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Investigating gesture-based avatar game representations in teenagers, younger and older adults ☆

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ABSTRACT

In game design, avatars are an important means of representing behavioural traits of the player. Designers are often faced with decisions on how the avatar's appearance may affect the game experience. Despite this, relatively little is known about how age influences self-representation in gesture-based avatars. In this paper, we present the findings of 54 mixed-age participants (i.e. teenagers, younger adults and older adults), who were asked to compare the design of three different avatar-types (i.e. cartoon, humanoid and silhouette). Comprising of a post-game questionnaire and individual semi-structured interviews, participants were asked to rank avatar preferences, and were questioned on their perceptions towards age representation. Our results show that there were significant group differences in the identification and awareness of visual features in the avatars for those below the age of 30, compared to those above 55 years old. This included variations in attention to detail and behavioural representation. The paper concludes by reflecting on game design challenges for these target groups, and recommends further avenues of pursuit.

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1. Introduction

Demographically, teenagers and younger adults represent two of the highest digital game playing groups, with older adults comprising of a smaller, yet growing number of gamers. For example, a 2008 U.S. survey identified that 36% of gamers (aged 65 and above) regularly played digital games on a daily or near daily basis [28]. Aligned with more recent statistics from the Entertainment Software Association [10], the growing trend in digital game adoption by older adults has drawn increasing interest in their roles as social mediators and educational tools in the facilitation of interaction between different age groups (e.g. [7,19,39,41]). This includes understanding how the affordances of digital games can help reduce social barriers between the young and old [39], improve the literacy of children in low-income households [7], and foster better engagement between family members and residents of retirement communities [41].

Related intergenerational game studies have varied from the use of augmented environments to mediate collaboration [18,19], to game features that build on the mental models of the players [39]. A common theme across these studies has been a focus on evaluating the usability of prototype games (e.g. [18,39]), with few known guidelines or recommendations to support intergenerational practices [7,41]. Subsequently, in the context of gameplay usage, relatively little is known in how to leverage on differences in player values, beliefs and technological understanding. This includes knowing how the visual representation of virtual characters and online identities are perceived across different age groups, particularly amongst low and high digital game adopters. Our prior work has identified that modifications in the physical characteristics of on-screen characters may be a playful attribute in reversing roles in intergenerational games [31]. Despite this, it remains questionable the extent that altering the visual representation of players across different generations may influence communication and collaborative goals.

Given the scale of possibilities for players to construct identities in unique and different ways, in this paper we examine how the self-identification and perception of age in avatar representation may vary across three age groups (i.e. teenagers, young adults and older adults). Building on the authors' preliminary research [32], the focus of this study is to identify the extent to which players could associate with three distinct gesture-based avatars (i.e. cartoon, humanoid and silhouette). In doing so, the research compares attitudes and player preferences to determine if there are identifiable group differences. Specifically, we explore avatar representation, in terms of homophily, expressiveness, attractiveness and engagement, using a post-game questionnaire and semi-structured interviews to extrapolate findings, and contribute to a limited body of

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knowledge in this area. Our work makes a number of contributions in terms of understanding how the perceptions of avatar representation vary across age. This includes the types of physical and behavioural attributes of the avatars that players perceive to be important. In addition, we outline the practical implications of these findings in terms of future research and game design.

2. Related work

Represented in many different forms, avatars are widely designed to enhance, engage, and to appropriately respond to player actions. Importantly, their presence can involve familiar forms of interaction [3], as players embody avatars, giving a level of realism to how they 'internally experience' themselves [37]. Equally, avatars can be instrumental in mediating interaction and increasing the self-awareness of other players within virtual environments. For example, in virtual teams, players have been reported to better identify with other interactants who have similar-looking avatars to themselves [24]. In turn, the ease to change the appearance and bodily representation of one's virtual self is perceived to be far more versatile than in real world interaction, and can account for interests in gender swapping and more idealised avatar forms (e.g. [9,37]).

Likewise, the type of game domain has been identified to influence the visual depiction of players. For example, a study by Vasalou and Joinson [40] reported that players in an online dating scenario carefully chose avatar features of themselves with the aim of impressing or gaining the attention of others. In a few instances, this included employing deceptive strategies to accentuate the perception of their physical image. Moreover, in relation to visual appearance, virtual players have been found to construct identities in abidance to social norms and practices (e.g. [37]). This includes maintaining a balance between updating appearances to reflect group expectations, while preserving a level of individuality from the group [25].

Alternatively, the virtual replication of a player's self in the bodily form commonly known as a *doppelganger* has been found to have a persuasive effect in changing the behavioural traits of the player [1]. This includes psychologically influencing player's willingness to exercise by manipulating the physical appearance of their avatar [12]. In other cases, it has been identified that players with different representations behave differently in virtual worlds. Namely, players with taller or more attractive avatars were more confident in negotiation tasks, or were willing to disclose more information [43].

On the other hand, beyond the use of immersive environments, it is understood that the perceptions of avatars are deeply characterised by their visual appearance. For example, in reviewing the paired interaction in a social chat context, Nowak and Rauh [27] identified that a partner was seen to be more credible when their avatar appeared less androgynous. Similarly, the authors described how more anthropomorphic representations attributed to an increase in partner credibility. In this context, the influence of the physical design of avatars in altering the perceptions of other players is perceived to be comparable to how people formulate impressions of others in the physical world [27]. Subsequently, the blurring between online and offline worlds illustrates the potential advantage of using avatars to enrich personalities and personas [37], to influence the perception of others [27,43], and to behave in a less inhibited manner compared to everyday life [23].

2.1. Avatar representation and age

According to Williams et al. [42, p. 816], understanding game character demographics has been described as *"a necessary step in applying theories of influence, identity construction and perceived social reality*". Specifically, the authors attribute game representation as an important means of measuring differences in social and cultural identity amongst minority groups. In reviewing the proportion of game characters in over 130 commercial games, Williams et al. [42] found that older adults were highly underrepresented. For example, compared to the 12% of older adults that make up the U.S. population, they accounted for less than 2% of the characters in the sampled games. In contrast, the teenage characters existed at a rate similar to their proportion in the general population (7%), while the number of adult characters far exceeded the national average (nearly 87% compared to a demographic census of 59%). Critically, this disparity in age representation was reported to be partially attributed to an industry that is predominately supported by young, male developers, in perpetuating their own identity within digital games [42].

