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# Neuro-Eastern

BI-MONTHLY Neurofeedback Newsletter

## this issue



"Real time Neurofeedback using functional Magnetic Resonance Imaging (fMRI): Challenges and Applications"

Details on page 3

Neuro-Eastern is the bi-monthly newsletter of Asia Pacific Neurobiofeedback Association (APNA). The views and opinions expressed or implied are those of the authors and do not necessarily reflect the views of APNA committee and management. No article in part or in whole should be reprinted without written permission.

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# EDITOR-IN-CHIEF'S NOTE


Assoc. Prof. Dr Aamir Saeed Malik
The Editor-in-Chief, NEURO-EASTERN
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This is the 3rd issue of NeuroEastern. As it is a bi-monthly newsletter of APNA, this 3rd issue is for May and June 2016. To start with, I would like to invite all of you to attend the 2nd APNA Annual Conference which will be held at Hotel Park Royal in Penang from 21 to 23 July 2016.

The authors will be presenting their papers on the first two days of the conference, i.e. 21st and 22nd July. The third day will be reserved for tutorials and hands-on training on neurofeedback and HRV feedback. For those of you who would like to learn Neurofeedback or HRV feedback, this will be a good opportunity to start the learning process.

It will also be an opportunity to network with biofeedback and neurofeedback clinicians and researchers. The main article in this issue is on 'Real time Neurofeedback using functional Magnetic Resonance Imaging (fMRI): Challenges and Applications'.

Functional magnetic resonance imaging (fMRI) has revolutionized the brain studies over the past two decades. In the article written by Rana Fayyaz Ahmad, he briefly highlights the real time neurofeedback with fMRI and its applications in neuroscience. In addition, he mentions the future trends of the use of fMRI for real time neruofeedback and simultaneous use with EEG.

***Main issue this month***

**Real time Neurofeedback using functional Magnetic Resonance Imaging (fMRI): Challenges and Applications**

It is important for the researchers and clinicians in neurofeedback to get involved in the various research activities with proper experiment design, sampling of the population and blind studies so that this field can grow and become acceptable in the medical fraternity.

The resources pages discuss the BESA research software. It is one of the important tools for Quantitative EEG analysis and source localization, including distributed and dipole source analysis methods. Samer discusses the various features of the software and how it can be useful in QEEG analysis.

We look forward to your feedback on this issue.

*Aamir*

# Asia Pacific Neuro-biofeedback Association (APNA)

## President's Message

**Dr. Kenneth Kang**

***Head of Spectrum Learning***

It is my sincere pleasure to welcome you to join APNA.

APNA is established to provide an oversight of the field of neurofeedback and biofeedback so as to promote and expand it as well as to safeguard consumer interests.

I would like to express my deepest gratitude for the practitioners and researchers who have come together to help make the establishment of APNA possible. With that, I also want to extend my warmest invitation to anyone who is passionate about this field to come join us and grow this field hand in hand with the community for the benefit of mankind.

## Brief Description

APNA is a non-profit organization for the purpose of joining the expertise of clinicians and researchers who are involved in the health care research and clinical applications of neurofeedback and biofeedback for serving the society. There is a growing number of professional clinicians, biomedical and computing engineers, who have expertise in medicine, psychology, therapy, engineering and development of new advanced computing solutions to biomedical problems.

These diverse experts started sharing their expertise, joint research collaboration, organizing joint events, and developing their professional network under the umbrella of APNA. These activities are at initial stages and expected to be at the peak in future including all the countries in the Asia Pacific region. It is very encouraging that the growing network of these professionals is promoting the clinical use of neurofeedback and biofeedback interventions to the general public for getting maximum benefits. Consequently, it will help people to consult certified practitioners of neurofeedback rather than non-certified consultants.

## VISION

1. To deepen our understanding of Asian mindfulness and meditation techniques and its health benefits with rigorous science
2. To promote its application in society to improve health, performance and quality of life

## MISSION

1. To promote research collaboration between researchers, clinicians and the community
2. To promote professional clinical use of neurofeedback and biofeedback in the AP region
3. To promote awareness of the benefits of neurofeedback and biofeedback to the general public

# Real time Neurofeedback using functional Magnetic Resonance Imaging (fMRI): Challenges and Applications

By Rana Fayyaz Ahmad
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## Neurofeedback

Neurofeedback (NFB) is specific form of Biofeedback, which feedbacks the brain activity to improve the brain's activation in the desired regions. EEG based feedback is the most commonly used in clinical applications. However, the use of a small number of electrodes made EEG unreliable for exact source localization of brain activated regions; it has very limited access to the deep subcortical brain regions. Even with the modern multi-channel EEG systems, the localization of electric sources is an ill-posed problem.

