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### Clive

- 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

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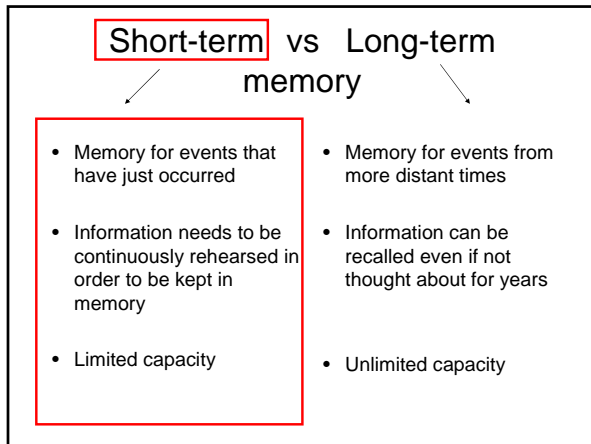
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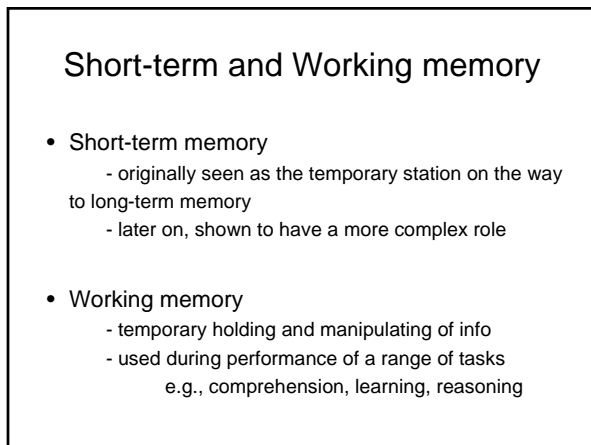
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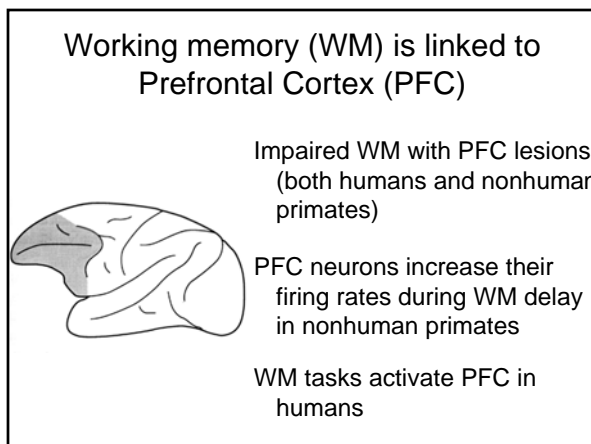
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- Working memory as keeping something in mind during a delay

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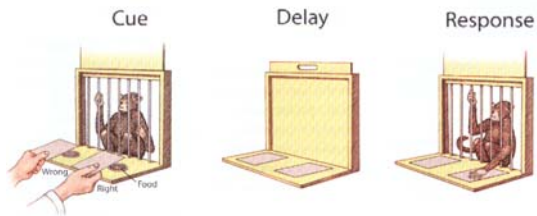
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### Delayed matching-to-sample



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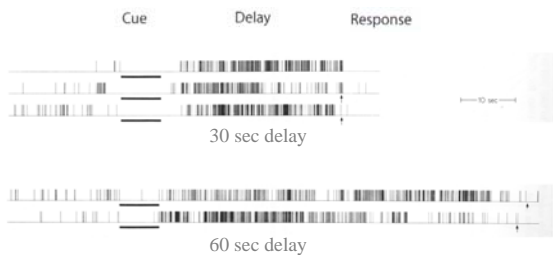
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### Activity of a prefrontal unit during delayed-response trials



From Fuster and Alexander, 1971

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# Working Memory

- Working memory as keeping something in mind during a delay  
**With distractors during the delay**

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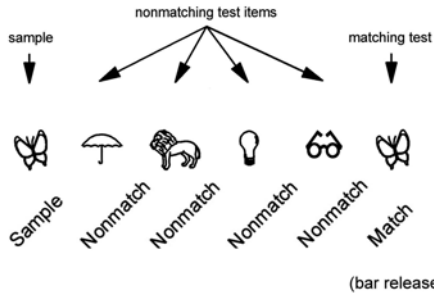
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## Delayed matching to sample task



