Debunking Differences between Younger and Older Adults Using a Collaborative Virtual Environment

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Abstract. Collaborative virtual environments allow younger and older people to interact over long distances and stay in contact with their families and friends. Thus, these virtual environments are considered to be both, a crucial factor for active and healthy ageing and a great chance for future developments that may enhance and alter communication for specific age groups. Yet, to date there is a lack of studies examining differences between younger and older adults with special regards to technology usage factors, presence related factors as well as anxiety measures and psychophysiological arousal during social interactions in a collaborative virtual environment. Consequently, the objective of the current study was to evaluate the above mentioned factors in a group of 20 younger and 20 older adults using a slightly stressful collaborative virtual environment. The corresponding results indicate that virtual environments could indeed be beneficial tools for the communication of both, younger and older adults. Yet, older adults reported significantly lower levels of social presence during the interaction and were less able to handle the system than younger adults. Interestingly however, both groups did not differ in their technology related anxiety or regarding physiological measures of stress during the experience of the virtual environment.

1 Introduction

Over the course of time, many technology-aided communication forms have evolved from purely text typed messages to a more sophisticated, complex and thus, more demanding exchange which has undoubtedly altered social interactions via technology (e.g. virtual surroundings, virtual representations of the self, digital voices). The collaboration and interaction of many people around the world in virtual spaces using avatars as digital representations of the self are no longer limited to the field of commercial video games. So called collaborative

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J.C. Anacleto et al. (Eds.): ICEC 2013, LNCS 8215, pp. 36–47, 2013.

virtual environments are also used for educational purposes, non-gaming virtual social communities like Second Life or the promising field of health related applications for therapy such as social skills trainings.

2 Related Work

Social participation as well as keeping in touch with family and friends are important factors for an active and healthy ageing. On the one hand the use of technological devices is discussed to be associated with a loss of quality in social contacts and with isolation. Yet, on the other hand social technologies like social network services or video games indicate the immense potential of technologies in increasing and enhancing social interaction with others [1]. Thus, collaborative virtual environments could act as an encouragement for people to stay in contact, play with their grandchildren or interact in a familiar environment with those who live far away. Nevertheless, collaborative virtual environments should not replace actual/physical visits of family members or significant others, but they could make these visits easer to communicate and get social support quicker and easier than through common paths of face-to-face interaction.

Several studies indicate that social interactions in collaborative virtual environments provoke behavioral and psychophysiological responses in users when interacting with avatars which are similar to responses when interacting with physically present "real-life" persons [2,12,25]. Recent studies illustrate the positive impact of social interaction and social support within virtual environments and provide evidence that virtually delivered social support can decrease the level of anxiety in stressful situations (e.g. [11]) as well as increase older adults' acceptance of virtual environments in particular [29].

Previous research [15] identified several factors which could act as barriers to the use of computer technology among older adults and could affect the quality of social interaction in collaborative virtual environments. Anxiety related to technological aspects has been identified as a key factor affecting the use of computer technology by older people [4]. Furthermore, prior computer experience has been shown to affect the performance of older people in virtual worlds [21]. Also, ease of use and perceived usefulness as well as the perception of accessibility of the product are seen as fundamental key factors for the user's intention to actually use the technology [8,24,28].

Other influencing factors factors (i.e. user characteristics) which have been repeatedly suggested to be responsible for the experience in and usage of collaborative virtual environments are related to the construct of (physical) presence. In contrast to immersion, which may be considered as a characteristic of technology [23], presence usually is broadly defined as the "perceptual illusion of nonmediation" [16]. While some researchers tend to define presence simply as the sense of "being there", other researchers differentiate between several separate aspects of presence including spatial presence, involvement and perceived realism (c.f. [16,10]). However, another element which is specifically necessary for the implementation of collaborative virtual environments is social presence.

Social presence refers to the degree in which the user believes to interact with another social entity and attributes mental states as well as personality to this social entity. It is a major contributing factor next to the so called behavioral realism in the Theory of social influence in virtual environments [3] which explains why people react to virtual others as if they were physically present. This theory underlines the importance of both, the evaluation of the virtual scenario (perceived realism) and the experience within the virtual environment (physical and social presence) in order for the collaborative virtual environment to be compelling and convincing.

To date, there is only little knowledge or evidence about differences between heterogeneous age groups using or interacting within collaborative virtual environments. Some findings revealed that older people seem to have greater difficulties in navigating and handling computer devices than younger adults [8]. Additionally, a study by Siriaraya and Ang [20] found that older adults showed significantly lower levels of social presence than younger adults, whereas physical presence produced inconclusive results [18,27,26]. Yet, a higher level of physical presence and social presence seem to be positive predictors of a general satisfaction with the collaborative virtual environments [9,20]. In sum, little is still known about age specific aspects of virtual reality experiences and about corresponding evaluations of the used technology.

