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VR Usability from Elderly Cohorts: Preparatory challenges in overcoming technology rejection

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***Abstract* – Virtual Reality (VR) usability is an emerging area that has made rapid progress among early adopters, but has so far failed to address the concerns of late adopters. In particular, elderly cohorts stand to benefit greatly from VR technologies as they enter areas of assistive technology, gerontechnology, and authentic modes of training. This study examined technology rejection criteria from a sample of 19 retired persons by comparing normative and VR practices for the fundamental learning of navigation using Google Earth mapping. This research discovered that three dimensional fear was a major factor in determining the acceptance and rejection of VR as a usable instrument for training elderly people in the use of navigation by means of enhanced mapping. This study examines the hypothesis that in combination, physical and pseudo physical realities require a range of preparatory exercises to acclimatize older users towards a stress-free approach to VR adoption. This study aimed to reveal new understanding about technology rejection in older populations, in particular where the physical presence of the wearing of VR equipment, in combination with the psychological and mental fear of the 3D experience, brought about high levels of technology rejection. Hesitation to accept VR equipment across both physical and perceptual boundaries is problematic for elderly users where rich 3D experiences are a requirement for successful, purposeful, and authentic tasking.**

Keywords— Elderly, VR, Acceptance, Technology Rejection, Human Computer Interaction, HCI, Gerontechnology, Authentic Tasking, VR Community, Assistive Technology, Virtual Reality, Immersive Environment, Simulated Experience, Use of Technology, Virtual Tourism.

I. INTRODUCTION

The immediate adoption of VR has so far been confined to early adopters who have an interest in 3D experiences. Many of these early adopters have Virtual Reality experiences that relate to an enhanced gaming experience. This study looks at Virtual Reality usage as a task-based exercise aimed at elderly cohorts in order to discover barriers to the trusted acceptance of VR. Elderly people are late adopters of technologies that combine physiological and cognitive skills. They are an important cohort to evaluate because they reflect a wide variety of challenges associated with new technology acceptance.

Despite the growth from gaming, widespread interest now focuses on non-gaming vectors where pseudo realities are connected to pre-determined authentic tasks. Such connections are significant because whilst 3D Virtual gaming is suited to younger audiences in general, the advantages of virtual reality usage by older people remains a sought-after objective, assisting in the therapeutic health care of people using VR technology [1].

At the same time, authentic virtual reality tasks are recognized as deliverers of a broad range of social, cultural and environmental engagements that are expected to be perceived by older people as useful, usable, and satisfactory [2].

This paper discusses the challenges of authentic tasks in the form of navigation and direction-finding exercises that seek to provide a rich experience in terms of sensation, perception, acuity, and awareness. The value of VR to elderly cohorts has so far attracted little attention. The majority of VR commerce and usage has extended to younger cohorts of users [3]. Combined with a range of off-the-shelf gaming experiences, VR has shown that persons with a passion for high-level graphics and richly explicit and lifelike details enjoy 3D environments such as VR over and above standard gaming practices [4]. At the same time, authentic tasks in VR such as navigational and direction-finding exercises may be restricted if the equipment used in the VR task is restrictive or limiting in nature [3]. The use of tethered VR devices is therefore of significant interest in determining the possible technology rejection of VR devices used in studies of elderly cohorts.

II. BACKGROUND

The use of VR for older cohorts has centered largely on therapeutic benefits that come about as a result of a safe and controlled environment where interactions can be performed to a high level of authenticity with minimal exposure to physical risk or harm [5]. Virtual reality offers the opportunity for experiences by older, less mobile participants where the sensory experiences remain rich and engaging, and where action and interaction is restored through the pseudo-reality of a virtual construct [6].

The literature on the technology acceptance of virtual reality instruments has centered on early adoption data, often identifying physical, mechanical, and technical componentry in order to advance and revise ongoing iterations of headset devices, hand controllers, and their connections [7].

. By comparison there is a relative paucity of literature that considers the late adoption criteria of older cohorts who represent divergent criteria in terms of adoption, usability, and trusted acceptance [8].

Older people have not commanded the same level of attention as younger early adopters of VR [1]. They represent a cohort of people who do not spend comparatively large amounts of money within the gaming industry. There have been several studies that have examined the value of virtual reality, however to date these studies are inadequate to answering some of the key challenges that face older populations [9]. As the global population greets the growing number of senior citizens who live longer and under more healthy conditions, there is a growing requirement to understand virtual reality componentry as useful instruments for assistive technologies, authentic training, and purpose-related experiences [10]. Such interactions represent the need for a different consideration of virtual reality technology [11].

