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Bring the Outside In: Providing Accessible Experiences Through VR for People with Dementia in Locked Psychiatric Hospitals

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ABSTRACT

Many people with dementia (PWD) residing in long-term care may face barriers in accessing experiences beyond their physical premises; this may be due to location, mobility constraints, legal mental health act restrictions, or offence-related restrictions. In recent years, there have been research interests towards designing non-pharmacological interventions aiming to improve the Quality of Life (QoL) for PWD within long-term care. We explored the use of Virtual Reality (VR) as a tool to provide 360°-video based experiences for individuals with moderate to severe dementia residing in a locked

psychiatric hospital. We discuss at depth the appeal of using VR for PWD, and the observed impact of such interaction. We also present the design opportunities, pitfalls, and recommendations for future deployment in healthcare services. This paper demonstrates the potential of VR as a virtual alternative to experiences that may be difficult to reach for PWD residing within locked setting.

CCS CONCEPTS

• **Human-centered computing** • **Human-centered computing~Virtual reality** • **Applied computing~Psychology**

KEYWORDS

Virtual Reality; Dementia; Long-Term Care; Locked Psychiatric Hospital; Patient-Centred Design; Person-Centred Care

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1 INTRODUCTION

As global population is ageing, the number of people diagnosed with Dementia (PWD) is growing. This growth has led to the emergence of research interest in providing interventions which aim to support PWD whose cognitive functions tend to degenerate as a result of dementia. Furthermore, there is currently no cure for dementia. Therefore, promoting wellbeing in PWD, especially those in long-term facilities, considered a quintessential measure of effective dementia care [1, 2]. Measures for Quality of Life (QoL) can include preserving autonomy for as long as possible and enabling PWD to maintain their life style and identity, including partaking in meaningful activities, and supporting social networks [3]. However, such interventions can become difficult to achieve in more rigid settings including in-patient services that are locked, low secure, medium secure, or high secure, where environmental and procedural restrictions are implemented depending on the risk that individuals may pose to themselves or others. As such, further research is needed to explore and develop novel interventions that can support QoL interventions for people residing within such potentially restricted environments.

Research within the HCI community has examined various uses of technology to aid and assist PWD residing within the community, including those in care homes. Such research is mostly aimed at providing interventions for training [4, 5], assistive technology (see a summary in [6]), detection and assessment [7, 8], or reminiscence [9, 10, 11]. Virtual Reality (VR) has also been examined in the research field of dementia care. In addition, existing literature mainly explored the use of VR as a tool for training and rehabilitation [12, 13, 14, 15] for individuals with early or mild dementia. However, little is known about the feasibility of VR for individuals who are at the later stages of dementia residing within in-patient services such as a locked psychiatric hospital. Therefore, it is unclear how we can design VR to benefit this patient group and what barriers a locked hospital may present to the deployment.

This study therefore aimed to understand how VR could be used to promote wellbeing among individuals with moderate to severe dementia residing in a locked psychiatric hospital. Through this study, we aimed to contribute to the research in the design community by examining the opportunities VR could offer to this patient group and further explore the design to capitalise on the benefits of VR. We also hoped to draw potential research directions towards a more deployable VR system for those who may face barriers in accessing different environments due to ill health, difficulties with mobility or legal restrictions.

1.1 Dementia in Long-Term Care

There are approximately 850,000 PWD in the UK [16] and 46 million people worldwide [17]. Dementia is an umbrella term that describes disorders of the brain, which are progressive in nature and effect cognitive functions. With a complex array of symptoms of dementia, PWD can progressively lose their sense of autonomy; including engagement in activities of daily living and capacity to make decisions in various or all aspects of their life [18]. Behaviours that challenges are very common with individuals in the moderate to severe stages of dementia [19]. This might include physical aggression toward self or others and verbal aggression [20]. Since dementia remains incurable and progressive, institutional care is essential for some [21]. Similar to the growing number of PWD, older offenders with mental disorders including dementia are the fastest growing group in the prison population [22]. In some cases, for offenders with mental disorders and comorbidities including dementia, referral to psychiatric hospitals is required to meet their specialised psychiatric and psychological needs. The levels of security within psychiatric hospitals depend on the risk(s) the individual pose to themselves and/or others. PWD who reside in a locked psychiatric hospital often present with symptoms of dementia that requires a level of psychiatric care and safety measures, such as behaviour that challenges, may have offence-related histories and, may be detained within the hospital for their own safety and/or for the safety of others under the Mental Health Act (2007) [23].

Extensive research has examined the important role QoL plays in the wellbeing of PWD. Studies suggest that almost half of long-term residents in care services with cognitive disorders are diagnosed with depression [24]. Subsequent reaction to symptoms of depression can contribute to cognitive decline, social withdrawal, lack of motivation and loss of interest in oneself and others [25]. Similarly, within forensic hospitals, research found that higher QoL results in lower levels of anxiety, depression and hostility within wards. Research suggests security measures within hospitals contribute to a lower QoL due to decreased autonomy, privacy, personal control, and restricted access to leisure opportunities [26]. For all the aforementioned reasons, research in dementia for individuals living with moderate to severe dementia in hospitals, is directed towards delivering innovative interventions that reduce behaviour that challenges, and supports their QoL.

1.2 VR Technology in Dementia Care

VR in mental health care has demonstrated its potential through decades of research in many areas including post-traumatic stress disorder (PTSD) [27, 28, 29], eating disorders [30, 31], and treatment of phobias [32, 33] as well as individuals with autism [34, 35] and schizophrenia [36]. Within each field, researchers have explored how VR

can be beneficial to the target users and distinctive VR features that traditional interventions may not be able to offer. For example, the main VR feature that makes it unique for treatments of phobias is the ability to control the stimuli and provide progressive exposure based on the patient's pace in a controlled safe environment away from unexpected real-environment factors [37].

In recent years, there have been emerging interests in using VR with PWD and examining the unique features that VR could offer to this patient group. Most VR research within dementia has focused on assessment and training of skills which typically decline with the course of the disease, including spatial navigation [12, 15] and attention [38, 39]. Furthermore, VR has been explored as a tool for memory training [40] and improving functional autonomy such as cooking activities [41]. Subsequently, research in dementia has attracted substantial attention within the HCI community especially because of the specific needs such population requires due to the decline in cognitive functions that affects the usability and acceptance of VR technology. Prior studies have explored such design requirements when developing Virtual Environments (VEs) experiences in both semi-immersive and fully immersive modalities [42, 43]. These studies demonstrated the importance of developing computer generated VEs (3D-VEs) that is custom to preferences, stories, or activities PWD would enjoy, as this could contribute to more meaningful and sustained engagement. However, the potential pitfalls of developing tailored 3D-VEs was highlighted in both studies. First, the time it takes to understand individual preferences and the time needed to visualise, generate, and test 3D-VEs is substantial and therefore places a time constraint for deployment. Second, the cost constraints when it comes to operating such methodologies to a wider use within in-patient service is considerable. Both major constraints could become a barrier to deployment.

We decided to take a different approach by using 360° video-based VEs (360-VEs). 360-VEs are recorded using omnidirectional cameras; a technology that allows several cameras to record in every direction all at the same time. The recorded videos are then stitched together to simulate a 360° view. Using such technique, users are able look around by rotating their head and upper body. Considering the wide spread use of VR in the consumer market, 360-VEs have become easily available at large quantities across online platforms. We believe that using 360-VEs could reduce the cost and development time, and by that, make VR more realistically deployable within a hospital medium and still be able to provide a tailored experience.

There is a lot to be learnt in regards to the potential of deploying VR technology within more complicated healthcare settings such as locked and secure hospitals. In such environments, the symptoms of later stages of

dementia could be more challenging for meaningful and effective user interaction. At the most fundamental level, we needed to understand whether a Head Mounted Display (HMD) would be tolerated by PWD who can exhibit behaviour that challenges. We also needed to examine the unique features of VR so that it can be deployed successfully in the future, in larger scale. In addition, we needed to understand what kind of benefits VR could provide to this patient group, and how we can design VR to enhance and maximise these benefits in the future.