Of the relatively few studies that have attempted to understand the effect of age on avatar representation, two notable exceptions include Griffiths et al. [14] and Blinka [4], both of whom reported age differences when playing virtual avatars. In the case of Blinka [4], it was reported that adolescent players had a stronger identification to avatars compared to players in their mid to late twenties. These findings were attributed to the teenagers need to perform well and to attain success in the gameplay. Separately, Griffiths et al. [14] also compared the differences between adolescence and adults in avatar behaviour and found that younger players were less likely to gender-swap. However, the authors were speculative to what caused such differences in the study.

More recently, the experimental work of Principe and Langlois [30] revealed that undergraduate students and young children share a common preference for attractive looking avatars. Using Nintendo Mii avatars for the visual stimuli, the study identified that preferences for facially attractive characters was reflective of real world practices when engaging in face-to-face communication. Alternatively, in exploring the online relationships of 180 gamers, Ducheneaut et al. [9] found that younger players preferred creating avatars of an age similar to their own, while middle-aged players preferred younger looking avatars. This was accounted to the middle-aged players desire to create an idealised, rather than actual representation of themselves.

Focusing on older adults, Cheong et al. [6] sought to compare identification factors between anthropomorphic and non-anthropomorphic images of humans, animals and objects. The results revealed that older adults faced difficulties in self-relating to image-based avatar representations, but indicated that younger looking avatars appeared more credible in their appearance. This was attributed to the younger avatars inducing more paternal or reminiscent qualities in the older adults. Contrastingly, in exploring age differences in the social presence of a virtual world, Siriaraya and Ang [34] found that a number of both younger (22–33 yrs) and older adults (55–80 yrs) preferred selecting avatars of an age different from themselves, with the older adults perceiving non-human avatars to be lower in social experience. Subsequently, the authors suggest that in designing virtual worlds, game developers should be cautious of using non-human avatars with older players.

In reflection of the work of Cheong et al. [6] and Siriaraya and Ang [34], the results suggest that there is a possible correlation between avatar-type preference and age. However, we believe further research is required to better understand this relationship. Speculatively, age differences in avatar representation may help mediate social interaction between generational cohorts, by conveying aspects of personality and behaviour. However, much of the previous game literature lacks supportive evidence to determine the extent to which perceptions of visual representation may vary across age groups. Subsequently, the goal of this study is to understand the extent participants can self-identify with three

different avatars, and in doing so determine if there are comparable group differences in representation. Based on a mixed-method approach, the following research questions are proposed:

RQ1: To what extent do the players of the different age groups self-identify with the avatars designed?
RQ2: How do perceptions of the visual representation of the avatars vary across the three age groups?

Further, drawing from the work of Ducheneaut et al. [9], a third research question is designed to address participant's interests in avatar age perception:

RQ3: Are there noticeable group differences in preferred age representation in game avatars?

3. Method

3.1. Participants

Using a between-subjects design, 54 participants (19 males, 35 females) consisting of teenagers (14–18 yrs), younger adults (21–30 yrs), and older adults (55–74 yrs) took part in the study. Each age group consisted of an equal number of participants ($n = 18$), who were recruited through local schools, polytechnics and community centres.

3.2. Game description

The evaluation of the study was completed on a prototype game. The game concept builds on the authors' prior work on designing gesture-based games for older adults [33]. Specifically, the game was designed to be easy to learn, with interactive elements that allowed players to express a range of movements in the on-screen avatars.

The objective of the game was to nurture a small set of garden plants from seedlings to adult growth, during which time their size, colour and shape would transform the longer they were successfully maintained. Body gestures were used to manipulate weather elements, such as blocking or directing rain and animated sunrays to feed a small set of garden plants. For example, in feeding plants with rain droplets, players could use various hand and arm movements to redirect the raindrops away or towards the plants. Nurturing four or more plants required greater multi-tasking and therefore, a default number of two plants were set in the game. To assist the gameplay, on-screen health bars were used to indicate the individual plants' well-being, warning players when sun and water levels were not optimal. In addition, an animated colour-coded timeline was used to indicate weather condition changes, thus allowing the players to plan ahead (see Fig. 1). With four levels in total, the game started with mild weather conditions and progressively became more varied and fast-paced. Additional elements such as attacking birds and lightning strikes increased the variety of game features, while rewards consisted of upgrading the plants with water and sun protection.

3.3. Avatar stimuli

Three life-size non-customisable avatars were designed for this study. Although two-dimensional, it was important that the avatars were not static representations but were able to be manipulated in real-time. This allowed the authors to test the avatars' functionality and to give a level of realism in playing a moving character. While facial features, such as the eyes and mouth remained fixed during the gameplay, players were able to manipulate on-screen objects by controlling lower and upper body movements. In terms of visual appearance, the three avatars consisted of a:

1. *Humanoid avatar:* Designed to resemble the most human looking, it included more proportionate body parts and facial features.
2. *Cartoon avatar:* Exaggerated and oversized body parts, with 'cartoony' looking features that resembled a person, but with simplified and enlarged details.
3. *Silhouette avatar:* A semi-transparent representation of the player's body shape with no graphical features included. This avatar was represented in the most minimalistic form with regard to its physical appearance (e.g. a simple semi-transparent shape). As compared to the other two representations that were fixed in their physical dimensions, the silhouette avatar represented a direct match to the player's bodily form. The lack of graphical detail was felt to be an important component in understanding how well players could self-identify with its appearance.

