

# Elder user's attitude toward assistive virtual agents: the role of voice and gender

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## Abstract

This paper reports on experiments devoted to explore the role of specific attributes of humanoid virtual agents that may influence elderly users' perception and attitude, determining their acceptance and adoption as assistive devices. In particular, it investigates elderly preference on agents' gender and the role of the agents' ability to use voice during the interaction. To this aim two different groups of seniors were involved in the experiments. The first group evaluated talking virtual agents, the second one the same virtual agents, but silenced. The data shows that elderly users, independently from their gender, prefer to interact with female agents, especially when they are able to talk to them, revealing the role played by the voice. Furthermore, it was found a significant effect of the elderly level of experience with technology: when interacting with agents with voice, elderly users with high technological experience were less interested and considered the proposed agents less attractive and appealing, while just the opposite occurred when interacting with silenced agents.

## 1 Introduction

The continuous and rapid development in Information and Communication Technology (ICT) produces innovations in several areas, many of these increasingly involves devices and applications that aims at promoting health and wellbeing for elderly people (Mansouri et al. 2017; Bonaccorsi et al. 2016; Pollack 2005). Intelligent technology for supporting eldercare, indeed, has become crucial in the recent decades considering the ageing population is growing significantly all over the world (United Nations report 2017), resulting in dramatic shortage of qualified care personnel (<https://eldercareworkforce.org/workforce-shortage/>) and increase of expenditures for national health care institutions (Rowe et al. 2016). Therefore, the challenge is to develop new technological solutions to support elderly individuals to stay healthy and active, enabling them to remain at home and live independently to the maximum possible extent (Christophorou et al. 2016).

Among these solutions, complex autonomous interfaces, such as virtual agents, are developed to support elderly in their everyday life, promoting health behaviors, such as following medical treatments, e.g. reminding to take medicines or do exercises, assisting them in their day to day tasks, as well as encouraging them to create and/or maintaining social contacts (Katrin G. et.al. 2014; Yaghoobzadeh et al. 2013; Ring et al. 2013).

In defining and developing assistive virtual agents account has to be taken of the specific needs and requirements of the elderly users, in order to ensure accessibility, usability and usefulness, that are primary factors influencing adoption of technology by older individuals (Heerink et al. 2010). The presence of these factors, however, does not predict the effective use of assistive technologies among elderly (Goher et al. 2017, Broadbent et al. 2012). Some characteristics of assistive virtual agents' design (e.g. appearance, attributes, etc.) influence users' perception and attitude and consequently affect users' behavior, in terms of adoption and correct use of technology (Díaz-Boladeras et al. 2013). Hence, it is of interest to explore which are virtual agents' features that move elder users'

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preference when interacting with them, determining their acceptance, efficient use, and expected improvement of elders' quality of life.

Several researches has showed the importance of agent's visual appearance in affecting human-agents interaction experience in general (Komatsu & Yamada 2011), and in applications for elderly users (Esposito et al. 2018a; Straßmann & Krämer 2017). When dealing with humanoid virtual agents, gender, as part of the information conveyed by visual cues, is of main importance in influencing user's expectations (Niculescu, et al. 2011). Indeed, it provides the first understandings about others, eliciting the application of categories (e.g., stereotypes), shaping the users social approach to the technological device just as it happens in human-human interaction (Hoffmann et al. 2009; Reeves Nass 1996).

Many studies have been conducted to investigate how this aspect affects user experience with agents (Pezzullo et al. 2017; Lunardo 2016; Payne et al. 2013), but very few are those considering virtual agent gender effect in assistive interfaces for elderly user (Esposito et al. 2018b, Cereghetti et al. 2015; Tsiourti et al 2014). Results from these studies reveal that elderly users tend to prefer to be assisted by female agents, maybe as the results of social and cultural bias with respect to the role to assist and aid usually ascribed to females.

In all the above mentioned researches, however, employed virtual agents were embodied conversational agent, i.e. they were able to use voice while interacting with users.