2 METHODOLOGY

2.1 Ethics

Participants were recruited from a locked psychiatric hospital in the UK that specialises in progressive neurological conditions, including dementia. The hospital provides specialist care to individuals who may present with behaviour that challenges and/or forensic-related risk. Ethical approval was sought from the hospital ([21]) as well as the UK National Health Services (NHS) research committee (17/LO/1477). Where concerns were expressed with regards to individual's capacity to consent to their participation, capacity assessments were completed using the 'Mental Capacity Act (MCA) 2005 Assessment Checklist' [44]. Where individuals were deemed to lack capacity, a relevant consultee was invited to consider providing consent on their behalf.

2.2 Study Design and Procedure

The study design emerged from rigorous discussions with experts in the field of dementia care and HCI in healthcare and a completion of a systematic review that examined the feasibility of VR for individuals with moderate to severe dementia [45]. Data was collected over a two-week period and included interviews and qualitative and quantitative observations. First, a clinical researcher observed PWD in care as usual for 15 minutes prior to the VR session and recorded "pre-exposure" quantitative measures. Then, escorted by a caregiver, PWD were invited to use VR in a room within the ward they reside on. PWD were offered an A3 paper "Menu" of 360-VEs to choose from. They were offered to spend time in VR for a maximum of 15 minutes and were reassured they had the choice to stop using VR at any time or not use it at all. The maximum duration was suggested to reduce the risk of PWD having adverse effects of using VR such as dizziness. Afterwards, PWD participated in a semi-structured interview then returned to care as usual and the clinical researcher observed the PWD for 15 minutes to record the "post-exposure" quantitative measures. Lastly, the caregiver supporting the PWD during the intervention participated in a semi-structured interview. Using the same procedure, the PWD were invited to a second session two weeks later. During the VR session, a

technical researcher managed the equipment and recorded qualitative observations then corroborated the notes using the video recordings of the sessions. As for “during-exposure” quantitative measures, the clinical researcher was occupied with supporting the PWD during the session and therefore, the measures were taken after the session by reviewing the video recordings. Overall, each session lasted approximately an hour to one and half hours on average.

2.3 Participants

Of the pool of eligible participants (n=38) within the hospital, 6 PWD were deemed to have capacity to consent and provided consent to participate, and 2 consultees consented on behalf of PWD that were deemed to lack capacity to consent. Therefore, the final sample included eight PWD (6=male, 2=female). The mean age was 69.63 years (range=41-88 years). Primary diagnoses included: dementia in Alzheimer’s disease (n=2); unspecified dementia (n=2); dementia in Huntington’s disease (n=2); mixed cortical and subcortical vascular dementia (n=1); and frontotemporal dementia (n=1). Secondary diagnoses included: recurrent depressive disorder (n=3); depressive episode (n=1); organic mood disorder (n=1) and paranoid schizophrenia (n=1).

The Global Deterioration Scale (GDS) [46] consists of seven stages of cognitive functions in dementia ranging from 1: “no cognitive decline” to 7: “very severe cognitive decline” was used to assess participant’s cognitive functions in dementia. The GDS mean score of participants was 5 (indicating moderately severe cognitive decline) with a minimum of 2 (indicating very mild cognitive decline) and a maximum of 6 (indicating severe cognitive decline). Sixteen caregivers were recruited to support PWD during their VR exposure, whose professions included nursing (n=11); occupational therapy (n=3); psychology (n=1) and physiotherapy (n=1).

2.4 VE Content Selection Process

A 90-minute workshop was conducted at a Specialist Neuro-Care Conference organised at the participating hospital. Attendees were a group of approximately 15 specialists such as clinical psychologists, psychiatrists, nurses and managers within dementia healthcare. During the workshop, the researchers presented an introduction to VR technology and the results of the systematic literature review [45]. Afterwards, attendees split into three groups and brainstormed the type of VR content suitable for PWD. Attendees suggested the following categories: 1) Travel (google maps, cities around the world, cruise). 2) Nature (beach, woodland, park). 3) Arts Experience (music, cinema, museum). 4) Hobbies and Sports (football, fishing, golf, bowling). 5) Social (pub). 6) Home (kitchen, workshop, and garden). 7) Pets (puppies, kittens). 8) Patient-Custom Content (e.g. Christmas or a

thanksgiving content with the family, locations from earlier life).

Through the workshop and based on the technical experience of the researchers in the HCI field, we critically discussed and agreed on the following exclusion criteria that was used to identify potential 360-VEs: 1) Resolution less than 2K (2048×1080) to avoid compromising resolution quality of content. 2) Sudden transitions between scenes to avoid PWD being startled or confused. 3) Moving, shaking, unstable camera recording to avoid inducing motion sickness. 4) Animals or people that are close to the camera that may be perceived as startling or scary. 5) Negatively high arousing content that may be perceived as startling or scary. 6) Audial content that is not consistent to the visual content, aiming to provide coherent audial-visual feedback and avoid distraction. 7) Audial content that is perceived loud, low, or noisy. 8) Explicit audial narration, as it is important for the PWD to hear the caregiver’s directions and prompts whilst using VR. 9) Computer generated content or special effects added onto 360-VE due to the lack of evidence on the effects this type of content could have on PWD. Based on these criteria, we identified the following number of videos within each category: 1) Travel (n=21), 2) Nature (n=14), 3) Arts Experience (n=25), 4) Hobbies and Sports (n=11), 5) Social Experience (n=0), 6) Home Experience (n=2), 7) Pets (n=5). Six researchers, three of which have an extensive clinical experience with PWD discussed and rated the videos independently (1: include, -1: exclude or 0: not sure). The highest rated videos were the cathedral, forest, sandy beach, rocky beach, and countryside, and were therefore included in the study. Snapshots of these VEs are displayed in figure 1.

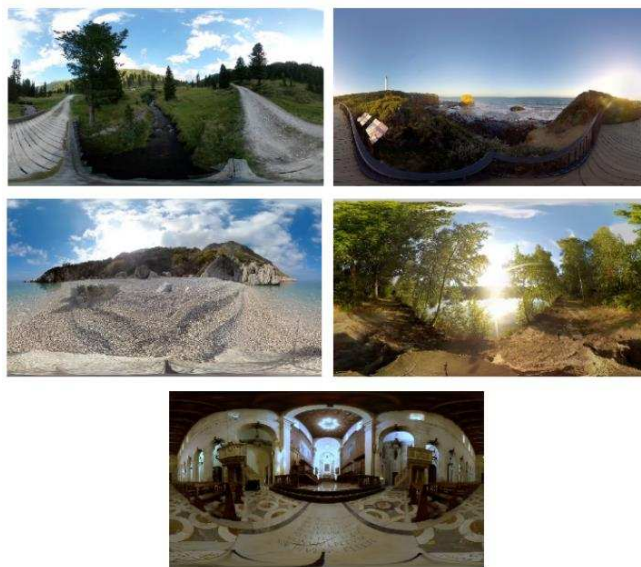


Figure 1: Snapshots of the VEs that were offered to the participants

2.5 Equipment

The Samsung Gear VR¹ HMD paired with a Samsung Galaxy S6 mobile phone was used to stream the audio and visual content. The Samsung Gear VR is a wireless HMD that can be used hands-free using its 3-point harness head strap and features optical lens with a 96° Field of View. The combined weight of the HMD (318 grams) and phone (138 grams) is 456 grams. The VR content was wirelessly streamed to an external laptop screen, mirroring the user's real-time VE's viewing angle; allowing caregivers to provide relevant prompts and support during the exposure. A video camera with a tripod was used to film individuals during the VR session, and a dictaphone was used when interviewing all participants. A laminated A3 paper VE menu was presented to the participant at the beginning of the session which included pictures and titles of the five different VE options they could choose from.

2.6 Data Collection and Analysis

A clinical researcher, who is experienced in using the observatory instruments, recorded the following measures for pre, during and post VR exposure: 1) Overt Aggression Scale-Modified for Neurorehabilitation (OAS-MNR) [47]: this scale records different types and severity of aggression categories: verbal aggression, physical aggression against objects; physical aggression against self; and physical aggression against others. 2) Observed Emotion Rating Scale (OERS) [48]: the scale measures the time spent expressing five affect types of emotions: pleasure; anger; anxiety; sadness; and general alertness. Ratings are measured on a Likert scale (1= never; 2= <16 seconds; 3= 16-59 seconds; 4= 1-5 minutes; 5= >5 minutes; and 7= not in view).

