Elders prefer female robots with a high degree of human likeness

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***Abstract*— Elders' acceptance of robots is still a novel field and a clear research methodology to assess users' preferences has not yet been developed. The exploitation of robots, as assistive technologies, requires the properly identification of users' needs and expectations and the matching of robot's role, appearance, and behavior to these needs. Robot's degree of resemblance to humans may play a fundamental role on their acceptance into domestic spheres. The present paper investigates elders' preferences towards female robots showing different levels of human likeness (two androids and a humanoid robot are involved in the study) considering their pragmatic, hedonic and attractive dimensions, as well as occupations elders entrusted to robots. A total of 51 elders (29 females) aged 65+ years were recruited. Participants were asked to watch video clips showing three speaking female manufactured robots (Erica, Sophia, and Pepper) and after each video clip, the Robot Appearance Questionnaire (RAQ) was administered. The results highlight that the degree of robot's human likeness affects elders' preferences in favor of android robots. Elders expressed a clear preference for female android rather than humanoid robots, in contrast with the current trend observed in literature. In addition, female robots were considered more suitable in performing housework rather than protection/security, healthcare, and front office occupations**

Keywords*— *Assistive technologies; Human-robot interaction; Users' acceptance

I. INTRODUCTION

Robot's technology is rapidly advancing through the implementation of autonomous and skilled systems to be exploited into domestic spheres, as for example, elders' assistants. Elders can appropriately be considered potential users of robot assistants since aging cause physiological and cognitive declines, making them more vulnerable and less efficient than young people in their autonomous living. Robots can assist elders in accomplishing several home-based tasks allowing them to continue living independently in their own homes [1], supporting them in executing several daily activities and monitoring their cognitive and health status [2]. It is imaginable that in a near future, assistive robots will play an essential role in elders' daily lives, considering that the aging of the worldwide population, will make prohibitive the costs to ensure to each senior in need a human assistant. For aged people, the acceptance of assistive robots (i.e. the extent they are willing to include such technology into their life) *"is an adaptive negotiation between the improvements provided by the offered resource and the struggles required to allocate it into their personal environment"* [3, p. 2]. In addition to the offered functionalities, to be considered are the emotional feelings robots' assistants may arouse, cognitive efforts required for their use, engagement they produces, and associated costs in having them. To be part of elders' life, it is crucial to investigate which features a robot should possess in order to be socially accepted. Seniors show a positive attitude toward robots, considering them useful instruments especially in workplaces entailing difficult and repetitive tasks. Moreover, robots are perceived by elders as helpful assistants for disabled people and capable to provide entertainment and companionship [4]. However, because of the "uncanny valley" effect [5] it is expected that elders tend to prefer humanoid rather than android robots since the first are designed to have slightly human resemblances, while android robots are almost equal to humans in appearance and behavior [6]. This hypothesis has been qualitatively confirmed by Wu and colleagues' research [7]. In this study 26 different robot's pictures (see [7] for details) were displayed on a screen to fifteen 65+ years aged adults, of which 3 were males, 8 were in good health status, and 7 diagnosed with mild cognitive impairments. After the vision of the robot's pictures, participants were asked to express their opinions on the seen robots. The selected group of elders criticized most of the seen robots, except for some *"small creative humanoid robots"* [7, p.1]. The Wu and colleagues' study [7] was qualitative rather than quantitative, and expressed a tendency. This tendency was quantitatively confirmed by Ferrari and colleagues [8]. The authors presented to a group of 182 differently aged participants (from 19 to 63 years, mean=27.70, SD=± 6.3) 18 photos depicting three mechanical (the four legged explorer robot of Toshiba, the Modular Snake by Carnagie Mellon University, and the Nomad Heavy Duty Wheeled Robot by CrustCrawler Robot), three humanoid (Kojiro, Kobian, and HRP4), and three android (Jules, Philip K- Dick, and Geminoid DK) robots and administered them the psychological scale for general impressions of humanoids (PSGIH) [9]. Their results showed that the more human-like are the robots, the more they are considered by human participants, as a *"damage to humans and to human identity"* [8, p. 290]. These studies support a negative perception of robots in general, and of android robots in particular, and seem do not justify the high economic investment for the development of social robots. However, Wu and colleagues' study was conducted considering 26 robots (both with android and humanoid semblances) through open

sessions where elders were invited to express their opinion after watching static pictures and video clips of the robots under examination. The interviews were not structured and several dimensions contributing to the concept of robot's appearance were neglected. The Ferrari and colleagues' research was conducted using only male resembling android robots, and among humanoid robots, only HRP4 was a female robot. The tree mechanical robots were, to a certain extent ill-considered, since they were far to be considered social, and surely with their shape cannot be accepted into domestic spheres. In addition, the shape of the mechanical robots may have affected the general mood and scared participants involved in the task. Finally, the work of Ferrari and colleagues covered a wide range of ages rather than assessing only seniors' opinions. Taking into account the gaps mentioned above, the present study aims at:

- Assess elders' preferences of only female humanoid and android robots;
- Assess seniors' preferences toward robot's ethnicities;
- Assess occupations seniors would entrust to female robots.

