



Towards an actor-based model of the neurofeedback/BCI closed-loop

Côme Annicchiarico, Fabien Lotte, Jérémie Mattout

► To cite this version:

Côme Annicchiarico, Fabien Lotte, Jérémie Mattout. Towards an actor-based model of the neurofeedback/BCI closed-loop. CORTICO 2022: Invasive and non invasive Brain-Computer Interfaces – A handshake over the cliff, Mar 2022, Autrans, France. hal-03931224

HAL Id: hal-03931224

<https://inria.hal.science/hal-03931224>

Submitted on 9 Jan 2023

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.

Towards an actor-based model of the neurofeedback/BCI closed-loop

Côme Annicchiarico^{*1}, Fabien Lotte², and Jérémie Mattout¹

¹Centre de recherche en neurosciences de Lyon (CRNL) – Université Claude Bernard Lyon 1, Université de Lyon, Université Jean Monnet [Saint-Etienne], Institut National de la Santé et de la Recherche Médicale : U1028, Centre National de la Recherche Scientifique : UMR5292 – CH Le Vinatier, 95 bd Pinel, bat B13 59 69677 Bron cedex, France

²Inria Bordeaux - Sud-Ouest (INRIA) – Institut National de Recherche en Informatique et en Automatique – 200, avenue de la Vieille Tour, 33405 Talence, France

Abstract

Neurofeedback training describes a closed-loop paradigm in which a Brain-Computer Interface is typically used to provide a subject with an evaluation of his/her own mental states. As a learning process, it aims at enabling the subject to apprehend his or her own latent cognitive states in order to modulate it. Its use for therapeutic purposes has gained a lot of traction in the public sphere in the last decade, but conflicting evidence concerning its efficacy has led to increasing efforts by the scientific community to provide better explanations for the cognitive mechanisms at work.

We intend to contribute to this effort by proposing a mathematical formalization of the mechanisms at play in this (arguably) quite complex dynamical system. Due to the subjective nature of the task, a representation of the subject and experimenter separate beliefs and hypothesis is an important first step to propose a meaningful approximation. We provide a first model of the training loop based on those considerations, introducing two pipelines. The direct pipeline (subject-> feedback) makes use of a coupling between cognitive and physiological states to infer latent cognitive states from measurement. The return pipeline (feedback-> subject) describes how perception of the indicator impacts subject behaviour. To describe the behaviour of an agent facing an uncertain environment, we make use of the Active Inference framework (1), a Bayesian approach to belief updating that provides a biologically plausible model of perception, action and learning.

The ensuing model is then leveraged to simulate computationally the behaviour and evolving beliefs of a neurofeedback training subject in tasks of varying nature and difficulty. We finally analyze the effects of several sources of error such as measurement noise or uncertainty surrounding the choice of the biomarker to conclude on their influence on training efficacy.

(1) Friston et al. Active inference and learning. doi:10.1016/j.neubiorev.2016.06.022

Keywords: Neurofeedback, Active Inference, Bayesian Inference, Computational Neurosciences

^{*}Speaker