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 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
Nonhuman primates

- Working memory as keeping something in mind during a delay
  - No distractors during delay
  - With Distractors during delay

- Different working memory processes
  - Simple retrieval (recognition)
  - Complex retrieval (monitoring)

Delayed matching-to-sample

Activity of a prefrontal unit during delayed-response trials

30 sec delay

60 sec delay

From Fuster and Alexander, 1971
Delayed matching to sample task

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

Nonhuman primates

- Working memory as keeping something in mind during a delay
  - No distractors during delay
  - With Distractors during delay
- Different working memory processes
  - Simple retrieval (recognition)
  - Complex retrieval (monitoring)
Lesion studies

Prefrontal lesions in monkeys impair working memory tasks.

What about different subregions?

Are some regions more important for particular WM tasks?

Delayed alternation task

- spatial
- object

Delayed alternation task - deficits

*Dorsolateral lesions*: do not cause impairment

*Ventrolateral lesions*: cause severe impairment
Recognition vs. Monitoring

• **Recognition:**
  - allows to make a choice on the basis of *general familiarity*
  - low mnemonic demands
  - preserved after DLPFC lesions

• **Monitoring:**
  - recalling and taking into account *one’s own past choices*
  - high mnemonic demands
  - impaired after DLPFC lesions

**Dorsolateral lesions:** impair **monitoring**

**Ventrolateral lesions:** impair **recognition**
(e.g., alteration tasks)
Recognition vs. Monitoring (Neuroimaging)

Recognition

Owen et al. (1996) Cerebral Cortex

Monitoring

The n-back task

Increasing working memory load

- Results in progressive recruitment of PFC regions in anterior direction
- More PFC is needed for higher WM load

Working Memory in humans

Proposed by Alan Baddeley (1982)

A three-part system:
- **visuospatial scratch-pad** (visual coding of info)
- **articulatory loop** (acoustic coding of info)
- **a central executive** (executive control: comprehension, learning, reasoning)

Working memory “slave” systems

- **Spatial**
  - Working memory for location info: right PFC

- **Verbal**
  - Working memory for verbal info: left PFC


Sala et al. (2003)
Working memory in the brain

• Posterior cortical regions (temporal, parietal, occipital) support modality specific working memory
• PFC supports working memory regardless of modality
• Ventrolateral PFC supports easier working memory, but dorsolateral PFC is activated during more difficult working memory tasks