Executive Control Mechanisms & Constructs

- **Two Constructs Under Discussion**
  - Dynamic Control Adjustment
  - Rule Generation & Selection

- **A Brief Background & Overview**
  - What does the construct entail?
  - Why has the construct attracted attention?
  - What is the evidence base behind it?

Dynamic Control Adjustment: The Stroop as Exar

Executive control is really needed here: To successfully resolve interference

YELLOW

GREEN

But it is not needed here: Reading can proceed automatically

A mechanism seems required to:
- detect and adapt to the presence/absence of interfere

Also:
- the detection/adaptation process must be dynamic

Dynamic Control Adjustment: The Stroop as Exan

Control demands are higher in this sequence

YELLOW RED BLUE YELLOW GREEN RED GRE

Than in this one

What happens Here? (CON)

What happens Here? (INC)

YELLOW RED BLUE YELLOW GREEN RED GRE

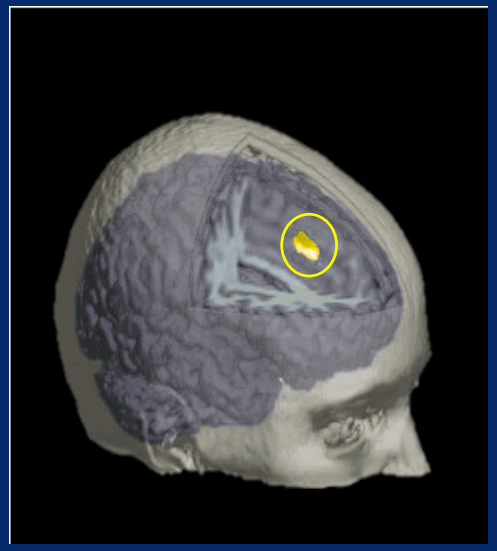
When interference is rare/minimal, control demand is lo
And so control state should adapt by relaxing

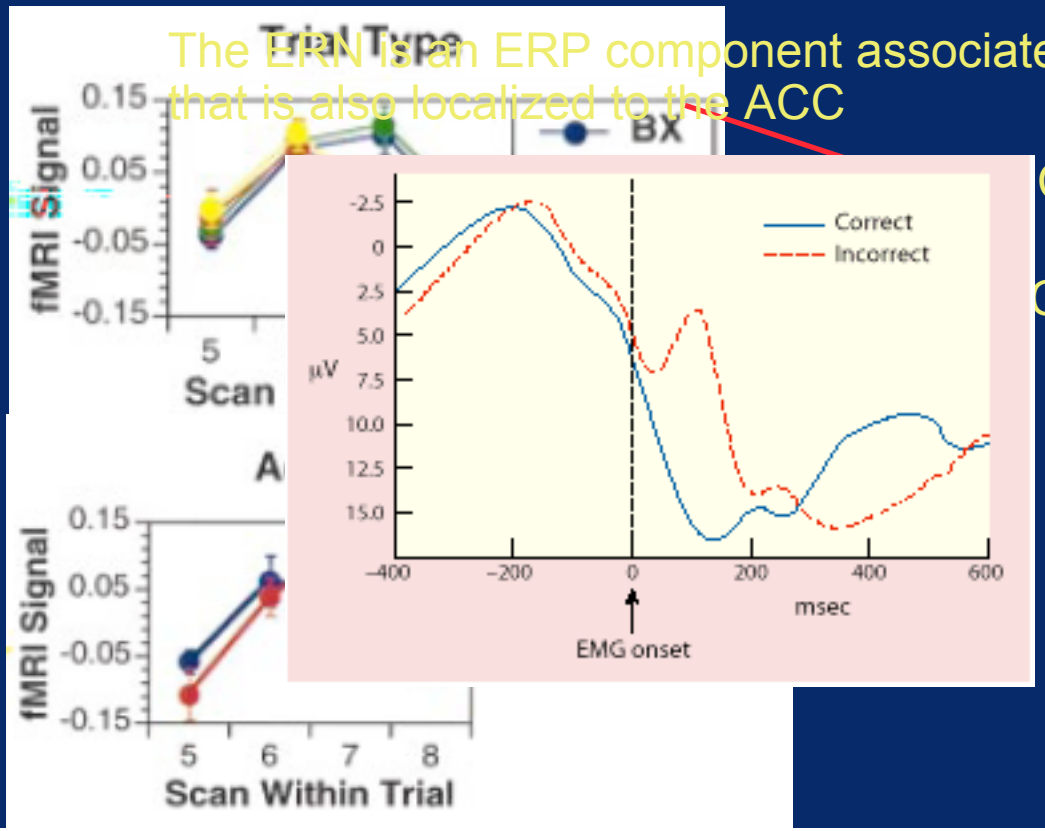
When interference is frequent/strong, control demand is
So control state should adapt by heightening

What is the mechanism of inteference detection and control adjustm

Conflict (interference) detection and the Anterior Cingulate Cortex (ACC)

- **Conflict monitoring theory** (Carter et al., Science 1998)
  - The ACC detects the presence of decision-level conflict or interference
  - The ACC also responds to presence of errors (ERN literature)
  - Errors are just a special case of high conflict





