Impact de la stimulation cérébrale transcrânienne sur l'apprentissage d'un jeu vidéo

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Introduction

La tRNS (transcranial Random Noise Stimulation) est une technique de neuromodulation relativement récente consistant à envoyer un faible courant alternatif d'intensité aléatoire au niveau du scalp afin de moduler la plasticité cérébrale. Cette technique potentialise en théorie les effets d'entraînements cognitifs (Elmasry et al., 2015). L'objectif de cette étude a été de tester les effets de la tRNS sur l'apprentissage d'un jeu vidéo mettant en jeu les fonctions exécutives.

Méthode

Dix participants (23,8 ± 5,6 ans ; 4 femmes) ont été recrutés et répartis en deux groupes de 5 (tRNS *vs* SHAM). Chaque participant a effectué 6 séances de 20 mn de jeu vidéo *Space Fortress* (Fig. 1, Mané & Donchin, 1989). La performance était mesurée via le score obtenu à l'issue du jeu. Trois séances d'évaluation (référence, court-terme et long-terme) et trois séances d'entraînement avec stimulation tRNS (1 mA) du cortex préfrontal dorsolatéral droit ont été réalisées (Fig. 2).

Résultats

Nos résultats n'ont pas montré de différence entre les deux groupes pour l'apprentissage et pour l'évaluation à court-terme. En revanche, le groupe tRNS a obtenu de meilleures performances lors de l'évaluation à long-terme ($p < 0,05$; d de Cohen = 1,55 ; Fig. 3).

Discussion

Bien que notre échantillon constitue une limite, ces résultats préliminaires sont en faveur d'un apport de la tRNS lorsqu'elle est appliquée pendant l'entraînement, avec un meilleur maintien des acquis de cet apprentissage sur le long-terme. Ce résultat est en accord avec d'autres études ayant montré un gain dans le maintien des apprentissages, aussi bien cognitifs et moteurs avec d'autres outils de stimulation cérébrale (Enriquez-Geppert et al., 2013). En conclusion, la tRNS apparaît être une technique intéressante pour stimuler la plasticité cérébrale, et nos résultats soulignent l'impact que pourrait avoir la tRNS sur les apprentissages longs.

Références

- Elmasry, J., Loo, C., & Martin, D. (2015). A systematic review of transcranial electrical stimulation combined with cognitive training. *Restorative neurology and neuroscience*, *33*(3), 263-278.
- Enriquez-Geppert, S., Huster, R. J., & Herrmann, C. S. (2013). Boosting brain functions: Improving executive functions with behavioral training, neurostimulation, and neurofeedback. *International Journal of*
- Mané, A., & Donchin, E. (1989). The space fortress game. *Acta psychologica*, *71*(1-3), 17-22.

A Matlab GUI to optimize features selection with OpenViBE

Juliana González Astudillo, Marie-Constance Corsi, Laurent Hugueville et Fabrizio De Vico Fallani.

In the last years many softwares have been developed to design EEG-based brain-computer interfaces (BCIs). One of the most widely used is OpenViBE [1] , [2] due to its flexibility in handling the processing pipeline. In motor imagery (MI)-based BCIs, the features selection is based on spatial patterns and frequency bands. To ensure the best discrimination between mental states, those features must be adjusted to the target exercise and, most importantly, to the subjects' specificity e.g. in terms of spectral patterns [3] and adopted strategies [4] .

The OpenViBE features selection block relies on two fixed channels (C3 and C4) within the α-β frequency range [5] . Thus, we could miss relevant information since these features might not be the most appropriate for the target subject. To address this issue, we developed a Matlab-based GUI to find the features that best differentiate two mental states. For that purpose, the coefficient of determination, r^2 , is computed between classes as a function of frequency and channels to elicit the most suitable features.

We finally tested the usefulness of the developed GUI on an OpenViBE dataset and on EEG recordings from a MI BCI experiment performed in our laboratory. For the first dataset, r^2 values suggested that there was a possible finer selection compared to the default one. Channel CP4 showed a more remarkable difference between conditions. Notably, selecting its associated features threw better accuracy (70%) than the combination of C3 and C4 (63%). We obtained similar results when we considered our experimental data. The strongest features differed from the fixed ones, giving 92% accuracy for r^2 selection (in this case, C3 and CP4) and 85% for the OpenViBE selection. These results demonstrate the usability of our developed tool as an OpenViBE complement for MI protocol.

References

. [1] Y. Renard *et al.* , "OpenViBE: An Open-Source Software Platform to Design, Test and Use Brain-Computer Interfaces in Real and Virtual Environments," *Presence Teleoperators Virtual Environ.* , vol. 19, no. 1, pp. 35–53, Apr. 2010.

