Assessing the Willingness of Elder Users in Using Virtual and Augmented Reality Technologies

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***Abstract*— Emerging technologies in the form of Virtual (VR) and Augmented Reality (AR) can play an important role in improving the lives of the elderly and as such efforts in designing elderly-friendly applications are of paramount importance. However, despite the importance of this topic, issues related to the attitudes of elder users towards new technologies are not thoroughly investigated in the literature. With our work, we aim to analyze issues related to the willingness of older people to use emerging technologies, determine the difficulties faced, and define design requirements that will make emerging technologies more accessible to elder users. Our investigation involves a three-stage hierarchical structure where in each step the participants are exposed to more technologically intensive interaction styles. Our study revealed, that elder people are willing to use advanced technologies in the form of Augmented and Virtual Reality provided that the issues of useful functionality, usability, and neat design are met. The results of this study are important for designers and developers of VR/AR applications for the elderly, who need to address the issues indicated by the target group, to allow them to regularly use such applications in their everyday life.**

Keywords-Virtual Reality; Augmented Reality; Elderly; Interface Design;

I. INTRODUCTION

The use of emerging technologies by the elder people is becoming increasingly important, especially in periods of social isolation caused either by external factors (i.e., a pandemic) or by internal factors associated with reduced mobility in the elderly. Through the use of emerging technologies, the elderly could be offered a way to reduce the side-effects caused by social distancing [1]. Also, AR can be used for assistive technology applications [2]. However, despite the importance of this topic, issues related to the attitudes of elder users towards new technologies and their intention to use such technologies are not thoroughly investigated in the literature.

Elder people experience a decline in many characteristics that may prevent them from using effectively emerging technologies like Virtual (VR) and Augmented Reality (AR) that rely on the activation of numerous senses. Indicatively elder people may face a) reduced mobility, due to arthritis, less muscle strength, and Parkinson, [3] b) reduced eyesight due to several age-related eye diseases such as cataract, macular degeneration, presbyopia, etc., [4] c) hearing loss that is usually accompanied with inability to perceive high frequencies or low volume sounds [5] and d) cognitive declines such as dementia [6].

The aim of our work is to determine, the factors that facilitate the use of emerging technologies by elder users, in order to empower the use of such technologies by the elderly through the design of VR / AR applications that suit the needs of elder users. The ultimate aim of this effort is to develop contemporary emerging technology applications that provide high levels of user experience to elderly users. Towards this end, we run a series of evaluations to determine the factors that influence the use of emerging technologies by older users. The design of the experiment is based on a three-stage hierarchical structure where in each step the participants are exposed to more technologically intensive interaction styles. Initially, at Stage 1 of the experiment, the general issues related to the use of the basic technology in conjunction the use of a common smartphone medical dose management application are explored. This experiment is mainly aimed at confirming the findings of other studies [7], i.e., to define the most important features that motivate users to utilize technological solutions provided by standard smartphone applications. During Stage 2 of the evaluation, we investigate the reactions of older people towards the use of more specialized application that goes beyond the standard use of a smartphone through the need to engage in a more technologically demanding interaction using the smartphone camera, like in the case of augmented reality applications. Stage 3 of the experiments involves the exposure of volunteers from the target group to using a Virtual Reality application with a dedicated VR headset. This experiment exposes the volunteers to new ways of interacting with 3D environments, enabling the derivation of conclusions related to the reactions/concerns of the target group towards using emerging technologies in the form of Virtual Reality.

Our study revealed, that elder people are willing to use advanced technologies in the form of AR and VR, provided that the requirements of useful functionality, usability and design are met. The results of this study are important for designers and developers of VR/AR applications for the elderly, who need to address the issues indicated by the target group, to allow them to use regularly such applications. In the remainder of the paper, we present a

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literature review on the topics of VR and AR applications for the elderly, followed by a description of the experimental evaluation. In Section IV a discussion, plans for future work and concluding comments are presented.

