Seniors' appreciation of humanoid robots

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Abstract. This paper is positioned inside a research project investigating elders' preferences and acceptance toward robots, in order to collect insights for the design and implementation of socially assistive robots. To this aim, short video-clips of five manufactured robots (Roomba, Nao, Pepper, Ishiguro, and Erica) were shown to 100 seniors (50 Female) aged 65+ years (average age: 71.34 years, DS: ±5.60). After watching each robot video-clip, seniors were administered a short questionnaire assessing their willingness to interact with robots, feelings robots aroused, and duties they would entrust to robots. The questionnaire's scores were assessed through ANOVA repeated measures in order to ascertain statistically significant differences among seniors' preferences. A clear uncanny valley effect was identified. The robot Pepper received significantly higher scores than Roomba, Nao, Ishiguro, and Erica on communication skills, ability to remind friendly and pleasant memories, comprehension, and ability to provide emotional support. In addition, Pepper was considered the most suitable, among the five proposed robots, in performing welfare duties for elders, children and disabled, protection and security, and front desk occupations.

Keywords: assistive technologies, uncanny valley effects, user's requirements, and expectations, user's acceptance, senior's preferences.

1. Introduction

Given the foreseen aging of the European populations (Eurostat 2018), it has become incumbent on society to improve the effectiveness of health care systems in providing social assistance and continuous monitoring of elderly physical and cognitive quality of life in order to set up prevention measures and timely treatments, provide assistance and rehabilitation tools, and concurrently lighten the costs for social care.

To this aim, robotic and virtual assistive technologies have been considered. In particular, several robotic assistants have been proposed for supporting elder's caregivers and relatives in their daily assistance routines. However, pursuing this, research have neglected to investigate to which degree elders accept to undertake an interaction with such robots.

For elders, accepting to be assisted by robots requires cognitive loads related to the difficulties to understand their functioning and adaptive efforts to allocate these resources in their personal environments. In addition, it has been observed that robots' appearance plays a fundamental role in terms of their acceptance (Phillips et al. 2017). To be accepted, robots must be reassuring, friendly, pleasant, able to interpret elders' emotional and social behavior, and must establish with them trustworthy relationships, supporting their health, and simplifying their access to telemedicine and

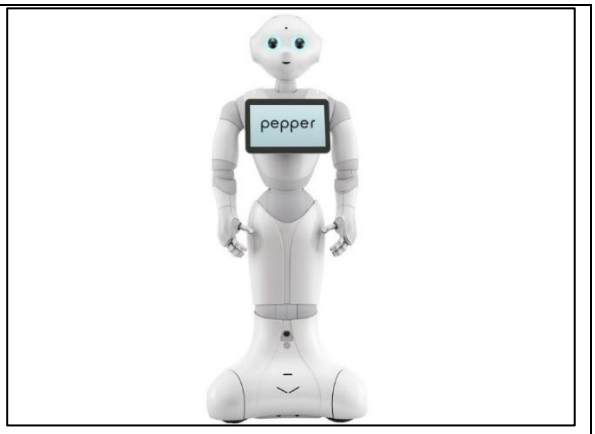
tele-care support services (Esposito & Jain 2016, Esposito et al. 2015). Acceptance to use a robot on a daily basis is a complex concept. It requires: a) strong users' motivations; b) accessibility and easiness of use; c) trustworthiness; d) comfortable and reassuring appearance of robots and e) robot' ability to interpret individuals' social rules and cognitive competencies (Peek et al. 2014, Komatsu et al. 2012, Maldonato & Dell'Orco, 2015, Troncone et al. 2014, Esposito & Esposito 2012, Broadbent et al., 2009). Users can experience the "uncanny valley" effect (Mori, 1970; Misselhorn, 2009), a situation in which a seemingly 'intelligent' human-like artefact trigger feelings of oddness and repugnance – the exact opposite of acceptance – generating an interactional failure. The "uncanny valley" effect manifests itself when a person is faced with human-like artifacts characterized by a certain percentage of resemblance to human beings. Familiarity with the stimulus, and probably positive feelings connected to it, increase up to a certain point, and then begin to decrease dramatically as the percentage of human likeness increases, associated with long lasting feelings of discomfort and strangeness. Wang et al. (2015) observed that the uncanny feeling is a multifaceted construct that cannot be reduced neither to a negative emotional response aroused by the excessive resemblance of the artifact to human semblances (Zlotowsky, 2015), nor to the emergence of an innate survival instinct in response to a threat, being the artifact deceptive and then, perceived as dangerous or harmful (MacDorman, 2015). Rather, the uncanny valley effect is due to a "*dehumanization process*" triggered by the detection of mechanistic features in artifacts assuming humanlike semblances. "*The more human observers attribute humanlike characteristics to (i.e., anthropomorphize) a human replica, the more likely detecting its mechanistic features triggers the dehumanization process that would lead to the uncanny feeling*" (Wang et al. 2015, p. 402, first column). The experiments proposed in the present research, suggest that, as long as important human features such as voice, body movements, and facial expressions cannot be appropriately rendered in robots, *the dehumanization process* leading to the uncanny valley effect due to the mechanistic features of humanness is observed (Brenton et al. 2005). In order to assess these effects, the present research investigates elders' willingness to interact with five manufactured robots (Roomba, Nao, Pepper, Ishiguro, and Erica), evaluating their perception of robot human likeness, feelings aroused and mansions entrusted to robots. It is essential to highlight that, while the concept of appearance is very complex and involve many physical and social factors, the proposed research restricts its investigation to the level of human-likeness displayed by robots.

