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The use of virtual reality to support participatory design processes in environmental design for cognitive change

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Introduction

Perceptions of ageing and how these are represented in public discourse can subject older people to prejudice and stereotype, framing them as frail and vulnerable, as well as being opposed to or unable to engage with new technologies. Yet, old age does not prevent the use of technology (Tacken et al., 2005) and older people, including people living with cognitive change, can offer helpful insights and provide valuable expertise by experience when included in designing the places and spaces they occupy.

Existing literature on the use of virtual reality (VR) for people with cognitive change such as mild cognitive impairment (MCI) or dementia has focussed on VR for assessment, therapeutic treatment and/or stimulation (Appel et al., 2021). While the potential for VR for other applications involving people living with dementia is recognised in the literature, this research remains in its infancy (Kim et al., 2019).

The two studies we shall discuss challenge age-based assumptions of older peoples interest in, and ability to engage with, modern digital technology, specifically VR. The aim of both studies was to explore the usability of fully immersive virtual reality (VR) systems as tools to support participatory design processes in the design of supportive housing models for people over 55 years old, including those with cognitive change. The connected projects occurred between 2020 and 2023 and were undertaken by a team of architects and social scientists at the University of Stirling. The first study, *Demonstrating Impact in Housing, Health and Social Care* (DIHHSC) was conducted remotely (during COVID-19 pandemic restrictions) whilst in the second project, Designing Homes for Health Cognitive Ageing (DesHCA), VR-based research was conducted primarily in-person.

This chapter has three objectives: (1) To summarise the two studies into the use of VR to support participatory design processes in environmental design for cognitive decline. (2) To discuss the opportunities of VR as a co-design tool amongst underrepresented groups and enable a full-scale immersive experience of architectural design projects that improve end-user contribution

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to the design process. (3) To propose that immersive VR-supported co-design methodologies may help to advance research on environmental design for dementia in a global context.

We suggest there exists an opportunity to deploy VR in the design of the built environment to enhance the design process by engaging the views of underrepresented groups such as older people and people living with cognitive change through their expertise by experience. VR enables the participant to immerse themselves in the environment and experience deeper 'presence' (Kim et al., 2019) as opposed to observing in 2D either on a flat-screen or paper print-out. With the full scale, and hyper-realistic nature of VR offering improved kinaesthetic sensation, both studies examined the extent to which VR-supported experiences of design proposals provided 'enhanced ecological validity', compared with traditional paper-based approaches to design review (Manera et al., 2016). VR-supported experience and review of design provide a powerful means overcoming the barriers of reading or interpreting architectural drawings, and positively influence participants' abilities to provide a deeper, more informed critique of design. We suggest that design critique improves with greater immersion and environmental role-play.

Finally, we hypothesise that the use of VR remotely in a global context can assess the efficacy of dementia design principles by engaging international users remotely in future environmental design research projects, thus gauging suitability of design features in regional contexts.

Background

Environmental design for dementia

The research team has expertise in environmental design for people living with dementia; a recognised non-pharmacological intervention to ameliorate psychological behavioural symptoms of dementia (PBSD),[1] and are experienced in its application on capital development projects globally (Kiuchi et al., 2020; Palmer et al., 2021).[2] Environmental design for dementia or 'dementia-friendly' design principles have been in existence since the 1980s (Fleming & Bowles, 1987). Evolving from these design principles and the research evidence that support them (Bowes & Dawson, 2019; Fleming & Purandare, 2010) are several environmental assessment tools which provide design guidelines prescribing design features which when implemented contribute to a dementia-friendly environment. Examples include the Dementia Design Assessment Tool (Cunningham et al., 2008), Enhancing the Healing Environment (The King's Fund, 2014), the Environmental Audit Tool (Bennett & Fleming, 2013) and the Therapeutic Environmental Screening Survey (Sloane et al., 2002). There was, however, a dominant environment in early tools (the care environment) and this reflected the prevailing wider societal understanding of the environment in which people with dementia inhabited, i.e., long-term care and not within the community. Recognising that people with dementia live within community settings, more recent design tools seek to provide guidance on designing community spaces (Fleming et al., 2017; Henry et al., 2021).

