Executive Functioning Skills for Children and Adolescents

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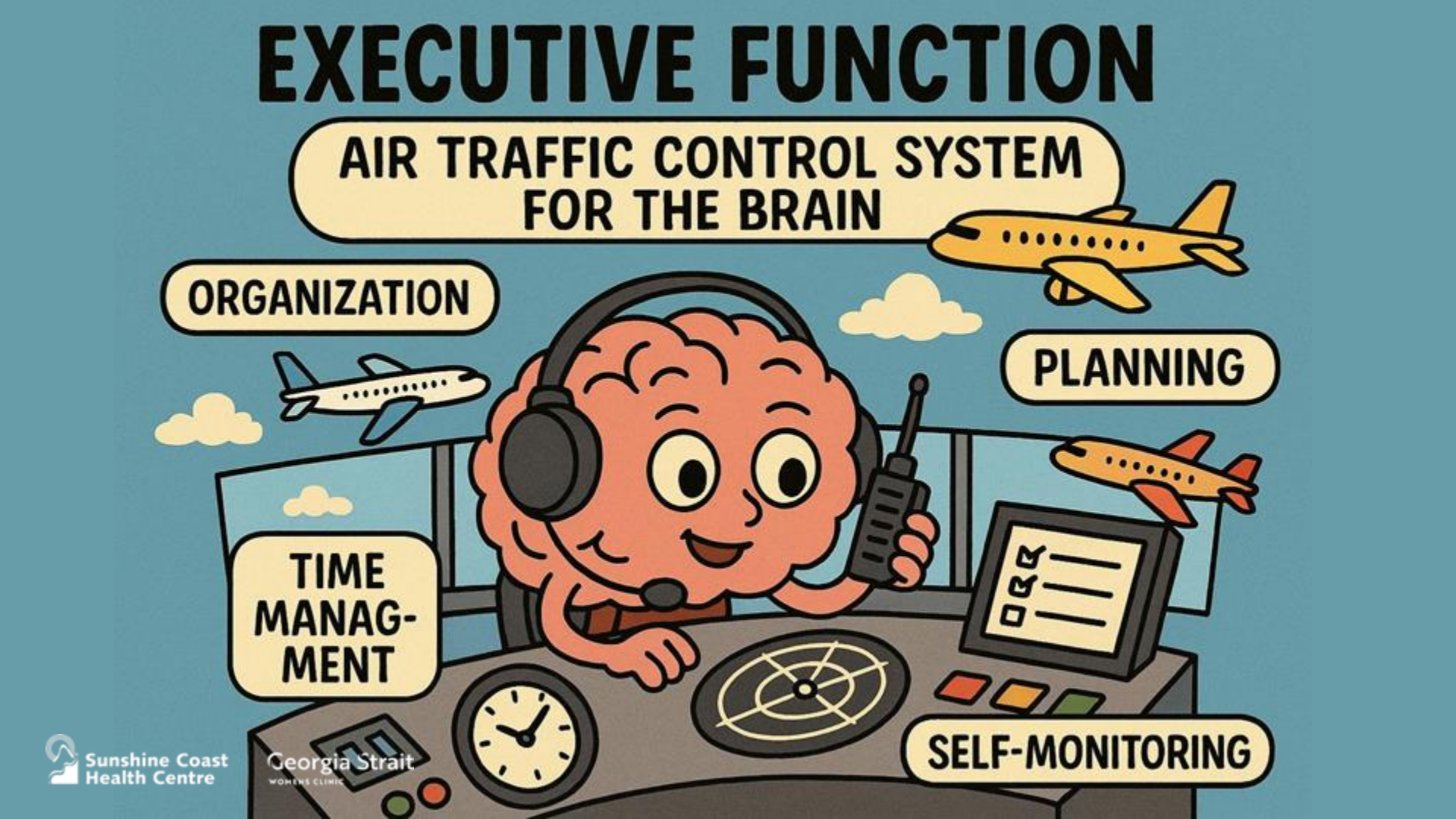