EEG neurofeedback has a tremendous history; however, there is a recent rise in attention to real time neurofeedback. Figure 1 shows the journal publications from 1994 to 2012. There is a significant rise in neurofeedback research studies [1]. Functional magnetic resonance imaging (fMRI) has revolutionized the brain studies over the past two decades. The main advantages of fMRI are that it has very high spatial resolution and the source localization of the functional brain activities is very accurate as compared to the EEG counterpart [2].

Based on these initial studies, the basic real time fMRI (rtfMRI) neurofeedback approach has been further developed and applied by different research groups over the last 5 to 10 years. These groups mostly addressed some of the fundamental questions in neurofeedback, specifically in rtfMRI neurofeedback. Neurofeedback and studies on self-regulation became one of the driving factors and the prime application of rtfMRI.

### Real time fMRI neurofeedback

Early work in real time neurofeedback using fMRI was initiated by Neils Birbaumer and colleagues at the University of Tubingen, Germany. They had also done EEG feedback for various clinical and neuroscience applications. They found that poor source localization and limited coverage of EEG limited the progress in NFB. For example, study of emotional processing and affective disorders are difficult because the subcortical regions or areas such as the amygdala was not exactly localized with EEG signals.

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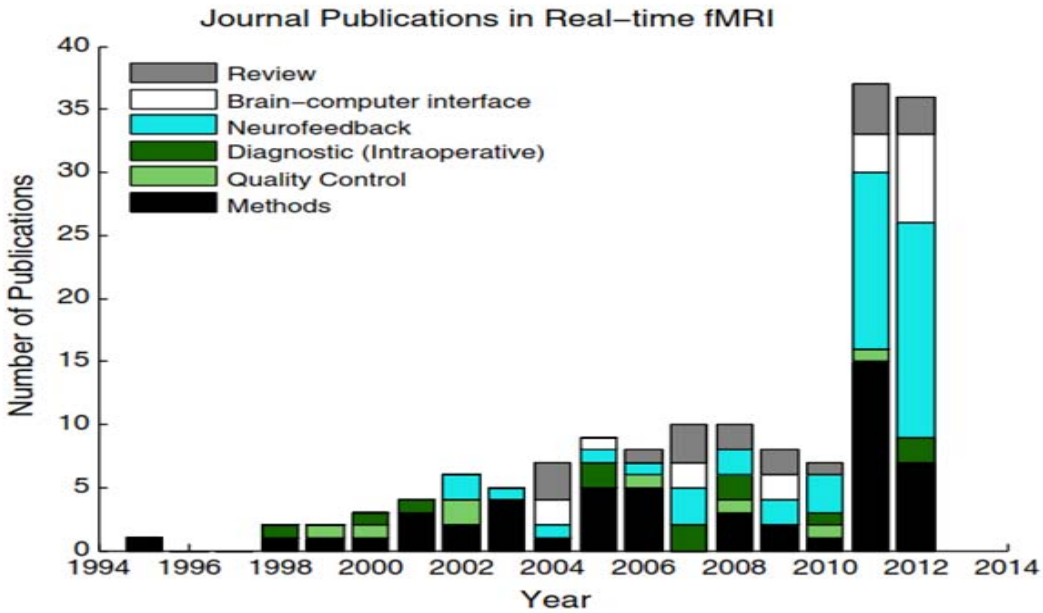


Fig.1 Publication statistics for real time fMRI

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Therefore, if a rtfMRI neurofeedback system could be developed, it can cater to these limitations as it captures the whole brain with high spatial resolution as well as subcortical areas. The main block of rtfMRI NFB is the real time processing unit for fMRI data. Any effective neurofeedback requires fast and accurate feedback for high contingency. However, one limitation of fMRI is the data acquisition speed against the spatial resolution. Therefore, the setup should be fast and flexible to include different types of acquisition methods, feedback and stimulus presentations to the participants.

The mental operations of the brain are considered as distributed which can be represented by the raw rtfMRI signal in any one brain region or small group of regions. It requires the computational machine learning method to quickly detect brain activation patterns in the rtfMRI signal which relates to some cognitive or mental task of interest. The block diagram of rtfMRI neurofeedback system is shown in Fig. 2. It shows a participant inside the MRI scanner and a series of functional MRI brain images being acquired. These images are processed online to see the brain regions activated. Feedback is also provided to the participant using visual stimulus.