More recently, research concerned with the generalisability of dementia design calls for critical discussion and new research to reflect global diversity, acknowledging that past research evidence has tended to reflect and reproduce the context of its production (Dawson & Palmer, 2020). The challenge to the delivery of dementia design in other cultures, countries and environment types is the need for those who are commissioning and designing environments to be familiar with overarching dementia-design principles. And further, to be sufficiently adept in their knowledge to be capable of suitably sensitive application of the principles to design and deploy environment features which are familiar to users whilst complementing the context of their application. Without this, the application of culturally imbued design features in another culture risks undermining the efficacy of the intervention.

It is important to note that a distinction is made by the authors between dementia-design principles and the features described in assessment tools and design guides. We favour the definition of 'design principle' as the overarching theme, and 'design feature' being the attribute which contributes to achieving the principle; most commonly the architectonic elements such as a door, chair or handle, and wall or floor finishes. This distinction is made in recognition that design principles, when considered in a global context, enable a more nuanced, culturally relevant approach to environmental design. Design features by contrast are specific; culturally imbued, influenced by the local vernacular, building codes and assume user familiarity.

Architectural design process and barriers

Conventional architectural design process is intricate and multifaceted, involving a series of activities that range from initial conceptualisation to project realisation. There are numerous barriers that can affect this process, including technical challenges, knowledge gaps and constraints imposed by the available communication tools (Kvan, 2000). Conventional design communication tools and methods such as sketches, 2D drawings, 3D models, blueprints, written reports and presentations, often fall short in conveying the full essence of the design, leading to misunderstandings and misinterpretations. Furthermore, these conventional methods can create an exclusionary process, whereby certain stakeholders, particularly those without specialised architectural knowledge, are inadvertently left out of the conversation.

Default othering

'Othering', as an effective conceptualised approach to learn emotional responses in medicine education (Shapiro, 2008) is also observed in the architectural profession (Buse et al., 2017). This concept refers to the tendency of architects to design based on their own perspective and anticipation of the end users. Such anticipation is built on 'imagined bodies' (Kerr, 2013) of the end users and knowledge gained from ideologies of care which reproduce prevailing ideals of care model and environment (Buse et al., 2017). It can be useful to reach an inclusive design result, but this can also result in environments that do not adequately consider the needs of diverse users. Such a 'default othering' approach often dominates the design process by its self-referential nature, leaving user experience and inclusion on the side lines. Lack of engagement with the actual end user has been one of the biggest challenges in architectural practice and becomes more problematic in designing for people living with dementia.

Conventional communication tools and methods in architectural design

Since the last decades of the 20th century, computer aided design (CAD) and building information modelling (BIM) emerged as a revolutionary tool in design, aiming to address some of these concerns. The CAD- and BIM-driven design approach allows for rapid prototyping and scenario testing, which can enhance the efficiency, productivity, quality and collaboration in construction workforce; an ethos advocated by Egan (1998) and Latham (1994). It centralises information, improving communication and understanding among project participants. However, CAD and BIM have their limitations. The primary concern is its accessibility, as the high cost of CAD and BIM software and necessary training often poses a barrier for non-professional end users, as well as smaller firms and individual architects (Succar, 2009). Moreover, the CAD and BIM process tends to focus heavily on technical and functional aspects of a building, sometimes overlooking the emotional, cognitive and sensory experiences of the end users. These concerns bring the question, where are the end users of design in these new tools? CAD, BIM and other similar technologies need to extend beyond the tangible and functional attributes of design and consider the experiential and human-centric aspects of architecture.