II. LITERATURE REVIEW

Technology has the potential to enhance the lives of older adults by improving their safety, security, and self-confidence in everyday life. However, too often older adults' abilities and limitations are not reflected in the design of current and future technologies. Although older adults experience specific limitations as they age, the word old does not necessarily identify people who are disabled or sick. Many people over the age of 65 are reportedly in good health [8]. There is a generally supported view of the interest of keeping older adults in sync with the latest technological developments. As well as joining with family and friends, technology can support older adults in improving social support [9], increasing access to medical knowledge [10], enabling them to engage as citizens in decision-making processes, and allow them to keep fit using dedicated fitness apps [11]. In many studies, the importance of using new technologies by elderly is considered.

Levy et al., [12] investigate how virtual reality related to serious games can be used to handle the pathological phobia of falling. Specifically, the fear of falling is the continuing fear of falling that cannot be explained by physical examination. In their experiment, 16 participants were randomly selected from either a treatment group or a waiting list, and the duration of the virtual reality therapy with serious games consisted of 12 weekly sessions. The mean age for the treatment group was 72 years and for the control group was 69 years. Participants' ratings of fear of falling were improved after treatment, leading to a significant difference between the two groups. As they mention, serious games-based virtual reality exposure therapy can be used to treat the fear of falling, though further studies are needed to confirm its effectiveness and determine its underlying mechanism.

Optale et al., [13] tested the efficacy of a program of VR Memory Training (VRMT) in improving the cognitive functioning of elderly adults with memory impairment. For the experiment, they assigned 36 elderly residents of a rest care facility with middle age the 80 years old. The experimental group experienced six months of VR Memory Training that involved auditory stimulation and VR activities in path finding while the control group experienced equivalent face-to-face training sessions using music therapy. The results indicate that the participants who received the VR Memory Training presented an improvement of general cognitive functioning and oral memory after the initial training period. The greatest results were observed in long-term memory, in keeping with the cognitive abilities stimulated by the auditory session of the VR Memory Training. The improvements in executive function capabilities, in contrast, were small and did not perform corrections for the reduced depression scores of the experimental group participants.

Lera et al., [14] rely on a human robot interaction architecture called MYRA, to build a system for elderly support and medical dose control that includes augmented reality to improve the interaction with the robot. Through their prototype, it is possible for the users to follow simple medical guidelines related to everyday pill dose, based on help provided once a pillbox is presented to the robot or to a camera. As they mention the elderly has the interaction with the robot and the pillbox and with the use of AR, the task could be complete. To the other side, somebody can control the robot and offer real-time assistance to the elderly, using the camera speakers and phone mounted onboard. The research concluded that the use of AR had indeed positive impacts on the users.

Peleg-Adler et al., 11] empirically investigate the feasibility of AR technology for older adults. In particular, they tested how older adults interact and use AR for a path plan task, considering the deficits and the constraints to their performance as compared to young adults. Both older and younger participants made a route plan task using both a see-through handheld AR application and a regular (non-AR) phone application. The estimated task completion time, error rate, device movements, and subjective impressions were recorded. These measures were used to evaluate the performance, learning, and user experience of participants when using an AR interface. Forty-four participants were selected from two age groups. The first group consisted of 22 community-dwelling, healthy adults over the age of 65, and the second group consisted of 22 younger people of the age of 25–40 mostly students from a large research-intensive university. It is important to mention that both groups reported daily use of a mobile device, with the younger group reporting a higher level of the smartphone experience. According to the results, older adults performed slower than younger adults in both interfaces. This is expected, as it is well known that perceptual and cognitive skills decline over age. This indicates that the effect of AR was similar for both age groups; the group's gains in speed and losses inaccuracy were of the same magnitude when using the AR in comparison to the non-AR application. This shows that although AR was unfamiliar to the older participants, their performance differences (compared to the non-AR) were similar to the younger adults. Thus, it suggests that AR impacts the performance of older adults in a similar way it impacts the younger population.

