able to perform a wide variety of tasks, they find applications in many areas of our everyday life. Industrial robots, for example, work on production assignment (logistic, manufacturing), service robots, on the other hand, assist humans in their tasks including domestic or household chores, transportation like self-driving cars, and defense applications such as survey drones. [1]. Robots are also applied to education, to facilitate learning and improve educational performance of students [2]; to medicine, for medical diagnoses and treatments, for supporting surgeries, as well as in rehabilitation exercises [3] and robots are foreseen as home or office personal assistants [4]. These applications, in addition to requiring improved sensors and very sophisticated technologies, imply a closer interaction with the user. Therefore, understanding robots' acceptance by their final users is central for appropriately informing designers in developing robots that will meet users' requirements and expectations and will be widely, satisfyingly, and pleasantly adopted.

These requirements are particularly important and compelling for healthcare robots assisting older people. Such robots are intended to promote and/or monitor seniors' health status, providing aids in everyday tasks, preventing physical and cognitive decline, through physical, mental, social, and emotional exercises useful for solving psychosocial problems. Technological assistive supports helping elders to retain their independence become even more indispensable considering the overgrowing elder population and the shortage of healthcare professionals [5]. To this aim, it is crucial to investigate which features a robot should possess in order to be accepted as part of elders' life.

Among the factors that have been identified in the literature as potentially impacting robot acceptance, appearance plays an important role in human-robot interaction and have critical effects on whether a robot can be adopted by elderly [6]. Whether a robot's shape should be more similar to a machine or be a human-like shape keeps controversial all the time [7] and, although there is a lot of research on this issue, there is still a lack of knowledge in what elders would prefer regarding robots' appearance [8]. In addition, when considering interacting with human-like looking (or android) robots users' expectations and behaviors are the same as in human-human interaction. Those who interact will exploit facial features, gender, age, ethnicity, and more to categorize each other, make inferences on their behaviors and take decisions about accepting, understand, and feeling engaged with their interlocutor. All of these features together are then, the first source for users to understand and accept the robot [9].

With the intent to further explore how these features affect elders' attitude towards healthcare technology and therefore robots' acceptance, the present study aims at investigating: a) elders' preferences towards robots with different degrees of human-likeness (humanoid versus android types); b) elders'

preferences for robots' gender; and c) elders' preferences for robots' ethnicity.

II. Material and Method

The experiments assessed elder's perception of female and male android and humanoid robots. Moreover, the considered android robots, with high degree of human-likeness, have Caucasian and Asian appearance.

Participants' willingness to interact with the robots, and their evaluation of robots' pragmatic, hedonic, and attractive qualities were investigated.

A. Participants

The study involved a total of 90 participants, all aged 65+ years and in a good health status, split into two groups. Group 1: 45 participants (23 females, mean age=73.04; SD=±7.03) evaluated video clips depicting female robots. Group 2: 45 participants (26 females, mean age=72.44; SD=±6.40) examined video clips depicting male robots. Participants' recruitment took place in Campania (south of Italy). They joined the study on a voluntary basis and signed an informed consent formulated according to the Italian and European laws about privacy and data protection. The research was authorized by the ethical committee at the Università degli Studi della Campania "Luigi Vanvitelli" with the protocol number 25/2017.

B. Stimuli

Six robots were selected for the experiment, three females and three males. Each set consisted in 2 androids, one with Caucasian and one with Asian traits, and 1 humanoid robot. The female robots were: Pepper, renamed "Tina" in order to contextualize its gender as female, (Figure 1a), Erica (Figure 1b) and Sophia (Figure 1c). The male robots were Romeo (Figure 2a), Geminoid HI-1, renamed Yuri, (Figure 2b) and Geminoid DK, renamed Albert (Figure 2c).

