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Differences between young and old users when interacting with a humanoid robot: a qualitative usability study

Abstract: With the aging of the population worldwide, humanoid robots are being used with an older population, e.g., stroke patients and people with dementia. There is a growing body of knowledge on how people interact with robots, but limited information on the difference between young and old adults in their preferences when interacting with humanoid robots and what factors influence these preferences. We developed a gamified robotic platform of a cognitive-motor task. We conducted two experiments with the following aims: to test how age, location of touch interaction (touching the robot's tablet or hand), and embodied presence of a humanoid robot affect the motivation of different age-group users to continue performing a cognitive-motor task. A total of 60 participants (30 old adults and 30 young adults) took part in two experiments with the humanoid Pepper robot (Softbank robotics). Both old and young adults reported they enjoyed the interaction with the robot as they found it engaging and fun, and preferred the embodied robot over the non-embodied computer screen. This study highlights that in order for the experience of the user to be positive a personalization of the interaction according to the age, the needs of the user, the characteristics, and the pace of the task is needed.

Keywords: socially assistive robots, human-robot interaction, old adults, young adults, aging, gamification, presence, embodiment, timing

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1 Introduction

Most industrialized countries are aging fast due to an increase in life expectancy and a reduction of child birth rate [1]. The number of old people in the western world is growing, and the number of seniors in the USA is expected to double from 40 million in 2016 to 80 million by 2050 [1]. In this aging society, it is expected that there will be a growing need for home, medical, and nursing care services [2]. For this purpose, robots, and in particular robots with appearance based on the human body, are expected to perform human tasks such as provide personal assistance, help with social care for the older population, or assist with cognitive therapy [3, 4].

Socially assistive robots (SARs) are a natural category for this endeavor. SAR was defined by Mataric and colleagues as "a system that employs hands-off interaction strategies, including the use of speech, facial expressions and communicative gestures to provide assistance in accordance with the particular healthcare context"' [3, 4]. This category has been expanding with increasing interest in the variety of opportunities offered by SARs, and now includes interaction that can involve physical interaction between the robot and the human, as in the work described here and elsewhere, e.g., in Sabanovic et al. they work with the PARO robot for people with dementia [5]. SARs are being used in different application with healthy older adults, e.g., to enhance their exercise motivation as described by Fassola and Mataric [4], and assisting individuals with enhanced activities of daily living in order to improve quality of life as described by Louie et al. [6]. Other applications include rehabilitation of stroke patients [7] and with adult patients suffering from dementia [8].

In order for robots to be effective assistive technology tools, they must be accepted and adopted by the in-

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tended user population [6]. Few studies have investigated how older adults relate to humanoid robots. Those studies have found the experience of the participants with human-like robots was positive [3, 4, 6]. Even as human-robot interaction (HRI) is becoming ubiquitous, there is very limited information regarding the difference between young and old adults in their preferences when interacting with humanoid robots and what factors influence these preferences. This information is of great importance since it could be that the same robot or the same tasks of a given robot do not equally suit both older population and a younger population and that older people have different needs from a robot compared to younger users. Nomura and Sasa compared young and old adults' interaction with a real robot versus a virtual robot. They found that, compared to the young group, more people in the older group complied with the real robot, had more positive impressions of both robots, and felt more attachment to the virtual robot [9]. Ezer et al. conducted a questionnaire by mail among young and older adults regarding their robot task preferences. They found that older adults indicated more willingness than younger adults to have robots perform critical monitoring tasks that would require little interaction between the robot and the human. They concluded this may be because older adults see more of a benefit to having a monitoring-type robot than younger adults [10]. These works demonstrate some of the differences between age groups when interacting with robots. There are still many aspects of the interaction that should be investigated, specifically, what age-related differences affect HRI. Many factors can affect how a person relates to a technological assistive tool, and these may include the age of the person, whether the system is embodied, and the type of interaction with the technology. Hence, in a group of healthy participants we investigated the age effects on user preferences when interacting with a humanoid robot using two qualitative usability experiments. Our goal in the current experiments was to test how age, location of touch interaction (touching the robot's tablet or petting its hand), and embodied presence of a humanoid robot affect the motivation of different age-group users to continue performing a cognitive-motor task.

