BRAINLOOPS PROJECT: BRAIN-COMPUTER FMRI INTERFACE FOR ENHANCING VISUAL-CONCEPTUAL LEARNING

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Background: Our project aims to facilitate brain anatomy learning via an adaptive tutorial based on real-time brain-computer interface (BCI). Using high-field 7T fMRI, we pursue patterns of brain activity that reliably predict the learning of association between a visual pattern (animated brain structure) and a numerical identifier. The tutorial will adapt the frequency of presentation of the to-be-learned items depending on real-time processing of the fMRI data. Thus, if the presentation of a specific item does not elicit a neural pattern, which predicts successful long-term learning, the learner will have more opportunities to encode this item.

Aims:
1) Identifying fMRI patterns that reliably predict long-term learning;
2) Designing and validating an adaptive BCI tutorial.

Method: The tutorial included 6 learning runs with training and testing sessions. In each run, 8 short video clips were presented. A brightness detection task was used as an active baseline. The testing phase included the following conditions: Multiple-choice test, certainty level assessment, and correctness feedback. The participants completed a final examination of all 24 learned items outside of the scanner. An identical examination design was administered after 7 days.
Neuroimaging data were collected during the learning phase using a 7T MRI scanner (Magnetom 7T Siemens, Erlangen, Germany) located at the Maastricht University. 32-channel head array coil (Nova Medical Inc.; Wilmington, MA, USA). Data were preprocessed using Brainvoyager QX version 20.4.0.
We performed a support-vector machine analysis to predict the participant's answer. Voxelwise difference beta values for the contrast CLIP-BASELINE were used as features in this analysis. The model was trained on randomly selected data from 80% of the runs and tested on the left-out data (fixed effect).

Preliminary results: The accuracy of the participants' answers was above chance level (16.7%) in the final examination and the follow-up exam. On average, the participants correctly replied to 62.5±9.46, 57.5%±14.38%, and 52.2%±21% of the questions, respectively. The average certainly levels were 56.77%±7%, 48.75%±4.51%, and 42.28±9.16, respectively. The average accuracy of the prediction that was based on the fMRI models was 64.02%±6.93% and 71.41%±6.08% in the final and the follow-up, respectively.

Conclusions: Our preliminary findings indicate the feasibility of predicting learning. Therefore, we believe that BCI, which is based on the resulting models could improve long-term learning.

Keywords: Brain-computer interface, Learning, Machine learning, Neural decoding

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