Could this agent's attribute modulate users 'preference toward agent's gender and attitude toward virtual assistive agents in general? To our knowledge, no studies have addressed the role of agents talking ability in this terms.

In the intent to address the above question, the present study explores elders' preference to interact with humanoid male and female virtual agents when they are endowed with a talking voice and when no voice is reproduced.

The final aim is to reveal some of the characteristics and attributes in the design of assistive virtual system that encourage elders to initiate a lasting interaction with them, providing the expected benefits in their everyday life.

## **2 Material and Methods**

The experiments were set up with the aim of evaluating elders' preference for virtual agents' gender and the effect of voice on these preferences, as well as on their interest to interact with the agents in general. Technology experience (i.e. participants' familiarity with technological devices such as smartphones, laptops, and tablets) has been also considered.

Elders' responses raised from the interaction with the agents were collected according to the pragmatic and hedonic dimensions of an interactive system firstly introduced by Hassenzahl through the AttrakDiff questionnaire (2003, 2004, 2014), and further enriched in this study by new items developed by the authors (more details in Section 2.3).

### **2.1 Stimuli**

In order to conduct these experiments four virtual agents were defined. The virtual agents were selected from the website BOTLIBRE ([www.botlibre.com](http://www.botlibre.com)) that allows users to freely create a customer service virtual agent according to their preferences and goals, providing a wide set of agents with different visual semblances. The selection of the agents was made by three experts on the basis of preferences dictated by the agents' professional and non-emotional appearance. The selected four virtual agents two males and two females, as illustrated in Figure 1, named Michael (Figure 1a), Eddie (Figure 1b), Julie3 (Figure 1c) and Victoria2 (Figure 1d) respectively, received 100% of agreements among the experts.

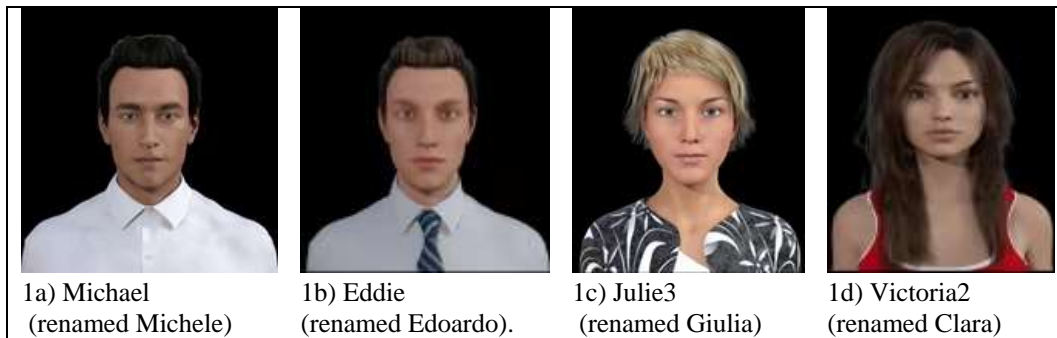


Figure 1: The four selected agents.

The agents were depicted half torso, with definite clothing. To contextualize the agent in the local culture (the experiments were conducted in Campania a south region of Italy) they were renamed Michele, Edoardo, Giulia and Clara respectively.

For each agent, two different stimuli were deployed:

- 1) With voice, each agent was provided with a different synthetic voice, producing the following Italian sentence "Hi, my name is Michele / Edoardo / Giulia / Clara. If you want, I would like to assist in your daily activity!" The synthetic voice has been created through the website Natural Reader ([www.naturalreaders.com](http://www.naturalreaders.com)) that allows converting text to speech. The voices (recorded using the free software Audacity) were embedded into each agent's video clips, which had an average duration of about 6 seconds.
- 2) Without voice, the same video but silenced.