2. Material and Methods

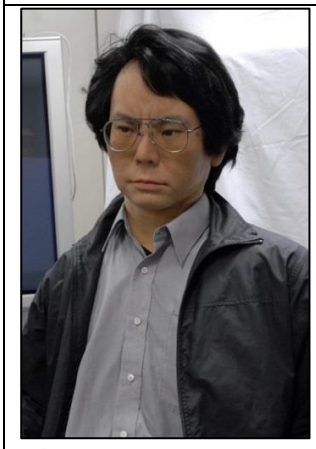
2.1 Stimuli

Five mute video clips depicting five well know robots were exploited. The videos were downloaded by "YouTube" search engine and edited in order to create short clips of approximately 40 seconds duration. The selected robots were: Roomba, Pepper, Nao, Erica, and Ishiguro (Fig. 1). *Roomba* is vacuum cleaner robot (www.irobot.it/roomba/), designed to help people in daily household cleaning; *Nao* (www.softbankrobotics.com/emea/en/nao) and *Pepper* are humanoid robots proposed by SoftBank Robotics (www.softbankrobotics.com/emea/en/robots/pepper) with the aim of assisting people in their daily life. *Ishiguro* is the exact copy of Ishiguro Hiroshi, (http://www.geminoid.jp/en/index.html) professor of artificial intelligence at University of Osaka, Japan. Hiroshi Ishiguro is also the creator of *Erica*, a robot capable of holding a conversation with humans while moving her facial features, neck, shoulders, and waist, with very closely resembling human movements. As previously stated, and as it appears evident from Fig. 1, the five proposed robots show different degrees of similarity to human beings. Roomba is a non-humanoid robot, the one among the five that is less reminiscent of human features. Nao and Pepper are humanoid robots, characterized by features vaguely resembling humans. Ishiguro and Erica, are android robots showing extreme levels of human likeness both in terms of shape, body movements, and facial expressions.

Roomba

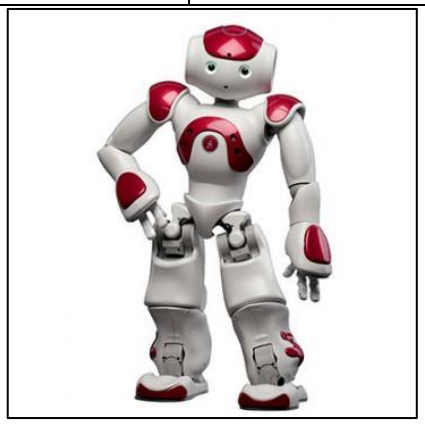


Pepper



Ishiguro

Erica



Nao

Fig. 1: The five manifactured robots exploited for the proposed investigation

2.2 Participants

The experiments involved 100 participants (50 females) all aged 65+ years (mean age= 71.34, SD= ±5.60) recruited in Campania, a region in the south of Italy. Participants reported vision corrected with glasses, several chronic diseases (such as prostatitis, benign tumor, esophageal reflux, diabetes, and arterial hypertension) but no psychological disorders. Participants joined the experiment on a voluntary basis, and signed an informed consent formulated in accord with the privacy and data protection procedures established by the current Italian and European laws. The experiment was approved by the ethical committee of the Università della Campania “Luigi Vanvitelli”, Department of Psychology, code number 25/2017.

2.3 Tools and Procedures

Participants were asked to watch each robot's video clip and immediately after complete a questionnaire. The questionnaire was divided into three clusters. The first cluster comprised two single items aimed at evaluating respectively seniors' willingness to interact with each robot, and robot's human likeness ("appearance"). The second cluster , named "Impressions" was constituted by six items, aimed to assess feelings aroused by robots in terms of 1) communication skills, 2) ability to arouse memories of someone or something, 3) efficiency, 4) language comprehension, 5) reliability, and 6) ability to provide emotional support. These items were assessed both as a whole under the label "Impressions" and singularly. The last cluster investigated occupations seniors would entrust to robots among welfare, housework, security/protection, and front office jobs. Each questionnaire item was rated on a 7-point Likert scale ranging from 1= not at all, to 7= very much. Participants were initially asked to read and sign an informed consent and fill in a data sheet providing information about their age, gender, educational level, and health problems. Subsequently, they were asked to watch each robot video clip and immediately after fill in the questionnaire. Participants were grouped into two groups. A first group of 50 subjects (25 males and 25 females) saw the video clips of Roomba, Pepper, Nao, and Ishiguro, while the second group (50 subjects, 25 males and 25 females) saw the video clips of Roomba, Pepper, Nao, and Erica. The experiment was conducted in participants' private dwellings. In order to avoid visual interference, a laptop with a bright, non-reflective screen was used. Participants were positioned on a chair next to a table in a quiet room. The experiment lasted approximatively 15 minutes.

