Incorporating quantitative EEG analysis into the MNI Open Science neuro-informatics ecosystem

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SUMMARY

This poster presents the integration of the Tomographic Quantitative EEG Analysis toolbox (**qEEGt**), as a plugin in **CBRAIN**.

CBRAIN is an open neuro-informatics platform, developed at the Montreal Neurological Institute (MNI), connected to a database system named LORIS. CBRAIN and LORIS are the pioneer efforts developed by the MNI for the purpose of open sicence.

qEEGt deploys the toolbox develop at the Cuban Neuroscience Center (CNEURO). It includes age regression equations and calculation of z- spectra based on a Normative Database collected by the Cuban Human Braing Mapping.

Introduction

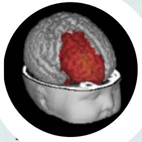
Revived interest in electrophysiology, driven by the maturity of EEG source imaging, has led to new informatics challenges (7). Integrating sophisticated EEG analysis with high-performance computing is pivotal to promulgating standardized methods across research and clinical settings (1).

In response, a joint collaboration from the Cuban Neuroscience Center (CNEURO), the University of Electronic Science and Technology of China (UESTC) and the Montreal Neurological Institute (MNI) is incorporating CNEURO's quantitative EEG methods into the MNI Open Neuroscience ecosystem, based on the LORIS and CBRAIN data- and tool-sharing platforms (3).

CNEURO's Quantitative EEG toolbox (qEEGt) offers VARETA source imaging method (2), age regression equations and calculation of z- spectra to produce age-corrected normative SPM maps of EEG log source spectra.

qEEGt Features

- **qEEGt** is mainly (but not only) for the analysis of the EEG resting state activity.
- It uses artifact free EEG epochs of quasi-stationery signals.
- Measurements are calculated for both EEG at the scalp as well as for the primary current at the sources by means of estimating the VARETA solution.



qEEGt Features

- Signal are transformed to the frequency domain by means of FFT to produce:
    - Cross-spectral matrices for the leads, for the whole frequency narrow band range (defined by the user)
    - Raw Log scalp/source spectra for Narrow/Broad-Band models.
    - Z-probabilistic measurements for the scalp/source spectra, using the norms of the Cuban population, in a range from 5 to 87 years.
    - Coherence matrices (*)

(*) coherence matrices have been widely used to assess EEG symmetry among homologous leads and hemispheres. It is not considered here as a measurement of connectivity.

Brain connectivity at the scalp makes no sense.

qEEGt Features

- Normative data are provided for:
  - Eyes Close and Eyes Open brain states
  - Average Reference, Linked-Ears and Laplacian montages
  - Traditional Broad Model (Hz): δ (1.5-3.5); θ (3.5-7.5), α (7.5-12.5), β (12.5-19.15)
  - Narrow Band Frequency range: from 0.39, step: 0.39, to: 19. 15 Hz
  - With or without correction by the Global Scale Factor

qEEGt Features

- For the Raw spectra:
  - Broad-Band model is defined at user’s convenience
  - Narrow Band Frequency range and resolution defined by user
  - Average Reference, Laplacian and Linked-Ears montages available, as well as re-referencing to any of the leads
  - Global Scale Factor correction at user selection (GSF*)

