

Developing VR-Based Neurorehabilitation Support Tools: A Step-by-Step Approach for Cognitive Rehabilitation and Pain Distraction during Invasive Techniques in Hospital Settings

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Abstract : Neurological disorders are a leading cause of disability and premature mortality worldwide. Neurorehabilitation (NRHB) is a clinical process aimed at reducing functional impairment, promoting societal participation, and improving the quality of life for affected individuals. Virtual reality (VR) technology is emerging as a promising NRHB support tool. Its immersive nature fosters a strong sense of agency and embodiment, motivating patients to engage in meaningful tasks and increasing adherence to therapy. However, the clinical benefits of VR interventions are challenging to determine due to the high heterogeneity among health applications. This study explores a stepwise development approach for creating VR-based tools to assist individuals with neurological disorders in medical practice, aiming to enhance reproducibility, facilitate comparison, and promote the generalization of findings. Building on previous research, the step-by-step methodology encompasses: Needs Identification- conducting cross-disciplinary meetings to brainstorm problems, solutions, and address barriers. Intervention Definition- target population, set goals, and conceptualize the VR system (equipment and environments). Material Selection and Placement- choose appropriate hardware and software, place the device within the hospital setting, and test equipment. Co-design- collaboratively create VR environments, user interfaces, and data management strategies. Prototyping- develop VR prototypes, conduct user testing, and make iterative redesigns. Usability and Feasibility Assessment- design protocols and conduct trials with stakeholders in the hospital setting. Efficacy Assessment- conduct clinical trials to evaluate outcomes and long-term effects. Cost-Effectiveness Validation- assess reproducibility, sustainability, and balance between costs and benefits. NRHB is complex due to the multifaceted needs of patients and the interdisciplinary healthcare architecture. VR has the potential to support various applications, such as motor skill training, cognitive tasks, pain management, unilateral spatial neglect (diagnosis and treatment), mirror therapy, and ecologically valid activities of daily living. Following this methodology was crucial for launching a VR-based system in a real hospital environment. Collaboration with neuropsychologists lead to develop A) a VR-based tool for cognitive rehabilitation in patients with acquired brain injury (ABI). The system comprises a head-mounted display (HTC Vive Pro Eye) and 7 tasks targeting attention, memory, and executive functions. A desktop application facilitates session configuration, while database records in-game variables. The VR tool's usability and feasibility were demonstrated in proof-of-concept trials with 20 patients, and effectiveness is being tested through a clinical protocol with 12 patients completing 24-session treatment. Another case involved collaboration with nurses and paediatric physiatrists to create B) a VR-based distraction tool during invasive techniques. The goal is to alleviate pain and anxiety associated with botulinum toxin (BTX) injections, blood tests, or intravenous placements. An all-in-one headset (HTC Vive Focus 3) deploys 360° videos to improve the experience for paediatric patients and their families. This study presents a framework for developing clinically relevant and technologically feasible VR-based support tools for hospital settings. Despite differences in patient type, intervention purpose, and VR system, the methodology demonstrates usability, viability, reproducibility and preliminary clinical benefits. It highlights the importance approach centred on clinician and patient needs for any aspect of NRHB within a real hospital setting.

Keywords : neurological disorders, neurorehabilitation, stepwise development approach, virtual reality

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