Semi-structured interviews were conducted by two researchers. However in some instances, an experienced caregiver who was familiar with the participant's background was sought to support facilitating the interview when barriers in communication (i.e. cognitive impairment, other medical issues) arose. Interviews with PWD aimed to reflect on their experience using VR over technology acceptance, presence, and emotional affect. Some of the questions were constructed based on the Usability Evaluation in Industry Questionnaire [49] and Presence Questionnaire [50]. For PWD who are able to elaborately express their answers, questions were asked in an open-ended nature to allow discussions. A simplified version was adopted for PWD who best respond to questions that are simple and closed-ended. Finally, to ensure the reliability of the answers, the same questions were asked more than once and sometimes in a different format. Interviews with caregivers aimed to reflect on

their observations of the PWD using VR and sought their professional opinion on the usability of VR in the locked hospital environment. All interviews were transcribed verbatim by two researchers.

Qualitative observations were also taken by a technical researcher who was dedicated during the sessions to record observations. The aim of these observations were to record any physical interaction participants had with the HMD, their behavioural responses, reactions and facial expressions in response to the VR experience. Furthermore, the notes captured the interaction between PWD, caregivers, and the HMD, as well as explored how the technology could be designed and enhanced to best fit such interaction in a locked care environment. The observation notes were then verified and corroborated later using the video recording, then by two researchers independently to gain an overall understanding and to ensure reliability of the observations.

The findings were drawn using thematic analysis; a method used for identifying, interpreting, and reporting patterns within datasets [51]. Overall, the findings were organised, presented and discussed to answer the following questions: "What potential benefits could VR experiences have within a locked hospital environment?", "how could these experiences be designed to benefit this patient group?" and "what are the deployment challenges that we need to address for successful implementation?". To answer the research questions, patterns in the data were coded then refined into themes. Finally, to further refine and verify the themes, three expert clinical psychologists in the field of dementia healthcare and two experts in HCI for healthcare critically discussed and reviewed each theme and underlying codes together. The primary resource of data presented in this paper is based on observation notes. Passages were quoted from our notes after they had been verified using video recordings. We occasionally used quotes from the transcribed interviews when needed to provide context and illustration of the findings.

3 FINDINGS AND DISCUSSION

Three main themes were identified as a result of the thematic analysis: a) the appeal of slipping into a virtual world, b) multi-dimensional benefits and c) a holistic user-centred intervention design. The thematic scheme is summarised in Table 1.

¹ <https://www.samsung.com/global/galaxy/gear-vr/>

Table 1: Thematic scheme summary

The Appeal of Slipping Into A Virtual World	Multi-Dimensional Benefits	A Holistic User-Centred Intervention Design
Virtual Outreach for a Personal Space	Therapeutic Effects of VR	Designing Meaningful Experiences
Engross Attention and Empower Autonomous Experiences	Cognitively Stimulating Interaction	Tailoring the VR Technology
A Portable Experience	A Unique Space for Building Therapeutic Rapport	The Role of the Caregiver

3.1 The Appeal of Slipping into a Virtual World

When assessing the potential of VR within restricted hospitals or in long-term care facilities, it is essential to understand what unique aspects of a virtual experience makes VR technology viable and valuable. Three sub-themes were identified; a) virtual outreach for a personal space, b) engross attention and empower autonomous experiences, and c) a portable experience.

3.1.1 Virtual Outreach for a Personal Space. There is extensive research in preventing violence and aggression in psychiatric services, due to the significant concerns toward the health and safety of the patients and caregivers [52]. Clinical practice has moved from restrictive approaches to manage risk such as seclusion (placement of a patient in an area where the patient is not allowed to leave) or restraint (administering mechanical, pharmacological, or medical interventions) towards less restrictive approaches when possible. These approaches includes preventive interventions by identifying and addressing the triggers to behaviours or developing interventions that aims to reduce these behaviours once they had developed [53]. The body of research identified the hospital physical environment as one factor that affect the behaviour of patients including behaviour that challenges and aggression. Such environment design factors could include space density and excessive stimuli such as the activity level within the hospital [54]. In such cases, studies suggests that one of the most effective non-pharmacological interventions in de-escalating patients include caregivers re-directing patients to a low stimulus environment and taking action in changing antecedent condition that might have elicited the aggressive behaviour [55].

Observations shows that VR could be utilized to create a private isolated space. Through this space, PWD can momentarily “escape” the reality of the hospital whilst receiving the necessary support from the caregivers. Our

observations suggest that this could be especially helpful in reducing behaviour that challenges. Using OAS-MNR, a total of eight aggressive behaviours were observed and recorded throughout the two-week study. Of those behaviours, seven behaviours were observed pre-exposure to VR, zero during, and one post-exposure. Although we did not observe many aggressive behaviours overall, which may in part have been due to the small sample size, aggression was not observed whilst using VR, and the total number of aggressive behaviours was considerably less in comparison from pre to post-exposure. Two out of these observations included PWD who were unsettled and verbally aggressive due to the changes in the environment (i.e. presence of the researchers) ceased to be aggressive once exposed to VR, and became calm for the entire time they spent in the VR.

“The PWD at the beginning was verbally aggressive by swearing at the researchers [...] asking them to leave the room, however when CG [caregiver] demonstrated using VR, even though he was still verbally aggressive and unsettled, he was interested in using VR. When PWD was using VR he appeared to enjoy being in his own world. We were informed this PWD could become agitated easily, and yet surprisingly, he tolerated VR and used it for the maximum period.”[PWD7, Observations, 1²]

It is as if VR “teleported” the PWD to a low stimulus world and isolated them from the physical world which contained elements that could have triggered their aggressive behaviour. Unlike other non-immersive or semi-immersive devices that are normally available on wards such as a television set where PWD could still be distracted by the high stimulus surrounding, VR is capable of physically isolating PWD from the physical world instantly without having to physically remove them from the high stimulus physical environment. Moreover, VR can simulate realistic immersive experiences by providing PWD an experience with a high degree of “presence” and yet retain the safety of PWD. Most participants reported a high level of presence during the interviews, reporting that it felt “real” or “like they were in there”.

“I was quite happy to be on my own.”[PWD4, Interview,2]

“It moves when you move, you feel like you’re within it I guess. You can’t see the [physical] room that you’re actually in so you are in that picture [VE].”[CG04, Interview, 1]

² PWD= person with dementia, CG= caregiver, source: observation notes or interview transcript, week: 1 or 2.

We believe that the sense of isolation in VR coupled with a suitable VE could provide a “soothing effect” for those who are agitated. This was also noticed by caregivers and some expressed their desire to try using VR for de-escalation in the future.

“It was relaxing for him so me as a nurse I think that I’m [going to] use it if someone is distressed [...] I can see the trigger coming I can take him in the quiet environment [VE] and we can go through this as a session. I think that may get somebody more relaxed [...] so he’s inside [the VE] when you distressed in your mental state, you have something there to focus on it that will distract your mind, make you more relaxed.”[CG05, Interview, 1]

In fact, this potential benefit of VR is not too foreign to the existing body of literature; VR has been used as a distraction technique in different areas, including pain management [56] for burns [57], painful procedures for cancer patients [58], and acute pain in exercising [59, 60]. The distraction technique in previous literature examined the context of providing the brain an alternative imagery to alleviate the users’ physical pain. However, to our knowledge, none examined the context of “escapism” in VR as an anchor to regulate one’s emotions through immersive personal spaces for individuals who are in long-term care. Our observations seem to point to the possibility of utilising VR for this purpose however, further in-depth research is needed to examine whether PWD will tolerate using VR at the moment when they are aggressive.

3.1.2 Engross Attention and Empower Autonomous Experiences. A key challenge when designing activities in general and recreational interventions specifically for PWD is to engage and sustain their attention and interest for a meaningful period of time. The fluctuation of cognitive impairment is a marked deficit of a dementia diagnosis, which contributes to difficulties in maintaining attention and struggles to deactivate irrelevant stimuli [20]. We found through our observations that VR was able to sustain the attention of PWD, whether that was through “thorough exploration” of a single VE or “surfing through” various VEs within one session. The ease of changing the VE allowed PWD to be quickly “transported” to different experiences, which was particularly useful for PWD who had a short attention span and could lose interest in one virtual space quickly.