Both the cartoon- and human-looking avatars were designed in male and female versions to be representative of the gender of the players (see Fig. 2). Variations in the design of the avatars, such as the absence of a mouth or eyebrows, or differences in the hairstyle and clothing were intentionally designed to allow the authors to determine how well the participants could recognise variations in the body details. This included how differences in the avatar designs influenced their perception of the characters. In this sense,

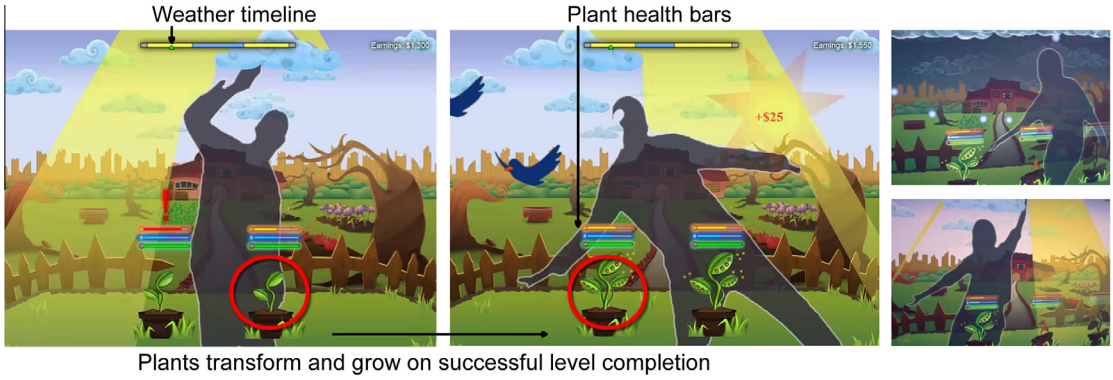

Fig. 1. The prototype game. In the left image, the clouds can be physically moved to redirect sunrays to/from the plants. In the middle image, the player can fend off attacking birds to protect their plants. The right images highlight further examples of the game.

Fig. 2. The study avatars: (left), humanoid; (middle) cartoon, and (right) silhouette avatar.

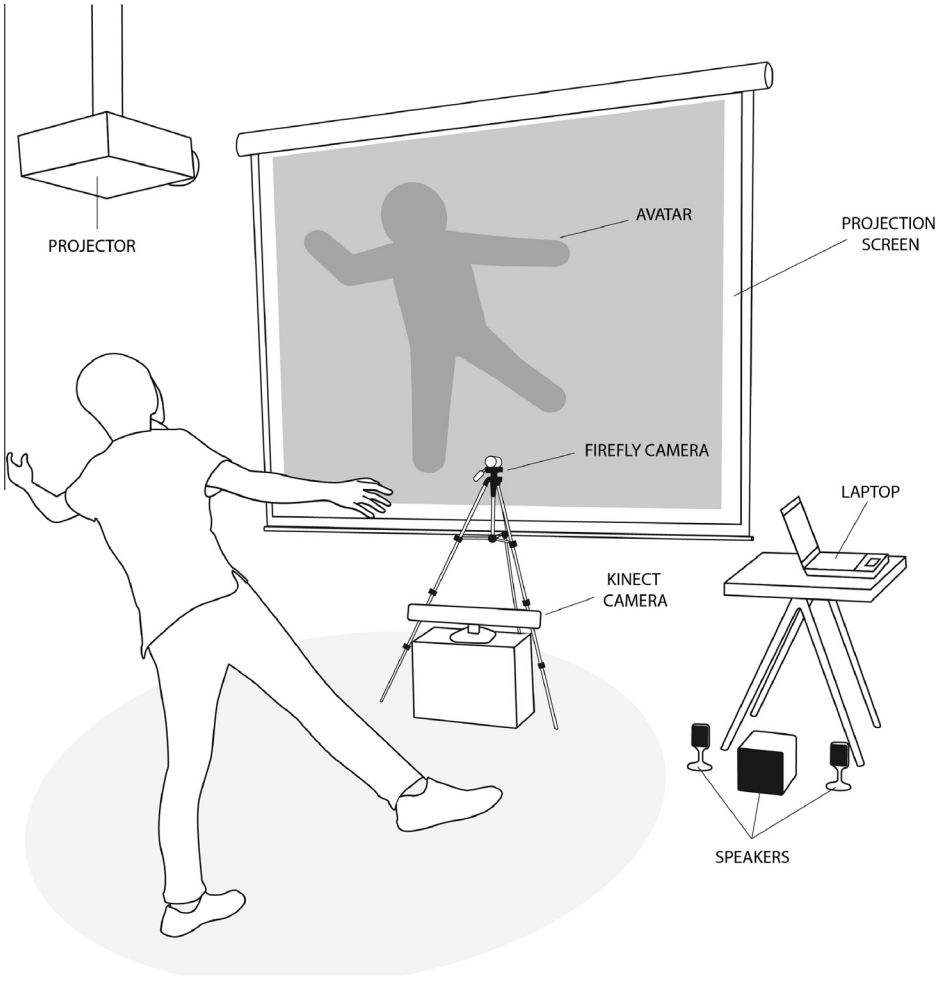

Fig. 3. Game setup.

the study avoided more controlled conditions, focusing on a wider range of pre-defined features within a small set of avatars.

3.4. Equipment and setup

The game setup consisted of a laptop (Intel Core i7 2.0 GHz, 6GB RAM), LCD projector and a 205 × 154 cm projection screen (see Fig. 3). For two of the avatar-types (humanoid and cartoon), gesture recognition was performed using a Microsoft Kinect camera, employing a skeleton-tracking algorithm to identify the joint positions of the players, and translate them into visual feedback in the avatar model using available APIs. For the third avatar-type (silhouette) a Grey Point Firefly camera was used, employing frame differencing and blob detection methods to formulate a smooth and stable representation of the player. This difference in image processing was necessary to develop appropriate graphical representations of the avatars.

3.5. Procedure

Each session was conducted with a single participant over approximately 80–90 min. In giving consent, each participant was instructed on the procedure and asked to complete a short background questionnaire. On completion, participants were

introduced to the interactive game through a practice trial using a separate, non-human looking avatar. Once familiar with the game concept, they were asked to progress through up to four levels of the game using each of the three avatars. For consistency, each participant was required to start at the same level of the game, as the sequence of the avatars was counterbalanced across sessions to control for an order effect. For each avatar, after 10 min of gameplay, participants completed a post-game questionnaire. Once all avatars had been played, participants were asked to recall the avatars, and rank their order of preference, giving reasons for their selection choices. Two facilitators then proceeded with a 15–20 min semi-structured interview to explore questions regarding participants' preferences in the avatar features designed. To conclude, participants were debriefed on the study.

3.6. Measures

Background questionnaire: This consisted of gathering information on participants' ethnicity, date-of-birth and gender. Rated on a 5-point Likert-type scale (1 = *never* to 5 = *daily*) participants were asked how often they played digital games, and on what type of device (e.g. PC, game console, handheld console, mobile phone, etc.).