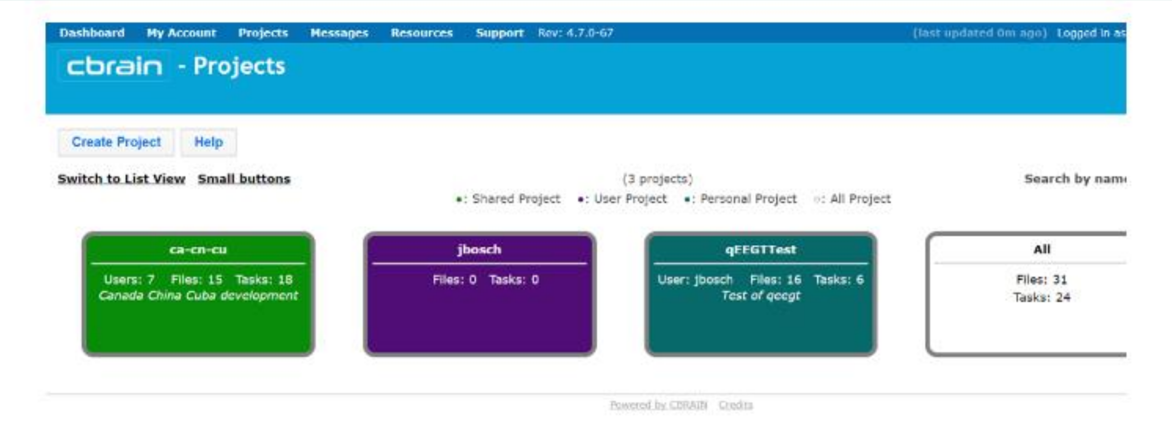
(*) GSF is a factor defined by (11) to account for the percent of EEG variability not related neurophysiological activity, thus, this factor makes the recordings from different devices and different persons more comparable.

qEEGt Features

- For both Z and Raw spectra the Broad-Band model includes:
  - Absolute Power
  - Relative Power
  - Mean Frequency: the frequency which divides the area under the spectra at each band in two equal parts.

qEEGt-CBRAIN Interface

1. The first step is to register as a CBRAIN user (if not yet done) and to login at the CBRAIN portal.
2. Then select the qEEG plugin and Launch the task.



