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What are Executive Functions?

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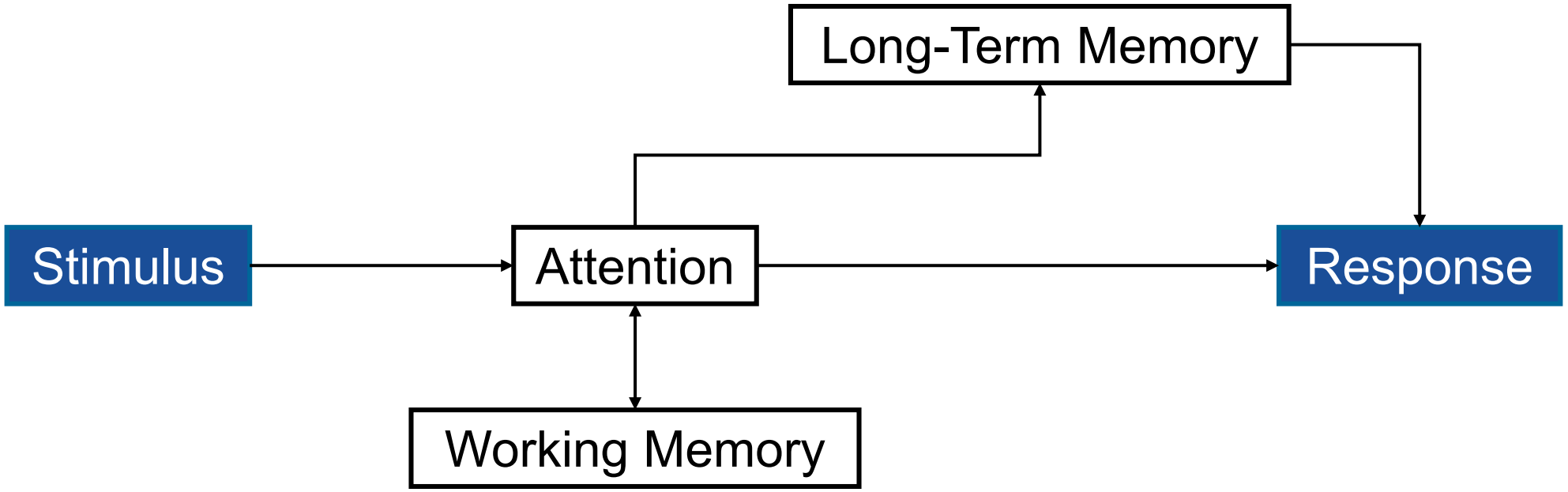
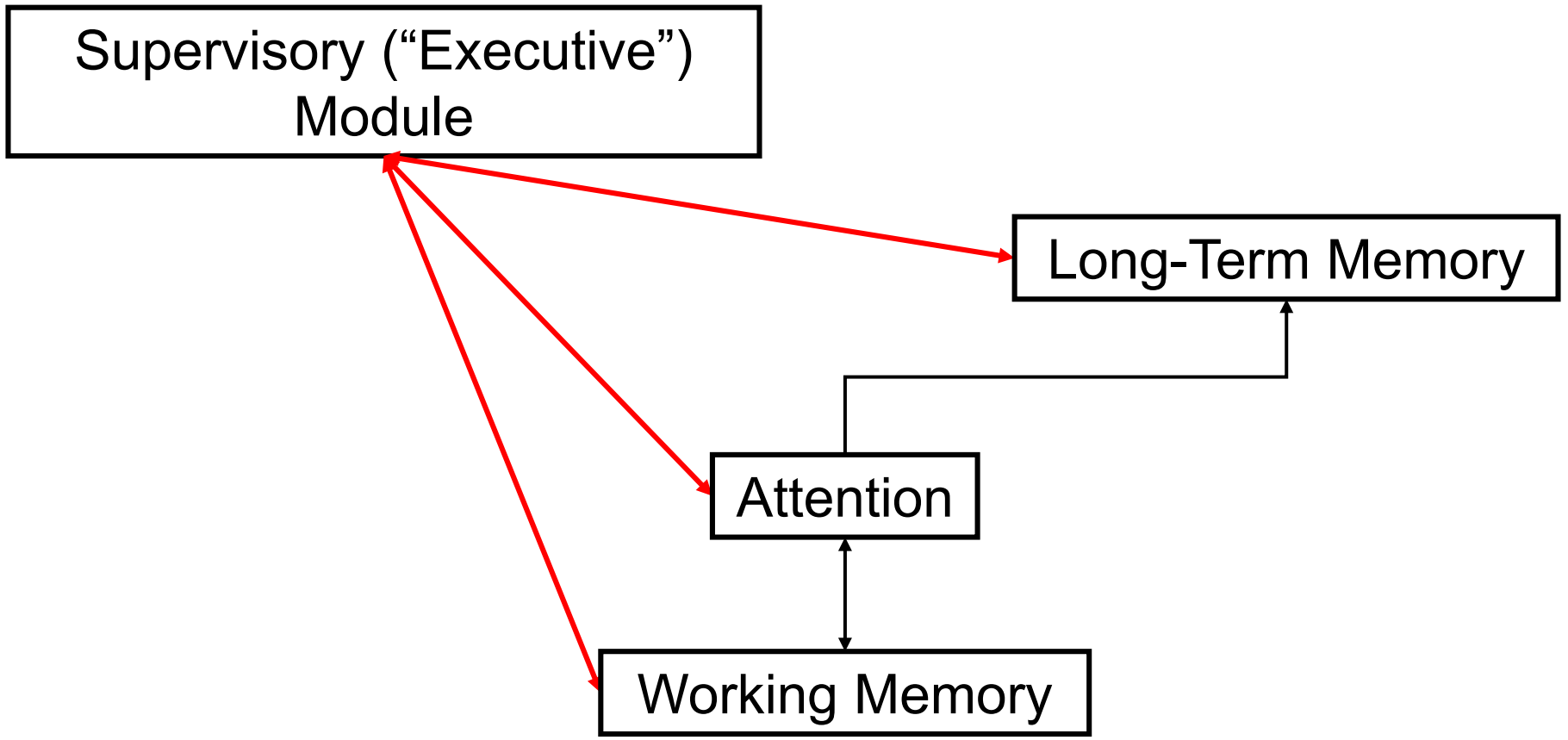
The Information Processing Model



The Information Processing Model



What is Executive Function?

Complex cognitive skills →

- lower order skills* that are coordinated, usually in the pursuit of a goal

**attention, memory, motor actions*

Historically, we assumed these skills were coordinated by a "supervisory" or "executive" module in the brain.

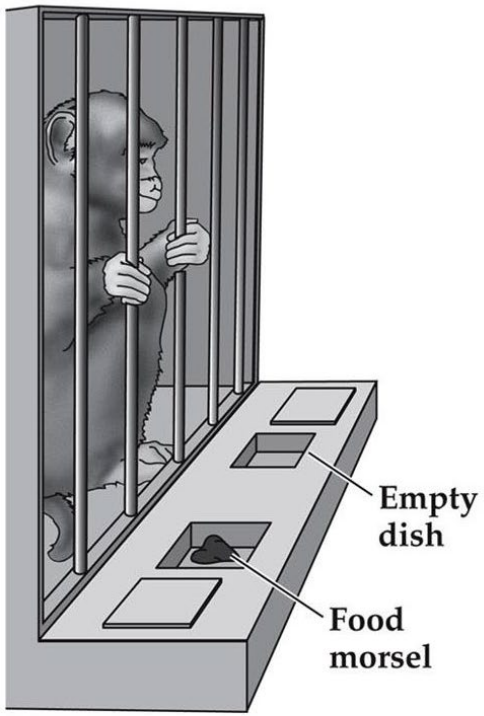
Thus, complex/coordinated skills were called "executive functions"

Where in the Brain is the “Executive”?

Delayed Response Test

Where in the Brain is the “Executive”?