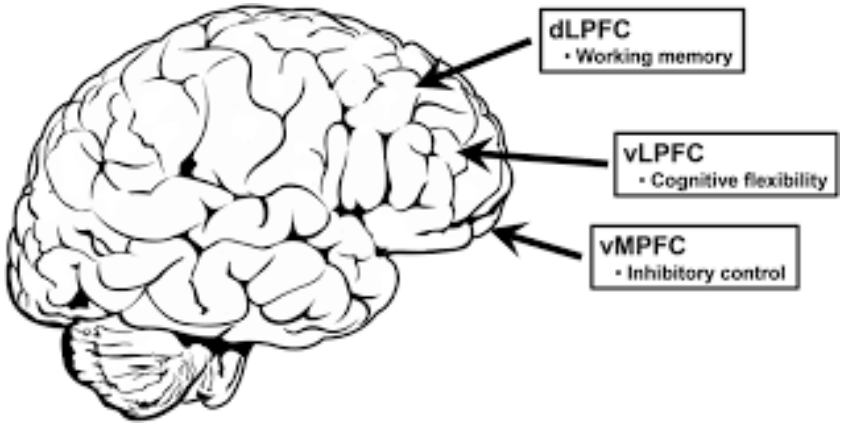
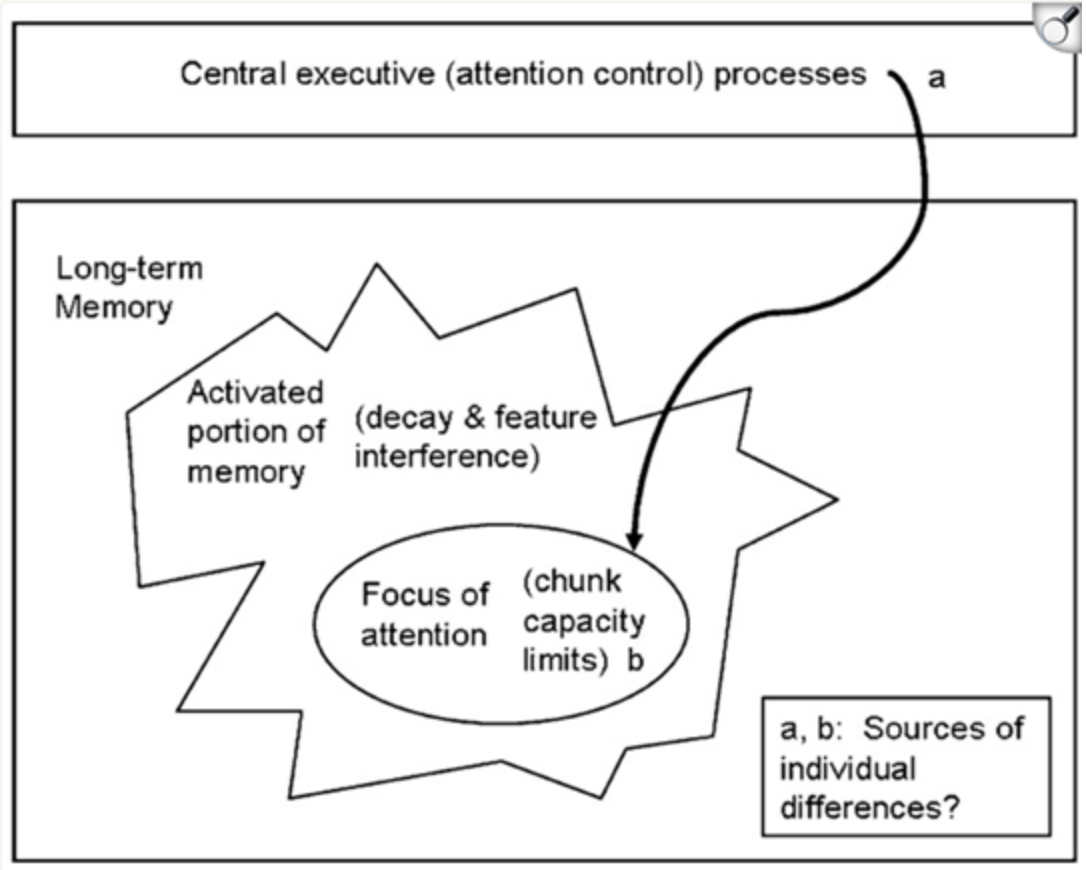
Sunshine Coast Health Centre
A Non-12 Step Mental Health Program
Georgia Strait | Women's Clinic