0.5 sec. stimulus presentation  
1 sec. delays

Miller et al. (1996) *J. Neurosci.*

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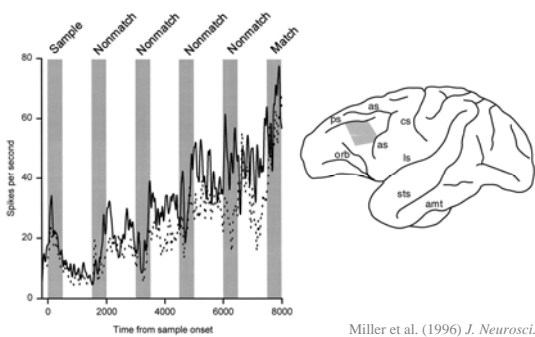
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## Activity of a prefrontal neurons during a delayed matching to sample task



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# Working Memory

- Working memory as keeping something in mind during a delay  
    With distractors during delay
- **What kind of information can prefrontal neurons maintain?**

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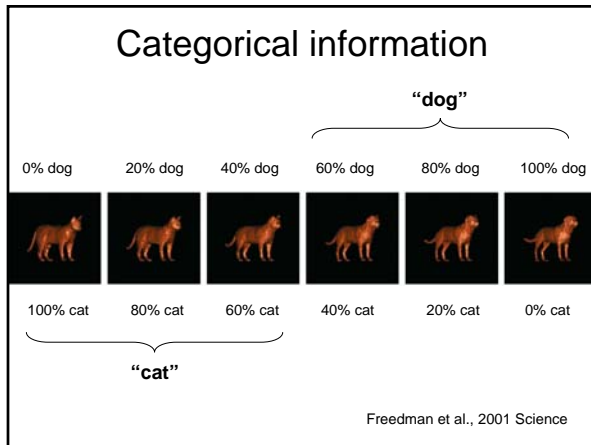
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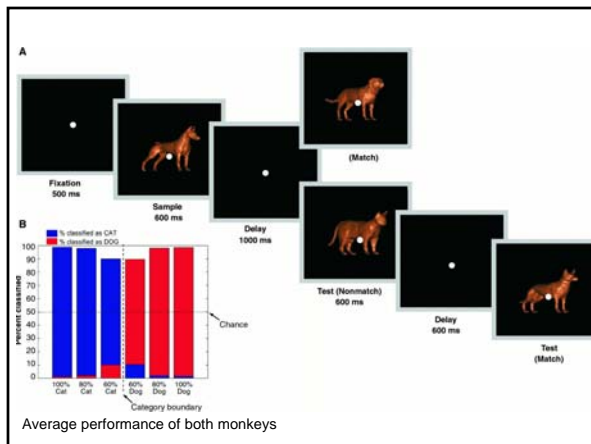
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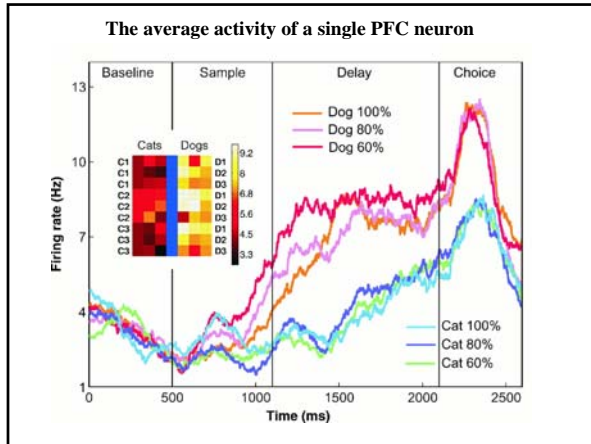
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- Working memory as keeping something in mind during a delay  
With distractors during delay
- What kind of information can prefrontal neurons maintain  
**concrete (objects)**, as well as  
**abstract (categories)**

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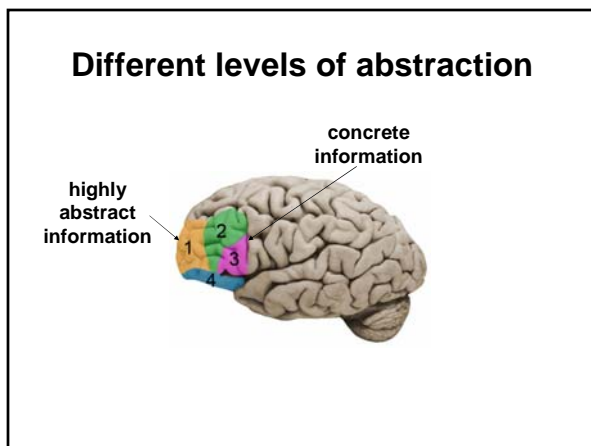
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**Verbal problem solving task: anagrams**

<b>Abstract</b>	<b>Medium</b>	<b>Concrete</b>
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