. [2] F. Lotte, L. Bougrain, and M. Clerc, "Electroencephalography (EEG)-based Brain-Computer Interfaces," p. 44, 2015.

. [3] V. Attina, E. Maby, R. Bouet, J. Gibert, J. Mattout, and O. Bertrand, "The importance of individual features for motor-imagery based BCI," presented at the 4th International Brain-Computer Interface Workshop and Training Course, 2008.

. [4] C. Neuper, R. Scherer, M. Reiner, and G. Pfurtscheller, "Imagery of motor actions: differential effects of kinesthetic and visual-motor mode of imagery in single-trial EEG," *Brain Res. Cogn. Brain Res.* , vol. 25, no. 3, pp. 668–677, Dec. 2005.

. [5] G. Pfurtscheller and C. Neuper, "Motor imagery and direct brain-computer communication," *Proc. IEEE* , vol. 89, no. 7, pp. 1123–1134, Jul. 2001.

DESIGN AND PRELIMINARY STUDY OF A NEUROFEEDBACK PROTOCOL TO REDUCE DROWSINESS

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NeuroFeedback (NF) consists in using electroencephalographic (EEG) measurements to guide users to perform a cognitive learning using information coming from their own brain activity, by means of a real- time sensory feedback (e.g., visual or auditory)[4].

Many NF approaches have been studied to improve attentional abilities, notably for Attention Deficit Hyperactivity Disorder [1, 2]. However, to our knowledge, no NF solution has been proposed to specifically reduce drowsiness.

Thus, we propose a complete EEG-NF solution to train users to self-regulate an EEG marker of drowsiness. This marker is based on a ratio of beta over theta/alpha power in Cz electrode. In addition to this EEG marker of drowsiness, we also carefully selected and designed the duration, the sequencing, the objective evaluation metrics and the visual and audio feedback to use in for each NF session.

Preliminary study with five healthy subjects showed that three of them could learn to self-regulate this EEG marker with a relatively short number of NF sessions (up to 8 sessions of 40 min). Clinical trials with sleep-deprived subjects are expected to begin in 2019 to study possible cognitive and clinical benefits of this self-regulation. The implementation of this NF solution is available for free[1], with the OpenViBE platform [3], under the AGPL-3.0 license.

References

[1] Micoulaud-Franchi J.-A., Geoffroy P. A., Fond G., Lopez R., Bioulac S., Philip P. EEG neurofeedback treatments in children with ADHD: an updated meta-analysis of randomized controlled trials. Frontiers in Human Neuroscience. 2014;8.

[2] Micoulaud-Franchi J.-A., McGonigal A., Lopez R., Daudet C., Kotwas I., Bartolomei F. Electroencephalographic neurofeedback: Level of evidence in mental and brain disorders and suggestions for good clinical practice. Neurophysiologie Clinique/Clinical Neurophysiology. 2015;45(6):423–433.

[3] RenardY.et al.OpenViBE:AnOpen-SourceSoftwarePlatformtoDesign,TestandUseBrain-Computer Interfaces in Real and Virtual Environments. Presence: Teleoperators and Virtual Environments. 2010;19(1):35– 53.

[4] Sitaram R. et al. Closed-loop brain training: the science of neurofeedback. Vol. 18. Nature Reviews Neuroscience. Nature Publishing Group, 2016.

[1]https://github.com/tmonseigne/NEUROPERF

Technologie Interface Cerveau Ordinateur pour l'Autonomie: Design ergonomique d'un casque EEG

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Dans le cadre d'un axe de recherche transversal INRIA Sophia-Antipolis-CHU de Nice sur les ICO, il a récemment été démontré qu'un prototype de P300 Speller développé par l'INRIA permet une communication alternative efficace chez des patients en situation de handicap (SLA) [1]. Pour être adapté à une utilisation quotidienne répétée et/ou de longue durée par des personnes en situation de handicap moteur lourd avec déficit du tonus cervical obligeant un appui occipital (voir Fig.1), le prototype de P300 Speller doit évoluer vers un système d'acquisition simple et ergonomique [2]. Bien que divers systèmes soient actuellement disponibles sur le marché, ils ne répondent pas ou tr´es peu a` l'hétérogénéité des utilisateurs, a` l'adaptabilité nécessaire aux capacités physiques et a` l'environnement parfois encombré d'appareils médicaux lourds pouvant créer des interférences comme par exemple la ventilation sur trachéotomie. Le projet actuel a pour but de développer un casque EEG sans fil, avec un nombre d'électrodes adapté [2]-[3] pour garantir a` la fois la qualité du signal et le confort, utilisant des électrodes sèches (voir Fig.2) alliant ainsi une répartition homogène de la pression de contact scalp-électrode [4] et une pénétration de différents types de cheveux afin de minimiser les artefacts présents sur les technologies d' électrodes sèches. Au cœur des objectifs du design se trouve l'alliance de fonctionnalité et d'esthétisme, soit être léger, confortable et personnalisable, nécessitant ainsi l'utilisation de matériaux adaptés pour un bon maintien sur différentes morphologies de tête et une pression optimale sur les électrodes [5]. Ce projet justifie donc une approche transversale regroupant plusieurs domaines de compétence : mécanique des matériaux et électronique (ingénieur mécatronicien), analyse du signal et adaptation des logiciels (INRIA) et expertise dans le domaine du handicap (CHU).