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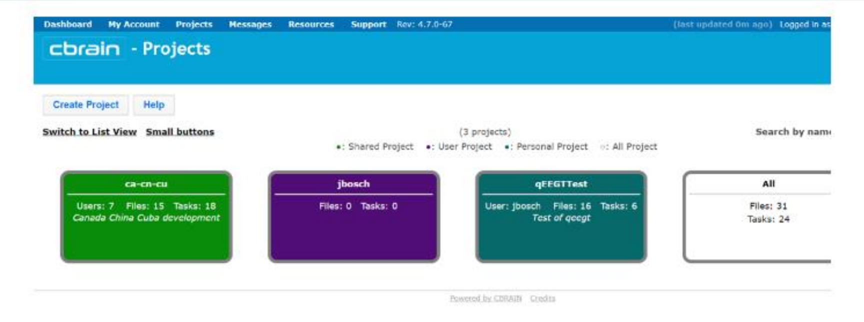
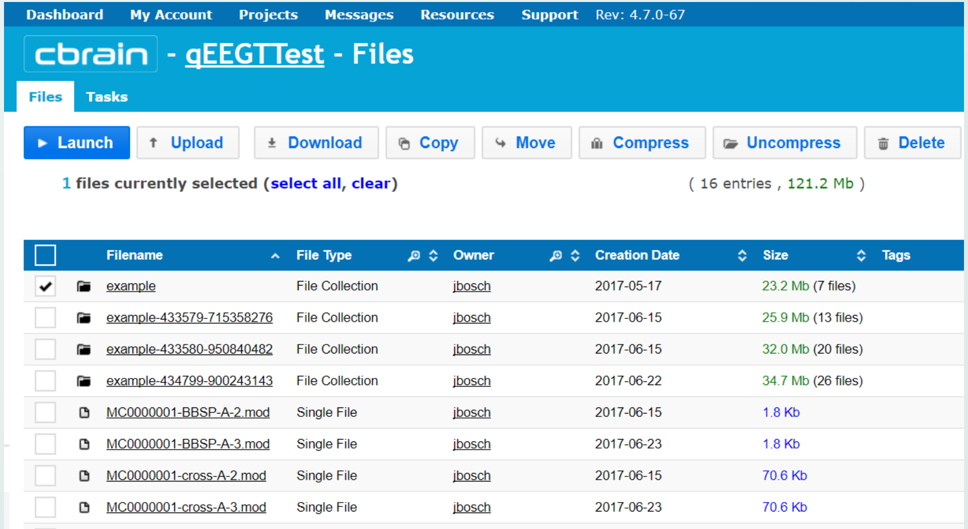
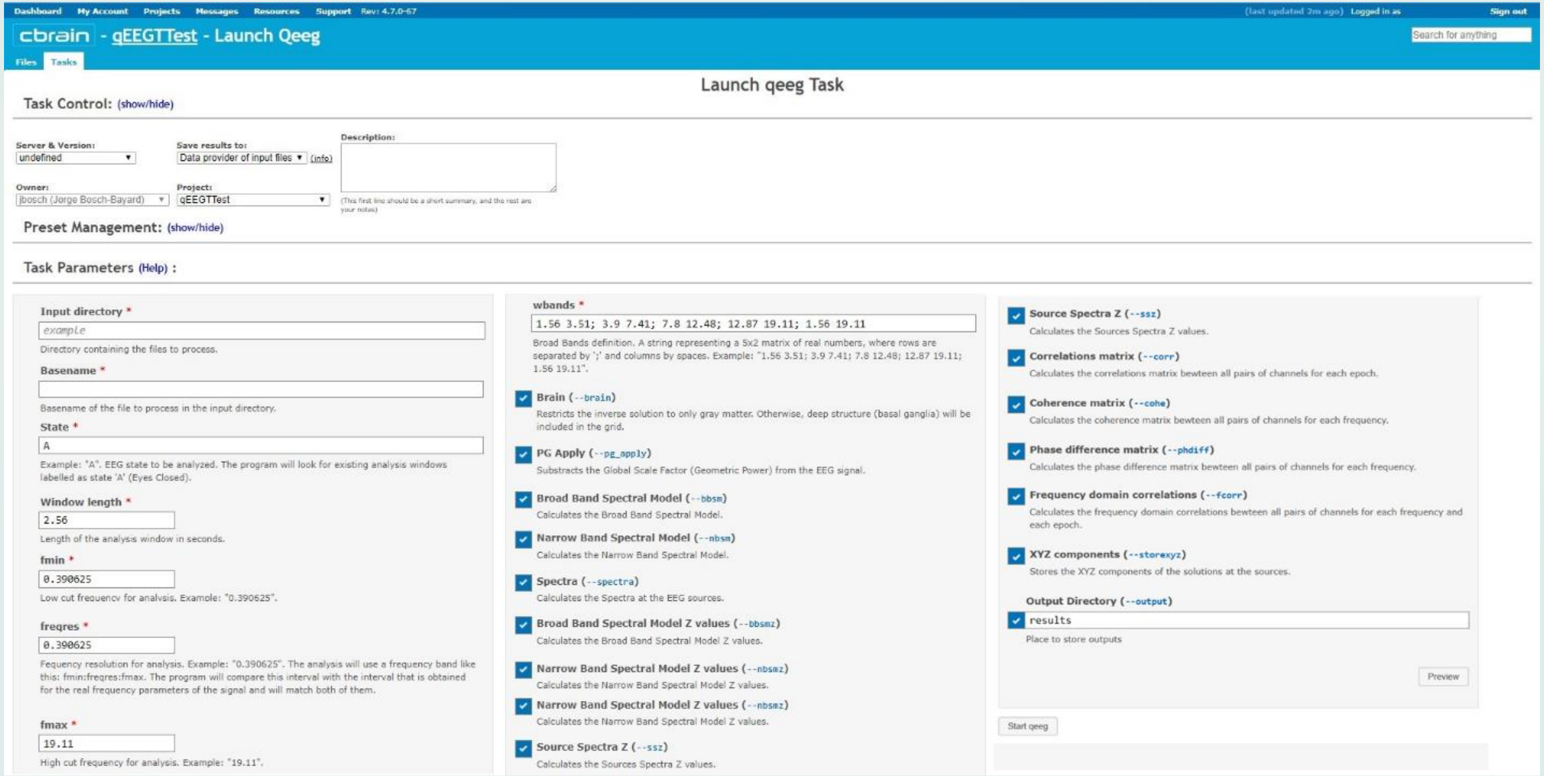