VR is a technology that can be adapted to progress and develop the quality of life of elderly people, and in so doing may also extend longer lifetimes [5][2]. Gerontechnology is an emerging discipline that specifically examines ways to improve the lives of elders by means of introducing technology solutions that extend mental and physical interaction within social and cultural environments [12]. ICT acceptance by some elderly people has been restrained by comfort issues in the use and handling of technical devices, computer interfaces, and electronic items [13][14]. Virtual reality can challenge these restrictions through the development of pseudo-reality environments that reduce physical complications by means of improved interfaces with enhanced sensory technology [8].

III. VR LATE ADOPTION BY ELDERLY

In order to examine the key factors that impact on the usability and possible adoption of tethered VR equipment this study drew from two previous studies. The work of Fisk and others [9] outlines the key factors of usability as learnability, efficiency, memorability, errors, and satisfaction. These factors allow for an understanding of the usability within a VR environment of both the interaction of users and the specific device tools used. The second set of factors was drawn from research by Holzinger and others [15] that identified the importance of physical impairments, familiarity and satisfaction, and appreciation of the benefit of using the device. Together these two studies form the determinative basis from which our virtual reality study is framed (ref see list 1).

LIST 1. FACTORS OF INFLUENCE

- Learnability
- Efficiency
- Memorability
- Errors
- Satisfaction
- Physical Impairments
- Familiarity and Satisfaction
- Benefits of Virtual Reality Usage

In the elderly cohorts, there are a number of factors that may prevent the trusted acceptance of a given technology. In some cases, these are physiological and in others they are cognitive [8]. This study looks at what causes the fear and uncertainty of elderly people when using VR. It considers the factors that prevent the trusted acceptance of virtual reality usage. This research is significant because if correctly identified, the factors of influence will allow for the deeper and richer establishment of training on older people, without the need to risk physical, social, or mental densities into standardized (non-virtual) training and learning tasks.

A. Trusted use of VR by older participants.

To test the usability of VR under authentic scenarios, a pilot study was undertaken to consider the use of tethered VR equipment under control conditions using hand-held wands as control and navigation devices. The study examined a group of 19 older Western Australians over the age of 65. Participants were recruited from known aged care associations and were chosen using a random selection process that drew participants from varied and different socio-economic backgrounds. All participants undertook the exercises as first-time users of tethered headset VR technology. The study used purposive sampling to obtain a generalizable dataset from less than 20 participants [16][17]. Saturation was obtained by the 19th participant and the homogeneous grouping of elderly novice VR users was considered to be an adequate sample using empirical saturation.

The study hypothesized that pseudo-physical realities in combination with authentic tasking can be a useful approach to the technology acceptance of VR and the reduction of technology rejection by elderly first-time users of VR.

IV. METHOD

To test each participant a room was selected and set up with a virtual reality environment on a flat even floor surface with a trackable area of 2.4 meters x 2 meters in area. Participants were individually and separately guided through an initial demonstration procedure. Technicians introduced each participant to a Series I HTC Vive Headset used in combination with two Vive Hand Controllers, with each hand-held tracking wand utilizing laser position sensors. Each participant was then familiarized using a demonstration program that interactively introduced the componentry of the

VR system by means of a Steam VR software package, the *Steam VR Tutorial*. Participants were invited to try out their equipment during the interactive demonstration. This first procedure took place in a 3D virtual reality environment. The demonstration incorporated the various controlling buttons, trackpads, and visual elements of the equipment and lasted for approximately 4 minutes.

Once participants had completed the demonstration procedure they were transferred to a second VR environment by means of the Steam VR library. The second procedure took place in the 3D environment of Google Earth VR. Participants were introduced to the procedure with an initial locational starting point, but were free to navigate to any point above the earth within an orbital zone surrounding the globe. To complete the procedure, participants were asked to find their way home to either their place of residence, or a previous address. Participants were allowed a total of 15 minutes to complete the task.

Equipment Specifications

The main components of the HTC Vive VR equipment consisted of two hand held wands, a single VR headset, and a set of headphones. The Headset is tethered to the main controls of the computer. The software was driven through an Asus ROG Strix GL 702 VM GC 175T Gaming Notebook. The Laptop used an Intel i7 quad-core processor. The machine used a 1TB hard drive, as well as a 128GB SSD hard drive. The laptop included an NVIDIA GeForce graphics module with GTX 1060 graphics required to run the Steam VR software packages in real-time. This hardware requirement is considered Vive Ready [20], a standard essential for a comfortable experience.