Gao et al., [15] mention that virtual reality technology is a tool that can provide effective treatment for the elderly by applying non-immersive virtual reality to the hallway or immersing a patient in a realistic environment, such as a city or park with a head-mounted display or inside a CAVE. In this way physical and occupational therapy sessions can be improved, thereby increasing the chance of successful adaptation to the real world. An example of an experiment was when participants found that exercising on a stationary bike with VR that immersed them in nature was much more enjoyable than traditional cycling without VR. Since VR was an interesting activity for older adults, this could lead to better compliance with a rehabilitation program, which in turn can lead to better outcomes for patients' health.

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III. EXPERIMENTAL EVALUATION

The aim of the evaluation is to investigate if the elderly are interested and willing to use AR and VR technologies, and what are the factors that will facilitate the regular use of AR and VR technologies by elder users. Our motivation for this research is to give some really useful tools that will benefit the elderly during periods of social isolation. The design of the experiment is based on a three-stage hierarchical structure where in each step the participants are exposed to more technologically intensive interaction styles. Stage 1 of the evaluation, concerns a collection and analysis of user reviews in relation to a health-related application that is popular among elder users. Through the specific application that they use in their daily life, the real needs that arise from the reviews are defined. Stage 2 of the evaluation that was carried out based on the use of a custom-made pharmaceutical management application, the goal was to expose users to a more technological demanding interface that requires the use of the camera as a means of obtaining comprehensive information about different medicines. Stage 3 of the evaluation involves the use a Virtual Reality application using a dedicated VR headset. Since this experiment involves the use of VR equipment for the first time for the majority of the users, the experiment included the necessary steps of introducing this type of technology to the volunteers. A more detailed description of the experiments carried out is described hereunder.

A. Stage 1: User evaluation of a Smartphone application

a) Aim: The aim of this study is to determine the most important design-related factors that motivate the target group to use a basic form of technological application in the form of a smartphone application. For the experiment, the free commercial application Pill Reminder and Medication Tracker by Medisafe [16] have been selected for evaluation. The application helps users to receive their medicines correctly so that they don't miss doses or receive double dosing by accident. To achieve the goal of this study a large number of user reviews are analyzed, in an effort to deduct conclusions related to the most important issues that attract users towards using this particular application.

b) Experimental Set-up: For the analysis of the results, 1000 user reviews were collected using the software Appbot that allows the collection of user reviews for an application and automatically categorizes customer feedback by theme with topics and tags. Among the reviews collected 166 reviews were not used in the analysis because they did not contain any information related to the parameters under investigation. All reviews were divided into the negative reviews (104 reviews rated with 1-2 stars indicating dissatisfied users) and positive reviews (654 reviews rated with 4-5 stars indicating satisfied users). In addition, user reviews were divided into the ones where users declared that they have a medical condition (116 users) and the ones where users do not state that they have a medical condition. Although, we did not have any data on the age of the users, it is reasonable to assume that most users who indicated a medical condition involve older people who are receiving medication due to some medical condition.

c) Results: User review analysis was carried out by initially filtering the reviews based on keyword analysis followed by content-based analysis in order to classify the reviews into the ones referring to functionality, usability, interface design, cost, number of existing users and user reviews (see Fig.1). Overall functionality, usability and interface design are determined as the most important factors for users, whereas issues like cost, number of existing users and user reviews do not seem to be important issues in all user reviews considered.

d) Discussion: The results indicate that to attract users to use an application the most important factors are the actual usefulness of the application (functionality), the usability, and the interface design. Also, there was no noticeable difference in these observations between the groups of people with or without health issues.