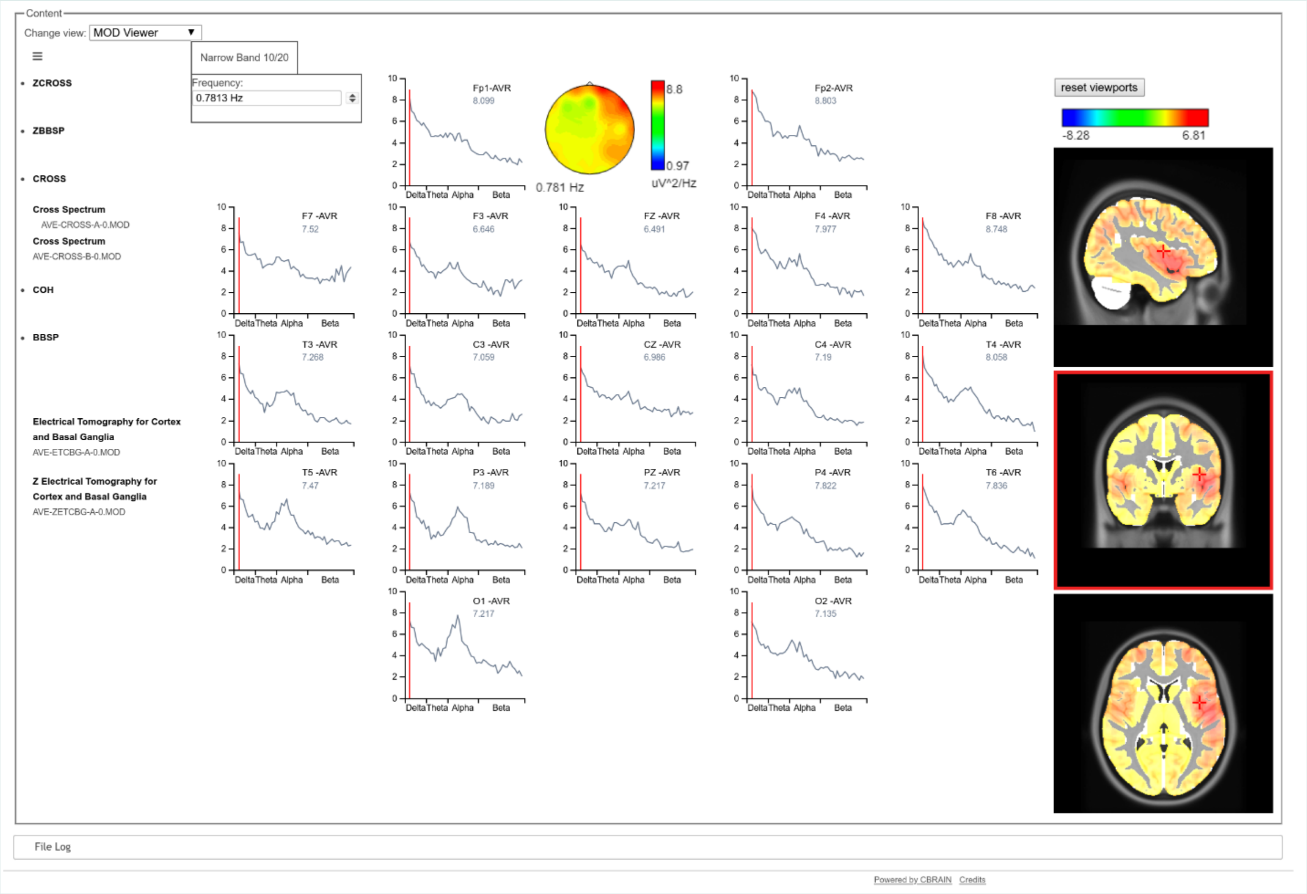


qEEGt-CBRAIN Interface

