Identificação e Validação de Biomarcadores em Imagem Médica - Modeling neural representations of events, states and procedures - representational similarity analysis as a neuroimage/behavioral biomarker

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Cognitive computational neuroscience

- Intersection of cognitive science, computational neuroscience and artificial intelligence.
- A brain map, at whatever scale, does not reveal the computational mechanism
- More generally, the topology and geometry of a biological neural network constrain its dynamics, and thus its functional mechanism.
    - Functional localization results, especially in combination with anatomical connectivity, may therefore ultimately prove useful for modeling brain information processing
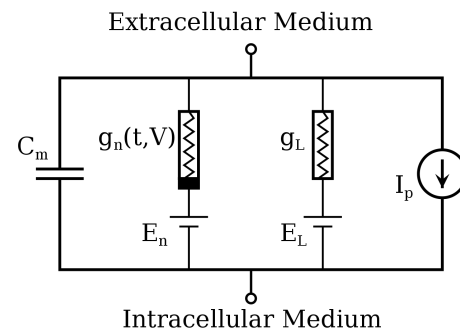
Hodgkin-Huxley model of the neuron (1952)
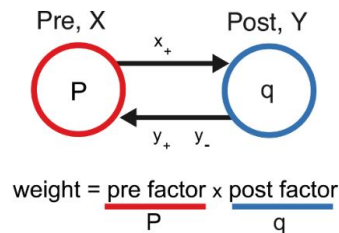
Unified pre- and postsynaptic long-term plasticity enables reliable and flexible learning (2015)

From experiment toward theory

- 1. Models of connectivity and dynamics
  - (...) correlation matrix among the measured response time series, which characterizes the pairwise 'functional connectivity' between locations.
    - By thresholding the correlation matrix, the set of regions can be converted into an undirected graph and studied with graph-theoretic methods.
    - Communities, hubs, rich-clubs
  - Effective connectivity analyses take a more hypothesis-driven approach, characterizing the interactions among a small set of regions on the basis of generative models of the dynamics
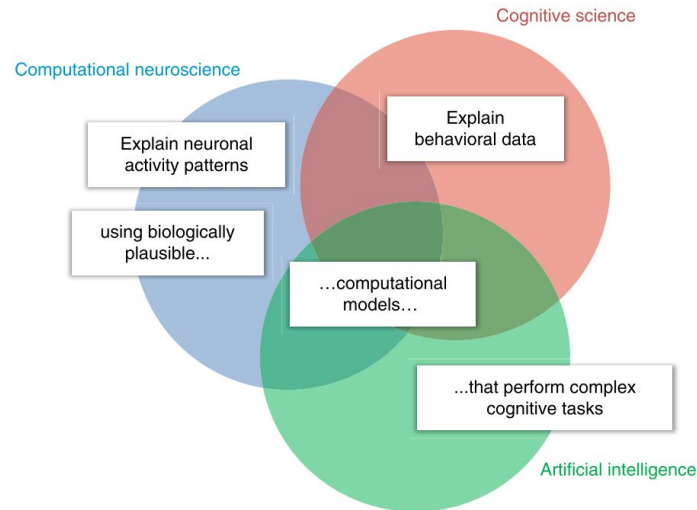

**Fig. 2 | What does it mean to understand how the brain works?** The goal

From experiment toward theory

- **2. Decoding model**
  - When particular content is decodable from activity in a brain region, this indicates the presence of the information. To refer to the brain region as 'representing' the content adds a functional interpretation
  - Decoding and other types of multivariate pattern analysis have helped reveal the content of regional representations

- **3. Representational model**
  - Representational models attempt to make comprehensive predictions about the representational space
  - In representational similarity analysis, the representational space is characterized by the representational dissimilarities of the activity patterns elicited by the stimuli.

dissimilarity matrix
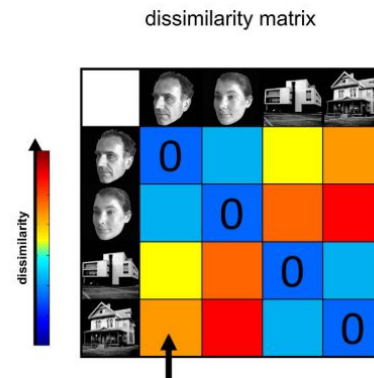
Representational similarity analysis – connecting the branches of systems neuroscience (2008)

Theory to Experiments

- Neural network models
  - Neural network models have demonstrated that taking inspiration from biology can yield breakthroughs in AI. It seems likely that the quest for models that can match human cognitive abilities will draw us deeper into the biology
- Cognitive models
  - Models at the cognitive level enable researchers to envision the information processing without simultaneously having to tackle its implementation with neurobiologically plausible components. This enables progress on domains of higher cognition, where neural network models still fall short.
    - production systems, reinforcement learning models and Bayesian cognitive models.