3. Analysis and Results

Several ANOVA repeated measure analyses, using the IBM SPSS (Statistical Package for Social Science) software, were conducted on the questionnaire's scores in order to assess participants' preferences toward robots in terms of willingness of interact ("Interaction"), degree of human likeness ("Appearance"), "Impressions" (both including as a whole the 6 items mentioned in section 2.3, and considering each item singularly) and "Occupations" entrusted to robots. Repeated measure ANOVA analyses were carried out considering participants (and only for Ishiguro and Erica robots' gender) as between factors. The scores obtained by each robot at items evaluating willingness to interact "Interaction", human likeness "Appearance", and "Impressions" , as well as those obtained for each occupation entrusted to robots, were considered as within factors.

The following sections compare the scores obtained, first for the android robots Ishiguro and Erica, and then for Roomba, Nao and Pepper. Since Pepper emerged as being favorite with respect to Roomba, and Nao, the scores obtained by Pepper, were compared with those obtained by Ishiguro and Erica, respectively.

Ishiguro vs Erica

No significant differences were found both for participants and robot gender (Ishiguro and Erica), nor for the within factors Interaction, Appearance, and Impressions (neither as a whole or as for each single item constituting the cluster). These results suggested that none of the two robots resulted favorite by elders. Significant differences were found among occupations seniors would entrust to robots ($F(3.294) = 7.261$ $p << .01$), with welfare (mean = 3.310) and front office (mean = 3.658) considered largely more suitable for them than protection/security (mean = 3.000) and housework (mean = 3.050). A significant interaction emerged between robot gender and occupations ($F(3.294) = 5.869$ $p < .01$). Bonferroni post-hoc tests showed that Erica (mean = 4.340)

was considered significantly more suitable than Ishiguro (mean =2.960) for front office occupations (see Fig. 2). No significant differences between the two android robots emerged for welfare, housework, and security/protection.

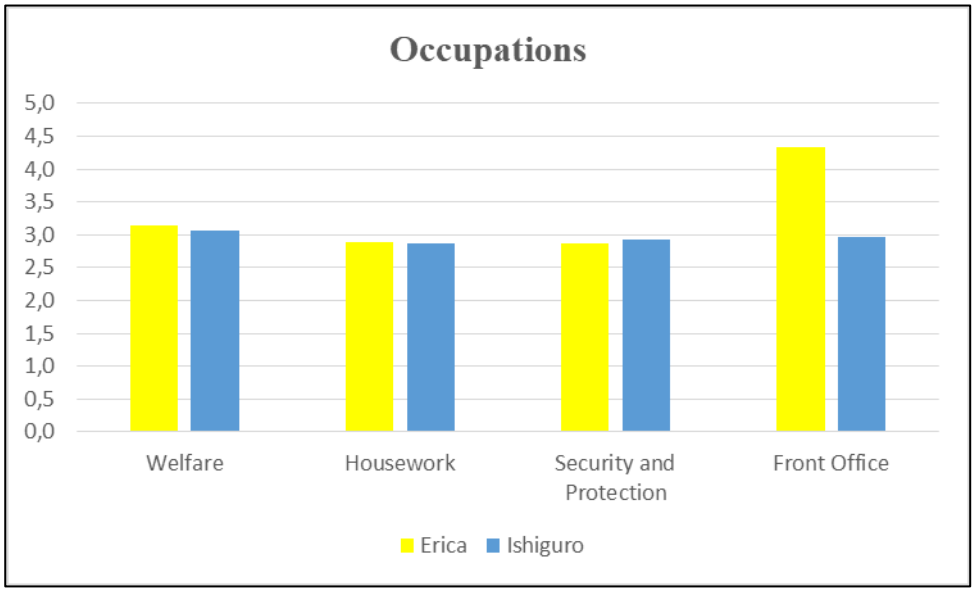


Fig. 2: Scores obtained for occupations entrusted to Erica and Ishiguro. Erica was considered more able to perform front office tasks

Roomba vs Nao vs Pepper

Unlike Ishiguro and Erica, the whole sample of participants (100 subjects) watched the video-clips of Roomba, Nao and Pepper. Repeated measure ANOVA analyses were conducted considering participants' gender as a between factor and "Interaction", "Appearance", "Impressions" and "Occupations" as within factors. No participants' gender effect was found. Significant differences emerged for the within factors. Detailed repeated measure ANOVA were performed on the single variables willingness to interact, appearance, and impressions. No significant differences among robots (Roomba mean= 4.080, Nao mean=4,450, Pepper mean= 4,430) were observed for the elders' willingness to interact with them ($F(2, 196) = 2.230$, $p = .110$). Pepper's appearance (Pepper mean = 4.320, see Fig. 3) was rated significantly better ($F(2,196) = 50.946$, $p << .01$) than Roomba (Roomba mean = 2.820, $p << .01$) and Nao (Nao mean = 4.220, $p << .01$). Pepper was also able to arouse significantly overall more positive (Pepper mean = 25.480) "Impressions" ($F(2,196) = 82.935$, $p << .01$) than Roomba (Roomba mean = 16.380, $p << .01$) and Nao (Nao mean = 23.700, $p << .01$). Nao was considered slightly significantly more human-like than Roomba ($p = .017$). Detailed analyses concerning items constituting the cluster "Impressions" revealed that Pepper (Pepper mean = 4.530, see Fig. 4), was considered significantly more communicative ($F(2,196) = 97.338$, $p << .01$) than Roomba (Roomba mean = 2.050, $p << .01$) and Nao (Nao mean = 4.160, $p = .038$), more able to arouse memories of someone or something ($F(2,196) = 21.146$, $p << .01$) than Roomba ($p << .01$), (Roomba mean = 2.130, Nao mean = 3.010, Pepper mean score= 3.200), more able to understood participants' language ($F(2,196) = 109.712$, $p << .01$) than Roomba ($p << .01$) (Roomba mean = 1.910, Nao mean = 4.000, Pepper mean = 4.380), slightly more reliable ($F(2,196) = 5.106$, $p = .007$) than Roomba ($p = .028$) (Roomba mean = 3.850, Nao mean = 4.080, Pepper mean = 4.220), and more able to provide emotional support ($F(2,196) = 75.982$, $p << .01$) than Roomba ($p << .01$) and Nao ($p << .01$) (Roomba mean = 2.050, Nao mean = 3.790, Pepper

