Interaction Design for Robotic Avatars Does Avatar's Aging Cue Affect the User's Impressions of a Robot?

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Abstract. Human Computer/Robot Interaction has concerned about developing embodied computer/robot agents effective for their use in user interaction. In particular, the study on the dependency of the interaction design on the target users has been of a core theme to investigate. For instance, in the case of designing an embodied agent such as an avatar specifically to support the performance of a robot assistant to the elderly, the aspect of social interaction with the older adults should be of a serious concern. In this paper, we present a study that explores the relationship between the degree of aging cues (i.e., the visual features related to the age of embodied agents) and the level of perceived anthropomorphism, intelligence, safety and likeability by the older adults as customers. The study found that avatar aging cues affect the perception of the older adults in intelligence and safety: the older adults perceived the agent more intelligent with older avatars but safer with younger avatars. However, the aging cue seems not affecting the sense of anthropomorphism and likeability on users. An Interesting finding is the difference in the likability associated with the aging cue according to the gender of the older adults: the male participants tend to like older avatars while the female participants the younger ones. Since how the older adults perceive the aging cues of avatars could affect their expectation and trust on the assistant robots, thus, the findings related to the aging cue influence in the design of a series of attributions of the robots in terms of their roles and capabilities. Based on the results of this work, we can approach toward design considerations to help guide interaction designers in creating the visual appearance of an embodied agency as the robotic avatar interfaces for the elderly.

Keywords: Robotics, avatar, embodied agent, elderly, aging cues, interfaces, user experience.

1 Introduction

Robots development for older adults is growing during the last decades. Population aging is a worldwide phenomenon, with the median age of the world population calculated to rise approximately to 38.1 years in 2050 from 26.7 years in 2000 [1]. The medical needs of older adults are often considerable. Access to a variety of health

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services is important for preventing illnesses, adapting therapies to changing needs, potentially reducing care costs, and ultimately for maintaining the health and well-being of our aging population [2, 3].

As well as the population aging is intrinsic to the processes that bring us changes in the educational level and the living standards [4], it has been affecting the technological development of new and improved robots specialized in target people like older adults. In robotics, the study of older adults' technology brought the creation of models such as the Almere Model [5], used to predict and explain acceptance of assistive social robots.Robots use a variety of techniques to portray a face, alternating from mechanical faces like Kismet [6] to animated faces showed on a display screen attached on robot's body. For screen-faces, the portrayal of facial representations by animated figures includes embodied conversational agents and avatars. The term avatar originally refers to the temporary human or animal body that a deity assumes [7], and last decades is well known with a similar meaning applied to the digital world.

HCI studies and HRI field have concerned about interaction mediators for users and embodied computer agents or avatars. Those agents or avatars, when appropriately designed, could play a very important role, as an instrument, in how people interact with technology in robotic systems. For example, using an avatar as the visual representation of an embodied agent for consumer robots that do not have physical head features such a face with eyebrows, eyes, mouth, etc. could play a user friendly-interface role for people interacting with technology like humans do, or at least, increases the sense of sociability and tendency to use.

Nowadays, the usage of avatars or customized images as on-screen representations of social presence in mobile technology or Internet is a common practice, and the idea of an intuitive interaction with embodied avatars to communicate and control technologies has become a popular expectation for HRI researchers. However, the real construction of these agents kept the simple idea of 3D or 2D representation of humanlike appearance. The true challenge in designing the avatar interface for a system that includes autonomous agents is representing the state of those agents.

Some studies about anthropomorphic representations for agents have been conducted [8, 9]. The main reason behind these studies is that the anthropomorphic representation allows a set of identifiable behaviors and facilitates social interaction. However, there is always a possibility that these representations convey in the wrong expectations about agent's capabilities, especially during avatar's initial exposure. If the design is not carefully conceived, these avatars may make the embodied agent seem more intelligent, capable, and trustworthy than actually the agent is. [10].

For older adults, robot builders have yet to understand the full potential for robotic avatars to socially shape people's interaction with robots. This discovery motivates us to research into the effects of visual aging cues in the user's perception of the robotic avatars, with the primary consideration of interaction guidelines intending to leverage the resulting effects and improve older adults' user experience.

According with the theory of Computers as Social Actors CASA, people interact with computers as they were social actors [11]. By adding a humanlike avatar to mediate the human-computer interaction, the social aspects of interaction become more explicit, and the role of the interface must be included in the design process of this

interaction. Thus that interaction, due to user and environment, has a tendency to change. Avatars, through their entire visual design (form features, clothing, facial expression, and gestures) express information and reflect contents in the same way as human–human social interaction [9, 12] through a visual communication channel. Several models have been developed to measure concepts such the Technology acceptance model TAM, and take those models to develop new models including the social aspects of interaction with embodied agents like robots or on-screen characters considering elderly users as well [5], However in HRI designers lack sufficient guidelines to ensure that avatars designs will play an efficient role in human-robot interaction.