3 Aim of the Study

Following the literature presented above, the scope of the present study was to evaluate a collaborative virtual environment and explore the potential differences between younger and older adults regarding their estimation of the virtual environment in terms of technology usage factors (intention to use, perceived usefulness, ease of use, perceived accessibility, and technology related anxiety).

Research question 1: Are there differences in the perception of technology usage factors between younger and older adults?

Consequently, presence related components like the sense of being there, perceived realism and social presence are said to be crucial in shaping the experience in collaborative virtual environments, yet results regarding possible age differences in the formation and degree of reported presence experiences are still inconclusive or non-existent. Therefore, the objective of the present study is to answer the following research question:

Research question 2: Are there differences in presence related factors between the two age groups in a collaborative virtual environment?

A third research question focuses on the subjectively perceived level of anxiety and corresponding psychophysiological responses during a social interaction in the virtual environment:

Research question 3: Are there differences between the age groups concerning the subjectively perceived level of anxiety and the psychophysiological stress level provoked during the social interaction in the virtual environment?

4 The VR-Cafe

Our virtual scenario consists of the following tasks: (i) learning how to control walking, (ii) entering a typical Viennese cafe and finding an empty table, (iii) interacting with the waiter, and (iv) interacting with strangers.

As a basis for the virtual cafe we modelled a typical Viennese cafe, including tables, seats, items on the tables, mirrors on the walls, textures, paintings, fotographs, news papers, vitrins etc. The result is a virtual representation of this cafe, being slightly larger inside. As modelling tools we used GIMP and Blender 3D, and for real time rendering we used the render engine OGRE3D. In order to create distinct looking avatars, we used our own head toolbox to model the heads of the research staff involved in this work.

The participant first has to learn how to control his avatar, seen from the first-person perspective. Since elderly people would most likely have troubles using off-the-shelf joypads for steering, we used an Android smart phone as input device. By tilting the phone, subjects could control their avatar. Learning to control their avatar's movements is done outside in an open area surrounded by buildings. The task is to follow a white rabbit (see Figure 1). We found that this natural gesture indeed also enables elderly people to control their avatar's movements smoothly.

After a certain time, the person should then enter the VR-cafe, and find an empty seat. In fact, all but one tables are taken, and the subject's task is to find this empty table and sit down. Again after some time, the waiter arrives and accepts an order, being either cafe or tea. Here, the psychologist can decide whether the waiter brings the correct order, or the wrong one.

After some time, a woman arrives and asks whether she can join the subject, the subject here may answer with yes or no (see Figure 2).

Fig. 1. Control training by following the white rabbit

Fig. 2. Social interaction inside the cafe

5 Experiments

5.1 Methods

The current study was conducted at the Department of Psychology at the University of Vienna in accordance with the current version of the Declaration of Helsinki. Prior to participation all participants signed an informed consent form indicating the experiment's procedure and the possibility to terminate participation at any time. All statistical analyses were conducted using SPSS Version 19 (SPSS, Inc. Chicago, USA) considering an alpha error of 5%.

5.2 Participants

The sample of younger adults (N=20) consisted of students who were recruited from several courses at the University of Vienna and received a course credit for their participation in the current study. In the group of the younger participants, 13 were female and 7 were male, with a mean age of 23.50 years (SD=2.782). The sample of older participants (N=20) consisted of healthy seniors. 10 older adults were female, 10 were male, with a mean age of 68.05 years (SD=8.275).

5.3 Procedure

All participants were invited to the laboratory on a weekday between 9 a.m. and 12 a.m. Upon their arrival, all participants signed the informed consent form and completed a short survey in a separate room. Following this, participants were guided to the laboratory where the physiological measures were applied. After a 5 minute resting period participants were instructed how to navigate through the virtual environment using the smart phone device (HTC Desire SV, Taoyuan) and the Head-mounted display (HMD, Sony HMZ-T1 3D Visor, Tokyo, Japan) with the externally applied head tracking system (TrackIR 5, NaturalPoint, Corvallis, USA). Subsequently, the participants started with a 5 minute preparation task, where they had to follow a virtual white rabbit through a virtual park. During the task they were given instructions via a pre-recorded male voice which guided them through the task. Following this preparation and training period the participants were invited to enter a virtual cafe which was located just across the street from the virtual park. There, the 5 minute experimental phase started, within which participants had to interact repeatedly with the two virtual characters (the waiter and a female guest). The last 5 minute phase was again a resting period, within which the participant was instructed to relax.

