Miller & Cohen 2001 – Overall model of PFC function

Overarching theory:

- PFC controls task-relevant behavior by biasing the system towards more low-valued, but task-appropriate response.
- PFC must be adaptable to changes in context, but robust to distracting stimuli

Evidence:

- PFC maintains activation to task relevant stimuli in the face of distractions; sensory cortex does not
- PFC activation to stimuli changes with current task goals and rules
- PFC has extensive connectivity with brain regions governing sensory input and response
- PFC damage results in perseveration on previously learned goals and rules, as well as increased distractibility

Big Questions:

- Is this model of PFC function essentially correct?
- Where does it run into problems?

Learning:

- Most of the learning described in the model is reinforcement learning based. This can be a slow process and is difficult to adapt to situations that require subgoals (Tower of Hanoi) and strategies (chess).
- They propose that there are 'natural' (read: high valued) responses that occur without PFC input and 'biased' responses (read low valued) that require PFC input to be chosen. Over many repetitions, biased responses may become more natural. Does this make sense as a complete theory of natural response?
- Since PFC can represent stimuli over time, the authors suggest that it could then associate a time-delayed stimulus with a reward. This is still basal ganglia based reinforcement learning, and it doesn't seem like dopamine neurons actually encode value like this.
    - When learning about cues that predict rewarding stimuli, the cue offset must be *precisely* locked to the reward onset, or dopamine neurons will continue to fire to the rewarding stimuli
- How does PFC assign its weights? How do the 'gates' open to allow writing of PFC?
- How are task goals changed quickly by instruction? Could it be linguistic representations of active symbols?

Active Maintenance

- People fail at tasks when they lose active maintenance of goals. Why doesn't PFC maintain short-term goals until they are complete?
- Exactly how do situation and task-dependent representations get learned and activated in the first place? Where does the context info come from?
- We have capacity limits on how much we can maintain at one time. Is this a biophysical constraint or some adaptive mechanism to prevent over-biasing of the system?

Other issues

- *Functional architecture*
    - The idea that PFC is divided into 'hot' and 'cold' regions seems a little spurious. A more accurate interpretation (in my mind) would be 'values' and 'goals', respectively.
    - Interesting functional theory: when training on mixed designs both computationally and in primates, PFC response becomes more complex and varied – this may imply that learning style may affect ability to handle complexity later. Agree or disagree?
- *Conflict monitoring*
    - How do we decide when to use PFC? Authors suggest and provide evidence that the ACC monitors conflict which then determines when PFC is used. If true, could explain why active maintenance fails as a sense of conflict diminishes.
- *Active Memory*
    - PFC could simply be a part of active memory. It could function as both storage and executive control by virtue of the active maintenance. If PFC is simply goal dependent memory, does that diminish its ability to be a general control center for novel behavior?