# Active Body, Active Mind – Effects On Brain Development

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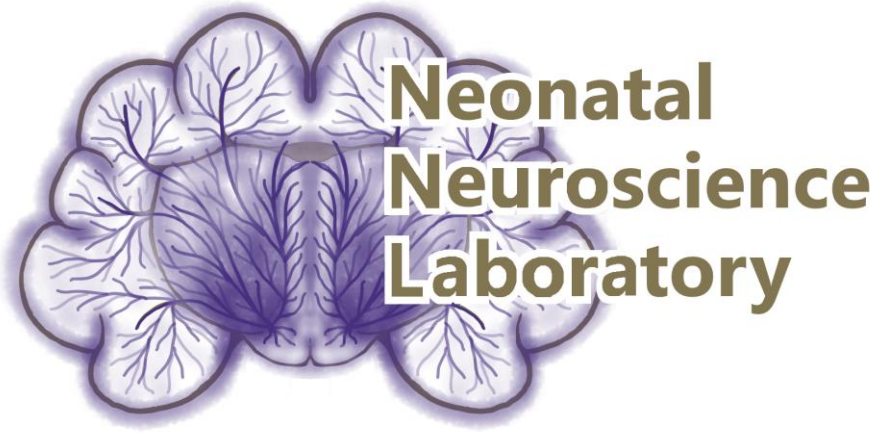
*Food for the Brain*

# My work




FOOD FOR THE BRAIN FOUNDATION



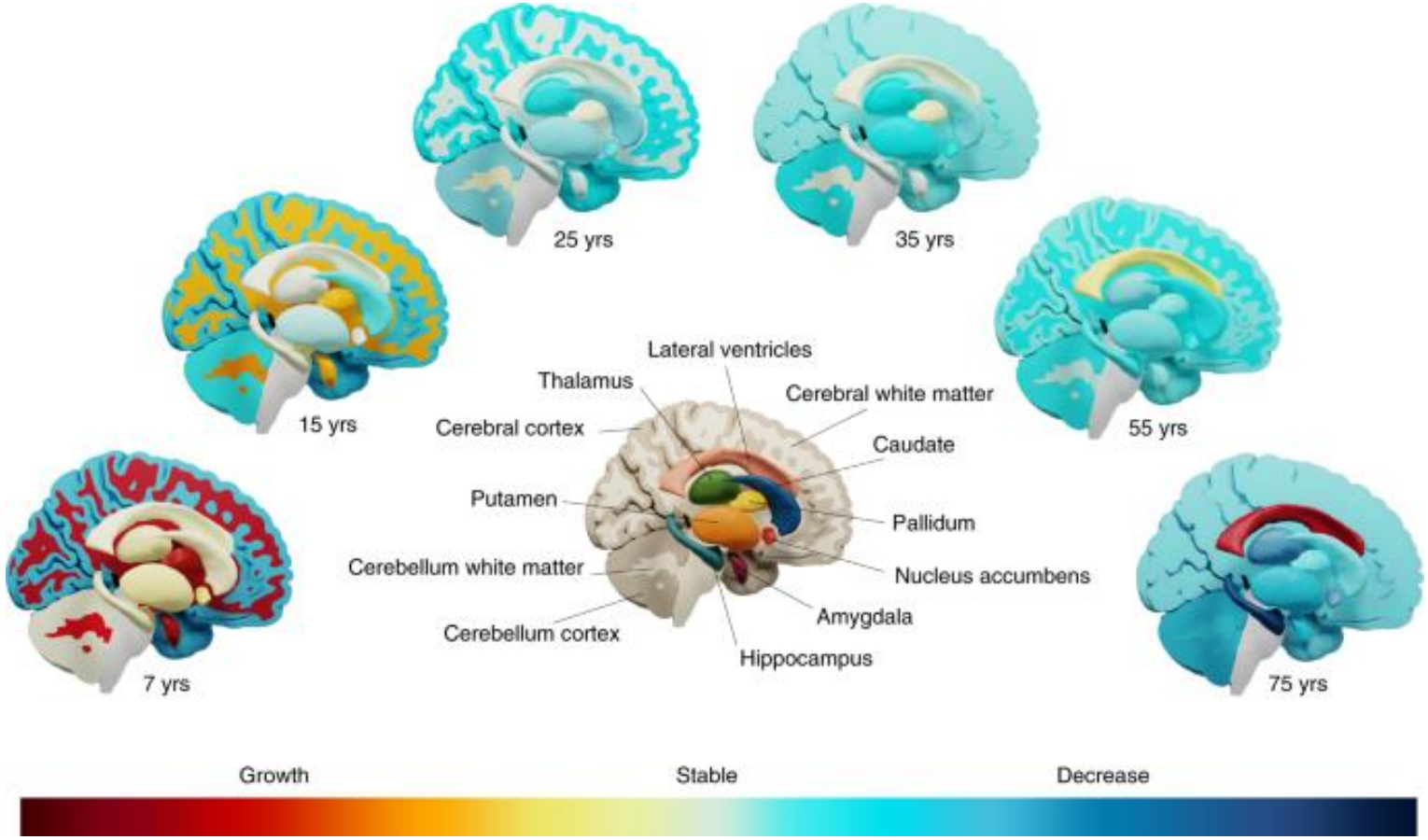

HINTSA

# Overview

- A way to think about what the brain needs
- The importance of stimulating the brain during development
  - Primary drivers of adaptation
- The importance of rest and recovery
  - Time for that adaptation to occur