“She reread the menu after each experience and became excited when a VE on the menu caught her interest. She viewed the VE and engaged in VR, and then when she no longer was interested in that VE, she went back to the menu and so on. It appears that having multiple VEs, with the menu in front of

her the entire time, as well as being able to set up the VEs swiftly continued the momentum of engagement even when the PWD had a short attention span or lost interest within a specific VE.”[PWD8, Observations, 2]

In 5 (out of 16) sessions, PWD spent 3 minutes or less in VR and in 11 sessions PWD spent 12 minutes or more. Nonetheless, it is important to note that the measure of success of a session with PWD is very individualised and that the quality of the time spent in VR is often more important to the length of time spent. For example, for an individual who may find engagement in activities of daily living difficult, if VR is able to trigger alertness and interest, the engagement could be perceived as meaningful regardless of how short it is.

“Looking at PWD’s engagement, it may look like he did not engage much or the time spent in VR was short, however, today he explored the VE on his own in multiple occasions, which is in comparison to last session, an achievement on its own, particularly for a PWD who presents with apathy.”[PWD1, Observations, 2]

One aspect that could have contributed to an active prolonged interaction is the element of surprise in VR. It is crucial to clarify that the VEs used did not include any quick motions or sudden appearance of visual elements. Therefore, the element of surprise in this case refers to elements that are not accessible within the hospital or something the PWD did not expect to see in the VE.

“He giggled whilst saying ‘I think it’s a cow, yes it is, it’s moving [the cow], I think it’s a cow! CG responded ‘yeah?’ he replied ‘yes it is! It’s moving, with its front legs and back legs, it’s a cow!’”[PWD4, Observations, 2]

Having the autonomy to choose the VE also seems to have contributed to the PWD’s interest in the VR experience as it was “their” choice and it piqued their interest at the time. In the study, PWD were invited to simply explore an open VE space (i.e. without having to perform specific tasks), in which they engaged in open-ended discussions with caregivers.

“PWD: It [VE] reminds you of some of the places I’ve been to [giggles]. CG: So what places does it remind you of? PWD: [country name]. CR: [country name]? PWD: Yeah I stayed there for a month, yeah, four-star hotel and everything, it was nice, it wasn’t too expensive neither! [Giggles] And they’ve got a flea market.”[PWD5, Interview, 1]

The open space within the VE provided the PWD the autonomy to steer the engagement and conversation in the direction that the individual felt like at the time. Such

shared thoughts ranged from personal and emotional life events, to their inner feelings and reflections. This is especially beneficial to such patient group where PWD may no longer exercise exhaustive autonomous lifestyles in their daily living within a locked psychiatric hospital medium, autonomous experiences could become more valuable.

3.1.3 A Portable Experience. In contrast to deploying VR in other settings, we needed to understand the locked hospitals' structure and restrictions as an additional challenge to design and implementation. There are a number of wards within the locked hospital, each focusing on different levels of care and diagnosis. The type of restrictions put in place are based on the risk each individual pose to themselves and/or others. Hence, choosing a technology that is portable and easy to admit to these wards is essential. In addition, in the case where equipment was set up in the room with PWD was present, the need for a speedy and easy set up to avoid participants experiencing discomfort or loss of interest was vital.

"With this PWD we had to conduct the session at their living space as per the hospital protocol. Which meant we carried the equipment and set it up on the spot. Furthermore, this PWD has a tendency to be short tempered and can easily become unsettled by changes in the environment; this meant that we needed to set up the equipment in a rapid manner." [PWD7, Observations, 1]

VR has the advantage of creating experiences that may be difficult for PWD to access. Such restrictions could be due to lack of mobility, ill health, or offence-related background. Inaccessibility could also refer to having environments that are unavailable due to uncontrolled factors like weather, location availability, or places of interest in the past, which no longer exist.

"Well especially in an environment like this, you can't get them to a forest walk every day, you can't get them to a beach every day, you can't get them to a cathedral every day and it's as close to those environments that they can then get to regularly. So it's definitely beneficial for them because I mean [PWD] wouldn't have seen the lovely countryside today if it hadn't of been virtual reality [...] walking is more difficult so he can't access those environments as easily as an abled bodied person." [CG04, Interview, 1]

We found that PWD were excited about the fact that they had a variety of VEs to discover. Such variety motivated some individuals to choose to explore two or more VEs within the same session, whilst others decided to go through the VE experiences one by one in different sessions. One PWD chose the same VE in both sessions, which highlights another important feature in VR:

generating consistent experiences. Caregivers expressed the potential of VR bringing experiences that might not be reproducible in real life, such as experiences from the past, or activities PWD loved but cannot do within the locked hospital environment. Both of which could be enjoyable and stimulating.

"Using it itself [VR] for transporting them back to, days gone by [...] I think it would be quite good, quite beneficial." [CG08, Interview, 1]

"Especially stuff like the beach for instance, they might have had a, previous love of going to the beach which is not something we can do here [...] it might bring back memories of something they've not done for a while if they do that one." [CG11, Interview, 2]

Only in recent years, VR technology has advanced from PC-based to portable display using mobile devices. Having a wireless mobile HMD that can be easily carried, admitted to the wards, and set up contributed to the successful inclusion of this patient group. In particular, VR has the ability to provide virtual mobility to PWD who may no longer experience the outside, simulating various types of experiences that can be "new" every time and can be easily reproduced and customised to individual preferences all in line with the hospital's security requirements and therefore reduce the "inertia and friction" of deployment to a minimal.

3.2 Multi-Dimensional Mutual Benefits

During the study, we observed various benefits that related directly or indirectly to the significance of exploring such environments. Here we present three sub-themes: a) therapeutic effects of VR, b) cognitively stimulating interaction, and c) a unique space for building therapeutic rapport.

3.2.1 Therapeutic Effects of VR. A common objective in many non-pharmacological interventions within long-term care is to provide experiences that enhance the overall wellbeing of the residents through promoting positive effects amongst PWD [18, 19, 54, 55]. The majority of PWD enjoyed the VR experience, and through our observations, it is prominent that VR promoted a positive uplifting mood and general well-being. We also found that the effect of VR was not only temporary whilst using VR, but also remained for a short term after the session.

"Post VR Observations - shared his experience with others, talked about the VR, laughed and smiled when talking about it, shook CG's hand and thanked them. Commented, "It was the best day ever". Talked to others including peers and CGs commenting, "Best day I've ever had." [PWD3, Observations, 1]

The results of the quantitative measure (OERS) confirmed our observations. Results indicated significant increase in pleasure from before VR exposure (Mdn=1.250) to during (Mdn=2.000) VR exposure ($p<0.05$) and from before to after (Mdn=1.750) VR exposure ($p<0.05$). Ratings of general alertness also significantly increased from before (Mdn=4.500) to after (Mdn=5.000) VR exposure ($p<0.05$).

The emotional state and mood of the PWD at the time of the VR session was one important factor that played a role in determining how participants used VR and what type of benefit they gained from the experience. For example, participants who were unsettled appeared to be physically relaxed and frequently took deep breaths when they engaged with VR. In this case, the caregivers gave them the space to be in the VE without interruptions.

“CG said: He looks mesmerised... it'd be a shame to take him out of the state he's in now just to check if he wanted something else [view another VE].”[PWD7, Observations, 2]

Sometimes the same PWD seemed to have experienced different form of therapeutic effect in each session. The type of stimuli within the VE may have played an additional role in how PWD perceived and interacted with VR.

“Today PWD was energised and actively describing VE, whilst the last session he sat calmly and appeared to be relaxed. The VE selected today (countryside) contains animals and elements in the rear and far, whilst in comparison to last time's VE (beach) didn't have as many elements to stimulate his mind. PWD was not directed to engage in a certain way in order to sense those feelings, instead he seem to naturally go with the VE.”[PWD4, Observations, 2]

Exploring VEs that could be inaccessible for this patient group was perceived positively. Some found the VEs calming and relaxing others found them exciting and energising. We conclude that exploring VEs broke the routine, was out of the norm, and had a positive effect on PWD.