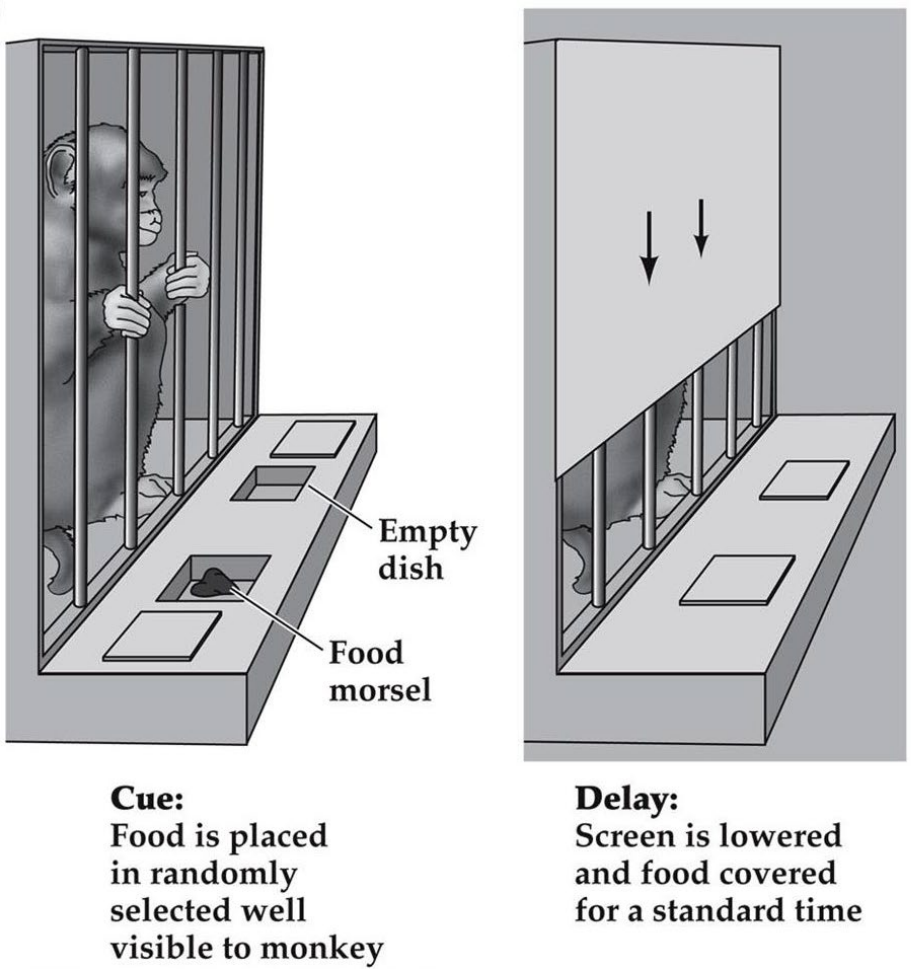
Delayed Response Test



Cue:
Food is placed in randomly selected well visible to monkey

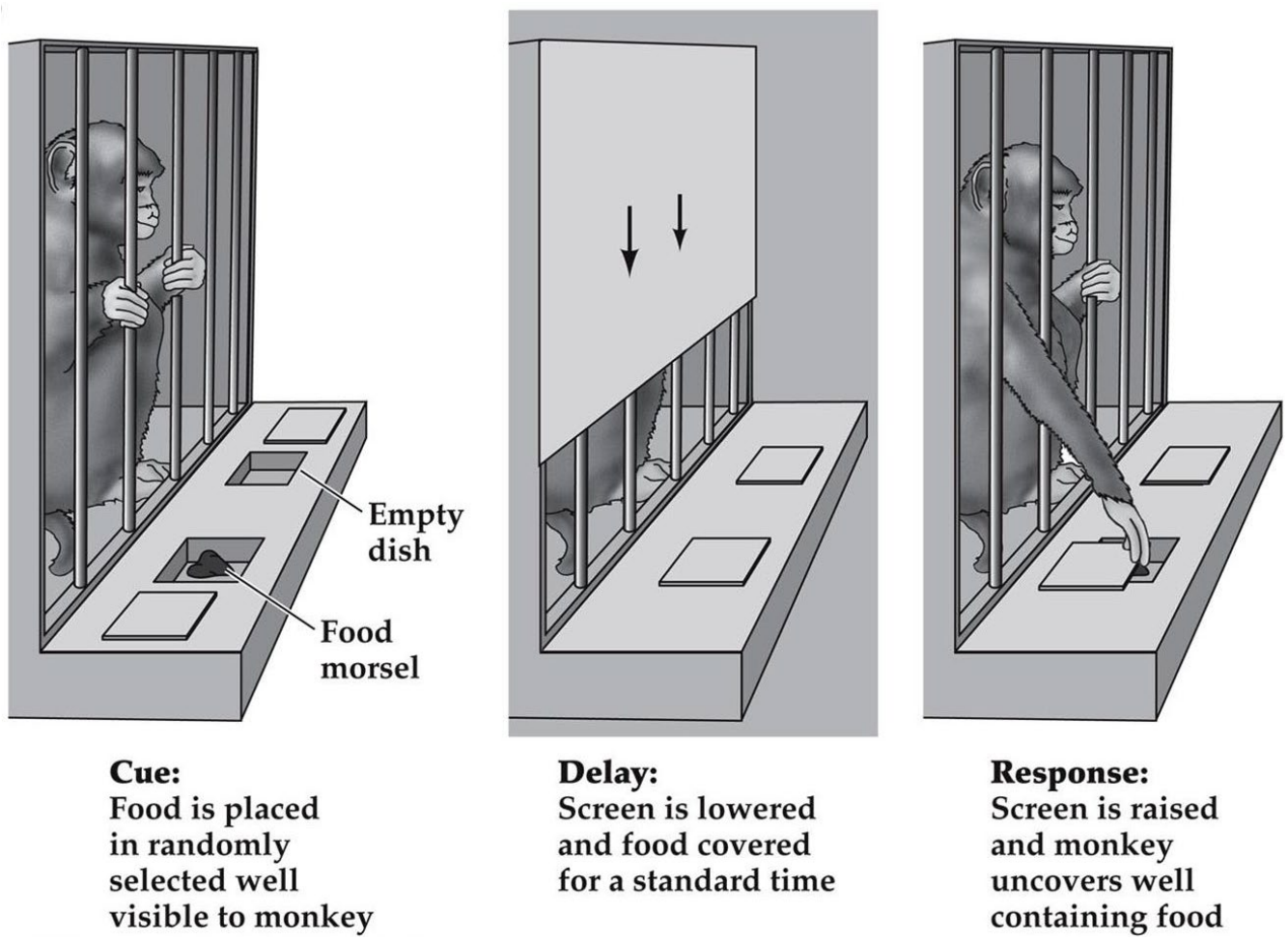
Where in the Brain is the “Executive”?

Delayed Response Test



Where in the Brain is the “Executive”?

Delayed Response Test

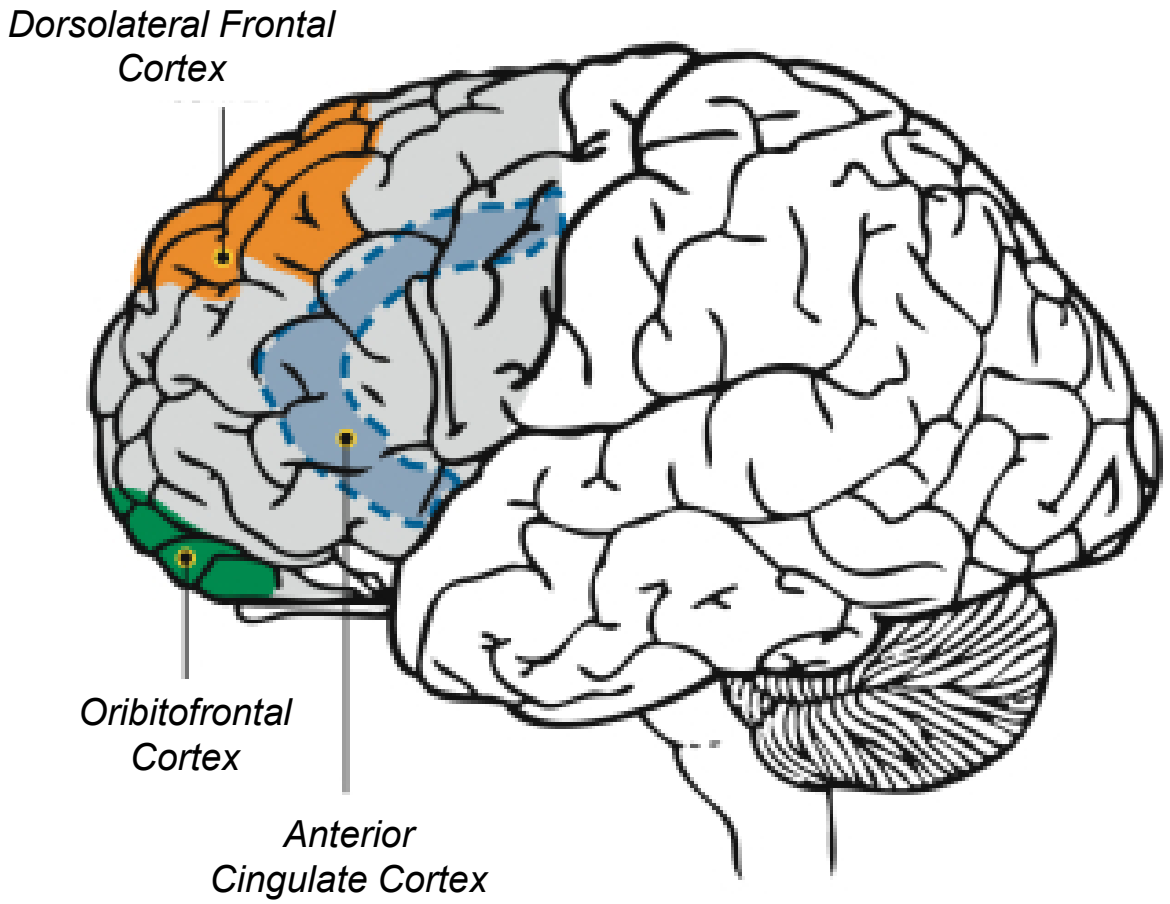


Where in the Brain is the “Executive”?