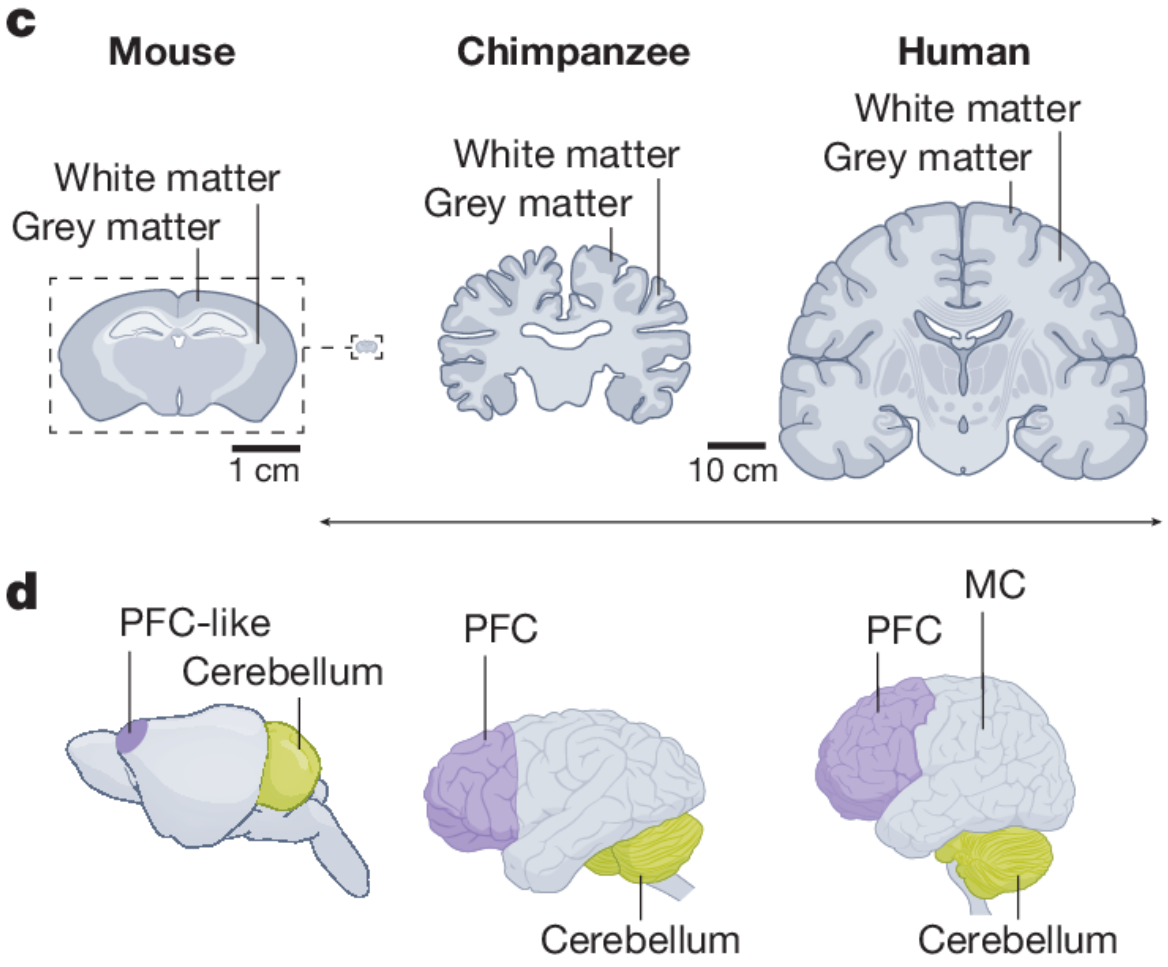
# The brain takes ~30 years to develop

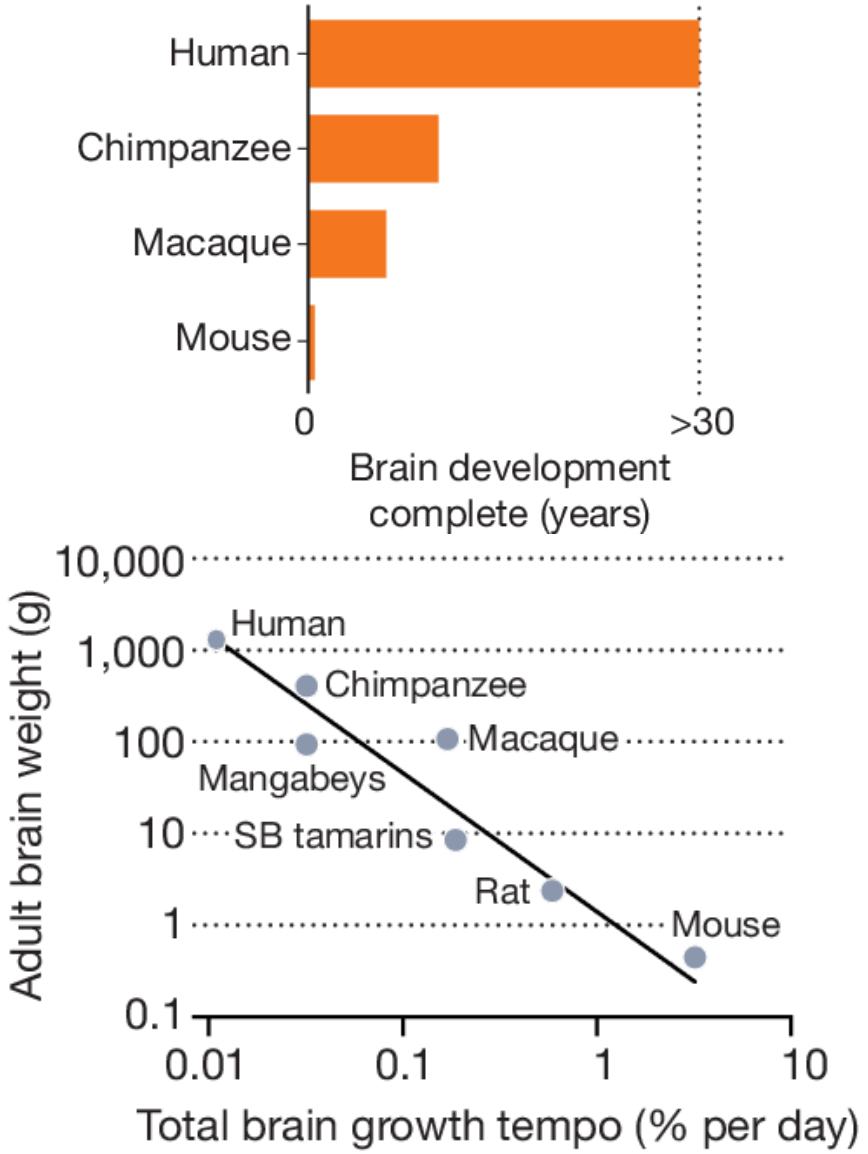
- The brain is dynamic and responsive across the entire lifespan
- Possible to intervene regardless of age




