

Abstract

Phase-amplitude coupling (PAC) is proposed to play an essential role in coordinating the processing of information on local and global scales. In recent years, the methods able to reveal trustworthy PAC has gained considerable interest. However, the intrinsic features of some signals can lead to the identification of spurious-epiphenomenal coupling. Most of the currently accessible methods do not support the discrimination of coupling origins, which results in overinterpretation of the results.

In order to assure reliable coupling analysis, we propose the original method, which includes most of the recommendations for detection of proper PAC. This easily accessible tool, called extended Modulation Index (eMI), is based on classical Modulation Index measure of coupling but additionally it contains the heuristic algorithm for differentiation between spurious and authentic PAC and integrated auxiliary plots that support further evaluation of the coupling properties.

The main goal of this dissertation is to evaluate the novel method for detection of phase-amplitude coupling. In order to confirm that eMI is a tool for reliable coupling analysis, the following hypothesis were verified by conducting appropriate studies.

First, we checked whether the novel method correctly detects the PAC coupling, and its sensitivity, specificity and dependence on the parameters of the analyzed signal is comparable with the reference methods. Next, we tested whether the eMI method, unlike the reference methods, supports the interpretation of the detected coupling. Then, we verified whether the information about the phase of slow oscillation for which there is a coupling, provided by the novel method, constitutes an advantageous feature characterizing PAC. Finally, we tested whether the eMI method is useful for studying the dynamics of phase-amplitude couplings.

Some of the studies were carried out on the simulated signals, and some on the electrophysiological signals. Most of the in vivo recordings come from a team that conducts extensive research on the effects of a subanesthetic dose of ketamine on rats at the Nencki Institute of Experimental Biology.

The results suggest that the novel method eMI is a tool for precise, multidimensional and reliable coupling analysis. Additionally the toolbox implementing eMI framework, the two reference PAC estimators and a set of sample scripts and signals is freely available at <https://github.com/GabrielaJurkiewicz/ePAC>.