Variants of the Delayed Response Test:

- Delayed alternation
- Discrimination learning
  - Simple cue learning
  - Complex cue learning
  - Shifts/Switches in rules

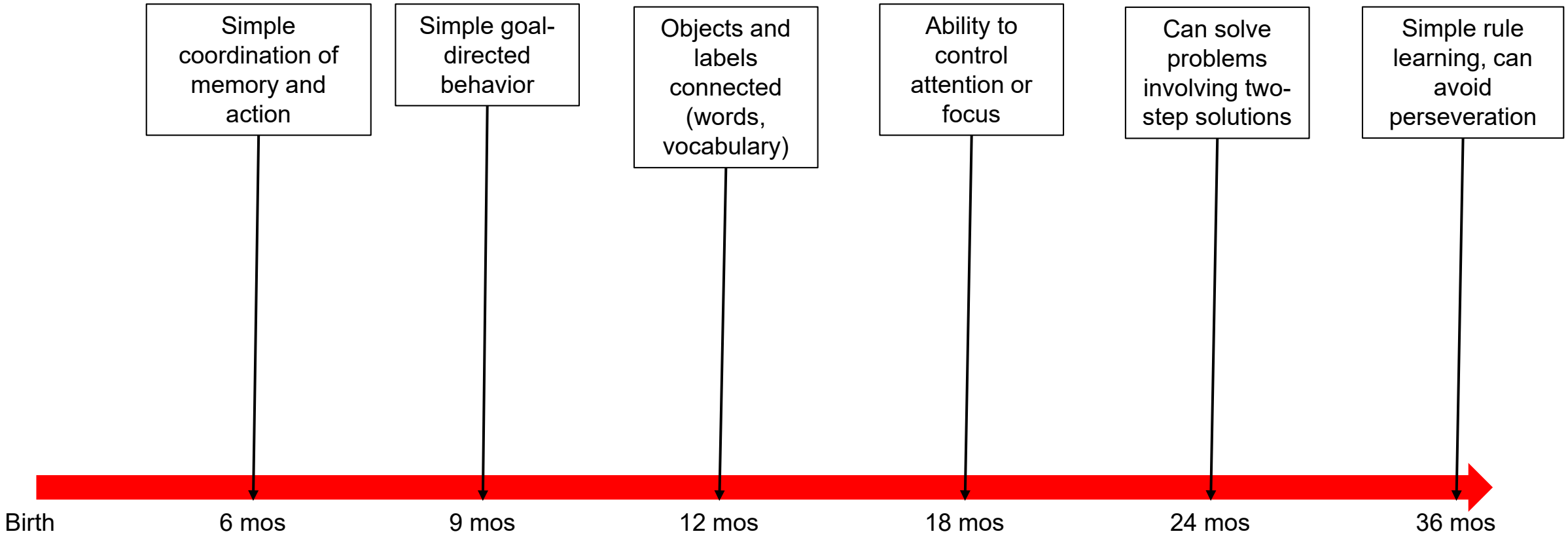
Where in the Brain is the “Executive”?



How does the Executive work?

- The frontal lobes generate executive function by *coordinating input involved in lower order cognitive processes* (e.g., attention, memory) or affective (emotional) processes.
- Integrative models of executive function:
  - Miller & Cohen (2001)
  - Kane & Engle (2001)
  - Colombo & Cheatham (2006)
  - Garon, Bryson, & Smith (2008)

When does the Executive develop?



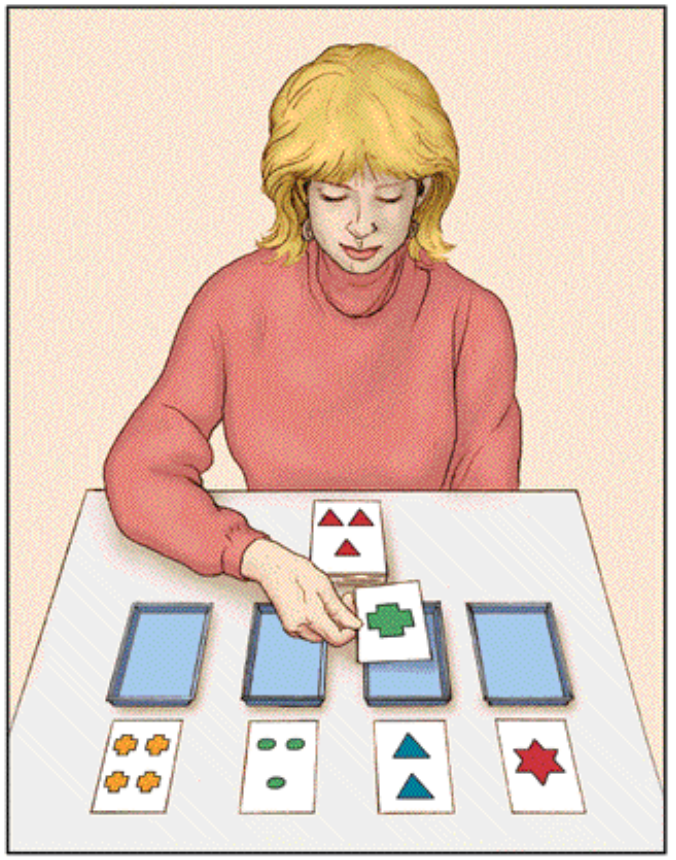
Tests of Human Executive Function

Most tests of Executive Function assess

- Rule Learning
- Inhibition
- Flexibility
- Problem Solving

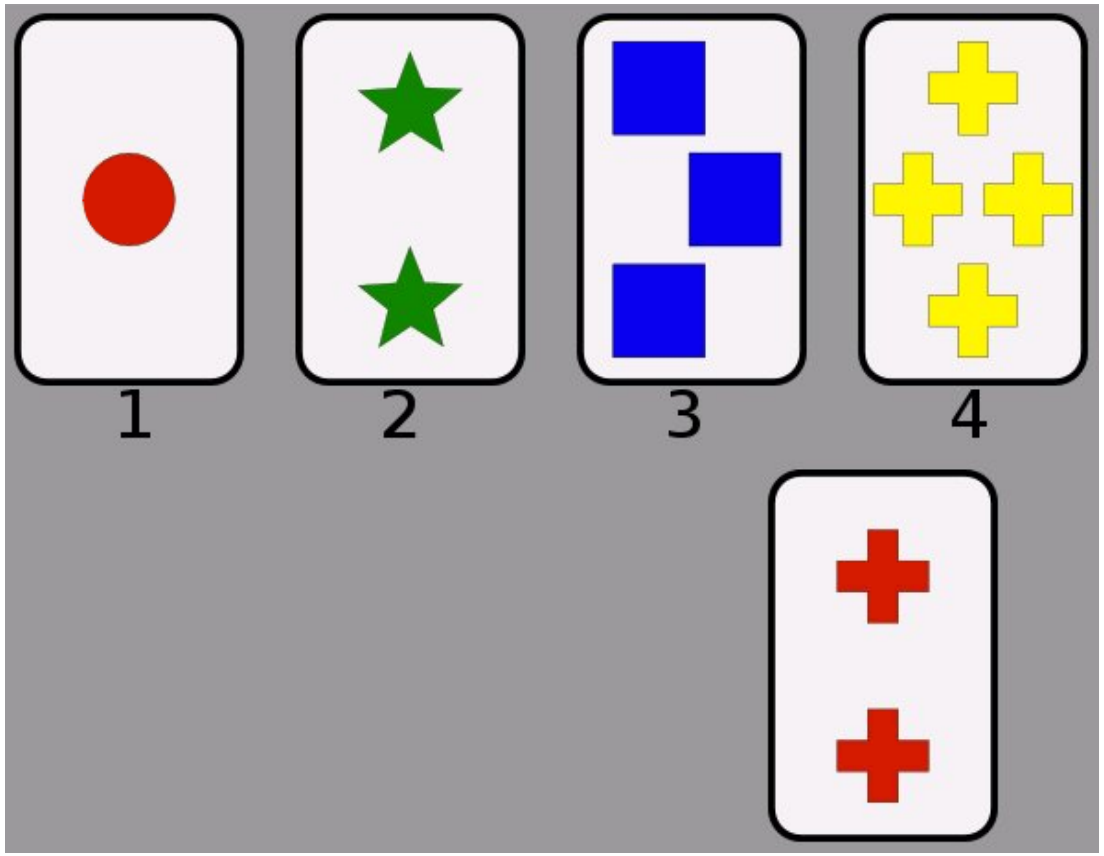
Tests of Human Executive Function

Wisconsin Card Sorting Task



Tests of Human Executive Function

Wisconsin Card Sorting Task



Tests of Human Executive Function

N-Back Tests
(working memory)