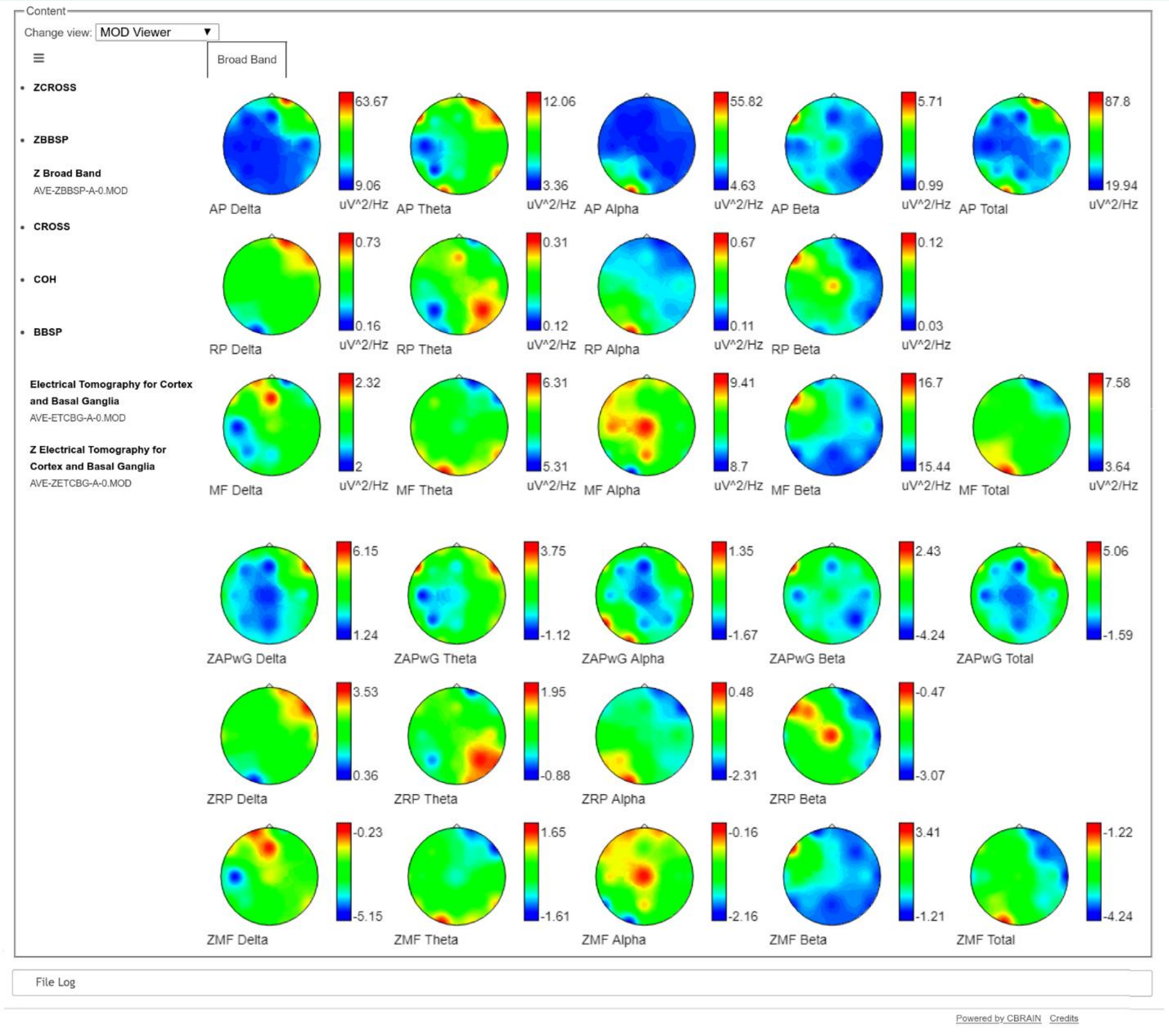
Set the parameters at the menu and start the task