mean = 4.380). In addition, Nao was considered significantly more communicative, more able to arouse memories of something, more able to understand participant language and more able to provide emotional support than Roomba (p<<.01). These results proved that the two android robots were preferred to the non-android robot Roomba. In addition, Pepper was preferred (it scored significantly higher) to Nao for emotional support and communication abilities. The analyses assessing preferences for robots' potential occupations revealed significant differences among robots for welfare (F (2,196) =47.248, p<<.01), protection/security (F (2,196) =18.122, p<<.01), front-office (F (2,196) =57.269, p<<.01) and housework (F (2,196) =41.932, p<<.01). Bonferroni post-hoc tests showed that Pepper and Nao were considered significantly (p<<.01) more suitable than Roomba (p<<.01) for welfare (Roomba mean= 3.250, Nao mean = 4.700, Pepper mean = 4.780). Pepper was considered significantly more suitable than Nao (p=.028) and Roomba (p<<.01) and Nao significantly more suitable than Roomba (p<.01) for protection/security (Roomba mean=3.020, Nao mean =3.760, Pepper mean = 4.190). Pepper was considered significantly more suitable than Nao (p=.017) and Roomba (p<<.01), and Nao significantly more suitable than Roomba(p<<. 01) for front-office (Roomba mean = 2.270, Nao mean = 3.930, Pepper mean =4.340, see Fig. 5). Roomba was considered significantly more suitable than Pepper (p<<.01) and Nao (p<<.01) for housework (Roomba mean = 5.050, Nao mean= 3.420, Pepper mean=3.740). No participants' gender effects were found.

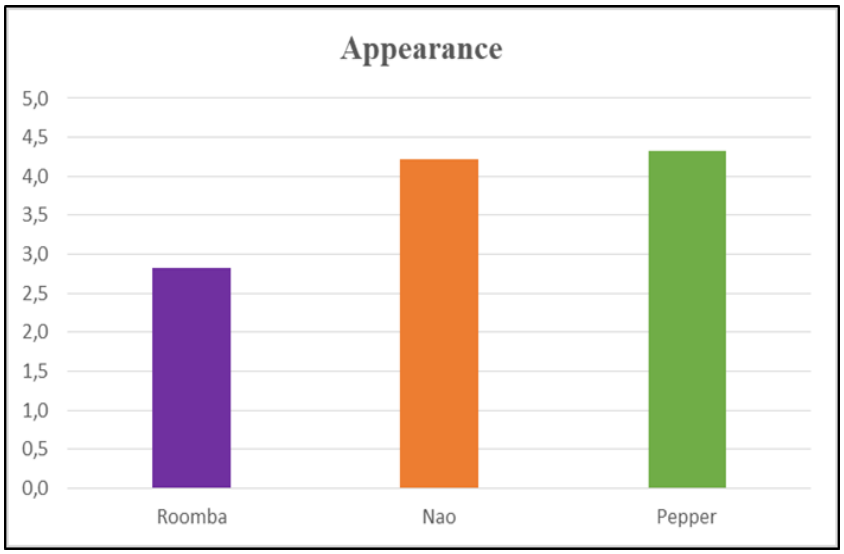


Figure 3: Preferences expressed by elders for the variable "Appearance"

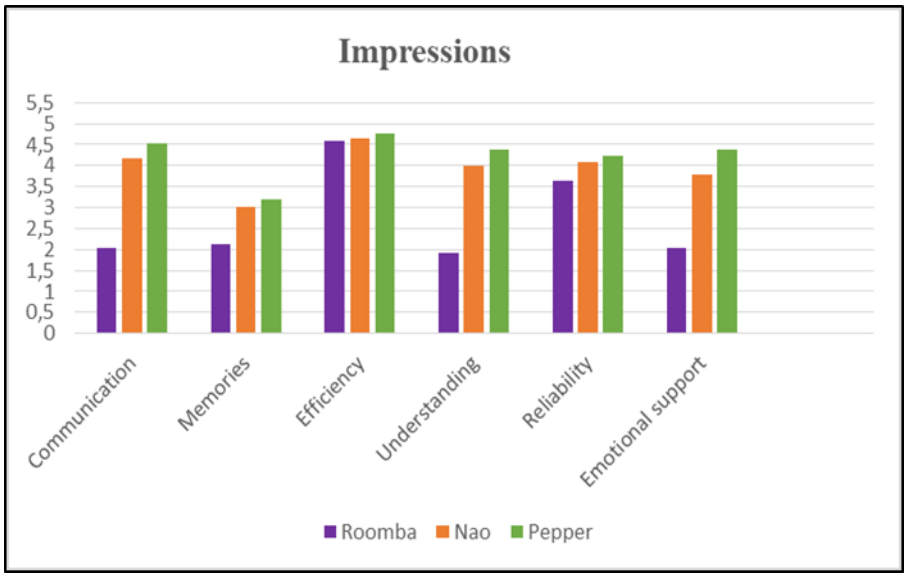


Figure 4: Impressions aroused by Roomba, Nao and Pepper in terms of communication, memories, efficiency, ability to understood language, reliability, and providing emotional support