5.4 Measures

Several psychometric measures as well as psychophysiological measures were used to detect differences between younger and older adults and to evaluate the virtual environment. These measures are explained in more detail below.

Psychometric Measures: Five factors from the technology usage inventory (TUI, [13]) were used to evaluate participants estimations of the virtual environment: participants were asked to rate four statements for each factor on a 7-point-Likert scale (does apply - does not apply) after completing the tasks in the collaborative virtual environment for the first four factors (item examples in brackets): (1) perceived usefulness ("This technology would help me cope better with my daily duties", (2) ease of use ("The application of this technology is easy to understand"), (3) perceived accessibility ("I think that almost everyone can afford this technology") and (4) technology-related anxiety ("I think that the use of this technology is always associated with some risk"). The fifth factor (5) intention to use the virtual environment was assessed using three questions (e.g. "Would you use this technology?") which had to be rated on 1000 mm visual analog scales (VAS) (not at all - extremely). Additionally, a five item questionnaire [2] was used to assess social presence (e.g. "The person appears to be sentient, conscious and alive to me", strongly agree - strongly disagree), whereas two single 4-point-Likert-scaled items (strongly agree - strongly disagree) from the iGroup Presence Questionnaire (IPQ, [19]) were used to measure the sense of being there ("In the computer generated world I had a sense of 'being there'") and the perceived realism of the virtual environment ("How real did the virtual world seem to you?"). Participants completed these items immediately after the last resting period. Anxiety was assessed before the beginning of the simulation and short after the virtual experience using the 20-item 4-point-Likert-scaled (very - not at all) state version of the State-Trait Anxiety Inventory (STAI, [14]). One example for an item used in the STAI is: "I am calm".
Psychophysiological Measures: Heart rate variability (HRV) was selected as a measure of a participant's physiological arousal during the experiment. HRV was recorded via M-EXG (Schuhfried BFB 2000 x-pert, Moedling, Austria) using three one-way electrodes (3M Medica RedDot electrodes, Perchtoldsdorf, Austria). A time-domain measure for HRV was used to predominantly detect changes in the parasympathetic tone of the participants when being immersed in the collaborative virtual environment. In accordance with the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology [22] the root mean square of successive differences (rMSSD) was obtained as a time-domain measure reflecting a short-time measure of heart rate variability. The rMSSD values were calculated from beat-to-beat intervals for all 5 minute periods (for the detailed description of the experimental design see "procedure"). High rMSSD values represent low physiological arousal, whereas low values indicate higher physiological arousal and physiological stress.

6 Results

The main characteristics of younger and older adults participating in the current study are shown in Table 1. Neither the heart rate variability measure rMSSD during the first resting period ($T(28.636)=2.016$; $p=0.053$; $d=0.65$) nor the subjectively reported state anxiety measured by the state-version of the State-Trait

Table 1. User characteristics

	Younger adults (N=20)	Older adults (N=20)
computer experience (y/n)	100% / 0%	85% / 15%
educational level (in yrs)	12 (0.000)	13.55 (3.364)
weight (kg)	63.350 (10.321)	77.10 (14.881)
height (meters)	1.70 (0.061)	1.71 (0.081)

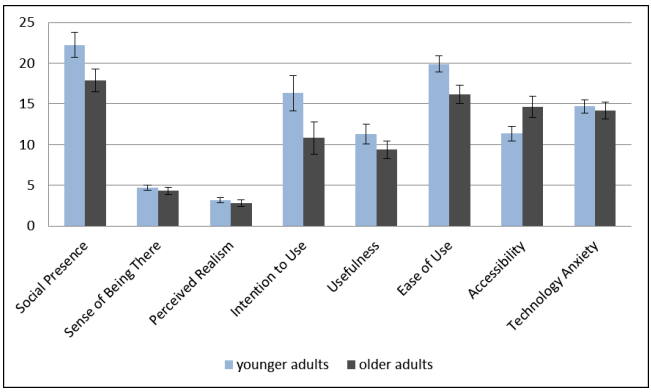

Fig. 3. Mean values (±SEM) of all psychological measures for younger (N=20) and older adults (N=20) (Values of the Intention to Use VAS were given in cm)

Anxiety Inventory (T(38)=1.660; p=0.105, d=0.54) did differ at a baseline level previous to the participants entering of the laboratory.[1]