2 Materials and methods

2.1 Participants

A total of 60 participants (30 young adults and 30 old adults) took part in two experiments. A convenience sam-

ple of young participants was recruited from the university's student social groups. Older participants were recruited via advertising sent to the mailing lists of retired university workers (academic and non-academic positions) and all the university exams inspectors. Older adults were ambulatory and independent in the community. Exclusion criteria were as follows: a vision impairment that would interfere with their ability to see the screen; a neurological or orthopedic impairment that would limit their hand movement; and a Mini-Mental State Examination (MMSE) score below 24 [11] (MMSE was tested in the older adults only). All participants gave their written informed consent to participate in accordance with the requirements of the Ben-Gurion University Ethics Committee, which approved this experimental protocol.

2.2 The robot

The robot used in the described experiment was the Pepper robot (Aldebaran SoftBank robotics). It is a humanoid robot, and it measures 120 cm in height (see Figure 1). The participants sat on a chair in front of the robot, at such a distance that they could touch the robot's chest tablet. A narrow table (60*15 cm) was positioned between the participant and the robot.

Figure 1: Experimental setup: The Pepper robot is showing a sequence of colored cups on its tablet. The participant has to organize a set of actual physical cups on the table according to the displayed picture.

2.3 Experiment 1

2.3.1 Participants

Ten old adults (70.8±5.7 years, 6 females) and 10 young adults (24.6±2.6 years, 5 females) participated in this experiment. All young participants and seven of the older adults were right handed. Participants could use either hand or both for playing the game, according to their own convenience.

2.3.2 Procedure

In each of the twelve trials, a row of colored cups was displayed on the robot's tablet. The participants had to organize a corresponding set of actual physical cups on the table according to the picture shown on the robot's tablet (see Figure 1). There were three levels of game difficulty: in Level 1 there were four cups, in Level 2 there were five cups, and in Level 3 there were six cups. The instructions and feedback were provided by the robot. The picture with the target order of the cups disappeared from the screen after 8-10 seconds. When they completed the task, participants had to either touch the robot's tablet (see Figure 2) or pet the robot's hand (see Figure 3). Half of the participants touched the tablet for the first six trials, and then petted the robot's hand, and the other half first petted the robot's hand, and then touched the tablet for the final six trials. After each trial, the robot either gave feedback on the performance (e.g., "try to do it faster next time") or on the results (e.g., "you succeeded!", "you were not right but try again!"). The feedback given by the robot was both verbal and with head and arm gestures (e.g., hand clapping). To determine the success or failure of each trial, we employed the "Wizard of Oz" (WOZ) approach [12]. The participants were not aware of the fact that the experimenter, and not the robot, was making the decision on how to respond. After two trials on the basic level (four cups) or after four trials on the second level (five cups), the participant could choose to either continue at the same level or change to a harder level of the game (more cups). After four trials on the basic level (four cups) or after six trials at the second level (five cups), the participants were forced to continue to the next level. There were a total of 240 trials, across all participants.

2.3.3 Questionnaire

At the end of the experiment, the participants answered a custom-built questionnaire, regarding their preferences, feeling, and thoughts about their interaction with the robot. The questionnaire was based on the "Godspeed questionnaire" [13] and included both Likert-scale questions and open-ended questions. It was structured as a five-point Likert-scale (1 – negative feelings, 5 – positive feelings), and included questions such as – "did you feel the robot was natural or fake?", "did you like the interaction with the robot?", "was the robot friendly?", "was it nice to relate to it?", "is the robot intelligent?" All of the questions for Experiment 1 are shown in Table 1. In addition, the questionnaire included open questions such as whether they preferred to touch the robot's tablet or to pet its hand and why. We chose a custom-built questionnaire comprised of a Likert-scale and of open-ended questions in order to capture the nature of the preferences and the differences between the two age groups.

Figure 2: In order to indicate completion of the task the participant is touching the robot's tablet.

