

Executive Function

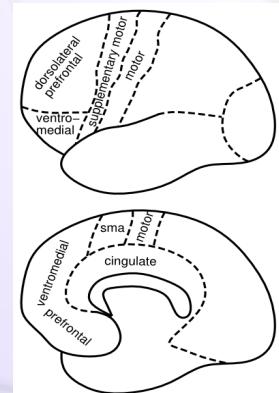
Computational Cognitive Neuroscience
Randall O'Reilly

Who is in Charge of your Brain??

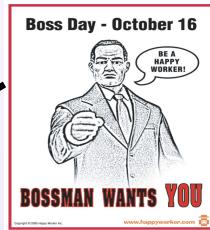
Prefrontal Cortex?

Integrates:

- Cognitive Control
- Planning
- Motivation
- Reward processing
- Decision making

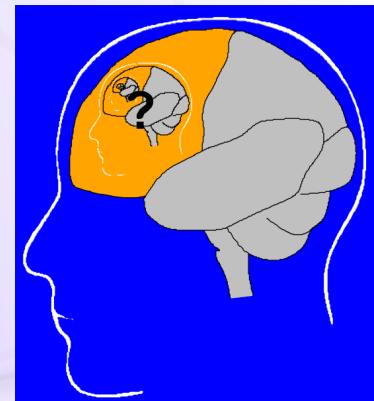


Key Idea: Top-Down Biasing

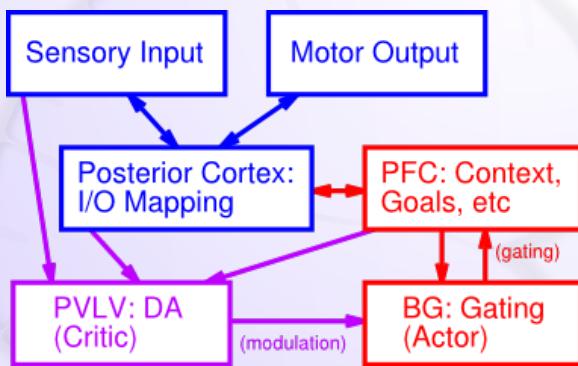


- PFC active maintenance provides top-down biasing of posterior-cortical processing

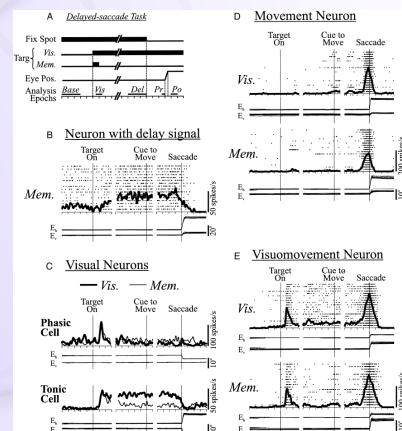
The Homunculus Problem



It Takes a Network..



PFC Does Active Maintenance



Active Maintenance Can Do it All

- Cognitive Control
 - Maintained activity drives top-down biasing
- Planning
 - Think about things that are not there (future)
- Motivation
 - Maintain goals
- Reward processing
 - Maintain possible outcomes
- Decision making
 - Maintain alternatives

The Need for Robust Maintenance

- "Every sound has to be an earthquake or tidal wave that topples governments and changes national boundaries and mutates whole species so they suddenly drift off the planet, across galaxies, only to return, years later, when nobody wants to know them cause their credit rating's bad or because they can't do the Mashed Potatoes." - MFU by HC, 1998
- Subjective experience of PFC lesion: dreaming!

