Principles of fMRI

Part II

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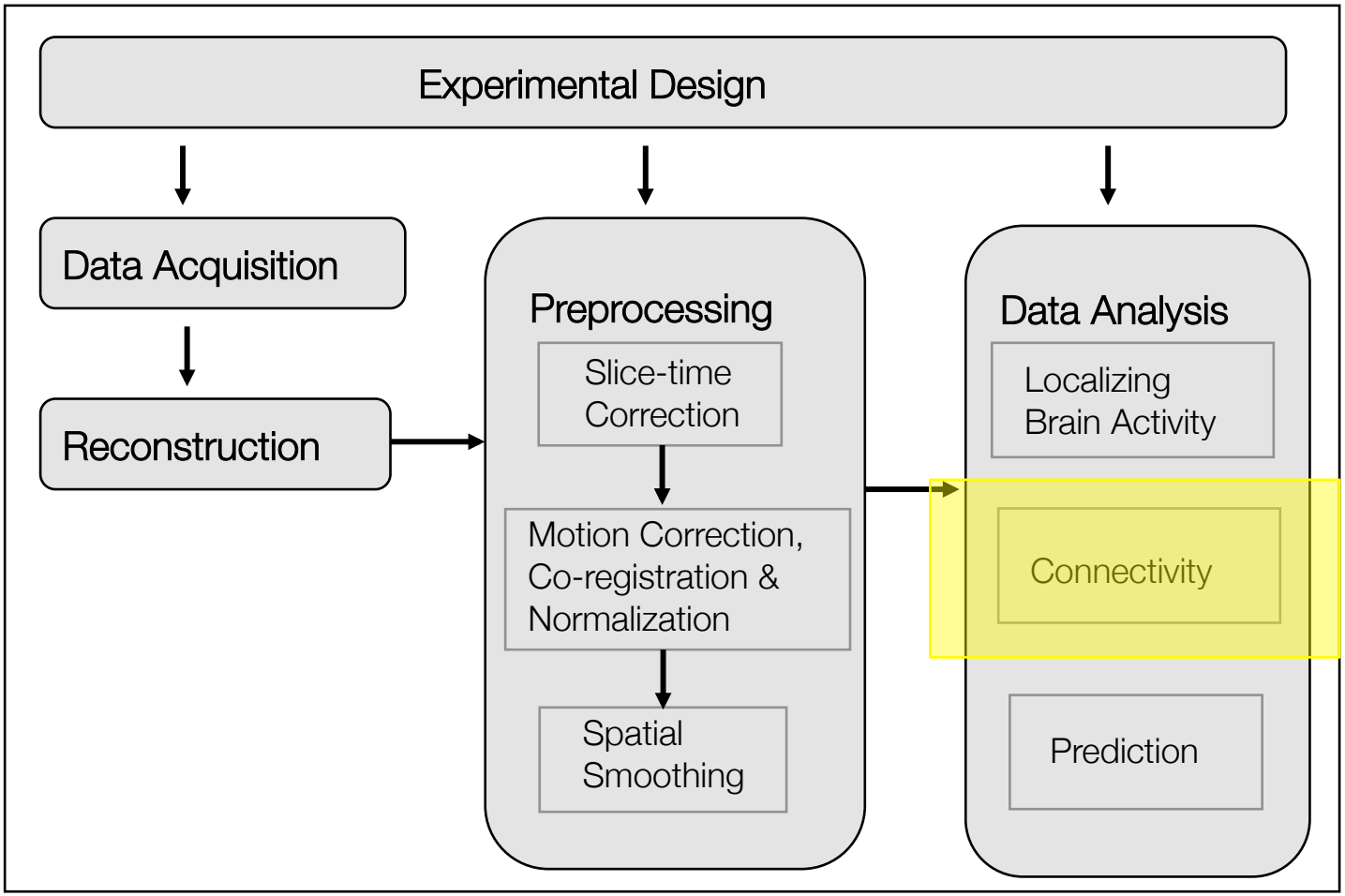
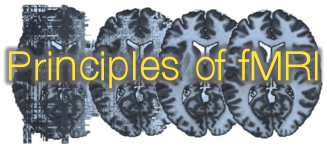
Brain Connectivity

Data Processing Pipeline



Brain Connectivity

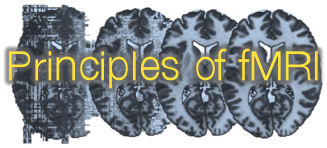


- Human brain mapping has primarily been used to construct maps indicating regions of the brain that are activated by certain tasks.

- Recently, there has been an increased interest in augmenting this type of analysis with connectivity studies.

- These studies seek to describe how brain regions interact and how these interactions depend on experimental conditions and behavioral measures.

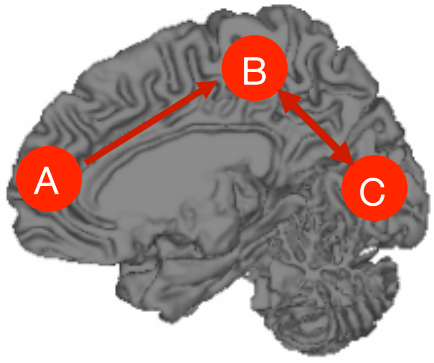
Brain Networks



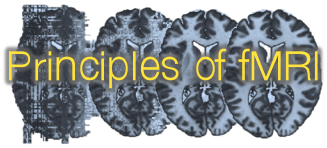
- It has become common practice to talk about brain networks, i.e. sets of interconnected brain regions with information transfer among regions.

