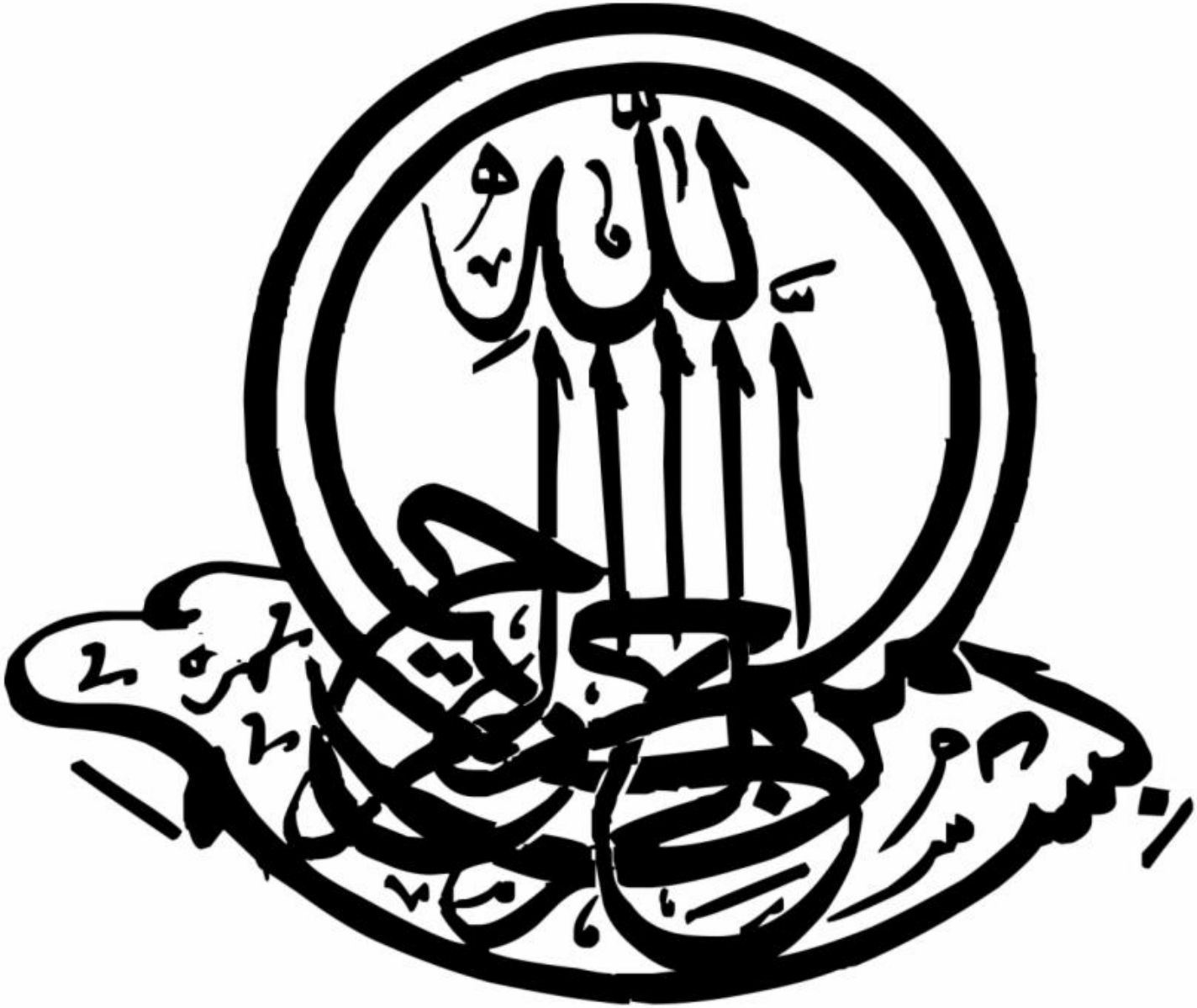
بسم الله الرحمن الرحيم

آزمایشگاه ملی نقشه‌برداری مغز

وبینار

(جلسه اول)

با موضوع

کاربرد رویکردهای چند مدالیته‌ای برای درک پدیده‌های شناختی "انجام دادن" یا "انجام ندادن"

سخنران

دکتر سید عابد حسینی

استادیار گروه مهندسی برق دانشگاه آزاد اسلامی مشهد

رئیس مرکز خدمات آزمایشگاهی و تحقیقاتی دانشگاه آزاد اسلامی خراسان رضوی

خردادماه ۱۳۹۹

۱۹

دوشنبه

ساعت: ۱۱ الی ۱۲

- لینک حضور در وبینار از طریق ایمیل و پیامک ارسال خواهد شد.
- در پایان وبینار از طرف سخنران ۲ سوال طرح می‌شود به دونفر از کسانی که پاسخ درست ارائه کنند ۱ساعت استفاده رایگان از خدمات آزمایشگاه داده خواهد شد.

رایگان

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National Brain Mapping Laboratory

web-99020.30

Multi-modal approaches to understanding cognitive phenomena

"Do" or "Not-to-do" ?

Dr. Seyyed Abed Hosseini

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June 8, 2020

Overview

What is a model?

Introduction

Terminology

What is multimodality?

- **Why do we need multimodality?**

Brain-mapping techniques

- **Invasive or non-invasive approaches**

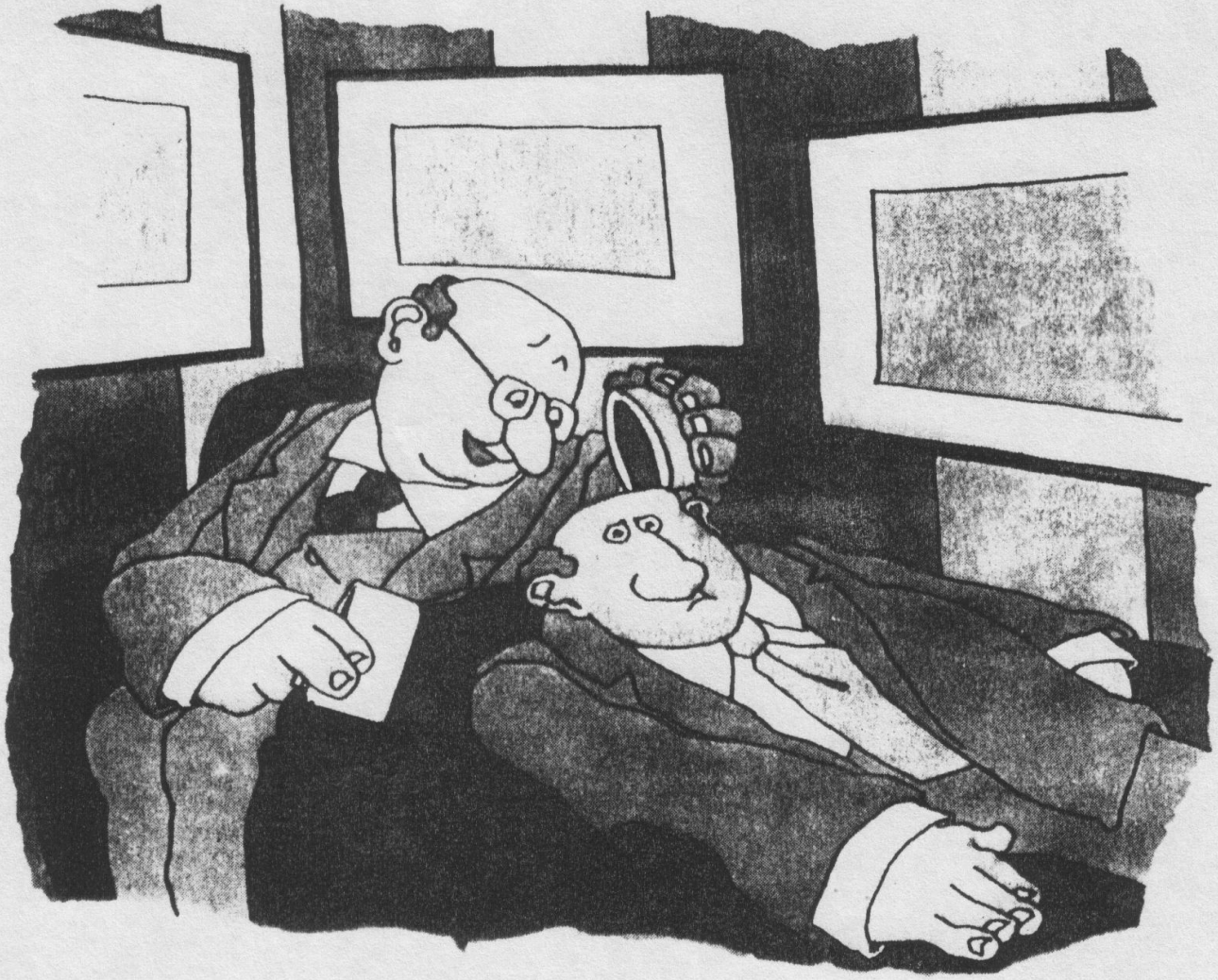
Why we need data fusion?