Fig 1. HTC Vive wand controller in 3 aspects. Rear, side and front

Fig 2.. HTC Vive headset showing tethering cable at rear

The tracking wands used a Microelectromechanical systems gyroscope (MEMS) with 70 laser positional sensors. Each wand deployed a discrete accelerometer that was calibrated to operate within the designated trackable area. Wands could be gripped (one in each hand) offering trackpad, menu buttons and system buttons allowing for full movement access and program control. The headset included a headband that covered the scalp laterally. The visual display was incorporated into the VR headset, and an additional mini jack input allowed users to wear headphones to allow for additional, audio interactions. The HTC Vive headset has a refresh rate of 90Hz and uses two screens one per eye. Each screen had a display resolution of 1080 x 1200 pixels. The calibrated trackable area was defined by the means of the two tracking wands, as well as the headset which would alert users to instances where a user might by getting too close in physical terms to the virtual realities of the calibrated area.

V. RESULTS

At the completion of both the demonstration/training procedure and the navigational direction-finding exercise participants were interviewed about their experiences. The results were analyzed through a qualitative process in order to ascertain key factors in the possible rejection of VR usage in elderly cohorts.

Utility findings: Participants were asked to explain their preconceptions towards virtual reality in terms of its likely usefulness. Participants held a range of views about the likely usefulness of virtual reality. The majority (79%) held the view that virtual reality was a frivolous undertaking that held little benefit. Many expressed the view that VR was only for games and only for younger people.

"I was a bit dubious… it seemed rather an unnecessary expense to me" (Respondent 3)

"I really didn't think it would be anything that I would enjoy, and I certainly didn't think it was something I could use, however I was intrigued to find out about virtual reality was like" (Respondent 14)

Participants (63%) indicated that they had a low expectation about being able to use VR for anything useful.

Many participants indicated that after completing the VR exercises they could begin to understand more about the possible uses of VR. Responses ranged from understanding practical applications to seeing the use of VR as exploratory, bold and audacious. Many respondents (42%) expressed a "wow" factor once they had used VR, yet still held their experience as positive in terms of its utility.

"It was a lot of fun but I could see potential for serious use" (Respondent 5)

Authentic Tasking: Respondents engaged strongly with the navigational task of locating their home using the VR Google Earth maps. Whilst some participants were unable to successfully complete the exercise (i.e. they were unable to locate their own street address in a Virtual Reality mapped setting), none of them expressed any perception of a phony or unrealistic experience. Participants strongly connected with the authenticity of the VR experience, in combination with a strong acceptance of the Google Earth maps in terms of utility and authenticity.

Frustrations and Hesitations: Respondents voiced a range of obstructions and hindrances in achieving the objective of successfully completing their tasks. The Chart (Table 1) indicates the main issues.

TABLE 1. FRUSTRATIONS AND HESITATIONS

Triggers and Buttons on the Hand Wands	Some participants stated difficulty with the position of some buttons on the hand devices. Some indicated difficulties due to arthritis in their hands. Some indicated difficulties with finding the trackpad and buttons by means of touch alone. Some indicated that the smoothness of the plastic made it difficult to press track and menu buttons with confidence. Some indicated concern that the hand devices were too fragile.
Headset and Tethering	Some participants stated that the headset was too heavy. Some participants did not like the feeling of the control cable running from the back of their head to the ground. Many were afraid that when they stepped on a cable (the tether) that they were doing some damage. Some felt anxious because they were tethered (connected) to a machine, and they did not want to be electrocuted or short circuited.
Audio factors	Many participants stated that the volume was too low. Some stated that it was inconsistent, and that sometimes it was too loud. Participants were concerned that in the demonstration procedure the accompanying sound of their hand wans activating lasers gave them an impression that the lasers were possibly real and that they could do damage by pointing them. Some found that background noise and conversations from other people in the room was distracting and disconcerting.
Invasiveness	Participants stated hesitations regarding the feeling of being enclosed. Some comments were in relation to feeling trapped on the containment mat, whilst others stated concern that they were connected by a cord, and that they were conscious of the cord touching their clothing or of themselves stepping on the cord. Some participants stated that the experience was frustrating and stressful. Some participants felt giddy and sought the safety and comfort of a chair, sitting down for a portion of their VR task.
Remembering Button Functions	Participants stated that whilst at first they could remember buttons they forgot during the main exercise and became frustrated because there were too many option (buttons) to choose from. Some stated that the combination of slippery plastic and hard to find buttons made them second guess button functionality.