Sophia is an android robot developed by the Hanson Robotic company. Pepper and Romeo are humanoid robots developed by SoftBank Robotics. Erica, Geminoid HI-1(Yuri) and Geminoid DK (Albert) are android robots developed by Professor Hiroshi Ishiguro from Osaka University. More specifically, Geminoid HI-1 is the exact replica of Professor Ishiguro, while Geminoid DK looks like Professor Henrik Scharfe of Aalborg University in Denmark. Video clips available on the website "YouTube" were selected for each of the abovementioned robots. The selected video clips showed the selected robots half torso, in a forward position. The video clips were edited in order to last approximatively the same duration (4-7 sec.) and each robot was provided with female and male synthetic voices respectively. The synthetic voices were created through the Natural Reader synthesizer (www.naturalreaders.com), recorded using the free audio software Audacity (www.audacityteam.org), and inserted in each robot's video clip using the application "Videomomenti", freely available on the Windows10 operating system. The speech produced was the Italian sentence "Ciao sono Tina/ Erica/ Sophia/ Romeo/ Yuri/ Albert. Se vuoi posso aiutarti nelle tue attività quotidiane" (Hi, my name is Tina/ Erica/ Sophia/ Romeo/ Yuri/ Albert. If you want, I would like to assist in your daily activities).

Fig. 1. The three selected female robots.

Fig. 2. The three selected male robots.

C. Tools

A digitalized version of the Robots' Acceptance Questionnaire (RAQ) was exploited in order to collect data concerning participants' preferences toward the proposed robots. It was the robotic version of the Virtual Agent Acceptance Questionnaire (VAAQ) developed inside the H2020 project Empathic (http://www.empathic-project.eu/) and described in detail in [10]. The questionnaire was created using a Java script and allowed to automatically randomize the presentation order of the questionnaire's sections presented to each participant. The questionnaire was, indeed, structured into 8 sections, plus an initial part, consisting of six items, devoted at gathering participants' socio-demographic information. Section 1 was made up by seven items, collecting details about participants' degree of experience with technology, and degree of difficulty while using technological devices such as smartphones, tablets, and laptops. Section 2 investigated participants' willingness to interact with the proposed robots, this section consisted in a single item. Section 3, 4, 5 and 6 (each one comprising ten items) assessed respectively: 1) robots' Pragmatic Qualities (PQ), i.e. how useful, effective, practical, clear and controllable the proposed robot is perceived; 2) robots' Hedonic Qualities-Identity (HQI), i.e. how original, creative, presentable, and aesthetically pleasing the proposed robot appears; 3) robots' Hedonic Qualities- Feeling (HQF) concerning both positive and negative emotions aroused by the vision of the robot; 4) robots' Attractiveness (ATT) evaluating how the proposed robot encourage increased use and positive emotions [10, 11].

Section 7, through three items, assessed whether and how robots' perceived age can affect participants' willingness to interact with them, while section 8 (composed by four items) evaluate which occupations participants would entrust to the

proposed robot among healthcare, housework, protection/security, and front office.

Questionnaire's items from sections 2, 3, 4, 5 and 6 required a response based on a 5-point Likert scale from 1=strongly agree, 2=agree, 3=I don't know, 4=disagree, to 5=strongly disagree. Moreover, since the questionnaire's sections 3, 4, 5 and 6 contemplate either positive or negative answers, scores from negative items were corrected in a reverse way. This implies that low scores summon to robots' positive evaluations, whereas high scores to negative ones.

D. Procedures

Participants, after being informed about the intent of the experiment and instructed on how to proceed, signed the informed consent. They were first asked to provide sociodemographic information and answer to the items in the section 1. Then, they watched and listened to each robot's video clip and, immediately after, they were required to complete for the seen video clip the remaining sections of the RAQ digitalized questionnaire.

III. RESULTS

In a first investigation, distinct ANOVA repeated measures analyses were carried out on the scores obtained from participants' group 1 and 2, in order to investigate elders' preferences among female and male robots, separately. In both the analyses, participants' gender was considered as between factor variable, and the scores at each RAQ section's items (willingness to interact, pragmatic qualities, hedonic qualities -identity and feeling- and attractiveness) were considered as within factors variables. The significance was set at $\alpha < .05$ and differences among means were assessed through Bonferroni's post hoc tests.

A second investigation was performed in order to assess whether and how the robots' type (android/humanoid) and ethnicity (Caucasian androids, Asian androids and humanoids) affect elders' preferences. In this case, the ANOVA repeated measures analysis was performed considering participants' and robots' gender as between factors variables. Again, the scores obtained at each RAQ section's items (willingness to interact, pragmatic qualities, hedonic qualities -identity and feeling- and attractiveness) by Caucasian android (Albert and Sophia), Asian android (Yuri and Erica) and humanoid (Romeo and Tina) robots were considered as within factors variables. The significance was set at $\alpha < .05$ and differences among means were assessed through Bonferroni's post hoc tests.