## Applications in Neuroscience

Real time fMRI NFB has potential for behavioural research as well as for treatment purpose if the feedback given to the subject is related meaningfully to the cognitive states that must be controlled. NFB studies on self-regulation is the major application of the rtfMRI. Self-regulation studies investigate the relationship between self-regulated brain activity and behaviour. Several studies using rtfMRI showed that healthy participants can learn to self-regulate the BOLD response using rtfMRI neurofeedback.

Another application of rtfMRI NFB is to study behavioural modulation in the pathology of brain. A small number of studies showed promising results for novel non-invasive treatments of clinical disorders e.g. tinnitus, depression, schizophrenia, stroke etc. A few studies carried out on emotional processing on healthy participants demonstrated that rtfMRI NFB may be used for disorders of emotional regulation and depression.

## Future Trends and Progress

Real time fMRI NFB applications have made considerable development and progress in the past decade. However, further fundamental questions remain and more technical development can be expected. Simultaneous EEG-fMRI neurofeedback has a great potential for NFB application due to its ability to provide better spatial and temporal resolutions at the same time. However, it may involve many technical challenges in terms of data acquisition and data processing. With the development of MRI compatible equipment, the issue of EEG data acquisition inside the scanner was resolved. The first NFB experiment with simultaneous EEG-fMRI was performed at Laureate Institute for Brian Research, USA by Vadim Zotev and his colleagues. They applied real time simultaneous EEG-fMRI to training of emotional self-regulation in healthy participants performing positive emotional induction tasks. Their results showed that participants were able to simultaneously regulate their BOLD-fMRI activation in the left amygdala and frontal EEG power asymmetry in the high beta band. They demonstrated the proof of the concept for self-regulation of both hemodynamic (fMRI)and electrophysiological (EEG) activities of the human brain. They suggested potential applications of rtfMRI-EEG-NFB in the development of novel cognitive neuroscience research paradigms and enhanced cognitive therapeutic approaches for major neuropsychiatric disorders, particularly depression [4].

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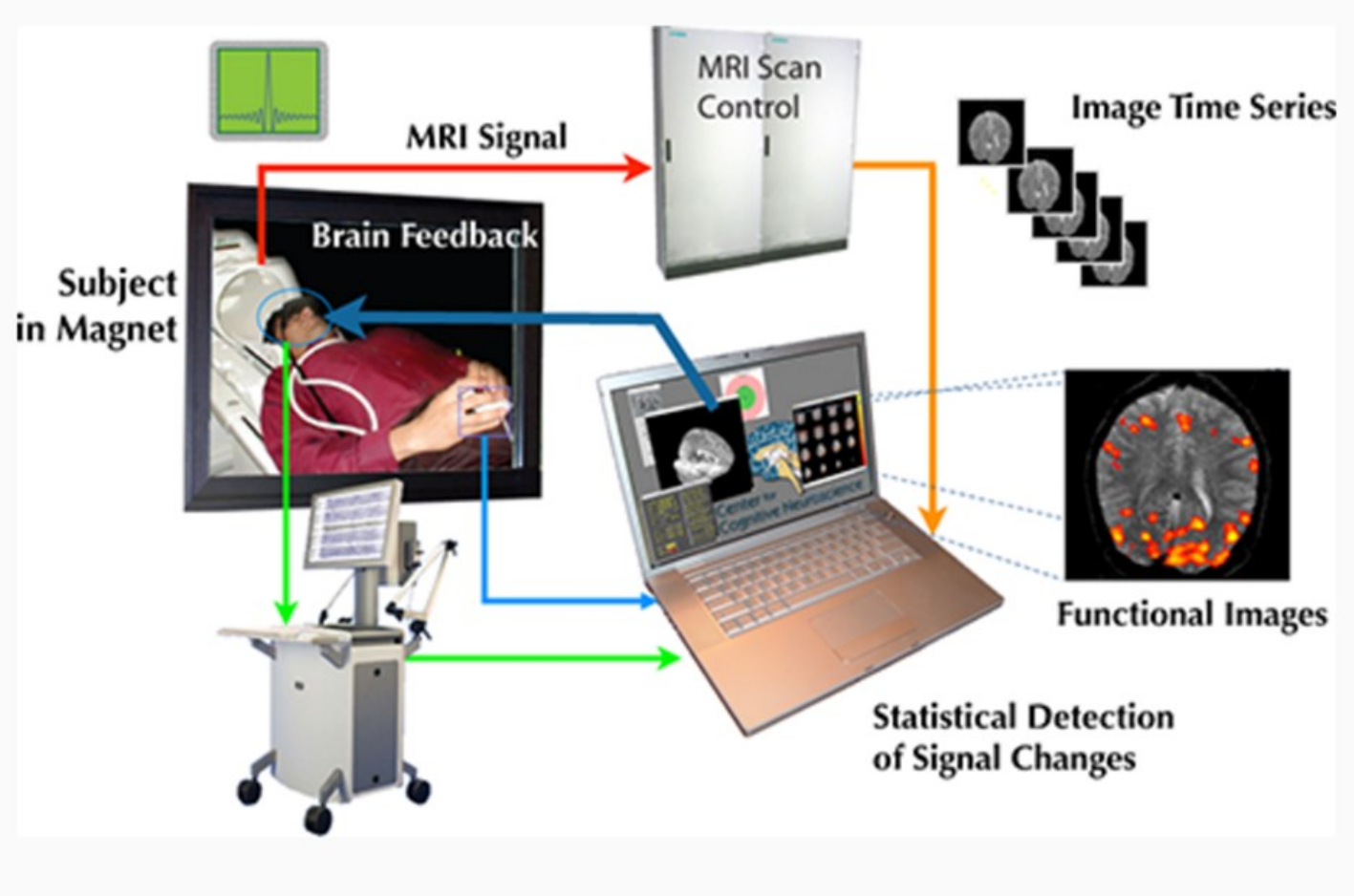