2.4 Experiment 2

In the second experiment we aimed to broaden the question of what affects the differences in preferences between age groups when interacting with a humanoid robot. We set out to test not only the preference of location of touch
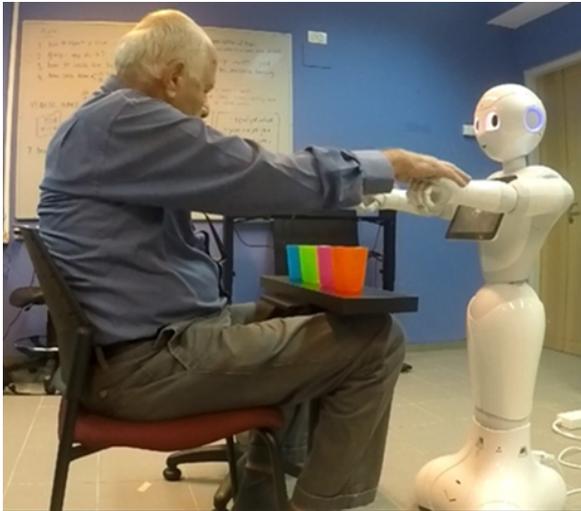
Figure 3: In order to indicate completion of the task the participant is petting the robot's hand.

Table 1: The custom-built questionnaire of Experiment 1.

Fake	1 2 3 4 5	Natural
Not pleasant	1 2 3 4 5	Pleasant
Machine like	1 2 3 4 5	Human like
I didn't like the robot	1 2 3 4 5	I liked the robot
Unconscious	1 2 3 4 5	Conscious
Artificial	1 2 3 4 5	Alive
Apathetic	1 2 3 4 5	Responsive
Unfriendly	1 2 3 4 5	Friendly
Incompetent	1 2 3 4 5	Competent
Unintelligent	1 2 3 4 5	Intelligent
Not nice to relate to	1 2 3 4 5	Nice to relate to
Unpleasant interaction	1 2 3 4 5	Pleasant interaction

interaction (robot hand versus tablet) but also whether the embodiment of the robot affected their preferences.

2.4.1 Participants

A total of 40 participants were recruited for this experiment: 20 young university students (24.7±2.2 years old, 10 females) and 20 old adults (69.4±5.6 years old, 10 females).

2.4.2 Procedure

We investigated the difference in the preferences of young and old adults when interacting with a robot versus with a computer screen. For the SCREEN condition, we used an LCD screen and a computer keyboard placed on a standard table. The 42-inch screen was placed on the wall in front of the table approximately 1 m from the table. Participants were asked to play the cup game as was described for Experiment 1. Ten games with one system were followed by ten games with the other system for a total of 400 trials with each system. Half of the participants in each age group started with the SCREEN condition, and half with the ROBOT. Before starting to play with the robot, each participant had two practice trials. As in Experiment 1, when the participants were playing with the robot and upon completion of the task, they were asked to touch the robot's chest tablet in five of the ten games and to pet its hand in the other five games . The order was blocked and counter-balanced across participants. When the participants were playing in the SCREEN condition, they had to press the space key on the keyboard when they finished organizing the cups. The feedback on performance in the SCREEN condition was displayed as text on the screen with no voice feedback. The picture with the target order of the colored cups was displayed on either the screen or the robot's chest tablet for 6-8 seconds. In the ROBOT condition, we used the camera embedded in the robot together with a custom-built image-processing algorithm to decide whether the participant arranged the cups correctly. The robot's camera captured the cups ordered on the table. The image was passed to the image-processing algorithm that outputs the order of the placed cups. This output was compared to the correct order automatically and autonomously, to determine whether the trial was successful or not. The robot then gave feedback to the users on whether they succeeded or failed. In the SCREEN condition, we employed a WOZ paradigm for determining success on each trial. In Experiment 2, when participants completed three sequential successful trials, they automatically continued to the next level (more cups).

2.4.3 Questionnaire

At the end of the experiment, the participants completed an open-ended custom-built questionnaire (see Table 2) regarding their preferences and their perception of the interaction and the game. They were asked what condition they preferred and why, and what would be their preferred system if they had to play two more games, or ten more games. In addition, they were asked what system they would like to take home with them. We used an open-ended custom-made questionnaire in order to understand the nature of the differences in preferences of the two age group for further future research.

Table 2: The open-ended custom-built questionnaire of Experiment 2.

Describe your experience from the game. What was good? What would you improve?
What did you think about the robot?
If you had to play two more games-which system would you prefer (ROBOT/SCREEN)? Why?
If you had to play ten more games-which system would you prefer? Why?
What system did you prefer? Why?
If you could take one system home, what system would you take? Why?
Did you prefer petting the robot's hand or touching its screen? Why?