Brouwer et al. Nature Neuroscience 2022

# The human brain is (slowly) shaped by the environment

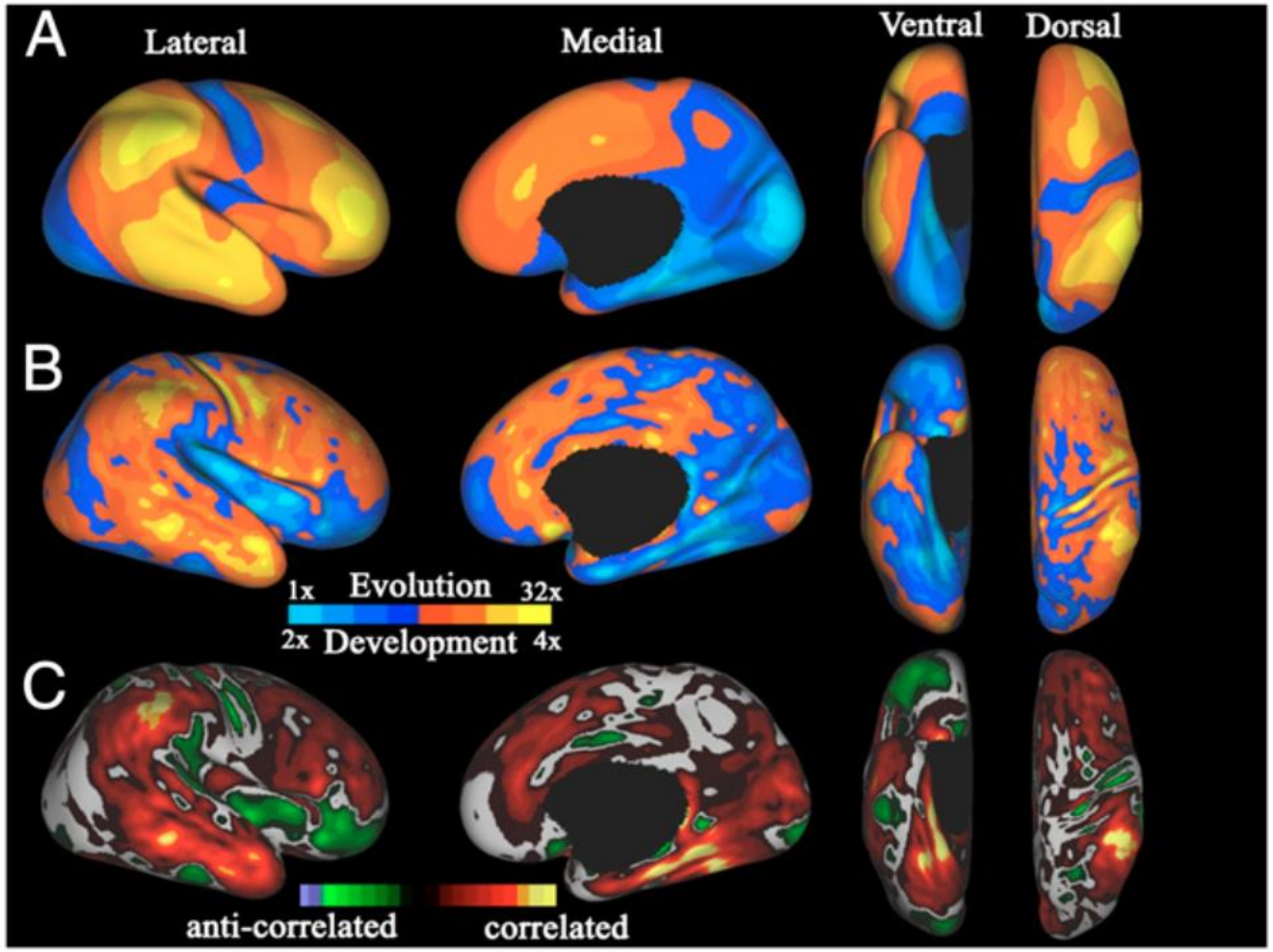



Lindhout et al., Nature 2024