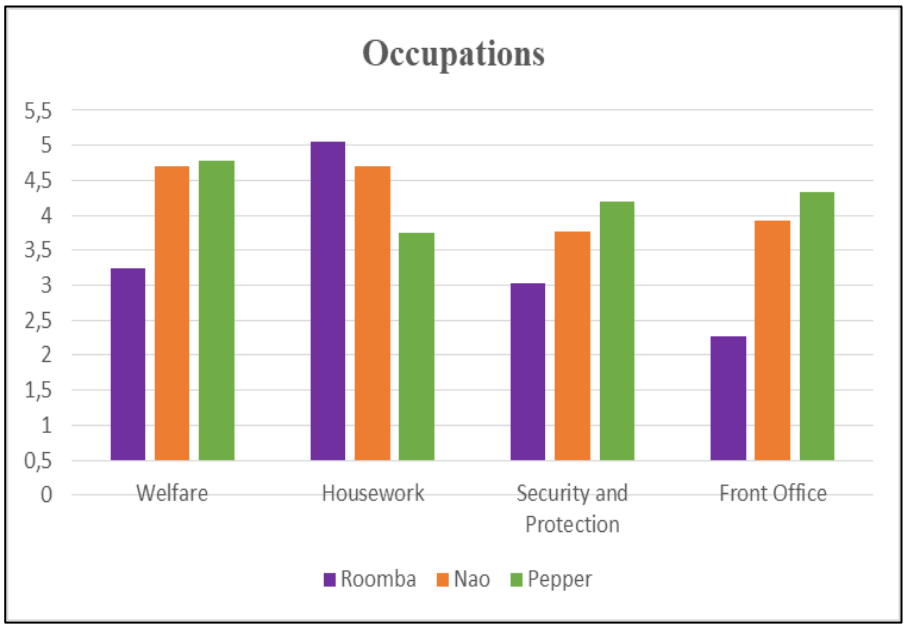


Figure 5: Occupations entrusted to robots by elders

Androids vs Humanoids Robots

As previously mentioned 50 participants (Group 1) participated to the assessment of Roomba, Nao, Pepper, and Ishiguro and the remaining 50 (defined Group 2) to the assessment of Roomba, Nao, Pepper and Erica. Since, as described in the above paragraph, a clear preference toward Pepper among seniors appeared, it was decided to compare Pepper's scores with those obtained by Ishiguro and Erica, respectively. These comparisons were carried out through repeated measures ANOVA analyses, considering participants' gender as a between factor and "Interaction", "Appearance", "Impressions" and "Occupations" as within factors.

Pepper vs Ishiguro

When comparing Pepper and Ishiguro, no participants' gender effect was found, for all the within factors under considerations. No significant differences were found between Pepper and Ishiguro for the variable appearance (Pepper mean =4.300, Ishiguro mean =4.260). Seniors scored the two robots equally well on their appearance. Significant differences emerged for "Interaction" ($F(1,48) = 9.984$, $p<.01$). Bonferroni post-hoc tests revealed a significant preference among seniors to interact with Pepper (mean = 4.020) rather than Ishiguro (mean = 3.140, $p<.01$). Figure 6 illustrates these results. Significant differences were observed for the cluster "Impressions" ($F(1, 48) = 5.548$, $p=.023$). Separate ANOVA analyses on each item of the cluster "impressions" showed significant differences between Pepper and Ishiguro for efficiency (Pepper mean =4.240, Ishiguro mean =3.700, $p=.019$), reliability (Pepper mean =3.740, Ishiguro mean =3.200, $p=.035$), and emotional support (Pepper mean =4.120, Ishiguro mean =2.980, $p<<.01$), in favor of Pepper, and for memories (Pepper mean =3.080, Ishiguro mean =3.660, $p=.023$) in favor of Ishiguro. No differences were observed for communication ((Pepper mean =4.060, Ishiguro mean =3.600) and language understanding (Pepper mean =3.840, Ishiguro mean =3.720), even though Pepper scored better than Ishiguro. Figure 7 illustrates these results. Concerning potential occupations seniors entrusted to robots, a significant difference ($F(7,336) = 8.536$, $p<.01$) emerged between Pepper and Ishiguro. Bonferroni post hoc tests revealed that seniors considered Pepper significantly more suitable than Ishiguro for welfare (Pepper mean= 4.460, Ishiguro mean = 3.060, $p<.01$), security/protection (Pepper mean= 3.560, Ishiguro mean = 2.920, $p=.032$), housework (Pepper mean=3.420 , Ishiguro mean = 2.860, $p=.049$), and front office (Pepper mean= 3.320, Ishiguro mean = 2.960, $p=.021$). These data are illustrated in Figure 8.