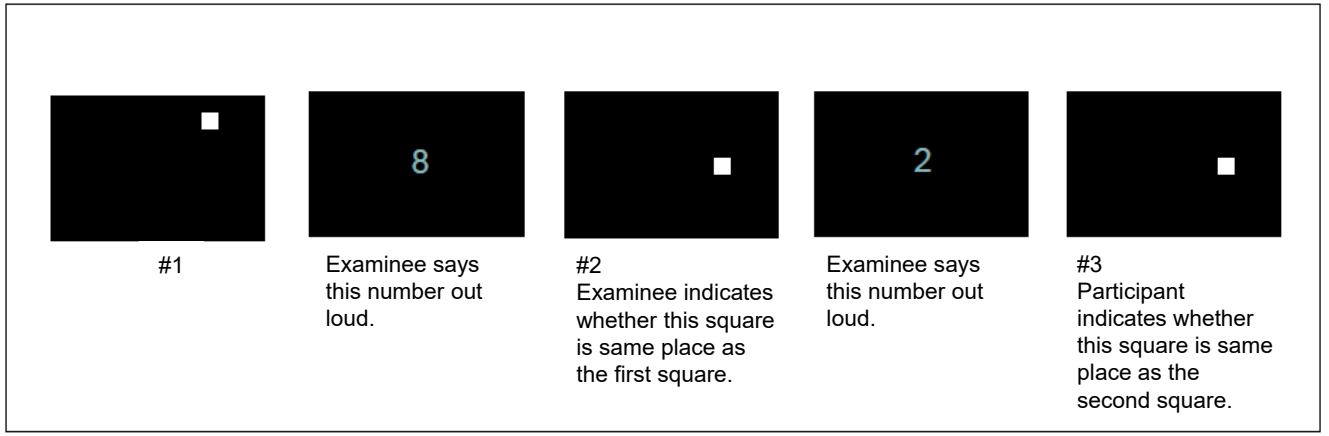


Figure 1. Example of 1-back stimuli

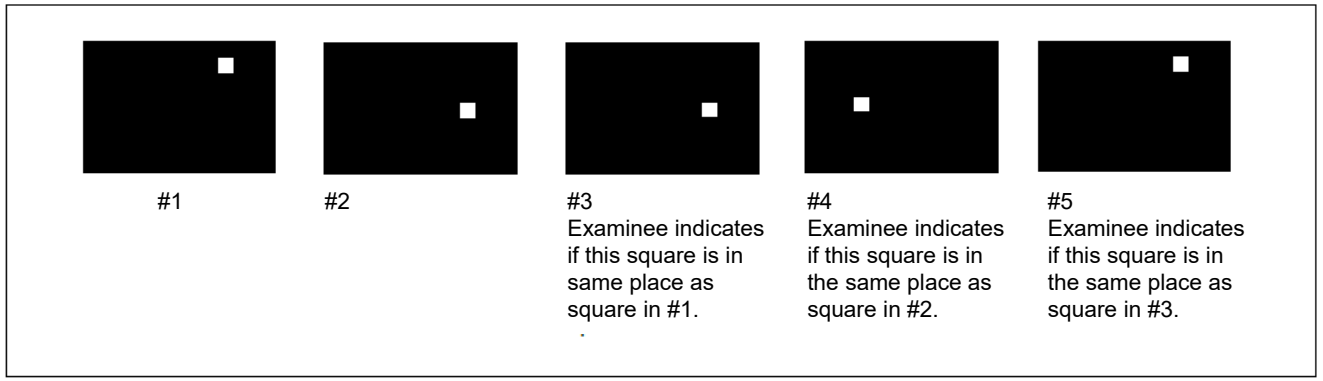


Figure 2. Example of 2-back stimuli

Executive Function Tasks for Children

Many of the tasks derived from adult neuropsychology are appropriate for younger subjects

- A-not-B task
- Go/No-Go
- Dimensional Card Sort
- Stroop Tests

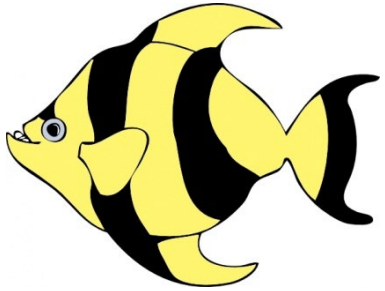
Executive Function Tasks for Children

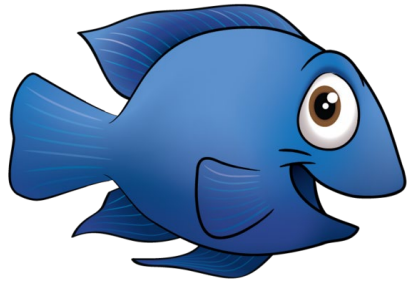
"A-not-B" task
(9 mos to 24 mos)

Executive Function Tasks for Children

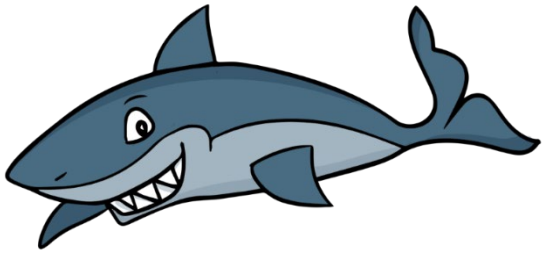
Go/No-Go Task

Go Stimuli (Fish):

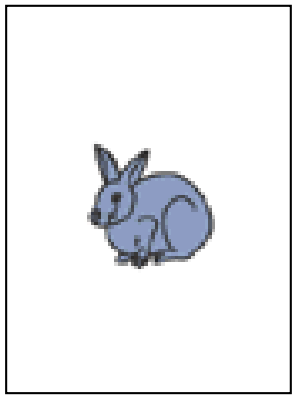


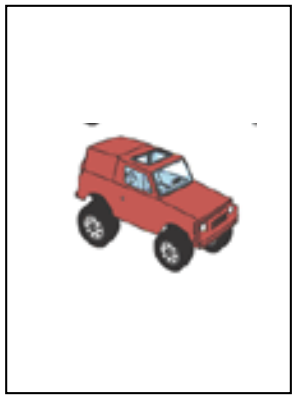


No-Go Stimulus (Shark):



