Chapter 11
Using Virtual Reality for Assessment and Rehabilitation of AD and MCI Patients: A Selective Overview

Giulia Binaghi
Catholic University of Sacred Heart, Milan, Italy

ABSTRACT

Alzheimer's disease (AD) is a primary cause of dementia in the ageing population affecting more than 35 million people around the globe. Acquisition of information in everyday life requires memorization in complex three-dimensional environments. Emerging ICT (information and computer technology) applications based on virtual reality (VR) environments can lead to a behavior modification as they provide a photorealistic virtual environment (VE). This chapter provides a selective overview of the empirical evidence available along last five years on the use of virtual reality (VR) to promote everyday life skills and cognitive impairment mitigation of AD patients. Virtual reality allows us to identify and treat deficits in memory that are relevant to everyday life yet not detectable with list learning. Articles related to virtual reality have been divided in two categories according to their use: whether for assessment and diagnostic or rehabilitative purposes. Clinical implications were critically discussed. Suggestions for future research and practice will also be provided.

1. INTRODUCTION

Alzheimer disease (AD) is the primary cause of dementia worldwide (Ritchie & Lovestone, 2002). AD is defined by the National Institute on Aging-Alzheimer's Association (NIAA; McKhann et al., 2011) as "evidence of progressive cognitive decline on subsequent evaluations based on information from informants and cognitive testing in the context of either formal neuropsychological evaluation or standardized mental status examinations."

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Currently, more than 35 million people are suffering from this disease around the globe (Brookmeyer, Johnson, Ziegler-Graham, & Arrighi, 2007). The basic pathological hallmarks of AD include widespread neuronal synaptic loss, excessive presence of astrocytes, aggregation of multiple proteinaceous deposits for instance β-amyloid plaques and neurofibrillary tangles (NFT) (Murph & LeVine, 2010).

People suffering from dementia are compromised in several cognitive domain (e.g., executive functions), to impede functioning in everyday life and social and occupational functioning. Impairment in the sense of orientation, and memory difficulties are related to the reduction of the temporal cortex volume, especially concerning the hippocampus, as well as the atrophy of the retro-splenial cortex. Serino and Riva (2013) claim that the translation between egocentric and allocentric frames, supported by the retro-splenial cortex, can be the basis of the spatial disorientation deficits. These deficits compromise the ability to link information between two landmarks (egocentric strategy) (Cushman, Stein, & Duffy, 2008). Patients with AD experience difficulties also when using an allocentric strategy (i.e., mental maps) or changing point of view between egocentric and allocentric views (Morganti, Stefanini, & Riva, 2015). These deficits are followed by a progressive decline in basic Activities of Daily Living (Millán-Calenti, Tubío,Pita-Fernández, Rochette, Lorenzo, & Maseda 2012).

Recently, several AD medical rehabilitation studies have shifted the focus to the field of virtual reality (VR) due to the rapid development of such technologies. To investigate everyday activities, virtual-reality offers the opportunity to bridge the gap between in situ approaches and laboratory settings. VR also demonstrates advantages in the treatment of dementia and reminiscence activities allowing experiences to be shared with family. These applications have an intuitive appeal but it remains unclear whether immersive virtual reality (IVR) can support the diagnosis or treatment of AD dementia (Johnson, 2018).

Until now, VR has been more employed in motor neurological disorders or in the treatment of mental health conditions, such as anxiety disorders or psychosis (Cogné et al., 2017). Researchers feared that patients would not tolerate the VR procedure (Flynn et al., 2003), but recently any danger was excluded (Laver et al., 2015). IVR has been utilized in public awareness campaigns allowing users to take reminiscence activities allowing experiences to be shared with family (Johnson, 2018). However, it remains unclear whether IVR can enhance the diagnosis or treatment of AD dementia. Moreover, VR applications are employed today as relevant experimental models of the real world to study how cognitive processes are embodied in complex and more natural behaviors (Rizzo, Schultheis, Kerns, & Mateer, 2004). Thus, immersive environment can easily stimulate the brain based on quantitative electroencephalogram (QEEG) analysis (Anopas & Wongsawat, 2014).

Few studies have analyzed the effects of topographical disorientation, that is one of the main hallmark of AD, (Aguirre & D'Esposito, 1999), because the lack of available behavioral measures of navigational capacity prevents researchers to detect early AD. Some studies hypothesize that a computer-based virtual reality (VR) test environment might yield comparable measures of broad applicability to the early detection of navigational impairment in mild cognitive impairment (MCI) and AD, identifying task and variables that influence navigational strategies and navigational success (Cushamn & Duffy, 2007; Monacelli, Cushman, Kavcic, & Duffy, 2003). Previous studies also focused on the ability to translate environmental- centered spatial information (allocentric) into body-centered ones (egocentric) in order to perform an efficient wayfinding during the active interaction in a complex virtual environment (Morganti, Carassa & Germiniani, 2007). Additionally, spatial memory difficulties in normal ageing and AD are extensively studied in large-scale environments using VR-based applications with 3D adaptations of both laboratory tests (Laczo et al., 2010) and naturalistic environments, evidencing encouraging results (Widmann, Beinhoff, & Riepe, 2012).