- **Why combining?**

How we perform it?

- **Challenges in multimodal recording**

Conclusion



"Looking good!"

What is a model?

- Abstractions of real-world systems or implementations of hypothesis
  - To demonstrate particular features of a system or hypothesis

- Description of a system

  in terms of

  - Constitutive objects and the Relationships among them,
    - Where the description itself is, in general, decodable or interpretable by humans

S. Motta and F. Pappalardo, "Mathematical modeling of biological systems," Brief. Bioinform., vol. 14, no. 4, pp. 411–422, 2012.

Modeling

White box

Gray box

Black box

System Model

- Representation of system and relations
- Special and Limited Condition
- Special purpose

- Ideal Model ?
  - No Comprehensive model
    - Universal & Complete

Model types:

- Mental Models
- Verbal (Descriptive) Models
- Conceptual (Diagrammatic) Models
- Physical Models
- Computational Models
  - Bio-inspired Models
  - Formal Models
  - Mathematical Models
    - Statistical and Artificial Intelligence-based Models
  - Computer Models

Good Model ?

- Correct
- Validate
- Simple

“...the single most critical piece of equipment is still the researcher’s own brain. All the equipment in the world will not help us if we do not know how to use it properly, which requires more than just knowing how to operate it.”

-- Endel Tulving, interview in Cognitive Neuroscience (2002, Gazzaniga , Ivry & Mangun, Eds., NY: Norton, p. 323)

knowing how to use different approaches properly, requires more than just knowing how to operate them!

Introduction

Introduction

Introduction

INVITED PAPER

Multimodal Data Fusion: An Overview of Methods, Challenges, and Prospects

This paper provides an overview of the main challenges in multimodal data fusion across various disciplines and addresses two key issues: "why we need data fusion" and "how we perform it."

By Dana Lahat, Tülay Adali, *Fellow IEEE*, and Christian Jutten, *Fellow IEEE*

ABSTRACT | In various disciplines, information about the same phenomenon can be acquired from different types of detectors, at different conditions, in multiple experiments or subjects, among others. We use the term "modality" for each such acquisition framework. Due to the rich characteristics of natural phenomena, it is rare that a single modality provides complete knowledge of the phenomenon of interest. The increasing availability of several modalities reporting on the same system introduces new degrees of freedom, which raise questions beyond those related to exploiting each modality separately. As we argue, many of these questions, or "challenges," are common to multiple domains. This paper deals with two key issues: "why we need data fusion" and "how we perform it." The first issue is motivated by numerous examples in science and technology, followed by a mathematical framework that showcases some of the benefits that data fusion provides. In order to address the second issue, "diversity" is introduced as a key concept, and a number of data-driven solutions based on matrix and tensor decompositions are discussed, emphasizing how they account for diversity across the data sets. The aim of this paper is to provide the reader, regardless of his or her community of origin, with a taste of the vastness of the field, the prospects, and the opportunities that it holds.

KEYWORDS | Blind source separation; data fusion; latent variables; multimodality; multiset data analysis; overview; tensor decompositions

I. INTRODUCTION

Information about a phenomenon or a system of interest can be obtained from different types of instruments, measurement techniques, experimental setups, and other types of sources. Due to the rich characteristics of natural processes and environments, it is rare that a single acquisition method provides complete understanding thereof. The increasing availability of multiple data sets that contain information, obtained using different acquisition methods, about the same system, introduces new degrees of freedom that raise questions beyond those related to analyzing each data set separately.

The foundations of modern data fusion have been laid in the first half of the 20th century [1], [2]. Joint analysis of multiple data sets has since been the topic of extensive research, and earned a significant leap forward in the late 1960s/early 1970s with the formulation of concepts and techniques such as multiset canonical correlation analysis (CCA) [3], parallel factor analysis (PARAFAC) [4], [5], and other tensor decompositions [6], [7]. However, until rather recently, in most cases, these data fusion methodologies were confined within the limits of psychometrics and chemometrics, the communities in which they evolved. With recent technological advances, in a growing number of domains, the availability of data sets that correspond to the same phenomenon has increased, leading to increased interest in exploiting them efficiently. Many of the providers of multiview, multirelational, and multimodal data are associated with high-impact commercial, social, biomedical,

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D. Lahat and **C. Jutten** are with the GIPSA-Lab, UMR CNRS 5216, F-38402 Saint Martin d'Hères, France (e-mail: Dana.Lahat@gipsa-lab.grenoble-inp.fr; Christian.Jutten@gipsa-lab.grenoble-inp.fr).

T. Adalı is with the Department of Computer Science and Electrical Engineering, University of Maryland Baltimore County, Baltimore, MD 21250 USA (e-mail: adali@umbc.edu).

Digital Object Identifier: 10.1109/JPROC.2015.2460697

Introduction

- The foundations of modern **data fusion** have been laid in the **first half of the 20th century**.
- Joint **analysis of multiple data sets** has since been the topic of extensive research, and earned a significant leap forward in the late **1960s/early 1970s** with the formulation of concepts and techniques such as multi-set canonical correlation analysis, parallel factor analysis, and other tensor decompositions.

DOI: 10.1109/JPROC.2015.2460697

Terminology

- We use the term ‘‘**modality**’’ for **each** such **acquisition framework** and is associated with one **dataset**
- The **whole setup**, in which one has access to data obtained from **multiple modalities**, is known as **multimodal**.
- Due to the rich characteristics of natural phenomena, it is **rare** that a **single modality** provides **complete** knowledge of the phenomenon of interest
- The increasing availability of **several modalities** reporting on the same system introduces **new degrees of freedom**, which raise questions beyond those related to exploiting each modality separately.
- A key property of multimodality is **complementarity (diversity)**
  - each modality brings to the whole some type of added value that cannot be deduced or obtained from any of the other modalities in the setup.
- As we argue, many of these “**questions**,” or ‘‘**challenges**,’’ are common to multiple domains.

