

BioPsyKit: A python package for the analysis of biopsychological data

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Summary

Biopsychology is a field of psychology that analyzes how biological processes interact with behaviour, emotion, cognition, and other mental processes. Biopsychology covers, among others, the topics of sensation and perception, emotion regulation, movement (and control of such), sleep and biological rhythms, as well as acute and chronic stress.

To assess the interaction between biological and mental processes a variety of different methods are used in the field of biopsychology, such as *electrophysiology*, assessed via biosignals like electrocardiogram (ECG), electrodermal activity (EDA), electromyogram (EMG), or electroencephalogram (EEG), *neuroendocrine and inflammatory biomarker*, assessed via saliva- and blood-based samples, *self-reports*, assessed via psychological questionnaires, as well as *sleep, activity and movement*, assessed via inertial measurement units (IMUs).

These methods are used to collect data either during standardized procedures in the laboratory or in the wild. The collected data are typically analyzed using statistical methods, or, more recently, using machine learning methods.

In order to combine all these tools necessary for a researcher in the field of biopsychology into one single Python package we developed BioPsyKit.

Statement of need

Researchers in biopsychology often combine different assessment modalities during experiments in order to capture the interaction between biological and mental processes. One example might be collecting salivary biomarker (e.g., cortisol) during an acute stress protocol and investigating the correlation between biomarker and psychometric data assessed via self-reports, such as perceived stress, state anxiety, or positive/negative affect. However, currently, there exist no Python package that allows to systematically combine, process, and analyze these different data modalities out of one hand by using one common API. For that reason BioPsyKit enables researchers to write cleaner and reproducible analysis code, export analysis results in a standardized format, and create high quality figures with for scientific publications.

BioPsykit Structure

The following section describes the structure and the core modules of BioPsyKit. **TODO: Overview figure**

Physiological Signal Analysis

The module `biopsykit.signals` allows for the analysis of various (electro)physiological signals (ECG, EEG, Respiration, Motion, ...). This includes:

- Classes to create processing pipelines for various physiological signals and for extracting relevant parameters from these signals. For physiological signal processing, BioPsyKit internally heavily relies on the `neurokit2` Python library (Makowski et al., 2021)
- Plotting functions specialized for visualizing different physiological signals

Sleep Analysis

The module `biopsykit.sleep` allows for the analysis of sleep. This includes:

- Different algorithms for sleep/wake detection from wrist-worn activity or IMU data, such as the Cole/Kripke (Cole et al., 1992) or Sadeh algorithm (Sadeh et al., 1994)
- Computation of sleep endpoints from detected sleep and wake phases
- Functions to import and process data from commercially available sleep trackers (e.g., Withings Sleep Analyzer)

Biomarker Analysis

The module `biopsykit.saliva` allows for the analysis of saliva-based biomarker, such as cortisol and alpha-amylase. This also includes the extraction of relevant parameters characterizing salivary biomarker (e.g., area under the curve (Pruessner et al., 2003), slope, maximum increase, ...).

Self-report Analysis

The module `biopsykit.questionnaires` allows for the analysis of psychometric self-reports, assessed via questionnaires. This includes:

- Functions to convert, clean, and impute tabular data from questionnaire studies
- Implementation of various established psychological questionnaires, such as Perceived Stress Scale (PSS) (Cohen et al., 1983), Primary Appraisal Secondary Appraisal Scale (PASA) (Gaab et al., 2005) and functions to compute scores from questionnaire data

Support for Psychological Protocols

The module `biopsykit.protocols` allows for analyzing data collected during various psychological protocols. This includes:

- Protocols for the assessment of acute stress in the laboratory, e.g., Trier Social Stress Test (TSST) (Kirschbaum et al., 1993), Montreal Imaging Stress Task (MIST) (Dedovic et al., 2005)
- Protocols for the assessment of biological rhythms in the wild (e.g., Cortisol Awakening Response (CAR))
- Specialized plotting functions for standardized visualization of data collected during these psychological protocols

Simplified Statistical Analysis

The module `biopsykit.stats` provides functions to easily set up statistical analysis pipelines (using `pingouin` (Vallat, 2018)) that are frequently used in biopsychological research and to export statistical analysis results in a standardized way.

Simplified Evaluation of Machine Learning Models

The module `biopsykit.classification` provides functions to easily set up, optimize and evaluate different machine learning pipelines for biopsychological problems.

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References

- Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A Global Measure of Perceived Stress. *Journal of Health and Social Behavior*, 24(4), 385. <https://doi.org/10.2307/2136404>
- Cole, R. J., Kripke, D. F., Gruen, W., Mullaney, D. J., & Gillin, J. C. (1992). Automatic Sleep/Wake Identification From Wrist Activity. *Sleep*, 15(5), 461–469. <https://doi.org/10.1093/sleep/15.5.461>
- Dedovic, K., Renwick, R., Mahani, N. K., Engert, V., Lupien, S. J., & Pruessner, J. C. (2005). The Montreal Imaging Stress Task: Using functional imaging to investigate the effects of perceiving and processing psychosocial stress in the human brain. *Journal of Psychiatry and Neuroscience*, 30(5), 319–325.
- Gaab, J., Rohleder, N., Nater, U. M., & Ehlert, U. (2005). Psychological determinants of the cortisol stress response: The role of anticipatory cognitive appraisal. *Psychoneuroendocrinology*, 30(6), 599–610. <https://doi.org/10.1016/J.PSYNEUEN.2005.02.001>
- Kirschbaum, C., Pirke, K.-M., & Hellhammer, D. H. (1993). The 'Trier Social Stress Test' A Tool for Investigating Psychobiological Stress Responses in a Laboratory Setting. *Neuropsychobiology*, 28, 76–81. <https://doi.org/10.1159/000119004>
- Makowski, D., Pham, T., Lau, Z. J., Brammer, J. C., Lespinasse, F., Pham, H., Schölzel, C., & Chen, S. H. A. (2021). NeuroKit2: A Python toolbox for neurophysiological signal processing. *Behavior Research Methods*, 53(4), 1689–1696. <https://doi.org/10.3758/s13428-020-01516-y>
- Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, 28(7), 916–931. [https://doi.org/10.1016/S0306-4530\(02\)00108-7](https://doi.org/10.1016/S0306-4530(02)00108-7)
- Sadeh, A., Sharkey, K. M., & Carskadon, M. A. (1994). Activity-Based Sleep-Wake Identification: An Empirical Test of Methodological Issues. *Sleep*, 17(3), 201–207. <https://doi.org/10.1093/sleep/17.3.201>
- Vallat, R. (2018). Pingouin: Statistics in Python. *Journal of Open Source Software*, 3(31), 1026. <https://doi.org/10.21105/joss.01026>