Some of these were physical and physiological. Some were mental. Others found the use VR an overwhelming experience. Some indicated that the equipment was not perfectly compatible with their levels of dexterity, sensory, and coordination-related abilities.

Three Dimensional Fears: In combination, the three-dimensional experience provided by the VR environment together with the partially masked physical interactions of touch and feel created three-dimensional fears and hesitations from participants. Sensory interactions that presented in the form of overly smooth wand buttons, excess tethering cable, and acknowledged headset weight, reinforced the perceptions of three dimensional fears. The repeated descriptions of sensory expectations by participants whilst learning basic proficiency in the use of the VR technology was reported as combinational in terms of participant responses. Whilst some participants made mention of the touchpad sensitivity or their trepidation towards the tether cables for fear of damage or electrocution, many participants described their hesitations as the combination of a disassociated engaged use of VR, with a distrust of electronic cabling and hand wands. These 3D fears emerged more frequently under situations where combinations of virtual and physical sensations showed as more frequent drivers of fear.

VI. DISCUSSION

From the results of the VR exercises, and the accompanying perceptions of participants, it is clear the trusted acceptance of virtual reality exercises that incorporate authentic tasking are unlikely to suffer from technology rejection if a range of physical and sensory adaptations can be introduced. Tethered VR equipment represents a difficult challenge for elderly people, both in terms of the physical reminder of the touch and feel of the tethering cable, but also in a mental sense as elderly participants grappled with the first-time concept of a virtual environment. There were sufficient instances of auditory problems to suggest that higher volume levels are required, but also that the quality of the audio should properly match the rich 3D visual qualities of the VR environment.

In order to mitigate technology rejection of VR systems more investigation into combinational fear drivers is required. Many participants were hesitant to engage with the VR technology used in this study. The need for participants to touch equipment beforehand, as well as familiarize themselves with headset equipment, tethering cables, and hand wands seems justified. 3D Fear is partly a mental challenge and partly a physical challenge. The transition to VR equipment that requires less tethering, and that incorporates texture-based differentiations between buttons and triggers, is both in line with market expectation built around a better user experience, as well as the reduction of three dimensional fear.

The use of authentic tasking as an introductory pathway for first-time elderly VR users shows that technology rejection can be mitigated where participants are involved in a task that holds high levels of utility when combined with a realistic 3D virtual environment. Whilst most participants held a preconceived view that VR was usually a technology toy for playing games, there was strong post-experience agreement with the idea that an authentic task such as interacting with Google Earth virtual reality maps held value for elderly people.

VII. RECOMMENDATIONS

This study recommends that further research is conducted into the widespread acceptance and trusted usage of VR by senior citizens, and that authentic tasking be incorporated into first-time usages for elderly cohorts. This recommendation implies that new VR software that include authentic tasks might specifically develop navigational map-based options that allow elderly cohorts to experience travel-related offerings to assist older people with mobility and accessibility limitations.

Feedback from participants in the study around difficulty using the Vive Controllers presents another area for further research. Investigation if changing the texture of various buttons and the trackpad of the Vive Controller would reduce issues with usage of the controller. This would provide a meaningful avenue of study. Further to this, mention of the tether as a concern with several participants suggests comparison of hardware with non-tethered solution may provide evidence of further acceptance of technology in the demographic in the study. Older participants will experience reduced sensory acuity with age [19]. The smooth surface structures of the HTC hand controllers could be adapted to incorporate different substrates that can be differentiated by coarse textures and non-standard surfaces.

Criticisms of first-time VR experiences from respondents supported the theory that preparation before usage of VR equipment may assist in the area of trusted technology acceptance. Participants stated that the demonstration procedure did not provide sufficient practice to firmly establish a working familiarity with the multiple buttons and interactive trackpad options incorporated within the HTC hand-held wands. By increasing the length of time that the demonstration procedure initiates each user, it will also be possible to increase the range of motions and meaningful interactions that could be rehearsed and prepared. Any extension of the existing Steam VR demonstration procedure should also retain a strong connection to the concept of authentic tasking.

VIII. CONCLUSION

Virtual reality is an emerging method of engaging elderly cohorts with high quality internet-based engagements with rich inclusion of information and visual appreciation of online information. The study of acceptance of VR in terms of older people indicates that with improved (in some cases bespoke) modifications of high quality tethered VR equipment it is probable to expect greater engagement and benefit from older cohorts. The distinction between perceived ideas about VR gaming as frivolous and lightweight versus authentic utility-based VR usage is important. Older cohorts of VR users can benefit beyond therapeutic offerings in broader and richer engagements from online technologies, online data, and pseudo-reality acceptance.

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