DOI: 10.1109/JPROC.2015.2460697

Terminology

- **Motivations for data fusion** are numerous
  - a more unified picture and global view of the system
  - improving decision making
  - exploratory research
  - answering specific questions about the system
    - identifying common versus distinctive elements across modalities or time
    - extracting knowledge from data for various purposes
- However, despite the evident potential benefit, and massive work that has already been done in the field, the knowledge of how to actually exploit the additional diversity that multiple data sets offer is still at its very preliminary stages.

Terminology

Data fusion is a challenging task for several reasons:

- The data are generated by very complex systems: biological, environmental, sociological, and psychological, to name a few, driven by numerous underlying processes that depend on a large number of variables to which we have no access.
- Due to the augmented diversity, the number, type, and scope of new research questions that can be posed is potentially very large.
- Working with heterogeneous data sets such that the respective advantages of each data set are maximally exploited, and drawbacks suppressed, is not an evident task.

Terminology

- Definition 1: **Diversity** (due to **multimodality**) is the property that allows to enhance the uses, benefits and insights, in a way that cannot be achieved with a single modality.
- Definition 2: **Data fusion** is the analysis of several datasets such that different datasets can interact and inform each other.

What is multimodality? Why do we need multimodality?

- For living creatures, multimodality is a very natural concept. Living creatures use external and internal sensors, sometimes denoted as ‘‘senses,’’ in order to detect and discriminate among signals
- In a dynamic and constantly changing internal and external environment.

Applications

- The purpose of this section is to show that multimodality is already present in almost every field of science and technology, and thus it is of potential interest to everyone.

Applications

Multisensory Systems

- Speech processing
  - speech recognition
  - speech activity detection
  - speech enhancement
  - speaker extraction
  - separation
- scene analysis
  - tracking a speaker within a group
  - Biometrics
  - monitoring, for safety and security applications
  - human–machine interaction
  - calibration

Applications

Biomedical, Health

- Understanding Brain Functionality
  - Electroencephalography (EEG)
  - Magnetoencephalography (MEG
  - functional Magnetic Resonance Imaging (fMRI)
  - structural Magnetic Resonance Imaging (sMRI)
  - Diffusion Tensor Imaging (DTI)
- Medical Diagnosis
  - Augment physical examination
  - Blood tests, biopsies,
  - Static and functional magnetic resonance imaging
  - Genetic,
  - Environmental
  - Personal risk factors

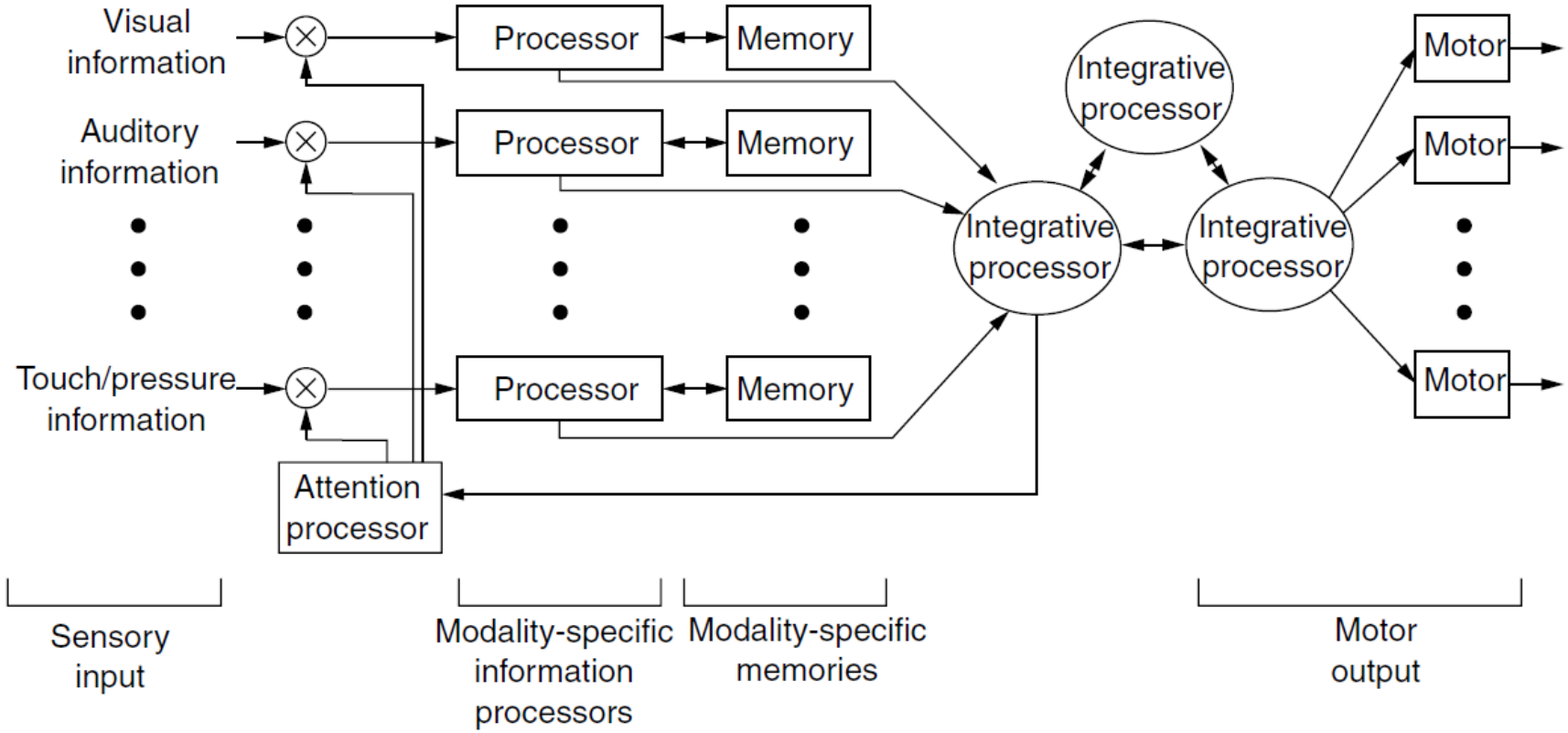
- Developing Noninvasive Medical Diagnosis Techniques
- Smart Patient Monitoring

