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The Effects of Manipulation of Visual Feedback in Virtual Reality on Cortical Activity: A Pilot Study

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***Abstract*—It is known that systematic visual distortions using virtual reality technologies, prisms or mirrors, may have therapeutic effects for patients suffering from stroke or body image identity disorders. However, there are few studies which directly investigate neural activity changes during visual feedback manipulation. In the present study we created an experimental setup for investigating the effects of systematic virtual reality-mediated visual feedback manipulation of finger movements on cortical activity. We performed tests with two healthy female subjects who performed a line-tracking task under four conditions manipulating visual feedback of their own hand. To investigate hemodynamic responses in motor areas during the line tracking task we used functional near-infrared spectroscopy (fNIRS). We predicted that viewing larger or smaller virtual movements of fingers, compared to the real movements, would affect activity in motor areas and thus the hemodynamic response.**

Our preliminary results showed changes in the hemodynamic responses between stimulation period and baseline. There were indications of possible differences between conditions, and also of adaptation effects within conditions. However these effects were not significant in our preliminary data and we therefore need to collect additional data to draw further conclusions.

I. Methods

The experiment was designed to induce a high amount of ownership of the virtual hand. The hardware setup consisted of a mirror display [1] and a simple finger input device. Participants were seated at a desk and looked in the direction of their hidden real arm onto a horizontal mirror, whereon the visual feedback (Figure 1) was projected from an overhead hanging LCD monitor. A simple input device under the mirror was used to record the movement of the participant's index finger. The subjects were asked to follow the virtual line with the virtual finger.

Two healthy right-handed subjects performed the finger-line tracking task under 4 different conditions (Figure 2) with 8 repetitions of the flexion/extension movement. One cycle of movement consisted of 1s finger flexion (2s in condition 2), 1s (2s) finger extension and two pauses of 0.5s (1s). The haemodynamic response was recorded with functional near-infrared spectroscopy (fNIRS) over F3 according to the international 10-20-system [2]. We assumed that the fNIRS sensor [3] covered secondary motor areas, preferably parts of the premotor cortex (PMC).

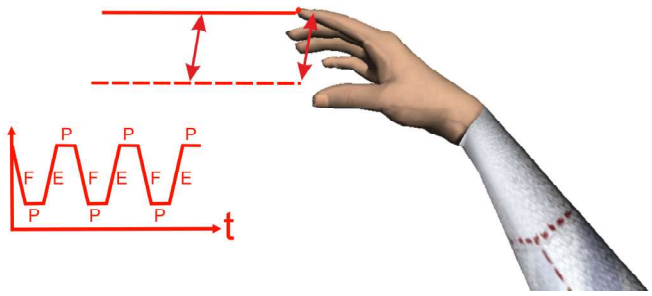

Fig. 1. The Virtual Hand and Target-Line presented to the participant: The virtual index finger moves with the the real index finger input. The red 3D-Line functions as the tracking target and moves between the extended virtual index finger and the virtual thumb. Over time this movement corresponds to a triangle wave (bottom left section) with constant speed at finger Flexion (F) and finger Extension (E) and short pauses (P) at the extrema.

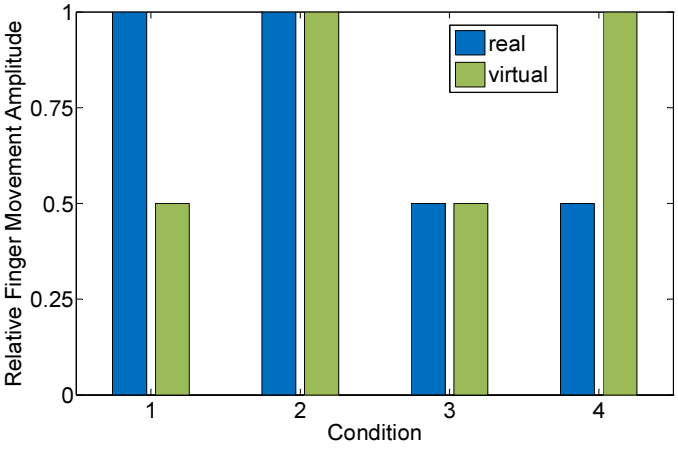

Fig. 2. Relative real/virtual finger movement task amplitudes for the experimental conditions. In conditions 2 and 3 the visual feedback of the subject's hand movement matched the real finger input. In condition 1 the virtual task range was reduced compared to condition 2, but the subject had to perform the same amount of real movement. This was achieved by downscaling the real finger input. In condition 4 the movement range of the virtual line was doubled compared to condition 3, but the line was also moving faster. Hence, by scaling the real finger input subjects performed an equal movement range and also an equal movement rate in these conditions.