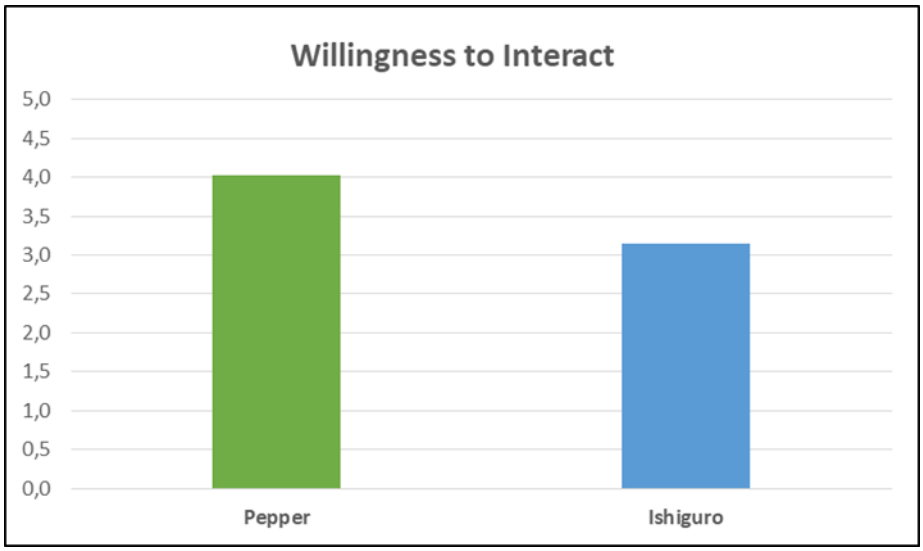


Figure 6. Senior's willingness to interact with Pepper and Ishiguro

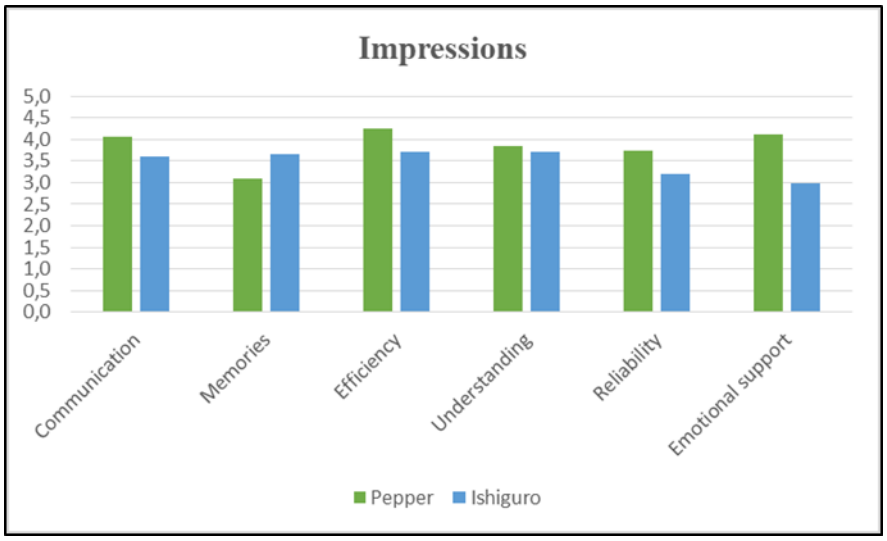


Figure 7: Pepper and Ishiguro differences in terms of impressions aroused

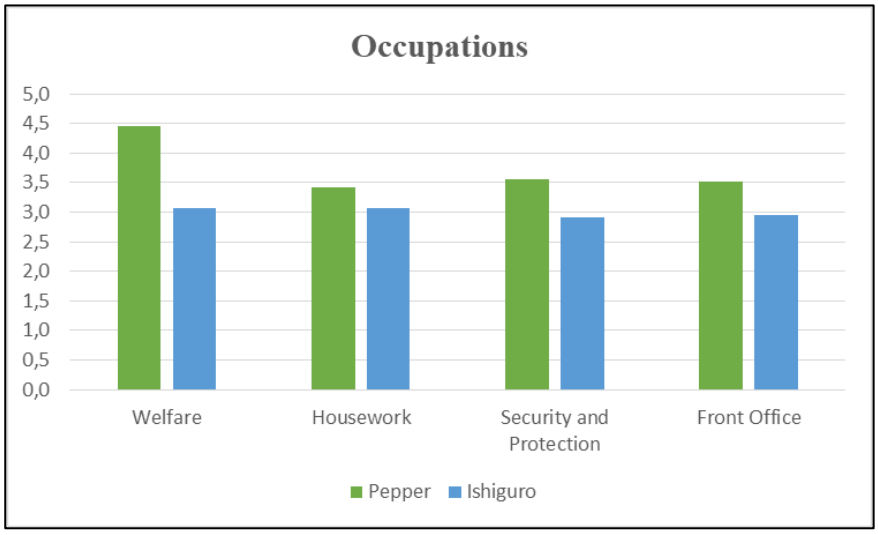


Figure 8: Pepper and Ishiguro scores in terms of occupations entrusted by seniors

Pepper vs Erica

When comparing Pepper and Erica, no participants' gender effect was found, for all the within factors under considerations. No significant differences were found between Pepper and Erica for the variable appearance (Pepper mean =4.340, Erica mean =4.680). Seniors scored the two robots equally well on their appearance. Significant differences emerged for "Interaction" ($F(1,48) = 43.626$, $p << .01$). Bonferroni post-hoc tests revealed a significant senior's preference to interact with Pepper (mean = 4.840) rather than Erica (mean = 2.920, $p << .01$). Figure 9 illustrates these results.