Applications

Environmental Studies

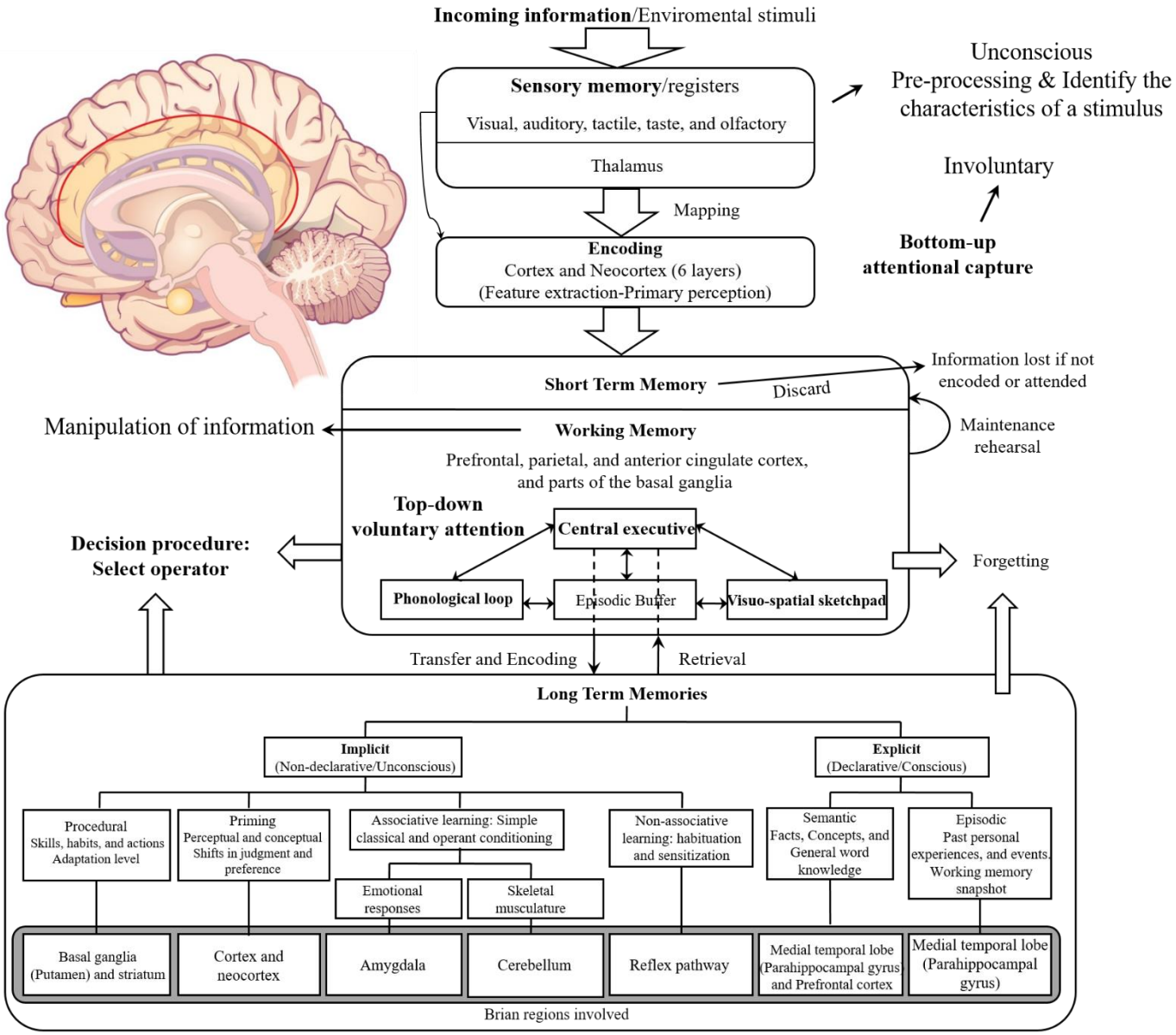
- Remote Sensing and Earth Observations
- Cosmology

Human information processing system
Multisensory Systems



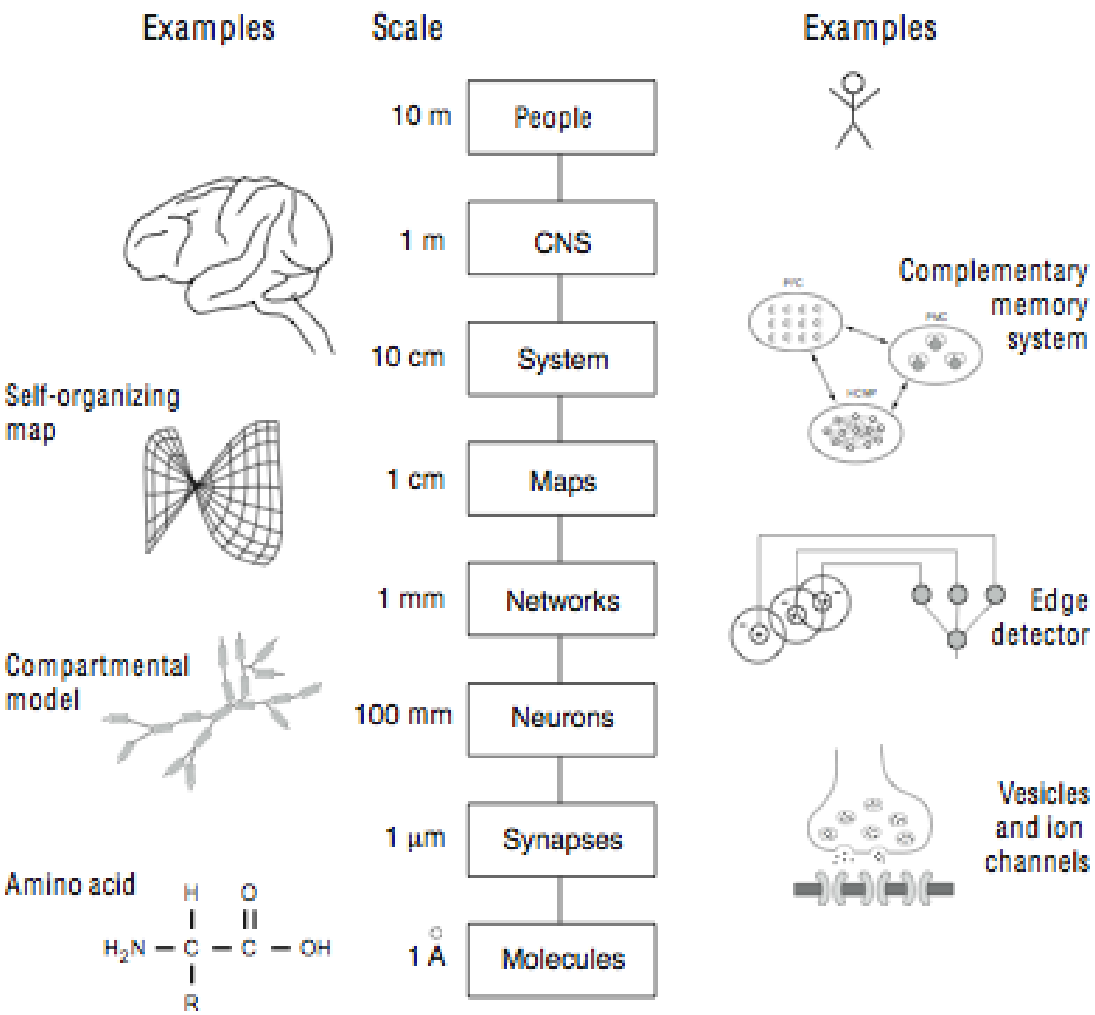
- A functional systems-level block diagram of human information-processing