Figure 1: Test étude préliminaire, textile waveguard original caps ANT B.V (Enschede, Netherlands) et électrodes à gel, plis induits par posture SLA

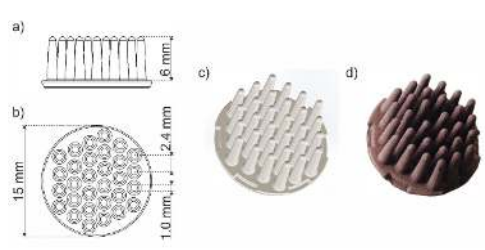

Figure 2: Illustration d'une électrode sèche multi-pins, polyurethane dureté Shore A98 (ANT B.V), avec dimensions

References

. [1] Violaine Guy, Marie-Helene Soriani, Mariane Bruno, Theodore Papadopoulo, Claude Desnuelle, and Maureen Clerc. “Brain computer interface with the P300 speller: usability for disabled people with amyotrophic lateral sclerosis”. In: Annals of physical and rehabilitation medicine 61.1 (2018), pp. 5–11.

. [2] Michael T McCann, David E Thompson, Zeeshan H Syed, and Jane E Huggins. “Electrode subset selection methods for an EEG-based P300 brain-computer interface”. In: Disability and Rehabilitation: Assistive Technology 10.3 (2015), pp. 216–220.

. [3] Yuki Ijichi and Hisaya Tanaka. “Electrodes arrangement on brain-computer interface for the ALS’s posture”. In: 2016 IEEE International Conference on Systems, Man, and Cybernetics (SMC). IEEE. 2016, pp. 004712–004715.

. [4] Patrique Fiedler et al. “Contact pressure and flexibility of multipin dry EEG electrodes”. In: IEEE Transactions on Neural Systems and Rehabilitation Engineering 26.4 (2018), pp. 750–757.

. [5] Daniël Lacko. “The application of 3D anthropometry for the development of headgear: a case study on the design of ergonomic brain-computer interface devices”. PhD thesis. University of Antwerp, 2017.

Leveraging BCI performances with the integration of connectivity and local features

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In brain-computer interfaces (BCI), the detection of different mental states is a key element. In Motor Imagery (MI)-based BCIs, the considered features typically rely on the power spectral density (PSD) of the control brain signals, but alternative features can be explored looking for better performance. One possibility is the integration of functional connectivity (FC) [1]. These features quantify the interactions between different brain areas that could represent a valuable tool to detect differences between two mental conditions. Here, we investigated the behavior of coherence-based FC features and PSD features, alone and in combination [2].

For a better comparison, we characterized the network centrality of each brain area by computing the weighted node degrees from the estimated FC networks [3]. To classify the subjects' mental state, we used the linear discriminant analysis (LDA) method Our classifier operates on single subject, single frequency bin and single channel. For each subject, we selected the best value in terms of classification performances (e.g. accuracy) comprised in the central left area. The best accuracy value is associated with a given (electrode; frequency bin) couple. Our results showed that alpha and beta frequency bands are usually more involved during the task. In fact, the accuracy obtained in those bands are higher. Another interesting result is that the fusion between connectivity feature and a local one gives higher accuracy for the majority of the subject, for 12 over 15. This means that the integration of features reflecting different brain mechanisms can be useful for the discrimination of different mental states [4].

Références

[1]Hamedi, Mahyar, Sh-Hussain Salleh, and Alias Mohd Noor. "Electroencephalographic motor imagery brain connectivity analysis for BCI: a review." *Neural computation* 28.6 (2016): 999-1041.