Recent advances in VR and related digital technology offer promising opportunities in this regard. VR allows designers to immerse themselves and their clients in the virtual representation of their designs, facilitating a better understanding of space, scale and user experience (Cousins, 2017; Portman et al., 2015). Moreover, VR has been used to simulate the experience of various user groups, such as individuals with disabilities, memory loss and dementia (Christie, 2017; Shen, 2021; Shen et al., 2021), thereby fostering empathetic and inclusive designs (Riva et al., 2021). These new technologies open another gate to designers and architects for user participation in inclusive design by experiencing and testing their ideas in VR. User participation could reduce the impact of gaps in designer knowledge, or flaws in their societal ideologies, helping to minimise othering during the design process.

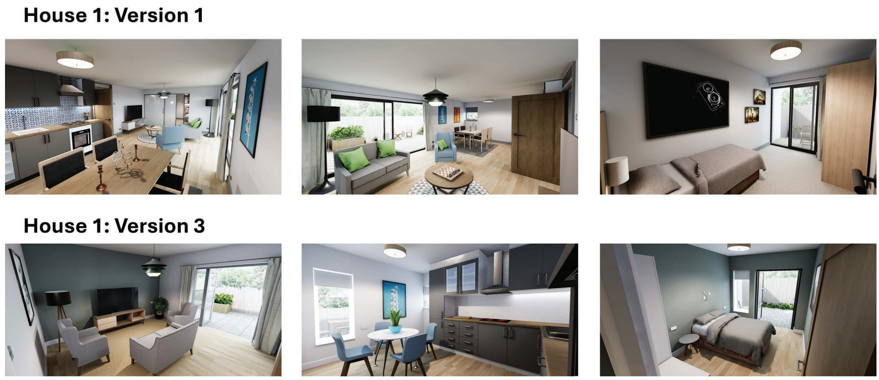

Figure 5.1 Virtual homes development in the case study projects.

VR and digital technology opportunities

VR is widely associated with recreational activities including gaming and has had success as a therapeutic tool to ease symptoms associated with conditions such as autism (Maskey et al., 2019), dementia (Appel et al., 2021) and post-traumatic stress disorder (Kothgassner et al., 2019). It is increasingly used as means of gamifying training, being especially useful for situations that are difficult to replicate in real life, due to cost, safety or perceptual reasons (Grassini & Laumann, 2020). More recently, the capability of VR to emulate audio visual and spatial perception challenges associated with conditions such as sight loss, hearing loss and dementia has allowed VR to provide immersive experiences that can enhance empathy towards people living with these conditions (Zwoliński et al., 2020). This chapter discusses two research studies that evidence a further constructive use of VR to support the meaningful involvement of people living with cognitive change in the architectural design process.

Experimental approach

Both studies revolved around the use of VR to support co-design of age and cognitively supportive homes. Both used iterative design processes, where protype home designs were improved and refined in stages (see Figure 5.1), in response to multiple rounds of participant feedback.

The first, and smaller, of the two studies, DIHHSC, was undertaken during national lockdowns associated with the COVID-19 pandemic. This necessitated a series of technical and methodological changes that would allow the research to proceed with remotely located participants. VR headsets were sent by courier to the participants homes, who were all older people living in various locations across England and Scotland. Participation took place over recorded MS Teams calls, where the researchers remotely guided participants through the virtual homes, prompting them for feedback on the designs.

The second and larger follow-up study, DesHCA, reverted to a face-to-face VR workshop format. This typically involved participants being supported on a one-to-one basis, by a member of the research team, as they experienced and commented on the VR home designs. Participants then joined facilitated group discussions about their experience of the VR. In this study, participants were a mixture of older people experiencing cognitive change and housing-related professionals, such as architects, builders and council officers.

Amongst the two participant sub-groups, professionals and older people, few older people reported having any previous experience of direct involvement in the environment design process. By contrast, many of the housing-related professionals contributed to design processes on a regular basis. Whilst some older people had been exposed to domestic adaptation or renovation projects in the past, only those with previous training in built environment disciplines admitted they could confidently understand or interrogate conventional design communication methods such as architectural floorplan drawings.

Participants exposure to, and confidence in using technology varied widely; from those who did not own or use a computer or smartphone through to those who were competent and confident users of internet-connected technologies such as smart speakers and social media.