Our research approaches this issue. We have conducted an experiment exploring the relationship between the aging visual cues of avatars and older adults' impressions. The study reported in this paper, employs robotic avatars designed by ourselves. Female anthropomorphic facial stylized caricatures that specifically allow us to explore whether these avatars with different aging cues produce any effect impressions for an assistant robot.

2 Literature Review

Several researchers have looked at the use and effect of embodied interface agents. [13, 14, 15,] Those HCI studies have investigated about avatar form (appearance, gender, gesture, ethnicity, etc…); agent interaction, agent task and agent performance. In our research, we focus on the design of aging visual cues for robotic avatars; older adults' perception of intelligence and safety, and impressions for likeability and anthropomorphism.

Prior to the study, researchers demonstrated that embodied agents are interpreted to have social presence for users and also that sociability increases when the embodied agent has a humanlike appearance instead of animalike or an abstract form [10]. Furthermore they also have investigated about the effects of graphic representation level, for example, whether the avatar is a simple drawing, a 2D avatar with more realistic features, a 3D modeling, or a real photography. [10].

HCI studies have examined how the user's age affects the way they interact with a computer system [16,17]. We want to look into the characteristics that describe the aging cues of an avatar in a consumer robot for elderly people. Some interesting works worth to be mentioned; a study by Benford [18] suggest that teenager users and users up late twenties may feel more comfortable interacting with an avatar character of the same age than them (younger may suggest lack of domain knowledge, while older may be considered old-fashioned and out of date). In addition, this study also mentioned that older users may prefer a younger character - they may regard a character their own age as knowing as little as they do about technology and thus being of little help. As younger generations are usually associated with being at ease with new technology, older users may believe they could be the best computer associates [18].

Cowell and Stanney found that people prefer young looking agents that appear to have their same or a similar ethnicity [9], supporting the human likeness effect that is frequently referenced in human-human interaction.

Regarding the gender of humanlike agents, several studies have explored concerns related to differences in the preferences between male and female users for male or female avatar. This study [14] found that men and women did not have a gender preference in the selection of an embodied agent with a human form, but since our work is related to an assistant consumer robot with a female voice, we take in consideration the results from previous personal interviews with Korean older adults and based on their responses we should consider the tendency for Korean elders to prefer female agents as a home assistant robot. It is also important to note the investigated impact of the avatar realism on the perceived quality of communication in a virtual world [19], an previous research found evidence that avatar realism had a significant effect on the behavior of individuals. Moreover, the same research suggests that in virtual worlds, individuals form impressions of other individuals based on visual cues of the target individual's avatar [20, 21] in a similar way as humans do in daily life.

Reviewing previous research, we found very interesting things, but many questions are still there. For instance, although different matters of how the age characterization of an avatar affects likeability or the perceived anthropomorphism have been explored in HCI, none of these studies have explored the relationship between the aging cues of robotic avatars and older adults, embodied agents capable of moving and interact in some sort of physical way rather than just a computer interface.

The advent of stylized interactive avatars for smart devices and robots express the need to specify effective, reliable and consistent design for embodied agents and thus their representations in avatars. There is little research to guide the creation of animated facial avatars for robotic interaction designers. In our case, we can apply our findings into interaction design guidelines for an embodied agent avatar using an assistant robot, "Homemate." It has a female voice and gives assistance delivering water, beverages and snacks, offering entertainment and communication tools and serving as a mediator for video chatting for older adults.

2.1 Research Question and Hypothesis

The primary purpose of the paper is to demonstrate that varying the aging cues of the robotic avatar, user's perceived intelligence, perceived safety, the anthropomorphism impressions and likeability of the robot are affected.

Hence, our main research question can be summarized as follows: For older adults, controlled by user gender and type of robotic avatar aging cues what is the relationship between the avatar aging cues and perceived intelligence, perceived safety, anthropomorphism, and the likeability impression? Therefore, we hypothesize:

- H1: Older adults' perception of anthropomorphic mobility will be affected by the type of avatar with aging cues.
- H2: The older adult's perceived intelligence of the robot will show a variation for each type avatar with aging cues.
- H3: Older adults' impressions will show a higher level of likeability for younger avatar than for older avatar.

- H4: Regarding older adults' emotional state during the interaction with the robot, the perceived safety will be affected by type of robotic avatar with aging cues.

3 Method

We conducted a 1x2 between subjects experimental design. All participants interact with only one type of avatar in a controlled scenario.