# The human brain is (slowly) shaped by the environment

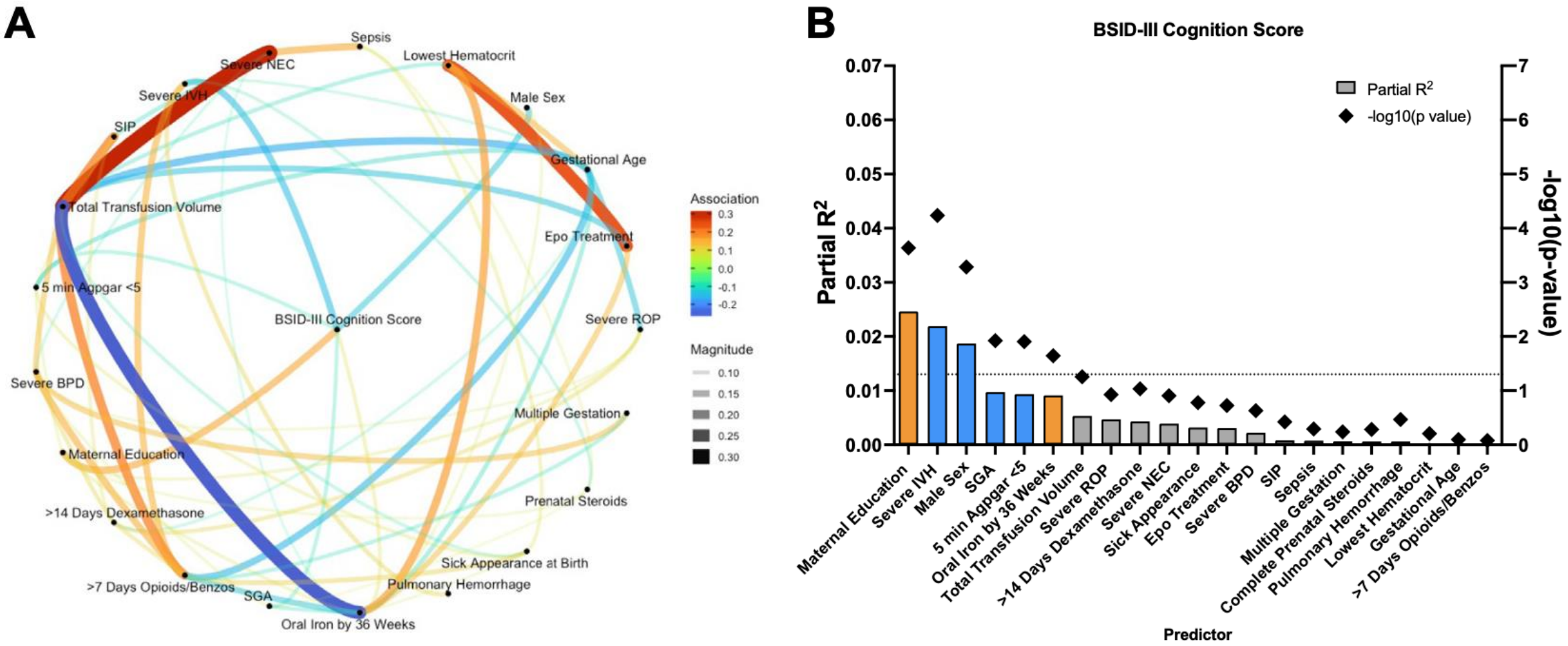
- Most recently evolved brain structures mature the slowest
  - Responsible for the most complex cognitive functions