[2]Ruta, Dymitr, and Bogdan Gabrys. "An overview of classifier fusion methods." *Computing and Information systems* 7.1 (2000): 1-10.

[3]De Vico Fallani, Fabrizio, et al. "Graph analysis of functional brain networks: practical issues in translational neuroscience." *Philosophical Transactions of the Royal Society B: Biological Sciences* 369.1653 (2014): 20130521.

[4]Corsi, M. C., et al. "Integrating EEG and MEG Signals to Improve Motor Imagery Classification in Brain-Computer Interface." *International journal of neural systems* (2018): 1850014-1850014.

Towards Measuring states of curiosity through Electroencephalography and body sensors responses

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The neurophysiological mechanisms underlying curiosity and intrinsic motivation are currently not well understood. However, being able to identify objectively, from neurophysiological signals, the curiosity level of a user, would bring a very useful tool both to neuroscientists and psychologists, to understand curiosity deeper, as well as to designers of human-computer interaction, in order to trigger curiosity or to adapt an interaction to the curiosity levels of its users. A first step to do that, is to collect neurophysiological signals during known states of curiosity, in order to develop signal processing/machine learning tools to recognize those states from such signals.

We propose an experimental protocol, that has been designed but has not been tested so far, in order to measure both brain activity through Electroencephalography (EEG) and physiological responses (heart rate, skin conductance, Electrocardiogram) when subjects are induced into different states of curiosity. During the experiment, fun facts will be presented to subjects to induce different levels of curiosity. We obtained those fun facts using the Google functionality "I'm feeling curious" as well as crowdsourcing. A subject will be able to choose a fun fact that makes him curious, and push forward with a 4-to-10 questions chain on this theme. For each question on a given theme, a subject will be able to reveal the answer (interpreted as a curious state) or to skip it (interpreted as a non-curious state). Skipping an answer will automatically break the chain and will point the subject to the next fun fact. Neurophysiological signals will be collected between a question and the choice of revealing the answer. Then the subject will grade the question on a 1-to-7 curiosity level scale. Neurophysiological measures during these states of curiosity will be recorded and we expect to find biological markers of curiosity by analyzing such information.

Towards a low-cost EEG band to induce Lucid Dream.

Morgane Hamon, Emma Chabani, Philippe Giraudeau

Lucid dreaming (LD) is a phenomenon during which the person is aware that he/she dreaming and is able to control the dream content (Laberge, 1985). Studies have shown that only 20% of people can experience lucid dreams on a regular basis (Snyder & Gackenbach, 1988). However, LD frequency can be increased through induction techniques (LaBerge 1988). External stimulation technique relies on the ability to integrate external information into the dream content (Dement and al. 1958). The aim is to remind the sleeper that she/he is dreaming. If this type of protocol is not fully efficient, it demonstrates how sensorial stimuli can be easily incorporated into people's dreams (Paul and al. 2014). The objective of our project was to replicate this induction technique using material less expensive and more portable. This material could simplify experimental procedures. Participants could bring the material home, then have a more ecological night. First, we used the OpenBCI cython, a low-cost EEG signal acquisition board in order to record and manually live- score sleep. Then, we designed a mask containing two LEDs, connected to a microcontroller to flash visual stimulation during sleep. We asked two volunteers to sleep for 2 hours in a dedicated room. One of the participants declares having a dream during which the blue lights diffused by the mask were embedded into the dream environment. The other participant woke up during the visual stimulation. These results are congruent with previous studies (Paul and al. 2014). This work marked the first step of a larger project. Our ongoing research includes the use of an online sleep stage scoring tool and the possibility to automatically send stimuli according to the sleep stage. We will also investigate other types of stimulus induction in the future such as vibro-tactile stimulation that showed great potentials (Stumbrys and al. 2012).

Keywords: Lucid Dream, Induction techniques, Sleep, Visual stimulation, Low-cost EEG

Do experimenters have an influence on MI-BCI user training?

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Throughout MI-BCI studies, human supervision plays a central role [7]. While providing emotional and social feedback [5], experimenters present the technology to users and ensure their smooth progress with BCI use. Though, very little is known about the influence experimenters might have on the obtained results. Literature from different fields such as ethics and business [3], social research [6] or economic research [9] indicate an effect of experimenters, and specifically their gender, on experimental outcome. Such an effect was recently suggested in neurofeedback training [8]. Yet, it had never been tested in BCI.

We investigated the potential influence of the experimenters' gender depending on the participants' gender on MI-BCI performances and progress, i.e., the evolution of performances. Six experimenters (3 men / 3 women) trained 59 randomly assigned healthy MI-BCI naïve participants they did not know (30 men / 29 women) during one MI-BCI session (following the Graz protocol [4]) during which they had to learn to perform two MI-tasks, i.e., imagine right or left hand movements.