3.2.2 Cognitively Stimulating Interaction . Multi-sensory cognitive stimulation for dementia has received a growing interest when exploring the applications in VR for this patient group. An increasing body of research explored the use of VR as a tool to enhance, train or assess specific skills that are degenerated or disrupted due to the diagnosis of dementia, e.g. relearning everyday activities [13], memory training [40], exercise and balance [61], and cognitive assessment [62] . These studies adopted a task-oriented design approach, in which the PWD would typically need to complete a series of pre-designed tasks in a specifically designed VE for the purpose of the

assessment or training. Whilst such approach has proved its efficacy especially with individuals with mild dementia, we found that the open-ended nature design used in this study instead provided individuals with free-form interactions where could PWD construct their own stories. We found that most PWD were self-motivated to engage with the VE at their own pace, paying attention to aspects that interest them at that moment. Caregivers' involvement in this sense included responding to PWDs thoughts with relevant prompts. This was also beneficial to caregivers as it allowed them to informally learn more about individuals' cognitive abilities through the VR interaction. During the caregivers' interviews, many reflected on their knowledge about PWD's cognitive abilities and compared it to what they observed during the VR session, discovering a new medium of learning more about the PWD they care for.

“I didn't realise [...] how good he could describe things. And that's taught me something that if he's telling me something now, I know that he's quite good at telling me [...] because he just described that [VE] scene you see, and he did really describe it in detail, which surprised me.”[CG13, Interview, 2]

Some domains within the cognitive functions could be easy to spot informally whilst PWD was using the VR. One example is recognition memory and language domains, which includes the ability to recognise the elements and describe the surroundings.

“He pointed with his finger, he looked like he was about to say something but he didn't. It appeared like he was trying to find the words to describe the element he was pointing at, but he couldn't find the words to describe it.”[PWD3, Observations, 1]

Another interesting outcome is reminiscence during or post exposure to VR. It is important to clarify that we did not personalise the VEs to match specific participants' interests during the VE selection process. Despite this, several PWD found connections with the VEs and reminisced about countries they are from, holidays they had been to, etc. In consistence with previous literature, we found that PWD reminisced through the similarity and resemblance the VE is to a memory from the past or being reminded of a memory through an element within the VE [43].

“I think it's a bridge! It's got the road, the road going like in [country] we call them [the word bridge in their mother tongue].”[PWD4, Observations, 2]

In conclusion, it seems that exploring a virtual world is not only providing a free-form engagement space for PWD, but also a lens for caregivers to further understand

the patient they care for in a non-intrusive, informal approach.

3.2.3 A Unique Space for Building Therapeutic Rapport .

Due to the changes in cognitive capacity, social abilities, and communication skills, PWD may be reluctant to participate in daily activities, in a bid to protect their dignity should they carry a task incorrectly, which is often accompanied by concerns towards how other people view PWD [63]. Hence, it is a challenge not only to persuade individuals to join an activity, but also to let their guard down and be truly engaged. During the sessions with PWD, we found a general sense of openness when stepping into the VE, whether it was by physically getting into a more comfortable position and exploring different angles within the VE more freely, or verbally by opening up about a variety of topics; memories and previous experiences, preferences and dislikes, or something as simple as sharing a joke. Many instances were recorded across the data where PWD and caregivers shared a moment together.

“He said ‘oh yeah I can see the steps and the ladder’... then jokingly said ‘oh I would not use that ladder’, everyone joined the laughter.”[PWD5, Observations, 1]

One key measure of presence in VR is the forgetfulness about the physical world surroundings [50]. We argue that perhaps “forgetting” the real world could present a mutual benefit for both PWD and caregivers. From one side, PWD felt free to be open, engaged, and sharing whilst in VR. On another side, caregivers were able to see the PWD more translucently not only as a patient, but also as a person with life experiences and further learn about their personal attributes, which could potentially be used in the future when caring for their patients in existing activities.

It has been established that relationships, including therapeutic relationships with caregivers is a key factor for a good outcome in long-term care [1]. We observed that VR allowed PWD to open up about their feelings and tell us more about themselves. Thus VR became a mutual platform where both PWD and caregivers could enjoy new experiences and promote a positive therapeutic connection between them.

3.3 A Holistic User-Centered Intervention Design

This theme emerged from our reflections that it is worthwhile to consider our experience, examine the shortcomings of our current approach and provide illustrations to the strengths and core aspects that contribute to a successful design and deployment of VR for PWD. We present each sub-theme outlining our understanding of the constraints, trade-offs, and opportunities involved in the following aspects: a)

designing meaningful experiences, b) tailoring the VR technology, and c) the role of the caregiver.

3.3.1 *Designing Meaningful Experiences* . One symptom of dementia is the loss of interest in activities, social life, and self [25]. Therefore, a vital aspect in HCI research for PWD is to design experiences that are engaging and meaningful for such user-group [42, 43, 64]. Perhaps unsurprisingly, the choice of the VE plays an important role in how PWD perceive the VR experience. Almost all caregivers stressed on the importance of creating experiences that are relevant to the individual’s interests, and how that could contribute to a more engaging experience.

“I know quite a lot of our patients like music, [it] is really important to them so maybe like, being at some sort of music venue or being at a gig or a concert, or perhaps like for patient who love cooking, maybe a kitchen for them.”[CG07, Interview, 1]

In addition to considering individual’s preferences, we found that it is also important to consider the behaviour of PWD and their symptoms of dementia. All selected VEs in the study fell under the “low arousal positive” category, which are perceived as calming and relaxing. In one instance, a PWD with a history of apathy did not find VR engaging. In such case, more research is needed to investigate the type of VEs that could be perceived as positively arousing and engaging to such PWD.

“This PWD presents with apathy, he was not engaged with the low arousal VEs that we provided. Whether it was the sounds of the choir in the cathedral or watching subtle waves on the shore of the beach, having a PWD that struggled to be alert, soothing audial/visual feedback was not helpful.”[PWD1, Observations, 1]

Generally, we thought that a simple interaction modality that included rotating the head and upper body to explore the VE would be accessible for PWD, but that was not always the case as we observed in one PWD with disorders of involuntary movements.

“CG encouraged her to move her head to the right; she attempted to and immediately smiled. However, she could only hold her head for a brief second. The fact that the only way to view different parts of the VE is to move the head resulted in PWD not being in control considering her involuntary movement.” [PWD6, Observations, 1]

A common challenge within HCI research is finding the balance between designing engaging experiences and yet retaining the simplicity of interaction. Maintaining the sense of suspension from the physical world is crucial for PWD to sustain the engagement and feel present in the

VE. The concept of embodiment within the VE (e.g. the sense of body ownership) is something we did not fully explore in our study, although we did observe PWDs commenting on it. From our observations, some PWDs enjoyed the simple interaction and did not appear to notice the lack of “owning” a virtual body within the VE. On the other hand, many participants found that laughable.

“She said: ‘Look at the mountain over there [while pointing with her finger]’ She stopped describing the VE suddenly once she realised she couldn’t see her finger, she moved around her finger whilst still pointing, in an attempt to ‘find’ it, then said: ‘where is my finger!’[...] She took off the HMD and burst into laughter.”[PWD8, Observations, 2]

Some studies explored the use of embodied interactions by providing individuals with mild dementia with interactive virtual avatars that responds to PWD’s bodily movements [43, 64] within 3D-VEs, and expressed the gained benefits of enhancing interaction by empowering PWD to achieve a greater sense of engagement in a natural manner. Such interaction modality could be further explored in the future within 360-VE context to examine whether we could replicate these benefits.

In addition to considering the content design and interaction modality, we also found the need for considerations to be made in the physical world environment to support PWD’s virtual experience. These aspects include having a physical “interaction space” around the participant to allow them to lean forward, rotate around, etc., as well as choosing the suitable seating arrangement to support the VR experience whilst considering the physical abilities of PWD.

“He tried to push the chair back in attempts to look further to the far right side, CG asked him to try to stay where he is for safety [...] The chair didn’t seem suitable especially for this PWD who was interested in the full 360 view and didn’t have the physical capability to fully turn around easily. A swivel chair could’ve been much helpful.”[PWD3, Observations, 1]

3.3.2 Tailoring the VR Technology . Unlike many digital technologies, HMDs needs to be worn on the head/face of the users. Having little literature examining the feasibility of using VR with individuals within the later stages of dementia, the first question comes to mind is whether or not this user group will tolerate wearing a HMD in the first place. Of the sixteen sessions, one instance was observed where PWD did not wish to keep the HMD. PWD elaborated that it felt unnatural to breathe whilst using VR, although her reaction changed positively in the second week.