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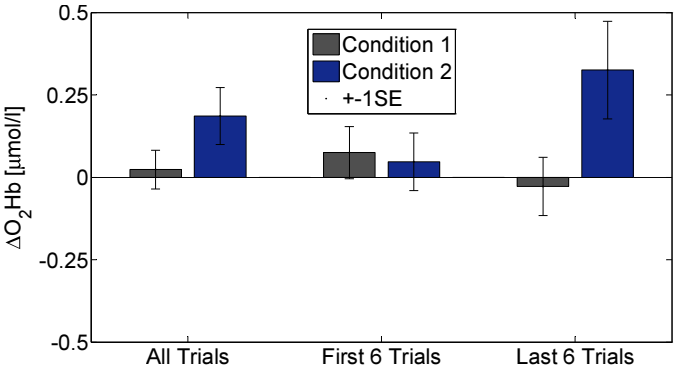
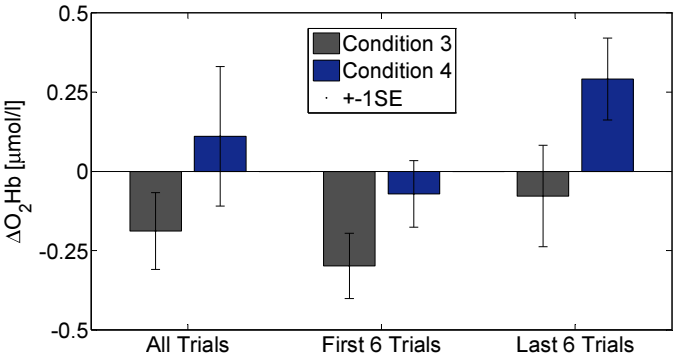
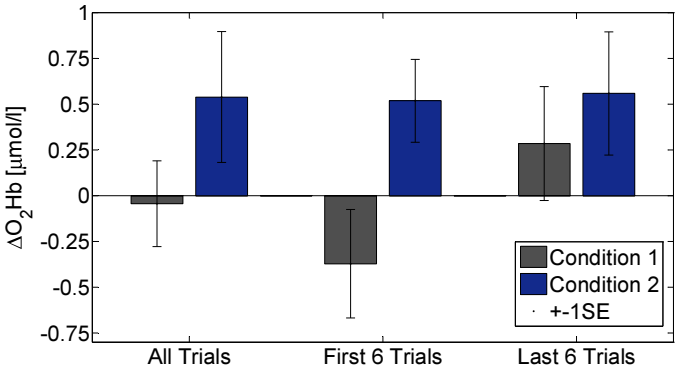


(a) Mean Oxy-Haemoglobin densities for Conditions 1 and 2 over all trials, over the first 6 trials and over the last 6 trials. The error bar on top of the mean density bars represents +- 1 standard error



(b) Mean Oxy-Haemoglobin densities for Conditions 3 and 4 over all trials, over the first 6 trials and over the last 6 trials. The error bar on top of the mean density bars represents +- 1 standard error

Fig. 3. Oxy-Haemoglobin data from Subject 1.



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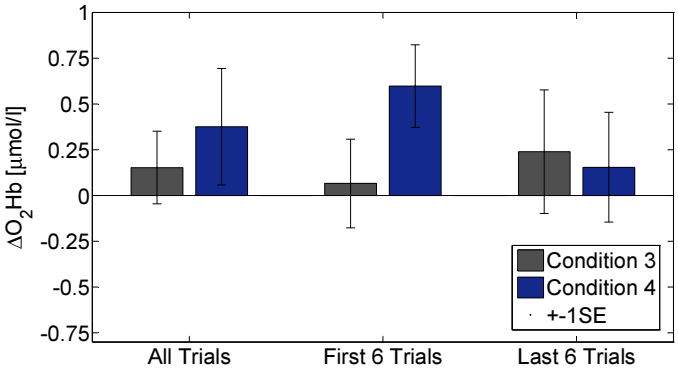

(b) Mean Oxy-Haemoglobin densities for Conditions 3 and 4 over all trials, over the first 6 trials and over the last 6 trials. The error bar on top of the mean density bars represents +- 1 standard error

Fig. 4. Oxy-Haemoglobin data from Subject 2.

II. Results

We observed a higher mean $\Delta[O_2Hb]$ density during the stimulation period than during the rest period for conditions 1, 2 and 4 in Subject 1 and conditions 2, 3 and 4 in Subject 2 (Figures 3 and 4). The activation changes in condition 2 tended to be higher than in condition 1 and also higher in condition 4 than in condition 3. However, the mean $[\Delta O_2Hb]$ values between the conditions were not found to be significantly different (One-way ANOVA test for both subjects individually and also averaged over both subjects). To investigate possible within-condition adaptation effects, we also split the data into the first 6 trials (adaptation phase) and the last 6 trials of each condition block. The results indicate differences between the first 6 and last 6 trials, although data was not statistically different.

III. Discussion

Our preliminary data suggests higher activations for conditions with a bigger movement range of the virtual finger. Additionally we found a possible within-condition adaptation effect. These findings suggest that manipulation of visual feedback may be useful for influencing cortical activity. Future work will focus on increasing the number of test subjects and adding further control conditions.

Acknowledgment

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