Our results suggest that, overall, women experimenters seem to influence positively participants' performances compared to men experimenters, more precisely they seem to induce better Quality-Weighted Accuracy performance (a metric considering the classifier output that participants were instructed to improve, inspired by the SensoriMotorRhythm quality score [1]) for both men and women participants.

Further analysis are needed regarding other variables that might influence or provide insights on our results, e.g. traits, state, experimenters' teaching competence, subjects' motivation or quantity and quality of interaction between participants and experimenters. There might also be other analysis to perform based on different performance metrics reflecting user performances independently of the classifier output [2]. Taking experimenter-related factors into account might lead to a conjoint progress of the global BCI performance and the validity and understanding of BCI experimental results.

References

1. Grosse-Wentrup, M., & Schölkopf, B. (2012). High gamma-power predicts performance in sensorimotor-rhythm brain-computer interfaces. Journal of neural engineering, 9(4), 046001.
2. Lotte F, Jeunet C. Defining and quantifying users' mental imagery-based BCI skills: a first step. Journal of neural engineering. 2018;15(4):046030.
3. Miyazaki AD, Taylor KA. Researcher interaction biases and business ethics research: Respondent reactions to researcher characteristics. Journal of Business Ethics. 2008;81(4):779-795.
4. Pfurtscheller G, Neuper C. Motor imagery and direct brain-computer communication. Proceedings of the IEEE. 2001;89(7):1123-1134.
5. Pillette L, Jeunet C, Mansencal B, N'Kambou R, N'Kaoua B, Lotte F. Peanut: Personalised emotional agent for neurotechnology user-training. In: 7th International BCI Conference, 2017.
6. Rosnow R, Rosenthal R. People studying people: Artifacts and ethics in behavioral research. WH Freeman, 1997.
7. Sexton CA. The overlooked potential for social factors to improve effectiveness of brain-computer interfaces. Frontiers in systems neuroscience. 2015;9:70.
8. Wood G, Kober SE. EEG Neurofeedback Is Under Strong Control of Psychosocial Factors. Applied psychophysiology and biofeedback. 2018;43(4):293-300. [9] Zizzo DJ. Experimenter demand effects in economic experiments. Experimental Economics. 2010;13(1):75-98.

THE USE OF HAPTIC FEEDBACK IN BRAIN COMPUTER INTERFACES AND NEUROFEEDBACK

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KEYWORDS: Neurofeedback, BCI, Haptic Feedback, EEG, fMRI, Multisensory, BMI, touch.

BACKGROUND

NF and BCI are promising approaches in different areas. These approaches are based on the recording of the cerebral activity associated with the requested task and the presentation of a feedback. This feedback can be in a visual, auditory [1][2] or tactile form [3]. Today, the use of visual feedback in a BCI/NF study is very common, but its use may seem questionable. For example, a visual feedback is not suitable for impaired visual system or during a mental motor imagery task; in this case, a haptic feedback would seem more appropriate. It has also been reported to feel more engaging than visual feedback [4], which could improve the sense of agency. Haptic BCI/NF could be a promising alternative for the design of the feedback and potentially improve the clinical efficacy of NF.

OBJECTIVE

The first aim of this survey is to provide a status report regarding advances in haptic based BCI/NF. The second goal is to recognise problematics that require further investigation and to recommend directions for future research in this area. We reviewed 15 articles from January 2007 to December 2018.

METHODS

We provide an overview of the existing design of haptic based BCI/NF in various applications. Applications related to haptic feedback are multiple: one of the most common uses of applying haptic in a clinical BCI/NF setting is rehabilita- tion training in patients with stroke.

CONCLUSION

Since the first haptic BCI/NF study in 2007 by Cincotti [4] and the first pilot study with patients by Buch [5] in 2008, several studies haptic based BCI/NF have been conducted. A critical review of these studies could contribute to gain knowledge and converge on the effectiveness of haptic feedback in general. It is important to highlight the evolution of the BCI/NF community on the interest of different sensory feedback other than visual.