It is worth recalling that due to the reverse correction of negative items, low scores summon to positive robots' assessments whereas high scores to negative ones.

A. Results - Female Robots' Assessment

Willingness to interact

No significant effects of participants' gender ($F(1,43) = 2.825$ $p = .100$) were found. A significant difference emerged among female robots concerning participants' willingness to interact with them ($F(2,86) = 14.613$, $p << .01$). Bonferroni's post hoc tests revealed that seniors showed a greater willingness to interact with Erica (mean= 2.482) rather than Sophia (mean= 3.414, $p << .01$) and Tina (mean= 3.260, $p << .01$).

Pragmatic Qualities

Robot's pragmatic qualities were not affected by participants' gender ($F(1,43) = 3.185$ $p = .081$) even though seniors significantly differed in their assessment of robots' pragmatic qualities ($F(2,86) = 6.710$, $p = .002$). Bonferroni's post hoc tests showed that this significant difference was between Erica (mean=27.766) and Sophia (mean= 30.715 $p = .002$), and not for Tina (mean= 29.247).

Hedonic Qualities (Identity)

Robot's hedonic qualities (identity) were significantly affected by seniors' gender ($F(1,43) = 5.070$, $p = .030$). Tina, Sophia and Erica were better evaluated by male (mean= 27.288) rather than female participants (mean= 31.290, $p = .030$). Seniors significantly differed in their assessment of robots' hedonic qualities (identity) ($F(2,86) = 18.780$, $p << .01$). Bonferroni's post hoc tests revealed that these differences were due to Erica (mean= 25.895) which was better evaluated than Sophia (mean= 31.354, $p << .01$) and Tina (mean= 30.618, $p << .01$).

Hedonic Qualities (Feeling)

Robot's hedonic qualities (feeling) were significantly affected by participants' gender ($F(1,43) = 6.042$, $p = .018$). Female robots were evaluated better by male (mean= 24.727) rather than female participants (mean= 29.159, $p = .018$). Seniors significantly differed in their assessment of robots' hedonic qualities (feeling) ($F(2,86) = 8.410$, $p << .01$). Erica (mean= 24.760) aroused more positive feelings than Sophia (mean= 28.213, p=. 001) and Tina (mean= 27.857, $p = .004$)

Attractiveness

Robot's attractiveness was significantly affected by seniors' gender ($F(1,43) = 7.427$, p=. 009). Female robots were considered more attractive by male (mean= 26.439) rather than female participants (mean= 31.087, p=.009). Seniors significantly differed in their assessment of robots' attractiveness ($F(2,86) = 8.152$, $p = .001$). Once again, Erica (mean= 26.674) showed greater engagement abilities than Sophia (mean= 30.261, $p << .01$) and Tina (mean= 29.355, p=. 017).

In summary, female robots were more positively evaluated by male rather than female participants, and among the three robots, Erica received significantly higher approvals for

willingness to interact, attractiveness, and hedonic (identity and feeling) qualities. These results are depicted in figure 3.

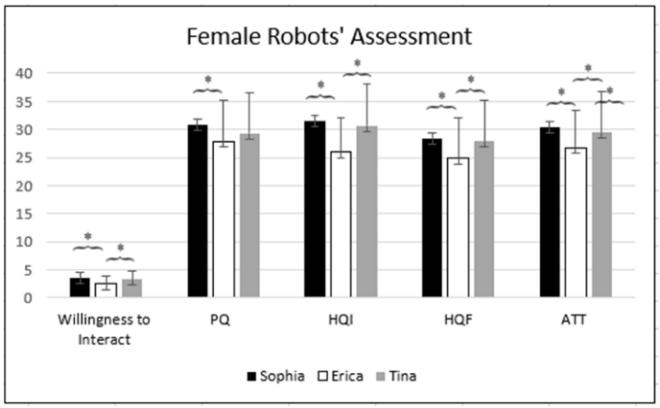

Fig. 3. Female robots' assessment (see text)

B. Results - Male Robots' Assessment

Willingness to interact

No significant effects of participants' gender (F (1,43) = 1.597, p= .213) and participants' willingness to interact (F (2,86) = .417, p= .660) with the proposed male robots (Albert mean= 2.641; Yuri mean= 2.634; Romeo mean= 2.497) were found.

