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)