3 Data analysis and results

Statistical analysis was performed using the SPSS Statistics toolbox (version 25).

3.1 Experiment 1

3.1.1 Petting the hand or touching the screen

We used the Chi squared test to compare the preference of petting the hand versus touching the tablet screen between the two groups. There was no difference between old adults and young adults in their preferences for touching the robot's tablet or petting its hand. We found a non-significant preference for touching the robot's hand versus its chest tablet (70% preferred the hand in both age groups, p=0.115). Those who preferred to pet its hand mentioned it felt more "human-like" and "intimate" to them. Those who preferred to touch the chest tablet noted it was a more familiar way for them to interact, as they touch the screens of other technological devices.

3.1.2 Preferences of the interaction with the robot

All participants rated the robot high on the 5-point Likert-scale. They reported they liked the robot (5.0±0.0 in the older group versus 4.0±1.3 in the young group), they found it friendly (4.8±0.4 versus 4.6±0.7 respectively) and capable (4.2±1.3 versus 4.0±1.2 respectively). In order to understand the differences in perception of the robot between the two age groups, as was measured by the Likert-scale questionnaire, we performed the Mann-Whitney rank-sum test for independent samples. Older adults found the robot more human-like than the younger adults (4.0±0.9 in the older group, 2.8±1.1 in the young group, p=0.029, U=22); They liked it more (5.0±0.0, 4±1.3 respectively, p=0.013, U=25) and found it more responsive (4.8±0.6, 4±1.1 respectively,

p=0.033, U=26). In the other parameters there were no significant differences between the two age-groups.

3.1.3 Performance on the cup game

All participants reported they enjoyed the game. The older adults reported they found the game challenging especially because of the memory and speed requirements of the game. All participants chose to continue to the next level when first asked and not to stay at the same level of game. All participants played two games at the basic level (four cups), four games at the second level (five cups) and six games at the advanced level (six cups). Success rates were higher among the young (87.5%) than the older adults (72.5%). Only two older participants succeeded on all twelve trials compared to five participants in the young group. Most failed trails occurred when a cup was added in the transition from level one to level two and from level two to level three. The mean time per trial from the time the picture was displayed until the participant was touching the screen or petting the robot's hand was 15.1 seconds (±1.7) for the older participants and 13.3 seconds (±3.8) for the young adults. In order to test the difference between the two age-groups in the time it took them to complete the task, we used the Mann-Whitney U test for independent samples. There was no significant difference between the two age groups in the time it took them to complete the task (p=0.123). The mean time for seven out of the ten young participants was shorter than 12.0 seconds and for the other three it was an average of 17.0-19.7 seconds.

3.2 Experiment 2

3.2.1 Robot versus screen

In order to test whether participants preferred the ROBOT condition or the SCREEN condition and the difference between the two age-group in this preference, we used the

Chi-Squared test. We found a significant preference for interacting with a ROBOT over a SCREEN (p<0.001), despite the slower response time of the robotic setup.

80% of the young adults and 50% of the older adults reported they prefer playing with the robot versus 20% and 35%, respectively, who preferred the SCREEN condition. The other participants had no preference. All of the results are summarized in Figure 4. We found a non-significant effect of age on this preference (ROBOT versus SCREEN, p=0.053). There was a stronger preference for the ROBOT over the SCREEN in the young group (p < 0.0001) versus the older group (p = 0.157).

90% of the young adults and 75% of the older adults stated they would like to take the robot to their home. The responses to the open-ended questionnaire reveal that participants found the robot more engaging than the screen. The participants reported the robot was "more interesting to play with"; "the interaction with the robot was more human-like"; "it was nice to receive real feedback from the robot and not just a written feedback from a computer screen".
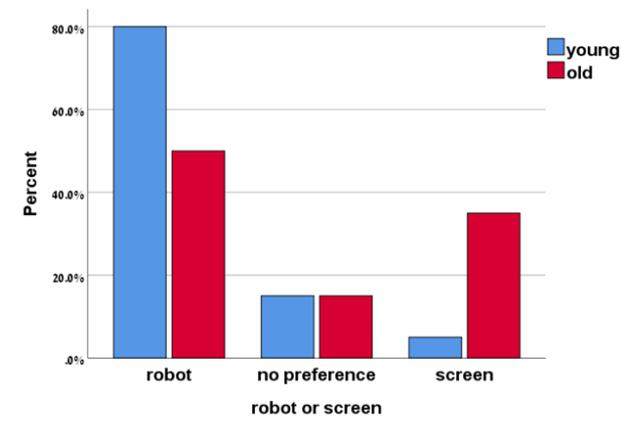

Figure 4: A summary of the preferences of both age groups in Experiment 2: robot, screen or no preference. Results are shown as percentage of each group.

