



HAL
open science

Median Nerve Stimulation to Detect Awake and Anesthetized States with Riemannian Classifiers

Valérie Marissens Cueva, Sébastien Rimbart, Ana Maria Cebolla Alvarez, Mathieu Petieau, Viktoriya Vitkova, Iraj Hashemi, Guy Cheron, Claude Meistelman, Philippe Guerci, Denis Schmartz, et al.

► **To cite this version:**

Valérie Marissens Cueva, Sébastien Rimbart, Ana Maria Cebolla Alvarez, Mathieu Petieau, Viktoriya Vitkova, et al.. Median Nerve Stimulation to Detect Awake and Anesthetized States with Riemannian Classifiers. Journées CORTICO 2024 - Collectif pour la Recherche Transdisciplinaire sur les Interfaces Cerveau-Ordinateur, <https://cortico.fr/>, May 2024, Nancy, France. hal-04570975

HAL Id: hal-04570975

<https://hal.science/hal-04570975v1>

Submitted on 3 Jun 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

Median Nerve Stimulation to Detect Awake and Anesthetized States with Riemannian Classifiers

Valérie Marissens Cueva^{1,2}, Sébastien Rimbart¹, Ana Maria Cebolla Alvarez³, Mathieu Petieau³, Viktoriya Vitkova³, Iraj Hashemi³, Guy Cheron³, Claude Meistelman⁴, Philippe Guerci⁴, Denis Schmartz⁵, Seyed Javad Bidgoli⁶, Laurent Bougrain², Fabien Lotte¹

¹Inria Center at Univ. Bordeaux / LaBRI, Talence, France; ²Université de Lorraine, CNRS, LORIA, Nancy, France; ³Laboratory of Neurophysiology and Movement Biomechanics, Université Libre de Bruxelles, Bruxelles, Belgium; ⁴CHRU de Nancy, Vandoeuvre-lès-Nancy, France; ⁵Hôpital Universitaire de Bruxelles - Université Libre de Bruxelles, Bruxelles, Belgium; ⁶CHU Brugmann, Bruxelles, Belgium. E-mail : valerie.marissens@loria.fr

Among all the operations with general anesthesia worldwide, some patients have had the terrible experience of Accidental Awareness during General Anesthesia (AAGA), an unexpected awakening during surgery [1], potentially leading to pain, recall of surgical events and post-traumatic stress disorders [2]. The inability to predict AAGA using only clinical signs, leads to the use of brain activity monitors [3]. Given AAGA patients' first reflex to move, impeded by neuromuscular-blocking agents, we propose using a new Brain Computer Interface (BCI) with Median Nerve Stimulation (MNS) to detect their movement intentions (MI). Combining MI and MNS significantly impacts MNS-generated patterns, leading to better MI detection accuracy. MNS also provides a trigger, resulting in better classification (+18%) compared to asynchronous BCI [4].

To continue in this direction, we analyzed the MNS patterns of 13 patients receiving propofol, an intravenous anesthetic, during surgery at CHU Brugmann, Belgium [5]. Two conditions were examined: EEG activities of preoperative MNS while the patient is awake (MNS-awake), and intraoperative MNS during various stages of anesthesia (MNS-anesthesia). Then, a Riemannian Minimum Distance to the Mean classifier achieved 97% test balanced accuracy in distinguishing awake and anesthetized states. We also observed the classifier's response evolution with anesthesia depth, in terms of distance between the MNS-awake class centroid and covariance matrices of other trials throughout the surgery (Fig. 1). This distance appears to track the patients' awareness level: it is greater during the maintenance phase, at deeper anesthetic concentrations, than during the induction or emergence phases. This holds potential for creating a one-class classifier using this distance, only relying on MNS-awake data, as MNS-anesthesia data are usually unavailable for calibration during regular surgeries.

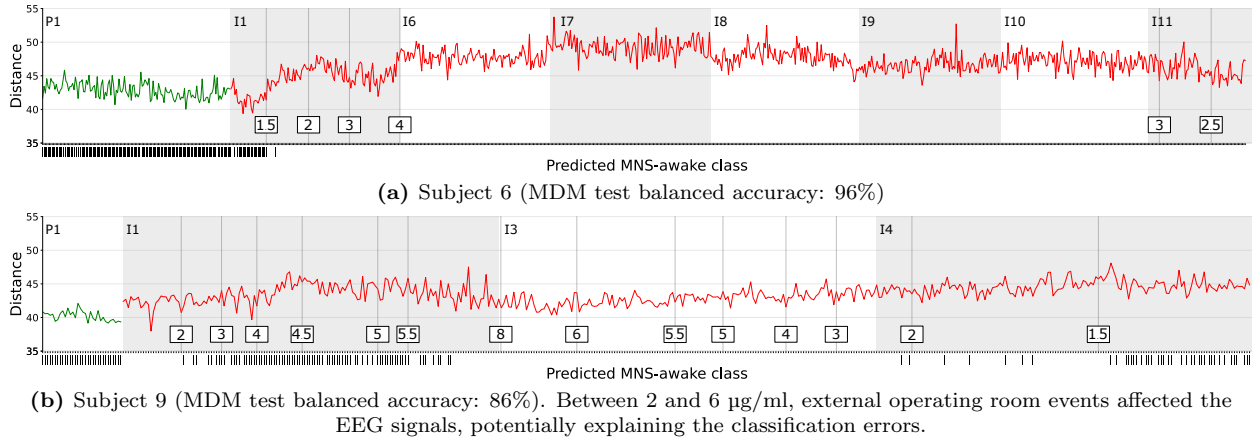


Figure 1: Distances of each test sample to the MNS-awake class centroid. Real labels are presented by colors: green for the preoperative session (MNS-awake) and red for the intraoperative session (MNS-anesthesia). Below, a bar indicates when the classifier predicted MNS-awake. When propofol reaches the target concentration, a gray line with a label indicate the corresponding propofol concentration (in µg/ml). Each run is differentiated by alternating background colors (white, gray), and labeled as preoperative (P) or intraoperative (I) runs.

- [1] Tasbihgou SR, Vogels MF, Absalom AR. Accidental awareness during general anaesthesia – a narrative review. *Anaesthesia*. 2018;73(1):112–122.
- [2] Leslie K, Chan MTV, Myles PS, Forbes A, McCulloch TJ. Posttraumatic stress disorder in aware patients from the b-aware trial. *Anesth. Analg.* 2010;110(3):823–828.
- [3] Bruhn J, Myles PS, Sneyd R, Struys MMRF. Depth of anaesthesia monitoring: what's available, what's validated and what's next? *Br. J. Anaesth.* 2006;97(1):85–94.
- [4] Rimbart S, Riff P, Gayraud N, Schmartz D, Bougrain L. Median nerve stimulation based bci: A new approach to detect intraoperative awareness during general anesthesia. *Front. Neurosci.* 2019;13.
- [5] Rimbart S *et al.* Detection of motor cerebral activity after median nerve stimulation during general anesthesia (stim-motana): Protocol for a prospective interventional study. *JMIR Res. Protoc.* 2023;12:e43870.