Hill et al., PNAS 2010

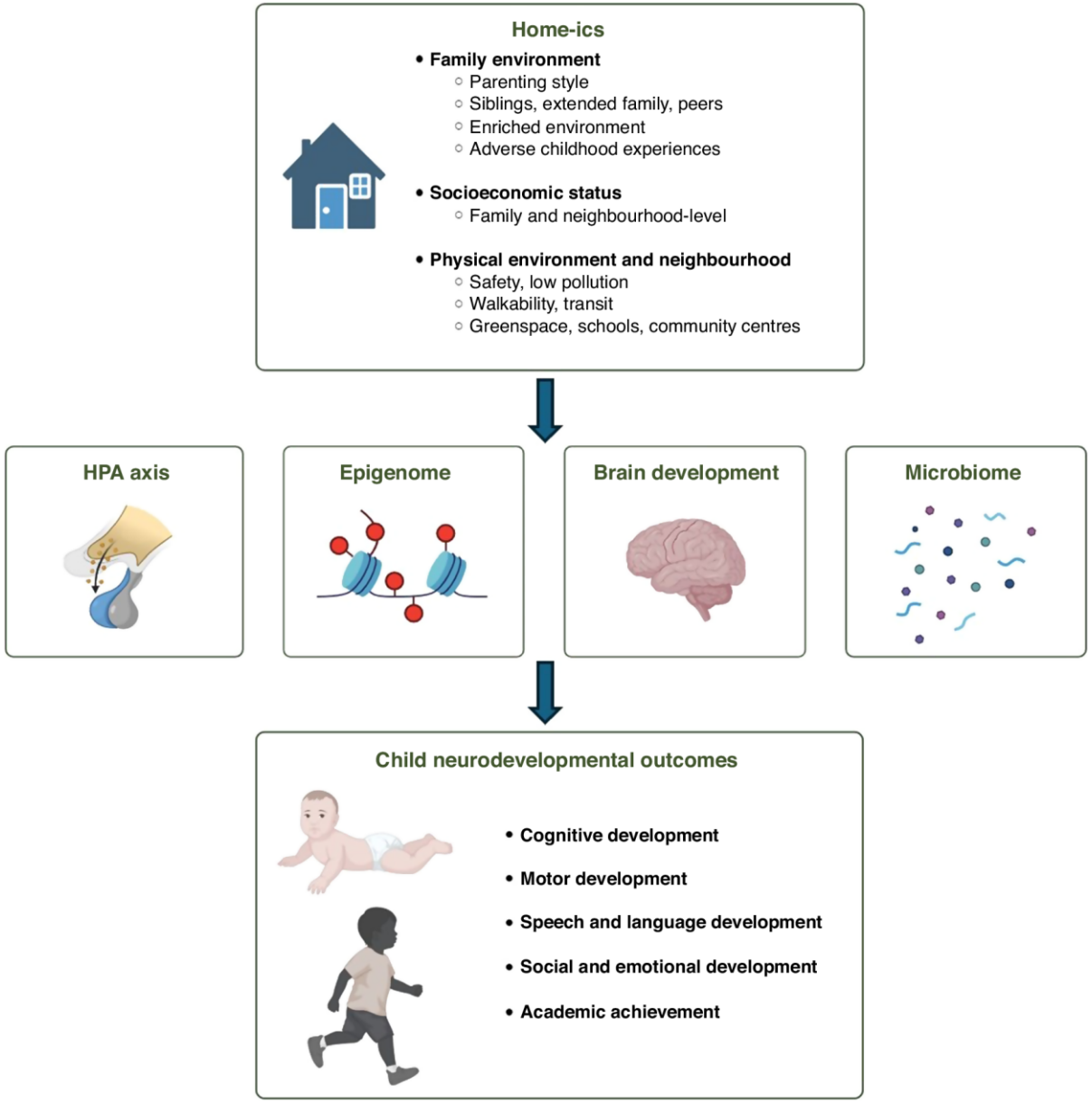
# Cognitive function is driven by environment