II. Material and Methods

The proposed investigation involved seniors aged 65+. The experiment investigated how elders perceive female android and humanoid robots, their willingness to interact with them, and their scoring of pragmatic, hedonic, and attractive dimensions. In addition, the experiment assess which occupations seniors would entrust to robots among healthcare, housework, protection/security, and front office.

A. Participants

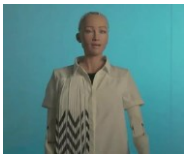
The 51 involved subjects (29 females), aged 65+ years (mean age=71.33; SD=±6.65), were in good health status. They were recruited in Campania, a region in the south of Italy. Participants joined the study on a voluntary basis and signed an informed consent formulated according to the Italian and European 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

The three robots selected for the experiment were: Pepper (Figure 1a) a humanoid robot developed by SoftBank Robotics. This robot was renamed as "Tina" in order to contextualize its gender as female. Erica (Figure 1b) an android robot with Asian traits created by Hiroshi Ishiguro and Dylan Glas, and Sophia (Figure 1c) an android robot with Caucasian traits developed by the Hanson Robotic company. A video clip was selected from videos available on "YouTube" for each robot. The selected video clips showed robots half torso, in a face-to-face position as they were addressing directly the seniors. The video clips were modified in order to last approximatively the same duration (5-7 sec.) and each robot was granted with a female synthetic voice. The synthetic female 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 Erica/ Tina/ Sophia se vuoi posso aiutarti nelle tue attività quotidiane*" (*Hi, my name is Erica / Tina/ Sophia. If you want, I would like to assist in your daily activities*).

(1a) Pepper (Tina)

(1b) Erica



(1c) Sophia

Fig. 1. The three selected female robots.

C. Tools

A questionnaire was developed in order to collect data concerning seniors' preferences toward the proposed robots. The questionnaire was structured into two sections. Section 1 was devoted at collecting participants' socio-demographic information, their degree of experience with technology, and their degree of difficulty while using technological devices such as smartphones, tablets, and laptops. Section 2 investigated seniors' preferences toward the three robots. This section included 3 subsections. The first subsection was devoted to assess seniors' willingness to interact with robots. The second was composed of 4 clusters each consisting of 7 items, either foreseen positive or negative answers, inspired by the AttrakDiff questionnaire [10], and investigating:

- Robots' Pragmatic Qualities (PQ): how useful, effective, practical, clear and controllable robots are perceived;
- Robots' Hedonic Qualities-Identity (HQI): how original, creative, presentable, and of good taste, robots appear.
- Robots' Hedonic Qualities-Stimulation (HQS): how exciting and engaging robots are sensed;
- Robots' Attractiveness (ATT): how attractive robots are considered, encouraging their increased use and positive emotions.

The third subsection was devoted to assess occupations seniors would entrust to robots among healthcare, housework, protection/security, and front office jobs. Each questionnaire's item 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. Since both the first and second subsection of the questionnaire (except the third subsection concerning robots' occupations) predicted either positive or negative answers, scores from negative items were corrected in a reverse way. This implies that for the first and second subsections, low scores summon to positive evaluations, whereas high scores to negative ones. Currently the questionnaire has been deeply revised summing up into a version called Robots' Appearance Questionnaire (RAQ), exemplifying the robotic version of the Virtual Agent Acceptance Questionnaire (VAAQ) developed inside the H2020 project Empathic (http://www.empathic-project.eu/) and described in details in [3].

D. Procedures

Participants were first asked to provide answers to items of section 1, then watch each robot's video clip and immediately after to complete the questionnaire's items from section 2.

III. Results

The results of the proposed experiment were assessed through ANOVA repeated measure analyses. Participants' gender was considered as between factor. The scores robots obtained at subsections 1 (willingness to interact) and 2 (pragmatic, hedonic, and attractive qualities) were considered as within factors. The significance level was set at $\alpha < .05$ and differences among means were assessed through Bonferroni's and when useful to enlighten seniors' preferences also Least Significant Difference (LSD) post hoc tests. Due to the reverse correction of negative items, low scores summon to positive robots' assessments whereas high scores to negative ones. ANOVA repeated measures analyses were also carried out to assess differences among occupations seniors would entrust to robots. Also in this case, seniors' gender was considered as between factor and scores obtained by each robot for their entrusted occupations - among healthcare, housework, protection/security, and front office jobs - as within factors. Again, the significance was set at $\alpha < .05$ and differences among means were assessed through Bonferroni's post hoc tests. When useful to enlighten seniors' preferences also LSD post hoc test were performed.