Fig.2 Block diagram of Real time fMRI Neurofeedback [3]

## References

[1] J. Sulzer, S. Haller, F. Scharnowski, N. Weiskopf, N. Birbaumer, M. L. Blefari, et al., "Real-time fMRI neurofeedback: progress and challenges," NeuroImage, vol. 76, pp. 386-399, 2013.

[2] N. Weiskopf, "Real-time fMRI and its application to neurofeedback," NeuroImage, vol. 62, pp. 682-692, 2012.

[3] M. S. Cohen. (2016, 16 April 2016). Real-Time FMRI. Available: http://www.brainmapping.org/MarkCohen/research/RTfMRI.html

[4] V. Zotev, R. Phillips, H. Yuan, M. Misaki, and J. Bodurka, "Self-regulation of human brain activity using simultaneous real-time fMRI and EEG neurofeedback," NeuroImage, vol. 85, pp. 985-995, 2014.

# BESA Research

By Samer Hanouneh
Email: hanouneh.s@gmail.com

**BESA Research** is considered a common software for sources analysis and dipole localization in EEG and MEG research. BESA Research has been established by virtue of 30 years' experience in human brain research by the team around Michael Scherg, University of Heidelberg, and Patrick Berg, University of Konstanz.

BESA Research is a multilateral user-friendly Windows programs with adjusted tools and scripts to do preprocessing for raw and averaged data for source analysis and connectivity analysis. All the important tools for source analysis are gathered and demonstrated in one window for fast and immediate selection of a large number of tools. The same applies to source coherence, time-frequency module, and other analysis windows. BESA research delivers simple and fast hypothesis testing, diversity of source analysis algorithm involving cortical imaging and volume imaging methods, integration with MRI and FMRI, age-appropriate template head models (FEM) and the probability to import head models (FEM) individually.

## Source coherence, a unique feature for viewing brain activity

**BESA Research** converts the cortical signals over the scalp into brain activity using source montage that comes from multi-source models.

The source coherence module delivers an excessively fast and user-friendly application of time-frequency analysis based on intricate extraction. The software gives the user the possibility of establishing event-related time-frequency displays of power, amplitude, or event related desynchronization/synchronization and coherence for the current montage by using surface channel sources. The software also gives the ability to separate the evoked and the induced activities. Furthermore, source coherence analysis explores the functional connectivity between brain regions. Also, the users have the opportunity to a choice between time-frequency windows and dynamic imaging of coherence sources.

## BESA Research features

BESA Research covers the whole range of signal processing and analysis from the collected raw data to dynamic source images. The following shows what BESA research can do:

### 1. Data review and processing module

For data review, BESA Research delivers several tools for reviewing and processing EEG and MEG data. BESA Research can read different EEG and MEG raw data formats by using reader options. It also gives options to import and export data to ASCII and binary files. Furthermore, BESA Research provides an interface with MATLAB for easy transfer of analysis results to MATLAB. For signal processing, several processes are involved in this option.