The ERN is an ERP component associated with er
that is also localized to the ACC

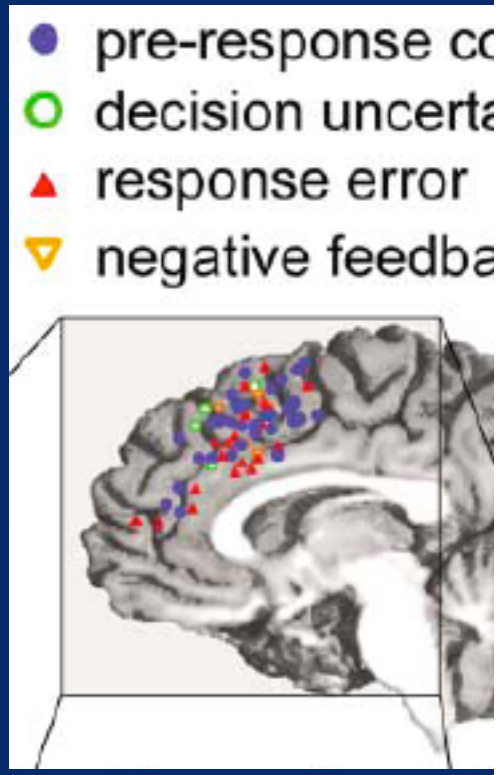
Conflict

Conflict

Performance monitoring and the Anterior Cingulate Cortex (ACC)

- **Basic findings have been replicated many times**
  - Dorsal ACC is reliably engaged when errors are committed
    - Additional effects may be related to error awareness (e.g., Pe component)
  - Dorsal ACC is reliably engaged across a range of S-R interference tasks (Stroop, Eriksen, Simon, go-nogo, etc)

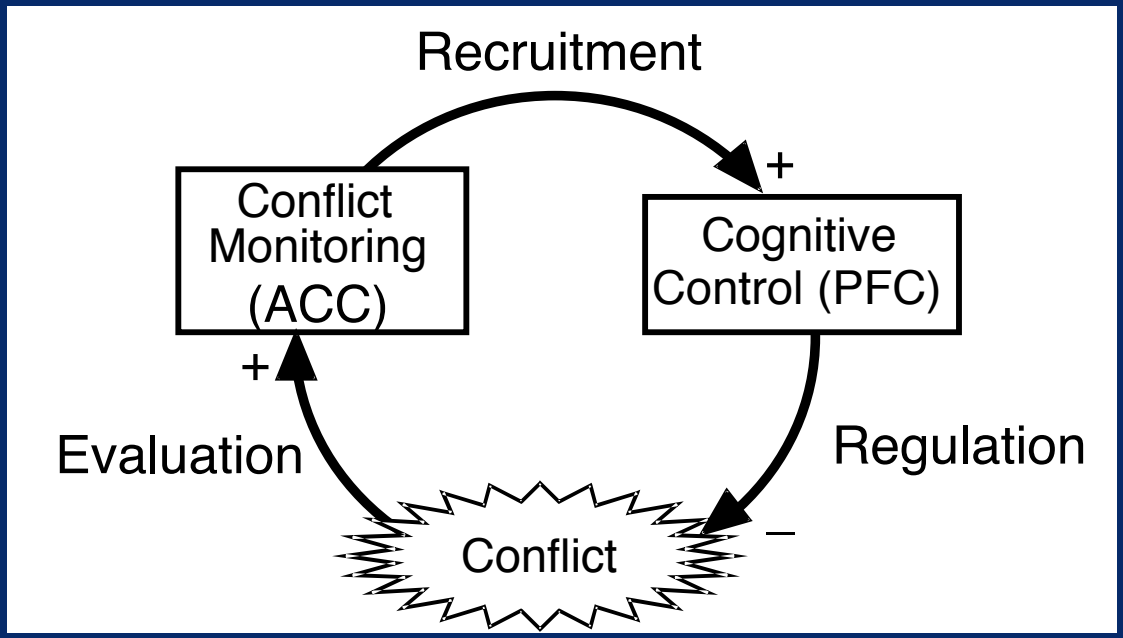
- **Functions may be a bit more broadly described**
  - Decision-level uncertainty (Barch et al., 2000)
  - Negative feedback (Holroyd et al., 2004)
  - Error expectation (Brown & Braver, 2005)



Dorsal ACC may be generically involved in monitoring on-going performance to detect when poorer than desired

Performance monitoring and the Feedback Control Loop

- **What is the point of performance monitoring in the ACC?**
  - **To provide signals that indicate when control processes need to be adjusted**
  - **Control state needs to adapt to environmental demands & contingencies**
    - **Low interference = low control (unbiased attention)**
    - **High interference = high control (focused attention)**