REFERENCES

[1] Nijboer F, Furdea A, Gunst I, *et al*. An auditory brain–computer interface (BCI). Journal of Neuroscience Methods. 2008;167(1):43–50.
[2] Robineau F, Saj A, Neveu R, Van De Ville D, Scharnowski F, Vuilleumier P. Using real-time fMRI neurofeedback to restore right occipital cortex activity in patients with left visuo-spatial neglect: proof-of-principle and preliminary results. Neuropsychological Rehabilitation. 2017:1–22.
[3] Murguialday A, . . . VA, 2007 I, 2007 U. Brain-computer interface for a prosthetic hand using local machine control and haptic feedback. ieeexplore.ieee.org. 2007.
[4] Cincotti F, Kauhanen L, Aloise F, *et al*. Vibrotactile feedback for brain-computer interface operation. Computational intelligence and neuroscience. 2007;2007:48937.
[5] Buch E, Weber C, Cohen LG, *et al*. Think to move: a neuromagnetic brain-computer interface (BCI) system for chronic stroke. Stroke. 2008;39(3):910–7.

Towards a new passive Brain-computer interface to detect accidental awareness during general anesthesia

Sébastien Rimbert, Nathalie Gayraud et Laurent Bougrain.

Introduction : Accidental Awareness during General Anesthesia (AAGA) occurs in 1-2% of high-risk practice patients and is responsible for severe psychological trauma, termed post- traumatic stress disorder (PTSD) [1, 2]. Currently, monitoring techniques have a limited accuracy in the prediction or detection of AAGA [3]. Since the first reflex for a patient experiencing AAGA is to move, a passive Brain-Computer Interface (BCI) based on the detection of an intention of movement would be conceivable to alert the anesthetist and prevent this phenomenon [4]. However, the way in which the propofol affects the motor brain activity and is reflected by the electroencephalographic (EEG) signal has been poorly investigated and is not clearly understood.

Methods : We analyzed the EEG signal (128 sensors) of 4 healthy volunteers during several motor tasks and under 3 propofol concentration (0 µg.ml, 0.5 µg.ml, and 1 µg.ml).

Results : The main objective of this study was to investigate how the EEG signal of the motor cortex was modulated with increasing sedation of propofol. Results indicated few variations in terms of ERDs and ERSs for each motor task, suggesting that intention to move can be detected under propofol.

The second goal was to verify that a passive BCI could detect the intention of movement, even when the subject is under propofol. Our results confirm that a state-of-the-art BCI can discriminate MI vs Rest under propofol. Indeed, classification accuracies are better for 3 out of 4 subjects.

We also proposed to use a median nerve stimulation as a routine procedure and classify MNS vs MNS+MI to detect an intention of movement during a general anesthesia. Our results are consistent with those previously announced: the classification is not impacted by propofol sedation, highlighting that this technique can be used to detect accidental awareness during general anesthesia.

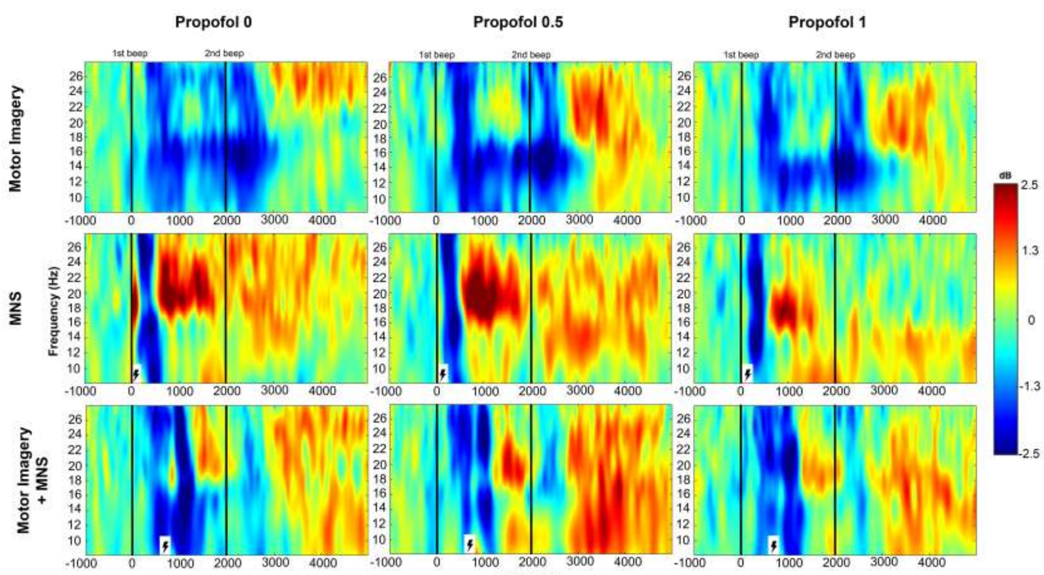

Figure 1 Time-frequency grand average analysis (ERSP) for MI, MNS and MI+MNS motor tasks under 3 propofol concentrations (0 µg.ml, 0.5 µg.ml and 1 µg.ml) for electrodeC3. Black lines indicate when the motor task started and finished. Red color corresponds to a strong ERS and blue to a strong ERD.