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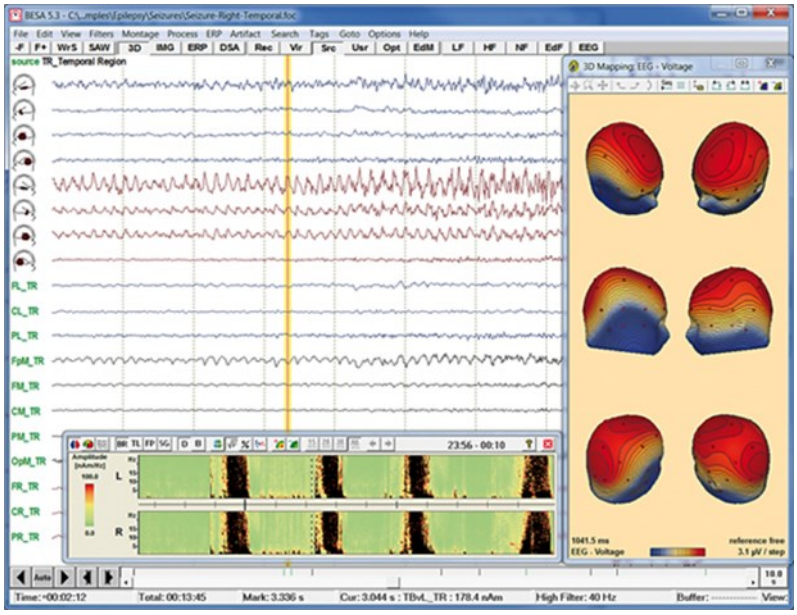
These processes including digital filtering (high, low and narrow bandpass); artifacts correction (Automated EOG and EKG artifact detection and correction. Also, advanced user-defined instantaneous artifact correction, computing the correlation and spectral analysis (Pattern detection and averaging by spatio-temporal correlation). The BESA Research allows the users to do all the previous processes just by a few mouse clicks. Data can be displayed in different styles to match the users requirements.



Onset of epileptic seizure with 3D whole-head maps

## 2. Source montage and 3D whole-head mapping

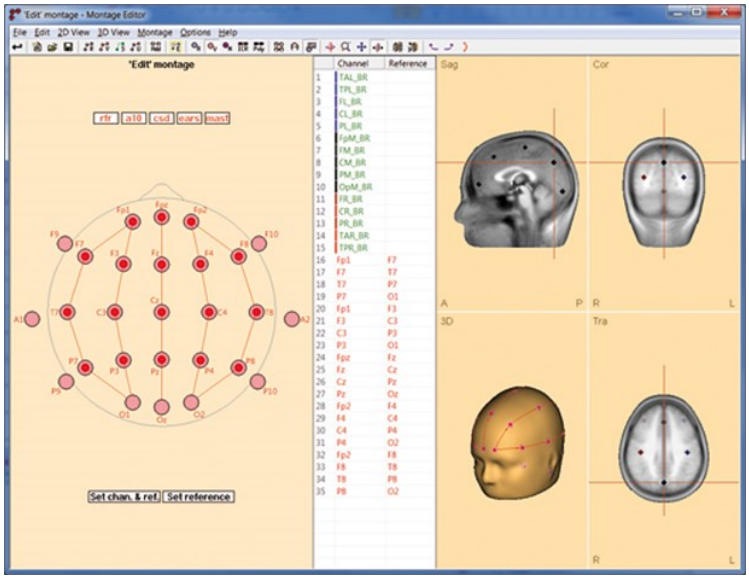
BESA Research provides with the users the ability to control and manage the montage by montage editing options. Different settings users can by change in this option are:

- Graphical editing of user montages for a different type of data review.
- Virtual montages according to the user setting.
- Computation of spontaneous arithmetic combinations of channels.
- Re-montaging to arbitrary channel averages (e.g. ears, mastoids, user-defined)
- Fast resorting for regional and hemispheric comparison.

A source montage in BESA Research typically shows frontal region, central, region, parietal region, temporal region and evoked potential. The users can define the source montage for different purposes.

- Transform surface EEG and MEG into brain source analysis.
- Get montage from multiple dipoles or regional sources models.
- Make normalization for different brain regions.
- Add more channels to show PCA components or artifacts channels, such as eye artifacts.