Representational similarity analysis

- How to establish the representational similarity matrix?
  - Pair-wise (conditions) similarity measures
    - Which ones can we use?
      - Correlation, euclidean distance, and other distances
    - We can use Multidimensional scaling (MDS) to visualize the similarity structure of the activity patterns.
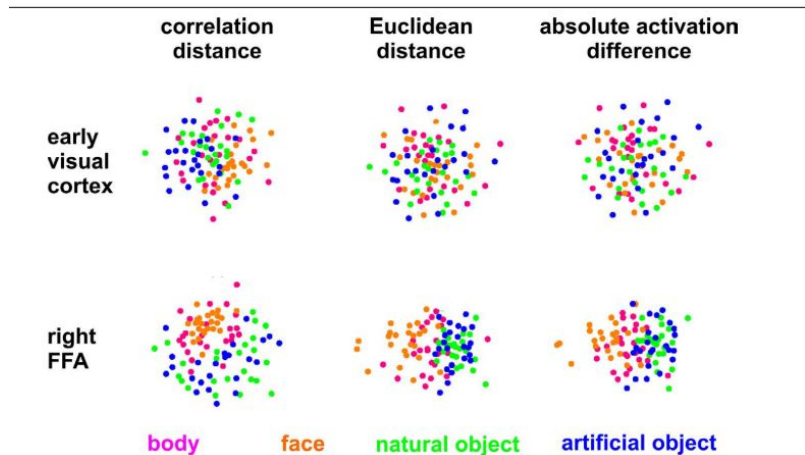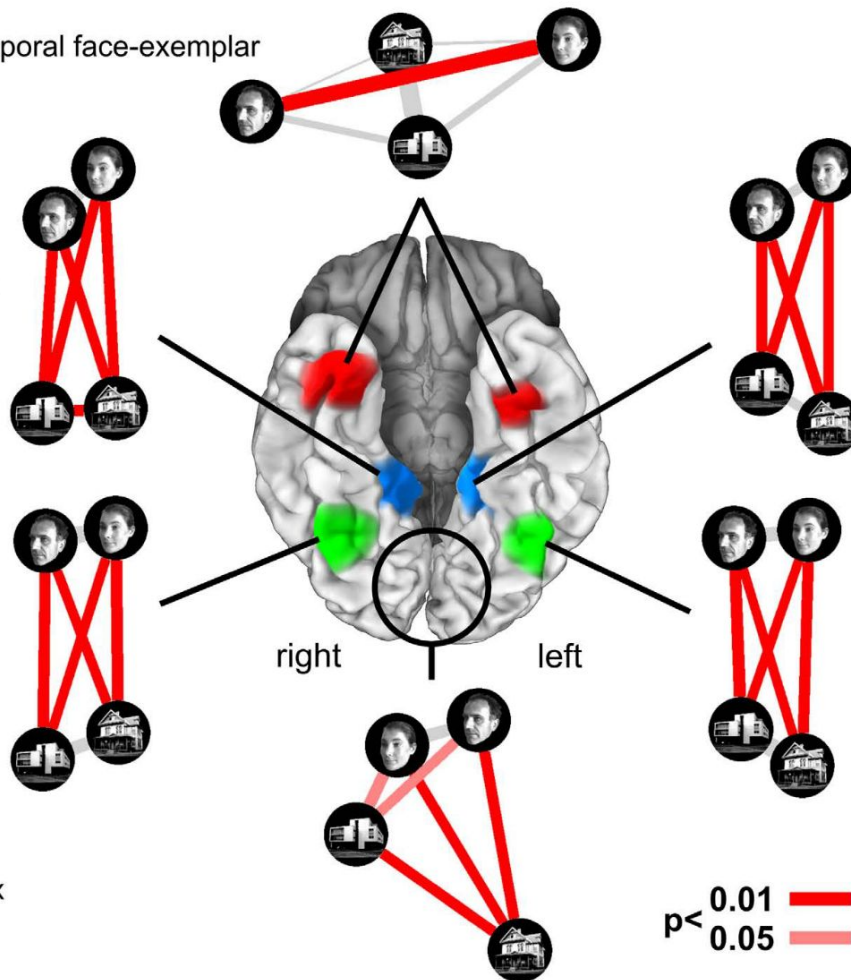
Anterior inferotemporal face-exemplar region

Parahippocampal place area

Fusiform face area

Early visual cortex

right

left

p< 0.01
    0.05

Discussion topics

- From data to theory vs from theory to experiments (estrutura das redes neuronais)
- Podemos fazer mapping com RSA?

Sayal - muito focado na review e RSA - que podemos fazer com o método?

Carolina - MVPA, cross-validation, balanced classes, a-priori masking (FIg.4); numero de condições - o que nos permitem acrescentar - comparar matrizes pre e pos amputação?

Joao Pereira - necessidade de fine-tuning dos dados