We prepared 2 female robotic avatars of our own design which were held consistent except for evident cues that suggested age differences. We analyzed that by keeping the design similar, we could better understand the effects of the avatar aging cues, These 2 types of stylized facial caricatures have simple gesture animation, moving mouth, hair, and random eye blinking either younger female or older female avatar designs.

Participants were asked to complete a brief questionnaire of 8 items in a semantic differential scale related to measure the perceived intelligence, safety, impressions for anthropomorphism, and likeability of the robotic interface. As the participants are not fluent in English, the questionnaire was previously translated to Korean language by a Korean native psychologist. By the end of the questionnaire participants were asked about 2 more questions. 1: The participant's age; and 2. How old they think the avatar is.

3.1 Participants and Stimulus Materials

Fifty two participants from the Jongno Senior Welfare Service Center in Seoul, South Korea were recruited to participate. N=52 (26 Males, 26 Females).

Since the robot used for this study has a young-sound female voice; we decided to show for each condition a different type of female stylized 2D avatar with simple gesture animations to participants separately. The avatar aging cues consisted on visual codifications of aging. For that we have highlighted differences in design for length and color of the hair, strong wrinkles marks in face and neck, eyes shadows, lips make up, and glasses "Fig. 1". Each avatar was capable of expressing four different expressions, Neutral, Confused, Wondering and Happy.

Fig. 1. Younger and Older avatar stimulus in Homemate robot

3.2 Measures

In order to measure perceived intelligence, perceived safety, likeability and anthropomorphism of the robotic avatars, the study adapted the Godspeed questionnaires to measure users' perception of robots [22]. We selected two items from anthropomorphism, likeability, perceived intelligence and perceived safety criterion, then translated them to Korean language. Those questionnaires using semantic differential scales reported that being implemented inside an experimental design have high likelihood of internal validity. See Apendix.

Anthropomorphism was assessed using two items extracted from the questionnaire. We selected two of the most commonly related with robots: Fake/natural and moving rigidly/moving elegantly. Likeability was assessed using two questionnaire items: Unkind/kind and Awful/Nice. Perceived intelligence was assessed using two semantic differential items in the questionnaire: Incompetent/Competent and Foolish/sensible .Perceived safety was assessed using two questionnaire items for rating the participant's emotional state: Agitated/Calm and Quiescent/Surprised [22]. During the exposure to the Homemate robot, participants answer the 8 items questionnaire. Bellow an example of those questions:

Antropomorphism

Please rate your impression of the robot on these scales:

Incompetent	1	2	3	4	5	Competent

By the end two more questions were asked for demographic and manipulation check purposes. First, the participant's age, and second, how old they think the avatar is.

3.3 Procedures

A controlled scenario was prepared in one of the coffee areas in the elderly center. Context was designed for a free observation of robot and the avatar with aging cues.

- Step 1: The participants for each condition were introduced with Homemate robot avatar. The robot approaches the participant and the experimenter briefly explains the capabilities of Homemate: Delivery service, entertainment, video chatting, etc. Experimenter used the same short discourse in both conditions for each older adult that participates in the experiment.
- Step 2: The participant is given an instruction to pay attention to the avatar in robot screen-head. In both conditions the robot continues moving slowly around the participant making "eye contact" displaying the sequence of expressions and moving its lips. None specific task was asked to the subjects during the experiment.
- Step 3: The participant is asked to rate the stimulus on a semantic differential scale by circling one of the numbers from 1 to 5.
- The experimenter asks about the participant's age and how old they think the avatar is.
- At the end experimenter asks the participants if they want to add some comments about the avatar.

4 Results

4.1 Descriptive Statistics and Inferential Statistics

Participants were 50% females and 50% males. The mean age of the respondents was approximately 74.58 years (SD=5.46) ranging between 62 and 91 years. A multivariate analysis was implemented for each one of the items evaluated. In Table 1, the results for F-test by stimulus show that the key concept of perceived intelligence has a statistical significant value in Incompetent/Competent **(p=.001)** and for Foolish/Sensible some differences among stimulus were found but not significant.

For the key concept of likeability results doesn't show any significant value or interaction between stimulus, Unkind/kind (p=1.0) Awful/nice (p=.298). For participant's perceived safety a statistical significant value was found between stimulus for Quiescent/Surprised (p=.00) and for agitated/calm some differences among stimulus were found but not significant (p=.291). The results for F-test by gender do not show any statistical significant value between Females and Males. Then, we used two-way ANOVA to find any more interaction effect. There was one interaction effect between Gender*stimulus on Moving rigidly/Moving elegantly p=.050 for the key concept of anthropomorphism. For Manipulation check we asked the participants: "how old do you think avatar is?" to make sure about our experimental stimuli and there is a clear difference for the two conditions.