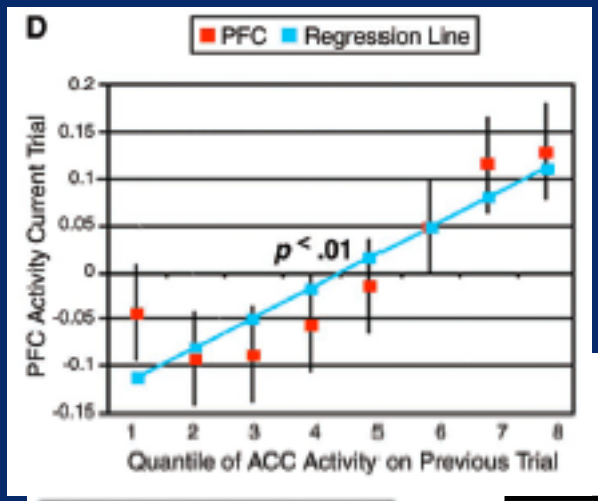


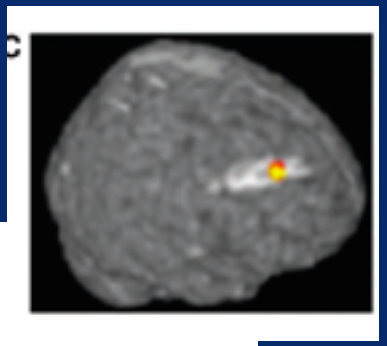
Dorsal ACC & PFC form a feedbac

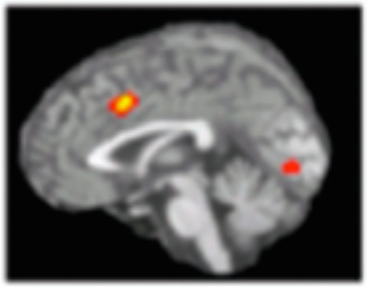
Dynamically adjusts control in resp to experienced conflict

(Botvinick et al., 2001 Psych Revie

ACC-PFC feedback loop (Kerns et al., 2003)







Recruitment

+

Conflict Monitoring (ACC)

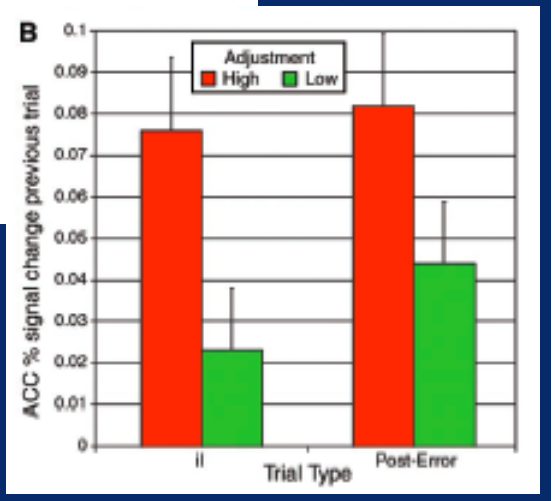
Cognitive Control (PFC)

+

Evaluation

Conflict

–



ACC activity increases following conflict (incongruent) or error trials

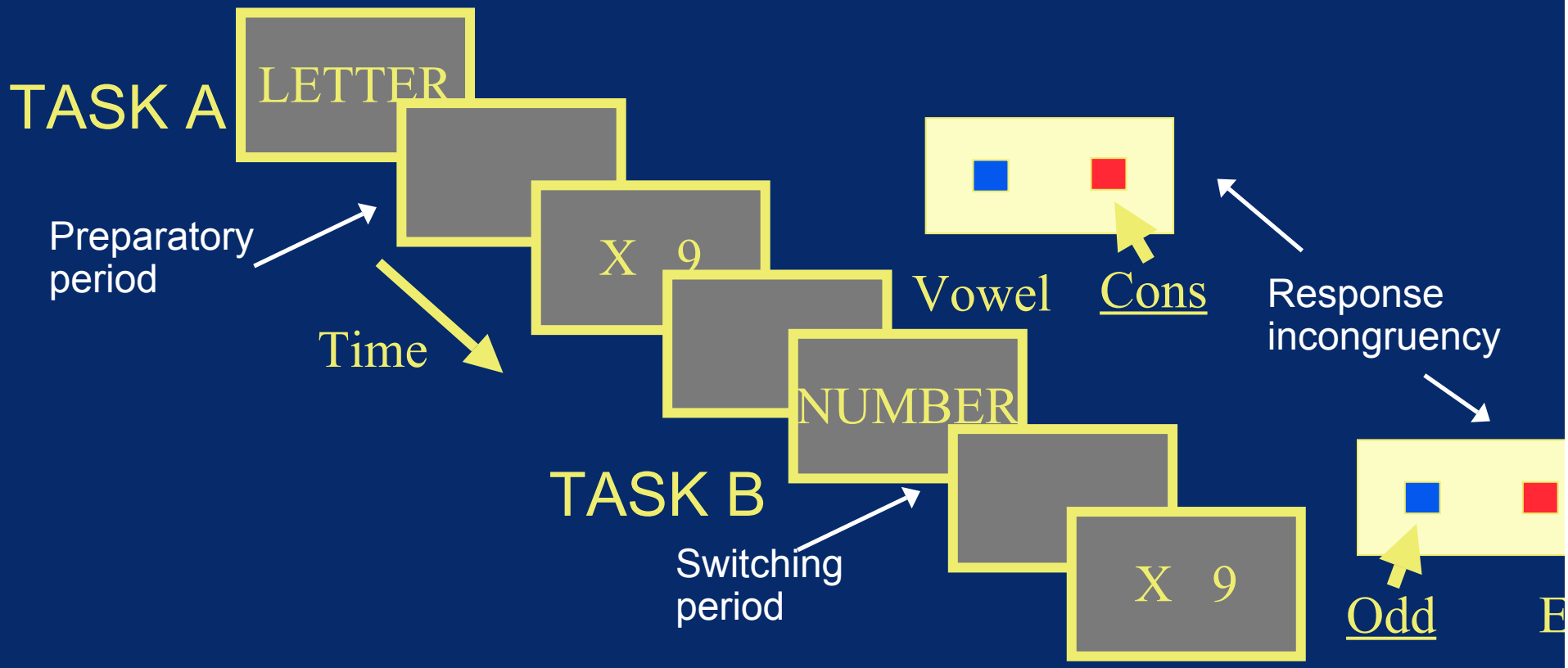
Increased PFC activity and decreased interference on subsequent trial