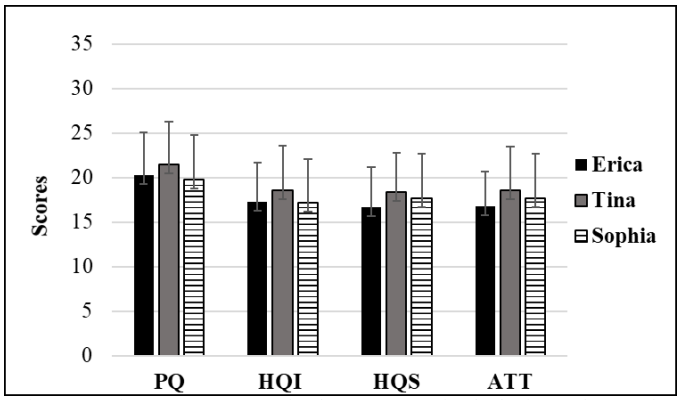


Fig. 2. Seniors' assessment of robots' pragmatic, hedonic, and attractive dimensions.

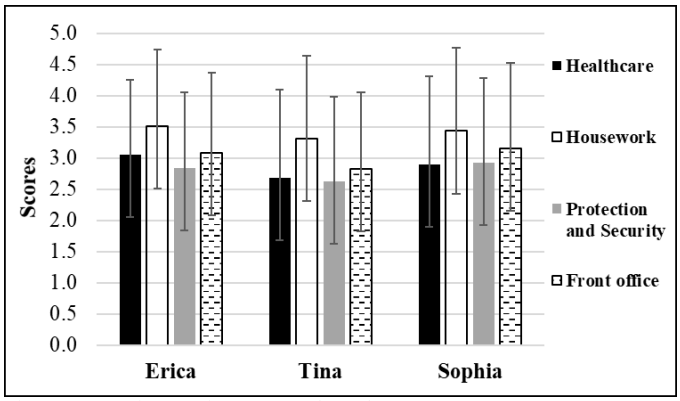


Fig. 3: Occupations seniors entrusted to robots.

A. Willingness to interact and robots' pragmatic, hedonic, and attractive dimensions

This section reports results concerning seniors' willingness to interact with each robot and their preferences concerning robots' pragmatic, hedonic, and attractive dimensions.

Willingness to interact: No participants' gender effect was found ($F(1,49) = .066$, $p = .798$). No significant differences emerged for seniors' preferences to interact with one particular robot ($F(2, 98) = 1.367$, $p = .260$). Seniors declared to feel equally comfortable in interacting either with Pepper, or Erica, or Sophia. In addition, the mean scores obtained by robots for this questionnaire's item (Erica mean= 2.16; Tina mean= 2.42; Sophia mean= 2.05) suggest that seniors evaluated positively a potential interaction with the robots, considering it as "likely possible".

Pragmatic qualities (PQ): No participants' gender effect was observed concerning the assessment of robots' pragmatic qualities ($F(1,49) = .013$, $p = .908$). The pragmatic qualities attributed by elders differed significantly among the three robots ($F(2,98) = 3.989$, $p = .022$). However, when Bonferroni's post hoc tests were performed these differences disappeared due to multiple Bonferroni's adjustments. A seniors' slightly preference first for Sophia, and then for Erica with respect to Tina was observed comparing the PQ means obtained by robots (Erica mean = 20.289, Tina mean = 21.502, Sophia mean =19.735). This consideration is sustained by LSD post hoc tests reporting a significant difference between Tina and Sophia ($p = .017$), and no significant differences between Tina and Erica ($p = .053$) and Sophia and Erica ($p = .350$).

Hedonic qualities- identity (HQI): No participants' gender effect was found ($F(1,49) = .771$, $p = .384$). No significant differences ($F(2, 98) = 2.446$, $p = .092$) emerged among robots concerning participants' assessment of hedonic qualities (identity). However, comparing the HQI means obtained by robots (Erica mean = 17.388, Tina mean = 18.625, Sophia mean =17.195), a slightly preference toward Sophia was observed. This preference was confirmed by LSD post hoc tests which reported a slightly significant preference for Erica with respect to Tina ($p = .043$) and a more robust significant preference for Sophia with respect to Tina ($p < .01$). No significant differences were observed between Erica and Sophia ($p = .755$).

