What is Memory?
Memory proper…is the knowledge of a former state of mind after it has already once dropped from consciousness; or rather it is the knowledge of an event, or fact, of which meantime we have not been thinking, with the additional consciousness that we have thought or experienced it before.

Forms of Memory
• remembering details of the last movie you saw

H.M. and the Amnesic Syndrome
Patient H.M.

1926	born
1942	first major seizure (age 16)
1953	bilateral medial-temporal lobe resection (hippocampus & nearby structures)
1955	first published report of pervasive and profound anterograde amnesia
1962	neuropsychological examinations characterizing the amnesic syndrome

Medial Temporal Lobe Lesions & Amnesia
Forms of Memory
• riding a bike or showboarding

Forms of Memory
• increased probability of using a word, phrase, or concept that has recently been uttered

What is Memory?
A change in the system, brought about by experience, that influences subsequent processes
Learning & Memory
Learning
• *the processes by which changes occur as a result of experience*

Memory
• *the record of the experience that underlies learning and that influences subsequent processing or behavior*
Long-Term Memory Systems

Long-Term Memory Systems
Memory: The Basic Problems

Insights into Memory's Architecture

Neural Firing & Hemodynamics
Neural Firing & Hemodynamics
Imaging Memory in Humans
Hemodynamic measures (indirect)
- PET
  - indexes changes in blood flow correlated w/ neural activity
  - strengths: can index metabolism and receptor density
  - limits: radiation; cost; low temporal and spatial resolution

- fMRI
  - indexes changes in blood oxygenation levels correlated w/ activity
  - strengths: non-invasive; high spatial resolution; individual or group analyses; permits event-related designs
  - limits: temporal resolution restricted by hemodynamic response
PET
PET
Signal is always RELATIVE
fMRI Signal Contrast
fMRI Blood Oxygen Level Dependent Contrast
BOLD fMRI Signal
fMRI Studies of Cognition
Neuroimaging Approaches
Binary comparisons
- full- vs. divided-attention during episodic encoding   (e.g., Shallice et al., 1994)

- "deep" vs. "shallow" processing during episodic encoding (e.g., Kapur et al., 1994)

- phonological store and rehearsal vs. rehearsal   (e.g., Paulesu et al., 1993)

Subtractive / Hierarchical Logic
Neuroimaging Approaches: Subtractive Logic
Issues to consider
- subtractive logic -- assumption of "pure insertion"
  – requires well-designed paradigms and correct task analyses
  – assumes processes do not interact
Parametric Designs
Systematically vary the levels of one factor
- e.g., varying working memory load (e.g., Braver et al., 1997)
Conjunctive Logic

Conduct multiple contrasts, each thought to share a common processing difference

Blocked fMRI Designs

Event-Related fMRI

Response to Averaged Single Trials

Variance Associated with Fixed Interval Designs
Variance Associated with Jittered Designs

Shorter Lags Yield Greater Neural Priming

Neural Regions Predicting Subsequent Memory

Choosing Your Design
Event-related designs
• minimize set effects (although state can effects still remain)
• permit subject-determined analysis, including parametric analysis
• provide an index of the task-elicited hemodynamic response
    – provides some limited temporal information
      (time to onset and time to peak)

Limitations of ER-fMRI
• task/process "impurity"
• lower statistical power
What does neuroimaging tell us?
Function-structure relations

Dissociative data to test cognitive and neural theories

Functional co-localization = novel process insights
What does neuroimaging tell us?
Correlational data -- does not address necessity
 – e.g., delay conditioning and MTL (Blaxton et al., 1996)