Rule Generation & Selection: The WCST as Exam

The Wisconsin Card Sort Test

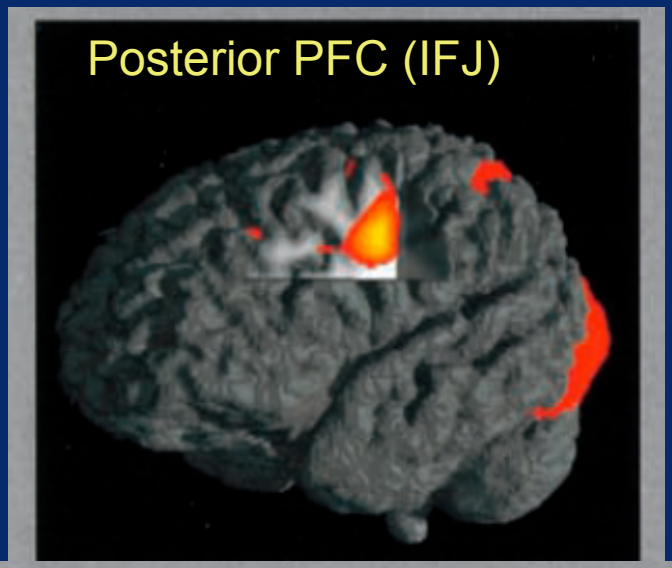
- **Task requires generation, maintenance shifting of "task-set"**
  - **I.e., Rules used to guide behavior**
- **Task deconstruction: Similar to Stroop**
  - **Performance monitoring: Detection of negat feedback**
  - **Attentional biasing: Focus on task-relevant dimension**
  - **Feedback loop: Performance monitoring lea attentional adjustments**
- **The critical difference**
  - **Attention shifting (updating) to new dimensi**
    - **In Stroop same dimension always relev**
  - **Multiple rule options are possible**
    - **Options must be generated (induced)**
    - **A single rule must be selected and impl**
- **One problem:**
  - **The WCST doesn't have a lot of construct va**