EXECUTIVE FUNCTION
AIR TRAFFIC CONTROL SYSTEM FOR THE BRAIN
ORGANIZATION
PLANNING
TIME MANAG-MENT
SELF-MONITORING
Sunshine Coast Health Centre
Georgia Strait
WOMENS CLINIC

Executive Functioning

- Processes of the brain that drive goal-oriented behaviour
- Often broken down into working memory, inhibitory control, and cognitive flexibility.
- Mainly occurs in the prefrontal cortex
- Variance in adolescence accounted for 90-100% by genetics




Central executive (attention control) processes
a
Long-term Memory
Activated portion of memory
(decay & feature interference)
Focus of attention
(chunk capacity limits) b
a, b: Sources of individual differences?

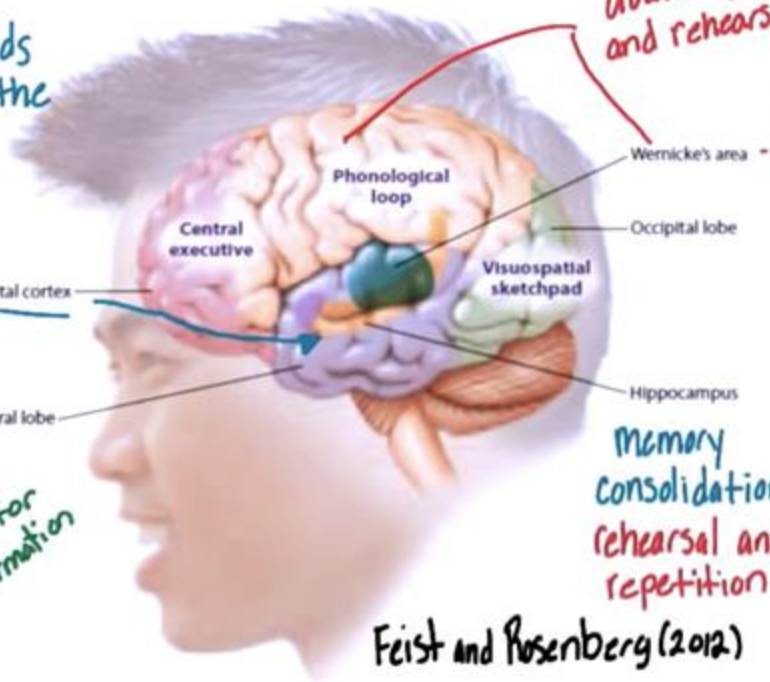
Working Memory

- Where thoughts are held and manipulated
  - Working (central executive/ active processing)
  - Memory (temporary storage/ rehearsal)
- We can choose what to think about and how to think about it (i.e. under top-down control)
- Bouts of spiking versus little or no spiking
- Brain uses multiple mechanisms to maintain information in working memory
- Memory struggles versus concentration

Short-term / working memory

focuses attention on sensory stimuli and holds it long enough to solve the problem at hand

Auditory input is processed and rehearsed



Wernicke's area - language comprehension

Visual input:
temporal lobe for spatial information
Occipital lobe for visual information

memory consolidation rehearsal and repetition

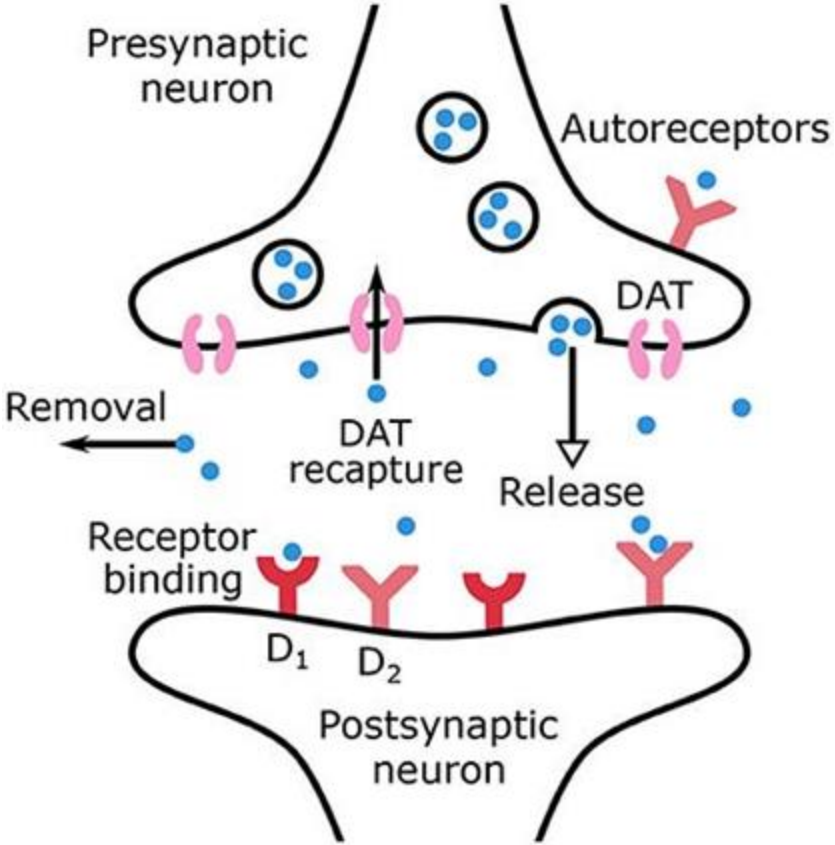
Feist and Rosenberg (2012)