Hedonic qualities- stimulation (HQS): No participants' gender effect was found ($F(1,49) = .000$, $p = .984$). A significant difference ($F(2, 98) = 4.202$, $p < .05$) emerged among robots (Erica mean = 16.779, Tina mean = 18.317, Sophia mean =17.596) concerning hedonic qualities' (stimulation). Bonferroni's post hoc tests revealed that these differences were due to a significant preference of seniors for Erica with respect to Tina ($p < .01$). No significant differences emerged between Sophia and Erica ($p = .578$) and Tina and Sophia ($p = .488$).

Attractiveness (ATT): No participants' gender effect was observed concerning the assessment of robots' attractiveness ($F(1,49) = .416$, $p = .522$). Significant differences were observed among robots (Erica mean =16.820, Tina mean =

18.625, Sophia mean =17.714) for the attractiveness scores (F(2,98)=6.970, p=.001). Bonferroni's post hoc tests revealed that these differences were due to a significant preference of seniors for Erica with respect to Tina (p<.01). No significant differences emerged between Sophia and Erica (p=.155) and Tina and Sophia (p=.198). These results suggest that Tina was the less favorite by elders for the pragmatic, hedonic and attractive dimensions. Figure 2 illustrates these results.

B. Occupations seniors entrusted to robots

This section summarizes results concerning occupations seniors entrusted to robots among healthcare, housework, protection/security and front office jobs. Please note that for these results low and high scores indicate respectively that seniors considered robots less or more suitable in accomplishing the proposed tasks.

Erica: No participants' gender effect was found (F (1,49) = 1.716, p=.196) among participants for Erica's possible occupations. Significant differences (F(3,147) = 3.767, p=.012) were found concerning Erica's suitability to the four different proposed occupations (Erica means for: healthcare=3.089; housework= 3.491, protection/security =2.888, front office =3.087). Bonferroni's post hoc tests revealed that Erica was considered significantly more suitable for housework than protection/security tasks (p=.026). No significant differences emerged concerning Erica's adequacy in performing the remaining proposed occupations. A significant interaction was found between participants' gender and Erica's entrusted occupations (F(3,147)=4.618, p<.01). Bonferroni's post hoc tests revealed that this was due to significant differences between male and female participants, with male considering Erica significantly more suitable than female participants in performing protection / security tasks (male mean =3.348, female mean = 2.429, p<.01).

Tina: No participants' gender effect was found (F (1,49) = .331, p=.568) for Tina. Significant differences (F (3,147) = 4.705, p<.01) emerged concerning Tina's suitability to perform the four different proposed occupations (Tina means for: healthcare = 2.675, housework = 3.290, protection / security =2.649, front office=2.804). Bonferroni's post hoc tests attributed these differences to the fact that Tina was considered more suitable by seniors for housework tasks with respect to healthcare (p<.02), protection/security (p<.01) and front office jobs (p<.05). No interaction was found between participants' gender and Tina's entrusted occupations (F(3,147) = 2.337, p=.076).

Sophia: No participants' gender effect was found (F (1,49) = .245, p=.623) for Sophia. Significant differences (F(3,147) = 2.808, p<.05) emerged concerning the assessment of Sophia's suitability to perform the four different proposed tasks. Bonferroni's post hoc multiple adjustments do not allowed to identify which occupations produced these differences. Nevertheless, Sophia's suitability to the four different proposed occupations received the following scores: healthcare=2.269; housework=3.416, protection/security =2.936, front office=3.162, suggesting that seniors were more keen to see Sophia in performing housework and front office rather than healthcare and protection/security tasks. No interaction was found between participants' gender and Sophia's entrusted occupations (F(3,147) = 1.557, p=.202). Figure 3 illustrates these results for the three proposed robots.

IV. CONCLUSIONS

The data obtained in this investigation shows an elders' positive tendency to initiate an interaction with female robots, and a clear preference toward android robots. This was observed for the pragmatic, hedonic and attractive dimensions, debating the suggested "uncanny valley" effect attributed to anthropomorphic robots, and some results reported in literature ([7-8] among others). A possible explanation of these results, in contrast with those reported by the current literature, is that female robots proposed as assistant are more accepted and overcomes the feelings of eeriness aroused by male robots. As regards robots' adequacy to occupations such as healthcare, housework, protection/security and front office, it emerged that elders showed a clear preference in considering Erica, Tina and Sophia more suitable in performing housework rather than protection/security, healthcare, and front office tasks. This could be linked to a seniors' cultural heritage tending to make a distinction among professions entrusted to men and women [11]. Finally, with respect to the humanoid robot Pepper, the Caucasian robot Sophia was considered more useful and of good taste, and the Asian robot Erica was considered more engaging and attractive suggesting some effects due to the different ethnicities of the proposed android robots. These results open rather than close several questions, suggesting that further investigations are needed to guide robot's design in assistive technologies, in order to understand the extent elders' preferences and perceptions are affected by robots' gender, ethnicity, and their appearance in general.

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