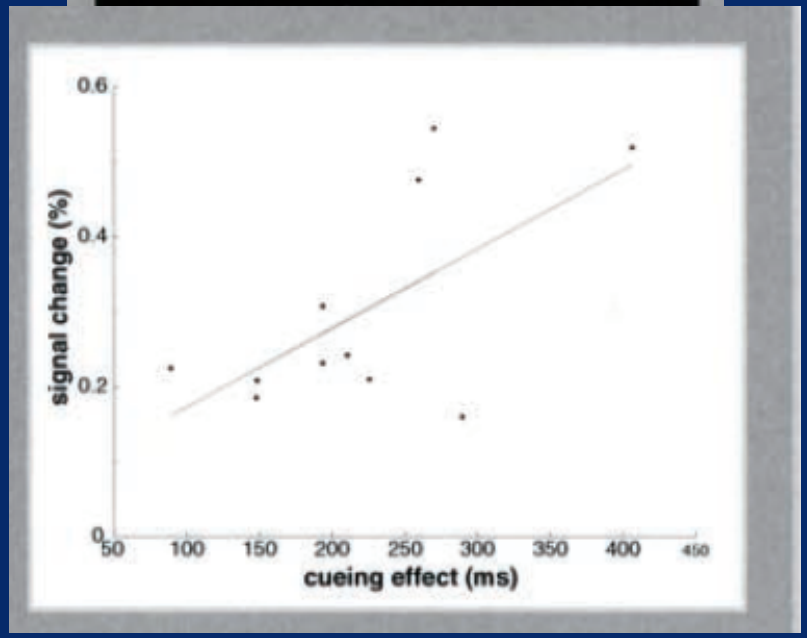
A simpler paradigm: Cued Task-Switching

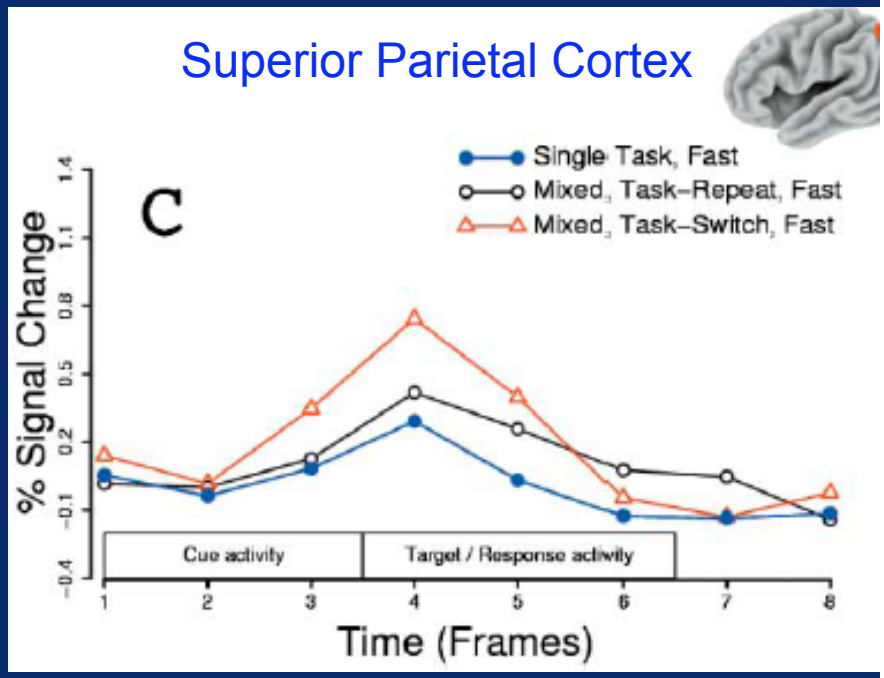


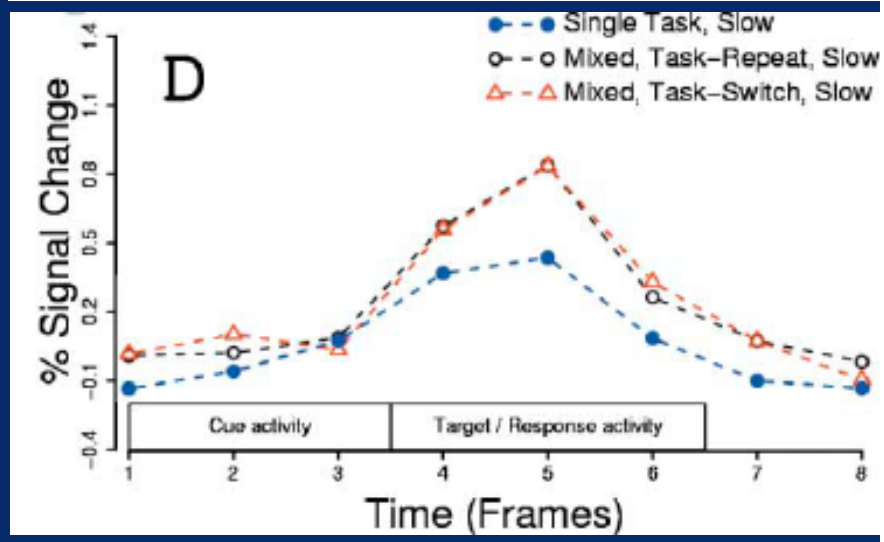
- **This paradigm enables examination of:**
  - **Task switching effects (task switch vs. task repeat trials or single task trials**
  - **Preparatory effects on task-switching (manipulation of preparatory period)**
  - **Other effects: Response incongruency; task difficulty asymmetry (e.g. Stroo**