Executive Function Tasks for Children

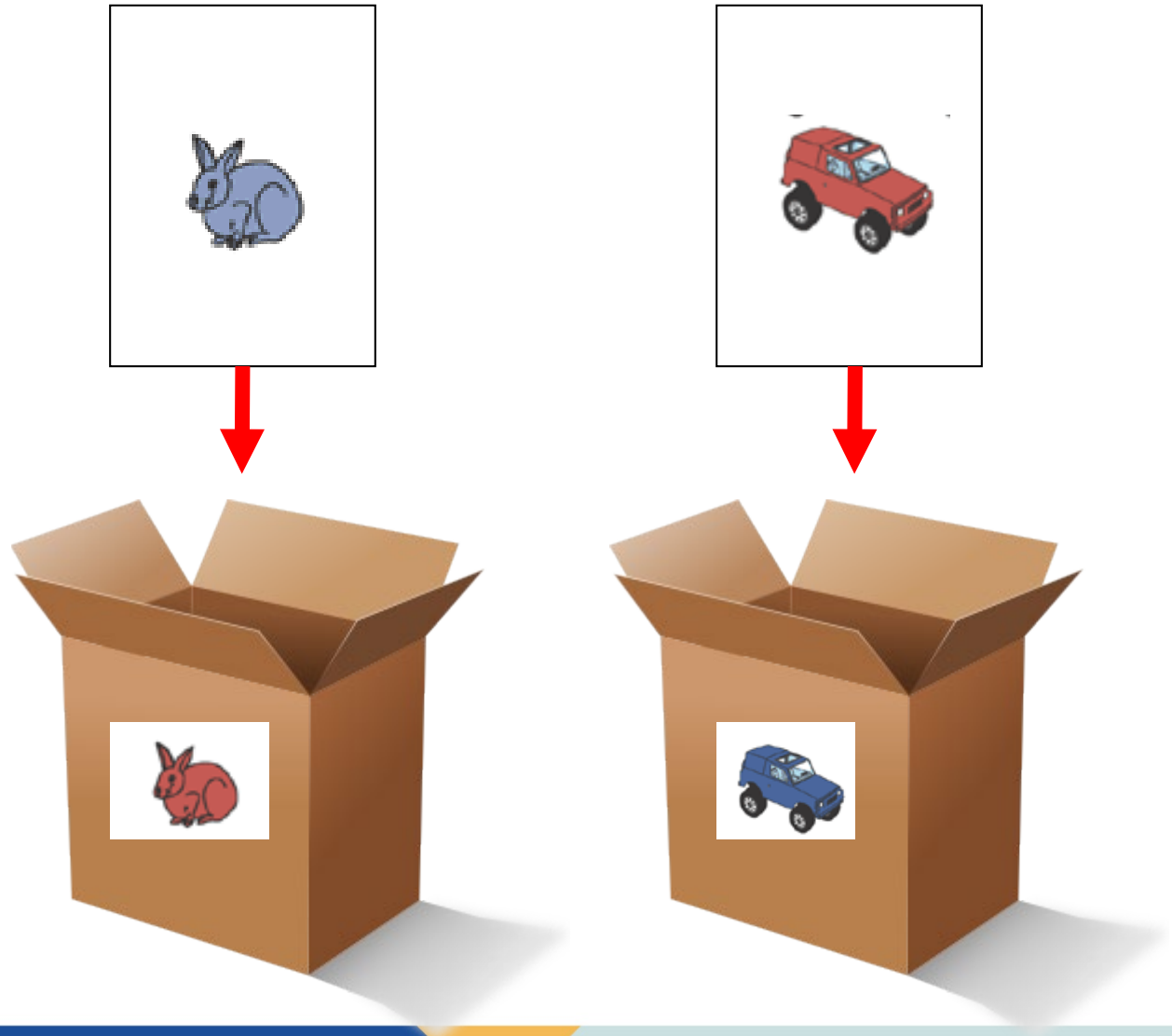




Dimensional Change Card Sort Task

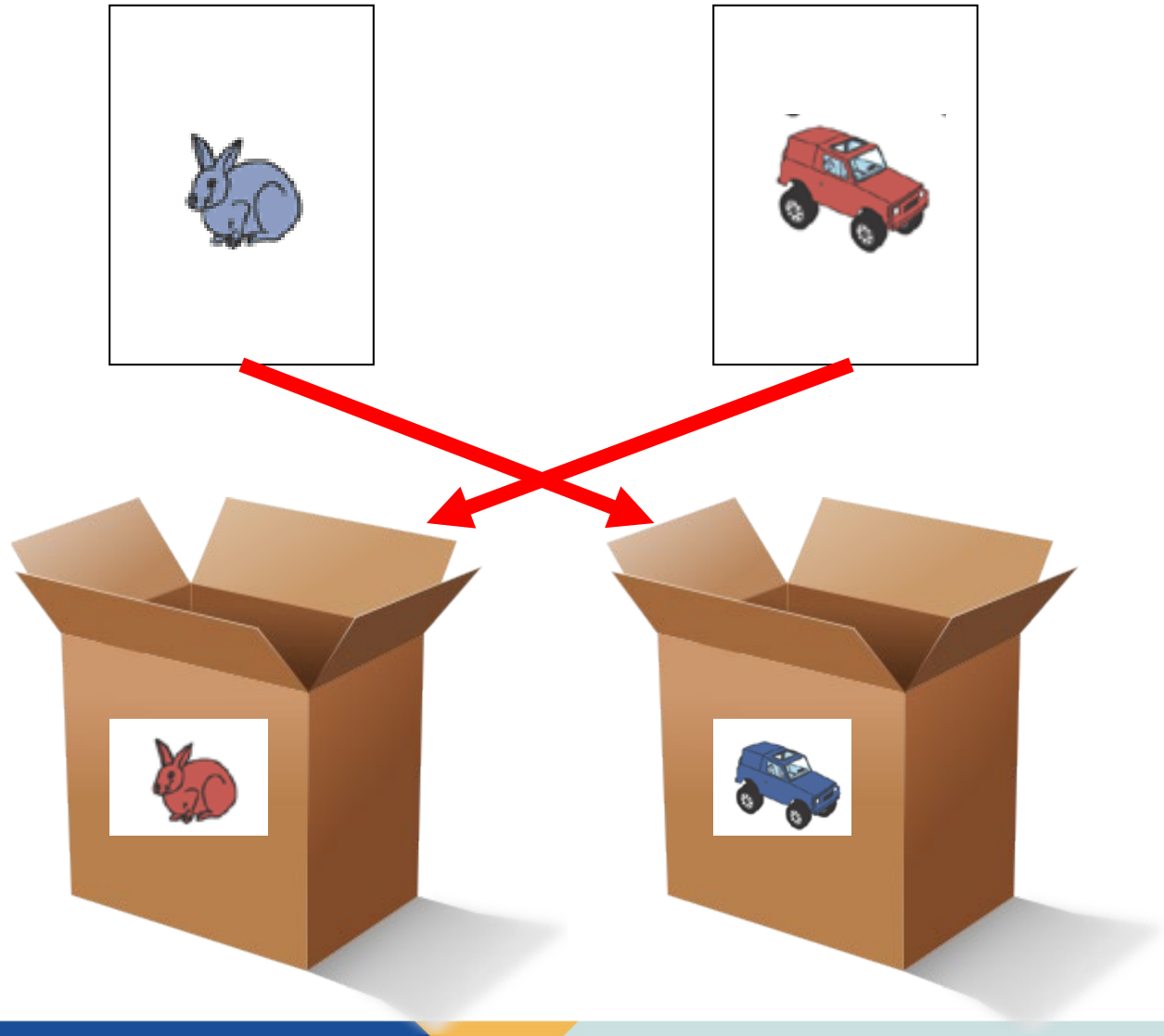
Executive Function Tasks for Children

Dimensional Change Card Sort Task



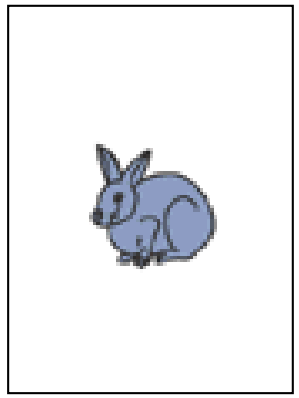
Executive Function Tasks for Children

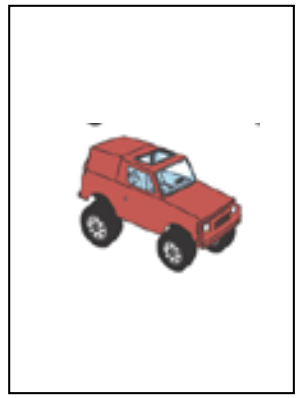
Dimensional Change Card Sort Task



Executive Function Tasks for Children

Dimensional Change Card Sort Task

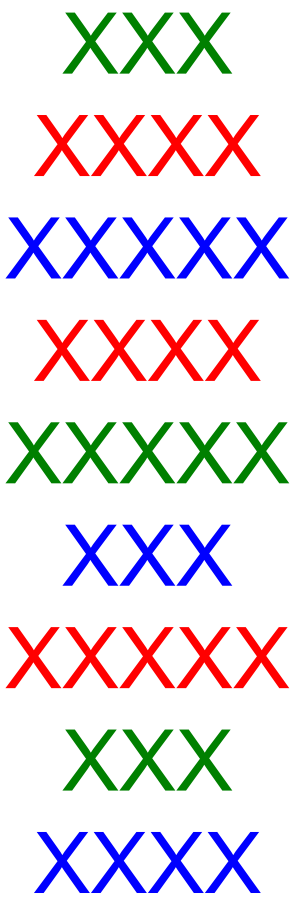




Switch sorting rule after mastery

Executive Function Tasks for Children

Classic Stroop Task



Executive Function Tasks for Children

Classic Stroop Task

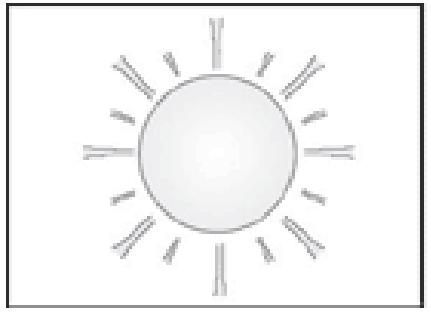
RED
BLUE
GREEN
BLUE
GREEN
RED
GREEN
RED
BLUE

Executive Function Tasks for Children

Adapted Stroop Tasks for Children

“Yellow”
(“Banana”)

“Red”
(“Apple”)

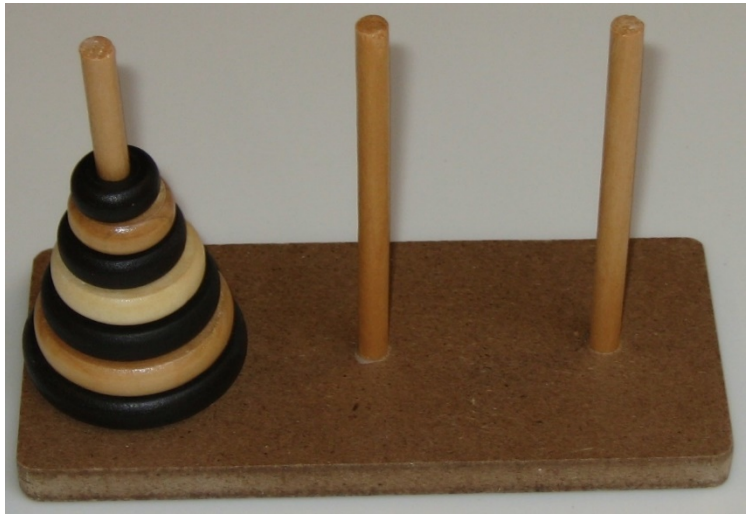


“Night”

