Abstract virtual environment for motor rehabilitation of stroke patients with upper limb dysfunction. A pilot study.

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ABSTRACT

A virtual environment for stroke therapy and the protocol of a pilot study that is ongoing to test the system are presented. The virtual environment utilizes abstract and fictive visualizations of human upper body movements to foster exercise and motor learning after a stroke.

1. INTRODUCTION

Motor rehabilitation after stroke benefits from the application of a set of therapeutic procedures (Langhorne et al. 2011). Several approaches that can be combined show to be promising, among these the use of virtual reality training scenarios (Laver et al. 2012). Computer technology holds many opportunities (e.g. increased motivation, data analysis, tele-control) for rehabilitation (Lange et al. 2009), yet this area is not fully explored today. A central property of the medium is its ability to transform data from one representational space to another. This property is addressed by a new virtual rehabilitation system, the "abstract virtual environment for stroke therapy" (AVUS). A pilot study is ongoing to test for the effects of the system.

2. ABSTRACT VIRTUAL ENVIRONMENT FOR STROKE THERAPY

The AVUS-system utilizes abstract and fictive visualizations of human upper body movements (see figure 1) to foster exercise and motor learning after a stroke. The patients' movements are captured with a Microsoft Kinect sensor and transformed using the Processing framework (processing.org) to generate aesthetic visuals with different levels of abstraction. Continuous interaction is provided meaning that every movement results in an immediate visual effect. During the therapy the patients explore in a self-directed manner their possibilities to produce various shapes. At the same time they exercise at their limits of motion. Music is played and used as input to manipulate the visualizations, too. The concept aims to allow for a high level of presence (Lombard et al. 1997), which helps to concentrate on the virtual effects of the movements.

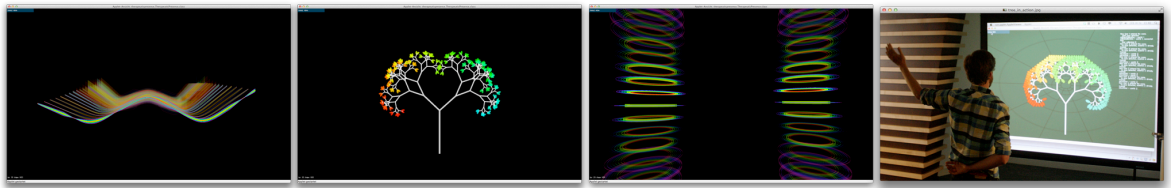

Figure 1. *Visualizations in the AVUS-system and an early version of the system in application*

A distinct mode of operation applies the mirror therapy principle (Ramachandran & Altschuler 2009). In this mode the movements of the unaffected body side are captured and then used to manipulate both sides of the visuals. An illusion of symmetric bilateral movement will be established for the patient. The mirror-therapy-mode aims to enhance motor learning on the affected side.

The AVUS-system was developed in close contact to patients and clinicians in three rehabilitation centers. These alpha tests asked for informal feedback on several release versions. In these tests the concept proved to be applicable.

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2. PILOT STUDY

The effects of training with the AVUS-system for motor rehabilitation of patients suffering from a stroke are tested in a pilot study that follows a controlled case-series design. The protocol for this study derives from the aforementioned alpha tests. A set of measurements is applied to check for effects on a broad basis.

In this early phase of application several hypothetical effects of the system can be expected. For this study the central effect to be looked for is whether the training improves motor function in the hemi-paretic arm. Besides this a correlation of high involvement with the therapy and functional outcome is hypothesized. During the mirror-therapy-mode higher exercise rates on the paretic side are expected. Successful identification with the abstract visualizations may result in improved ability to perform motor-imagery. Finally the self-directedness of the therapy may amplify the subjective impression of the functional outcome.

2.1 Participants

Participants in the study are hemi-paretic patients in the sub-acute and chronic phase after stroke showing at least minimal proximal arm function as well as stable posture control. The therapy can be performed standing or sitting. Excluding criteria are visual impairments, strong cognitive impairments, dementia, global aphasia and epilepsy. The recruitment and the study take place in a neurological rehabilitation center that is specialized in stroke care. All participants are in-patients receiving an individually focused therapy program.

2.2 Study protocol

The participants are randomized into two groups. The experimental group (EG) is trained daily with the AVUS-system. The control group (CG) receives unspecific upper-limb movement training while listening to background music. The procedure for the EG follows three phases. In the first phase the patients observe the visualizations of prerecorded movements and mentally imagine performing the corresponding movements. In the second phase the patients explore the three visualizations each for 90 seconds while operating the system with both upper body sides. The third phase utilizes the mirror-therapy-mode in the exact same progression. Between all phases short relaxation breaks take place. Both groups receive their treatment for approximately 15 minutes on 5 successive days in addition to their standard rehabilitation program.

2.3 Methods

Motor function (Fugl-Meyer-Score upper extremity, FMA-UE) and mental imagery ability (NOI Recognise left-right-discrimination of hand images) are assessed pre and post intervention. The subjective impression of the functional outcome is evaluated using a colored analog scale. These measures are applied for both groups. Participants in the EG additionally respond to the iGroup presence questionnaire (IPQ) after each therapy session to evaluate their level of involvement and presence. The AVUS-system logs the motion data during the therapy. This data is compared between phase 2 and 3 of the therapy program to test for higher activity in mirror-therapy-mode. A semi-structured interview asks for the subjective experience with the system.

3. PRELIMINARY RESULTS

5 patients (3 EG, 2 CG) participated in the study so far. All participants completed the study program. No adverse events can be reported. Subjective reports of the patients in the EG were positive. The EG showed improved motor function (mean FMA-UE increase 6,2±4,55) as compared to the CG (mean 0±8,48). However the poor performance of the control group can be ascribed to a fall incident of one patient. All other statistical results as well as the semi-structured interviews are yet to be analyzed.

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