BESA Research
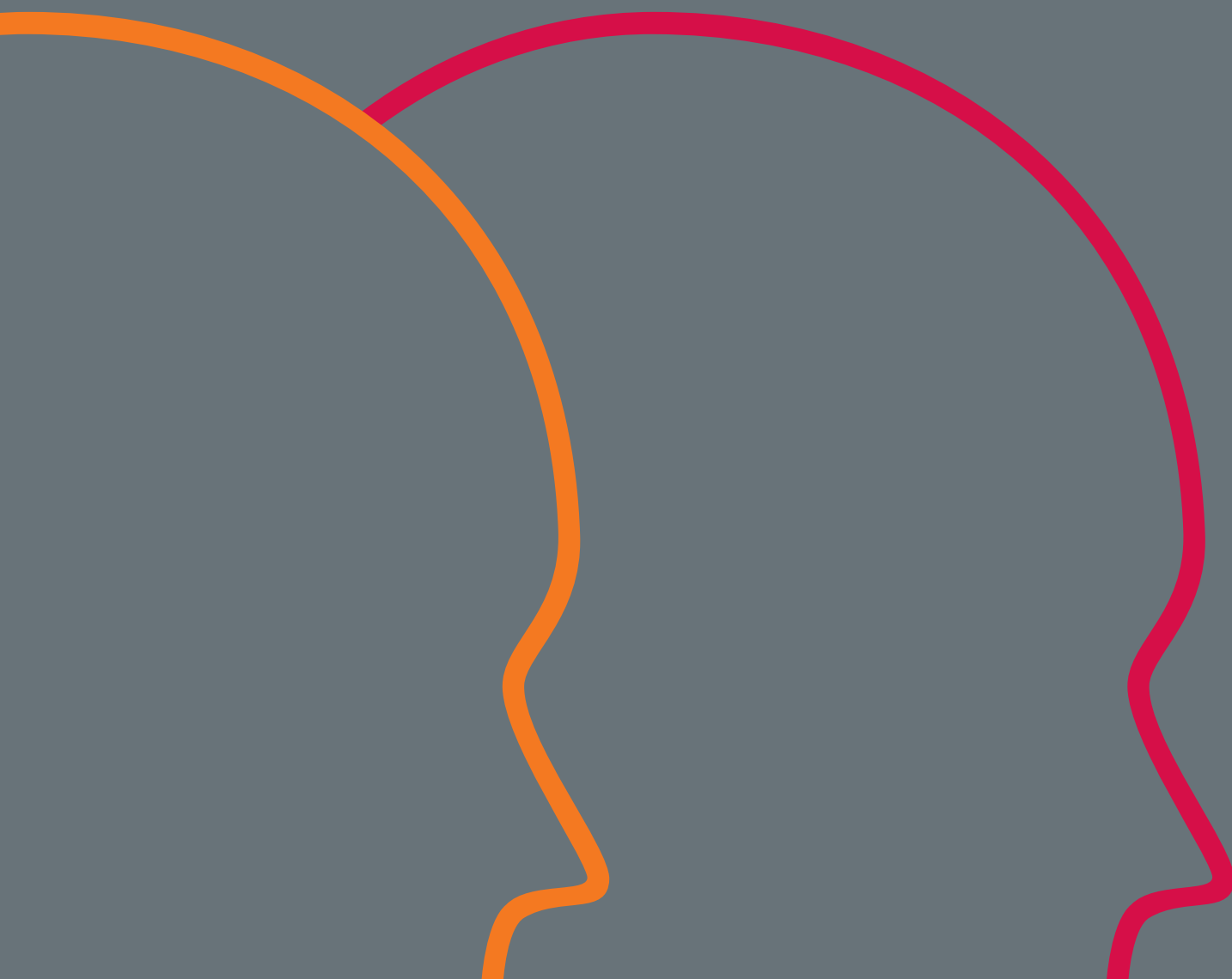
Quick Guide

BESA®

Research 7.0

Quick Guide on Resting State Source Montages

Document: Resting State Source Montages

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1. Introduction Resting State Networks

The default mode network (DMN) is the most commonly known brain network associated with resting state activity. It comprises brain regions that become less active, when the subject is engaged with a task, and in turn more active when the subject is resting (Raichle, MacLeod et al. 2001; Buckner, Andrews-Hanna et al. 2008). Thinking of the DMN as a "baseline" state of the brain would be misleading, as DMN brain regions have been linked with remembering the past, envisioning future events, and considering the thoughts and perspectives of other people (Buckner, Andrews-Hanna et al. 2008). This internal reflection is likely to happen when the brain is not otherwise engaged and the corresponding network thus becomes active in resting state.

