Towards BCIs in stroke rehabilitation: Initial tests with robotic feedback

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Exercising motor imagery (MI) is known to be an effective therapy in stroke rehabilitation, even if no feedback about the performance is given to the user. When providing additional real-time feedback, the Hebbian plasticity can be elicited that is likely to result in an increased cortical plasticity, and has the potential to improve the functional recovery. In this publication a MI based Brain-Computer Interface (BCI) is presented that is linked to a rehabilitation robot (Amadeo, tyromotion GmbH, Austria), giving motoric and haptic feedback to the user. Tests on healthy users were performed that proved the feasibility of controlling the robot via a BCI.

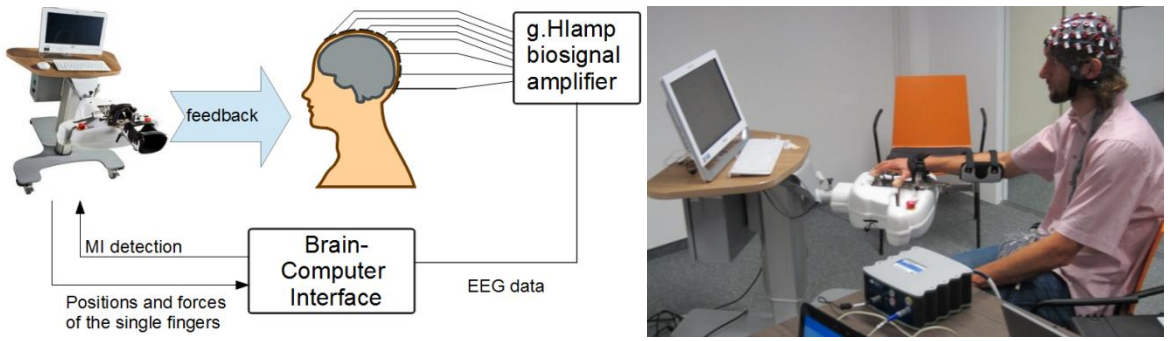

Figure 1: Left: schematic workflow. The device reads the brain signals and sends the classification result to the rehabilitation robot. Right: Photograph of the setup.

Four healthy users participated to the tests. The right hand was fixed in the robot (see Figure 1, right). For MI-classification the method of Common Spatial Patterns was used. The computer screen presented the actual command of performing either left-hand or right-hand MI to the user. If a correct pattern of right-hand MI was detected, the robot performed a complete movement (flexion and extension) of the hand, thus giving online feedback. After a predefined refractory period the robot was ready for the next trigger. Each user performed 120 trials for setting up a classifier and 40 trials for testing the error rate of the previously calculated classifier. One trial lasted 8 seconds the cue appeared after three seconds; the user had then 5 seconds for activating the robotic feedback.

Table 1: error rates of the performed sessions

Session #	Minimum error rate (%)	Average error rate (%)
1	7,50	22,00
2	5,00	13,70
3	31,30	49,50
4	10,00	23,30
mean ± std	13,45 ± 12,07	27,13 ± 15,51

Results are shown Table 1. For each user, the minimum error rate is measured at the single time point during the trials (averaged over 40 trials of the last run) where the control error rate reached the lowest value. Also the average error rate between second five and second eight of the trials was calculated and written into the third column of Table 1. The average error rate proves the good control level users achieve with the device.

Recent control tests with a MI-BCI giving VR-feedback to the user showed only 3% difference in control accuracy, when comparing a group of eleven healthy users versus eleven stroke patients. Hence we expect to gain similar results when testing the robotic feedback with stroke patients, a clinical study that will investigate also the rehabilitation success is currently under development.