“Day”

Executive Function Tasks for Children

Problem-Solving Tasks

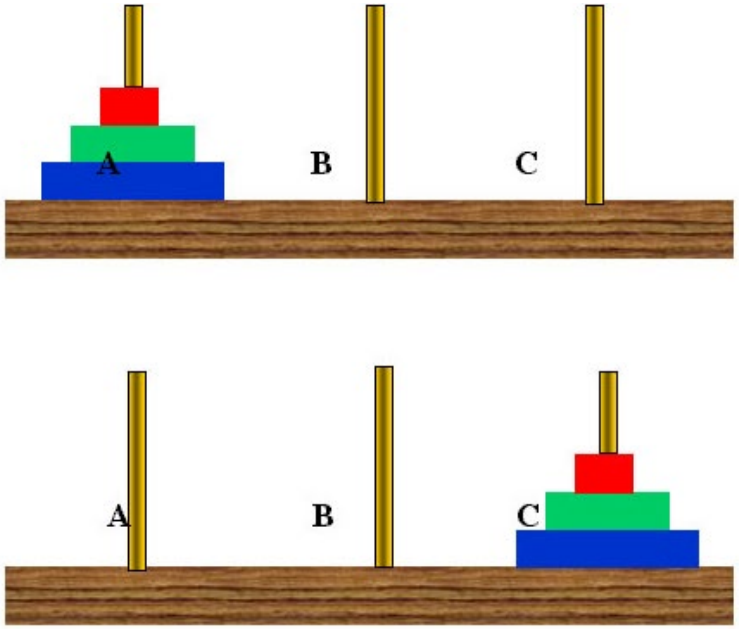


Goal: Move rings from the left peg to the right peg, retaining size order shown.

Rule: A bigger ring may not be placed on top of a smaller one

Executive Function Tasks for Children

Problem-Solving Tasks



This simplified form of the task can be solved in as few as 7 steps

Executive Function and Self-Regulation

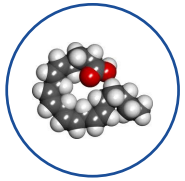
Executive Function → regulation of emotion and clinically-relevant behavior problems

“Hot” vs. “Cool” Executive Function Tasks

- “Cool”: (standard assessments) do not involve emotion
- “Hot”: include positive or negative emotional consequence (e.g., delay of reward)

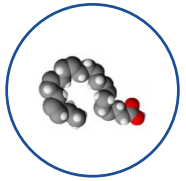
Nutrition and Executive Function

Nutrition and Executive Function



Arachidonic Acid (ARA)

- An omega-6 LCPUFA
- Abundant in the brain
- Protects brain from stress, contributes to repair.
- Thought to be important in growth
- We usually get enough omega-6 in our diet from eggs, meat, dairy



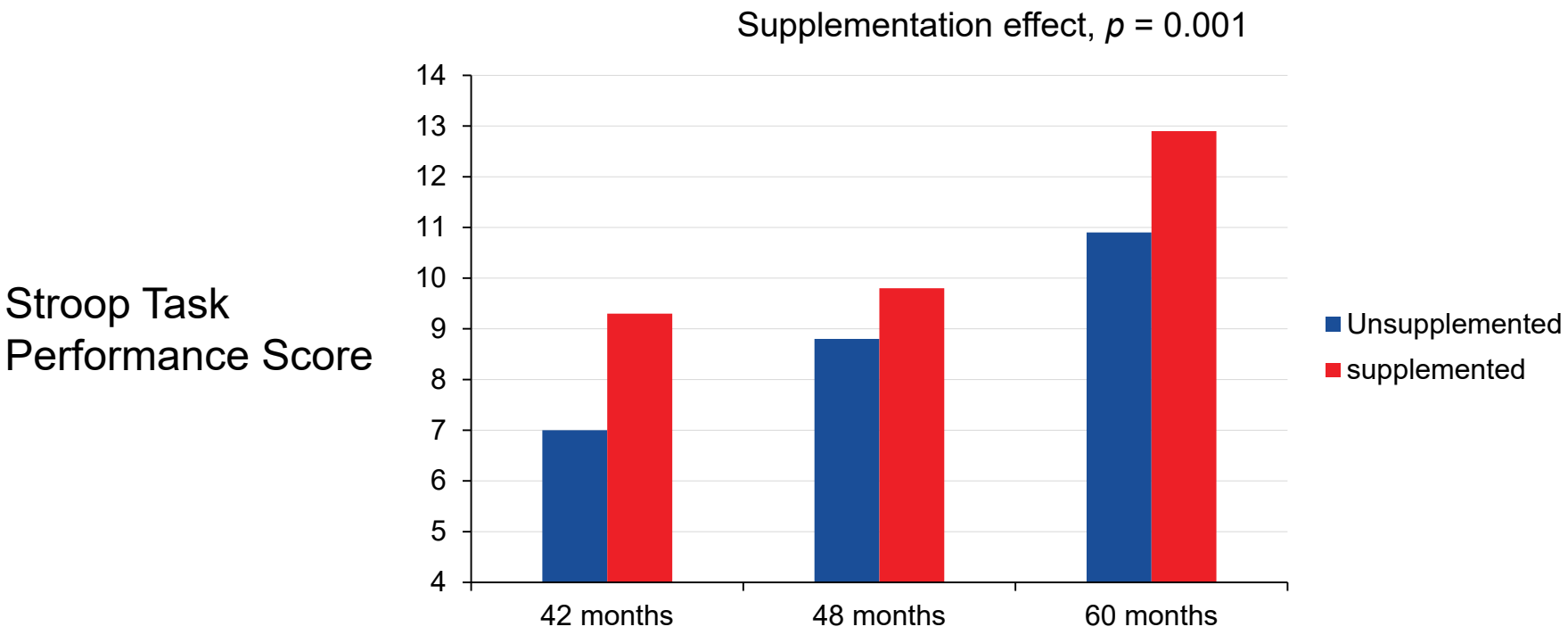
Docosahexaenoic Acid (DHA)

- An essential omega-3 LCPUFA
- Anti-inflammatory
- Critical to eye and brain structure, and brain signaling
- American diets are deficient
- Common dietary source: coldwater oily fish

Nutrition and Executive Function

Study	Postnatal Study: DHA Intake and Measurement of Development (DIAMOND)	Prenatal Study: KU DHA Outcomes Study (KUDOS)
Dates	2004-2017	2006-2017
Sample size	120 formula-fed infants	350 mothers
Groups	Four groups: 0.00%, 0.32%, 0.64% and 0.96% DHA (of total fat in formula) and 0.64% of ARA fed from birth to 12 months	Two groups: 0 mg vs. 600 mg DHA daily from enrollment to delivery
Follow-up	Children followed from birth to age 10	Mothers followed to delivery Children followed from birth to age 7
Outcomes	Children: health and neurocognitive outcomes	Mothers: pregnancy outcomes Children: health and neurocognitive outcomes