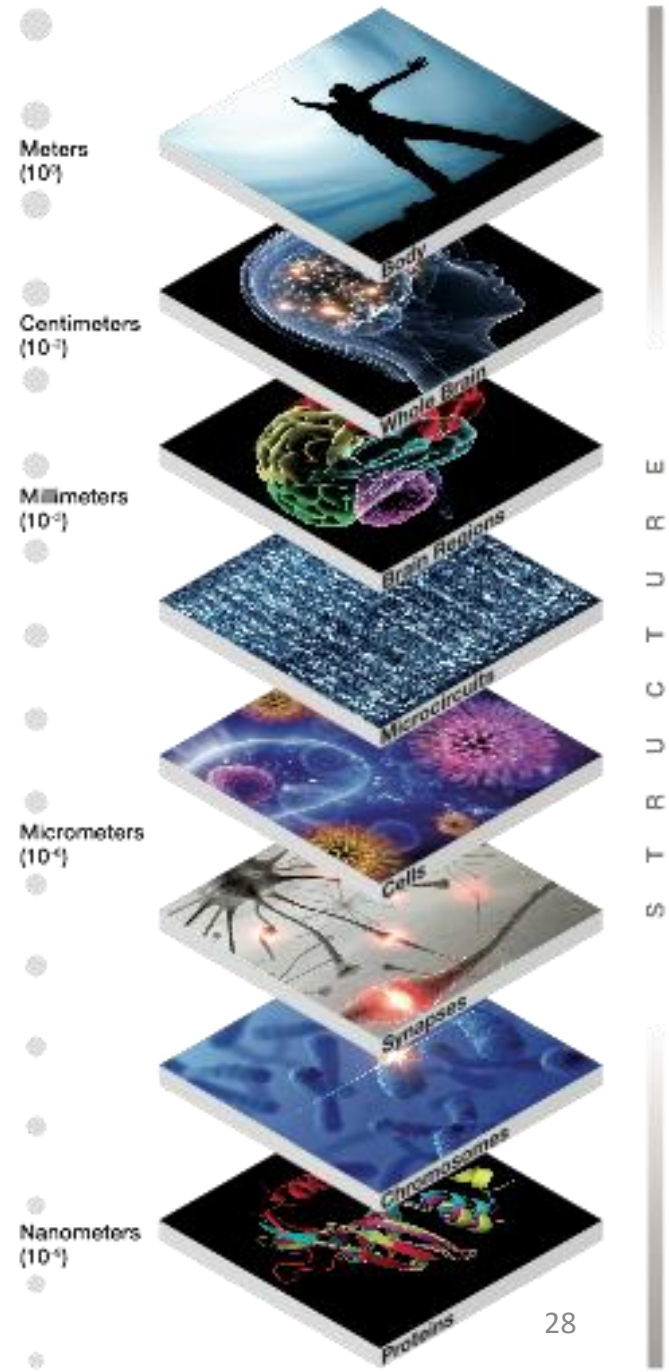
A general cognitive architecture of the memory and attention in the brain



