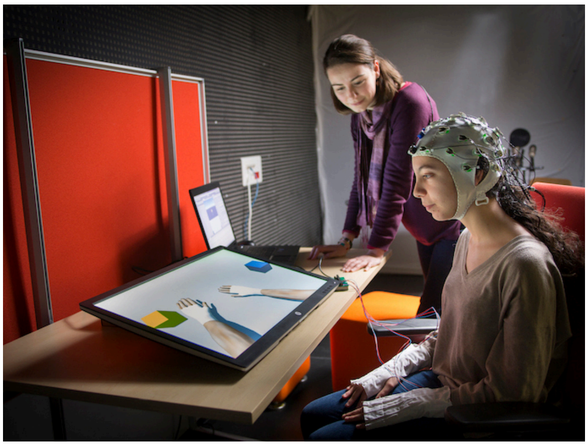
Boosting Brain-Computer Communication with high Quality User Training

Results in Brief

Tailored training improves effectiveness of brain-computer interfaces

BrainConquest's training methods, which enabled a tetraplegic user – unfamiliar with brain-computer interfaces – to reach high levels of proficiency, could benefit a range of motor-impaired users or those undergoing rehabilitation.

DIGITAL ECONOMY



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Brain-computer interfaces (BCIs) translate brain activity, typically electroencephalography (EEG) signals, into commands for interactive applications, such as assistive technologies.

This could enable the motor-impaired, for example, to control speaking/spelling devices or wheelchairs through brain activity, as their EEG signals, generated when thinking of movement (e.g. left or right hand), are translated into device actions.

Yet, BCIs are still rarely used outside laboratories, mainly because they are too unreliable.

"Improvements typically focus on tweaking the technology, but controlling a BCI is a skill that can be taught," explains project coordinator of the European Research Council funded BrainConquest project, Fabien Lotte. "As with most skills, ability varies widely, and it is not well understood why some users seem better at controlling BCIs than others."

After studying how users learn to control BCIs, BrainConquest developed models and learning principles to inform the first tailored training package in this field.

“We home-trained Wilfred, a tetraplegic BCI user participating in the 2019 Cybathlon BCI series competition. Though we didn’t win, he did help us unexpectedly identify a new type of BCI learning, where users adapt to the expectations of BCI algorithms, rather than having to produce ever more distinct EEG signals,” says Lotte.

The project has already received widespread recognition with various awards, including the USERN Prize 2022, the Neuroergonomics Conference 2021 Young Investigator Award and a 2022 Open Science honourable mention for Open Source Research Software.

The project’s technical assets are freely available through the open-source BCI software platforms OpenViBE and BioPyC.

User learning modelling

Computational modelling helped the project develop their training approach.

Modelling found that users with more stable patterns of motor brain activity at rest were better at motor BCI control. Moreover, user performance could be predicted based on the characteristics of the EEG patterns used by BCI algorithms, such as which brain areas are used most.

While inferring users’ mental states from EEG signals, such as their ‘movement intention’ or ‘workload’, is how BCIs work, BrainConquest went further.

“For the first time, we also estimated attention or curiosity types, such as sustained or divided, from their EEGs, giving us further insights into learning modes,” adds Lotte.

Modelling also analysed actual BCI learning, to observe how training influenced BCI control. EEG patterns were measured as users undertook tasks and received different types of feedback. The system identified which user profiles benefited from which feedback type.

The project found that multimodal feedback – a combination of vibrotactile and visual feedback, social feedback (with an artificial learning companion) or biased feedback (convincing users their BCI control is better or worse than in reality) – is key to improved performance.

“We saw first-hand the importance of personalised training; BCI users learn differently. For instance, users who prefer group work will improve with our artificial learning companion; those who prefer working alone, obviously won't," explains Lotte.

Expanding the scope

The team is currently applying their results to post-stroke rehabilitation, where patients can stimulate brain plasticity in their damaged brain areas, thanks to motor BCI-based feedback training.

"We still lack an overall theory of BCI use; BrainConquest's user training is only one component. My new project, Proteus, will study the EEG variability and BCI control performance, between and within users, to develop algorithms more suited to variabilities," concludes Lotte.

Additionally, with international partners, Lotte recently started involvement in two other projects: using BCI to monitor user experience in virtual museums, BITSCOPE, and BCI to detect intraoperative awareness, when patients wake up during surgery, BCI4IA.

Keywords

BrainConquest
brain-computer interface
BCI
EEG
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assistive technologies
stroke
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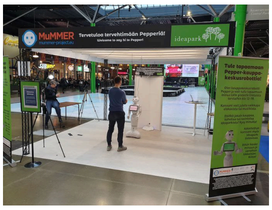

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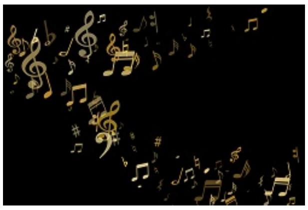

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BrainConquest

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