

Chapter 43

The Use of Virtual Reality Tools for the Assessment of Executive Functions and Unilateral Spatial Neglect

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ABSTRACT

Virtual Reality is one of the most promising tools in the development of new methods for neuropsychological assessment and rehabilitation. Neuropsychological assessment is typically carried out by administering paper-and-pencil tests to patients. However, these tests have some limitations, due to the fact that they are not effectively able to evaluate the subject's performance of daily activities. To cope with this void, neuropsychologists base their evaluation on their clinical experience, often successfully. Nevertheless, this is not an evidence-based practice, thus it is not considered optimal from a medical decision-making perspective. More recently, however, the increasing accessibility of advanced technology such as virtual reality has opened new possibilities for neuropsychological assessment and rehabilitation. Starting with this frame, the chapter explores the changes that have occurred over time in the neuropsychological assessment and rehabilitation up to the most recent VR-based tools. In particular, we will present a VR-based PC tool for the assessment of executive functions, and a VR-based mobile tool for the assessment and rehabilitation of unilateral spatial neglect. In accordance with the literature, we show the potential for virtual reality, highlighting the advantages, limitations, and the possible future challenges.

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INTRODUCTION

The aim of neuropsychological assessment has extensively changed over time. Before the neuroimaging, neuropsychological assessment was conducted for defining which brain area could have been damaged after cerebral lesions and was an extension of the neurological examination (Benton, 1984). After the diffusion of the neuroimaging techniques (for example, TAC), it has been possible to better determine the brain area damaged and the neuropsychological assessment aims to evaluate cognitive functioning in order to develop a personalized rehabilitation program (Ruff, 2003).

However, the change in the purpose of neuropsychological assessment did not initially lead to a change in the used tools. Typically, the neuropsychological assessment is carried out through the administration to patients of paper-and-pencil tests. This approach presented some limitations in the area of ecological validity, the degree of relevance or similarity of a test or training system with respect to the real world and in its value for predicting or improving daily functioning (Parsons, 2011; Wilson, 1998)

With the dramatic advances of new technologies, there has been a change in neuropsychological assessment. More specifically, thanks to computer-based tools it is possible an easy and standardized administration, an automatic data recording, and a quick correction of test. On one side, the traditional classical paper-and-pencil tests have been translated into their computer-based version, and, on the other side, more recently, new tests have been developed using Virtual Reality (VR). Unlike paper-and-pencil tests computer-based, that do not seek to develop new tests but mimic existing ones, tests that use VR has allowed the development of new tests able to assess specific cognitive functions in a similar real environment.

VR is a technology that has the potential to enhance the abilities to assess various cognitive domains to identify particular deficits and target real-life activities (Bohil, Alicea, & Biocca, 2011; Riva & Gaggioli 2009; Rose, Brooks, & Rizzo, 2005). VR is usually defined as a computer-simulated life composed by 3D environments, in which user can interact with the environment as if it were the real world (Biocca, 1992).

Indeed, virtual environments can represent many everyday life scenarios in order to reproduce lifelike-experience, generating a similar real physical presence and recreating similar real sensory experiences. The sensory experiences, including virtual sight, sound and touch, are generated by the integration of input devices, such as stereoscopic displays (Head-Mounted displays), specific sound speakers and/or headphones, and haptic systems (wired gloves).

In neuropsychology, VR offer to patients the possibility to be active participants within realistic virtual environments and not only passive viewers of their assessment and rehabilitation programs (Riva, Mantovani et al. 2004), and to clinicians to precisely record the individual's performance in controlled situations (Brooks & Rose, 2003).

In literature there are many studies that showed that VR is a promising tool for the assessment and rehabilitation of cognitive functions (Kim, Chun, Yun, Song, & Young, 2011; Jebara, Orriols, Zaoui, Berthoz, & Piolino 2014; Pedroli, Serino, Cipresso, Pallavicini, & Riva, 2015; Raspelli et al., 2012). You and colleagues (You et al., 2005) showed, through fMRI, that virtual environments and situations are able to activate the same brain areas involved in the real experiences. Furthermore, the high ecological validity of VR allow to user to perceive the virtual environment as real, tending to transfer the expected capabilities and skills from the virtual world to the real one in a almost automatic way (Brooks & Rose, 2003).

Furthermore, VR offers several features for improving neuropsychological assessment: controlled and safe settings, multimodal and multiple stimulation, and feedback about answers, (Bohil, Alicea, & Biocca,

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