Chapter 12
Cognitive Performance in Immersive Environments After Acquired Brain Injury

Ineke van der Ham
Leiden University, The Netherlands

ABSTRACT

The use of immersive environments such as virtual and augmented reality is quickly developing. For cognitive assessment and training in a neuropsychological setting, this offers a perspective for innovation and improvement of existing methods. Most of the current clinical uses of immersive environments focus on factors such as anxiety, or motor activities for physical therapy. Cognitive applications, concerning, for example, memory, attention, visuospatial processing, are relatively scarce. In this chapter, considerations of using immersive environments for cognitive purposes are presented. In addition to immersion, the individual experience of immersive environments, as expressed by sense of presence, will be discussed. By examining advantages and disadvantages of using immersive environments to measure and train cognitive performance, recommendations for clinical use of these methods are provided.

INTRODUCTION

Immersive technologies like virtual reality (VR) and augmented reality (AR) are growing exponentially and have seemingly endless potential for assessment, learning, and entertainment (Allcoat & von Mühlenen, 2018; Lee et al. 2010; Molina-Carmona et al., 2018, Navarro & Sundstedt, 2020). Applications come in many forms, and are beginning to take on substantial roles in education, training, and healthcare programmes, worldwide. The recent need for social distancing has further stimulated a surge in virtual solutions, for instance for museum visits (Kunjir & Patil, 2020), to stimulate international student collaboration in education (de Back et al., 2020), and to provide healthcare digitally (Papara et al., 2020) Where initial applications mainly concerned entertainment, more recent developments include implementation within education and healthcare settings. For instance, Bogomolova and colleagues (2020) describe an application where medical students can use AR by wearing a HoloLens head mounted display.

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Through this device, the users can view three dimensional human anatomy and moreover, they are able to interact with the AR projection through hand movement, by e.g. resizing or rotating the image or to tap on certain option buttons. Also specific patient groups can benefit from IEs. A number of studies show that exposure therapy can be highly effective when the object of a specific phobia, e.g. being in an airplane, can be realistically recreated, without actually being exposed to it (Parsons & Rizzo, 2008).

Despite the inherent appeal of these examples, some caution also seems appropriate. Immersive environments are still distinctly different from real environments and therefore present their users with cognitive challenges. Especially neuropsychological patients may present particular challenges in using IEs. Often, immersive learning is used to convey visuospatially complex information, ranging from geometric-shape learning in augmented reality for children (Gecu-Parmaksiz & Delialioglu, 2020) to augmented reality medical education for adult students (Bogomolova et al., 2020). Immersive environments (IEs) also allow for full control over the characteristics of the environment, which can be useful for example, for training navigation ability in virtual environments for stroke patients (van der Kuil et al., 2018) in a secure environment. However, a clear understanding of what drives learning effectiveness in these immersive applications is still lacking.

Reports on IE learning effectiveness are limited and diverse. Immersive learning can even lead to adverse effects in some situations, e.g. when users lack the required spatial skills to accurately process the immersive environment (Price & Lee, 2010), are hindered by stereotypical beliefs about using immersive technologies (Chang et al., 2019), or an entirely different spatial function is trained because of the three dimensional depiction (Kozhevnikov & Dhond, 2012). Moreover, application in vulnerable populations such as patients with acquired brain injury may pose substantial problems, such as cybersickness and cognitive demands that are too high (Weech et al., 2019). It is imperative to understand what is required to obtain a beneficial effect of learning in IEs and how this differs across individuals.

To this end, the current chapter will focus on the use of immersive environments in diagnostics and rehabilitation of patients with acquired brain injury. The number of IE tools that are being developed for this particular population is steadily increasing. After an initial focus mainly on using IEs to train motor skills as part of physical therapy, cognitive applications serving diagnostics as well as rehabilitation are on the rise. Due to the specific profile of such patients, in terms of potential cognitive limitations and often higher age, some caution in the use of novel technology is advisable. Therefore in this chapter, the working mechanisms of immersive environments are explored, within the context of neuropsychological diagnostics and rehabilitation. An in depth discussion of current literature will result in a set of recommendations for the use of IEs in neuropsychological practice, taking into account particular advantages and disadvantages. Furthermore, future directions for research and clinical applications are discussed.

BACKGROUND

The use of immersive technology dates back to the 1960s, when the first multisensory virtual experience was created (Mazuryk & Gervautz, 1996). This was soon followed by the first implementation of AR, with an optical, see-through head-mounted display (Arth et al., 2015). Due to technological challenges that needed to be tackled, it was not until the 1990s that the IE industry started to surge, and became highly popular, but expensive. With further technological innovation and large-scale commercial production in the past decade (e.g. Oculus Rift, HTC Vive, Microsoft Hololens), the use of IEs is now highly accessible and affordable.

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