For 3D whole head mapping, the BESA Research provides viewing to the whole spline interpolation for CSD mapping and voltage. Also, it shows a 3D or 2D view of maps, sensors, and head surface point. In addition, it also displays the MEG maps of flux and planar gradients at the scalp surface. Time series maps can also be display in this option with easy selection for viewpoint, the number of maps, and epoch interest.

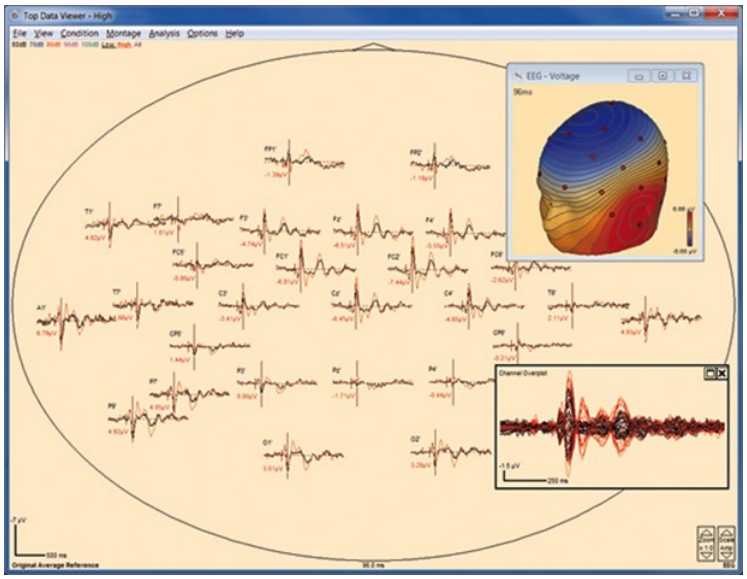


Graphical display of a user-defined montage

## 3. ERP analysis and averaging

BESA Research provides a module which can help users to extract the event-related potentials or field from raw data. Interactive tools are optimized to make the user have their own scripted paradigms with predefined trigger definition, conditions and setting for averaging easily. Generally, data files have artifacts, BESA Research in this option allows the user to scan the artifacts automatically. If the users face bad channels, they can easily identify and remove it for data by using an advanced 2D selection. After analysis for ERP displays, the BESA Research can display the results in different ways:

- Topographic display and 3D whole-head mapping of averaged waveforms.
- User definable layout with postscript export.
- Over-plot of various conditions.
- Show extra channels (polygraphic, intracranial, source, EEG, MEG).
- Event-related desynchronization/synchronization: demonstration of ERS/ERD waveforms.



Top data view of two averaged conditions in a P3 paradigm

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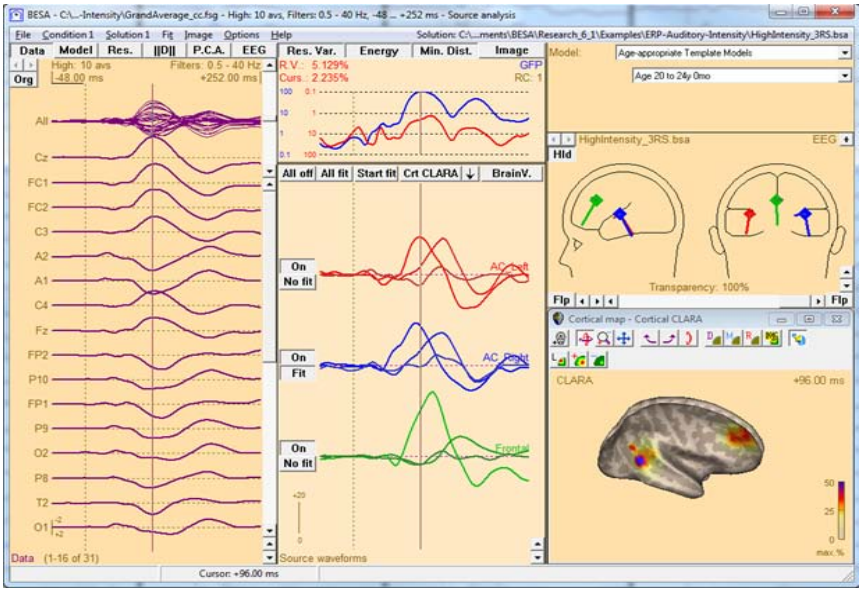
## 4. Source analysis and imaging

Source analysis in BESA Research is easy to process because BESA is a highly versatile and user-friendly Windows. BESA gathers all the sources analysis information in one glance including data, PCA, ICA sources waveform, and source localization in 3D head schemes, standardized or individual MRI. Users can select between different options of the art source modeling technique and head models. 2D and 3D source imaging can be performed with projection onto a standardized or individual MRI. The cortical images that BESA Research provides are:

- Imaging solutions are truly computed on the individual or standard cortices, not projected.
- Cortical LORETA.
- Cortical CLARA.
- Minimum norm images based on the individual brain surface.