6.1 Psychological Questionnaires

In order to estimate whether younger and older participants showed any difference on the technology usage scales and the assessments of presence related factors (sense of being there, perceived realism, social presence) group comparisons using Student t-tests were conducted. To correct the violation of the assumption of homogeneous variances for the two groups the Welch-Test was applied to the analysis. Results showed that the group of younger participants as compared to the older adults reported a significantly higher intention to use the collaborative virtual environment for social interaction (T(38)=1.865; p=0.070; d=0.59), and rated the handling of the virtual simulation as more usable than the

[1] Effect sizes d ranged between 0.20 and 0.49 indicate a small effect; effect sizes ranged between 0.50 and 0.79 indicate medium effects and effect sizes ranged over 0.80 indicate large effects. Effect sizes η^2 around 0.01 indicate small effects, while effect sizes around 0.06 indicate medium effects and all values over 0.14 indicate large effects.

older participants (T(37)=1.153; p=0.017; d=0.80). Additionally, the younger participants in the present study differed significantly from the group of older participants in terms of the perceived accessibility of the used system (T(35)=-2.087; p=0.044; d=0.69). However, no statistically significant differences were found regarding the participants' perceived usefulness of the virtual environment (T(37)=1.153; p=0.256; d=0.37) and their reported anxiety toward new technologies (T(37)=-0.409; p=0.685; d=0.13). Furthermore, the group of younger participants as compared to the older participants reported higher levels of social presence (T(38)=2.101; p=0.042; d=0.66), yet there was no difference between the two groups concerning other present related factors like the sense of being there (T(38)=0.663; p=0.511; d=0.21) or the perceived realism of the virtual environment (T(33.369)=0.670; p=0.508; d=0.22). The different distributions between the two groups (means±SEM) on the technology usage scales and the presence related factors are displayed in Figure 3. Furthermore, a repeated measures ANOVA was employed in order to compare the two groups of younger and older participants concerning their subjectively perceived levels of state anxiety (State-Trait Anxiety Inventory, STAI) before and after the experimental procedure. As shown in Figure 4, there is a symmetrical increase for both age groups regarding their perceived level of anxiety over the course of the experiment, including all four experimental phases (rest, preparation, social interaction, rest). The subsequent analysis of the reported anxiety levels indicates a significant main effect of time (F(1, 38)=5.811; p=0.021; η^2=0.13), but no differences between the two groups (F(1, 38)=2.166; p=0.149; η^2=0.05) and no significant interaction of time and group (F(1, 38)=0.096; p=0.758; η^2=0.03).

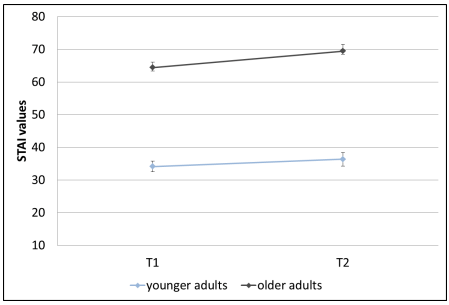

Fig. 4. Mean STAI-state anxiety values (±SEM) of younger (N=20) and older adults (N=20)

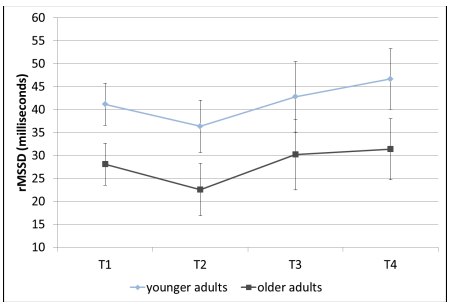

Fig. 5. Mean rMSSD levels (±SEM) of younger (N=20) and older adult (N=20) participants

6.2 Psychophysiological Measures

Similar ANOVAs were calculated for the autonomous responses (rMSSD, as a marker for changes in parasympathetic tone) over the course of the 4 experimental phases (rest, preparation, social interaction, rest). All results were corrected

by the Greenhouse-Geisser procedure because of the violation of the sphericity assumption. Both groups responded symmetrically regarding their rMSSD scores during the whole experimental period. There was a decline in rMSSD values for the preparation period, when all participants became familiar with the system and its handling. Yet, there was neither a significant main effect of time ($F(1.914, 72.713)=2.632$; $p=0.081$; $\varepsilon=0.638$; $\eta^2=0.07$) nor a significant effect of group ($F(1, 38)=3.127$; $p=0.085$; $\eta^2=0.08$) or a significant interaction effect of time and group ($F(1.914, 72.713)=0.055$; $p=0.941$; $\varepsilon=0.638$; $\eta^2 =0.01$). Figure 5 depicts the rMSSD means (±SEM) according to the four experimental phases (rest, preparation, social interaction, rest).