B. Stage 2: Evaluation of a pilot application that requires camera-based interaction

a) Aim: The experiment in Stage 1 reconfirmed the need to provide functionality and usability to attract the target population to using an application. In Stage 2, we explore the reactions of elder people towards the use of applications with a more technologically enhanced interaction style. More specifically, the aim of this experiment is to investigate the reaction of the target group in relation to a new technology and whether they are willing to use such technologies. More specifically the application under evaluation offers more advance capabilities than a simple smartphone application since it incorporates the use of the camera and audio-visual feedback.

b) Description: This experiment is based on the Easypharm application (see Fig.2), an application designed by Anastasiadou [17] as a means of providing an easy to use

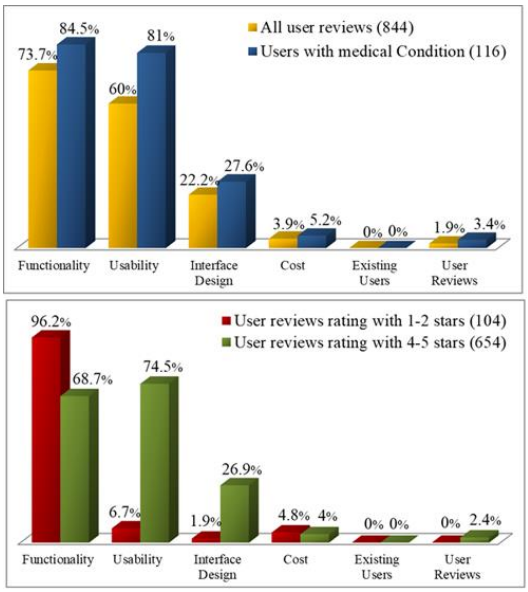

Fig. 1. Top: Results of all user reviews and the users with a medical condition, Bottom: Results of user reviews of dissatisfied users who rated the application with 1 or 2 stars and satisfied users who rated the application with 4 or 5 stars.

and universally acceptable application for managing medicine administration. Among other features, the Easypharm application aims to help the user, who may have reduced vision, by directly identifying, by scanning a QR code, the necessary information that is available on medicine packages.

c) Experimental Set-up: Fifteen adults (6 male, 9 female) aged 50-70 years (mean 57 years) participated in the experiment. The selection of the target group was done based on the typical target group expected to use pharmaceutical applications. Each volunteer who participated in the experiments was an experienced smartphone user who received a pharmaceutical treatment at some stage in his/her life. Both aforementioned factors are important to safeguard that participants could evaluate objectively the pharmaceutical management application. All volunteers were asked to complete a series of actions in relation to specific tasks. Through the process, results were obtained through observation of the actions of the participants while they were completing the preset tasks. At the end of the process, the participants completed a questionnaire that contained 11 questions (see Table I) and attended an interview where they were asked to answer questions related to their experience.

d) Results: According to the results, 33% of users would like to use the application in their daily lives. In relation to the usefulness of the application only 7% of users disagreed with the question stating that the application is designed to meet the needs of users. Based on the results of question 11 it is derived that the most important factors that make users use the application are the functionality, usability, and interface design of the application. In contrast, volunteers did not consider the cost of an application or the user's reviews as an important factor in selecting the application. With the above data we conclude that the target group that was evaluated is willing and would be interested to learn more and use on daily basis more advanced applications. As part of the analysis of the results, the fifteen volunteers were divided into two groups where the first group (with six volunteers) contains the ones who had a severe medical problem and had to use a pharmaceutical management application whereas the second group contains the volunteers with no serious medical problems. A comparison of the responses of volunteers between the two groups indicates no significant differences between the responses from each group were detected.

e) Discussion: Through the monitoring during the evaluation, it was observed that most users were able to complete the script process. Only a small section of users was unable to locate some buttons on the screen. It was obvious that people over the age of 65 are less familiar with new applications and need more time to adapt to new interfaces. When assessing the application, participants tried to adapt directly to the application environment to quickly identify the commands they were asked, although it was not easy for everyone.In conclusion, it was observed that users are willing to use a more technologically intensive application as long as the factors of functionality, usability, and interface design are covered.

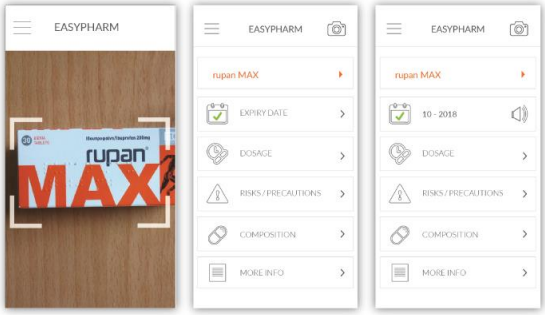

Fig. 2. Interface design of Easypharm application.

