Designing virtual environments for motor rehabilitation: towards a framework for the integration of best-practice information

Thomas Schüler[1], Luara Ferreira dos Santos[2], Simon Hoermann[3]
[1]SALT AND PEPPER Software Solution Center & University of Osnabrück, Osnabrück, GERMANY
[2]Rehabilitation Robotics Group, Chair of Industrial Automation Technology, Technische Universität Berlin, Berlin, GERMANY
[3]Department of Medicine (DSM) & Department of Information Science, University of Otago, Dunedin, NEW ZEALAND

Introduction

Virtual reality (VR) systems have been shown to be effective for the treatment of patients with motor impairments; however, the exact characteristics that lead to improvements are not well understood and more research is still needed to optimize therapeutic outcomes and VR systems [1]. **Today it is not known exactly how features of a virtual environment impact upon treatment outcomes**.

There are numerous separate components that together constitute a virtual environment, such as avatars, game objects, the virtual world, or sound effects. And it is this level of detail that needs to be considered during the design and development of therapeutic VR applications. Thus in order to be able to gain from best-practice during the design process, **a framework is needed that makes it possible to analyze the available design options more comprehensively**. We propose to separate the mainly visual feedback provided by VR systems and identify three distinct feedback types that are important for motor rehabilitation.

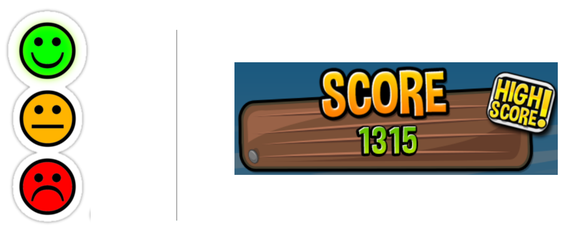
Movement Visualisation

The patients are represented in VR by means of movement visualization, where motor actions are captured and transferred to a graphical object that is synchronously animated. To orient themselves in the virtual world and to manipulate objects, patients identify with the movement visualization.

Examples for best-practice considerations

- observing virtual limbs movements activates motor brain regions [2]
- the body image will be transferred to the avatar [3]
- realistic visualization: expectation for real world actions
- abstract visualization: may foster imagination [4]
- feedback distortions may accelerate motor adaptions

Performance Feedback



The patients have to accomplish tasks and gain information (KP/KR) about their performance. The task as well as the points or level will be visualized in some way in order to add meaning to the patients' exercises and inform them about their progress.

Examples for best-practice considerations

- differentiate knowledge of performance (KP) and knowledge of results (KR) [5]
- facilitate external focus on the effects of movements [6]
- consider using auditory / haptic channel to reduce visual load
- adapt challenges to the patients' skill level [7]

Context Information

Background objects and animations give the VR system the impression of a real environment that is not just a technical artefact for therapeutic purposes. Atmospheric sensory stimuli in the form of sounds can add to the vividness of the experience.

Examples for best-practice considerations

- use approriate physical world context (may be real, abstract or fictive)
- embed the tasks in a realistic environment to aid transfer to everyday life
- rhythmic music fosters active movements [4]
- consider merging virtual and real objects using augmented reality or virtuality [8]
- consider to deliver haptic context information

Discussion

The above framework carries on the work of others who analysed the opportunities of VR technology for rehabilitation (e.g. [9,10,11,12]). It however focuses on the different feedback types that a VR may deliver. These feedback types demand special consideration during the development of a VR rehabilitation system, when the task is to design a system that satisfies predefined therapeutic needs. A systematic overview that follows the above framework and gives best-practice advice will be valuable for this task.

Even though each of the three feedback types individually is suggested to have an influence on motor learning or transfer; combining them will probably be most effective for therapeutic VR applications. Therefore a consideration of all interrelations between feedback types is important for a holistic realisation of motor learning and has to be elaborated in future work.

Support us building a systematic overview of best-practice that may aid the development and design of future VR rehabilitation systems. Send us your considerations **on www.vr-rehabilitation-checklist.org**

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Contact

Thomas Schüler
t.schueler@salt-and-pepper.eu
www.salt-and-pepper.eu

Luara Ferreira dos Santos
santos@iwf.tu-berlin.de
www.iat.tu-berlin.de

Simon Hoermann
simon.hoermann@otago.ac.nz
www.otago.ac.nz