Recent research (Power, Cohen et al. 2011; Bressler and Menon 2010) has shown that several other brain networks known to become active during certain tasks can also be identified in resting state. Among them are the fronto-parietal task control system as well as the dorsal and ventral attention system (Power, Cohen et al. 2011). These networks seem to be stable systems that are internally connected even when no particular task is given.

The resting state networks DMN, fronto-parietal task control system as well as the dorsal attention system and the ventral attention system are available in BESA Research as source montages. They allow investigating resting state EEG and MEG data in a swift and straight-forward manner.

2. How the Resting State Source Montages were created

BESA resting state source montages are based on **source solutions**, for which **regional sources** were placed at the MNI locations of the brain regions of interest. Source locations were derived from the following publications:

DMN	Power, Cohen et al. 2011, Supplementary Information
Fronto-Parietal Task Control Network	Dosenbach, Fair et al. 2007
Dorsal Attention Network	Power, Cohen et al. 2011, Supplementary Information
Ventral Attention Network	Corbetta and Shulman 2002

Bilateral Sources representing the same brain regions that were not perfectly symmetrical were symmetrized favoring the position of the less superficial source.

Additional noise sources were placed to increase the sensitivity of the sources of interest. Noise sources are easily identified by their name.
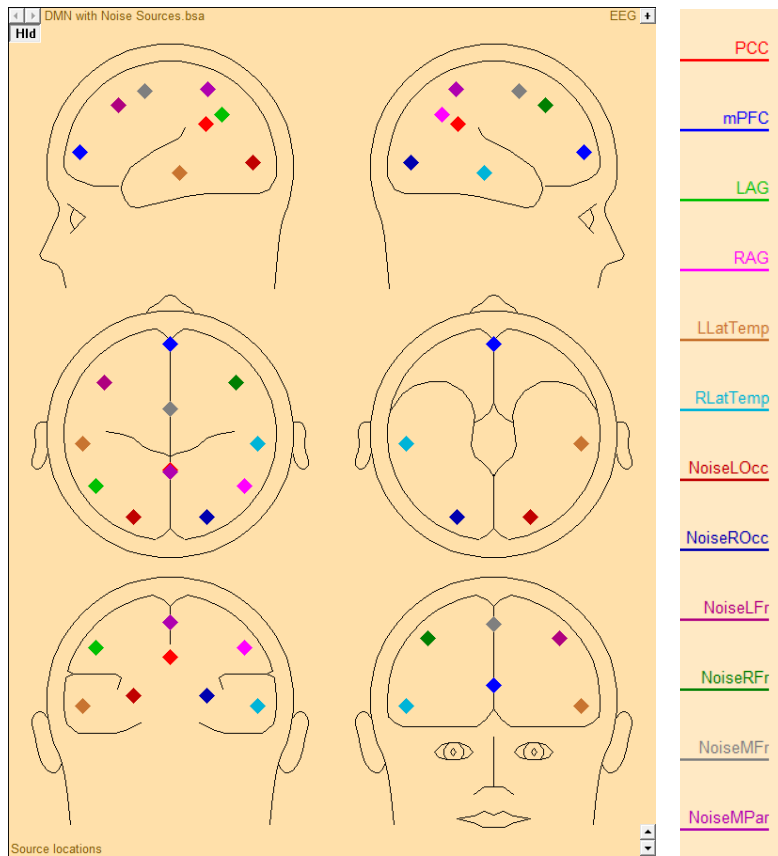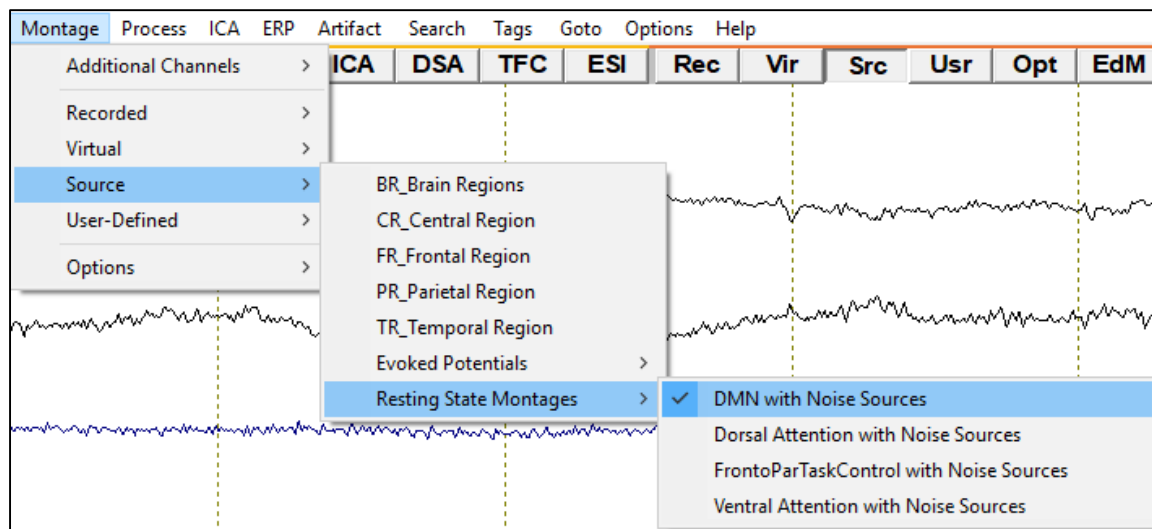
Figure 1: DMN source solution with additional noise sources

