December 2019

BESA Connectivity 1.0 Update History

Version 1.0 November 2019

Improvements

All workflows

- Several different color maps are now available for data display in the 2D results display windows. These include:

    o For diverging data types (TSE and Imaginary part of coherency), the color maps *Standard* and *Blue to Red*.

    o For sequential data types (absolute TF amplitude and all the other connectivity methods), the color maps *Standard*, *Rainbow*, and *Viridis*.

- Mouse hover in the Detail windows reveals the current data value under the mouse cursor in a tooltip text.

Time-Frequency Analysis

- Trial epochs are now enhanced by zero padding if the provided padding is not sufficient to cover the wavelet width or low pass filter width required for the time-frequency transformation. This means that the lowest frequencies are now available even if no or short padding was supplied with the data epochs. However, be aware that there is a cone of influence that may influence your data result if very low frequencies and long wavelets are used. Look up the chapter Cone of influence in the manual or the program help for more information.

- In work step Set Parameters, individual trials can now be selected using the cursor keys, for easy browsing through the data.

- If no baseline interval is provided, previously the computation of TSE values was meaningless. Now, in that case, the pre-stimulus interval is used for TSE computation as substitute baseline interval.

Connectivity Analysis

- In the 3D window, an information text is now shown with the connectivity values of the currently selected channels at the current time-frequency cursor. Hovering the mouse pointer over a channel shows the channel label.

- In the 3D display mode, the granularity of threshold can be adjusted with much higher precision than before.

Bugfixes

Time-Frequency workflow

- Wavelet computation showed a periodic artifact at high frequencies in TSE display for certain wavelet parameters. This bug was fixed.

- Wavelet computation amplitudes were too high due to a normalization issue. This affected the display of absolute values (ABS check box), but not the TSE display. This is now fixed.

- Individual trial exclusion with two conditions where number of trials differed in the two conditions could result in a program crash. This is now fixed.

- Time-frequency displays of channels without coordinates (e.g. polygraphic channels) were cropped if more than 36 channels were displayed. This is now fixed.

- Time labels for data with more than 1000 ms data length were sometimes wrong. This is now fixed.

- In Time-Frequency workflow, the Amplitude scale bar occasionally lost the tick marks after hiding and showing sub-windows. This is now fixed.

Connectivity workflow

- ASCII data export of connectivity data showed a wrong start time if the baseline interval was different from the pre-stimulus interval. This bug was fixed.

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

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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.

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)

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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.