3.2.2 Petting the hand or touching the screen

45% of the young adults and 60% of the older adults preferred petting the robot's hand versus 40% and 30%, respectively, who preferred touching the robot's tablet in order to indicate the end of the trial. The rest of the participants had no preference. We found a significant preference for touching the robot's hand versus its chest tablet (p=0.008) when tested across all subjects. The young

group did not show a significant preference for hand versus tablet (p=0.212), whereas the older group did show a significant preference for touching the robot's hand (p = 0.022). See Figure 5.

As in Experiment 1, participants who preferred touching the robot's hand mentioned it felt more "human-like", whereas participants who preferred touching the robot's screen mentioned it was more similar to other familiar interactions with technology in everyday use.
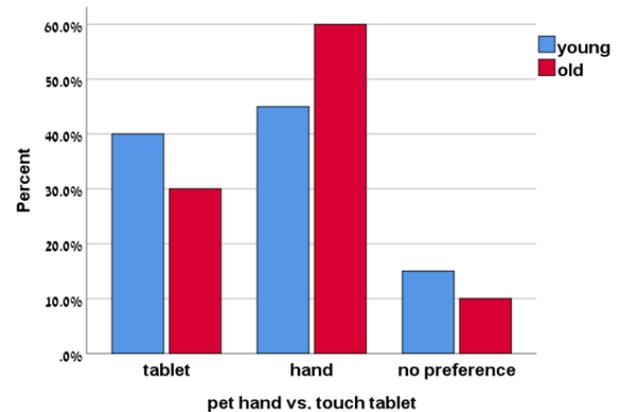

Figure 5: Summary of the results of Experiment 2: preference of petting the robot's hand or touching its tablet in order to indicate completion of the task. The results are presented as percentage of each group.

3.2.3 Performance on the cup game

The overall success rate was 83% for the older adults and 93% for the young adults. The success rate in the ROBOT condition was 84% and in the SCREEN condition it was 92%. In the ROBOT condition, the young group successfully completed, on average, 9.2 (±0.8) trials, and the older group completed, on average, 7.6 (±1.6) trials. In the SCREEN condition, the young group successfully completed, on average, 9.5 (±0.8) trials, and the older group completed, on average, 9.0 (±1.1) trials. The difference between the two age-groups in their performance in the two conditions was tested using the Mann-Whitney U test. In the ROBOT condition we found a significance difference between the two age-groups (p<0.0001), while no significant difference was found between the two age-groups in their performance in the SCREEN condition.

In order to test the correlation between the performance on the cup game in either condition (SCREEN versus ROBOT) and the preferred system, we used the Spear-

man correlation test. No correlation was found between the performance of the task in either system and the preferred system (ROBOT or SCREEN) for both age-groups.

In order to test the difference between the two groups in the time it took them to complete the task in the second experiment, we used the one sample t-test for independent variables. The average time per game with the robot was 11.0 seconds (±0.9 s.) for the young adults and 13.3 seconds (±2.2 s.) for the older adults. The average time per game with the computer SCREEN was 8.1 seconds (±1.4 s.) for the older adults and 6.5 seconds (±1.0 s.) for the young adults. In both conditions (ROBOT/SCREEN), younger adults completed the tasks significantly faster than the older adults (p<0.001). Time to complete the task in the ROBOT condition was slower than in the SCREEN condition for both age groups (p<0.0001).

4 Discussion

The aim of these two sequential experiments was to investigate the differences between young and old adults in their preferences, perceptions, and performance when interacting with a humanoid robot (Experiments 1 and 2), to compare these preferences to the interaction with a computer screen (Experiment 2), and to test what factors influence these preferences.

