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## Cognitive ability predicts motor learning on a virtual reality game in patients with TBI

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### Abstract

**BACKGROUND:** Virtual reality games and simulations have been utilized successfully for motor rehabilitation of individuals with traumatic brain injury (TBI). Little is known, however, how TBI-related cognitive decline affects learning of motor tasks in virtual environments.

**OBJECTIVE:** To fill this gap, we examined learning within a virtual reality game involving various reaching motions in 14 patients with TBI and 15 healthy individuals with different cognitive abilities.

**METHODS:** All participants practiced ten 90-second gaming trials to assess various aspects of motor learning. Cognitive abilities were assessed with a battery of tests including measures of memory, executive functioning, and visuospatial ability.

**RESULTS:** Overall, participants with TBI showed both reduced performance and a slower learning rate in the virtual reality game compared to healthy individuals. Numerous correlations between overall performance and several of the cognitive ability domains were revealed for both the patient and control groups, with the best predictor being overall cognitive ability.

**CONCLUSIONS:** The results may provide a starting point for rehabilitation programs regarding which cognitive domains interact with motor learning.

Keywords: Cognitive ability, virtual reality, traumatic brain injury

### 1. Introduction

Application of virtual reality games for motor rehabilitation of individuals with acquired brain injury has received considerable interest over past decades (Cherniak, 2011; Holden, 2005; Mumford & Wilson, 2009). Practice in safe and motivating virtual environments allows relearning of motor and functional skills, thereby facilitating recovery across several domains (Flanagan et al., 2008; Schultheis et al., 2002). Studies applying virtual reality games and simulations reported improvements of static and dynamic postural stability (Suárez

et al., 2006); gait (Batson et al., 2011); cognitive abilities (Rose et al., 2005); abilities to perform ADL (Flanagan et al., 2008; Mathies et al., 2007; Schultheis et al., 2002; Zhang et al., 2003), and fine arm movements (Cirstea et al., 2003; Rand et al., 2005) in patients with brain injury. While noticing a facilitatory effect of virtual environments, authors also agreed that recovery after brain damage requires motor learning (Holden, 2005; Sullivan, 2007; Wulf et al., 2010). Motor learning can be defined as an internal process that results in a relatively permanent change in an individual's capability to perform a motor task (Kerr, 1982; Magill, 2004; Schmidt & Wrisberg, 2004).

The mechanisms underlying motor learning in intact nervous system may not necessarily be the same in individuals with brain injury (Levin, 2011). Brain damage

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