3. Applying Resting State Source Montages on your data

3.1.   EEG

For EEG data, the resting state source solutions were saved as source montages and are automatically available from the Menu "**Montage / Source / Resting State Montages**".

All sources are **regularized** with a regularization constant of 1%.

3.2.   MEG

For MEG data, source montages are not pre-saved as there are varying MEG sensor types depending on the MEG system and manufacturer. MEG users should **send a segment of their raw data to source analysis** and load the desired source solution in the source analysis module. Source solutions for resting state networks can be found here:

"**C:\Program Files (x86)\BESA\Research_7_0\Montages\SourceMontages\Resting State Montages**".

After loading the source solution, it is possible to save it as a source montage with "**File / Save Source Montage As**". The source montage will now be applied on the data in the main window and is also available from the menu option "Montage / User-Defined".

4. Mean FFT Analysis in Resting State Source Space

Before applying the desired resting state source montage on the raw data, artifacts should be dealt with either by artifact correction and / or artifact rejection (as part of the mean **FFT** scan).

After applying the resting state source montage, a mean **FFT** can be calculated on the source waveforms associated with the source channels, i.e. the ongoing brain activity in the resting state network. Mean **FFT** performs block-wise **FFTs** on the whole dataset and the mean output is created when the end of the file is reached. Hereby, information can be drawn on the frequency content of the whole dataset.

