Cybersickness in Virtual Reality Neurofeedback Trainings

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Introduction: Virtual Reality (VR) serves as a modern and powerful tool to supplement neurorehabilitation, as well as neurofeedback (NF) and brain-computer interface (BCI) applications. To increase user motivation, adherence to training, or enjoyment, VR is increasingly used as visual feedback environment in BCI/NF applications[1]. However, between 20-80%[2] of all the users develop symptoms of cybersickness, such as nausea, oculomotor problems or disorientation during VR interaction. This raises the question of the extent to which cybersickness affects participants in the completion and success of the NF/BCI tasks. Hence, we investigated whether cybersickness inducing VR paradigms influence the success of a NF training task.

Material Methods and Results: 39 participants (mean age: 23.08 years; 51.3% female) had to complete a single electroencephalography (EEG) NF session consisting of seven feedback runs, in which they should increase their SMR (12-15 Hz) power while keeping Theta (4-8 Hz) and Beta (16-30 Hz) power as low as possible. Visual feedback was presented via an HTC Vive Pro VR goggle (see Fig. 1). Half of the participants received visual feedback in a VR environment inducing only slight cybersickness (constant VR). The other half received visual feedback in a varying VR environment, in which the field-of-view, camera angle and movement speed alternately changed, which strongly induces cybersickness. NF success was defined as an increase in SMR power across feedback runs. To investigate sickness, the simulator-sickness questionnaire (SSQ) had to be filled out before and after the session, furthermore the heart rate was acquired as an objective measure of sickness.

The results of a 2x2 ANOVA (factors group and early vs. late SMR) showed that in both, the constant and the varying VR environment, participants could increase their SMR power across the feedback runs ($F(1,36) = 9.11$, $p = .005$, $\eta_p^2 = .202$, see Fig. 2), but there were no group differences ($F(1,36) = 0.05$, $p = .830$). We could also show that sickness symptoms as assessed with the SSQ (2x2 ANOVA with factors group and pre-post-test) increased in both groups over the training ($F(1,37) = 57.10$, $p < .001$, $\eta_p^2 = .509$), but again there were no significant group differences ($F(1,37) = 0.82$, $p = .372$). The varying VR environment only led to descriptively higher SSQ values ($M = 40.31$, $SD = 24.43$) compared to the constant condition ($M = 31.70$, $SD = 33.49$). However, participants in the cybersickness inducing environment (varying VR) showed a higher (2x2 ANOVA with the factors group and early vs. late heart rate) heart rate across runs compared to the constant VR group ($F(1, 36) = 4.25$, $p = .047$, $\eta_p^2 = .106$), which often is an indicator for cybersickness.[3]

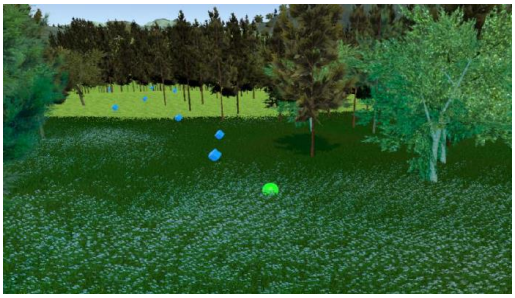

Fig. 1
Neurofeedback paradigm

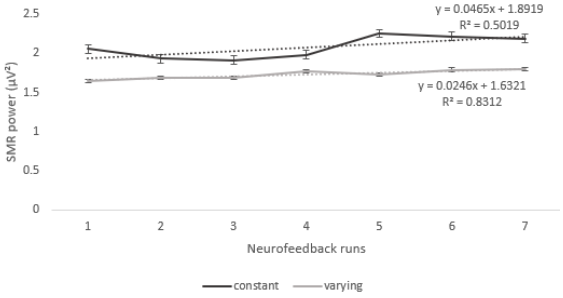

Fig. 2
Mean SMR power during NF training (error bars show SE)

Discussion: Cybersickness did not interfere with the NF success under these specific conditions, even though the cybersickness inducing VR environment (varying VR) resulted in descriptively higher sickness symptoms compared to the constant VR environment.

Significance: Showing that sickness symptoms in VR do not necessarily impair NF/BCI training success takes us one step further in evaluating the practicability of VR in BCI and NF applications.

References

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