## 2.2 Participants

The experiment involved 91 elderly participants, all aged 65+ years, recruited in the Campania region, in the south of Italy. The sample was split into two groups: the first group (group 1) consisting in 46 subjects (mean age= 71.59, SD= ±6.32; 24 females) evaluated video clips portraying talking virtual agents (with voice), the second group (group 2) consisting in 45 subjects (mean age= 71.22, SD= ±6.66; 25 females) tested on video clips portraying silenced virtual agents (without voice).

Participants were in good health, with no hearing and eyesight problems (appropriately corrected with glasses in some cases), and their task was to assess their preferences toward the four selected virtual agents on the pragmatic and hedonic dimensions of the interactive system (see section 2.3 for more details) and their willingness to initiate a lasting interaction with them. Participants accepted to participate at 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 ethical committee of the Department of Psychology at the Università degli Studi della Campania, "Luigi Vanvitelli", authorized this research with the protocol number 25/2017.

## 2.3 Materials and Procedures

The administration of stimuli has been carried out either in participants' private dwellings, or day-care facilities for older people. Participants in the two groups were asked to watch (and listen, in the case of group 1) each agent's video clip and immediately after to complete a questionnaire.

An ad-hoc questionnaire was developed by the authors and structured in the following clusters:

- 1) Cluster 1 was devoted to collecting participants' socio-demographic information, and their degree of familiarity and understanding toward smartphones, tablets, and laptops (technology experience);

- 2) Cluster 2 first collected participants' willingness to be involved in a long-lasting interaction with each of the proposed agents, then was clustered in four sub-clusters, each consisting of 10 items, investigating the practicality, pleasure, feelings, and attractiveness experienced by participants while watching the agents' video clips. The items proposed in each sub-cluster were inspired by Hassenzahl's theoretical model underpinning the qualities an interactive system should possess in order to receive a high acceptance from the user (2004). According to this model, a user's perception of interactive systems varies along two dimensions:
  - a. the system's pragmatic qualities (PQ), which focus on the usefulness, usability, and accomplishment of the tasks of the proposed system. A system receiving high scores in the PQ dimension is intended to be perceived by the user as well structured, clear, controllable, efficient, and practical.
  - b. the system's hedonic qualities (HQ), which focus on motivations, i.e. the reason why a user should own and use such an interactive system, (hedonic quality stimulation (HQS), identification, i.e. how captivating, as well as, of good taste the system appears, (hedonic quality identification (HQI), A system receiving high scores in the HQS and HQI sub-clusters is meant to be original, creative, captivating as well as presentable, professional, of good taste, and bringing users close to each other. These pragmatic and hedonic dimensions affect the subjective perception of the system's attractiveness (ATT) and give rise to behaviors as increased use, or dissent, as well as, emotions as happiness, engagement, or frustration. Please note, HQS will be substituted in the following with HQF (where F stands for feelings), while HQI Identification will be substituted with "Identity".

Cluster 2 of the proposed questionnaire is therefore organized in 4 sub-clusters, devoted to measure respectively the pragmatic quality (PQ), the hedonic identity (HQI), the hedonic feeling (HQF), and the attractiveness (ATT) of the four agents. The complete questionnaire had two more clusters respectively devoted to assessing the type of professions seniors would endorse to the agents, among which were welfare, housework, protection and security, and front office jobs, and agents' age preferences. The authors developed these two last clusters after the data collection had started and thus they were not administered. Future works will, however, include such data.

Each questionnaire item required a response given on a 5-point Likert scale with 1=strongly agree, 2=agree, 3=I don't know, 4=disagree, and 5=strongly disagree. Since both the second and third section of the questionnaire contained positive and negative items evaluated on a 5-point Likert scale, scores from negative items were corrected in a reverse way. This implies that low scores summon to positive evaluations, whereas high scores to negative ones. Participants were first asked to provide answers to the items of cluster 1, then they were asked to watch each agent's video clips and immediately after to complete the items from cluster 2.

### 3 Data Analysis

The data obtained from each group of participants (group 1: evaluating agents' video with voice, and group 2: evaluating agents' video without voice) were first analyzed separately.