Mean **FFT** can be started from the menu "**Process / Mean FFT Spectrum**". The dialogue allows specifying the data range (by default all data) and the block length, BESA Research will use for calculating individual **FFTs**. Artifact thresholds for the source channels can also be defined. Mean **FFT's** output will give an overview of the frequency content of the individual source channels.
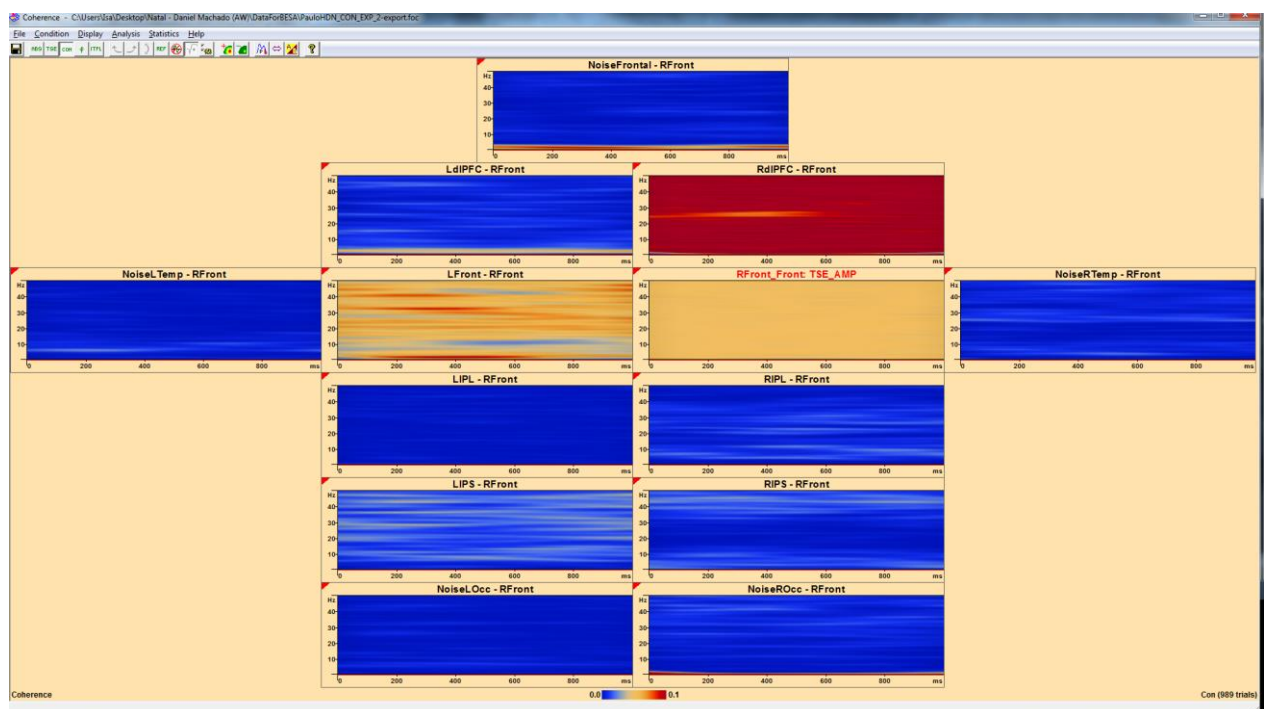
5. TFC Analysis in Resting State Source Space

For **TFC analysis** in BESA Research, it is required to insert triggers in the raw resting state data. This can be done by pressing "**ERP / Insert Triggers**". After insertion of the triggers, a **paradigm** must be created ("**ERP / Edit Paradigm**") that will allow the calculation of the time-frequency plots based on the inserted triggers in the final tab. Please make sure that any filters are only applied for artifact scanning in the **filter tab** and not for "averaging", as this would also reduce the frequency domain for time-frequency analysis.

For **TFC analysis** of resting state data it is recommendable to not use any baseline correction in the paradigm window. If possible, however, a control resting condition should be used (e.g. eyes open / eyes closed) that can be contrasted with the resting state condition of interest in the time-frequency window. Since time information related to trigger events is irrelevant here (we just use the inserted triggers as a vehicle to perform the time-frequency decomposition), choose a large time sampling in the TFC settings (e.g. 1 Hz, 50 ms, or 0.5 Hz, 100 ms).