Results



CBRAIN qEEGt visualization tool. Log raw EEG spectra at the scalp for the leads. The topographic and 3D tomographic maps are drawn at frequency 0.78 Hz, where the cursor is located. The red color at the maps show increased frontal activity, that extents to the temporal in the right hemisphere. The 3D tomographic maps show that the maximum of the activity is in the temporal pole.
Similar graphs can be obtained for the Z values, both at the sensors as well as at the sources.



Results

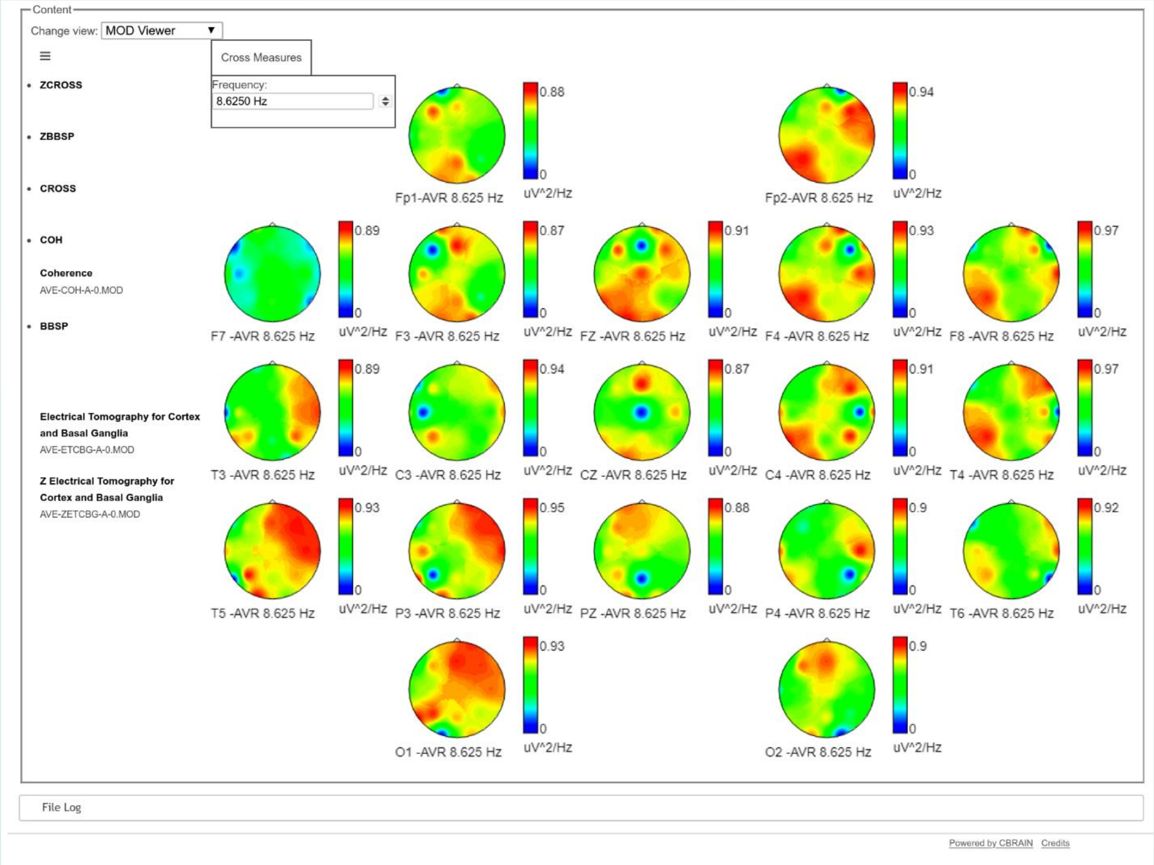
CBRAIN qEEGt visualization tool. Broad-Band model at the scalp.