In both experiments, both old and young adults reported that they found the robot engaging, that they enjoyed the interaction, and that they would like to be in further interaction with the robot. In the second experiment, when the robot was compared to a screen, we found a significant preference for interacting with a robot over a screen in the young group (p<0.001). Both groups reported they enjoyed the novel experience of an interaction with a robot. The differences in the preferences between both conditions in the different age groups are discussed below. One of the reasons for this difference could be due to the slow response time of the robot in the second experiment. The response time of the robot when using the image processing algorithm was slower compared to the response time of the computer where we used the WOZ paradigm. The participants responses emphasize the gap between the expectations of users when encountering such a novel human-like robot such as the Pepper robot and its actual performance, i.e., slow response time. Lohse [14] referred to the notion that what users expect of a robot strongly influences their ratings of the interaction. If the robot satisfies the expectations, the users are usually pleased. If not, their experience of the interaction is negative. In her

work, Lohse found that it was the performance of the robot and not its social behavior which was the cause for the gap between the user's expectations and the actual performance of the robot. When comparing the time to complete the task between both experiments, we see that the mean time to complete the task in the first experiment was slower than the mean time to complete the same task in the ROBOT condition in the second experiment. This could be due to the fact that in the first experiment the picture was displayed on the robot's screen for a longer time (8-10 seconds) than in the second experiment (6-8 seconds). In the second experiment, where the picture disappeared after less time, the participant completed each trial in less time.

Comito et al. [15] referred to the characteristics of the interaction with Nao and Pepper - robots with a human-like face. They mentioned the lack of fluency in communication between the robot and the participant because of the rather slow response time of the robot. In our first experiment, we partially overcame it by using the WOZ paradigm as it was the wizard, and not the robot, making the decision on how to respond. In the second experiment, the robot was an autonomous system and for the SCREEN condition, we used the WOZ paradigm, which was indeed faster than the robot responses. *Despite the longer time it took the robot to respond, both old and young adults preferred the interaction with the robot over the interaction with the screen*. Even participants that preferred the SCREEN condition, mentioned that if the robot's responses would have been faster, they would prefer the ROBOT condition since they found it more "fun", "human-like" and "engaging". Yet, this preference could be due to the novelty effect of the interaction with the robot and the game; an effect that should be further investigated. Koay et al. [16] in a five weeks longitudinal interaction with a humanoid robot showed that there is a habituation effect to the robot. In contrast, in a review conducted by Leite et al. [17] they describe different longitudinal interactions with a humanoid robot in therapeutic or health-related scenarios. In all of the studies that they described, the longitudinal interaction had a positive and accumulative effect. However, there was a single study per population group (e.g., older adults, children with autism) and each had a limited sample size. Larger studies are needed to establish the effect of a long-term interaction with a humanoid robot.

The relatively high ratings that the participants gave to the interaction with the robot can stem, in part, from the expressive gestures that the Pepper robot used in the interaction. Participants in both experiments reported they liked the gestures of the robot. This was emphasized when the ROBOT condition was compared to a SCREEN. Par-

ticipants in the second experiment mentioned they preferred the human-like physical feedback of the robot over the written feedback which was shown only as text on the computer screen. These findings are in line with former studies. Chidambaram et al. [18] demonstrated a robot was significantly more persuasive when it used gestures. Hand gestures have been found to improve user ratings for robots on scales such as likeability and intention for future contact in a number of studies [18–21].

We asked what people preferred not only when the screen was separate from the robot (embodiment as robotic physical presence), but also when a screen was part of the robot's body. Embodiment as the way the person relates to the robot, is the interaction similar to that performed with a technological device, like a tablet, or similar to how one interacts with another human, like touching their hand. We also tested the effects of age on these preferences.

We found in Experiment 1 that both young and old adults preferred petting the robot's hand and not touching its tablet. This was more emphasized in the older age group in the second experiment (p=0.022), as they found this interaction more human-like and intimate. The results showing that participants preferred to touch the robot in a human-like fashion (touching its hand versus its tablet) are in line with those of Adalgeirsson and Breazeal [22] and with those of Mamode et al. [23] who found that embodiment leads to stronger social engagement than a screen. Mann et al. also found that people preferred interaction with a robot more than an interaction with a tablet [24]. They mentioned participants found the robot was more enjoyable to interact with than the computer tablet, and reported higher desire to interact with the robot again in the future [24]. Lee et al. compared an interaction with an embodied robot to a virtual robot and also found that people evaluate a physically embodied social agent more positively than a disembodied social agent [25]. They concluded that physical embodiment has an added value for people's social interaction with agents, however, physical embodiment with no possibility of tactile interaction decreases an agent's social presence [25].