Stroop Task: Top Down Biasing

RED

Stroop Task: Top Down Biasing

GREEN

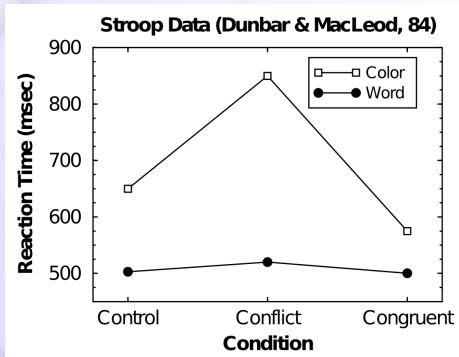
Stroop Task: Top Down Biasing

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Stroop Task: Top Down Biasing

GREEN

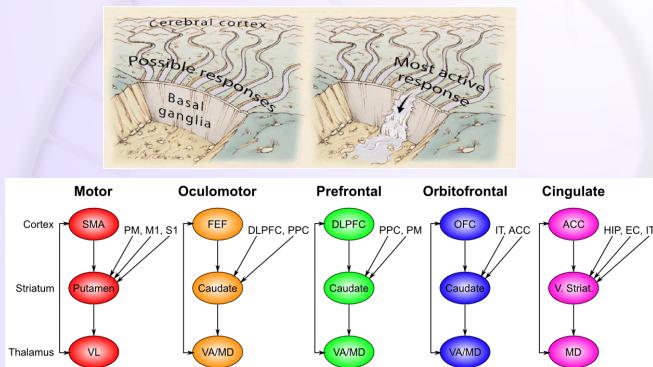
Asymmetric Conflict



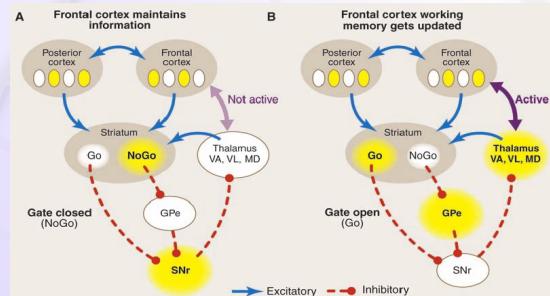
Robust Active Maintenance

- In Stroop model, we just clamp PFC units on..
- What makes them “clamped” in the real brain?
- BG!

Motor Gating => Cognitive Gating

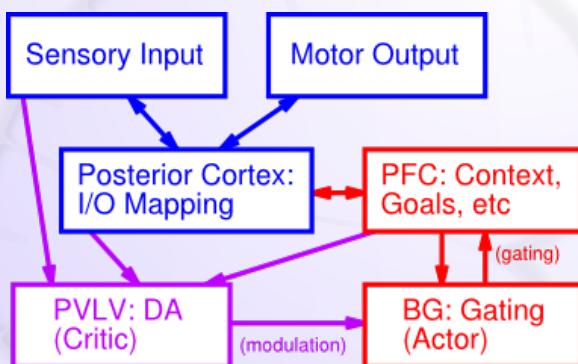


Dynamic, Adaptive Gating (BG)



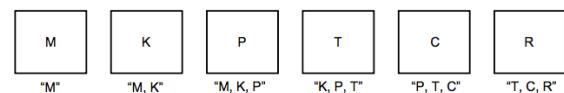
- Toggles PFC bistable states
- Resembles transistor logic gate!

PBWM System

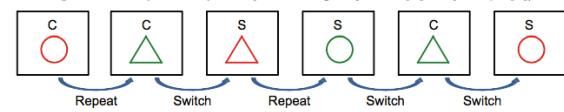


Examples of different EF tasks

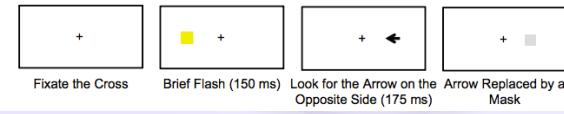
Updating: Letter Memory Task (Always Remember the Last 3 Letters)



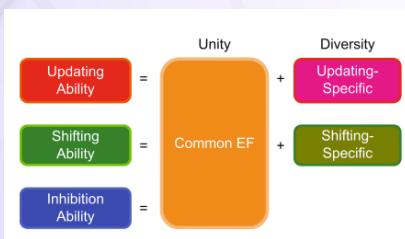
Shifting: Color-Shape Task (Classify Each Target by Color [C] or by Shape [S])



Inhibition: Antisaccade Task (Report the Arrow Direction Presented on the Nonflashed Side)