Post-game questionnaire: This consisted of 18 items[1] designed in four subscales: *Attractiveness* (ATT), *Homophily* (HOM), *Expressiveness* (EXP), and *Engagement* (ENG) (see Table 1). Each item was rated on a 5-point Likert-type scale (1 = *strongly disagree* to 5 = *strongly agree*), and included both positive and negative statements. Negative items were reverse-scored and subscales were calculated by summing and then dividing the number of items in the related subscale.

Items for *attractiveness* and *homophily* were influenced from McCroskey et al. [22] validation of physical attraction and homophily measures, while two of the items for *expressiveness* were adapted from Marcos et al. [21] comparison of a three-dimensional graphical avatar with a robotic head. Game studies, such as by Nowak and Rauh [26], Hamilton and Nowak [16], Hooi and Cho [17] and Cheong et al. [6], have all used homophily as a measure of perceived similarity in avatar representation. In such cases, more attractive or human-looking avatars to the players were reported to increase perceptions of homophily. In contrast, all items for *engagement* were replicated from the author's prior work [32].

Post-game avatar ranking: Using an A4 frontal image of each avatar (with the correct gender representation), participants were asked to rank the avatars in order of preference on a scale of 1–3 (1 being the most liked and 3 being the least liked).

4. Quantitative results

The results are divided into two sections. Post-game questionnaire findings, including avatar ranking preferences and gameplay experience are first reported. This is followed by a rich description of the post-game interviews regarding the indication of preferences and associated interests in the game. The discussion then reviews these findings, including the implications for further research. As the questionnaire data was identified to be non-normally distributed, non-parametric tests were conducted. As recommended by Field [11], for post hoc analysis, effect size was used to compare the strength of the relationship between groups, while to reduce the chance of Type I errors, significance values were adjusted accordingly using Bonferroni correction.

[1] In the case of homophily and attractiveness, from the questionnaire's initial construction, one item was removed from each of the subscales as they were felt to be unsuitably phrased.

Table 1
Post-game questionnaire.

ATT	The avatar was attractive
	The avatar looked strange
	The avatar was appealing
	I disliked the way the avatar looked
HOM	The avatar looked like me
	I could identify with the avatar
	The avatar was a good representation of myself
	The avatar possessed physical features that I have
EXP	I liked the avatar's movements
	The avatar moved fluidly
	The avatar felt unnatural
	I could express myself easily through the avatar
	The avatar's movements were awkward
ENG	I looked forward to seeing the avatar advance in the game
	The avatar was not engaging for this type of game
	I would play the game again with this avatar
	It was exciting to play as the avatar
	Interacting with the avatar was not interesting

4.1. Gameplay experience

As expected, gameplay experience was highest amongst teenagers and younger adult groups. For example, 38.9% of the older adults reported no prior experience in playing games on a PC, compared to just 11.1% of the teenagers, and 5.6% of the younger adults. Across all the age groups, handheld game consoles were used the least (teens 66.7%, younger 66.7% and older 94.4% *rarely* or *never* used); while for both the teenagers and younger adults, playing games on a mobile phone was the most common (*daily* usage both 38.9%). In contrast, a third (33.3%) of the older adults reported no digital game experience, while the highest gameplay was reported using both PC and mobile phone technologies (*daily* usage both 11.1%).

4.2. Avatar ranking preferences

In terms of avatar-types, 56.6% of the teenagers and 50.0% of the younger adults stated that their most preferred avatar was the silhouette, while 38.9% of the older adults selected the humanoid. In contrast, 44.4% of the teenagers indicated the cartoon, 44.4% of the younger adults the humanoid, and 61.1% of older adults the silhouette as their least preferred choice (see Table 2 for a full list of rounded percentages).

4.3. Avatar ratings

For internal consistency, Cronbach's alpha was used to verify the reliability of the item scores in each of the four subscales. The intercorrelation of items was found to be of a good consistency: *attractiveness*, $\alpha = .79$; *homophily*, $\alpha = .82$; *expressiveness*, $\alpha = .90$; and *engagement*, $\alpha = .80$.

4.3.1. Within groups

Friedman's test was used to analyse ranking scores *within* the age groups. This was followed by post hoc comparisons using Wilcoxon signed-rank tests with Bonferroni correction at level .0167 ($\alpha = .05/3$).

For the **teenagers,** a significant difference was identified in the self-rating of *homophily*, $\chi^2(2) = 12.87$, $p < .01$, and *expressiveness*, $\chi^2(2) = 9.56$, $p < .01$. Post-hoc analysis indicated that the silhouette avatar was perceived to be significantly more homophilous

Table 2
Preference choices per avatar-type (those highlighted in bold indicate a higher preference).

	Teenagers	Younger adults	Older adults
First preference			
Cartoon	27.8%	33.3%	33.3%
Humanoid	16.7%	16.7%	**38.9%**
Silhouette	**55.6%**	**50.0%**	27.8%
Second preference			
Cartoon	27.8%	**38.9%**	**44.4%**
Humanoid	**55.6%**	**38.9%**	**44.4%**
Silhouette	16.7%	22.2%	11.1%
Third preference			
Cartoon	**44.4%**	27.8%	22.2%
Humanoid	27.8%	**44.4%**	16.7%
Silhouette	27.8%	27.8%	**61.1%**

($T = 15.50$, $r = -.48$) and expressive ($T = 11.00$, $r = -.52$) than the cartoon avatar. Likewise, for **younger adults**, there was a significant difference in *homophily*, $\chi^2(2) = 9.38$, $p < .01$ for the three avatars, with the silhouette perceived to be more homophilous than the humanoid ($T = 25.00$, $r = -.41$).

In comparison, for the **older adults** a significant difference was also identified in *homophily* for the three avatars, $\chi^2(2) = 8.10$, $p < .05$. However, while homophily was perceived higher in the silhouette compared to the cartoon ($T = 38.00$, $r = -.31$) and humanoid ($T = 37.00$, $r = -.27$), with Bonferroni correction there were no significant differences between the pairs, and medium effect sizes reported [11]. Moreover, no further statistical differences were identified within the three age groups (Fig. 4).

4.3.2. Between groups

To investigate further, the Kruskal–Wallis test was used to compare for differences *between* the age groups. Post-hoc comparisons were performed using Mann–Whitney U tests with a Bonferroni correction level of .0167.