Pragmatic Qualities

No significant effects of participants' gender (F (1,43) = .785, p= .381) and no significant differences (F (2,86) = 2.253, p= .111) in elders' evaluation of robots' pragmatic qualities (Albert mean= 28.465; Yuri mean= 29.341; Romeo mean= 29.712) were found.

Hedonic Qualities (Identity)

Robot's hedonic qualities (identity) were not affected by participants' gender (F (1,43) = .706, p= .405) even though seniors significantly differed in their assessment of robots' hedonic qualities (identity) (F (2,86) = 6.605, p= .002). Bonferroni's post hoc tests revealed that Albert (mean= 28.115, p= .019) and Yuri (mean= 28.433, p= .013) were evaluated significantly better than Romeo (mean= 31.014).

Hedonic Qualities (Feeling)

No significant effects of participants' gender (F (1,43) = .515, p= .477) and no significant differences (F (2,86) = 1.019, p= .365) in elders' evaluation of robots' hedonic qualities (feeling) (Albert mean= 25.938; Yuri mean= 26.661; Romeo mean= 26.759) were found.

Attractiveness

No significant effects of participants' gender (F (1,43) = .472 p= .496) and no significant differences (F (2,86) = 1.369 p= .260) in elders' evaluation of robots' attractiveness (Albert mean= 27.281; Yuri mean= 28.415; Romeo mean= 28.364) were found.

To summarize, male robots differed significantly only for hedonic qualities (identity), where Albert and Yuri were significantly preferred to Romeo. These results are summarized in figure 4.

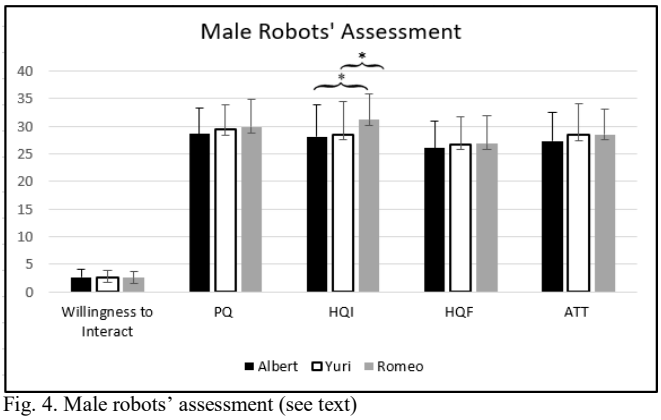

Fig. 4. Male robots' assessment (see text)

C. Results – Human-Likeness, Robots' Ethnicity and Gender (Caucasian Android, Asian Android and Humanoid robots' comparison).

Willingness to interact

A significant effect of participants' gender (F (1,86) = 4.401, p= .039) emerged. Male participants (mean= 2.557) were more available than female (mean= 3.086 p= .039) to interact with the proposed robots. No effects of robot's gender (F (1,86) = 3.348, p= .071) and no interactions between robots' and participants' gender (F (1,86) = .227, p= .635) appeared.

Participants' willingness to interact with the robots (F (2,172) = 7.016, p= .001) was significantly affected by the robots' type. Bonferroni's post hoc tests showed that Asian android robots – Yuri and Erica (mean=2.558) significantly differed from the Caucasian androids – Albert and Sophia (mean= 3.027, p=.001) and the humanoid robots - Romeo and Tina (mean=2.878, p=.038). Results also showed an interaction (F (2,172) = 8.590, p<<.01) between robot's gender and robots' types for participants' willingness to interact with them. Bonferroni's post hoc tests revealed that the Caucasian android Albert (mean= 2.641) was preferred to Sophia (mean= 3.414, p=.015); and the humanoid Romeo (mean= 2.497) was preferred to Tina (mean=3.260 p= .009).

Pragmatic Qualities

No significant effects of participants' (F (1,86) = 3.900, p= .051) and robots' gender (F (1,86) = .004, p= .952)

emerged., No significant interactions emerged between robots' and participants' gender (F (1,86) = 1.033, p= .312) and no significant differences (F (2,172) =2.551, p= .081) emerged among the type of robots in terms of their pragmatic qualities. A significant interaction (F (2,172) =7.628, p= .001) emerged between robots' gender and elders' assessment of robots' pragmatic qualities. However, when Bonferroni's post hoc tests were performed these differences disappeared due to multiple Bonferroni's adjustments.