Task-switching findings

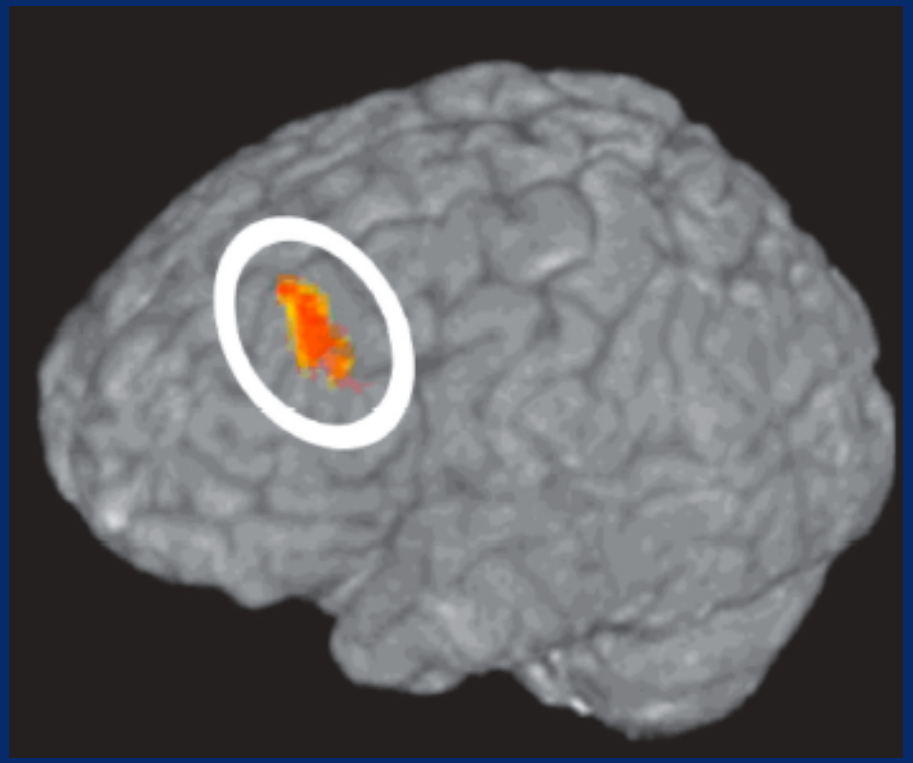




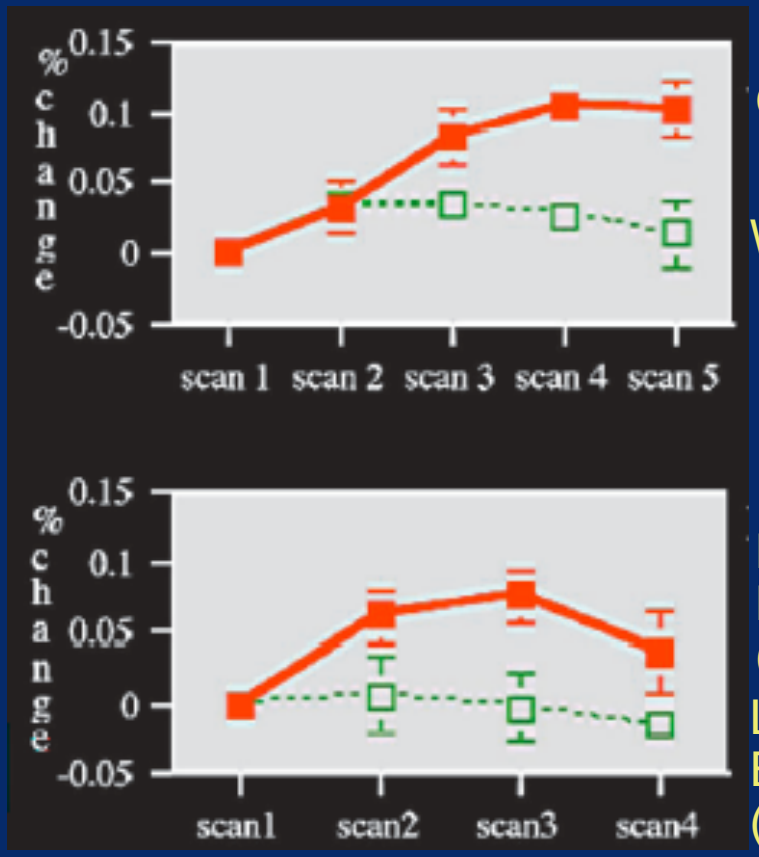




DLPFC Activity



Stroop Task



AX-CPT

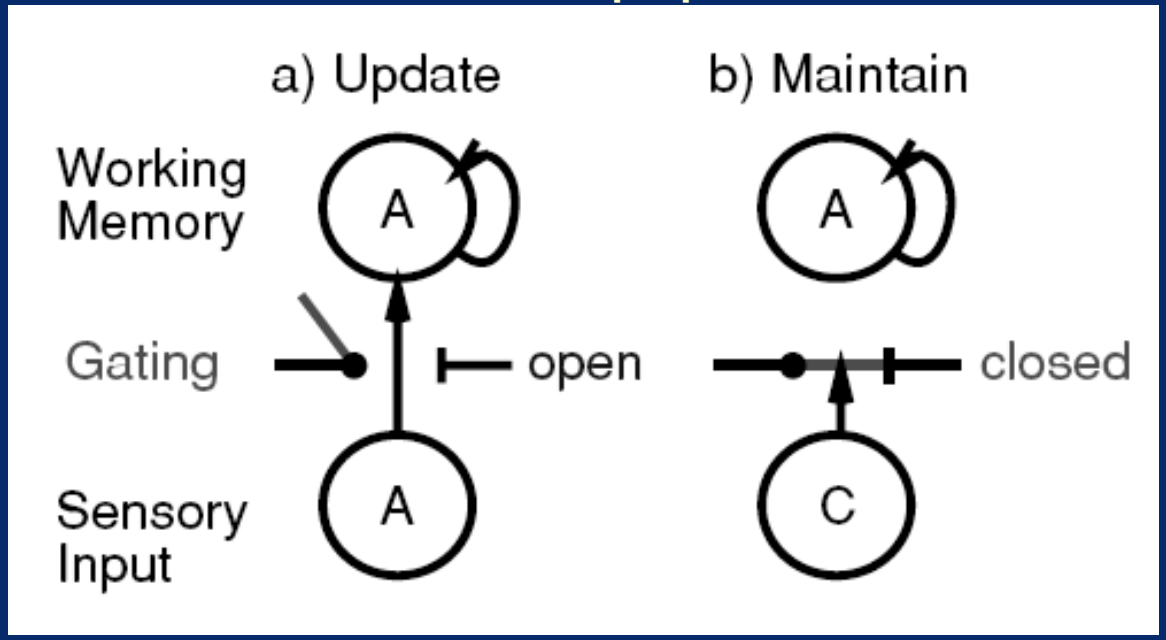
Unresolved Issues:

- Is this rule generation & selection, or goal maintena
- Can they be dissociated?

Updating: Computational Mechanisms

- Task-set (Goal / Rule) generation/selection may involve gating mechanism
  - Protects maintained information from afferent input
  - Enables robust maintenance in the face of distraction

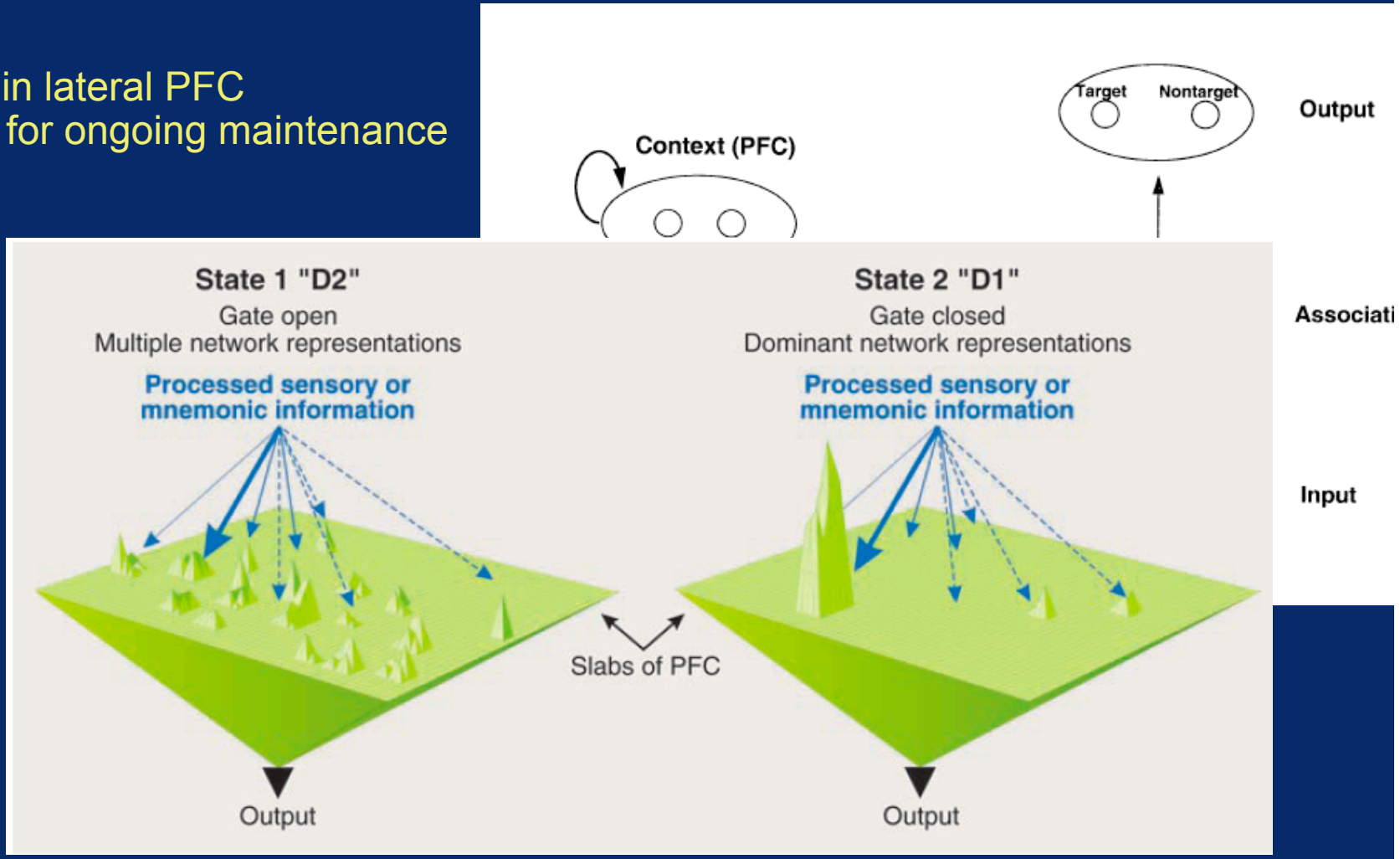
- "Gate must be opened" to update task-set (goal/rule)
  - What serves as the gating mechanism?
  - Two different accounts have been proposed…