Significant differences were observed for the cluster "Impressions" ($F(1, 48) = 24.088$, $p << .01$). Separate ANOVA analyses on each item of the cluster "Impressions" showed significant differences between Pepper and Erica for communication (Pepper mean = 5.000, Erica mean =3.920, $p << .01$), efficiency (Pepper mean s= 5.300, Erica mean =4.000, $p << .01$), reliability (Pepper mean = 4.700, Erica mean =3.840, $p << .01$), language understanding (Pepper mean = 4.920, Erica mean =4.160, $p < .01$), and emotional support (Pepper mean = 4.640, Erica mean e=3.360,

p<<.01), in favor of Pepper, and for memories (Pepper mean =3.320, Erica mean =3.760, p=.043) in favor of Erica. These results are illustrated in Fig. 10.

Concerning potential occupations seniors entrusted to robots, a significant difference (F (7,336) =21.029, p<<.01) emerged between Pepper and Erica. Bonferroni post hoc tests revealed that seniors considered Pepper significantly more suitable than Erica for welfare (Pepper mean= 5.100, Erica mean = 3.560, p<<.01), security/protection (Pepper mean= 4.820, Erica mean = 3.080, p<<.01), housework (Pepper mean=4.060 , Erica mean = 3.240, p<.01), and front office (Pepper mean= 5.100, Erica mean = 3.560, p<.01). These data are illustrated in Figure 11.

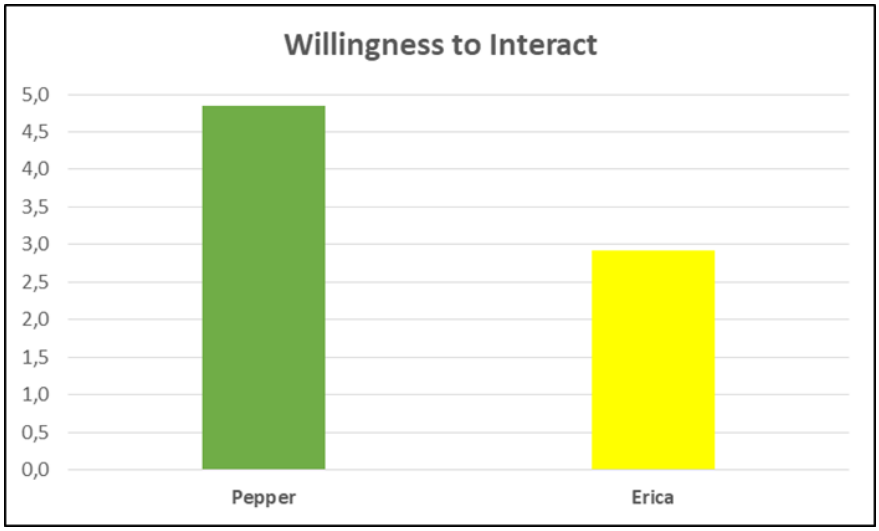


Figure 9: Pepper and Erica scores representative of seniors' willingness to interact with them