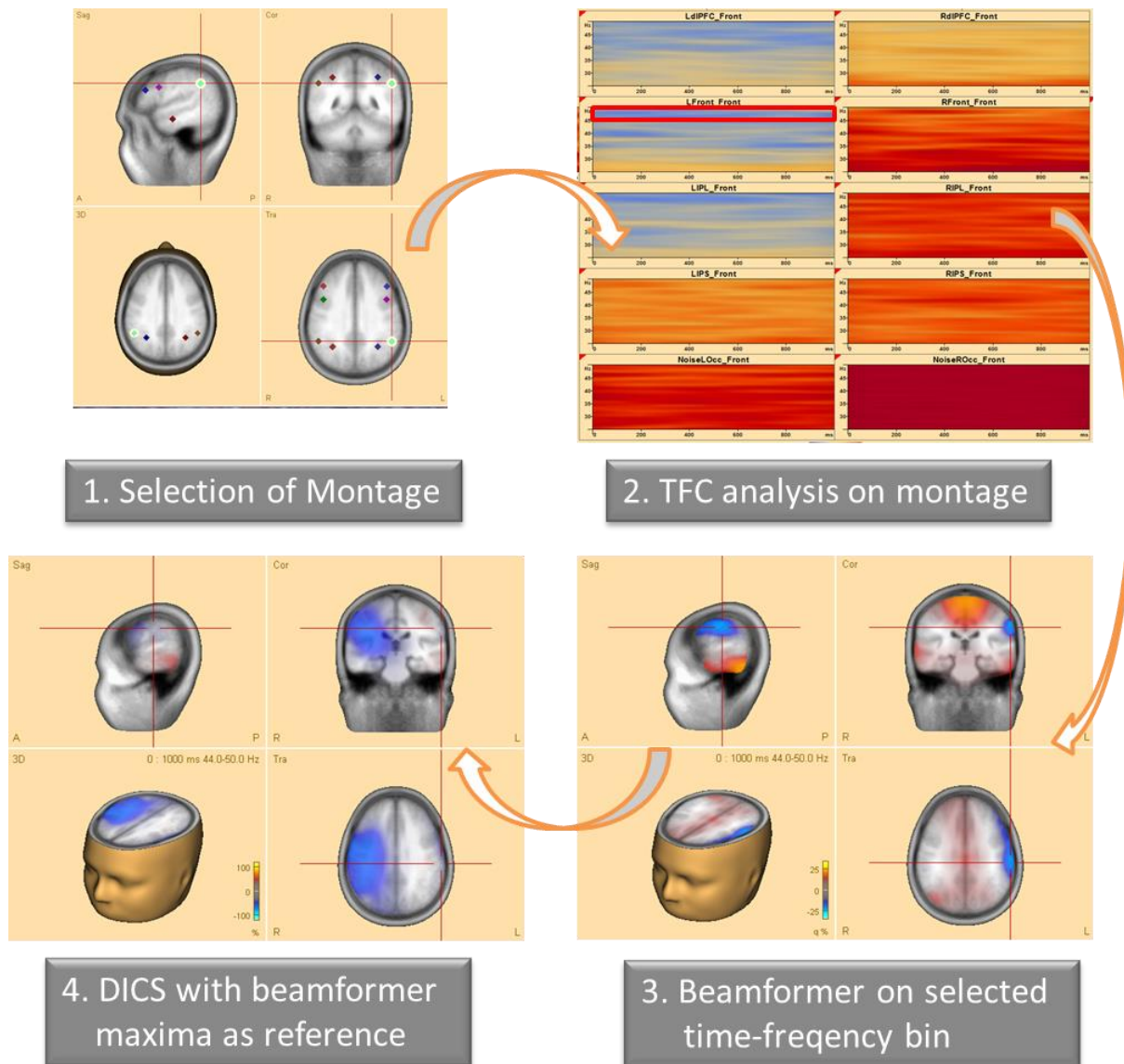In the time-frequency display, the results should be displayed as absolute values (the ABS button

`ABS  TSE  COH  φ  ITPL`). If a control condition is available the two resting state conditions can also be

contrasted by pressing the according subtraction button ( ). Coherence can be calculated between any resting state source channel and all other channels:

This example shows resting state connectivity between the right-frontal source (red label) and the left-frontal source, as well as the right dorso-lateral prefrontal cortex. No strong coherence is found with the other network sources or the noise sources.

It is possible to apply **beamformer** and / or **DICS** analysis on the time-frequency range of interest, suggesting the following possible workflow:

1. Selection of Montage

2. TFC analysis on montage

4. DICS with beamformer maxima as reference

3. Beamformer on selected time-freqency bin

6. References

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3. Corbetta, M. and G. L. Shulman (2002). "Control of goal-directed and stimulus-driven attention in the brain." Nat Rev Neurosci **3**(3): 201-215.
4. Dosenbach, N. U., D. A. Fair, et al. (2007). "Distinct brain networks for adaptive and stable task control in humans." Proc Natl Acad Sci U S A **104**(26): 11073-11078.
5. Power, J. D., A. L. Cohen, et al. (2011). "Functional network organization of the human brain." Neuron **72**(4): 665-678.
6. Raichle, M. E., A. M. MacLeod, et al. (2001). "A default mode of brain function." Proc Natl Acad Sci U S A **98**(2): 676-682.

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