For the **cartoon avatar**, significant differences were found between the age groups in three out of the four subscales: *attractiveness*, $H(2) = 9.30$, $p = .01$; *homophily*, $H(2) = 13.71$, $p = .001$; and *expressiveness*, $H(2) = 8.95$, $p < .05$. Specifically, the older adults self-rated *homophily* (older-teens, $U = 59.50$, $r = -.54$; older-younger, $U = 64.00$, $r = -.52$), and *expressiveness* (older-teens, $U = 83.00$, $r = -.42$; older-younger, $U = 78.50$, $r = -.44$) significantly higher than the teenage and younger adult groups; while *attractiveness* was perceived significantly higher by the older adults than the younger adults ($U = 71.50$, $r = -.48$).

Likewise, for the **humanoid avatar**, significant differences were found between the age groups in all of the subscales: *attractiveness*, $H(2) = 13.24$, $p = .001$; *homophily*, $H(2) = 13.07$, $p = .001$; *expressiveness*, $H(2) = 8.57$, $p < .05$; and *engagement*, $H(2) = 7.82$, $p < .05$. Post-hoc comparisons further indicated that the older adults perceived a higher amount of *attractiveness* ($U = 50.50$, $r = -.59$), *expressiveness* ($U = 72.50$, $r = -.47$), and *engagement* ($U = 68.50$, $r = -.50$) than the younger adults; while *homophily* was perceived as significantly higher by the older adults than both the younger adults ($U = 60.50$, $r = -.54$) and teenagers ($U = 71.00$, $r = -.48$).

In comparison, there were no significant differences in the scoring of the avatars between the teenagers and younger adults. Finally, no significant differences were identified in the **silhouette avatar** when comparing between the three age groups.

In summary, the results indicate that for the *between* group comparisons, the older adults related more positively to the visual characteristics and movement of the cartoon and humanoid avatars compared to the teenagers and younger adults, whose avatar preferences appeared to be similarly aligned. In contrast, in comparing the questionnaire scores *within* groups, both the teenagers and younger adults both perceived a closer resemblance to the silhouette compared to the other avatars. A difference that was less apparent in the older adults. On the other hand, in comparing the interaction of the avatars, in many cases there were no significant differences in their perceived engagement in the game.

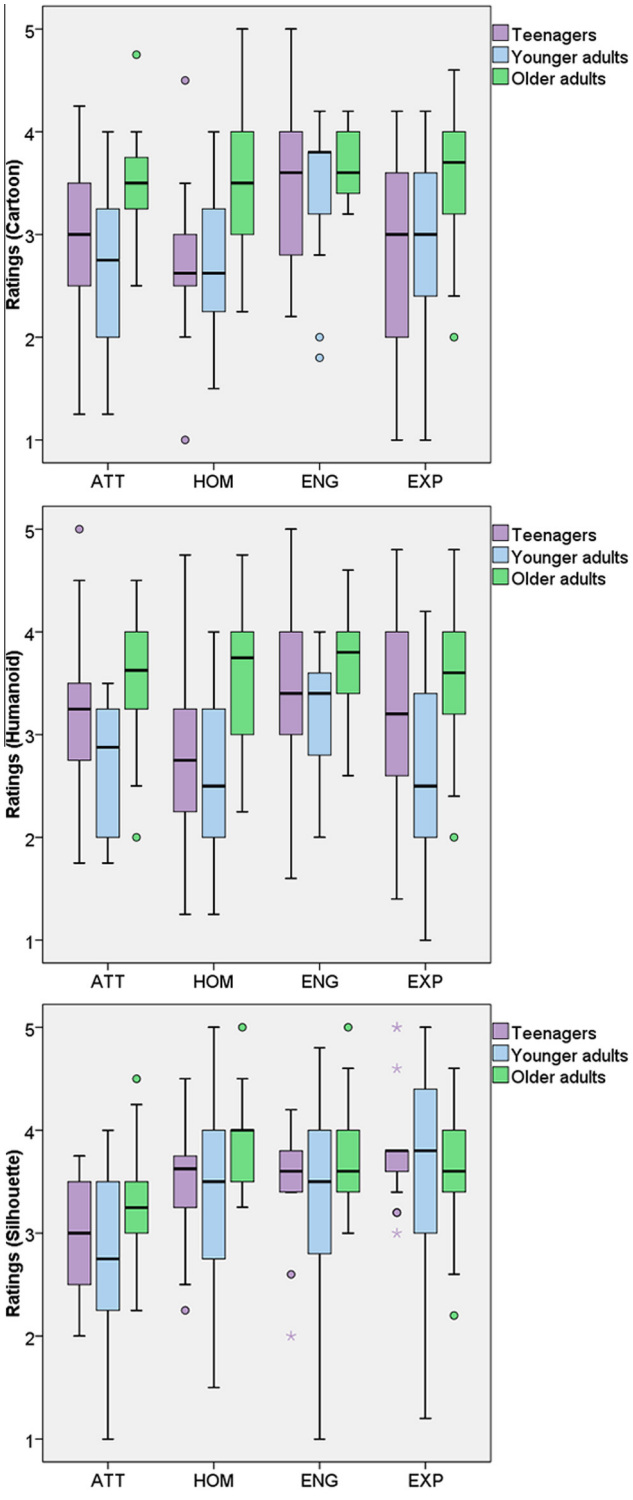

Fig. 4. Boxplots of the subscale ratings of the post-game questionnaire. (*Top*), cartoon; (*middle*) humanoid, and (*bottom*) silhouette avatars. Circles are outliers and stars are extreme outliers.

5. Qualitative results

To help formulate a better understanding of the results, we examined players' feedback for evidence supporting their selection choices. Approximately 18 h of audio recordings were transcribed by two independent researchers. As proposed by Gibbs [13], through thematic analysis, the data was manually coded and related themes were established by comparing and reviewing relationships in participant's responses. A selected summary of these findings is reported below.