DA-PFC Gating

Phasic dopamine (DA) activity in lateral PFC serves as gating
- enables updating to occur (Braver et al., 1999, 20

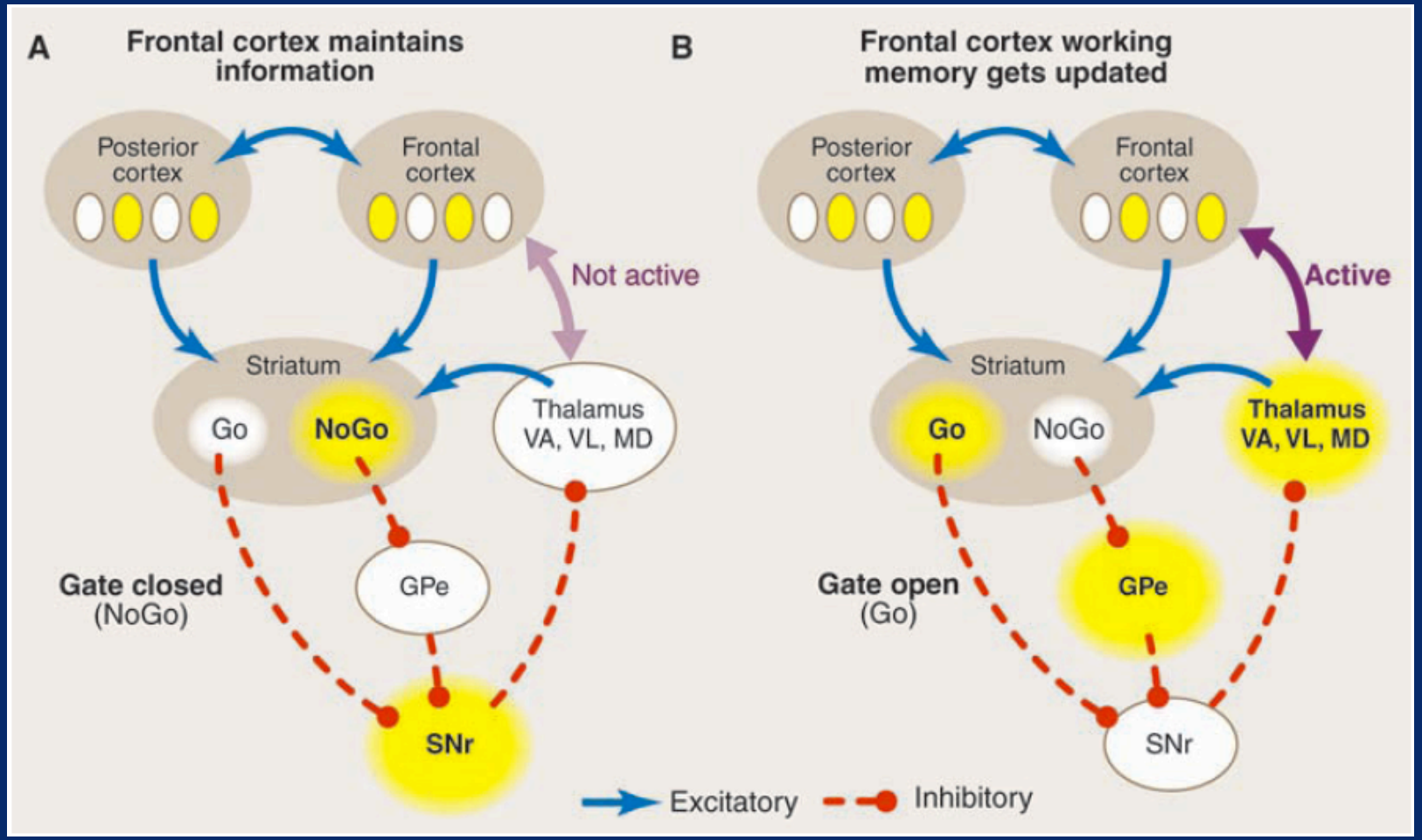
Tonic DA in lateral PFC
Important for ongoing maintenance



More recent work suggests important D1 vs. D2 receptor effects (Durstewitz et al., 2000)

BG-PFC Gating

Basal ganglia (BG) disinhibition of thalamus can also serve as gating signal
Allows for selective updating -- DA system helps learn when to gate



Summary

- **Dynamic Control Adjustment**
  - Potential Construct Definition:
    - Detection of interference, adjustment of control state, dynamic adaptation to leve interfence
  - Potential Neural Systems: ACC, ACC-PFC feedback loop
  - Tasks typically used: Stroop, Simon, Eriksen, go-nogo/Stop signal

- **Rule Generation & Selection**
  - Potential Construct Definition:
    - Selection of a task-set (i.e., collection of appropriate S-R mappings), maintenanc task-set (different construct?), updating of task-set when appropriate
  - Potential neural systems: Lateral PFC, superior parietal cortex, DA-PFC projection, B circuitry
  - Tasks typically used: Task-switching paradigms, WM updating paradigms, hierarchic paradigms (e.g. 1-2 AX-CPT)