“PWD explained that she didn’t like the HMD because she couldn’t breathe, CG asked if she felt claustrophobic, she answered yes.”[PWD8, Observations, 1]

One aspect future design could consider is the physical health of PWD. For example, with an individual who wears medical glasses, it would have been impossible to use a rigid HMD that cannot contain the medical glasses’ frames. Another example is in regards to PWD with involuntary movement disorders and the choice of handheld versus 3-strap harnessed HMDs.

“The session with this PWD who have a type of an involuntary movement disorder, could have resulted in failure if the headset we used was handheld. The 3-strap harness has to be solid onto PWD’s head to ensure her safety.”[PWD6, Observations, 1]

Research has concluded that handheld headsets were more acceptable to individuals with mild dementia in comparison to harnessed HMD [42]. However, in our study, only one PWD preferred to hold the headset using their hands, which resulted in her experiencing temporary feeling of dizziness as she was struggling with coordinating her head-hands movements. This was the only PWD who also reported feeling dizzy.

“PWD didn’t rotate her head, instead she shook it. The pads of the HMD were not rested on the PWD’s forehead and cheeks. The HMD was following through the head position rather than being in sync with head movement.”[PWD8, Observations, 2]

3.3.3 The Role of the Caregiver . In line with the important notion of a person-centred care in the therapeutic milieu [65], we found that the open-ended VE allowed caregivers to adjust the interaction dynamically to best suit PWD. The role of the caregiver and the amount of “assisted interaction” from the caregiver differed from one PWD to another. It is highly depended on the PWD’s mood, how they wished to explore the VE, coupled with the individual’s skills and abilities. Assisted interaction is a well-known notion in HCI and has been briefly discussed in the context of dementia [66, 67]. One interesting angle which could be considered further based on the observations in this study is how we could develop assistive interactions within the VE to enhance the interaction from the “inside” world, to complement the caregivers’ support from the “outside” world. For instance, from our observations, it is crucial that the caregiver is aware and able to interpret PWD verbal and non-verbal reactions, especially to those who are unable to verbalise their thoughts.

“PWD didn’t verbalise a word however he immediately started to look visibly distressed. It

appeared that he did not know how to take the HMD off even though he was physically able to. CG immediately responded by removing the HMD, and assured him verbally that it's okay and patted his shoulder to comfort him."[PWD2, Observations, 1]

Hence, we believe that to support future deployment of VR especially in large scale, we can draw from the wealth of knowledge generated in the affective computing community, a field that aims to enable intelligent systems to recognise, infer and interpret human reactions. Such research examined the recognition of emotional elicitation using different modalities such as gestures, eye gaze, and biofeedback (see a summary in [68]). We suggest examining the potential in aiding caregivers by providing them with additional insights to prompt changes and modify the interaction accordingly. This is especially crucial as PWD's face was covered by the HMD hence preventing the caregivers to effectively interpret their emotional responses.

We also observed the important role of the caregiver in helping "transition" PWD from the physical world to the virtual world and back. One individual was tearing up, and feeling emotional saying "*it's all gone now*". The caregiver provided PWD with support then expanded on how they felt and what this experience meant to them. The PWD reported feeling happy about the experience.

"CG: so these, this is a happy emotion? PWD: Yes. CG: Or was it a sad emotion? CG: No, happy... I feel happy [...] it was very good feeling [...] I felt quite emotional."[PWD4, Interview, 1]

Many examples were given throughout the findings that demonstrates the importance of being aware of the patient's abilities and how to best interact with them. Furthermore, the role of the caregiver varied from one patient to another, driven by the support that PWD need, and dependant on their mood and presentation at that time.

4 IMPLICATIONS AND RECOMMENDATIONS

This study examined the use of VR in a relatively unexplored design space i.e. locked psychiatric hospitals. Considering the sensitive nature of this domain, we layout some directions for future research and considerations for real world deployment. Throughout the study, we observed the importance of examining the hospital's physical structure as a vital factor that contributes to VR intervention design. We found that using a light, portable and easily administered HMD is crucial in the case where therapies are often carried out in wards where PWD resides. Secondly, for successful deployment, it is crucial for a VR therapeutic activity to be in line with individual patients' therapy regime which enables the use of VR to fit seamlessly within locked hospital practices. This could be

done either by incorporating methods of communication that best suits the patient, incorporating 'before' and 'after' procedures or rituals to best transition the patient in and out of the VR activity, or by adopting the hospital's protocols that are patient-specific, including conducting a session at a patient's personal space.

When considering the VR content design, the literature body mainly examined the use of 3D-VEs [42, 43] and cited the cost of deployment and time for development and personalisation as the main constraints to deployment within a large-scale setting. We concluded that 360-VEs hold a strong potential for large-scale deployment. A wide variety of 360-VEs are now available on online platforms, which enables ease of personalisation at low cost. Unlike 3D-VEs, filming 360-VEs do not require extensive technical background, therefore, relevant staff at the hospital could easily generate relevant virtual experiences to each patient. When choosing suitable VEs for PWD, we suggest considering the exclusion criteria we have used and factoring in individual preferences and the symptoms of dementia such as behavior that challenges, aggression, or apathy, as well as levels of cognitive decline and other medical issues that could interfere with PWD's interaction with VR.

It is crucial for the interaction design to deliver meaningful experiences. We found that the open-ended approach that we adopted combined with a set of different VEs enabled PWD to gain a sense of autonomy that may not be available in real life circumstances (i.e. freely explore the beach) living in a locked hospital. Such autonomy is exhibited by the ability to choose and expand freely within the experience they wish to explore and construct their own narrative, all whilst being in a safe environment supported by caregivers. We encourage researchers and clinicians to capitalise on the sense of presence within the VE by "transferring" PWD to various locations as an alternative when restrictions or external factors become a barrier for PWD from experiencing the physical world environments.

5 CONCLUSION

This paper describes a study that examines the deployment of VR for individuals with moderate to severe dementia residing in a locked psychiatric hospital. The study was limited due to the relatively small sample, which was in part due to the barriers faced when recruiting participants as a result of lengthy process of assessing capacity to consent and exploring consent through appropriate consultees. Only once a short-term adverse effect of VR was observed in this study, however, a large-scale, longitudinal study is needed to systematically identify whether there are potential long term adverse effects of VR and how they can be minimised. Another limitation is that our study was restricted to a single hospital setting which limits the

generalisability of findings. Nonetheless, the study presents the different aspects of experience design, interaction design, hardware design, and deployment considerations for potential future research. The study contributes to the emerging body of research in the use of digital technology in dementia by presenting the opportunities VR offered to this patient-group and the challenges we faced in the deployment of VR within such context. Specifically, we introduce the idea of using VR as a “personal space” especially for individuals in long-term care. We also highlight the need to further examine the feasibility of using VR for when PWD present with behaviour that challenges. Furthermore, we could explore how to capitalise on the use of VR as a cognitive stimulation tool in a non-task-oriented manner especially for PWD who may find task-oriented assessments difficult. We believe this paper lays the foundations for the deployment of VR at a large scale in locked psychiatric hospitals.