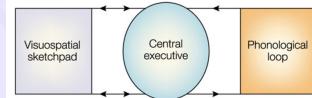


Different parts of EF



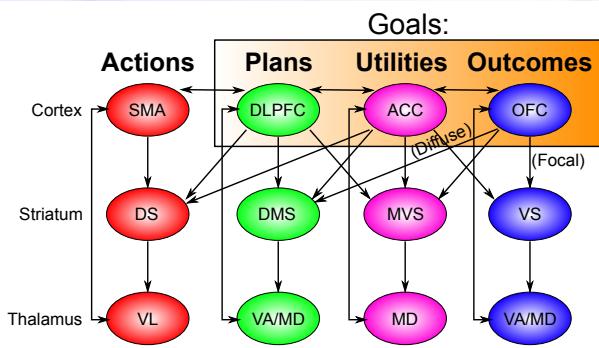
Friedman & Miyake, 2012

Baddeley/Hitch model

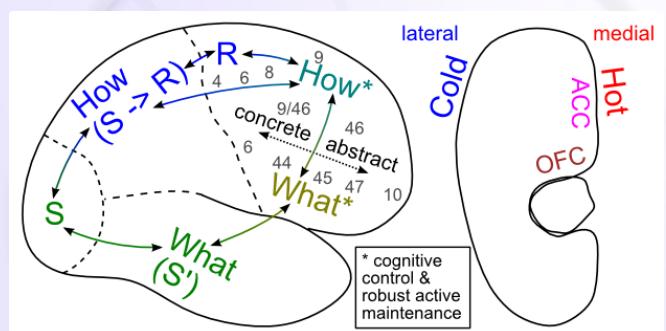


- Influential account of working memory
 - Phonological loop: Hold information for a few seconds, maintain through rehearsal
 - Central executive: Switch & focus attention
 - Visuospatial sketchpad: ongoing manipulation of visual/spatial items

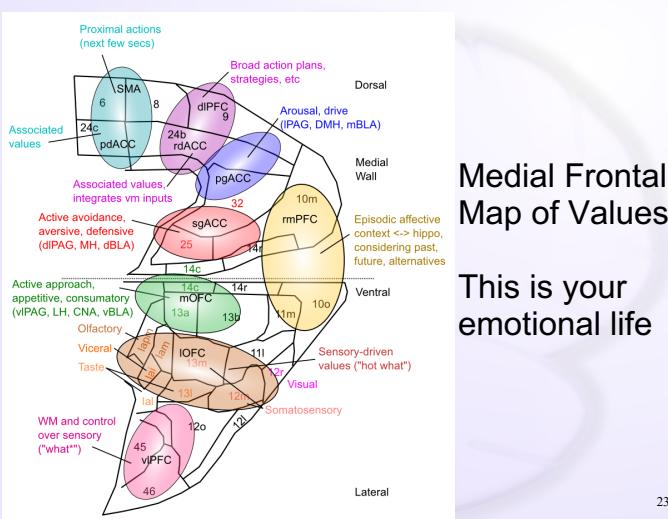
Chain of Command..



Executive Function



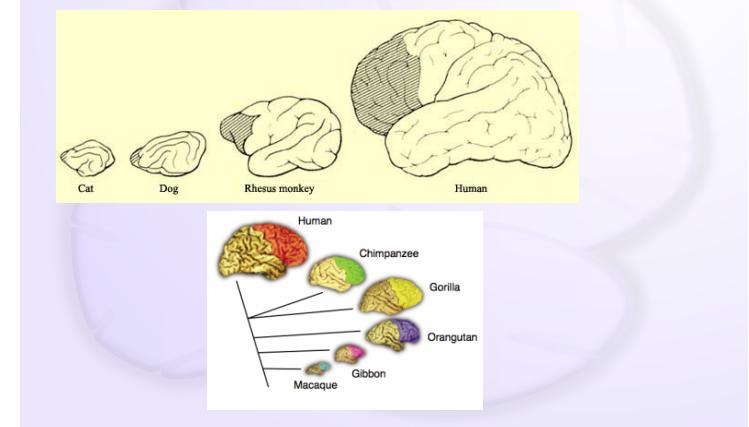
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Medial Frontal Map of Values

This is your emotional life

Prefrontal cortex across species



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Biological Basis of PBWM