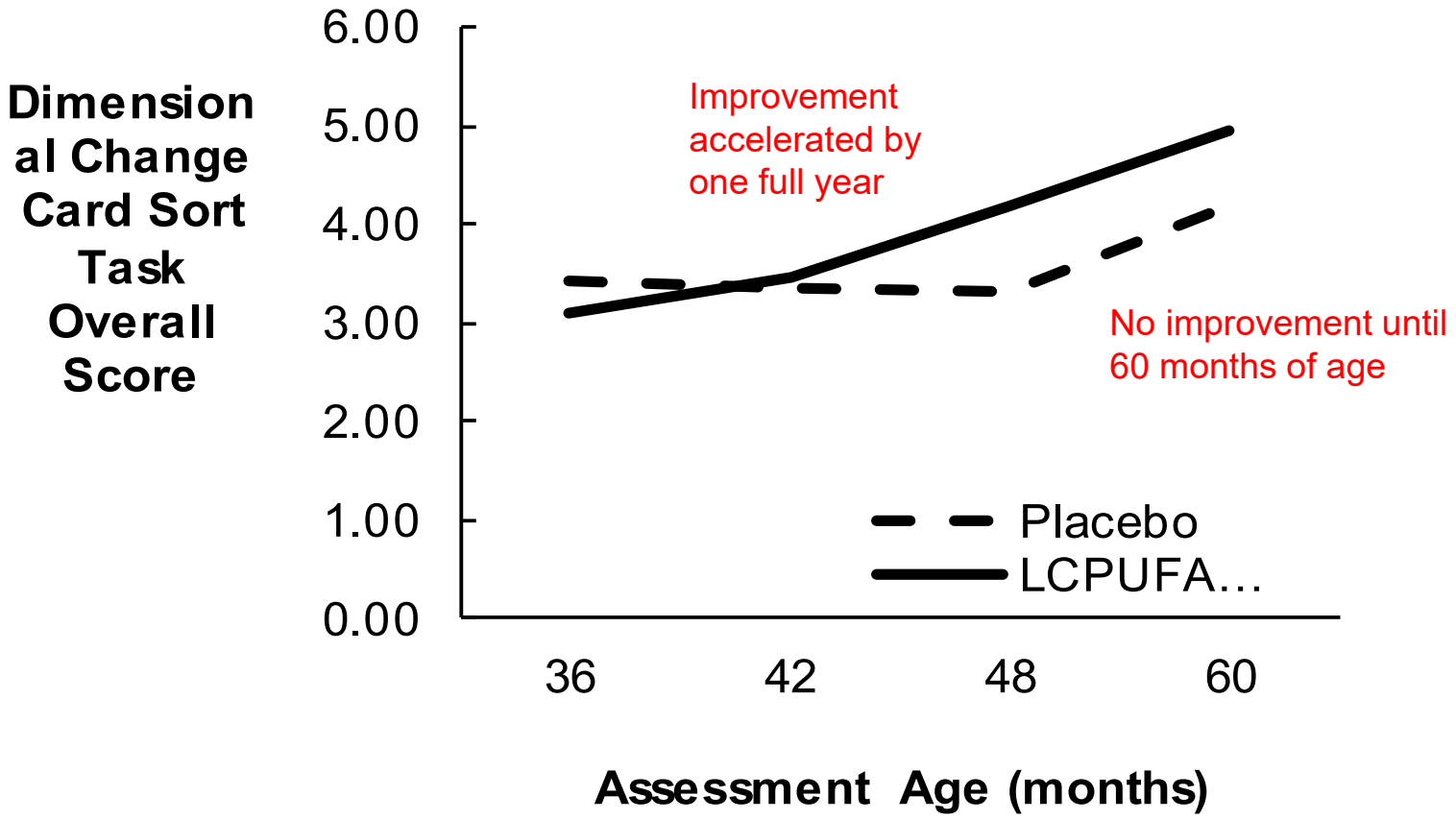
Nutrition and Executive Function



LCPUFA-supplemented infants scored better on Stroop tasks at all ages

Colombo et al., *Am J Clin Nutr*, 2013; 98: 403-412

Nutrition and Executive Function



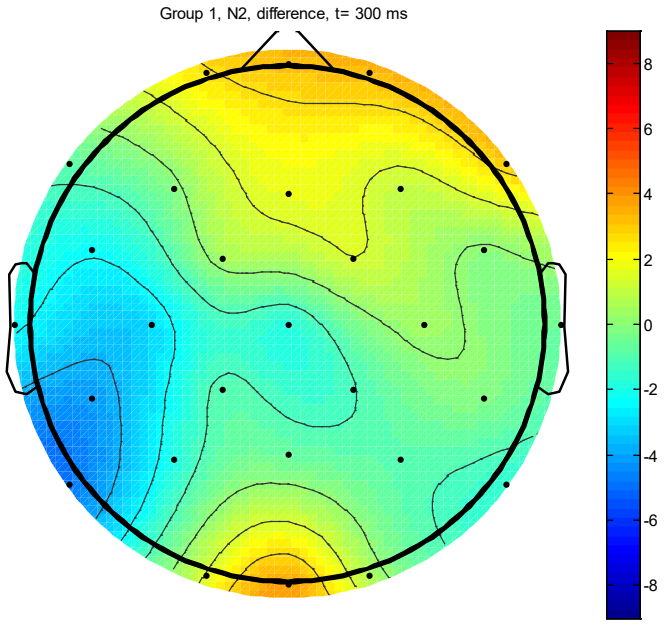
Colombo et al., *Am J Clin Nutr*, 2013; 98: 403-412

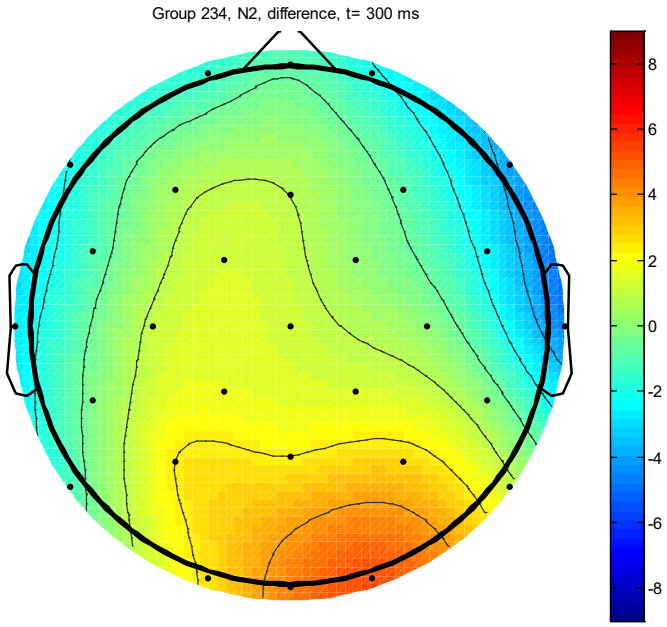
Nutrition and Executive Function

Brain responses of supplemented and unsupplemented infants on the Go/No-Go task

These are from “shark” trials where children are supposed to *inhibit* responding

Nutrition and Executive Function





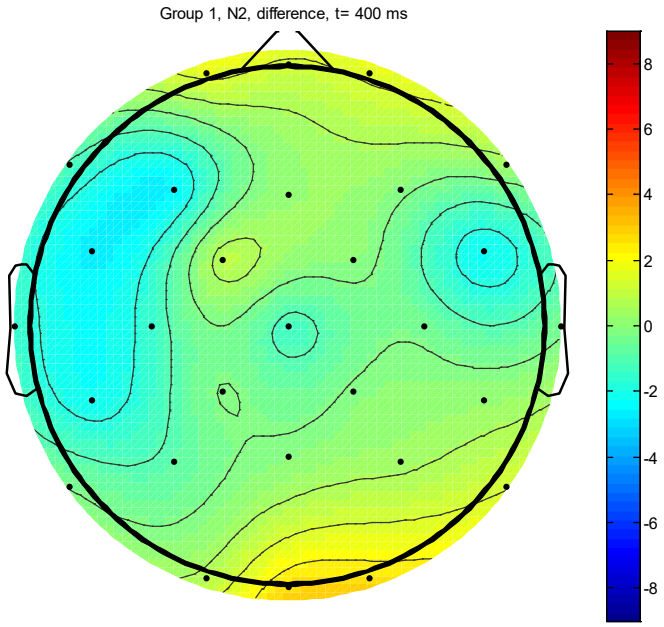
Control

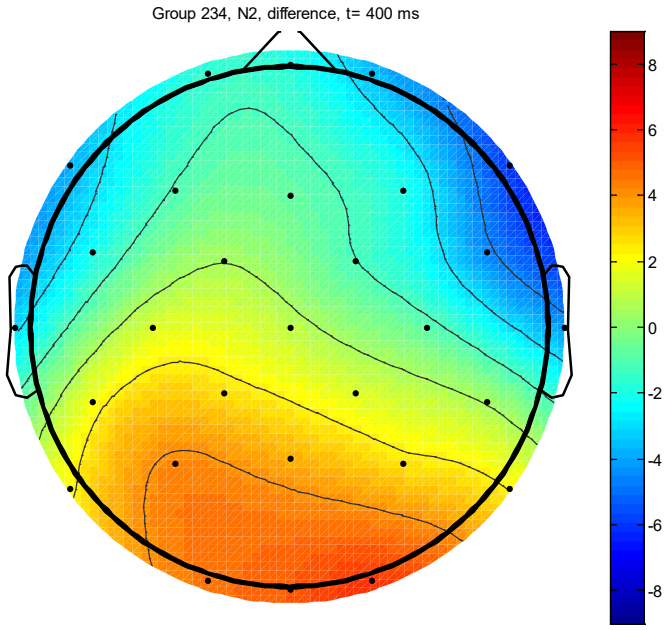
LCPUFA

300 ms

Liao et al., 2017, *Dev Sci*. Sep;20(5).

