The added value of HD-EEG recordings in the diagnosis of Alzheimer’s disease and Mild cognitive impairment.

*Hot topics in Dementia research*

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Definitions

- AD is the most common type of dementia (60-80%)
  - Cognitive impairment
  - Functional impairment
  - Behavioral disturbances
- MCI
  - Cognitive impairment
  - No interference with daily activities
  - High risk
History of EEG

- H. Berger, 1929
- The “one and only” brain studying method 1945-1970
- Replaced by neuroimaging
- New perspectives
- Multi-scientific study groups
From EEG to HD-EEG
“a technological progress”

- 19, 32, 56 channels
- HD-EEG 64, 128, 256, 512 channels
- 10/20 international system
EEG resting stage data analysis

Qualitative
[visual]
- Clinical practice

Quantitative
- Spectral Analysis
- Brain source localization
- Functional connectivity
- EEG microstates
- Connectomics
- Theory of Graphs
- ......
Visual Analysis of EEG in Alzheimer’s Disease

- Early stages: Abnormal activities are not usually seen
- Later stages: abnormal findings > slow waves
- Normal EEG in these patients raises questions about the diagnosis!
- Detects epileptic activity / epileptiform pattern

Quantitative spectral analysis (qEEG) in AD

- power increase of delta and theta activity
- power decrease in alpha and beta activity
qEEG and AD diagnosis

- high sensitivity at group level
- Differential diagnosis
- rate of correctly identified AD cases by electrophysiological
  - 29%- 42% early stages
  - 60%- 80% later

EEG microstates
Microstates in AD

- Shorter average microstate duration vs Normal Aging
  - Mild AD
  - Moderate AD
- Differential Diagnosis with FTD
  - Shortening of microstate C
  - Reversal of microstate transition (D > C) Vs controls (C > D)

Connectivity Studies based on EEG

- Disconnectivity of cortico-cortical connections in AD
- Accurate diagnosis of MCI Vs Healthy (83%) (Granger causality measure)
- Progressive MCI lower $\theta$ synchronization in comparison to stable MCI (sensitivity 87%, specificity 60%)
- Medication effectiveness

Comparison of Different Cortical Connectivity Estimators for High-Resolution EEG Recordings

Laura Astolfi,\textsuperscript{1,2,3} Febo Cincotti,\textsuperscript{3} Donatella Mattia,\textsuperscript{3} M. Grazia Marciani,\textsuperscript{3,4} Luiz A. Baccala,\textsuperscript{5} Fabrizio de Vico Fallani,\textsuperscript{3} Serenella Salinari,\textsuperscript{1} Mauro Ursino,\textsuperscript{6} Melissa Zavaglia,\textsuperscript{6} Lei Ding,\textsuperscript{7} J. Christopher Edgar,\textsuperscript{8} Gregory A. Miller,\textsuperscript{8} Bin He,\textsuperscript{7} and Fabio Babiloni\textsuperscript{2,3}
Cortical sources of resting state electroencephalographic alpha rhythms deteriorate across time in subjects with amnesic mild cognitive impairment

Claudio Babiloni a,b,*, Claudio Del Percio b, Roberta Lizio b, Nicola Marzano c, Francesco Infarinato b, Andrea Soricelli c,d, Elena Salvatore e, Raffaele Ferri f, Cinzia Bonforte f, Gioacchino Tedeschi g, Patrizia Montella g, Annalisa Baglieri h, Guido Rodriguez i, Francesco Famà i, Flavio Nobili i, Fabrizio Vernieri i, Francesca Ursini i, Ciro Mundi k, Giovanni B. Frisoni l, Paolo M. Rossini b,m
Brain neural synchronization and functional coupling in Alzheimer's disease as revealed by resting state EEG rhythms

Claudio Babiloni a,b,*, Roberta Lizio b, Nicola Marzano c, Paolo Capotosto d, Andrea Soricelli c,e, Antonio Ivano Triggiani f, Susanna Cordone f, Loreto Gesualdo g, Claudio Del Percio b
Research Article

Neuroplastic Effects of Combined Computerized Physical and Cognitive Training in Elderly Individuals at Risk for Dementia: An eLORETA Controlled Study on Resting States

Charis Styliadis, Panagiotis Kartsidis, Evangelos Paraskevopoulos, Andreas A. Ioannides, and Panagiotis D. Bamidis
Small-world brain networks

Functional disorganization of small-world brain networks in mild Alzheimer’s Disease and amnestic Mild Cognitive Impairment: an EEG study using Relative Wavelet Entropy (RWE)

Christos A. Frantzikis, Ana B. Vivas, Anthoula Tsolaki, Manousos A. Klados, Magda Tsolaki and Panagiotis D. Bamidis
EEG Origin- Neuronal Generators

- Fundamental issue
- 150 years old- “Inverse problem”
- Traditional approach
  - Lesion studies
  - Intracranial recordings
- Computational algorithms-Low Resolution Electromagnetic tomography (LORETA)

Brain Source mapping  (Bahador Bahrami 2006)

If

then

FORWARD MODEL

And on and on and on and ...
Brain source mapping

Forward Model

Experimental DATA

Inverse Solution

Which forward solutions fit the DATA better (less error)?
What algorithms do.

Iterative Process

Until solution stops getting better (error stabilises)
The more electrodes the better???

- **Forward EEG solution:**
  - at least 128 electrodes are needed to correctly sample the scalp potentials
  - 256 electrode systems achieve the highest accuracy in the absence of noise measurement

- **Reverse solution**
  - by increasing the number of electrodes can improve the source imaging and localization accuracy experimental and clinical value on the pre-surgical evaluation and follow up of epileptic patients
  - by increasing the electrodes up to 256, increases the accuracy of surface Laplacians in the presence of noise in simulation experiments
  - By increasing the number of electrodes up to 256 increases the spatial information content of the inverse cortical potential distribution that can be solved from the scalp potential

- improves the signal-to-noise ratio (SNR) of the signal generated by deep EEG sources

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Can we do the same with less electrodes?

- Dangerous
  - Misinterpretation
  - Ignores the spatial aspect of the signals
- Problematic connectivity analysis
Conclusions (1)

Flexibility

Cost effectiveness

Ease of use

High Temporal resolution

HD-EEG POWERFUL Brain imaging device

Reasonable spatial resolution

Conclusions (2)

- EEG Renaissance period
- Great research interest
- EEG responses after stimulation is expected to give more accurate results
- Clinical perspectives
- More studies, larger samples, HD-EEG
- Multi-scientific study groups

“The full capability of EEG is highly underestimated”

Michel & Murrey, 2012.

64 ch.
Video EEG

256 ch.

128 ch.
Ευχαριστώ για την προσοχή σας

Thank you