Most participants were aware of VR and its use for gaming, but they had never previously experienced VR for themselves. Some participating housing professionals had previous recreational experiences of using VR, while only a handful indicated using it as part of an environmental design project. Even though the professionals contributing to the research included architects from firms who are known for co-creative design practices, none indicated any previous use of VR for end-user consultation or co-design processes.

The immersive nature of VR raised various questions around maintaining comfort, safety, and inclusion for participants of different abilities. This included concerns about risk of injury should the participant trip, or physically crash into objects whilst inside the headset. Similarly, that individuals may be uncomfortable wearing the VR headset, or potentially feel unbalanced or dizzy from the novel sensory experience. These issues were carefully considered in the design of the methods used for the research, which were approved by the University research ethics panel.

The VR headset-based activities took place in defined obstacle free spaces, making use of a digital boundary function, which provided visual warning to the users when they got close to the edge of a defined 'play' zone. One-to-one support provided by researchers helped participants to stay safe and comfortable during in-person workshops. For the remote workshops, ensuring that the participant's web camera was set up to see the full extent of their 'play' zone, allowed researchers to provide verbal safety cues where needed. Where participants were uncomfortable or unable to wear a VR headset, researchers could act as a proxy by casting a live video feed from the VR headset to a display screen and following the participant's instructions on where to go and what to look at in each VR model. In the DesHCA study, participants were provided with further alternative means of reviewing the designs, including print outs, pre-recorded video walkthroughs and an interactive web-based 3D viewer.[3]

Discussion

Co-production

Designing environments for people living with dementia and their care partners requires a deep understanding of their unique experiences and challenges. Conventional collaboration in architectural design involves stakeholders contributing their expertise and perspectives in a sequential manner. This allows architects to gain insights into the lived experiences of people with dementia, fostering the creation of supportive spaces tailored to their unique needs (Fleming et al., 2017). However, while effective, it may not capture the full spectrum of the end user needs or preferences, particularly for people with cognitive change who may find it difficult to understand the design drawings and express their experiences and preference verbally.

VR technology provides an effective platform to facilitate co-production and involve these individuals in the design process. In both the studies, regardless of whether joining remotely or in-person, participants immersed themselves in the virtual homes and actively left comments on the design features they felt were positive, or conversely uncomfortable or difficult to use. From these comments, the facilitators, as designers, were able to make sense of what the priorities are in the home environment that could better support healthy cognitive living. The virtual homes were then updated based on these priorities. During the walkthrough process, both the participants and the facilitator initiate a discussion or enquiry. The conversations between the facilitator and the participant in the virtual environment were interactive and engaged, as natural as the conversation in a physical building.

Removing the barriers to engagement within the design process

As most participants had not previously experienced VR, there was a sense of curious, yet nervous, excitement amongst them in advance of their VR experience. This feeling was more obvious amongst some participants who made statements like "I'm not much good with technology". However, in most cases, once participants put the VR headset on, they immediately began to enjoy the experience, typically becoming engrossed in the hyper-reality of what they were experiencing.

Within a few minutes of entering the VR, most participants had settled into the experience and were confidently navigating their way around the virtual environment, providing critique of the design. As the session progressed, and participants became more comfortable in their conversation with the researcher, they increasingly engaged in self-advocacy by providing rationale for observational feedback on the designs. This feedback linked to practical matters, personal taste, experience of caring for others or their personal experience of living with physical, sensory or cognitive impairments.

The alternative paper-print and screen-based methods for viewing the designs became valuable tools for supporting participant engagement in the research. In some cases, for more hesitant participants these mediums provided familiar initial ways of engaging with the designs, typically becoming steppingstones in building up confidence before later trying the full VR experience.

These mediums were also useful for the small number of participants who found the headsets uncomfortable for any reason. Reverting to the alternative viewing methods allowed these participants to maintain enjoyment of their participatory experience and contribution to the research. Notable differences for this group included that they made fewer observations overall, with their feedback containing reduced content or nuance around detailed design, especially spatial ergonomics, compared to participants who had reviewed the home designs in full VR.