TABLE I. INDICATIVE QUESTIONS USED DURING THE EVALUATION

	A*	***N****	***D****
Q1. The overall response to the application was satisfactory.	33%	60%	7%
Q2. It was difficult to read the characters on the screen.	-	13%	87%
Q3. The application information organization was clear.	33%	60%	7%
Q4. The text in the application was readable.	33%	53%	14%
Q5. It was easy to remember the information displayed on the screen.	33%	60%	7%
Q6. Implementing actions in the application was complex.	7%	7%	86%
Q7. The application was designed to compete with the needs of users	33%	60%	7%
Q8. I was able to quickly complete the tasks and scripts using the application.	33%	53%	14%
Q9. The information contained in the application is clear.	33%	60%	7%
Q10. I would like to use the application in my everyday life.	33%	53%	14%
Q11. Which parameters will make you use this type of app: functionality, usability, design, cost, existing users, and reviews.	-	-	-
****A=Agree, N= Neutral, D = Disagree***			

C. *Stage 3: valuation of the use of a virtual reality application by the elderly*

a) Aim: The results of the experiments in Stage 1 and 2 show that if a target population is presented with an application with useful functionality and friendly interface, they are willing to use the application, even if the application demands more dedicated interaction styles. The experiment in Stage 3 aims to investigate whether these observations are still valid for a completely new type of applications, in the form of Virtual Reality. More specifically, the aim of the experiment was to test the reactions of elderly towards the use of a virtual reality application.

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b) Experimental Set-up: Ten participants aged between 50 to 70 years participated in the experiment (see Fig.3) which was completed using an Oculus Go running the application ”First Aid Training” [18]. For the purposes of the experiment, users were asked to complete a series of operations in order to obtain results related to the reactions of the volunteers towards the use of a virtual reality application.During the process, volunteers completed a pre-experiment questionnaire that contained questions about their attitude towards Virtual Reality. To get acquainted with using a virtual reality interface, all volunteers had the chance to use for a few minutes a game that required them to move in a virtual space and interact with virtual objects. During the actual experiment users used the ”First Aid Training” application according to the voice instructions given to them by the experiment administrator, and finally they were asked to answer a post-experiment questionnaire. Initially the instructions were given so that for any reason the user felt unwell to stop the process immediately. Furthermore, in order to prevent possible accidents, the evaluation was done with the users sitting.

c) Results: Participants were 50% women and 50% men with a mean age of 62 years. 50% of the participants were suffering from some disease while only 30% had used virtual reality applications again. The experiment was performed to get an inside of the factors that prevent members of the target group to use advanced technology. It was found that a large percentage of the participants used virtual reality for the first time and yet would like to practice using it to learn about health issues. Users' responses before and after (see Table II) using the virtual reality app indicate that several users have changed their view on whether virtual reality is useful for seniors after they used the VR application. Before running the experiment only 20% considered that VR can be useful for older people but this rate increased to 50% after the exposure to the VR application (see questions B5 and C8 in Table II). A percentage of 30% initially disagreed on whether is it useful to use virtual reality to practice on health issues, while after the use of the VR application, this figure dropped to 10% (see questions B4 and C7 in Table II). Finally, users were asked to answer what kind of applications they would be interested in using virtual reality applications and the most popular answers were around social platforms, relaxing, news, and education. These results show that initially, users out of ignorance were negative towards using such technologies in everyday life, but after they had the chance to be introduced to VR technology it was evident that they are willing to incorporate VR in their everyday activities. It was also noticed that the cost of virtual reality equipment is an issue that concerns them so that they can make daily use of the application, while they seem to be quite satisfied with the interface design as 70% would not like a change in the interaction style.

Fig. 3. Picture captured during the interaction with the virtual reality environment and the use of Oculus Go VR Headset.

