

# Computer-Based Neuropsychological Rehabilitation: Virtual Reality and Serious Games

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## INTRODUCTION

Neurocognitive rehabilitation of people with acquired brain injury (ABI) is a part of neuropsychological rehabilitation that has gained increased interest in response to the growing incidence of this type of injury and to the possibility of post-injury survival, often associated with physical and cognitive deficits, as well as emotional and behavioral changes. These problems call for the need of innovative interventions that can overcome the limitations of traditional approaches to ABI. The recent developments in Information Communication Technology (ICT), such as e-Health and Telemedicine, offer promising solutions, contributing new ways to deliver services. Registering a recent significant growth, the use of Serious Games (SG) and of immersive technologies in the field of rehabilitation provides the opportunity to develop new products that are computer-based and that can be used at a distance in assessment and neurocognitive rehabilitation practices, increasing the ecological validity of the instruments in this area. However, while presenting new possibilities, these technologies also involve new challenges. The investigation of the applicability and effectiveness of these products is thus crucial. The objectives of the present work are (1) to present the definition and main characteristics of SG and Virtual Reality (VR), (2) to discuss implications of their use in the rehabilitation of ABI patients, (3) to discuss the importance of systematic research on the effects of SG and VR, particularly in terms of patient behavior and cognitive functioning, and (4) to present paradigms that can be used to assess different cognitive functions and behavior.

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## **BACKGROUND**

### **Virtual Reality and Serious Games**

For a long time, game design and technologies like VR were applied almost exclusively to the movie industry, media and electronic games. Their main purposes were entertainment, enjoyment and fun, and only recently was their use extended to other ends (Gigante, 1993).

VR has been defined as “an advanced form of human-computer interface that allows the user to ‘interact’ with and become ‘immersed’ in a computer-generated environment in a naturalist fashion” (Schultheis & Rizzo, 2001, p. 210) or, “sensory data generated by a computer system may be perceived as physical reality, especially when perception is enabled by use of the body in a manner similar to physical reality. The system ideally displays in all sensory modalities; fully encloses the person in these displays; tracks head position and orientation but also the movements of the whole body, determining the visual stereo and spatialised auditory displays as a function of this tracking” (Slater, Perez-Marcos, Ehrsson, & Sanchez-Vives, 2009, p. 215).

Three main and distinctive characteristics of VR are presence, involvement and interaction. Presence refers to “the illusion of being in the rendered virtual place. When contingent events in the virtual world apparently relate directly to the participant, then further there is the illusion that what is occurring is real. Under these conditions participants tend to act and respond to the virtual reality as if it were real” (Slater et al., 2009, p. 215). Involvement can be defined as participation and persistence of the users in the task, or degree of motivation. Finally, interaction is the capacity of the virtual environment (VE) to react to the user’s action. The more the immediate environment changes in response to this action, the more interactive the VE is.

In sum, this technology allows the creation of stimuli with properties identical to real ones. Its three-dimensionality confers an increased sensation of presence to the user, making laboratorial emulation of the reality possible, and its interactive character contributes to dynamical and personalized experiences. In fact, computer-generated VEs are becoming more and more realistic (Dores et al., 2011).

The development of devices such as head-mounted displays, eyeglasses or gloves has contributed to this realism. In the past, this equipment’s excessive weight and high cost made its application in the field of neuropsychological rehabilitation very difficult. Today, three-dimensional (3D) viewing is also possible in 3D monitors without glasses or head-mounted displays, even if this technology is not yet available to everyone.

The main difficulties about generalizing the use of VR in rehabilitation are still the selection of the adequate interaction devices and methods. The interaction methods must allow the navigation in detailed 3D environments and the manipulation of specific objects, always associated with the provision of feedback to the patient. Navigation, manipulation and feedback must be considered natural and intuitive for different users with various disabilities, backgrounds and practices. Even with the large diversity of available interaction gadgets (joysticks, mouse, gloves, trackers, etc.) and feedback media (image, sound, tactile stimuli), there is not a perfect solution that fits all the requirements and that can be considered easy to use to all individuals with disabilities. Due to these difficulties, the development of different interaction solutions seems crucial (Dores, 2012).

The expectation is that, in the near future, these new tools allow an increasingly multi-sensory stimulation, involving possibilities such as sensing smells, the wind in our faces and the touch/grasp of the objects in the environment, all combined in an easy way.

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