Repeated measure ANOVA analyses were conducted on the scores obtained from each questionnaire cluster and sub-cluster, considering the gender of the participants and their degree of experience with technology as between factors. The degree of experience with technology was determined separating the participant sample into two groups: participants who used a technological device often or every day were considered at "high level of expertise", while participants who used a technological device rarely or never were considered at "low level of expertise".

Scores obtained by the two female agents (Clara and Giulia) on each questionnaire cluster - i.e. on the acceptance to interact with agents, on the pragmatic (PQ), hedonic quality identity (HQI), hedonic quality feelings (HQF), and attractiveness (ATT) dimensions - were added together, and the same was done for scores obtained by male agents (Edoardo and Michele). In a previous study (Esposito et al. 2018b), where the same 4 agents were employed in a similar experiment, it was showed that female agents were able to attract the preference of elderly users with respect to male

agents regardless of which specific agent was involved. Such scores were considered within subject factors together with agents' gender.

In order to investigate the role of voice (the agents' ability to talk) on the elderly users' evaluation of the agents, a comparison among the data obtained from the two groups of participants (group 1 and group 2) was then performed. In this case, participants' group (1 and 2), participants' gender and their level of experience with the technology constituted between factors, while scores on each questionnaire cluster and agents' gender (as described above) were considered within factors. Main differences among group means were assessed through Bonferroni post hoc tests. The significance level was set at  $\alpha = .05$ . The scores obtained from the questionnaire's negative items were reversed so that lower scores indicate strong preferences and higher scores low preferences toward the agents' dimensions defined by the questionnaire clusters.

## 4 Results

Results on users' assessment of the proposed agents are first reported for each group of participants separately. They indicate how the female and male agents have been evaluated on the willingness to interact, and the pragmatic, hedonic, and attractiveness dimensions of the interactive system by elderly users of the two groups. Then, results on the comparison between the data obtained by the two groups of users are reported to highlight the role of agent's voice on the users' preferences.

### 4.1 Results on elderly's evaluation of talking agents (Group 1)

#### - *Willingness to interact with the agents*

Significant differences were found among female and male agent's evaluation on the elderly willingness to interact with them ( $F(1,42) = 41.233, p < .001$ ). These differences were due to users' lower score (that means more positive evaluation) attributed to female (mean score = 3.25) with respect to male agents (mean score = 4.99).

#### - *Pragmatic Qualities (PQ)*

Agents' pragmatic qualities were differently assessed by participants ( $F(1,42) = 45.963, p < .001$ ). Female agents were evaluated as more useful, easy to use and able to accomplish several tasks (mean score = 41.08) than male agents (mean score = 65.89).

#### - *Hedonic Qualities – Identity - (HQI)*

Significant differences were found in the assessment of agents' HQI ( $F(1,42) = 37.915, p < .001$ ). Even in this case, female agents obtained lower scores (mean score = 44.36) than male agents (mean score = 68.30).

An interaction emerged between participants' gender and their degree of experience with technology ( $F(1,42) = 4.687, p < .05$ ). Bonferroni post hoc tests revealed that female participants with high experience with technology attributed to the agents higher (more negative) HQI scores (mean score = 60.71), than female participants with low technological experience (mean score = 53.33).

#### - *Hedonic Qualities – Feelings - (HQF)*

Agents' HQF scores differed significantly ( $F(1,42) = 35.045, p < .001$ ), these differences were due to more positive scores obtained by female (mean score = 43.02) with respect to male agents (mean score = 65.32).

A significant effect of users' technology experience ( $F(1,42) = 7.368, p < .05$ ) on the assessment of the HQFs features attributed to the agents was also found. Bonferroni post hoc test showed seniors highly technological experienced evaluated the proposed agents less exciting, appealing, and captivating (mean = 56.96) than low experienced ones (mean score = 51.38).