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REFERENCES

- [1] R. A. Kane, "Long-Term Care and a Good Quality of Life," *The Gerontologist*, vol. 41, pp. 293-304, 2001.
- [2] C. Nieuwenhuizen and H. Nijman, "Quality of Life of Forensic Psychiatric Inpatients," *International Journal of Forensic Mental Health*, vol. 8, pp. 9-15, 2009.
- [3] L. Chenoweth, M. T. King, Y.-H. Jeon, H. Brodaty, J. Stein-Parbury, R. Norman, M. Haas and G. Luscombe, "Caring for Aged Dementia Care Resident Study (CADRES) of person-centred care, dementia-care mapping, and usual care in dementia: a cluster-randomised trial," *The Lancet Neurology*, vol. 8, pp. 317-325, 2009.
- [4] J. A. Anguera, J. Boccanfuso, J. L. Rintoul, O. Al-Hashimi, F. Faraji, J. Janowich, E. Kong, Y. Larraburo, C. Rolle and E. e. a. Johnston, "Video game training enhances cognitive control in older adults," *Nature*, vol. 501, pp. 97-101, 2013.
- [5] V. Manera, P.-D. Petit, A. Derreumaux, I. Orvieto, M. Romagnoli, G. Lyttle, R. David and P. H. Robert, "Kitchen and cooking, a serious game for mild cognitive impairment and Alzheimer’s disease: a pilot study," *Frontiers in Aging Neuroscience*, vol. 7, 2015.
- [6] A. J. Bharucha, V. Anand, J. Forlizzi, M. A. Dew, C. F. Reynolds, S. Stevens and H. Wactlar, "Intelligent Assistive Technology Applications to Dementia Care: Current Capabilities, Limitations, and Future Challenges," *The American Journal of Geriatric Psychiatry*, vol. 17, pp. 88-104, 2009.
- [7] A. Bankole, M. Anderson, T. Smith-Jackson, A. Knight, K. Oh, J. Brantley, A. Barth and J. Lach, "Validation of Noninvasive Body Sensor Network Technology in the Detection of Agitation in Dementia," *American Journal of Alzheimer’s Disease & Other Dementias*, vol. 27, pp. 346-354, 2012.
- [8] H. Jimison, M. Pavel, J. McKanna and J. Pavel, "Unobtrusive Monitoring of Computer Interactions to Detect Cognitive Status in Elders," *IEEE Transactions on Information Technology in Biomedicine*, vol. 8, pp. 248-252, 2004.
- [9] N. Kuwahara, S. Abe, K. Yasuda and K. Kuwabara, "Networked Reminiscence Therapy for Individuals with Dementia by using Photo and Video Sharing," *Proceedings of the 8th international ACM SIGACCESS conference on Computers and accessibility*, pp. 125-132, 2006.
- [10] G. Gowans, J. Campbell, N. Alm, R. Dye, A. Astell and M. Ellis, "Designing a Multimedia Conversation Aid for Reminiscence Therapy in Dementia Care Environments," *Designing a multimedia conversation aid for reminiscence therapy in dementia care environments*, vol. CHI '04 Extended Abstracts on Human Factors in Computing Systems, pp. 825-836, 2004.
- [11] B. Kikhia, J. Hallberg, J. E. Bengtsson, S. Savenstedt and K. Synnes, "Building digital life stories for memory support," *International Journal of Computers in Healthcare*, vol. 1, p. 161, 2010.
- [12] K. K. Zakzanis, G. Quintin, S. J. Graham and R. Mraz, "Age and dementia related differences in spatial navigation within an immersive virtual environment," *Medical Science Monitor*, vol. 15, pp. 140-150, 2009.
- [13] T. Yamaguchi, D. A. Follope, P. Richard, E. Richard and P. Allain, "A Dual-Modal Virtual Reality Kitchen for (Re)Learning of Everyday Cooking Activities in Alzheimer’s Disease," *Presence: Teleoperators and Virtual Environments*, vol. 21, pp. 43-57, 2012.
- [14] D. Sonntag, "Kognit: Intelligent Cognitive Enhancement Technology by Cognitive Models and Mixed Reality for Dementia Patients," *Cognitive Assistance in Government Papers from the AAAI 2015 Fall Symposium*, 2015.
- [15] L. A. Cushman, K. Stein and C. J. Duffy, "Detecting navigational deficits in cognitive aging and Alzheimer disease using virtual reality," *Neurology*, vol. 71, pp. 888-895, 2008.
- [16] M. Prince, M. Knapp, M. Guerchet, P. McCrone, M. Prina, A. Comas-Herrera, R. Wittenberg, B. Adelaja, B. Hu and D. e. a. King, "Dementia UK: update," *Alzheimer’s Society*, 2014.
- [17] M. Prince, A. Wimo, M. Guerchet, . G.-C. Ali, Y.-T. Wu and M. Prina, "World Alzheimer Report 2015: The Global Impact of Dementia, An analysis of prevalence, incidence, cost and trends," Alzheimer’s Disease International (ADI), London, 2015.
- [18] L. Garcia, A. Kartolo and E. Methot-Curtis, A Discussion of the Use of Virtual Reality in Dementia, INTECH Open Access Publisher, 2012.
- [19] C. Beck, L. Frank, N. R. Chumbler, P. O’Sullivan, T. S. Vogelpohl, J. Rasin, R. Walls and B. Baldwin, "Correlates of Disruptive Behavior in Severely Cognitively Impaired Nursing Home Residents," *The Gerontologist*, vol. 38, pp. 189-198, 1998.
- [20] J. Cohen-Mansfield, "Nonpharmacologic Interventions for Inappropriate Behaviors in Dementia: A Review, Summary, and Critique," *American Journal of Geriatric Psychiatry*, vol. 9, pp. 361-381, 2001.
- [21] H. Verbeek, S. M. G. Zwakhalen, E. Rossum, T. Ambergen, G. I. J. M. Kempen and J. P. H. Hamers, "Dementia Care Redesigned: Effects of Small-Scale Living Facilities on Residents, Their Family Caregivers, and Staff," *Journal of the American Medical Directors Association*, vol. 11, pp. 662-670, 2010.
- [22] A. Girardi, P. Snyman, M. Natarajan and C. Griffiths, "Older adults in secure mental health care: health, social wellbeing and security needs measured with HoNOS-secure across different age groups," *The Journal of Forensic Psychiatry & Psychology*, pp. 1-20, 2018.
- [23] M. H. Act, 2007. [Online]. Available: http://www.opsi.gov.uk/acts/acts2007/ukpga_20070012_en_1.
- [24] A. S. Schreiner, E. Yamamoto and H. Shiotani, "Positive affect among nursing home residents with Alzheimer’s dementia: The effect of recreational activity," *Aging & Mental Health*, vol. 9, pp. 129-134, 2005.
- [25] D. Kitching, "Depression in dementia," *Australian Prescriber*, vol. 38, pp. 209-211, 2015.
- [26] C. Long, A. McLean, A. Boothby and C. Hollin, "Factors associated with quality of life in a cohort of forensic psychiatric in-patients," *The British Journal of Forensic Practice*, vol. 10, pp. 4-11, 2008.
- [27] J. G. Beck, S. A. Palyo, E. H. Winer, B. E. Schwagler and E. J. Ang, "Virtual Reality Exposure Therapy for PTSD Symptoms After a Road

