

Exploring Virtual Reality for the Assessment and Rehabilitation of Executive Functions

Elisa Pedroli, Applied Technology for Neuro-Psychology Lab, IRCCS Istituto Auxologico Italiano, Milano, Italy

Silvia Serino, Applied Technology for Neuro-Psychology Lab, IRCCS Istituto Auxologico Italiano, Milano, Italy & Psychology Department, Catholic University of Milan, Milan, Italy

Federica Pallavicini, Department of Human Sciences for Education “Riccardo Massa”, Centre for Studies in Communication Sciences CESCO, University of Milan Bicocca, Milan, Italy

Pietro Cipresso, Applied Technology for Neuro-Psychology Lab, IRCCS Istituto Auxologico Italiano, Milano, Italy & Psychology Department, Catholic University of Milan, Milan, Italy

Giuseppe Riva, Applied Technology for Neuro-Psychology Lab, IRCCS Istituto Auxologico Italiano, Milano, Italy & Psychology Department, Catholic University of Milan, Milan, Italy

ABSTRACT

This article describes how a neuropsychological assessment and rehabilitation are typically carried out using paper-and-pencil tools. However, these protocols cannot effectively evaluate the subject's performance of daily activities. More recently, the increasing accessibility of new and powerful technology has presented new possibilities. Virtual reality is one of the most promising tools with the increasing ecologicity in the neuropsychological field. The availability of new portable instruments has increased the accessibility and usability of this technology. Using this frame, the changes that have occurred over time in the neuropsychological practice up to the most recent VR-based tools have been explored. In particular, the focus will be on executive functions as the most sensitive cognitive domain within the ecological validity of the tools. In accordance with the literature, the authors show the potential for the use of virtual reality in the assessment and rehabilitation of executive functions, highlighting the advantages, limitations, and potential future challenges.

KEYWORDS

Behavioral Assessment of the Dysexecutive Syndrome (BADS), Multiple Errands Test (MET), Neuropsychological Assessment, Neuropsychological Rehabilitation, Virtual Reality

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). Unfortunately, at the beginning, the change of purpose has not translated into a change of tools. The second step of the improvement of the neuropsychological assessment begins with the introduction of the computer-based tools.

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These tests use a computer interface, like computer or tablet, to administer and correct tests. Usually the test is the computer-version of the classical paper and pencil test. It is rare to find a new test developed specifically for this modern technology. On one side, the advantages of computer-based test are several: more accurate time data, easy administration, automatic data recording, increased standardization of administration. On the other side, the principal problems about the use of these tools are that the normative data cannot be simply applied to computerized version and, generally, don't give an additional useful information for the clinician (Parsey & Schmitter-Edgecombe, 2013; Parsons, 2015). In the light of what said before a great challenge for neuropsychology has been to find new way to better measure, understand, and predict daily life abilities. Indeed, one of the most relevant issues with respect to neuropsychological assessment in the laboratory is the lack of the validity of the protocols, those results in limitations for generalization of the investigated abilities in daily life situations. In the recent decades, neuropsychology, cognitive psychology and cognitive neuroscience have been worked together to understand the complexity of cognitive processes, the functional neuroanatomy underpinning those cognitive domains, and the implications of cognitive impairments in neurological patients for models of normal cognitive functioning.

Virtual Reality (VR) is a new technology that could help to improve neuropsychology assessment (Bohil, Alicea, & Biocca, 2011; Riva & Gaggioli, 2009; Rose, Brooks, & Rizzo, 2005). Technically speaking VR is composed by 3D environment, a user can interact with the environment thanks to different input or output computer devices (visual, auditory or haptic). Virtual environments could represent many everyday life scenarios and are programmed to record precise measurements of the individual's performance in a controlled situation. (Brooks & Rose, 2003). Thanks to these devices, the user can interact with the environment as if it were the real world.

In neuropsychology, VR is used to offer a new human-computer interaction paradigm in which patients are active participants within realistic virtual environments and not only a passive viewer (Riva, Mantovani, & Gaggioli, 2004).

In the literature are many jobs that demonstrate the important characteristics of VR. You in an article from 2005 (You et al., 2005) used fMRI to prove that virtual environments activate the same parts of brain of the real environments. The high ecological validity of the virtual reality training was demonstrated by proving that the skills learned in a virtual environment can be reported in a real situation (Brooks & Rose, 2003).

VR offers several requirements for improving neuropsychological assessment: controlled and secure settings, multimodal and multiple stimulation, feedback about answers, (Bohil et al., 2011; Riva et al., 2004; Schultheis & Rizzo, 2001). It is also possible to control and manipulate the tasks within reasoned, ecologically valid and engaging environments using Virtual Environments (G. Riva & Gaggioli, 2009). The high level of engagement derives from a process call "transformation of flow", that is the ability of a subjects to use an optimal (flow) experience to discover and use psychological resources as sources of involvement (Riva, Castelnuovo, & Mantovani, 2006).

It is also important understand the limit of the use of VR system in the clinical settings.

First, VR requires high costs both for hardware and software creations and not all the hospitals are able to invest in new technology. Even maintain the equipment and have and adequate technical support is expensive.

Developing new functional task in some new virtual environments requires a close cooperation between clinicians and technicians and it is not always possible or easy. By designing intuitive VR applications and providing adequate training, developers may also help medical personnel in using these tools independently. It is hard to find a setting and an adequate number of patients for testing a clinical VR application.

Because of these reason in the community of clinicians and researchers there is low availability of standardized protocols that can be shared (Pedroli, Serino, Cipresso, Pallavicini, & Riva, 2015; Riva, 2009; Tsirlin, Dupierri, Chokron, Coquillart, & Ohlmann, 2009).

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