Working memory

- Profound memory impairment
  - Long-term memory
    - “robbed of knowledge of his own life”
  - Short-term (working) memory
    - “moment to moment consciousness”, “time vacuum”
    - “relate yourself to the past and project yourself into the future”
- Certain aspects of mental life preserved
  - Procedural memory (skills)
  - Emotions

Clive
Short-term vs Long-term memory

• Memory for events that have just occurred
• Information needs to be continuously rehearsed in order to be kept in memory
• Limited capacity

• Memory for events from more distant times
• Information can be recalled even if not thought about for years
• Unlimited capacity

Short-term and Working memory

• Short-term memory
  - originally seen as the temporary station on the way to long-term memory
  - later on, shown to have a more complex role

• Working memory
  - temporary holding and manipulating of info
  - used during performance of a range of tasks
    e.g., comprehension, learning, reasoning

Working memory (WM) is linked to Prefrontal Cortex (PFC)

Impaired WM with PFC lesions (both humans and nonhuman primates)
PFC neurons increase their firing rates during WM delay in nonhuman primates
WM tasks activate PFC in humans
• Working memory as keeping something in mind during a delay

Delayed matching-to-sample

Activity of a prefrontal unit during delayed-response trials

From Funahashi and Alexander, 1991
• Working memory as keeping something in mind during a delay
  With distractors during the delay

Delayed matching to sample task

Activity of a prefrontal neurons during a delayed matching to sample task

• Working memory as keeping something in mind during a delay
  With distractors during delay

• What kind of information can prefrontal neurons maintain?

Categorical information

Freedman et al., 2001 Science

Average performance of both monkeys
The average activity of a single PFC neuron

- Working memory as keeping something in mind during a delay
  - With distractors during delay
- What kind of information can prefrontal neurons maintain
  - Concrete (objects), as well as abstract (categories)

Different levels of abstraction
Verbal problem solving task: anagrams

Abstract  Medium  Concrete

A P e a l p  D n c a e  D k e s
H m a r  T p i r  F o d o
G a c r e  S n g o  B O l t e t

Christoff et al. (2009) Brain Research

Concrete  Medium  Abstract

z = -18 mm  z = 24 mm  z = 0 mm
x = .34 mm  x = -44 mm  x = -34 mm

The average activity of a single PFC neuron
PFC neurons code memory information categorically … both during the “Sample” and “Delay” intervals

The prefrontal cortex (PFC)

Cognitive control

Perception and memory

PFC biases neural processes occurring in posterior brain regions

Cognitive control

• Considered one of PFC’s primary functions

• Helps us to engage in selective attention (e.g., looking for your friend whose wearing a red jacket)

• Implemented by increasing the gain of sensory or motor neurons that are engaged by task- or goal-relevant elements in the external environment
The prefrontal cortex serves to

- Actively maintain patterns of activity that represent goals and the means to achieve them
- Provide bias signals throughout the rest of the brain, e.g.
  - Sensory modalities
  - Memory retrieval
  - Emotional evaluation
- Guide the flow of neural activity along pathways that establish the appropriate mappings between inputs, internal states, and outputs needed to perform a given task