Perception, cognition, and other psychological processes do not happen in isolation

Functionally connectivity is...

"the temporal correlation of a neurophysiological index measured in different brain areas." Friston et al., 1993.

Functional connectivity approaches allow researchers to ask a host of interesting questions:

- Whether brain regions A and B are functionally correlated?
    - If so, does it depend on task, drug, intervention, etc?
- What other brain regions are functionally correlated with brain region A?
- Is the correlation between regions A and B direct, or is it mediated by region C?

Functional connectivity approaches allow researchers to ask a host of interesting questions:

- What are the “intrinsic” networks in the brain during rest?
  - Or during some particular task?

Functional connectivity can be assessed using a variety of techniques

Basic goal: finding correlations/similarities in BOLD signal, between different brain regions, across time.

Different techniques address different specific questions.

Functional connectivity techniques can be classified as model-driven or model-free

- Typical hypothesis-testing requires a model-based approach (see Smith et al., *NeuroImage* 2010).
  - e.g., is A correlated with B?
  - Directionality can be assessed using lag-based approaches.
- Data-driven (model-free) approaches are useful for exploratory characterization of correlated regions.

Model-driven approaches to functional connectivity

- Correlation/covariance approaches

  Assesses linear relationships between variables (brain regions). Areas that are highly correlated are interpreted as being functionally connected (Biswal et al., 2005).

- Coherence

  Similar to correlation, but in frequency domain. Invariant to lag effects and interregional differences in the HRF (Sun et al., 2004).

- Mutual information

  Capture similarities between variables (brain regions) that are non linear (Hlinka et al., 2010).

*Partial correlation/coherence/mutual information models can be specified to test more specific hypotheses (i.e., what is the correlation between A and B, if we control for the effects of C?)

Model-driven approaches to effective connectivity

-Cross correlation

Models a lag term in the correlation (e.g., what is the correlation between A(t) and B(t+1)?). (Golestani & Goodyear, 2011)

-Structural equation modeling

Test competing path models. (McIntosh & Gonzalez-Lima, 1994)

-Dynamic causal modeling

Construct neuronal models (architecture, time constants). (Friston et al., 2003)

-Granger causality

Akin to performing partial correlation analysis with lag in one of the variables. (Goebel et al., 2003)

Model-free approaches to functional connectivity

Principal Component Analysis

Orthogonal linear transformation to find coordinate system(s) (component(s)) that maximizes variance. (Friston et al., 1993)

Independent Component Analysis

Assume observed signal is comprised of linear combination of independent components, do source decomposition. (Damoiseaux et al., 2006)

Factor analysis

Can the variance across all variables be explained by fewer, unobserved factors? Regions that load into the same factor can be interpreted as being functionally connected. (McLaughlin et al., 1992)

Cluster analysis

Unsupervised categorization of voxels with similar attributes based on distance parameter. Voxels that cluster together may be functionally connected (Baune et al., 1999)

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