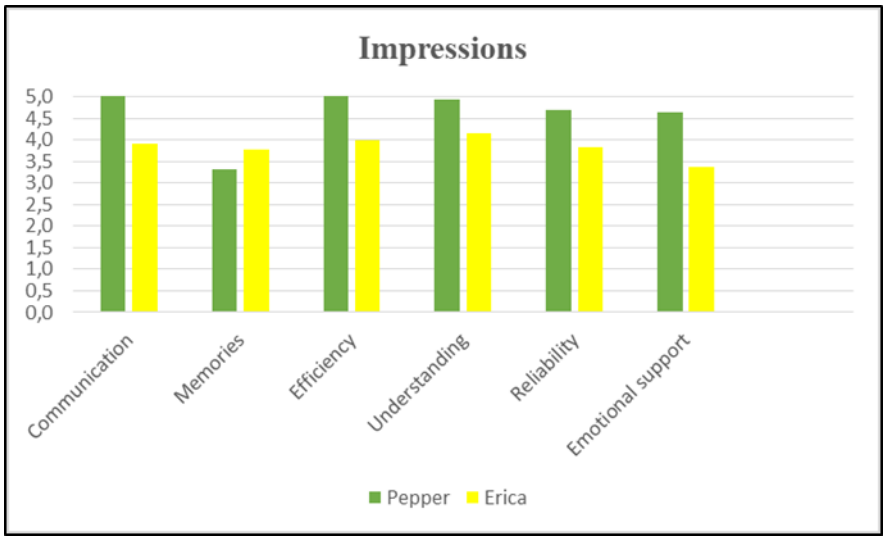


Figure 10: Pepper and Erica differences in terms of Impressions aroused

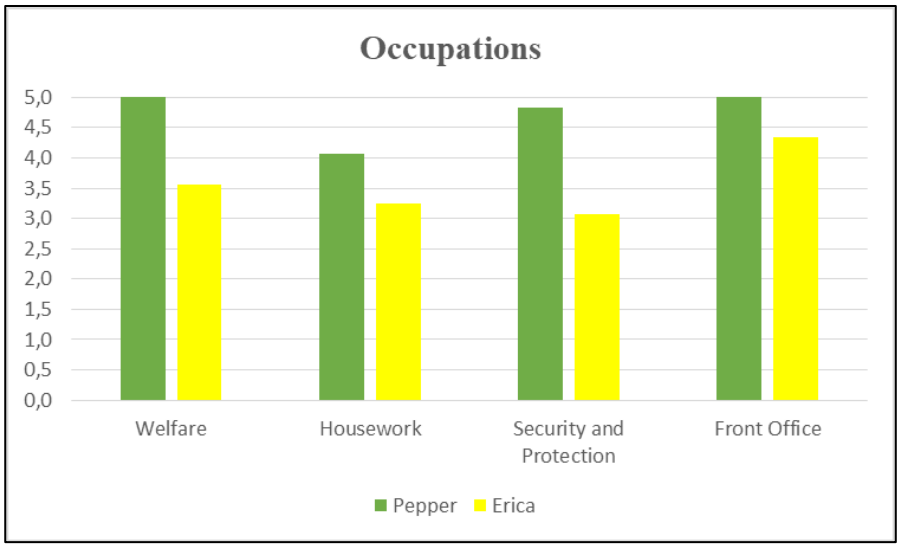


Figure 11: Pepper and Erica differences in terms of occupations entrusted by elders

4. Discussion and Conclusion

The present investigation was carried out with the aim to investigate elderly people's preferences among five robots, characterized by different levels of human likeness. As previously mentioned, the selected robots show different degrees of similarity to human beings. Roomba is certainly the one whose features are last reminiscent of a person, being a tool useful for house cleaning. Nao and Pepper, are humanoid robots with features remotely resembling human beings, and finally Ishiguro and Erica are characterized by a high level of human likeness to the extent that, at first glance, they can be mistaken for real people. The proposed investigation tested first who, between Ishiguro and Erica, was favored by elders, then compared them with the elders' most favorite robot among Roomba, Nao, and Pepper. For each robot the following attributes were tested: participants'willingness to interact with them, robots' appearance and general impressions aroused by them. Since appearance is a complex concept is noteworthy to underline here that the present investigation considers only one aspect of it, namely robots' level of human-likeness. In addition, seniors were required to select among welfare, housework, protection/security and front-office occupations which one is more suitable for the proposed robots. Results showed that seniors did not expressed any major preference between Erica and Ishiguro, either in terms of willingness to interact, or appearance, or impressions and robots' gender. This can be probably attributed to the fact that the two robots are very similar in terms of human likeness, both in body shape and movement skills. Seniors, however, considered Erica more suitable than Ishiguro for front office occupations, suggesting a senior gender preference toward Erica for this task.

The comparison among Roomba, Nao, and Pepper, was carried out in order to understand whether humanoid are more attractive than plain robot features and to what extent small differences among robots play a role on elders' robot's acceptance, considering that Nao and Pepper have similar humanoid features while Roomba acted as control to test acceptance in terms of practical purposes. It emerged that Pepper's appearance was greatly appreciated by seniors, to the extent that their willingness to interact, their feelings about it, and its appearance scored significantly higher

compared to Roomba and Nao. More specifically, Pepper's communication skills, and its ability to provide emotional support scored significantly better than Roomba and Nao, while its ability to arouse memories of someone or something, to understand people and be reliable, scored significantly better than Roomba and equally well than Nao. Interestingly, when seniors were asked to indicate how much suitable they considered Pepper, Nao, and Roomba to perform welfare protection/ security tasks and front office occupations, Pepper scored significantly higher than Nao and Roomba and Nao significantly higher than Roomba, suggesting a clear senior preference toward Pepper. Roomba was considered the most suitable among the three robots in performing housework task, which was a clearly expected result since Roomba is essentially a vacuum cleaner.

In order to understand which level of human likeness seniors would accept in robots and assess also gender differences, comparisons were made between Ishiguro and Pepper and then between Erica and Pepper, within two different groups of 50 seniors each.

The results suggest that seniors did not have a gender preference since neither Ishiguro or Erica were preferred to Pepper, although Erica was preferred over Ishiguro for front-office works. Seniors expressed a greater willingness to interact with Pepper, considering it more efficient, communicative, reliable, able to understand language, able to provide emotional support and performing welfare, security/protection, housework, and front office occupation than Ishiguro. Similarly, seniors' preferences were all significantly in favor of Pepper, when Erica and Pepper were compared. Pepper was considered more communicative, efficient, reliable, comprehensive and emotionally supportive than Erica, as well as more able to perform welfare, protection/security, housework, and front office occupations.

In summary, the humanoid robot Pepper was the preferred by seniors. An interesting detail concerns Pepper's scores in terms of *appearance.* When Pepper was compared with Ishiguro and Erica, who were characterized by a higher level of human likeness than Pepper, no significant differences emerged among them, suggesting that seniors were not enthusiast of the high degree of human likeness of Ishiguro and Erica. This reaction of seniors is observed probably because the excessive level of resemblance of robots to human beings negatively affect their evaluation and lead people to refuse their daily use, because of the "uncanny valley effect", i.e., a feeling of discomfort and eeriness caused by their excessive resemblance to a human being. Our data goes in this direction. However, the current investigation account only of few features driving user's acceptance of robots. More investigations are needed in order to design socially believable human-robot interactions and increase users' acceptance of such assistive technologies.

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