Hedonic Qualities (Identity)

Significant effects of participants' gender (F (1,86) = 5.307, p= .024) were observed, since male (mean= 27.960) evaluated robots better than female participants (mean= 30.517, p=.024). No effects of robots' gender (F (1,86) = .008, p= .928) were found. No significant interaction between robots' and participants' gender (F (1,86) = 1.695, p= .196) emerged. Significant differences among robots' types (F (2,172) = 16.538, p<<.01) were observed for hedonic qualities (identity). Bonferroni's post hoc tests revealed that Asian androids – Yuri and Erica (mean=27.164) received better scores than Caucasian androids – Albert and Sophia (mean= 29.735, p<<.01) and humanoid robots – Romeo and Tina (mean=30.816, p<<.01). An interaction between robots' gender and seniors' assessment of their hedonic qualities (identity) (F (2,172) = 10.021 p<<.01) was observed. Bonferroni's post hoc tests showed that the Caucasian android Albert (mean= 28.115) was better evaluated than his female counterpart Sophia (mean= 31.354, p= .030) while the Asian android Yuri (mean= 28.433, p= .047) less preferred than his female counterpart Erica (mean= 25.895).

Hedonic Qualities (Feeling)

Significant effects of participants' gender (F (1,86) = 5.787, p= .018) were observed, since male participants (mean= 25.355) evaluated robots' hedonic qualities (feeling) better than female participants (mean= 28.041, p= .018). No significant effects of robots' gender (F (1,86) = .193, p= .662) and no significant interaction between robots' gender and participants' gender (F (1,86) = 2.444, p= .122) emerged. Significant differences concerning seniors' assessment of robots' hedonic qualities (feeling) (F (2,172) = 4.738, p= .010) emerged among robots' types. Asian androids (mean= 25.710) differed significantly from Caucasian android (mean= 27.076, p= .034) and humanoid robots (mean= 27.308, p= .013). A significant interaction emerged between robots' gender and seniors' scores on their hedonic qualities (feeling) (F (2,172) =7.372, p=.001). However, when Bonferroni's post hoc tests were performed these differences disappeared due to multiple Bonferroni's adjustments.

Attractiveness

Significant effects of participants' gender (F (1,86) = 6.684, p=. 011) were observed. Male (mean= 27.009) evaluated robots more attractive than female participants (mean= 29.774, p=. 011). No significant effects of robots' gender (F (1,86) = .482, p= .489) and no significant interactions between robots' and participants' gender (F (1,86) = 3.098, p= .082) emerged. No significant differences (F (2,172) = 2.969, p= .054) were found among robots' types concerning seniors' assessment of robots' attractiveness. An interaction between robots' gender and seniors' assessment of robots' attractiveness (F (2,172) = 7.717, p= .001) emerged. Bonferroni's post hoc tests revealed that seniors showed to prefer the Caucasian android Albert (mean= 27.281) significantly more that its female counterpart Sophia (mean= 30.261, p= .025).

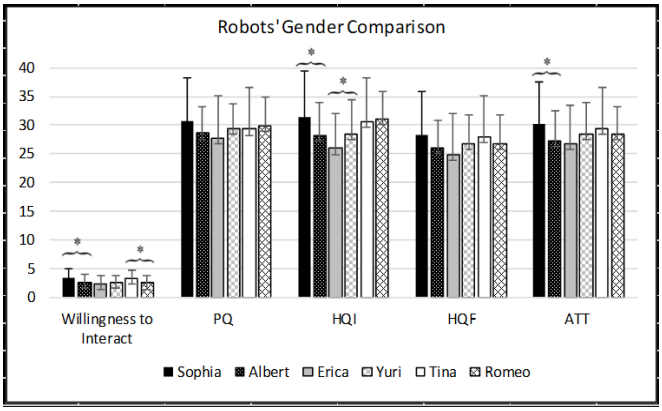

Fig. 5. Comparison among Caucasian, Asian android and Humanoid (male and female) robots.