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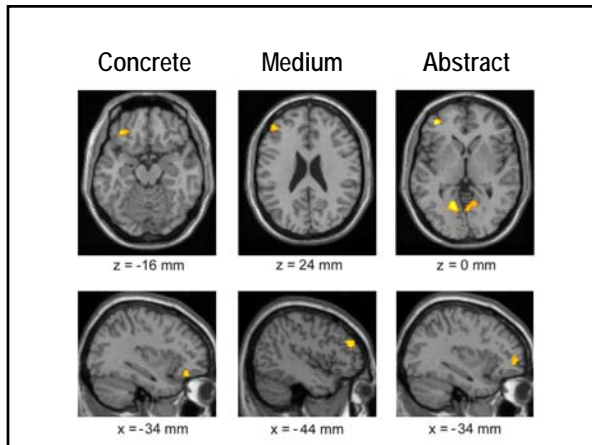
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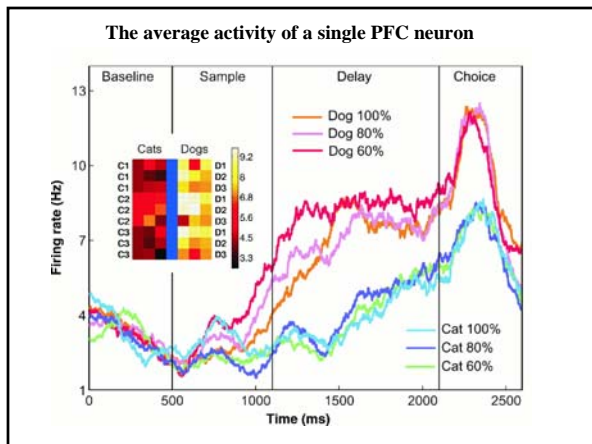
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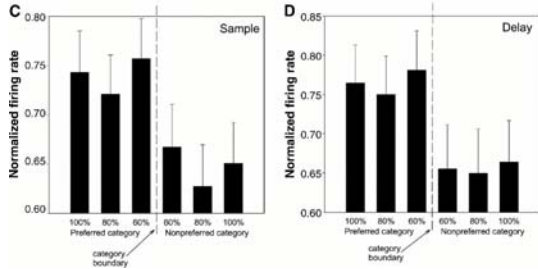
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**PFC neurons code memory information categorically**

... both during the "Sample" and "Delay" intervals



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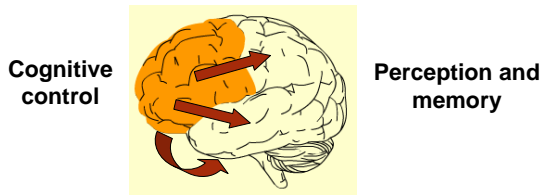
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**The prefrontal cortex (PFC)**



**PFC biases neural processes occurring in posterior brain regions**

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**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

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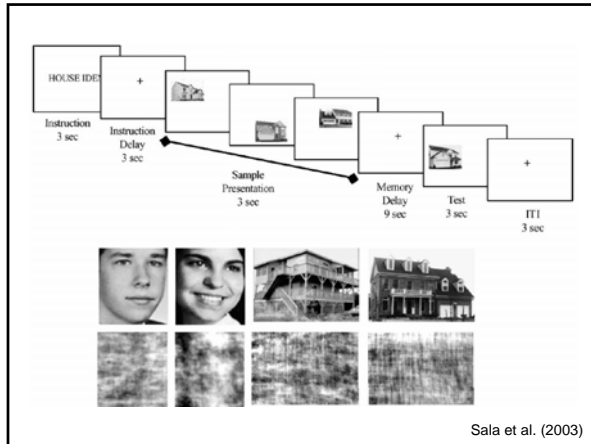
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# Working Memory



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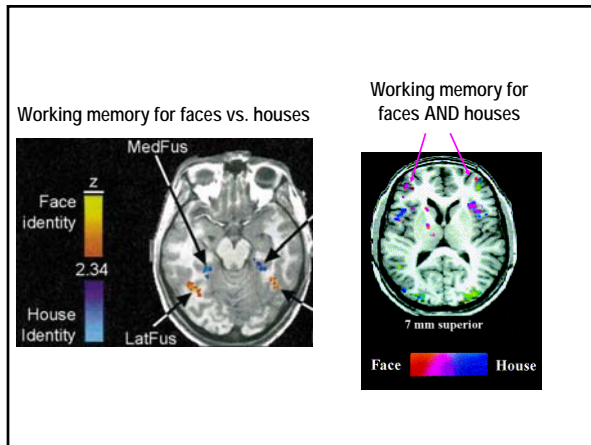
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The prefrontal cortex serves to

- 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

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