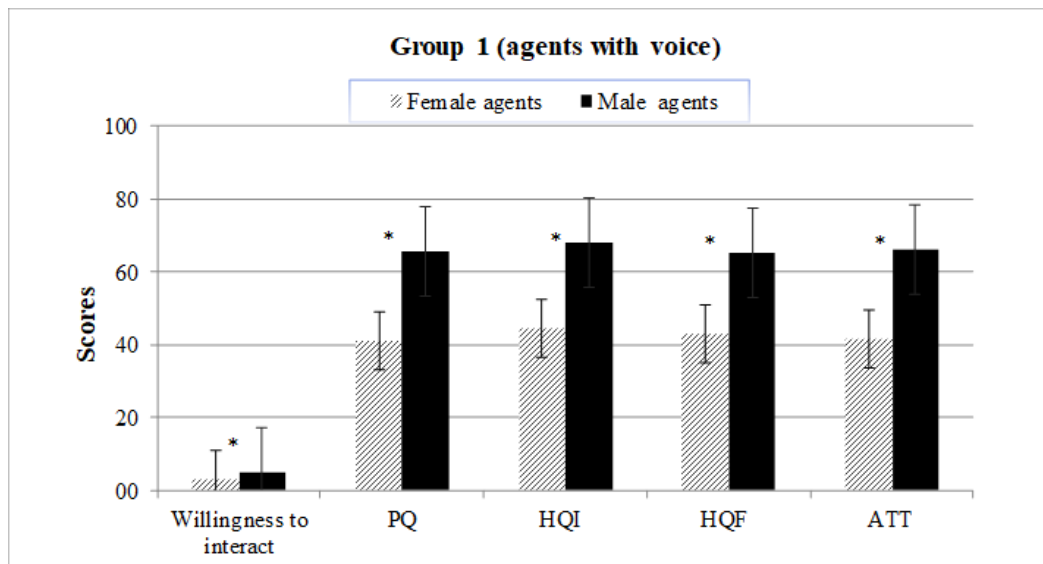


Figure 2: Evaluation of male and female agents by elder users from group 1.

- *Attractiveness*

Agents' scores obtained for the Attractiveness dimension were significantly different ( $F(1,42) = 49.853, p < .001$ ). Participants recognized female to be more attractive (mean=41.64) than male agents (mean score=66.54).

Participants' experience with technology ( $F(1,42)=4.288, p<.05$ ) significantly affected the assessment of ATT features. According to Bonferroni post hoc tests, participants with high technological experience scored the agents less attractive (mean=56.31) than those with low technological experience (mean score=51.87). In addition, a significant interaction was found between users' gender and their level of technology experience: female participants with high technological experience found the agents less attractive (mean=58.62) than female participants with low technological experience (mean score=49.79).

The main results described above are displayed in figure 2.

## 4.2 Results on elderly's evaluation of silenced agents (Group 2)

- *Willingness to interact with the agents*

A significant effect of users' level of experience with technology on the willingness to interact with agents was found ( $F(1,41) = 10.446, p < .05$ ) and revealed, in contrast to what found for the group 1, that participant with high experience were more available (mean score = 4.75) to interact with the agents than participants with low technological experience (mean score= 6.99).

No significant differences were found between scores given by users to female and male agents.

- *Pragmatic Qualities (PQ)*

Scores obtained by users with high technological experience were significantly different from those obtained by users with low degree of technological experience ( $F(1,41) = 7.076, p < .05$ ). The first group attributed lower scores to agents' pragmatic qualities (mean score= 53.67) than the second one (mean score = 64.94) even to the agents' pragmatic qualities.

No agents' gender effect was found.

- *Hedonic Qualities – Identity - (HQI)*

Agent's gender affected the evaluation of HQI. Indeed, significant differences ( $F(1,41)=9.322, p<.05$ ) in the scores obtained by participants showed that they evaluated female agents as more pleasant (mean score= 54.78) compared to male agents (mean score= 58.62).

