Using VR, eye tracking and EEG to transform the design of care homes for people with dementia.

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Abstract. As elderly people's needs are changing, there is an emergent demand for a "new generation of buildings" that helps them to live independently. Architects and designers need to embrace a human - centred design perspective in developing such care homes. Virtual reality is an ideal platform for human spatial navigation assessment since it allows participants with dementia to perceive as well as act upon an interactive environment that can be made very life-like [2]. Theta oscillations using EEG (electroencephalogram) during the spatial navigation in the virtual environment can investigate the sensorimotor integration [7] in addition to eye tracking technology providing more information about spatial cues and colour that direct indoor navigation. This paper presents the background and the methods that will be used to evaluate a novel portable VR application for navigation in care houses for people with dementia. This VR application aims to provide a rationale for therapeutic environmental design that meets the needs of elderly people based on navigation problems that will be identified by examining interviews from the staff of care homes and spatial analysis of the environment.

Keywords: VR, eye tracking, EEG, dementia, care homes

1 Introduction

Spatial cognition research has drawn significant attention over the last years due the increasing interest in designing user-friendly buildings which are more likely to attract the user to stay longer, visit a wider range of attractions and explore. There is an overwhelming amount of literature suggesting that people with dementia have difficulties recognizing places and finding their way in new locations. Those that are residents in care homes face a variety of difficulties that lower their living standards. According to a study, based on interviews with the carers, it has been observed that that 41% of Alzheimer's disease (AD) patients had difficulties in finding their way in their neighbourhoods, and 30% experienced problems even navigating inside their houses [1]. Pai and Jacobs (2004) found that 54% of AD patients at a dementia clinic had problems recognizing locations or finding their way and for 25% of them this confusion was one of the early symptoms of their neurodegeneration [12]. All the above are strongly related to the relationship between architectural design and human behaviour. Poor environmental design may cause confusion in people with dementia, leading to a loss of autonomy and consequently to a low quality of life. There is a growing need for evidence-based architecture for people with dementia. According to Marquardt (2011), not only wayfinding abilities are affected by architectural design

but many other symptoms of dementia such us agitation, aggression and temporal disorientation are targeted by environmental interventions that are implemented in nursing home design [9]. Gaining insight into the mechanisms underlying spatial disorientation, would allow us to develop general architectural design guidelines, which will facilitate effective wayfinding. In general, these design guidelines will ensure the promotion of the well - being for people with dementia through spatial organization and appointment of the physical environment. Environmental interventions that promote wayfinding can be implemented on two levels: the design of floor plan and environmental cues, which include furniture, colours etc. whereas many studies [5][13] so far have focused mainly on the architectural layout of care houses.

There are specific cognitive phenomenon that are related to spatial navigation and affect patients' daily life. A person has to be able to recognize landmarks but also orient oneself in respect to them. Even though there have been comprehensive developments to the concepts of landmarks and navigation, little has been found in regard to the different functions landmark play to efficient and successful navigation [10]. According to the Dementia Design Checklist [4], there should be landmarks such furniture, plants or artwork that are generally interesting and attract the attention, to help people in finding their way to their bedroom. Lewis et al. (2010) suggests that "there should be distinctive internal landmarks at less than 30m along the travel routes" [8]. Another study has suggested that pictures and colour can help people navigate. At each decision-making point such as junctions in hallways, there should be a distinctive landmark that can be memorable such as artwork or a recognizable object [3].

Even though there are a few studies on colour perception for people with dementia, more systematic research should be undertaken on the behavioural and emotional influence of colour application on the environment for people with dementia. Research has shown that even though basic visual functioning can be the same for people with dementia and without, sense of contrast sensitivity, visual attention and colour can be significantly different [14]. It has been found that regardless of the cognitive impairment, older people can distinguish easier colours in the yellow/red range compared to blue/green range [14]. Such links might help the creation of spaces which promote better orientation.

In this context, further systematic combination of appropriate colour application on landmarks will contribute significantly to better orientation in care homes. Therefore, a multi-session experimentation staged in a virtual environment would be required to test with dementia patients the hypothesis on the determinants of spatial navigation in relation to landmarks and colour. With the addition of using eye tracking and theta oscillations measurement with the incoming sensory information about spatial cues and landmarks, these studies can evaluate the significance of certain cues and colour differences for a successful navigation.

2 Method

Various research groups have utilized immersive virtual reality (VR) to study human spatial navigation [2]. Although virtual environments are an exciting new medium for investigating difficult-to-study problems under realistic and controlled conditions, the results of such experiments are of questionable value if virtual environments lack ecological validity. Several lines of evidence suggest that realistic virtual environments increase distance perception and improve the wayfinding strategies of the subjects [2][6]. Participants can be fully immersed in this artificial environment, something that is impossible to do with table top tests [6]. Studies have shown that it is feasible to immerse people with dementia into a virtual environment as they can feel a sense of control with no significant deterioration due to sickness and well-being [6].

Therefore, a series of studies will be undertaken which will provide information and systematic review of certain aspects regarding colour and specific landmarks that affect the successful orientation in care homes. Initially, qualitative interviews with both care takers and also residents would provide information about any orientation strategies and the distinctive cues which help patients' navigation. These data, in addition to spatial analysis of the specific care home, will be reflected on the development of a virtual environment that replicates realistically the care home based on the collected information. The next step involves a multi session experimentation where the participants, the patients with dementia, would become familiar with the environment. These experiments would employ EEG technology which shows the oscillatory partners of activity and eye tracking to identify the 'important' landmark cues and to test the hypothesis on determinants of successful spatial navigation. The theta oscillations in human brain have been associated with navigation, sensorimotor and memory function [7]. Hence, recorded theta episodes could indicate the positions in the VR environment where a theta episode occurred. A statistical analysis would determine whether the EEG results will be consistent with the behavioural results. The eye tracking will confirm which cues or features attracts the patients' attention and aid their navigation strategy.

3 Conclusion

The paper presents briefly the background and the methods employed which investigate how landmarks and colour schemes can aid in succesfull orientation in care homes. The results from this study, are likely to lead to a better understanding of the wayfinding strategies in urban environments and aid in developing and evaluating novel portable applications for navigation assistance. Virtual environments, which are currently in use in spatial cognition research, are fairly simple and they lack the details and the realism of the actual environment. This study aims to provide a realistic virtual environment based on information collected from care takers and residents. The general purpose of the project is to identify the landmarks/cues in combination with the appropriate colour scheme that simplify spatial orientation. After the identification of certain architectural features and patterns, we will be able to create design guides based on empirical evidence that demonstrated the effectiveness of them, to enhance the navigability inside the care homes. The

experiments are likely to establish the characteristics of built environments that hinder or facilitate orientation of people with dementia. Since, this project is at the early stages of interviews with care-takers, future work is in plan for the development and evaluation of the proposed experiments.

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