Improving Working Memory

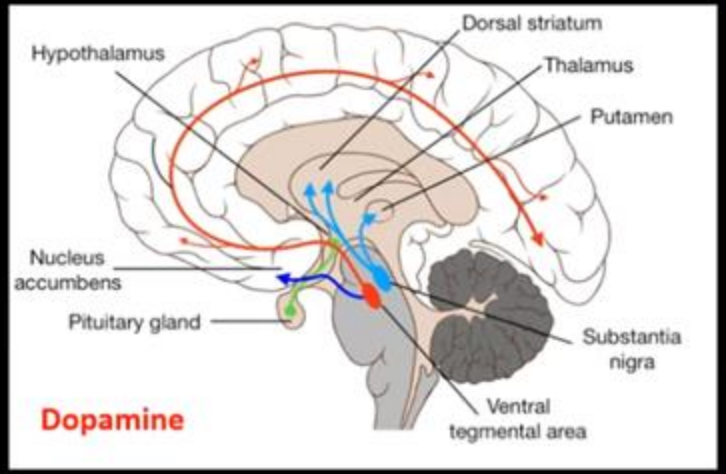
- Researchers disagree over benefit of WM training
- [Computerized] Training short-term memory improves short-term memory moderately (Rapport et al., 2013)
- No effect of WM training on typically developing children (Sala & Gobet, 2020)

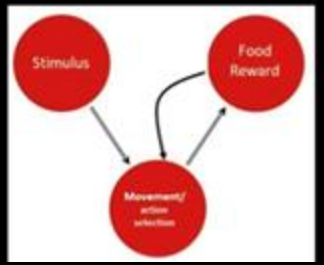
Cognitive Flexibility

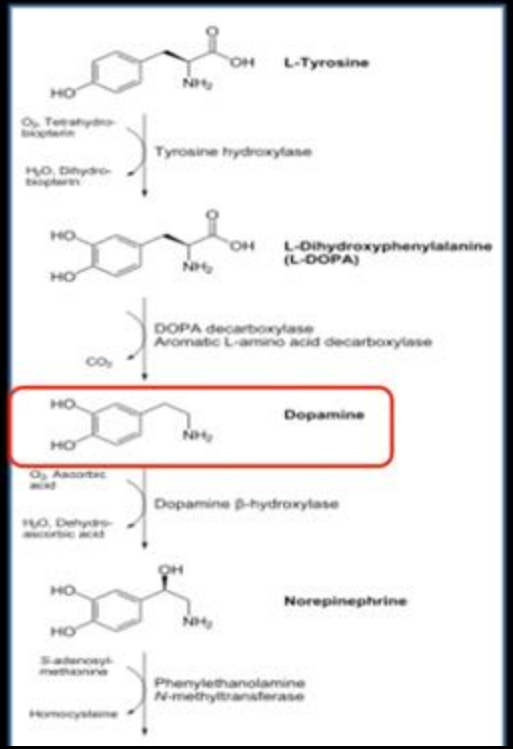
- The ability to shift and update actions in conjunction with task, goal, and environment
- Dopaminergic signaling in striatum is strongly implicated in executive functions including cognitive flexibility
- Dopamine plays an important role in adapting to new information and switching between mental strategies (Miederer et al., 2025)
- Higher cortical dopamine levels means lower striatal dopamine levels
- Links to increased self-harm in adolescence


Presynaptic neuron
Autoreceptors
DAT
Removal
DAT recapture
Release
Receptor binding
D1
D2
Postsynaptic neuron