- 697 extremely preterm infants assessed at 2-years old



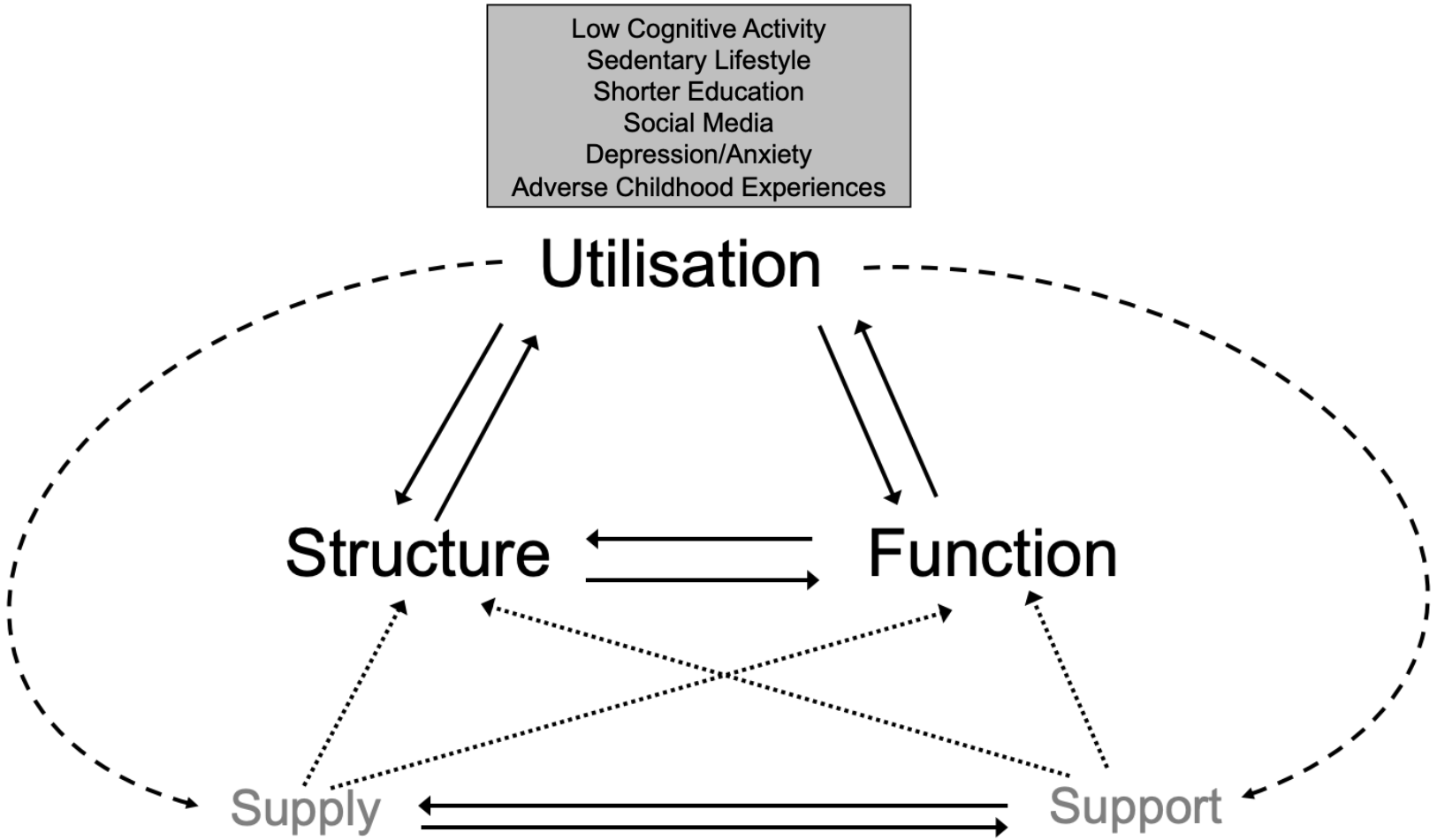

Wood, Juul *et al.*, eClinicalMedicine 2023

# Home-ics and brain development




Christensen *et al.*, Pediatric Research 2024

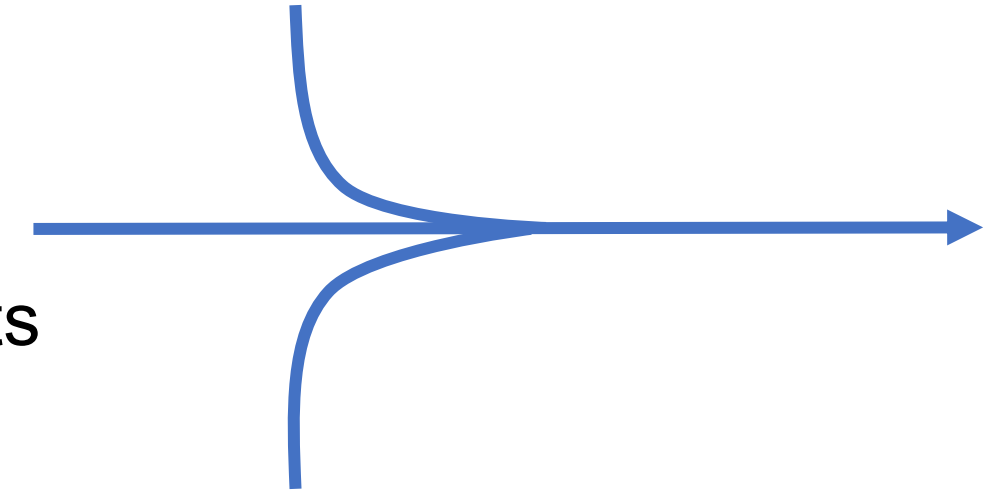
# A system for brain health

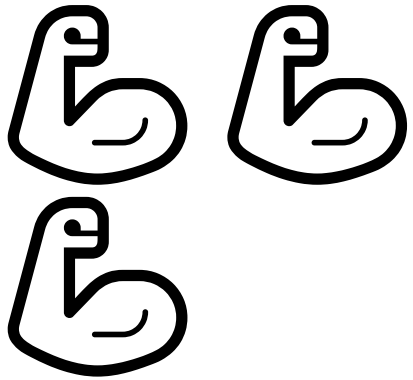


# A simplified model – strength as an example

Supply