References

[1] P. Sebel, T. Bowdle, M. Ghoneim, I. Rampil, R. Padilla, T. Gan, and K. Domino, “The incidence of awareness during anesthesia: a multicenter united states study.” Anesth Analg , vol. 99, no. 3, pp. 833– 9, 2004.

[2] K. MacGregor, “A waking nightmare: how can we avoid accidental awareness during general anaesthesia?” J Perioper Pract , vol. 23, no. 9, pp. 185–90, 2013.

[3] S. Tasbighou, M. Vogels, and A. Absalom, “Accidental awarenessduring general anaesthesia - a narrative review,”Anaesthesia, vol. 73,no. 1, pp. 112–122, 2018.

[4] Y. Blokland, J. Farquhar, J. Lerou, J. Mourisse, G. J. Scheffer, G.-J. van Geffen, L. Spyrou, and J. Bruhn, “Decoding motor responses from the eeg during altered states of consciousness induced by propofol,” Journal of Neural Engineering , vol. 13, no. 2, p. 026014, 2016.

Adaptive stimulus parameter setting for c-VEP BCI

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A code-modulated visual evoked potential (c-VEP) BCI allows for spelling from a keyboard of flashing characters (see Fig.1). All characters flash according to a predefined pseudo-random binary sequence, circular-shifted by a character-dependent time lag. For a given character, the binary sequence evokes a VEP in the EEG of the subject [1], which can be used as a template. This template is obtained during a calibration phase. A c-VEP BCI can potentially achieve a very high-speed communication level [1] and the setting of stimulus parameters is fundamental to obtain a high performing BCI. Many studies investigate different stimuli layout parameters such as the size, color, proximity of the stimuli, different length sequences, different lags between adjacent stimuli [2] and the stimulus presentation rate [3]. Analyzing these studies is clear that it is not possible to define an universal optimal stimulus parameter setting suitable for each BCI user. In this work we design a subject-dependent c-VEP BCI, with four different stimulus presentation rates of 15 Hz, 20 Hz, 30 Hz and 60 Hz (see Fig. 2), in which it is possible to find the optimal stimulus presentation rate per each subject thanks to an adaptive setting parameter phase. This phase takes place at the beginning of each session, it replaces the longer traditional calibration [1], and allows to define the stimulus parameters that are used during the spelling phase. The objective is to find the optimal presentation frequency to obtain a pleasant stimulus per each subject, reaching a high performance and keeping the flash duration unchanged even when stimulus presentation rate is lower of 60 Hz, which is the most common value of frequency rate used in c-VEP BCI. We acquired data from 4 subjects in two sessions. The results obtained for the offline spelling show the variability between subjects and therefore the importance of subject-dependent adaptation of c-VEP BCI.

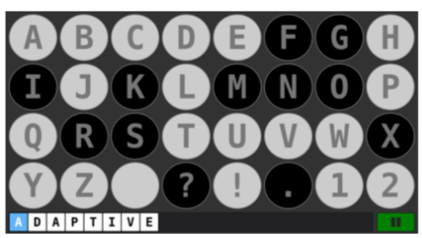

Figure 1: Virtual keyboard. If the bit in the corresponding binary stimulation sequence is 0 the character flickers in light grey, if it is 1 in black.

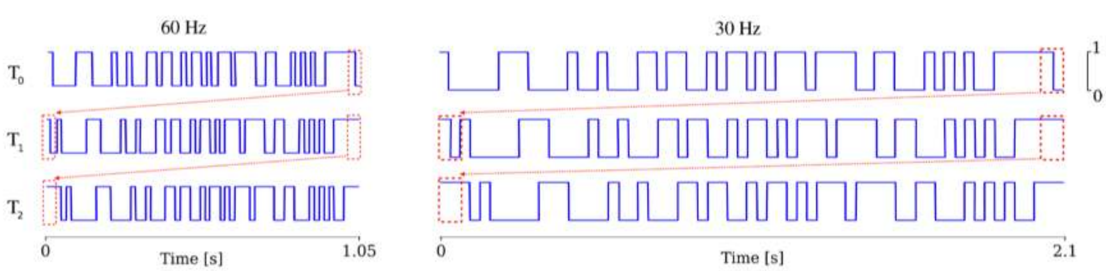

Figure 2: Illustration of the circular-shift process for the stimulus sequence for the first 3 targets, respectively "A", "B" and "C" in the virtual keyboard. On the left, the stimulus sequences have a frame rate of 60 Hz and on the right, a frame rate of 30 Hz. The figure shows the stimulation sequence for the target T0, for the target T1, circularly shifted with a time lag τs with respect to T0 and for the target T2, circularly shifted with a time lag τs with respect to T1.The red dash boxes indicate the time lag τs that depends on the stimulation rate.