Discrete multiple source analysis and Cortical CLARA image on inflated cortex

## 5. Integration with MRI and FMRI

BESA research provides an easy interactive interface, BESA MRI, to make the source analysis using individual FMRI data easily for the users. Furthermore, BESA research gives the users the ability to link to Rainer Goebel's BrainVoyager™ (BV) program. The bidirectional connection between the two programs allows for source seeding from fMRI clusters with one mouse click.

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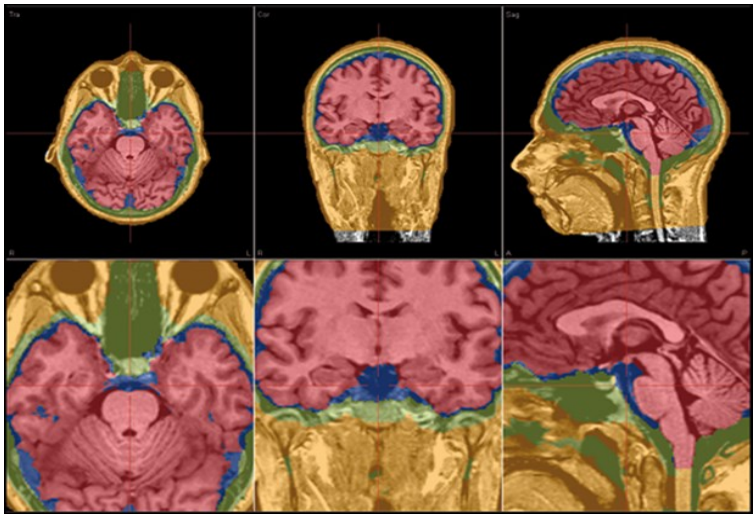
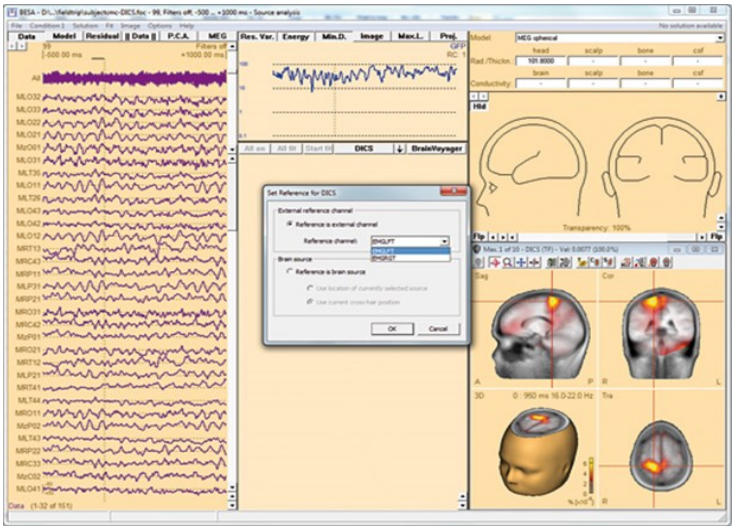


Coregistration and FEM model generation in BESA MRI

## 6. Source coherence and time-frequency display.

Source coherence analysis shows the functional connectivity between different brain regions. The analysis occurred by transforming the surface signals into brain activity by applying brain source montage obtained from multiple source models. The new source coherence module allows the users to implement time-frequency analysis based on complex demodulation in a fast and easy way. The users can easily establish event-related time-frequency shows of power, amplitude, or event-related synchronization/synchronization and coherence for the existing montage by applying brain sources or surface channels. Also, it can separate the induced and evoked activities.