5.1. Bodily movement

5.1.1. Engagement

All groups favoured the immersive aspects of controlling the life-size avatars through body gestures, providing a novel factor for both gamers and non-gamers alike. This positive feedback can help account for the more consistent ratings of *engagement* across the three avatars. In particular, a number of the older adults favoured the mild form of physical exercise in playing the game. Specifically, it was reported that unlike exergames where players may consciously mimic the actions of an on-screen character, in this study, the direct manipulation of the avatars in a casual game provided a subtler form of physical stimulation: *"When you focus on hitting the thing and blocking, you tend to forget you are actually moving yourself. And I think, subconsciously it actually helped us to exercise, even reflexes our mind*" (older adult, P1).

5.1.2. Homophily and expressiveness

Two thirds of the teenagers and younger adults, and a third of the older adults, perceived the silhouette to be a more natural representation of the player: *"It's more sensitive to my movements*" (younger adult, P2); *"You feel it's you, you can connect more*" (teenager, P9). Specifically, higher ratings of *homophily* across the three age groups related to a stronger resemblance of the avatar in mirroring their physical form: *"The shadow one is different from the way the rest work... mimicked quite closely to what I am, sort of, even down to my fingers*" (younger adult, P1). This included comments by the older adults in being able to better assess there on-screen control: *"I also want to see myself, my natural self in movement. How awkward it is... then I also know how I can improve my coordination*" (older adult, P3). In this sense, better movement was associated with more control of the avatar, creating a stronger sense of empowerment in the game. Similarly, the higher ratings of *expressiveness* in the teenagers and younger adult groups were frequently attributed to the fluid and accurate movement of the silhouette, particularly in comparison to the oversized bodily features of the cartoon, which were perceived to move more mechanically: *"The conjoining of the hands. It makes it look like a puppet*" (younger adult, P13).

5.2. Visual appearance and art style

5.2.1. Attractiveness and visual representation

For the older adults, the differences in the questionnaire ratings of *attractiveness* in the cartoon and humanoid compared to the silhouette were commonly attributed to their visual detail. For example, the cartoon was favoured for its colourful and bright design, while preferences towards the humanoid were often characterised by richer and more human-looking qualities: *"Looked macho, looked pleasant... gave us the impression that it reflects our image*" (older adult, P1). In both cases, these were seen as positive incentives in wanting to play the game. In contrast, the lack of graphical detail in the silhouette was reported to detract from the game: *"When you play a character, the graphics must be very attractive, make you want to play the game. To me, it's my opinion, she doesn't look so committed*" (older adult, P11). These included remarks that the aesthetic qualities of the character appeared dull and vague, in what was described by one participant as 'lacking in feeling', while others drew a dislike to its colour: *"Black. I don't like anything that is dark*" (older adult, P13).

Alternatively, while many of the older adults tied their preferences to the visual appearance of the avatars, the teenagers and younger adults commonly compared their suitability in matching to the context of the game: *"He actually suits the game's environment... the atmosphere is like cartoony*" (younger adult, P16). In particular, individuals were critical of specific features, like too much make-up on the face, or an appropriate body size (e.g. the arms appearing too short). Despite this, the cartoon was often perceived to better align with the graphical style of the game, despite some opinions that the avatar's visual attire (e.g. the overalls) seemed to lack fashionable qualities or personal appeal (e.g. it looks ugly). Consequently, to improve the character representation, the teenagers and younger adults were more likely to suggest customising features and adding personal attributes of themselves (e.g. dyed hair) that blended into the 'art style' of the avatar. Extending the silhouette concept further, this included mixed preferences for being able to super impose their bodily form into the game: *"Since the technology seems to be capturing the outline, why not just as well capture the entire player*" (younger adult, P14).

5.2.2. Prior knowledge and homophily

Approximately two thirds of the older adults aligned their personal interests to the humanoid features, given its closer resemblance to their physical self: *"It's more human so you feel like you are in the real world*" (older adult, P6). This included suggestions to increase the level of visual realism by modifying the avatar to match a more stereotypical representation of a farmer/gardener character: *"He should be good looking, but not clean-cut. More manly type, you know. The hair should be a bit, not so straight, a little messy, but messy in a way not ugly. And the clothing should be more rugged, some more arm muscles*" (older adult, P17). In this sense, the older adults often imposed expectations from the real world onto the game and avatar: *"Do you still wear boots in a garden? I don't think so, unless you're going in a forest... I felt as a gardener you should actually cover your* [sleeves]" (older adult, P13); *"May be she should have a straw hat instead of long hair. Or may be tie up her hair. Normally farmer girls don't have long hair. All dangling down, it will impede her doing her work*" (older adult, P4).

In comparison, the teenagers and younger adults were more critical of the anthropomorphic appearance of the humanoid in being out-of-sync in the game's environment: *"It felt strange to have a character that was very human in a very cartoon setting*" (younger adult, P10); *"He looks like a guy from* [The] *Sims... he looks too normal for the game. Everything is in proportion*" (teenager, P18). Again, this stemmed from the perception that there was a mismatch in representation, in what was described as making the character look 'awkward' in the game.

5.3. Attention to detail

Over three quarters of the teenagers and younger adults commented on the visual discrepancies between the cartoon and humanoid forms. These ranged from variations in height and hand size, to missing or fixed facial features, such as an absence of eyelashes or a mouth in the cartoon, and mannequin-like features of the humanoid: *"He's freaky-looking... he stares at you, and he smiles at you the whole time, I don't do that*" (younger adult, P18); *"This feeling that his expression is always the same, whether the plants die or not*" (younger adult, P6).

In comparison, only a third of the older adults reported differences in the bodily forms and the behaviour of the cartoon and

humanoid avatars, which they attributed to focused attention on playing the game: *"I was concentrating on hitting the birds and blocking the sun, so I didn't really pay attention to the movement*" (older adult, P1). Moreover, the older adults that recognised visual differences in the avatars tended to be more conservative in their responses: "*His movement seems quite okay, sometimes a little bit out of shape*" (older adult, P2). Subsequently, in comparing the feedback of the three groups, for the teenagers and younger adults, the perceived lack of emotional qualities in the cartoon and humanoid were reported to decrease their credibility, which in turn can help further explain the lower ratings in *attractiveness*, *expressiveness* and *homophily* in these modalities.

5.4. Age representation

Across all the age groups, the cartoon was reported to be younger than the humanoid. This was primarily due to a lack of defining features that made it harder to determine the cartoon's age: *"He has the size of course of a teenager to an adult, but there's no, you know, features that describe age really. I mean wrinkles or style to depict a certain age group*" (younger adult, P1); *"It's really difficult see cus he doesn't have many defining features. But, he just seems like somebody from the seventies or eighties... not too old, not too young*" (younger adult, P15).