6.3 Discussion

Current literature indicates possible differences between younger and older adults regarding the nature of their experience when being immersed in a collaborative virtual environment [26,27]. These assumptions however, still prove to be inconclusive due to the lack of well balanced experimental designs and/or sufficiently well selected samples [18]. Thus, the present study aimed at debunking possible differences between healthy younger and older adults using a rather stressful virtual scenario within which the participants were asked to interact with two virtual characters represented by the computer.

In the present sample younger adults in contrast to their elderly counterparts were found to report significantly higher levels of social presence when being immersed in the collaborative virtual environment and when interacting with the virtual characters. This result is in line with some research [20] which also found significantly lower social presence ratings in older adults. Interestingly however, the two current groups of participants did not differ on any measure of physical presence. Both, younger and older adults reported very similar experiences regarding their sense of actually being in the virtual environment and showed comparable ratings on the level of realism they attributed to the virtual scenario. Regarding physical presence, research is still inconclusive, ranging from the assumption of a negative relationship between age and presence [26] to results showing a significant advantage of older adults over younger adults [18]. In the light of these diverging findings it is be safe to assume, that the differences between the two aspects of presence found in the current study – one embracing a physical experience of actually being in a virtual environment and the other comprising the attribution of sentience to a computer generated image of a person – might stem from different individual characteristics that may be subject to change over the course of life.

Another aspect that might shape or even determine to some extent the experience of presence is the evaluation of the virtual environment itself as well as of corresponding factors such as technology related anxiety [20]. The ratings obtained in the current study using the technology usage inventory [13] indicate significantly poorer evaluations of the technology by the group of elderly participants: In contrast to young adults older participants rated the virtual environment as being quite difficult to handle and not very accessible to them.

Also, older participants showed a much less pronounced intent to actually use the virtual environment than younger participants. Considering the presence experience as an illusion of nonmediation [16] it becomes obvious that a poor ease of use would draw the attention away from the virtual environment and its virtual characters and toward the handling of the hardware and thus, possibly hinder the formation of both, physical and social presence. It is interesting to note however, that although older adults rated the accessibility of the technology as quite low and showed an altogether lower intention to use it than their younger counterparts; they did not differ from the younger group regarding their perception of the technology's usefulness. Also, younger and older adults did not differ on their level of technology related anxiety. Similar to the level of technology related anxiety (see TUI, [13]), the two groups showed no significant differences in their subjectively reported state anxiety level as measured by the State-Trait Anxiety Inventory [14]. The significant increase over time (pre/post virtual experience) was symmetrical for both, younger and older adults. Self-reported Anxiety in this context may be seen as a perceived arousal stemming from the social interaction within the virtual environment and not from the virtual environment itself. Remarkably however, psychophysiological measures (rMSSD) had their peak during the preparation period, when participants learned how to handle the smart phone and how to navigate the virtual environment. In contrast, the physiological arousal levels were low during the virtual social interaction. Again, no group differences were found regarding heart rate variability measures indicating that younger and older participants were alike in their perception of the overall experience of the collaborative virtual environment.

6.4 Limitations

It is worth noting that the group of older participants in the present study predominantly consisted of highly educated older adults with a considerable amount of prior computer experience. Additionally, the experiment was conducted using a highly immersive interface technology, a head mounted display (HMD), which to date is still rather seldomly used in private households for entertainment purposes.

7 Conclusion

With respect to possible differences in emotional responsiveness and compassion between younger and older adults an additional measure of empathy might prove very insightful for the evaluation of social presence experiences when comparing older and younger adults in future studies. Also, the inclusion of personality factors [12] might shed more light on the relationship between the experience in virtual environments and its evaluation. Also, research has shown that there might be gender differences in the experience of presence [7]. Unfortunately, the current sample size did not allow for a thorough analysis of possibly existing differences, but future studies should account for probable differences between male and female users of virtual environments. In sum, the results of the current

study indicate that older adults may benefit just as well from the experience of collaborative virtual environments as their younger counterparts. The relatively low levels of technology related anxiety in the current sample of older adults as well as their satisfying levels of presence all allow concluding that virtual worlds might also be a useful tool for social interaction in older adults.

Acknowledgements. This study was funded by the Austrian Research Promotion Agency (FFG), Projectnumber: 831199, ICARUS Project. We also thank Ellen Baumm, Antonia Scholz and Anna-K. Heinzle for their help.

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