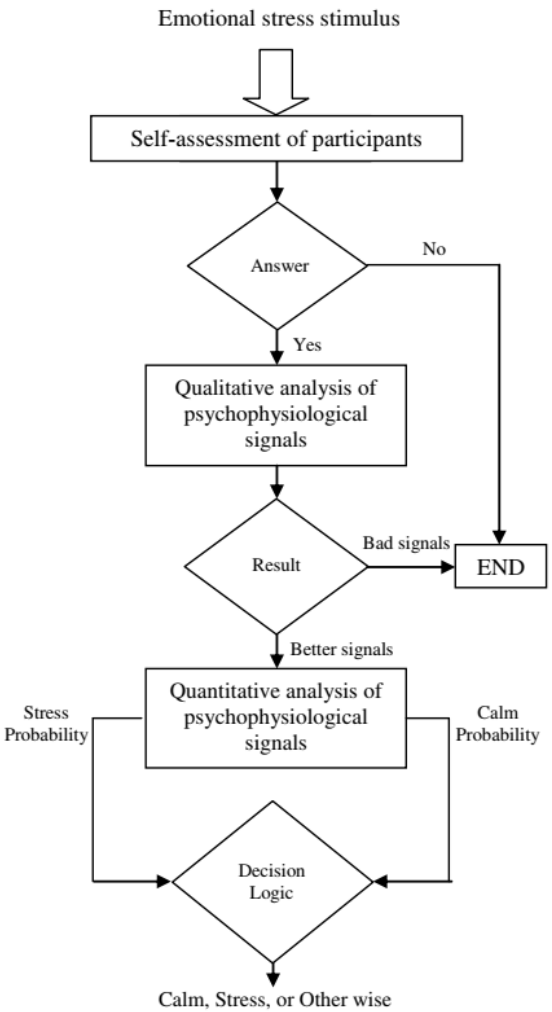
DOI: 10.1007/s13246-019-00743-8

Levels of Organization





Labeling process of EEG signals

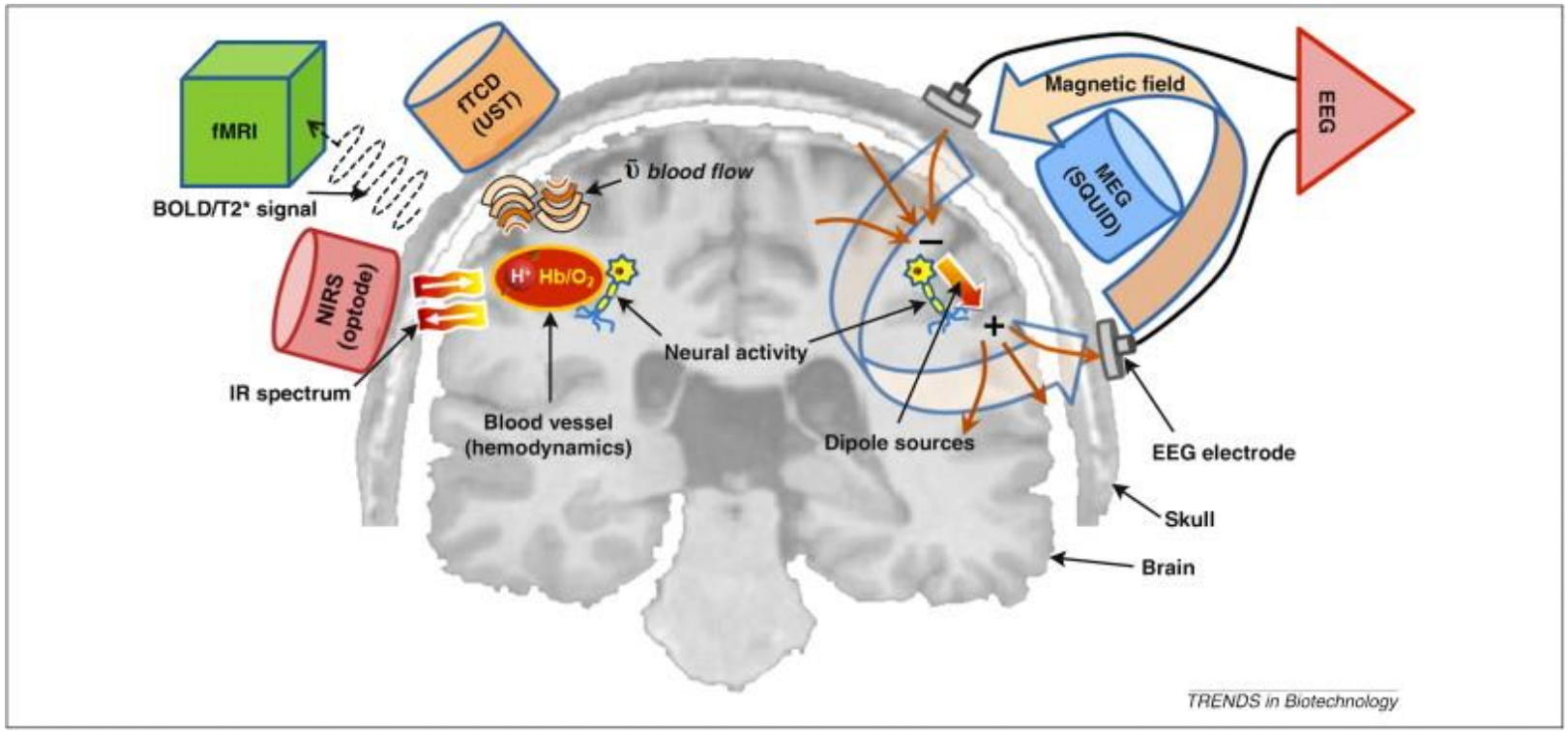


DOI: 10.1142/S0218339010003640

Brain-mapping techniques

- functional Magnetic Resonance Imaging (fMRI)
- Diffusion-Tensor Imaging (DTI)
- Positron Emission Tomography (PET)
- Single-Photon Emission Computed Tomography (SPECT)
- functional Near-InfraRed Spectroscopy (fNIRS)
- Magnetoencephalography (MEG)
- ElectroEncephaloGraphy (EEG)
- Event Related Potential (ERP)
- Evoked Potentials (EPs)
- Transcranial Magnetic Stimulation (TMS)
- regional Cerebral Blood Flow (rCBF)
- regional Cerebral Metabolic Rate of glucose (rCMRglc)
- Functional TransCranial Doppler sonography (fTCD)

Invasive or non-invasive approaches



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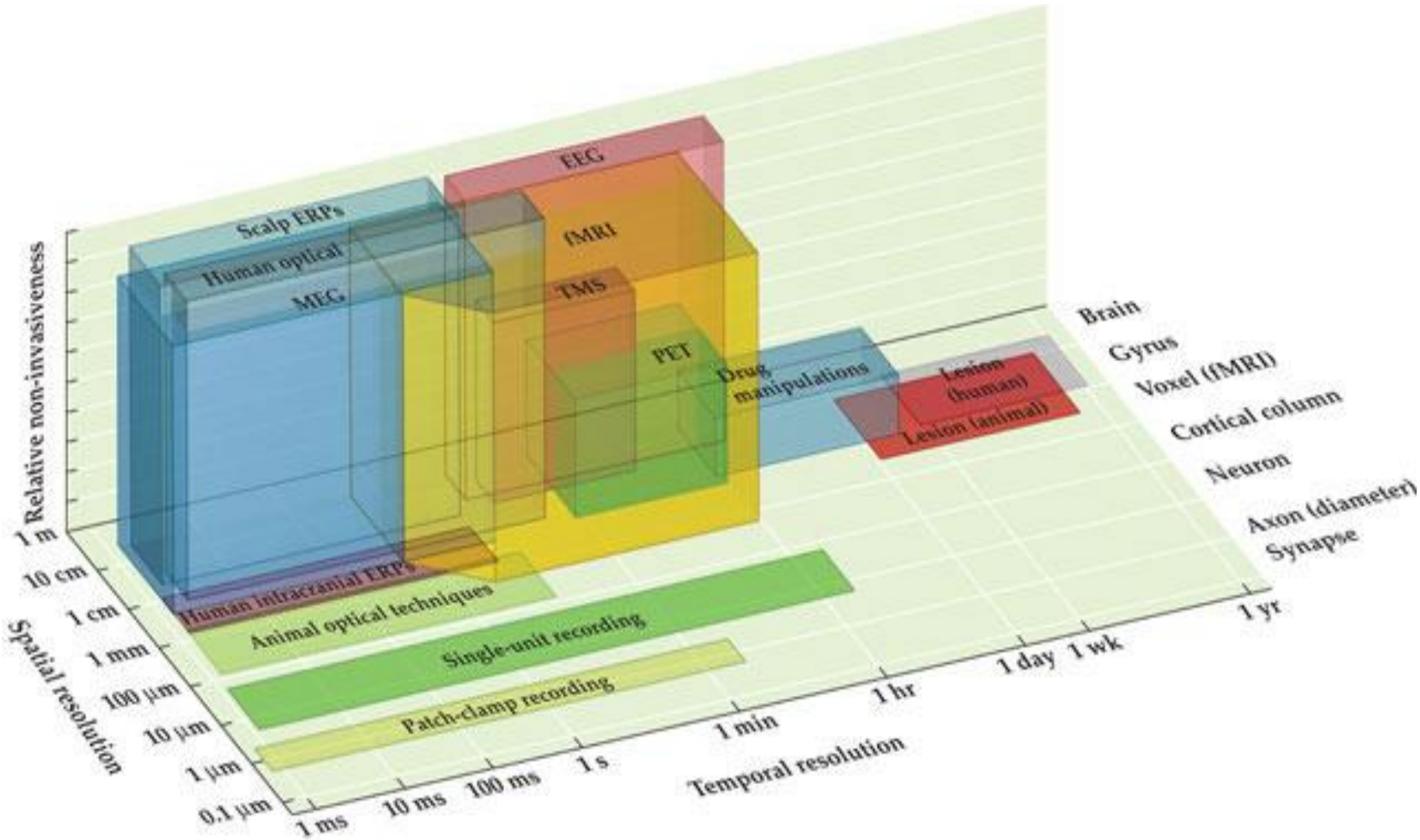
Why we need data fusion?



http://sites.sinauer.com/animalphys3e/boxex15.02.html

Non-invasive neuroimaging modalities

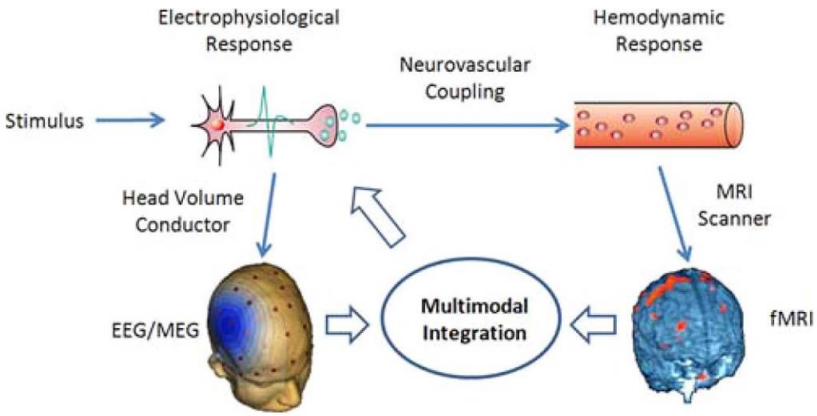
- Electrophysiological principles
  - Electroencephalography (EEG)
  - Magnetoencephalography (MEG)
- Hemodynamic/metabolic principles
  - functional Magnetic Resonance Imaging (fMRI)
  - Positron Emission Tomography (PET)
  - Single-Photon Emission Computed Tomography (SPECT)
  - Near-Infrared Spectroscopy (NIRS)