A question that should be asked is why the preference of petting the robot's hand was more pronounced in the older group and why they felt this interaction was more human-like. We posit that the characteristics of the older age underlie these preferences. Older people tend to be more lonely [25]. Loneliness is accompanied by lack of physical interaction and communication. Touch, particularly with another person, is central in building the foundations of social interaction, attachment, and cognition, and early social touch has unique, beneficial, neuro-

physiological and epigenetic effects [26]. Lee et al. showed that the more a person feels lonely, the more the person feels social presence when physically interacting with a social agent [25]. Thus, further studies on the importance of touch interaction and the effect of physical interaction with a robot, especially in the older population, are necessary.

In both experiments, the older adults found the game more challenging due to the memory and speed components of the game. Even though older adults noted that the short display time of the image on the robot's tablet was challenging for them, when they perceived the subsequent response time of the robot to be too slow, it diminished from the success of the interaction. Mead & Mataric [27] noted that when interacting with a robot, it is important for the interaction to succeed. They found that robot *performance* factors—rather than human-robot proxemics—are significant predictors of user evaluations of the robot's competence, anthropomorphism, engagement, likability, and technology adoption [27]. Trust is also a central condition for successful interactions between patients and SARs in a rehabilitation context. Kellmeyer et al. proposed that safety, shared intentionality, predictability of behavior, and mutual attunement are particularly salient prerequisites for establishing trust between humans and SARs [28]. It may be that when a robot performs slower than expected, it diminishes from the trust that is generated with the human participant. In Experiment 2 of the current study, older participants mainly noted the following factors as affecting their preferences: (1) The slow response time of the robot compared to the computer; (2) The bigger size of the computer screen compared to the robot's tablet screen on which it was easier to see the images; and (3) The bigger size of the table in the SCREEN condition compared to the narrow table in the ROBOT condition on which it was easier to place the cups as less attention and accuracy were required to make sure the cups do not fall off the table. None of the young adults mentioned the experimental set up as a factor influencing their preferences, but some of them did mention the slow response time as a factor influencing their preferred system when asked about a longitudinal interaction. In the work by Eizicovits et al. [29] they found that slower response time of the robotic system compared to the computer-controlled one negatively affected the young group's motivation to continue playing but not that of the older group. The difference between the responses of the older group in that study and the current one highlights the importance of personalizing the design of HRI and tailoring it to the specific task. Personalization of the task was also discussed by Kashi & Levy-Tzedek in a mirror game task with a robot. In their work they demon-

strated individual differences in preferences of different users when interacting with the robot [30]. When designing an intervention for the older population, factors such as the distance from the robot, the size of the screen, and the reaction time of the system can influence the success of the interaction and people's evaluation of the robot and should be taken into consideration. The response time of the robot should be faster and correlate to the characteristics and the pace of the interaction and of the task in order to gain the user's trust and improve their perception and feelings of engagement. This is highly important in vulnerable populations such as older adults or stroke survivors where robots can assist in maintaining a training regime, and it is important for users to experience success of the interaction in order to persist with the training. In conclusion, in order for the experience of the user to be positive, it is important to personalize the interaction according to the age, the needs of the user, the characteristics, and the pace of the task. From these two experiments, we learned that humanoid robots are well received by different age groups, and preferred over a non-embodied system, despite a slower response time. Yet, there are characteristics of each age-group that do influence the interaction with humanoid robots. These differences should be further investigated and taken into consideration when designing interactions with a humanoid robot.

A limitation of the second experiment is that there was a difference in the response time of the two experimental setups that participants reported to affect their preferences. And yet, despite the slower response time of the robotic system, it was preferred by both age groups, suggesting that equal response times would lead to an even larger preference for the embodied robot. Further research is needed to investigate these questions.

5 Conclusions

We showed in our study that there are differences between old and young adults in their perceptions and preferences regarding the interaction with humanoid robots. Both age groups enjoyed the interaction with the human-like robot, but in order for this interaction to be even more successful, the response time of the robot should be shorter. Further research is needed to test the preferences of different populations when interacting with humanoid robots and to investigate the effect of longitudinal interaction on these preferences.

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