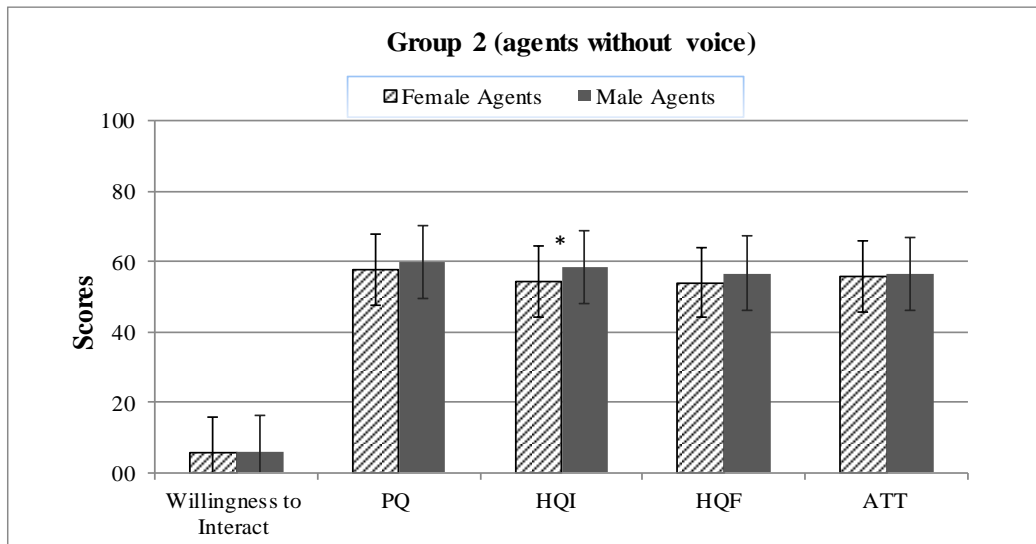


Figure 3: Evaluation of male and female agents by elder users from group 2.

For *Hedonic Qualities Feelings (HQF)* and *Attractiveness* dimensions of the proposed agents, no significant effects were found for users within group 2.

Figure 3 summarizes the main results from group 2.

### 4.3 Results on the comparison between group 1 and 2

#### - *Willingness to interact with the agents*

A significant difference between the two groups of users on the willingness to interact with agents was found ( $F(1,83)= 22.312, p<<.001$ ). In particular, participants from group 1 (with voice) attributed more positive scores to the agents (mean score = 4.12), than those from group 2 (without voice) (mean score= 5.87).

Agents' gender significantly affected all participants' (Group 1 plus Group 2) evaluation ( $F(1,83)=34.971, p<<.001$ ). Female (mean score=4.50) obtained higher preference than male agents (mean score=5.49).

An interaction was found between agents' gender and participants' group ( $F(1,83) =19.736, p<<.001$ ). Bonferroni post hoc tests showed that participants from group 1 were more prone to interact with female agents (mean score = 3.25) rather than with male agents (mean score= 4.99), while this effect did not emerge for users from group 2.

#### - *Pragmatic Qualities (PQ)*

Evaluating the agents' pragmatic qualities, a significant difference was found among the two participants' groups scores ( $F(1,83)=6.012, p<.05$ ). Participants from group 1 (mean score= 53.48) found agents more useful and clever than those from group 2 (mean score= 59.30)

A significant difference was found among scores obtained by female and male agents ( $F(1,83)=47.690, p<<.001$ ). Female agents (mean score= 49.59) were preferred by the total of participants (Group 1 plus Group 2) with respect to male agents (mean score= 63.20).

In addition, an interaction emerged between agents' gender and participants' group ( $F(1,83)=32.267, p<<.001$ ). Bonferroni post hoc tests showed that users from group 1 assigned more positive scores to female (mean = 41.08) than male agents (mean score= 65.88), while this effect did not occur for participant within group 2.