Z-values and Log-raw EEG spectra are shown at the same screen. Above the Log-raw values for the 4 frequency bands at every Lead. Below, the same results for the Z-spectra.

The red color in the raw Absolute Power maps (first row) show the same frontal and temporal higher slow activity (Delta and Theta) that was observed in the previous Figure in the right hemisphere.

The Alpha activity is concentrated in the contrary hemisphere (O1).

Results



CBRAIN qEEGt visualization tool. Topographical maps of the coherences of one electrode against the rest, at a specific frequency (8.6 Hz in the example). In each map, the blue dot refers to the position of the target electrode, showing its coherence regarding the rest of the head. Values in these maps go from 0 (blue) to red (1). For example, the maps of T5, P3 and O1 show a very high coherence between the parieto-occipital leads of the left hemisphere with the frontal and temporal leads of the contrary hemisphere.

References

1. Babiloni,et al. (2019). International Federation of Clinical Neurophysiology (IFCN) – EEG research workgroup: *Clinical Neurophysiology*. https://doi.org/10.1016/j.clinph.2019.06.234
2. Bosch-Bayard et al. (2001). 3D statistical parametric mapping of EEG source spectra by means of variable resolution electromagnetic tomography (VARETA). *Clinical EEG (Electroencephalography)*, *32*(2), 47–61.
3. Das, S. et al.(2015). The MNI data-sharing and processing ecosystem. *NeuroImage*, *124*(Pt B), 1188– 1195.
4. Evans, A.,et al. (1993). 3D statistical neuroanatomical models from 305 MRI volumes. In *Proceedings of IEEE- Nuclear Science Symposium and Medical Imaging Conference* (pp. 1813–1817).
5. Friston, K. J. et al. (2007). *Statistical parametric mapping : the analysis of funtional brain images* (1st ed.). Amsterdam ;;Boston: Elsevier/Academic Press.
6. John, E. et al. (1977). Neurometrics. *Science*, *196*(4297), 1393–1410. https://doi.org/10.1126/science.867036
7. Hernandez-Gonzalez, G.et al. (2011). *Clinical Eeg And Neuroscience*, *42*(3).
8. Pernet, D. C. et al. (2018). BIDS- EEG: an extension to the Brain Imaging Data Structure (BIDS) Specification for electroencephalography. *PsyArxiv*. https://doi.org/10.31234/OSF.IO/63A4Y
9. Sherif, T. et al. (2014). CBRAIN: a web-based, distributed computing platform for collaborative neuroimaging research. *Frontiers in Neuroinformatics*, *8*, 54. https://doi.org/10.3389/fninf.2014.000
10. Valdés-Hernández, P. A., et al. (2009). Approximate average head models for EEG source imaging. *Journal of Neuroscience Methods*, *185*(1), 125–132. https://doi.org/10.1016/j.jneumeth.2009.09.005
11. Hernández, J. L. et al. (1994). A global scale factor in brain topography. The International Journal of Neuroscience, 76(3–4), 267–278.

CONCLUSIONS

The present qEEGt plugin is the first step to introduce quantitative EEG functionalities in CBRAIN, one of the most widely used ecosystems for brain imaging analysis.

The “normative SPM of EEG source spectra” based on the use of EEG normative databases are released in an open source toolbox for the first time.

The introduction of the Global Scale Factor is a key feature to make EEG recordings from different sites, EEG devices and persons more comparable for statistical purposes.

The EEG features obtained from the qEEGt are widely used in many of the new novel procedures of variable classification: biomarkers, early brain illnesses detection, alone or in combination with other kinds of neuroimages.

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THANK YOU!

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