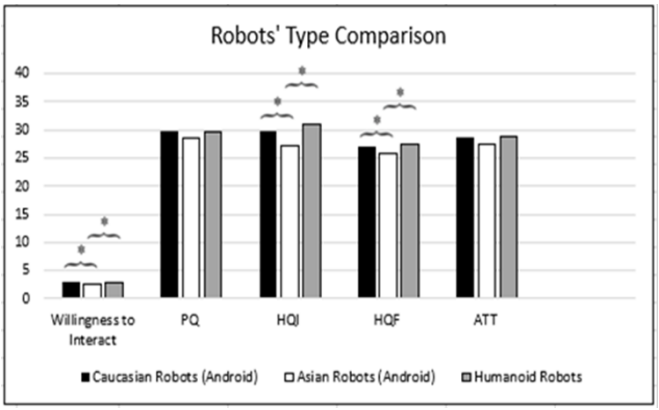

Fig. 6. Comparison among Android and Humanoid robots.

In summary, the comparison among robots' types showed that males were significantly more positive than female participants in their willingness to interact and their evaluation of robots' hedonic (identity and feeling), and attractive qualities. As depicted in figure 5, seniors showed a preference for the Asian android robots (Yuri and Erica) with respect to the Caucasian android (Albert and Sophia) and the humanoid (Romeo and Tina) robots in terms of willingness to interact and hedonic (identity and feeling) qualities. As shown in figure 6, seniors' preferences were also affected by the gender of each proposed robots' type (Asian and Caucasian androids and humanoids). In particular, the male robots Albert and Romeo were preferred with respect to their female counterparts Sophia and Tina for the willingness to interact. Albert was preferred to Sophia for the hedonic (identity) and

attractive qualities. Instead the Asian android Erica was preferred to its male counterpart Yuri for the hedonic quality (identity).

IV. CONCLUSIONS

This study aimed at assessing elders' preference towards robots' appearance, considering robots' degree of human-likeness (humanoid and android types) gender and ethnicity (Asian and Caucasian). The obtained results reveal that elders have a positive attitude to interact with robots and prefer the android type. Indeed, when evaluating the sets of female and male robots, elders found the female robot Erica and the male robot Albert more useful, appealing, pleasant and engaging than the female robots Sophia and Tina, and the male robots Yuri and Romeo. Along the debated issue about the need for a robot to be more machine or human-like shaped, this data could lead to speculate that a human-like looking robot may stimulate users to attribute to it human qualities and behaviors, instilling sense of familiarity and trust. This possibly seems to be of significant value for elder users dealing with assistive robots.

As regarding the effect of the robots' gender, the comparative analysis shows that Albert (the Caucasian male robot) was considered more able to encourage interaction, more likeable and attractive than his female counterpart Sophia. On the other end between the two Asian android robots, Erica was considered more pleasant and enjoyable than her male counterpart Yuri. These results suggest that for android robots, i.e. for robots showing a high degree of human-likeness, gender preferences are not so straight as it has been shown for virtual agents [10]. Preferences may be strongly driven by the human-likeness and consequently social expectations. Therefore, it was expected that the Asian android Erica was significantly preferred to the Caucasian android Sophia and the humanoid Tina. Sophia is designed without hair which is something socially unusual in human females, and this feature may have generated seniors' rejection. This social effect seems to be strong to the extent that scores assigned to Sophia and Tina are similar and differ significantly from those assigned to Erica both in seniors' willingness to interact, as well as, for pragmatic, hedonic, and attractive qualities seniors assigned to the three female robots. This was not true for male robots (see figure 4). In this case the Caucasian android Albert scored significantly better than the Asian android Yuri and humanoid Romeo only for the hedonic quality of identity, i.e. on only on how seniors considered original, creative, presentable, and aesthetically pleasing the proposed robots.

The results of this investigation also suggest that male seniors were significantly more available to be assisted by robots than female seniors. Male seniors scored significantly better than females ones on their willingness to interact with robots and on their attributing positive scores to robots' hedonic (identity and feeling) and attractive qualities. This result is particularly true for female robots to which male seniors' scores were always significantly higher than female ones both for hedonic (identity and feeling) and attractive qualities. This result may find its justification in seniors' cultural and social heritage, which in the case of south Italian people conceives a form of labor division exemplified through cultural distinctions among masculine and feminine professions. In this social culture, men were assisted by women in the domestic spheres (and when they were sick, for food, for housework jobs) also during their active life. Therefore, male seniors may be more prone to be assisted than women while aging. However, these preferences may change for societies with a different cultural heritage. At the light of these considerations, further investigations are needed to help robots' developers in designing assistive technologies able to efficiently meet elders' expectations.

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