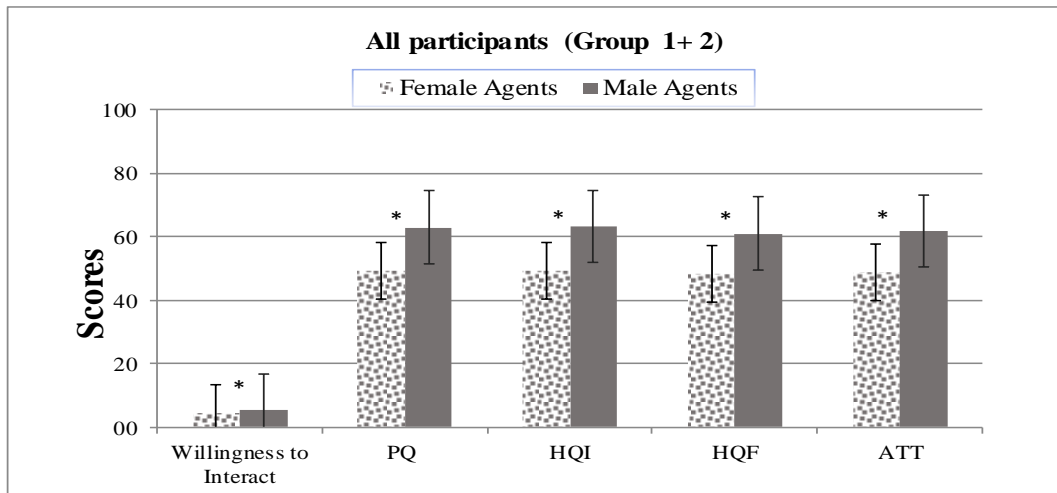


Figure 4: All participants' assessment of female and male agents.

- *Hedonic Qualities – Identity - (HQI)*

Agents' HQI scores differed significantly ( $F(1,83)=45.036, p << .001$ ). Female agents (mean score= 49.56) were preferred by all participants (group 1 plus group 2) with respect to male agents (mean score = 63.46).

An interaction emerged between agents' gender and participants' group ( $F(1,83)=23.502, p << .001$ ). According to the results of Bonferroni post hoc tests this was due to the fact that participants from group 1 were more prone to identify themselves with the female (mean = 44.36) than with male agents (mean score= 68.30), while this effect was not found for participants of group 2.

- *Hedonic Qualities – Feelings - (HQF)*

Agents' HQF were differently assessed by the total of participants (group1 plus group 2) ( $F(1,83)=36.895, p << .001$ ): female agents obtained better scores (means score= 48.61) than male agents (mean score=61.06).

An interaction between agents' gender and participants' group ( $F(1,83)=23.145, p << .001$ ) was found. Bonferroni post hoc tests showed that for participants within group 1 female were evaluated more positive (mean = 43.02) than male agents (mean score= 65.32), while this effect did not emerge for group 2.

- *Attractiveness*

Agents' attractiveness was differently assessed by all participants (both group 1 and 2) ( $F(1,83)=44.331, p << .001$ ), who preferred female (mean score= 48.69) with respect to male agents (mean score =61.63).

The interaction emerged between agents' gender and participants' group ( $F(1,83)=37.859, p << .001$ ), once again showed, through the results of Bonferroni post hoc tests, that users from group 1 significantly preferred female (mean = 41.64) than male agents (mean score= 66.54), while this effect did not emerge in the group of participants tested on silenced agents.

The main results described above are displayed in figures 4 and 5.