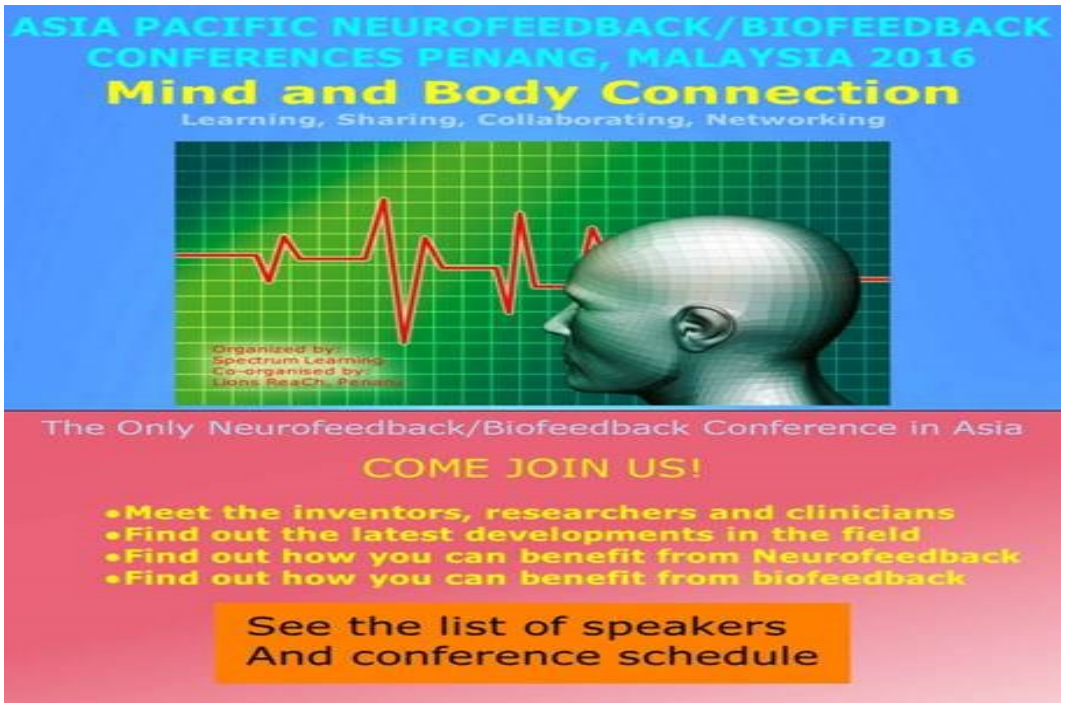
Coherence can be calculated between any pair of locations in the brain

## Conclusion

BESA Research provides advanced tools that cover a wide range of analysis steps, involving raw data import, re-montaging, artifacts reduction and correction, averaging, mapping, peak detection source analysis, 3D source imaging (LORETA, CLARA, sLORETA, and others), batch scripting, time-frequency analysis and source coherence.

## Neurofeedback Applications

- Attention Deficit Disorder
- Autism
- Anxiety & Post Traumatic Stress Disorder
- Bipolar Disorder
- Chronic Fatigue Syndrome
- Chronic Pain
- Cerebral Palsy
- Dissociative Disorders
- Depression and Mood Disorders
- Epilepsy
- Head Injury
- Hyperactivity Disorder
- Learning Disorders
- Myoclonic Dystrophy
- Obsessive-Compulsive Disorder
- PMS
- Peak Performance
- Sleep Disorders
- Stroke
- Substance Abuse and Addiction
- Violence




**Conference Date:** **21 to 22 Jul 2016 (Thursday and Friday), 8.30am to 5.30pm daily**

**Pre-conference: 20 Jul 2016 (Thu)**
What is Neurofeedback - with hands on experience - Open to public

**Post-Conference: 23 Jul 2016 (Saturday)**
1. Application of neuroffedback and biofeedback for depression and anxiety (morning)
2. QEEG Analysis - with hands on examples (afternoon)

**Venue:**
Sunway Hotel Georgetown, Penang
Meet@LG1 Conference Hall
Lorong Baru, 10400 George Town, Penang Malaysia

**Conference Price:**(2 tea breaks and buffet lunch)
1. SGD140 per person
2. Early bird SGD125 per person
3. SGD118 for APNA members (15% discount)

**Pre-Conference Workshop:**
**What is Neurofeedabck (Introduction)**
By Dr. Kenneth Kang
20th July (Thur evening, 7 pm - 9 pm) SGD10

**Post-Conference Workshop:**
**1. Neurofeedback for Depression and Anxiety**
By Prof. Dr. Gabriel Tan and Ms Eleanor Fong
23 July (Sat morning, 9 am to 12 n) SGD50

**2. QEEG Analysis - with hands-on examples**
By Prof Dr. Aamir, Prof Dr. Nidal and Mr. Hafeezullah

For registration and more information visit conference website:

http://www.spectrumlearning.com.sg/nfbconference2016/