- Accident: An Uncontrolled Case Series," *Behavior Therapy*, vol. 38, pp. 39-48, 2007.
- [28] B. O. Rothbaum, L. F. Hodges, D. Ready, K. Graap and R. D. Alarcon, "Virtual Reality Exposure Therapy for Vietnam Veterans With Posttraumatic Stress Disorder," *The Journal of Clinical Psychiatry*, vol. 62, pp. 617-622, 2001.
- [29] J. Difede, H. Hoffman and N. Jaysinghe, "Multimedia Reviews: Innovative Use of Virtual Reality Technology in the Treatment of PTSD in the Aftermath of September 11," *Psychiatric Services*, vol. 53, pp. 1083-1085, 2002.
- [30] G. Riva, M. Bacchetta, M. Baruffi and E. Molinari, "Virtual-reality-based multidimensional therapy for the treatment of body image disturbances in binge eating disorders: a preliminary controlled study," *IEEE Transactions on Information Technology in Biomedicine*, vol. 6, pp. 224-234, 2002.
- [31] G. Riva, M. Bacchetta, M. Baruffi, S. Rinaldi and E. Molinari, "Virtual reality based experiential cognitive treatment of anorexia nervosa," *Journal of Behavior Therapy and Experimental Psychiatry*, vol. 30, pp. 221-230, 1999.
- [32] B. O. Rothbaum, L. Hodges, S. Smith, J. H. Lee and L. Price, "A controlled study of virtual reality exposure therapy for the fear of flying," *Journal of Consulting and Clinical Psychology*, vol. 68, pp. 1020-1026, 2000.
- [33] A. Garcia-Palacios, H. Hoffman, A. Carlin, T. A. Furness and C. Botella, "Virtual reality in the treatment of spider phobia: a controlled study," *Behaviour Research and Therapy*, vol. 40, pp. 983-993, 2002.
- [34] M. R. Kandalaft, N. Didehban, D. C. Krawczyk, T. T. Allen and S. B. Chapman, "Virtual Reality Social Cognition Training for Young Adults with High-Functioning Autism," *Journal of Autism and Developmental Disorders*, vol. 43, pp. 34-44, 2012.
- [35] L. E. Boyd, S. Gupta, S. B. Vikmani, C. M. Gutierrez, J. Yang, E. Linstead and G. R. Hayes, "vrSocial: Toward Immersive Therapeutic VR Systems for Children with Autism," in *CHI*, 2018.
- [36] D. Freeman, "Studying and Treating Schizophrenia Using Virtual Reality: A New Paradigm," *Schizophrenia Bulletin*, vol. 34, pp. 605-610, 2007.
- [37] P. L. Weiss, R. Kizony, U. Feintuch and N. Katz, "Virtual reality in neurorehabilitation," *Textbook of neural repair and rehabilitation*, vol. 51, pp. 182-97, 2006.
- [38] G. M. Doniger, M. S. Beeri, A. Bahar-Fuchs, A. Gottlieb, A. Tkachov, H. Kenan, A. Livny, Y. Bahat, H. Sharon and O. e. a. Ben-Gal, "Virtual reality-based cognitive-motor training for middle-aged adults at high Alzheimer's disease risk: A randomized controlled trial," *Alzheimer's & Dementia: Translational Research & Clinical Interventions*, vol. 4, pp. 118-129, 2018.
- [39] V. Manera, E. Chapoulie, J. Bourgeois, R. Guerchouche, R. David, J. Ondrej, G. Drettakis and P. Robert, "A Feasibility Study with Image-Based Rendered Virtual Reality in Patients with Mild Cognitive Impairment and Dementia," *PLOS ONE*, vol. 11, p. e0151487, 2016.
- [40] G. Optale, C. Urgesi, V. Busato, S. Marin, L. Piron, K. Priftis, L. Gamberini, S. Capodici and A. Bordin, "Controlling Memory Impairment in Elderly Adults Using Virtual Reality Memory Training: A Randomized Controlled Pilot Study," *Neurorehabilitation and Neural Repair*, vol. 24, pp. 348-357, 2009.
- [41] D. A. Foloppe, P. Richard, T. Yamaguchi, F. Etcharry-Bouyx and P. Allain, "The potential of virtual reality-based training to enhance the functional autonomy of Alzheimer's disease patients in cooking activities: A single case study," *Neuropsychological Rehabilitation*, vol. 28, pp. 709-733, 2015.
- [42] J. Hodge, M. Balaam, S. Hastings and K. Morrissey, "Exploring the Design of Tailored Virtual Reality Experiences for People with Dementia," *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems - CHI '18*, 2018.
- [43] P. Siriaraya and C. S. Ang, "Recreating living experiences from past memories through virtual worlds for people with dementia, 2014.
- [44] M. C. Act, "Mental Capacity Act," 2005. [Online]. Available: http://www.legislation.gov.uk/ukpga/2005/9/part/1/crossheading/res_earch..
- [45] V. Rose, I. Stewart, K. Jenkins, C. Ang and M. Matsangidou, "A Systematic Literature Review Exploring the Feasibility of Virtual Reality Interventions with Individuals Living with Dementia," *ICAT-EGVE*, 2018.
- [46] B. Reisberg, S. H. Ferris, M. J. Leon and T. Crook, "The Global Deterioration Scale for assessment of primary degenerative dementia," *American Journal of Psychiatry*, vol. 139, pp. 1136-1139, 1982.
- [47] N. Alderman, C. Knight and C. Morgan, "Use of a modified version of the Overt Aggression Scale in the measurement and assessment of aggressive behaviours following brain injury," *Brain Injury*, vol. 11, pp. 503-523, 1997.
- [48] M. P. Lawton, K. Van Haitsma and J. Klapper, "Observed Emotion Rating Scale," *Journal of Mental Health and Aging*, vol. 5, pp. 69-82, 1999.
- [49] J. Brooke, "SUS: a _quick and dirty_ usability scale. In P.W.Jordan, B. Thomas, B.A. Weerdmeester, & LL. McClelland (Eds.), Usability Evaluation in Industry (pp. 189 194). London: Taylor and Francis,," 2018.
- [50] S. Nichols, C. Haldane & J.R Wilson, "Measurement of presence and its consequences in virtual environments," *International Journal of Human-Computer Studies*, vol. 52, pp. 471-491, 2000.
- [51] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative Research in Psychology*, vol. 3, pp. 77-101, 2006.
- [52] M. E. Johnson and P. M. Hauser, "The Practices of Expert Psychiatric Nurses: Accompanying The Patient to a Calmer Personal Space," *Issues in Mental Health Nursing*, vol. 22, pp. 651-668, 2001.
- [53] B. N. Gaynes, C. L. Brown, L. J. Lux, K. A. Brownley, R. A. Van Dorn, M. J. Edlund, E. Coker-Schwimmer, R. Palmieri Weber, B. Sheitman, T. Zarzar, M. Viswanathan and K. N. Lohr, "Preventing and De-escalating Aggressive Behavior Among Adult Psychiatric Patients: A Systematic Review of the Evidence," vol. 8, no. 68, pp. 819-831, 2017.
- [54] K.R. Chou, R.B. Lu and W.C. Mao, "Factors relevant to patient assaultive behavior and assault in acute inpatient psychiatric units in Taiwan," *Archives of Psychiatric Nursing*, vol. 16, pp. 187-195, 2002.
- [55] K. Canatsey and J. M. Roper, "Removal from Stimuli for Crisis Intervention: Using Least Restrictive Methods to Improve the Quality of Patient Care," *Issues in Mental Health Nursing*, vol. 18, pp. 35-44, 1997.
- [56] M. Matsangidou, C. S. Ang and M. Sakel, "Clinical utility of virtual reality in pain management: a comprehensive research review," *British Journal of Neuroscience Nursing*, vol. 13, no. 3, pp. 133-143, 2017.
- [57] H. G. Hoffman, D. R. Patterson, G. J. Carrougner and S. R. Sharar, "Effectiveness of Virtual Reality_Based Pain Control With Multiple Treatments," *The Clinical Journal of Pain*, vol. 17, pp. 229-235, 2001.
- [58] K. Wolitzky, R. Fivush, E. Zimand, L. Hodges and B. O. Rothbaum, "Effectiveness of virtual reality distraction during a painful medical procedure in pediatric oncology patients," *Psychology & Health*, vol. 20, pp. 817-824, 2005.
- [59] M. Matsangidou, C. S. Ang, A. R. Mauger, B. Otkhmezuri and L. Tabbaa, "How Real Is Unreal?," *Human-Computer Interaction - INTERACT 2017*, pp. 273-288, 2017.
- [60] M. Matsangidou, C. Ang, A. R. Mauger, J. Intarasirisawat, B. Otkhmezuri and M. N. Avraamides, "Is your virtual self as sensational as your real? Virtual Reality: The effect of body consciousness on the experience of exercise sensations," *Psychology of Sport and Exercise*, 2018.
- [61] D. McEwen, A. Taillon-Hobson, M. Bilodeau, H. Sveistrup and H. Finestone, "Two-week virtual reality training for dementia: Single case feasibility study," *Journal of Rehabilitation Research and Development*, vol. 51, pp. 1069-1076, 2014.
- [62] M. Mendez, A. Joshi and E. Jimenez, "Virtual reality for the assessment of frontotemporal dementia, a feasibility study", *Disability and Rehabilitation: Assistive Technology*, vol. 10, no. 2, pp. 160-164, 2014.
- [63] L. Nolan, M. McCarron, P. McCallion and J. Murphy-Lawless, "Perceptions of stigma in dementia: An exploratory study, 2018.

- [64] K. Morrissey, J. McCarthy and N. Pantidi, *The Value of Experience-Centred Design Approaches in Dementia Research Contexts*, 2018.
- [65] D. Brechin, G. Murphy, I. James and J. Codner, "Briefing paper: Alternatives to antipsychotic medication: Psychological approaches in managing psychological and," *Leicester: British Psychological Society*, 2013.
- [66] J. Hoey, C. Boutilier, P. Poupart, P. Olivier, A. Monk and A. Mihailidis, "People, sensors, decisions: Customizable and adaptive technologies for assistance in healthcare," *ACM Transactions on Interactive Intelligent Systems (TiiS)*, vol. 2, no. 4, 2012.
- [67] S. Czarnuch and A. Mihailidis, "Home Assistive System for Dementia," *Gerontechnology*, vol. 10, no. 3, pp. 169-182, 2011.
- [68] S. Poria, E. Cambria, R. Bajpai and A. Hussain, "A review of affective computing: From unimodal analysis to multimodal fusion," *Information Fusion*, vol. 37, pp. 98-125, 2017.