- Adequate Protein/Calories
- Micronutrients

Stimulus
- Train
- Lift Weights





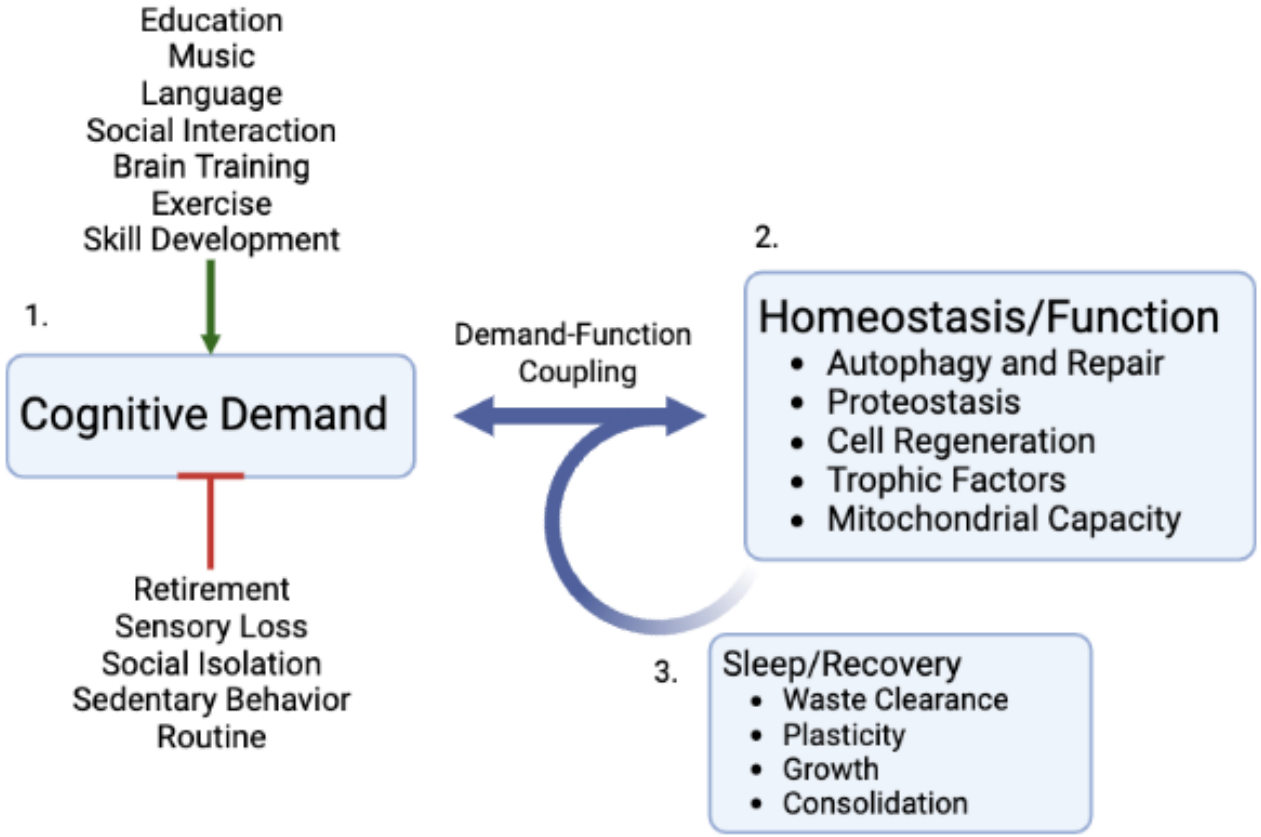
Function
- Strength

Structure
- Muscle Mass

Support/Recovery
- Sleep
- Rest

# Demand-function coupling in the brain

- The function of a tissue is determined by the stimulus
  - Same as with exercise and fitness/strength
- Similar across all stages of life