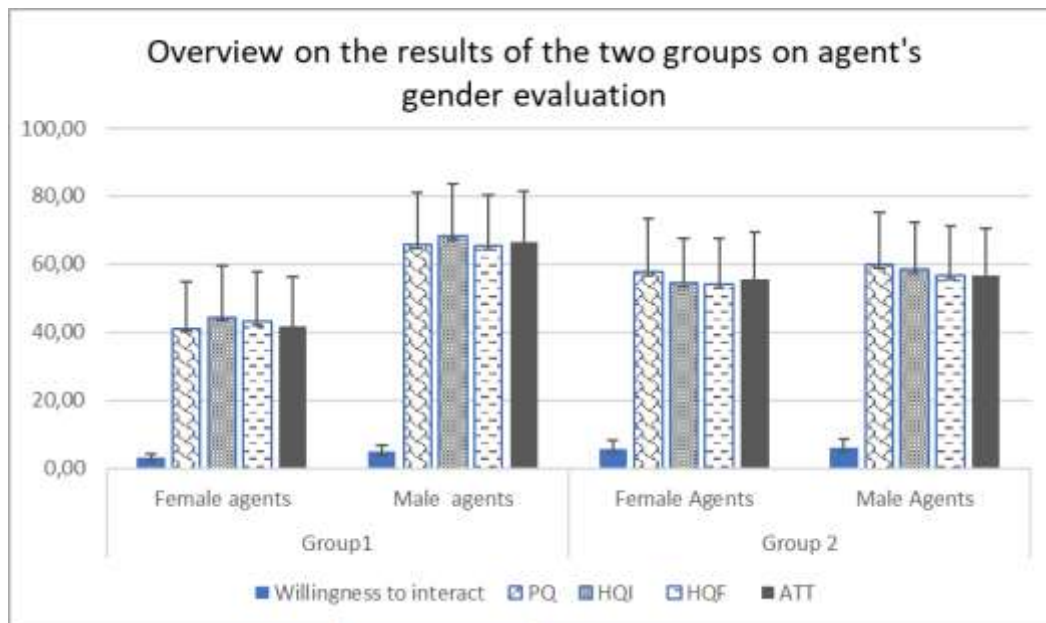


Figure 5: Comparison on the evaluation of agents' gender by the two groups of users.

## 5 Discussion and Conclusions

In the present study two different groups of elderly participants were involved in the evaluation of assistive virtual agents. The data obtained by participants of the first group, assessing video clips portraying talking virtual agents, showed a strong preference for female agents independently from users' gender and level of technology experience. Indeed, elderly users found female more worthy to interact with, more useful, efficient and well designed (PQ dimension), more captivating, exciting, engaging (HQI and HQF dimensions) and attractive (ATT dimension) than male agents.

Furthermore, for this group of users, the level of experience with technology influenced their perception of agents' hedonic and attractive qualities: users with high experience felt less captivated and engaged when interacting with the proposed agents.

The data collected from users evaluating video clip showing silenced agents interestingly revealed that agents' gender did not affect users' preferences. Differences in the agent's scores were only found for HQI dimension, where female agents were significantly judged more positively. In addition, in contrast to what emerged from data get by the first group of participants, users' higher level of experience with technology positively affected their willingness to interact with the agents and the evaluation of their pragmatic qualities. Trying to provide an explanation for this surprisingly result, it could be hypothesized that high experienced users are more sensitive to the imperfect synchronization between voice and mouth movements of the proposed talking agents, and that affected their judgment on agents' pleasantness, this did not happen when silenced agents were evaluated.

The difference between the two groups of participants, the first strongly expressing preference toward female agents and the second one, where the agents' gender effect did not occur, was confirmed by the comparative analyses performed on the data, suggesting that the presence of talking ability in the agents plays a role in users' attitude toward them. The presence of voice, actually, also influenced the general evaluation of the agents that were considered, regardless of gender, more worthy to interact with, efficient, well structured, and user friendly when using voice to interact with the participants. In addition, the comparison showed that when considering the total of participants, users from group 1 and 2 together, again agents' gender effects was shown: users preferred to interact with female agents.

The results above described show how some characteristics in the design of complex autonomous computer interfaces influence elderly users' perception and attitude affecting their interest in interacting with assistive virtual agents. On one hand, they reveal the strong effect of agents' gender in elderly users' interest to interact with such technological support: elderly prefer to interact and to

be assisted by female agents. On the other hand, they highlight the role of the agent's ability to use voice in the interaction. This attribute has different effects: it makes the agents more attractive in general; it seems to enhance the user's preference for female agents; it affects the evaluation by users with high level of experience with technology suggesting the importance of synchronization between agents' voice and movements.

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