Nutrition and Executive Function





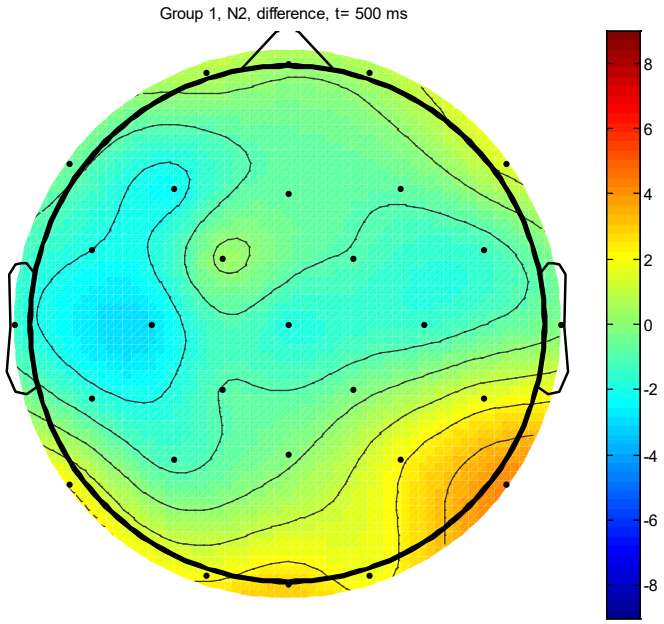
Control

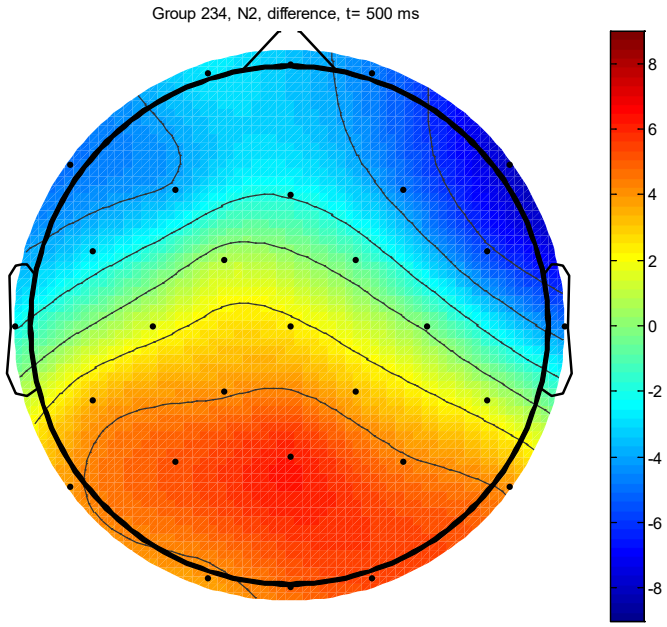
LCPUFA

400 ms

Liao et al., 2017, *Dev Sci*. Sep;20(5).

Nutrition and Executive Function





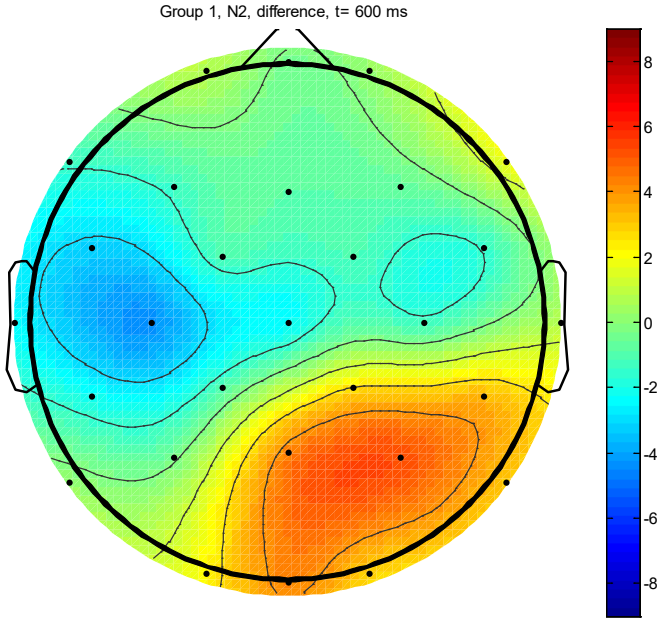
Control

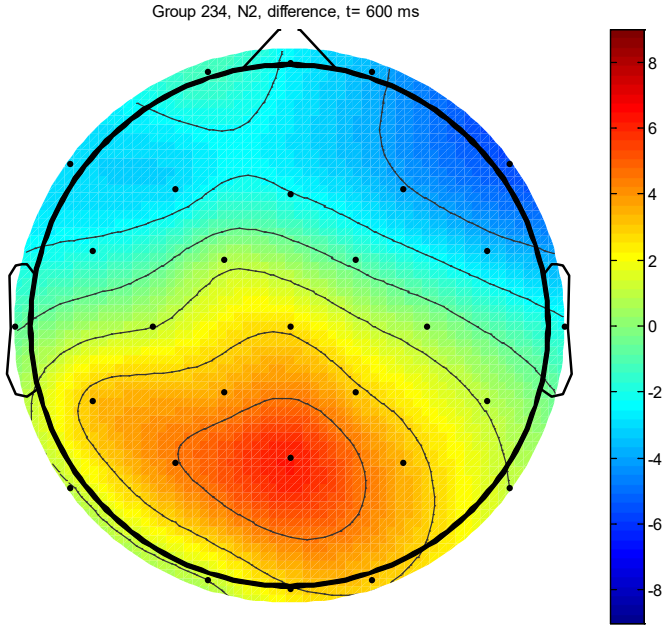
LCPUFA

500 ms

Liao et al., 2017, *Dev Sci*. Sep;20(5).

Nutrition and Executive Function





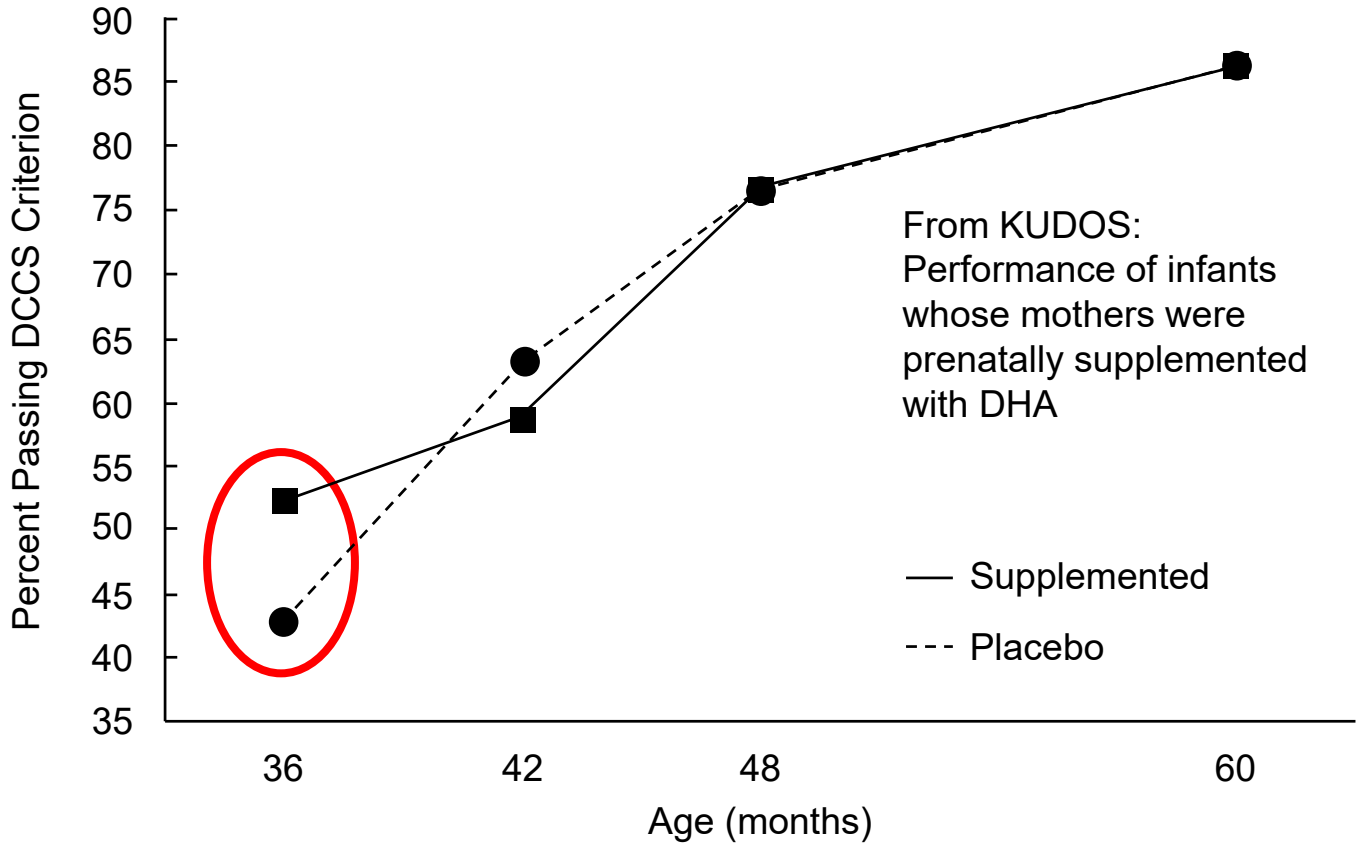
Control

LCPUFA

600 ms

Liao et al., 2017, *Dev Sci*. Sep;20(5).

Nutrition and Executive Function



Colombo et al., *Am J Clin Nutr*, 2019

Questions

THANK YOU