Remote engagement & wider inclusion

The remote methodology of DIHHSC demonstrated the usability of VR for effective and efficient remote consultation with older people and people with cognitive decline. This has many potential future uses and we propose one wider application of this method could be use within resident/patient consultations in rural settings. For example, trialling a virtual home adaptation prior to construction whilst at the same time supporting the user to make informed decisions about their home and explore the appropriateness of the proposed adaptations. The remote methodology also presents wider implications for global research, which we discuss later.

DesHCA demonstrated the value that multi-disciplinary stakeholder consultation can bring. When stakeholders can engage on an equal standing in a fully immersive environment (i.e., without reliance on prior professional knowledge or experience to interpret paper-based architectural drawing) their confidence and ability to critique from their own experienced position improved.

Participant VR engagement in both studies enabled a form of 'process architecture' (Fröst & Warren, 2007), supporting collaborative engagement whereby ideas and expertise by experience were able to be tested, validated and incorporated as the design developed. This shifted the architectural process away from the linear approach of staged refinement (RIBA, 2020) to an iterative design-experience-design loop reconfiguring the design until a majority consensus was achieved, or no further changes proposed. This facilitated more detailed design critique and offered stakeholders greater exposure to and improved understanding of each other's needs.

The hyper-realism of the house designs and virtual environment in both studies, resulted in participants engaging in virtual 'house-play' (mimicking familiar activities – such as navigating a kitchen set-up within the virtual environment to assess the design suitability) whilst simultaneously providing design feedback/critique. This simultaneous experience-critique relationship demonstrated a high level of immersion and deep sense of presence within the virtual environment which researchers attributed to the quantity and depth of design comments received.

Wider implications on environmental design (principles) for dementia in other countries and cultures

The relationship between environments and culture is congruent; environments are cultured[4] (Rapoport, 1980). Environmental design is therefore variable, informed by the beliefs and behaviours of the culture in which it is located but conversely it also has a role in shaping and informing behaviours through its design. The central concern of environmental design for dementia in a global context is its suitability and applicability given the occidental cultural influence which informed the principal schema (Marshall, 2001). We suggest therefore that there is a conceptual approach made available through the development of our methodology. This methodology, especially with its geographically unrestricted remote participating functionality, can enable one to look globally at the dementia-environment interaction and role of 'culture' in the field of environmental design for dementia.

Conclusion

Two VR participatory co-design studies were undertaken between 2019 and 2023 with older adults with and without cognitive change. The studies demonstrated that older people can engage with VR for the first time, remotely, confidently and to such extent that their depth of presence within the virtual environment enables detailed, nuanced design critique. The hyper-realism and virtual-house play demonstrated that VR can equalise stakeholder engagement in the design process, providing a more balanced, equitable consultation and design process. Finally, the findings show that remote participatory co-design with VR can be successfully deployed over substantial geographic distance, enhancing the potential role for VR both within industry as a means of enhancing the process of environmental design for dementia, and as a means of supporting further advancement in participatory design research.

In-depth box

- Designing for dementia requires deep understanding unique experiences and challenges of the condition, but this is often absent from the design process.
- VR technology provides an effective platform for high quality co-production by supporting direct and meaningful end-user involvement in the design process.
- The hyper-realism of the immersive VR experience of design proposals, paired with verbalised experience-critique can significantly enhance the confidence, depth and nuance in stakeholder feedback on design proposals.
- Our VR supported participatory design methodology, including its remote participation functionality, is globally relevant, providing opportunities for improving environmental design for dementia across all cultures, locations and environment types.

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Notes

1. https://www.stir.ac.uk/about/faculties/social-sciences/our-research/research-groups/cedar-centre-for-environment-dementia-and-ageing-research/
2. https://www.dementia.stir.ac.uk/
3. The VR design viewer used during participant workshops which was laterly overlayed with researcher design tips available at: https://www.deshca.co.uk/explore-deshcas-designs
4. For our purposes culture is the embodiment of a belief structure and lifestyle typical to one group.

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