- To construct a network:
  - Define a set of nodes (e.g., ROIs)
  - Estimate the set of connections, or edges, between the nodes.

	A	B	C
A	0	1	0
B	0	0	1
C	0	1	0



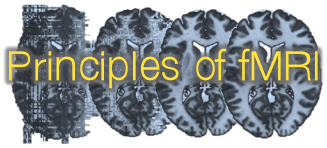
Network Methods



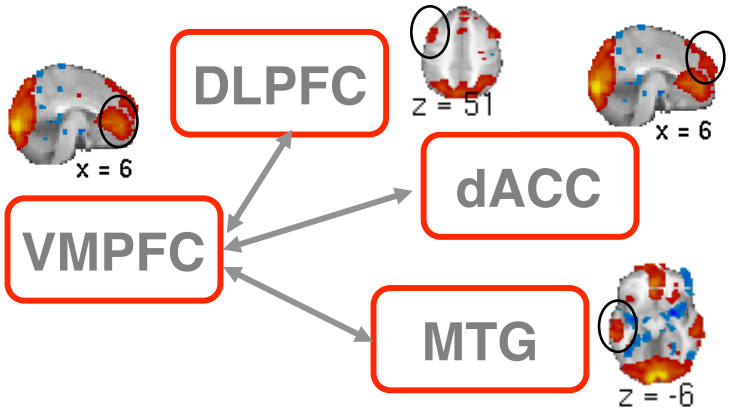
- A number of methods have been suggested in the neuroimaging literature to quantify the relationship between nodes/regions.

- Their appropriateness depend upon:
  - what type of conclusions one is interested in making;
  - what type of assumptions one is willing to make;
  - the level of the analysis;
  - and the modality used to obtain the data.

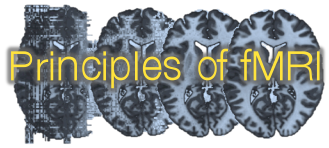
Brain Connectivity



- Functional Connectivity
  - Undirected association between two or more fMRI time series and/or performance and physiological variables.
  - Makes statements about the structure of relationships among brain regions.
  - Usually makes no assumptions about the underlying biology.

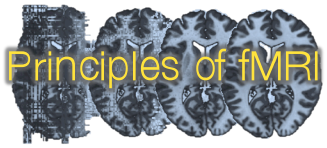


Functional Connectivity



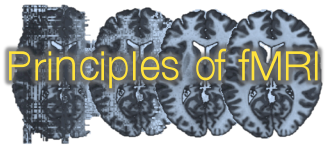
- Methods include:
  - Seed analysis
  - Inverse covariance methods
  - Multivariate decomposition methods
    - Principle Components Analysis
    - Independent Components Analysis
    - Partial Least Squares

Scope of Inference

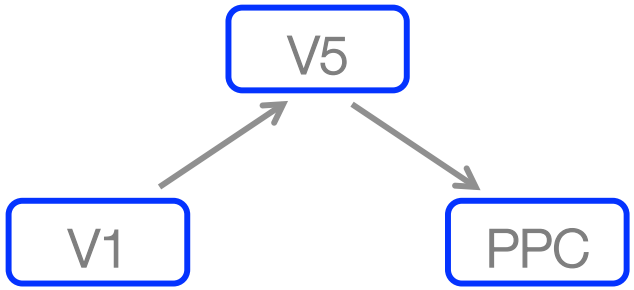


- A goal of functional connectivity analysis is to make inferences on the structure of relationships among brain regions.
  - "These regions form a network"
  - "Regions are more connected during task A than B…"
  - "This task is associated with activation of pain pathways…"

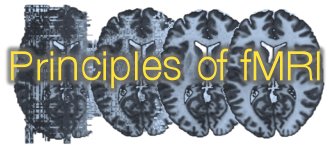
Brain Connectivity



- Effective Connectivity
  - Directed influence of one brain region on the physiological activity recorded in other brain regions.
  - Claims to make statements about causal effects among tasks and regions.
  - Usually makes anatomically motivated assumptions and restricts inference to networks comprising of a number of pre-selected regions of interest.

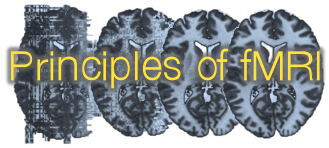


Effective Connectivity



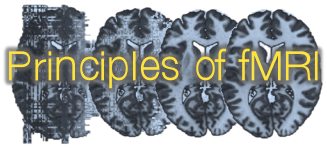
- Methods:
  - Structural Equation Modeling
  - Granger Causality
  - Dynamic Causal Modeling
  - Bayes Net

Scope of Inference



- A goal of effective connectivity analysis is to make statements about causal effects among tasks and regions.
  - "Frontal cortex enhances connectivity between visual areas and hippocampus."
  - "VMPFC inhibits the amygdala"

Levels of Analysis

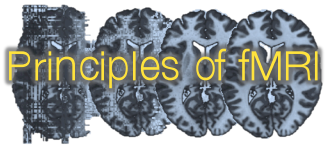


- Connectivity can be studied at different levels of analysis, with different interpretations at each.

- Connectivity across time can reveal networks that are dynamically activated across time.

- Connectivity across trials can identify coherent networks of task related activations.

Levels of Analysis



- Connectivity across subjects can reveal patterns of coherent individual differences.

- Connectivity across studies can reveal tendencies for studies to co-activate within sets of regions.

End of Module

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