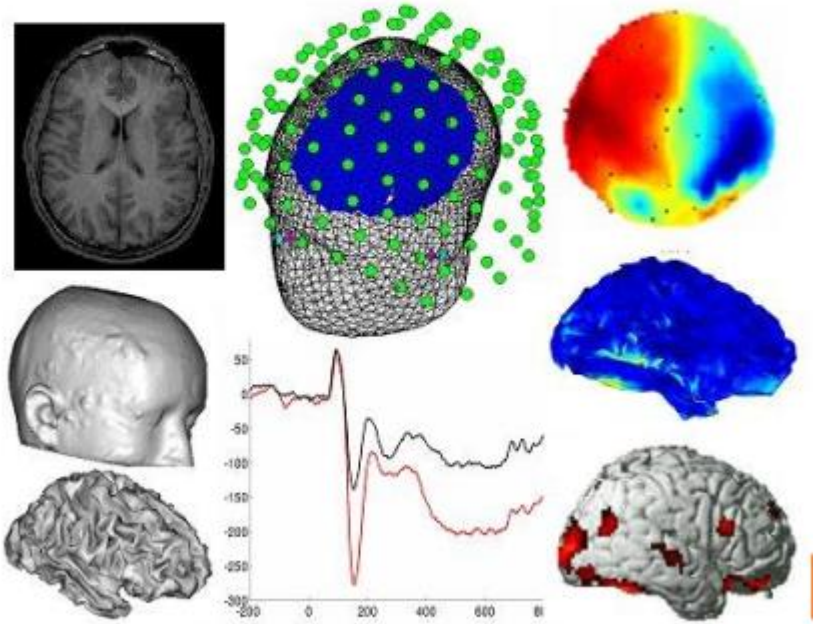
Non-invasive neuroimaging modalities

- Strengths and limitations of these modalities depend largely upon the **spatiotemporal characteristics** of the measured “source” signals in relation to neuronal activity, as well as many diverse sensing and imaging methods applied to individual modalities.

Why Combining?

http://fmri.uib.no/





http://bmet.wikia.com/wiki/Electroencephalography

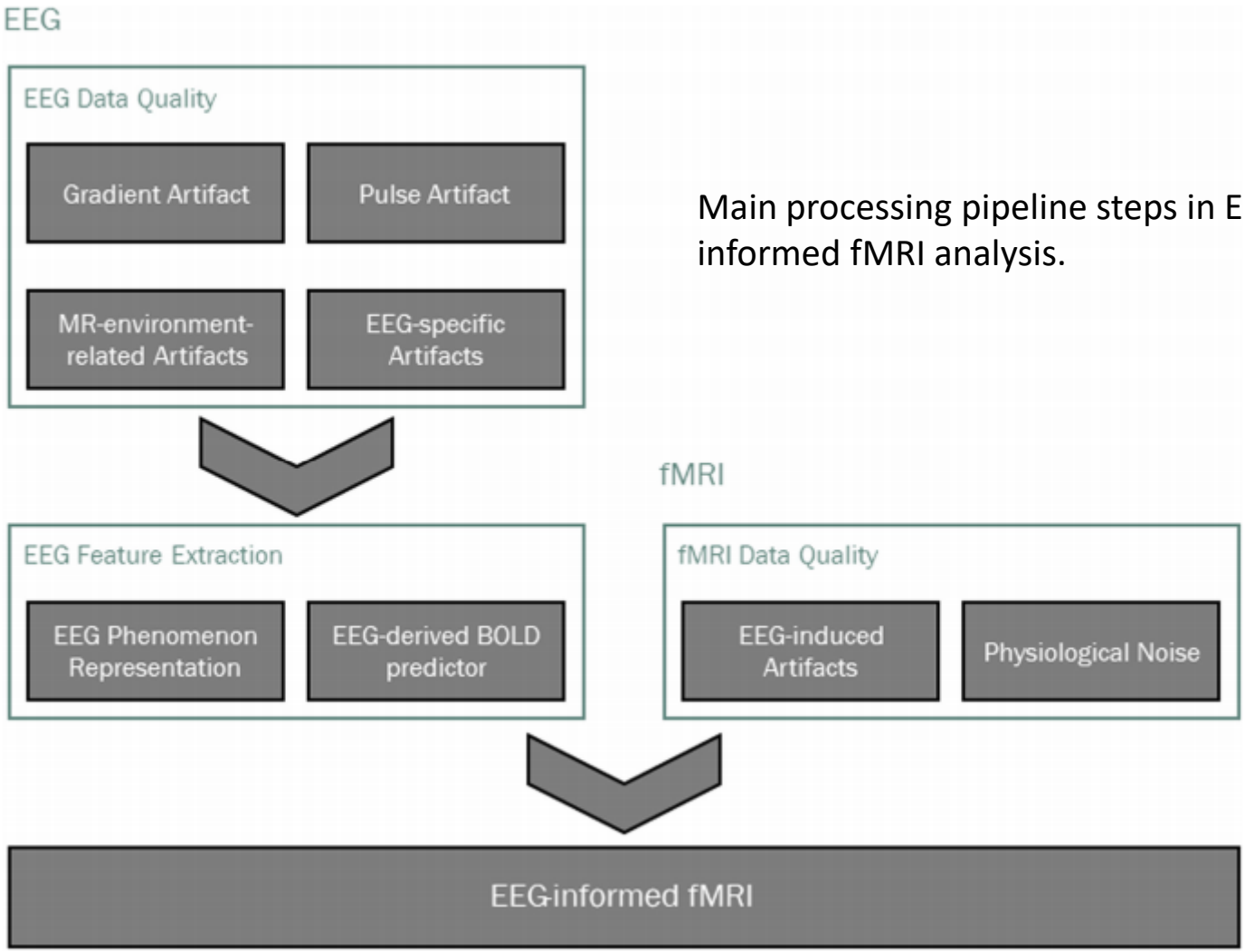
Combining EEG and fMRI

- **EEG/MEG** signals recorded at scalp have high **temporal resolution** in order of milliseconds and poor **spatial resolution.**
- fMRI provides much better **spatial localisation** of brain activity than is possible with EEG.
- simultaneous acquisition of EEG and fMRI is **highly desirable**.

Challenges in multimodal recording

- The combination of EEG with fMRI forms a powerful tool for the investigation of brain function, but concurrent implementation of EEG and fMRI poses **many technical challenges**.

