Feedback Visualisation in Virtual Reality-based Motor Rehabilitation

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1 Introduction

Most of the established motor rehabilitation therapies for brain lesioned patients are based on the concept of peripheral sensory stimulation. Robot assisted techniques, for example, enable intensive repetitive motor training. In contrast, central sensory stimulation therapies (e.g. mirror therapy) improve cortical reorganization and functional mobility without peripheral sensory stimulation through movements of the affected limb.

Recent findings in motor rehabilitation research emphasize the importance of providing enhanced feedback to patients. Particularly, Virtual Reality (VR) gives new possibilities for customized and high intensity technology-based training systems for motor recovery [1, 2]. Patients perform motor tasks, which are represented in a virtual environment and enhanced with game elements. Generally, the real-time interaction with the system is captured through motion-tracking technologies and displayed on a screen or a head mounted display. Importantly, motor learning is facilitated through multimodal feedback on the patient's performance at the clinical intervention. The visual channel is thereby used as the main way to provide information during and after task performance.

However, since there is not enough knowledge yet about the characteristics of the visual feedback yet, VR-based therapies run the risk to be developed ineffective and suboptimal for rehabilitation purposes. This contribution reviews recent research on feedback visualisation and discusses considerations for the feedback development process.

2 Feedback Visualisation

A classification of visual feedback components is necessary for a systematic development of VR-based therapies. A current feedback visualisation model proposes a classification of three feedback types, namely: i) Movement Visualisation (MV), ii) Performance Feedback (PF), and iii) Context Information (CI) [3]. Within a virtual environment the patient's movements are represented through an Avatar (MV) and information on the quality of task execution is presented (PF). Both feedback types are embedded in a virtual world (CI).

All three feedback types can be implemented and combined in different manners and modalities. Performance Feedback, for example, can have an influence on motor learning depending on whether it provides information on performed therapy movement patterns (knowledge of performance) or outcome of the movement (knowledge of results) [4]. Regarding Movement Visualisation, a previously conducted systematic literature search showed six different forms of movement representation in systems designed for neurological patients [5]. Unfortunately, there is no categorization of Context Information so far.

Some considerations for therapeutic effective VR visualisations can be derived from established therapy approaches. First, peripheral sensory stimulation can be enhanced through motivating and individualized adaptive Performance Feedback. Hence, repetitive therapy tasks can be created more interesting and challenging, and therefore improve patients compliance and endurance [2]. Furthermore, central sensory stimulation may be complemented through anthropomorphic Movement Visualisation in upper extremity therapy systems [6]. Finally, the transfer of learned skills into the real life environment may be associated with the design of Context Information [3].

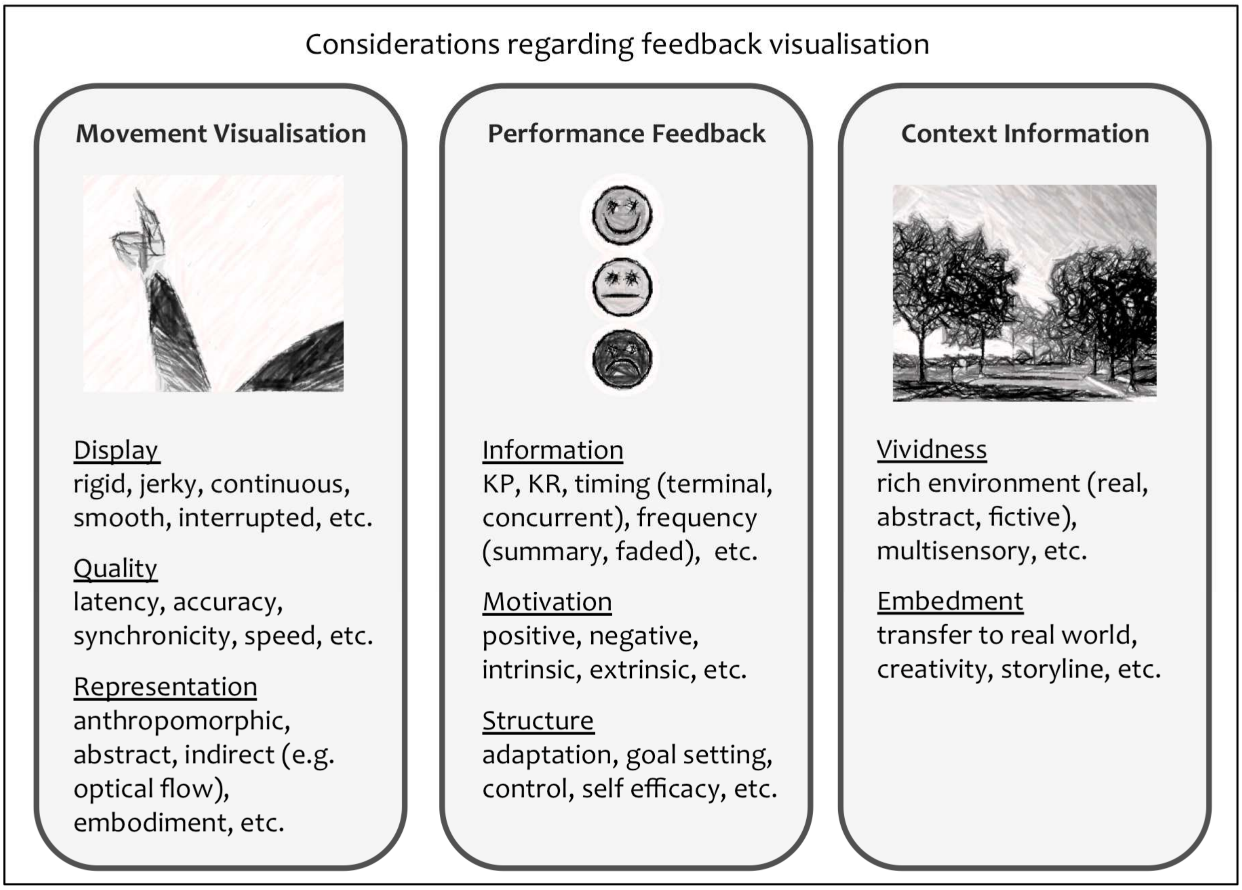

Figure 1: Three types of feedback visualisations used in VR-based motor rehabilitation.

3 Conclusion

Visual feedbacks play an important role in VR-based therapy approaches. The characteristics of these feedbacks are currently investigated. However, there is insufficient research on the effectiveness of specific feedback categories and components on motor outcome. Nevertheless, categorisations can be used to apply and analyse research findings of different fields in this context. Furthermore they indicate parameters for future studies and for the development of purposeful VR-based rehabilitation systems.

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