TABLE II. MAIN QUESTIONS FROM THE QUESTIONNAIRE

Before using virtual reality	***A****	***N****	***D****
B1. I believe that VR applications are intended for entertainment.	90%	-	10%
B2. I believe that using VR can improve my daily life.	30%	10%	60%
B3. I believe that I can integrate the use of VR in my daily routine.	10%	10%	80%
B4. I would like to use the VR to practice on health issues.	60%	10%	30%
B5. I think the VR is useful for older people.	20%	40%	40%
After using virtual reality	***A****	***N****	***D****
C1. It was easy for me to navigate the VR area.	60%	30%	10%
C2. My experience with the VR was enjoyable.	90%	10%	-
C3. I believe that I have learned about the resuscitation position.	60%	30%	10%
C4. The experience in the VR makes me dizzy.	40%	10%	50%
C5. I had a hard time figuring out what to do.	60%	10%	30%
C6. I managed to complete the process.	90%	-	10%
C7. I would like to use the VR to practice on health issues.	70%	20%	10%
C8. I think the VR is useful for older people.	50%	30%	20%
****A=Agree, N= Neutral, D = Disagree***			

d) Conclusion: Based on the results from the experiment, we concluded that before getting exposed to the VR application, the target group believed, due to ignorance, that VR was mainly for fun. After using the application, they thought it was useful for their own needs and they see the possibilities it offers to them. Also, users indicate that they are willing to use such technologies and although it was new for them did not find particular difficulties in using the application with the interface. A new parameter that was included in Experiment 3 and did not exist in the other experiments, was the cost as a high-quality VR experience requires the purchase of equipment to use virtual reality and this could be an obstacle for the elderly, in adopting this technology. Given the possibility of using cardboard-based VR systems, the issue of cost can be partially addressed. Finally, it was observed that functionality is a main factor that attracts users to use VR applications, so particular emphasis should be placed on the development of useful

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applications. The limitations of our experiments are the small sample of users who participated in the experiments that was mainly attributed to the difficulty of attracting volunteers during the pandemic. Due to the same reason, it was not possible to use the same group of volunteers for all phases of the experiment.

IV. CONCLUSION AND FUTURE WORK

A three-stage experimental evaluation aiming to investigate if the elderly use advanced technologies, if they are interested and willing to use them, and lastly the factors that influence users in terms of using new technology for their daily lives was presented. Also, the aim was to increase the accessibility of emerging technologies and user satisfaction. Based on the results, we conclude that older people are not put off by the prospect of using more technologically advanced technologies as long as the requirements of functionality, usability and design are met.

On top of that, in the case of the need of using dedicated equipment, the issue of the cost is also introduced as an important factor. Furthermore, in the case of new technologies, it is important to provide training, as this will allow elder people to realize the full; potential offered by emerging technologies. Covering these needs of the users, then they can use VR and AR applications on a daily basis with satisfaction. Also in this case, functionality and usability are the key points that the user needs to meet his needs. In addition, with a specific audience, the desire to use such technologies and learn more information on how to integrate them into their daily lives has been observed. Results indicate the main factors to be considered for developing successful VR/AR applications. These results will be utilized for fulfilling our goal of designing VR and AR applications to support the elderly during periods of social isolation.

This research, aims to study more generally the use of technologies in the elderly to see the rationale behind the use of technologies and not as targeted as the above examples. An additional goal is to study how really useful and beneficial it is to use such technologies in the elderly so that they do not have any hesitation to use them in real life. Based on the outcome of our experiments, in the future we plan to develop a virtual reality application where it will create in the user the feeling of joy and nostalgia at the same time, in a way that is deemed to raise interest among older users. Also, in the future we plan to run evaluation experiments with more users in order to reinforce the validity to the results. According to the needs of the users, we will try to create new applications and implicate the target audience at each stage of the design in order to make sure that we meet their requirements and needs. The implication of members from the target group in the design process will guarantee that the requirements of functionality and usability will be met.

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