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BESA Connectivity 1.0 Update History

Version 1.0 April 2018

Feature overview

BESA Connectivity 1.0 provides optimized, user-guided workflows for time-frequency and connectivity analysis of EEG/MEG data. Multiple well-established methods are provided. The program is optimized for user-friendly workflow-based interaction. All analyses are computed automatically; user interaction steps required are reduced to a minimum. The time-frequency and connectivity values computed in BESA Connectivity can be directly used for scientific reports. The outcomes can be exported in open ASCII formats for further statistical analysis. All results are visualized and can be directly used for publications.
BESA Connectivity 1.0 integrates optimally with data that were analyzed in BESA Research 7.0 or higher, but it can also process data from other software packages as long as they conform to the BESA Connectivity file format.
BESA Connectivity 1.0 automatically identifies connectivity patterns between montage channels, regional sources, dipole sources, or virtual sensors, which can be visualized using 2D matrices or 3D visualization. Input data can be provided in sensor space (surface EEG/MEG channels, or polygraphic channels), or in source space (virtual channels located inside the brain, e.g. from a source montage).

Workflows

There are two workflows with four work steps each in BESA Connectivity:

- Time-Frequency Analysis

  The general approach to analyze event-related EEG/MEG oscillations is based on the decomposition of the EEG/MEG signals into magnitude and phase information for each frequency and to track their changes over time. This procedure is referred to as ‘time-frequency analysis‘ and comprises those methods that study a signal in both the time and frequency domains simultaneously.
  In BESA Connectivity, two approaches for computing time-frequency decomposition are provided:

  - Complex Demodulation is based on the convolution of the EEG/MEG signal with series of sine and cosine waves.
  - Wavelet Transform uses series of complex Morlet wavelets or Mexican Hat wavelets to extract the magnitude and phase information.

- Connectivity Analysis

  BESA Connectivity 1.0 offers six connectivity measures in the frequency domain. Three measures belong to the class of phase-based methods: Coherence, Imaginary Part of Coherency, and Phase Locking Value (PLV). The other three measures belong to the class of Granger Causality-based connectivity approaches: Granger Causality in the frequency domain (or Granger–Geweke Causality), Partial Directed Coherence (PDC), and Directed Transfer Function (DTF). An overview of the distinctions between the connectivity measures is given in Table 1.

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Table 1. Comparison of the methods for estimating brain connectivity

	Coherence	Imaginary Part of Coherency	PLV	Granger Causality	PDC	DTF
Non-directional	●		●			
Directional		●		●	●	●
Bivariate	●	●	●	●		
Multivariate					●	●
Linear	●	●	●	●	●	●
Frequency domain	●	●	●	●	●	●

Results display
Results are displayed either in a grid view to show all connectivities in one view, or in a 3D view of the brain or skin surface, with connection strength encoded in thickness of connecting arrows.

The displays are highly interactive and also support additional analysis options:
• Sum of inflow / outflow for each channel / source
• Average over time
• Average over frequency

In both workflows, comparison options are available:
- Two conditions can be compared.
- Two different time-frequency decomposition methods can also be compared.

Results of either workflow can be saved in a project file; projects can be organized in groups, and can be re-loaded at any later point in time.

Export options
Data export:
Result data can be exported into open ASCII formats. The following export options are available:
- Time-frequency decomposition (average over all trials)
- Time-frequency decomposition (single trials)
- Averaged waveforms for all channels
- Connectivity results (connectivities between all sensors / sources)

Image export:
The result visualization can be exported as vector graphic (eps), portable network graphic with user-defined resolution (png), or scaleable vector graphic (svg).

Video export:
The connectivity change over time can be exported as video with user-defined time range, duration, and brain / head rotation.

A comprehensive Help function is available. Context-sensitive help is available for each workflow step.