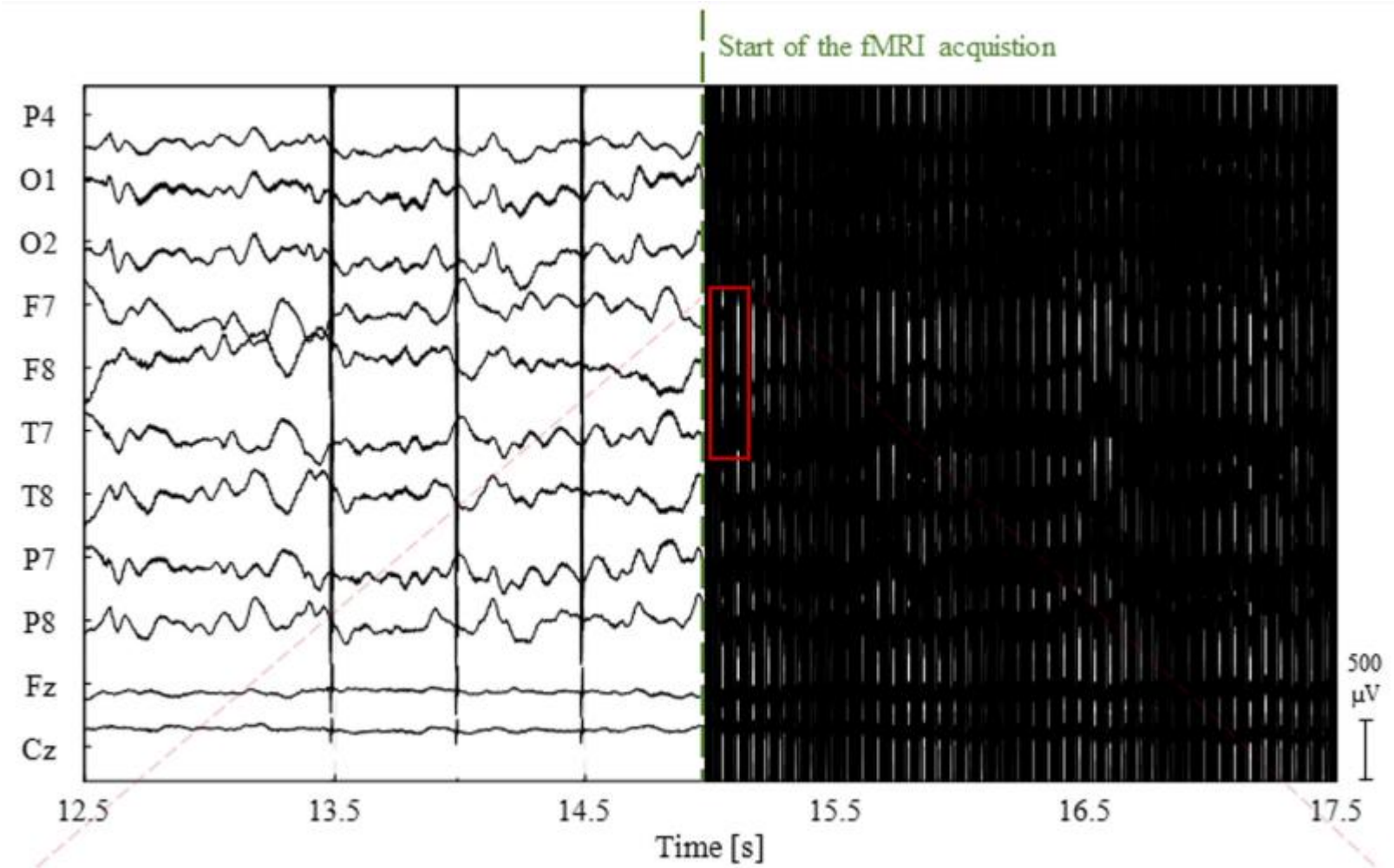
Challenges in multimodal recording



Main processing pipeline steps in EEG-informed fMRI analysis.

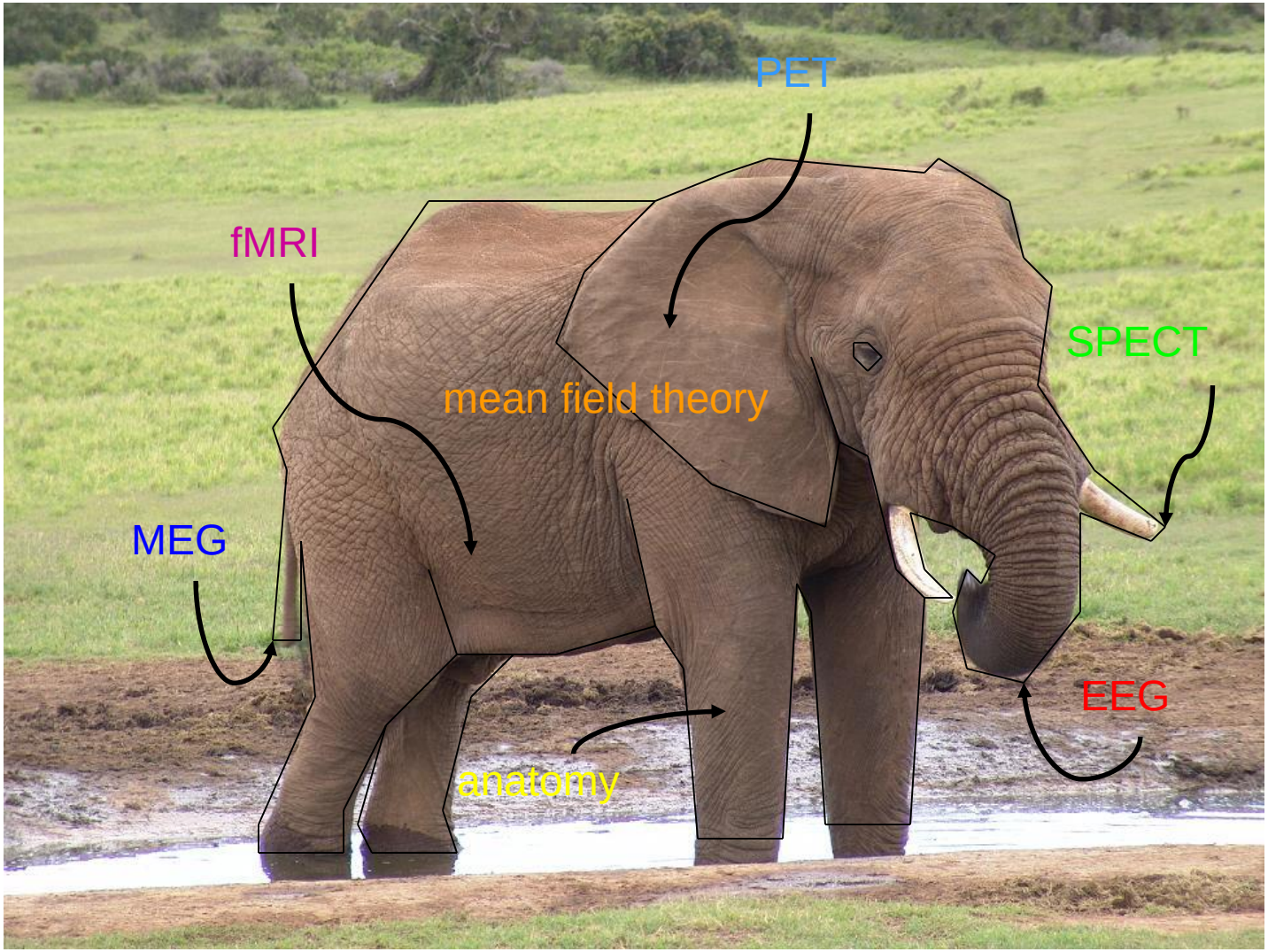
DOI: 10.3389/fnhum.2018.00029

Challenges in multimodal recording



DOI: 10.3389/fnhum.2018.00029

Conclusions



The End

Thank you for your Attention!

Seyyed Abed Hosseini

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آزمایشگاه ملی نقشه‌برداری مغز

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خردادماه ۱۳۹۹

۲۱

چهارشنبه

ساعت: ۱۱ الی ۱۲

- لینک حضور در وبینار از طریق ایمیل و پیامک ارسال خواهد شد.
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