Dopamine Neurotransmission



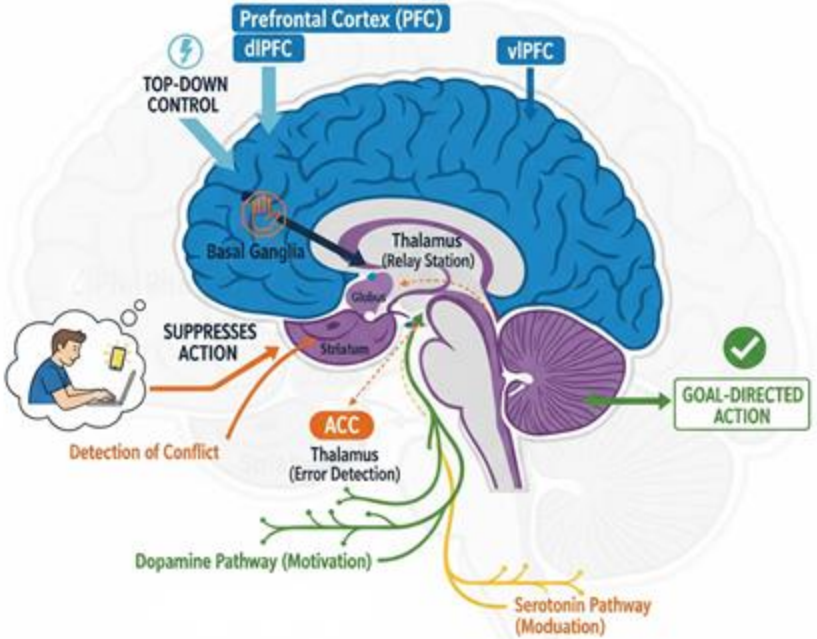




Improving Cognitive Flexibility

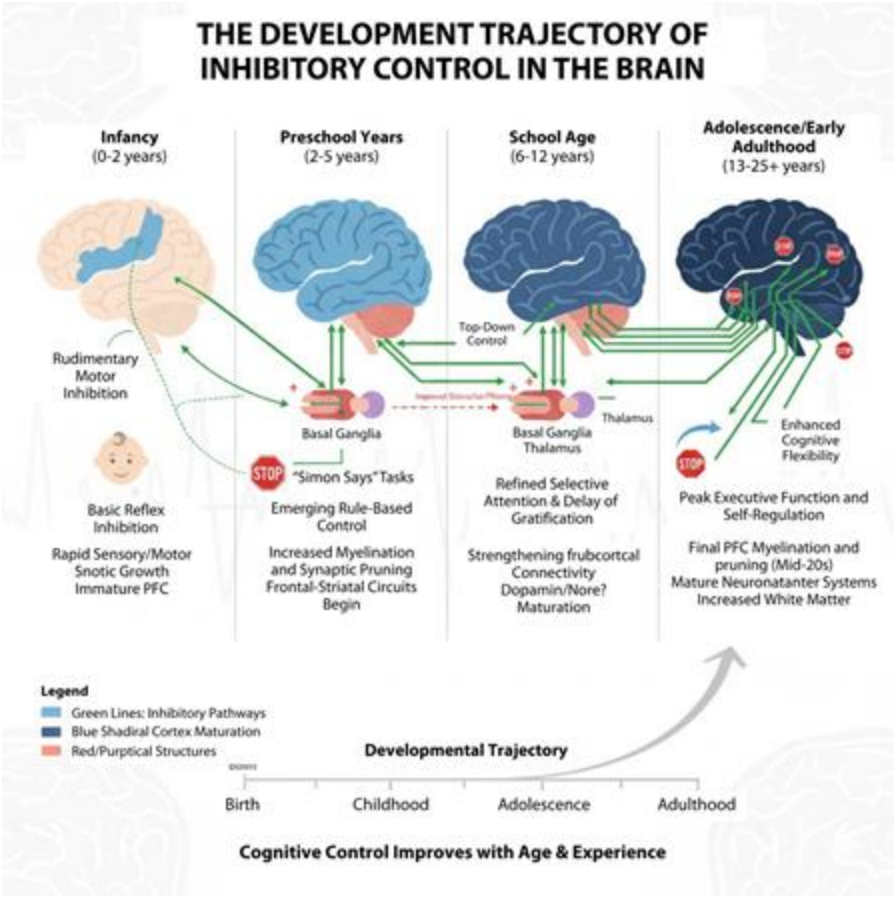
TABLE 1 | Comparison of noninvasive neuromodulatory techniques in improving cognitive flexibility (CF).

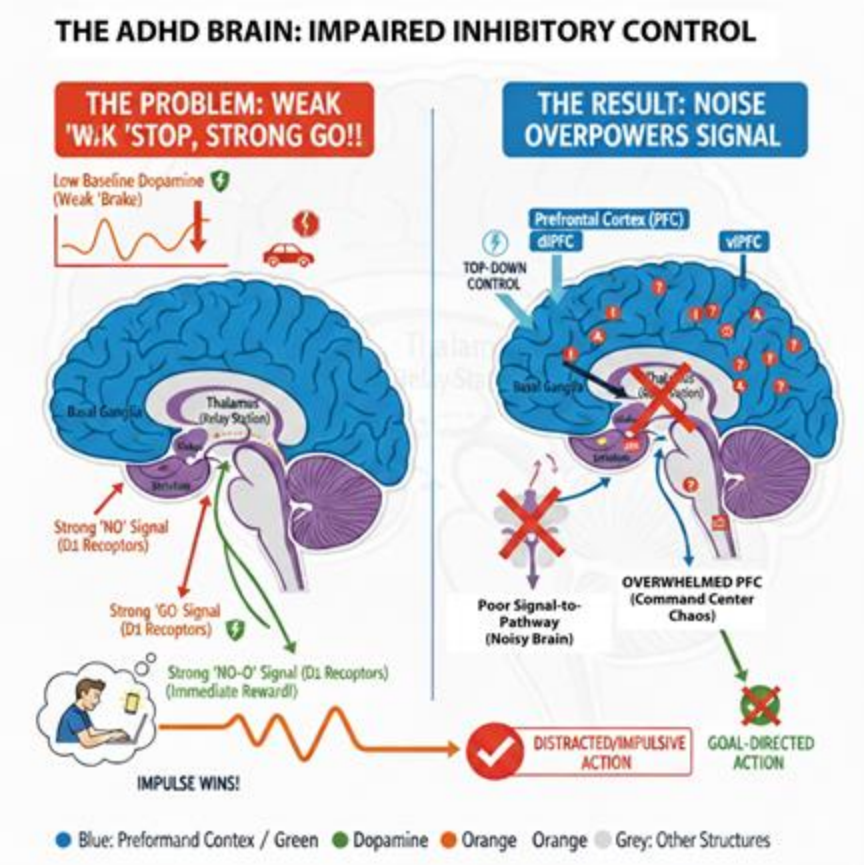
Technique	Modality	Mechanism of action	Effects on CF
transcranial Direct Current Stimulation (tDCS)	Noninvasive stimulation by direct electrical current	Modulates cortical excitability by altering the membrane potential	Promising improvements: studies show enhanced CF, especially in prefrontal tasks, but some show no effect
repetitive Transcranial Magnetic Stimulation (rTMS)	Magnetic stimulation via repetitive pulses	Induction of neuroplastic changes by modulating synaptic plasticity and membrane potential	Positive effects on CF, particularly with DLPFC targeting, but some interventions show no effect
Photobiomodulation (PBM)	Low-level near-infrared light therapy	Improves mitochondrial function and cortical blood flow	Positive effects on CF, particularly in neurological conditions with cognitive deficiencies
Virtual reality (VR)	Computer-simulated interactive and dynamic environments	Provides immersive nature and ecologically valid cognitive tasks	Effective in improving CF via real-life simulation
Neurofeedback (NF)	Real-time EEG-based self-regulation	Voluntary modulation of brainwave activity	Generally positive effects on CF, especially in ADHD and ASD children