References

. [1] G. Bin, X. Gao, Y. Wang, Y. Li, B. Hong, and S. Gao. “A high-speed BCI based on code modulation VEP”. In: Journal of neural engineering 8.2 (2011), p. 025015.

. [2] Q. Wei, S. Feng, and Z. Lu. “Stimulus specificity of brain-computer interfaces based on code modulation visual evoked potentials”. In: PloS one 11.5 (2016), e0156416.

. [3] H. Nezamfar, S.S.M. Salehi, and D. Erdogmus. “Stimuli with opponent colors and higher bit rate enable higher accuracy for C-VEP BCI”. In: 2015 SPMB. IEEE. 2015, pp. 1–6.

Impact of MI-BCI feedback for post-stroke and neurotypical people

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The efficiency of BCI in general and of BCI based post-stroke motor rehabilitation therapy, in particular, depends on the feedback that is provided [2,4]. Feedback arriving to the brain are either extrinsic (information originating from an external source, e.g., a screen or a person) or intrinsic (somatosensory sensations felt by the person during the training). Both types of feedback have proven efficient for healthy participants to control a BCI [3,7] and to promote functional recovery post-stroke [1,5].

Literature indicates that the type of feedback might have an impact on BCI efficiency in terms of performances. For example, an intrinsic somatosensory feedback might be more effective than an extrinsic visual feedback for post-stroke rehabilitation and for neurotypical persons in a multitasking context [3,6]. However, there are no information in the literature regarding the influence that feedback might have over long-term learning. There is also a gap in the literature regarding the potential impact of the profile of the participants, e.g., kinesthetic abilities, on the type of feedback to provide.

In this work our aim is to explore the impact of modality of feedback, as well as users' neurophysiological and psychological characteristics on user experience, BCI performances and neurophysiological markers. To do so, we analyzed the literature and implemented accordingly a MI-BCI with realistic visual and tactile feedback. We also designed protocols for which we plan to include forty neurotypical and post-stroke patients. Each of them will take part in 10 MI-BCI training sessions during about an 1 hour each. Training sessions will differ depending on the type of feedback which is provided, i.e., either a realistic visual feedback alone or the same visual feedback and a tactile feedback in addition.

References

1. Biasiucci, A., Leeb, R., Iturrate, I., Perdikis, S., Al-Khodairy, A., Corbet, T., ... & Viceic, D. (2018). Brain-actuated functional electrical stimulation elicits lasting arm motor recovery after stroke. Nature communications, 9(1), 2421.
2. Grosse-Wentrup, M., Mattia, D., & Oweiss, K. (2011). Using brain-computer interfaces to induce neural plasticity and restore function. Journal of neural engineering, 8(2), 025004.
3. Jeunet, C., Vi, C., Spelmezan, D., N'Kaoua, B., Lotte, F., & Subramanian, S. (2015, September). Continuous tactile feedback for motor-imagery based brain-computer interaction in a multitasking context. In Human-Computer Interaction (pp. 488-505). Springer, Cham.
4. Lotte, F., Larrue, F., & Mühl, C. (2013). Flaws in current human training protocols for spontaneous brain-computer interfaces: lessons learned from instructional design. Frontiers in human neuroscience, 7, 568.
5. Mottaz, A., Corbet, T., Doganci, N., Magnin, C., Nicolo, P., Schnider, A., & Guggisberg, A. G. (2018). Modulating functional connectivity after stroke with neurofeedback: Effect on motor deficits in a controlled cross-over study. NeuroImage: Clinical, 20, 336-346.
6. Ono, T., Shindo, K., Kawashima, K., Ota, N., Ito, M., Ota, T., ... & Ushiba, J. (2014). Brain-computer interface with somatosensory feedback improves functional recovery from severe hemiplegia due to chronic stroke. Frontiers in neuroengineering, 7, 19.
7. Ramos-Murguialday, A., Schürholz, M., Caggiano, V., Wildgruber, M., Caria, A., Hammer, E. M., ... & Birbaumer, N. (2012). Proprioceptive feedback and brain computer interface (BCI) based neuroprostheses. PloS one, 7(10), e47048.