Leveraging on the game design, when asked about avatar preferences in playing games, barring a few exceptions, the majority of the teenagers and younger adults indicated a preference for playing an avatar of a similar age (e.g. within 5–10 years of themselves). For these groups, child-like avatars were often perceived as being cute and playable, while older avatars dismissed as being comical and less representative: *"I feel if she is very old she cannot move very fast*" (teenager, P5). Subsequently, only a few of the more experienced gamers considered the age of the avatar to be dependent on the type of game played: *"It has to suit the game's world, suit the game's atmosphere. It's like a WoW* [World of Warcraft] *thing, if I want to play an old wizard, a hardcore guy, I would prefer to play an old guy than like a younger guy. Depends on the game's law, depends on the game's theme*" (younger adult, P16).

Conversely, over half of the older adults expressed a preference to playing a younger avatar, which was often characterised by negative associations with old age (e.g. sluggish movement and poor memory), and/or a desire to feel younger in the game: *"You can forget yourself when you look at a younger avatar on the screen. You can forget about how old you actually are*" (older adult, P8). Given the physical nature of the game, participants often associated a need for a more exuberant character, drawing direct comparisons between the age of the avatar and its physical form: "*If it is the same* [older] *age, the movement wouldn't be so fast*" (older adult, P2). Subsequently, a more youthful avatar was reported to be an important motivational factor in encouraging older players to mimic similar mannerisms during the gameplay: "*If the avatar is very active, it also reminds myself that we should be active*" (older adult, P9). Alternatively, for those older participants who did not share the same opinions, they were more cautious of an age gap in representation if the avatar looked too young. This led to suggestions for more 'neutral looking' avatars that avoided any explicit reference to age, of which the silhouette was favoured.

6. Discussion

The results obtained from this study indicate a number of generational differences in the perceptions of the avatars for participants below the age of 30, compared to those above 55 years old. Importantly, these results are more detailed than our earlier work, which provide preliminary findings from a smaller sample of (the present) participants [32].

For the older adults, the similar ratings of the subscales for the avatars were noticeably different to sentiments expressed during the individual interviews. Examples of this included the rating of *attractiveness* in the silhouette, which was rated similarly to the other two avatars, despite criticism to its lack of graphical detail. In this sense, had the authors only based the results on the questionnaire findings, they would have provided a limited understanding towards the older adult's perceptions of the avatar representations. For the older adults, given the potential 'novel effect' of rating the avatars, this suggests a mixed method approach that includes qualitative feedback is an important aspect of the elicitation process. Alternatively, we found no evidence that the older adults could not identify with the avatars shown, as they were articulate in expressing selection choices. In contrast, the lack of statistical significance in the scoring in the teenagers and younger adults suggests that their interests and preferences were similarly aligned. With the exception of *engagement*, lower questionnaire ratings by these groups indicate the teenagers and younger adults were more critical of the representation of the game avatars, which are further reflected in their subjective responses.

6.1. Visual and behavioural representation

As we have previously demonstrated, there was a significantly higher rating of *homophily* in the silhouette avatar. This suggests that despite a lack of graphical features, a number of the players could self-relate to the silhouette, reporting it favourably to a more graphic-rich form. In avatar research, Hooi and Cho [17] have highlighted how homophily is often associated with a player's physical appearance. However, in the case of the silhouette, given its lack of high-fidelity graphics, we believe the natural orientation of the avatar, and bodily outline created a stronger sense of self-identification. Subsequently, a stronger preference expressed by the teenagers and younger adults for the silhouette appears to be related to its more human-like behaviour. In this regard, we note some similarities to the *chameleon effect,* and how the mimicry of actions by a partner can lead to a greater sense of social cohesion and rapport [5,15]. The work of Bailenson and Yee [2] has illustrated how participants responded more favourably in a virtual environment to an embodied agent that mimicked their head movements, compared to a pre-recorded version. In a similar vein, the natural and direct mirroring of movements by the silhouette may have generated a greater affiliation with the avatar, although clearly more research is needed to determine the strength of this relationship.

In comparison, many of the older adults were drawn to the humanoid's appearance because of its richer features. As such, given the focus on visual characteristics, it would be interesting to know whether the same features would be perceived to be important through more prolonged gameplay exposure, or whether they are more superficial and limited to the short period of time when playing the avatar is still a novelty. Previous game research by Smeddinck et al. [35] has suggested that older adults prefer graphics that convey visual detail over simplistic shapes, but perceive higher levels of physical exertion in low-fidelity representations. In this study, although we did not identify the same differences in game performance based on graphical representation, we do note some parallels to the type of information preferred.

6.2. Uncanny effect

Researchers (e.g. [38]) have indicated that in human-looking avatars, perceived uncanny facial expressions can elicit a sense of unease due to their limited emotional responses and behaviour.

Likewise, in this study, we incorporated artificial facial expressions that may have exaggerated the unnatural look of the avatars, drawing more negative responses amongst some participants, especially the younger generation. This brings into question the extent that differences identified in this study may be accountable to age-related changes in attention, particularly the performance demands of controlling the avatar while simultaneously manipulating the game features. For example, prior research has established age-related issues in distinguishing visual search items [20,29], and the completion of secondary tasks [36].

Although speculative, the steeper learning curve of the older adults may have availed less attentional resources to the less salient features of the avatars, which were inconsequential to the goal of the game. In this case, they related to fixed or missing facial expressions, or constraints in the mechanical movement of the cartoon and humanoid. In turn, we see this as a particularly interesting finding given a number of the older adults emphasized the importance of aesthetic qualities in the avatars. As a result, we propose that future studies would benefit from understanding age-related gaze pattern differences in avatar-mediated interaction, of which there is a limited amount of known literature.

6.3. Perceived age and age preferences

Previous research has identified that computer efficacy can be an important attribute in the interpretation of avatar representations [27]. In this study, given the generational differences in the groups, it is unsurprising that there were more direct comparisons by the teenagers and younger adults to simulation games like *The Sims*. Subsequently, game experience appears to be an important factor for explaining differences in the perceived qualities of the avatars, such as the importance of portraying personal attributes of the players. On the other hand, it should also be noted that for both the gamers and non-gamers alike, old age commonly had negative connotations in avatar representation, which were typically built upon stereotypical perceptions. That is, older avatars were often assumed to be less agile and slower, while younger avatars, more vibrant and active.