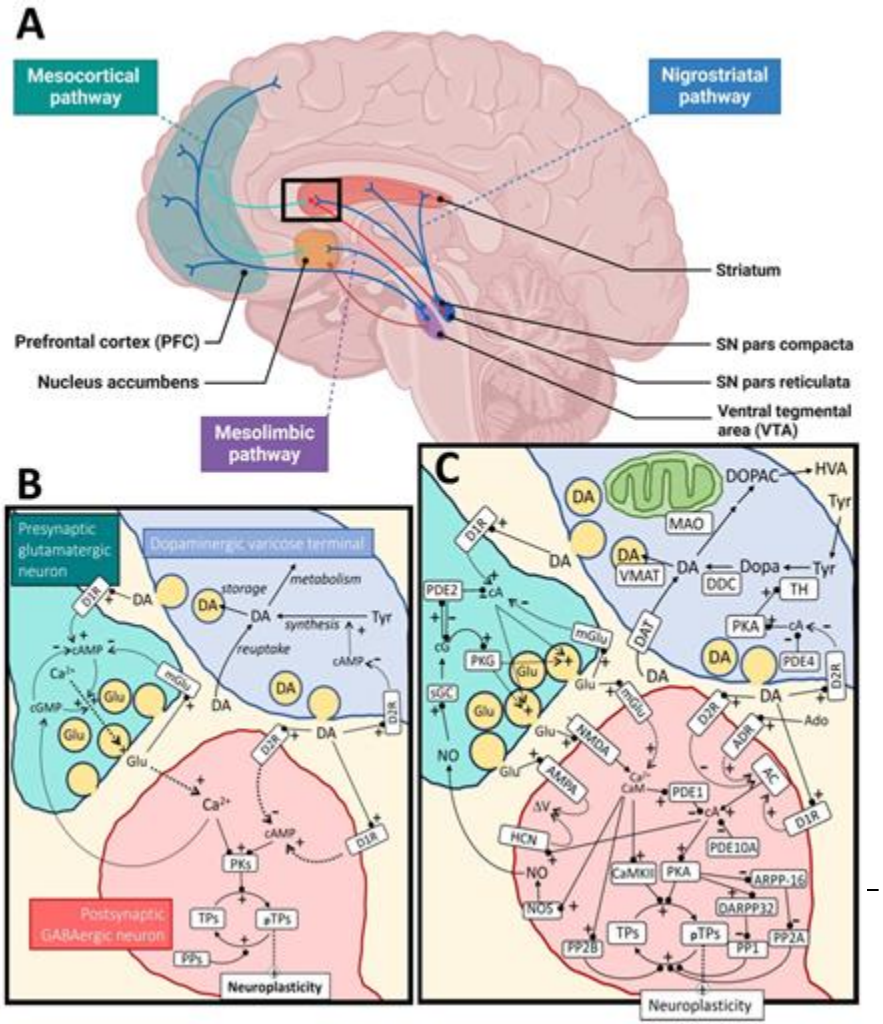


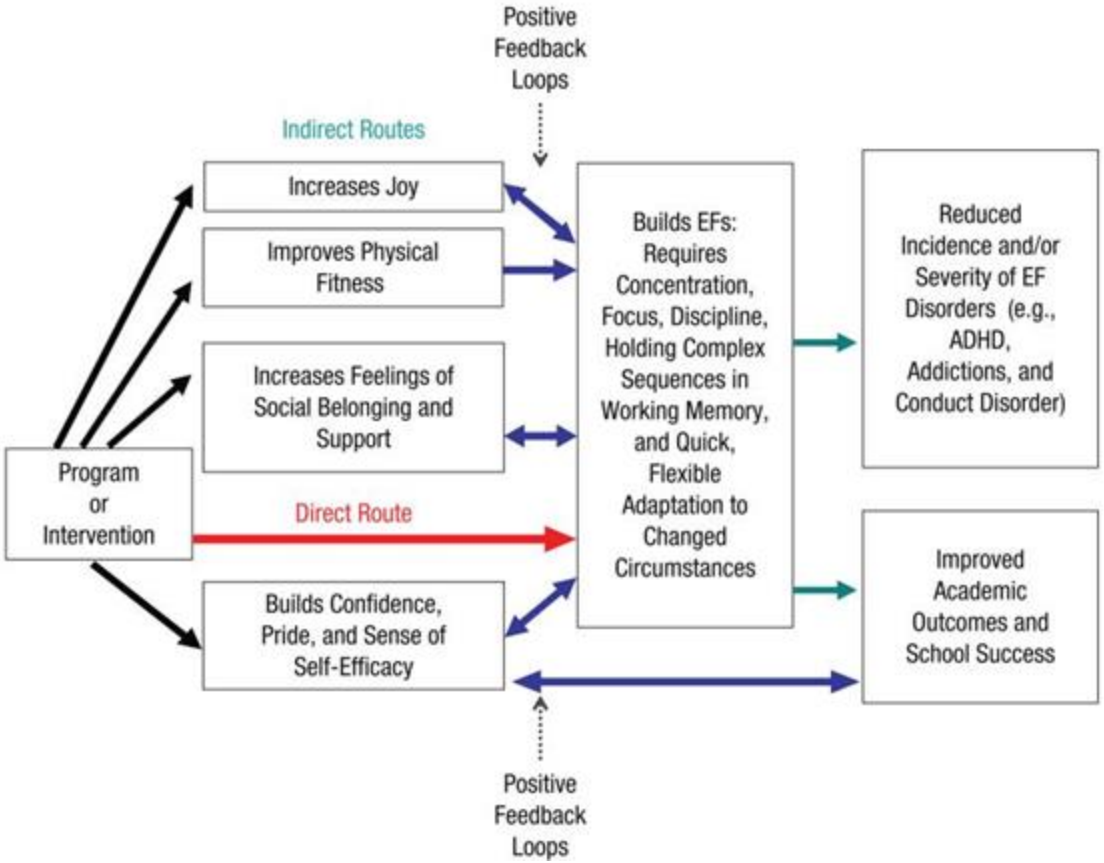
INHIBITORY CONTROL: A NEURAL CIRCUIT

Blue: Command Center Orange Orange Green/Yellow Neurostmitters


THE DEVELOPMENT TRAJECTORY OF INHIBITORY CONTROL IN THE BRAIN
Infancy
(0-2 years)
Preschool Years
(2-5 years)
School Age
(6-12 years)
Adolescence/Early Adulthood
(13-25+ years)
Rudimentary Motor Inhibition
Basic Reflex Inhibition
Rapid Sensory/Motor Snotic Growth
Immature PFC
Basal Ganglia
STOP
"Simon Says" Tasks
Emerging Rule-Based Control
Increased Myelination and Synaptic Pruning
Frontal-Striatal Circuits Begin
Top-Down Control
Basal Ganglia
Thalamus
Refined Selective Attention & Delay of Gratification
Strengthening frubcortcal Connectivity
Dopamin/Nore? Maturation
Enhanced Cognitive Flexibility
Peak Executive Function and Self-Regulation
Final PFC Myelination and pruning (Mid-20s)
Mature Neuronatanter Systems
Increased White Matter
Legend
Green Lines: Inhibitory Pathways
Blue Shadiral Cortex Maturation
Red/Purptical Structures
Developmental Trajectory
Birth
Childhood
Adolescence
Adulthood
Cognitive Control Improves with Age & Experience


