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# MultiPy – An open-source Python toolbox for multimodal real-time analysis

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*Introduction:* Real-time data processing is essential for interpreting neural signals in mobile brain-computer interfaces (BCI) and neurofeedback (NFB) [1]. Current systems often rely on unimodal approaches like electroencephalography (EEG) or functional near-infrared spectroscopy (fNIRS) [2]. EEG provides high temporal resolution for detecting fast electrical brain activity but is limited by noise, artifacts, and poor spatial information. Conversely, fNIRS measures hemodynamic responses such as blood flow and oxygenation with higher spatial specificity and lower artifact sensitivity but suffers from slower temporal resolution due to the nature of hemodynamic signals [3]. Combining EEG and fNIRS could offer complementary insights, improve accuracy, and address challenges like BCI illiteracy [3,4]. However, implementing real-time multimodal systems remains challenging due to a lack of software for simultaneous integration and analysis [4]. To address this, we present **MultiPy**, an **open-source Python toolbox** that integrates and analyzes **EEG and fNIRS** data in real time.

*Material, Methods and Results:* MultiPy is a graphical user interface (GUI) toolbox (cf. Fig. 1) designed to integrate real-time data streams from multiple modalities via the Lab Streaming Layer (LSL) protocol [5]. It includes three modules that can operate independently or together. The **fNIRS module** enables visualization, preprocessing, and key functions such as channel quality assessment, pruning, and converting light intensity to hemoglobin concentration using the modified Beer-Lambert law. It also offers motion artifact and (extracerebral) systemic activity correction, with or without short-distance channels. The **EEG module** provides real-time signal visualization and robust preprocessing tools, including artifact subspace reconstruction and temporal filtering. The **feature extraction and machine learning (ML) module** extracts time- and frequency-domain features from both modalities and integrates them using ML algorithms. Additionally, EEG and fNIRS data can be combined using a generalized linear model (GLM), allowing EEG features to inform fNIRS GLM analysis. Preliminary tests show MultiPy successfully integrates and synchronizes EEG and fNIRS data streams in real time, improves signal quality through preprocessing, and mitigates motion artifacts and noise using advanced algorithms.


*Figure 1 GUI of MultiPy in the fNIRS module, showing channel selection, real-time data visualization and available preprocessing options.*

*Conclusion:* The open-source MultiPy toolbox facilitates real-time integration and analysis of EEG and fNIRS data and is designed to support any device that enables real-time data streaming via the LSL protocol [5], thus aiming to increase the reach of NFB and BCI applications. This promotes accessibility and standardization in the field and allows researchers to easily develop and test multimodal approaches. Since MultiPy is open-source software, the community can participate in the development, provide feedback, and make MultiPy a versatile and comprehensive tool for advancing neurotechnology.

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