In this context, more demeaning age perceptions may in part be contributed to variations in life experiences, in recognising that the teenagers had yet to reach adulthood, or younger adults face challenges experienced in later life. For example, for the older adults, having a younger avatar may allow them to re-visit a more youthful past. On the other hand, as the young players did not have such lived experiences, they may have found it harder to relate to the notion of being old. Moreover, given that both the teenagers and younger adults idealised playing someone around their own age, this indirectly appears to reflect the work of Williams et al. [42], who identified that adults, followed by teenage characters, were the two highest representations in mainstream games.

6.4. Research considerations

In summing up our research study, we see a number of benefits and related issues of gesture-based avatars that warrant further investigation. Four areas are highlighted below.

First, compared to previous studies that have evaluated avatars using still images (e.g. [6,26]) our findings confirm the importance of the playability of the avatars, and their ability to manipulate related features. Namely, we believe that in the evaluation of virtual avatars, players should not only be subjected to viewing still images, but should also be able to engage with them as 'interactive entities' to assess their applicability. As such, the use of still images by Cheong et al. [6] may have been a confounding reason as to why the older participants failed to relate more to the avatars shown. Moreover, as demonstrated in this study, fewer reported discrepancies in the avatar features by the older adults suggests game practitioners should consider the value of measuring avatar effects over a longer period of time. Specifically, to determine how awareness and attention to detail may change through more prolonged usage.

Second, as previously reported, the exaggerated body parts in the cartoon avatar appear to have accentuated players' awareness for physical inaccuracies, particularly amongst the teenagers and younger adults. In avatar research, outside of digital games there are few daily opportunities to learn bodily movements from a third person viewpoint [8]. Subsequently, a high rating of homophily in the silhouette avatar reinforces the importance of the realistic replication of bodily movements from an outside perspective, in providing players with valuable feedback and identification in the game. This includes positive feedback by the older adults in being able to assess their performance by directly mapping physical actions in the gameplay. For novice gamers, this may be an important attribute in helping to reinforce an understanding of their game performance. Based on our findings, natural kinetic movement plays a key role in influencing perception choices, and as such, there is clear value in further exploring its influence in the context of gesture-based avatars. As previously reported, given preferences to the silhouette despite its use of low-fidelity graphics, suggest a better need to understand how natural movement influences self-identity in full-body avatars.

Third, for the older adults, preferences were influenced by social expectations of how the avatar should look, compared to the teenagers and younger adults, who were more likely to want to incorporate personal attributes of themselves in the game. These variations in the way player's desired their avatars to appear suggest some form of customisation may help accommodate for visual preference differences. However, this raises further questions of how to optimise identity features for diverse user groups. For example, it is plausible that too many enhancements may discourage interests from inexperienced players, while for others it may be an essential part of the character ownership. Although the range of body modifications may be somewhat dependent on the type of game played, arguably more intuitive design tools are needed to select, guide and prioritise identity features, without imposing limitations on player choices. The notion of customisation modes (including pre-defined templates) has been suggested to accommodate for different population needs [9], however in this study, interests in 'specific' visual details by the older and more novice gamers implies the need to invest some time to personalise features.

Finally, beyond chronological age per se, little is known of the extent avatars should match the physical characteristics of older players (e.g. how young is too young). Given participants negative perceptions of age in this study, the depiction of more varied representations of older adults may positively influence changes in the behavioural responses of other players. In an intergenerational context, this includes understanding the extent changes in visual appearance should include modifications to the gameplay abilities of the players to account for gaming experience, or physiological differences in age-related skill sets. Our results indicate the possibility of enhancing physical attributes of the players for more youthful representations may be an attractive feature for some older adults. However, as previously identified, this has to be weighed against changes that may appear to be 'too unnatural' if the avatar looks too young.

6.5. Study limitations

During this study there were a number of variations in the visual design of the avatars (e.g. clothes, facial features, hairstyle, etc.). While these visual differences became a useful focal point in the semi-structured interviews, further research would be

necessary to validate the avatar preferences identified in this study. Equally, a more balanced gender sample may help establish more detailed results. Given there were no options to customise avatar features, allowing participants to personalise avatars may warrant a difference in the preferences identified. This includes considering the effects of game genre or game-type on visual representation, while examining variations in the visual design and avatar stimuli (e.g. the age of the avatar, art-style, level of realism, number of facial features, etc.).

7. Conclusion

In summary, the results from this study outline the effects of avatar representation, including the main avatar features that influence player preferences. Relatively few studies have examined cohort differences in avatar design, particularly in relation to comparing between younger and older age groups.

Within the context of this study, we outline a number of findings in relation to player's awareness to visual details in the avatars, and how differences between behavioural and visual realism influenced responses in different age groups. Namely, for the younger players, the more realistic movement of the avatars played an important part in influencing their preference choices. Compared to the older adults, they were also more likely to pick up on missing facial details, and stylistic aspects that appeared to be out-of-sync in the game. In contrast, while some of the older adults reported similar discrepancies, the number of cases was noticeably fewer. Rather, the older adults were more likely to favour the design of the humanoid avatar, given a closer resemblance to their physical self.

In terms of the age of the avatars, the notion of playing an older avatar drew a number of negative comments. This may reflect players' limited exposure to different game genres, however across the age groups a number of stereotypes were perceived in playing older avatars. For some of the older adults, this included drawing parallels between the age of the avatar and its physical form. That is, younger looking avatars were perceived to be livelier and more physically active than those of an older age. These comparisons to the physical world were also evident in descriptions of how the farmer/gardener character should appear in the game. Alternatively, others were more conscious that the choice of the avatar must be representative of the style of the game.

In looking to extend this research further, there are clearly important questions to answer in how prior game experience may influence avatar perceptions, or how opinions may vary through prolonged exposure to the game. Amongst the growing demographics of older gamers and interests in intergenerational gameplay, it is our hope that game designers will consider the importance of avatar representation amongst more diverse user groups. In particular, we hope the findings presented in this paper will encourage further research to understand how virtual avatars can positively influence and enrich player experiences across different generations.

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