THE ADHD BRAIN: IMPAIRED INHIBITORY CONTROL
THE PROBLEM: WEAK 'W.K 'STOP, STRONG GO!!
THE RESULT: NOISE OVERPOWERS SIGNAL
Low Baseline Dopamine
(Weak 'Brake)
Prefrontal Cortex (PFC)
dlPFC
vlPFC
TOP-DOWN CONTROL
Basal Ganglia
Thalamus
(Relay Station)
Strong 'NO' Signal
(D1 Recoptors)
Strong 'GO' Signal
(D1 Recoptors)
Strong 'NO-O' Signal (D1 Receptors)
(Immediate Reward!)
Poor Signal-to-Pathway
(Noisy Brain)
OVERWHELMED PFC
(Command Center Chaos)
IMPULSE WINS!
DISTRACTED/IMPULSIVE ACTION
GOAL-DIRECTED ACTION
Blue: Preformand Contex / Green
Dopamine
Orange
Orange
Grey: Other Structures


A
Mesocortical pathway
Nigrostriatal pathway
Striatum
Prefrontal cortex (PFC)
Nucleus accumbens
SN pars compacta
SN pars reticulata
Ventral tegmental area (VTA)
Mesolimbic pathway
B
Presynaptic glutamatergic neuron
Dopaminergic varicose terminal
Postsynaptic GABAergic neuron
Neuroplasticity
C
DOPAC
HVA
MAO
VMAT
DDC
TH
Dopa
Tyr
Neuroplasticity


Positive Feedback Loops
Indirect Routes
Increases Joy
Improves Physical Fitness
Increases Feelings of Social Belonging and Support
Program or Intervention
Direct Route
Builds Confidence, Pride, and Sense of Self-Efficacy
Builds EFs: Requires Concentration, Focus, Discipline, Holding Complex Sequences in Working Memory, and Quick, Flexible Adaptation to Changed Circumstances
Reduced Incidence and/or Severity of EF Disorders (e.g., ADHD, Addictions, and Conduct Disorder)
Improved Academic Outcomes and School Success
Positive Feedback Loops

Development of EF

- Dynamic, might be best explained by gene-by- environment mechanisms
- Exposure to prenatal deprivation and substances of abuse can reduce cognitive ability
- Violence, abuse and environmental deprivation can all contribute to worsening EF
- Environmental differences explain variance in adulthood EF

Interventions

- **CogMed and other computer practice**
  - Improves specific skills practiced
  - No evidenced it transfers to other untrained EF domains
  - Questionable whether learned skills can be applied to real world situations

Interventions

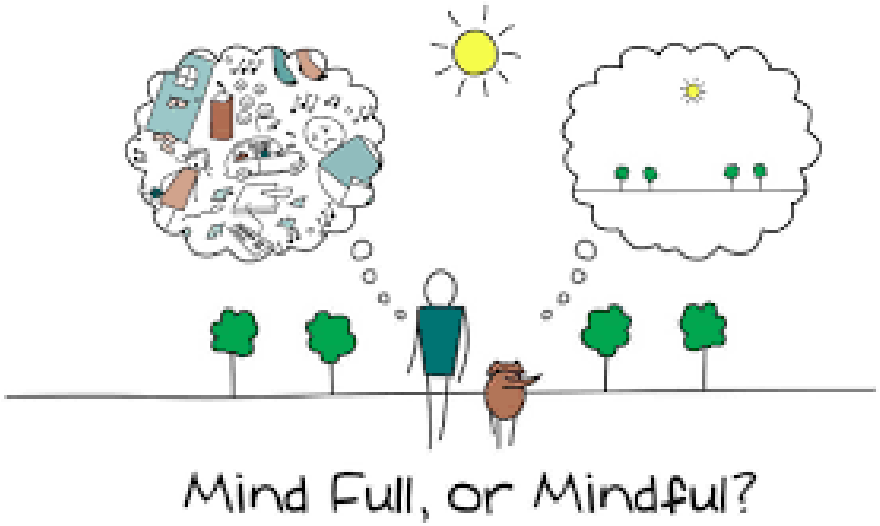
- **Environmental Training**
  - Ex. Circle time games such as “freezing” when music stops
  - Found to enhance inhibition only in preschoolers who entered the study with lower inhibition control than average
  - Chronic physical activity (such as sports) has been shown to help improve aspects of EF
  - Cognitively challenging activities, such as team sports, more helpful than non-engaging aerobic exercise

Interventions

- **Tools of the Mind and Montessori**
  - Include activities that foster EF, such as pretend play, waiting your turn for a certain material
  - Activities such as theatre, orchestra and choir may help with EF skills

Interventions

- **Self-regulation Skills**
  - Mindfulness meditation
    - Observing sensations and thoughts without judgement
    - Teaches sustained focus, task switching
  - Teaching skills
    - Planning before acting



Interventions

- **Biofeedback-enhanced Relaxation**
  - Uses EEG or EMG signals
  - Teach children to have control over the physiological reactions
  - Some studies found to have a large effect on working memory and inhibitory control skills (in neurodivergent children)
  - Other studies found no impact on Neurofeedback for ADHD