Young robotic avatar: age mean=26.81, Older robotic avatar: age mean=38.50. So, we found that they were the right stimuli for the experiment.

Table 1. F-Test By Stimulus

Independent Samples Test					
	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Fake / Natural	,61	50	,543	,192	,314
	,61	40,029	,544	,192	,314
Moving rigidly / Moving elegantly	-,9	50	,362	-,269	,293
	-,9	47,771	,362	-,269	,293
Unkind / Kind	,00	50	1,000	,000	,232
	,00	47,528	1,000	,000	,232
Awful / Nice	1,1	50	,298	,231	,219
	1,1	49,797	,298	,231	,219
Incompetent / Competent	-4	50	,001	-,654	,185
	-4	47,107	,001	-,654	,185
Foolish / Sensible	-1	50	,336	-,231	,237
	-1	49,986	,336	-,231	,237
Calm / Agitated	1,1	50	,291	,308	,288
	1,1	41,684	,292	,308	,288
Quiescent / Surprised	3,8	50	,000	1,115	,294
	3,8	48,596	,000	1,115	,294

4.2 Hypotheses Testing

The results indicate that these robotic avatar representations with aging cues are judged to inherently affect the degree of safety and intelligence of robots. Those aging cues together with subtle behavioral cues (e.g., eyes blinking and lips movements) can have an important effect on the user's appraisal of robot's capabilities.

- H1. This hypothesis was not totally supported by our analysis. However an interesting interaction was found for Gender: (Female, Male)*Stimulus type (Younger avatar, Older avatar) suggesting that users' gender also influences perceptions.
- H2.mThere was a slight difference between stimuli for Foolish/Sensible; however there was a statistical significance of people's perceptions for Incompetent/Competent between younger avatar and older avatar, perceiving the older avatar as more competent. This suggests that the visual cues of aging in a robotic avatar could affect users thinking about how intelligent a robot could be. Thus, this hypothesis was supported.
- H3. The results do not support this initial hypothesis. It seems regardless robotic avatar with aging cues people's impressions are not affected. It was interesting that the same mean value 3.69, for both types of avatar with aging cues regarding kindness (Kind/Unkind) was found, suggesting that older adults perceived the same state of kindness regardless of stimulus type. Some similar results were founded for Awful/Nice semantic differential question.
- H4. This hypothesis was supported.
- The avatar with aging cues was appraised to have significantly differences for user's perceived safety. Results showed that older adults considered their own state interacting with the young avatar as more surprising and their own state interacting with the older avatar as more quiescent. Nonetheless, it brings the possibility for a future research to find out if there is any connection for impressions of vitality and user's perceived safety.

5 Discussion

5.1 Theoretical Implications

In Human Robot Interaction field, interaction designers of robotics interfaces and avatars should be aware of the user's impressions toward the avatar for the selection of appropriate representations, behaviors and visual cues. These visual adoptions might have a dramatic effect on the user's judgment of the agent and the perceived intelligence and perceived safety which the user places upon the robot during the interaction.

In this study, the way how an avatar is visually designed and express its visual features with aging cues, draw on socially understood roles, behaviors and expectations in human robot interaction.

5.2 Practical Implications

Our results can contribute in the interaction design for a robotic avatar for a cognitive consumer robot "Homemate". This robot has a female voice and gives elderly assistance delivering water, drinks or snacks, facilitates communication through video chatting and entertainment tools for older adults. Additionally, there are user studies in HCI concerning avatars and agents designs but not a deep understanding whether the same principles can be applied for HRI and avatars embedded in robotic interfaces.

Furthermore, with the aging of our society, older adults have been becoming in one of the one of main targets for the robotic industry, therefore investigate which is the more reliable way to achieve user expectations about robots, from the interaction design to the technical and engineering implications that it conceives is strongly needed.

5.3 Limitations and Future Research

The findings in this current study could provide a set of design considerations to help guide interaction designers in creating the visual appearance of embodied avatar agents, but are still there some concepts to be tested regarding the impressions for anthropomorphism, likeability and animacy of the avatars with aging cues. In addition, we can consider a comparative study with American older adults, male avatars and perhaps conduct a future experiment considering generational effect and applying the same questionnaires to young people and children.

Few limitations of the study should be acknowledged in order to interpret its findings effectively. First, while there are several assistant robots for elderlies, our focus in this study was on Homemate Consumer Robot which has a screen instead of head. Second, the subjects were Korean older adults without including individuals with serious physical or psychological disabilities. Thus, the results in the study have a limited generalizability.

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