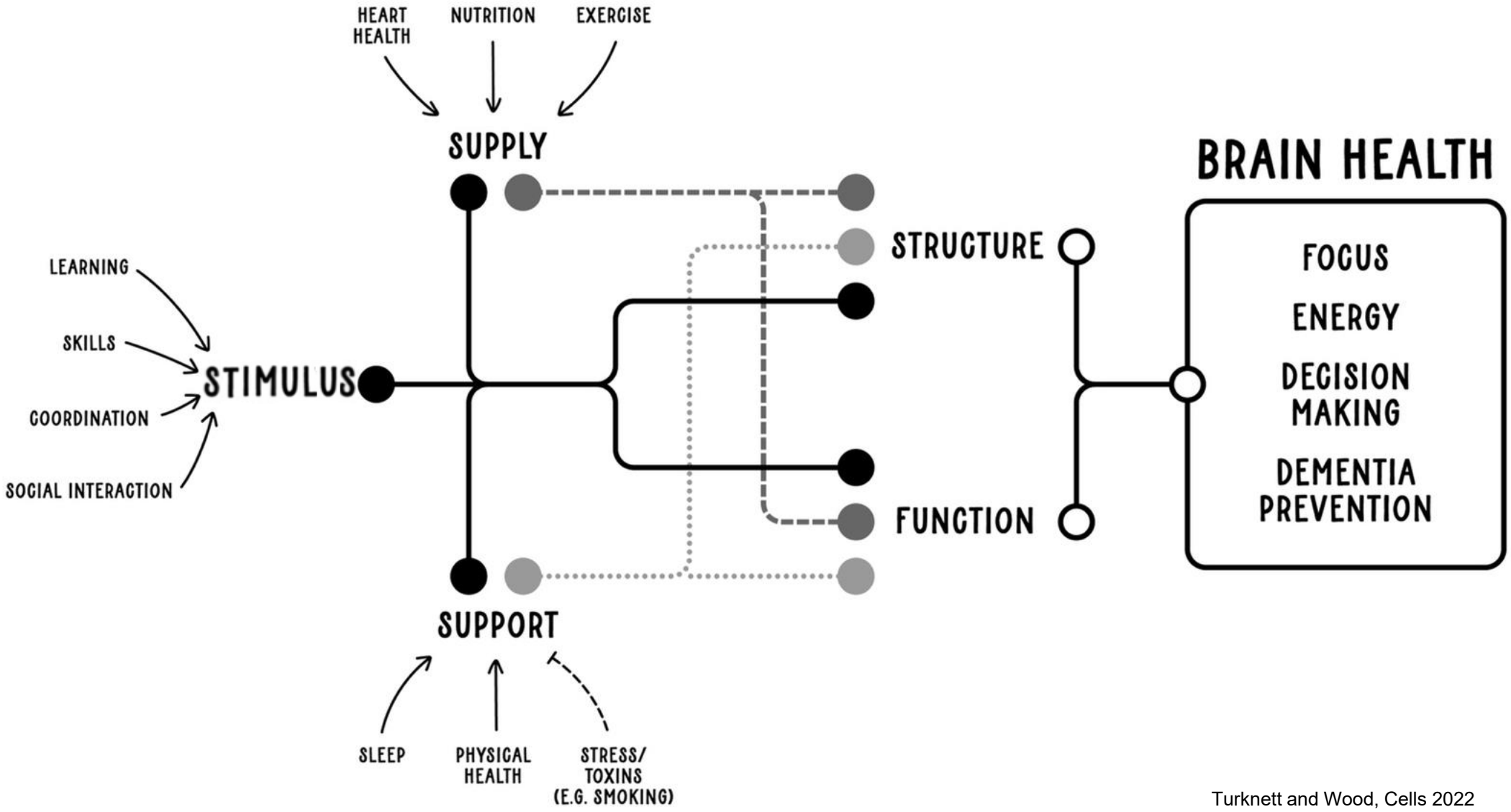



Turknett and Wood, Cells 2022

# Your brain is just like your muscles

- Multiple interacting factors for brain development
- Stimulus
  - Physical activity, cognitive, and social activity
- Supply
  - Vascular health and nutrient status
- Support
  - Sleep, stress, avoiding toxic exposures

# My model of brain function




Turknett and Wood, Cells 2022
Credit: Alex Stewart, Derek & Eric Design Agency

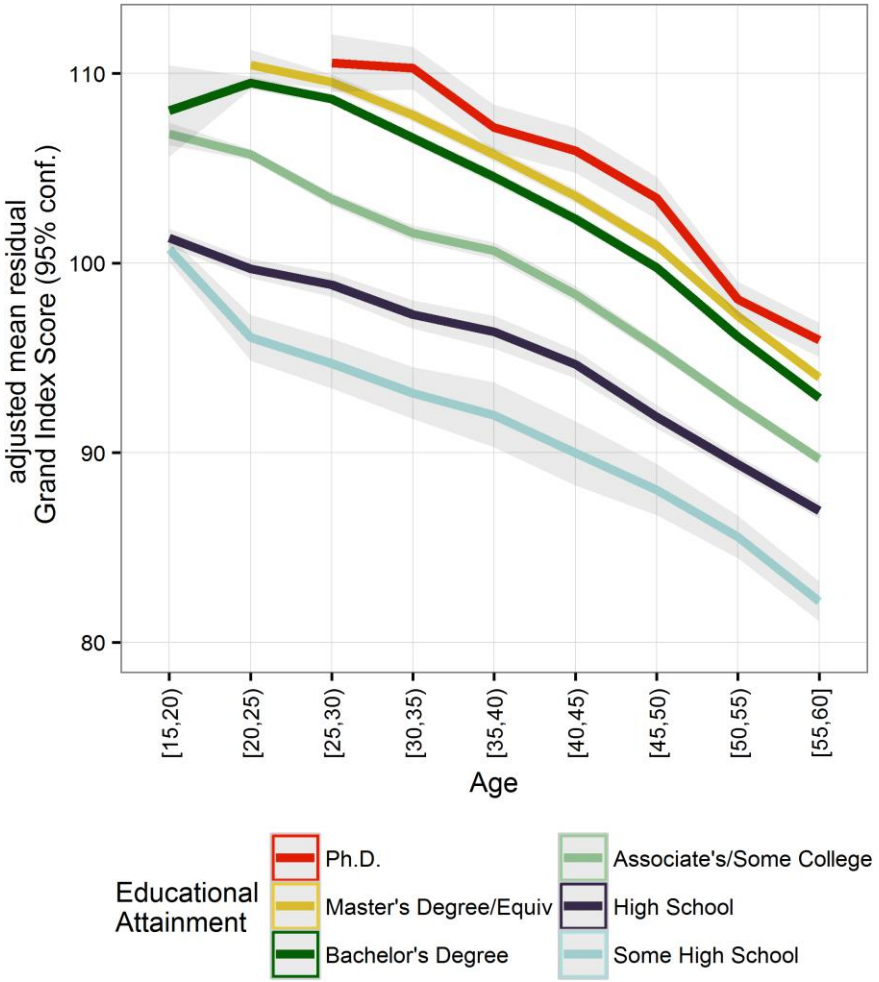
# Lifting weights for your brain

- Brain function is driven by learning new things
  - Adapting to the environment

- Complex skill learning improves cognitive function in kids
  - Languages
  - Music
  - Unstructured play
  - Sports
  - Video games

# Education shows the importance of stimulus

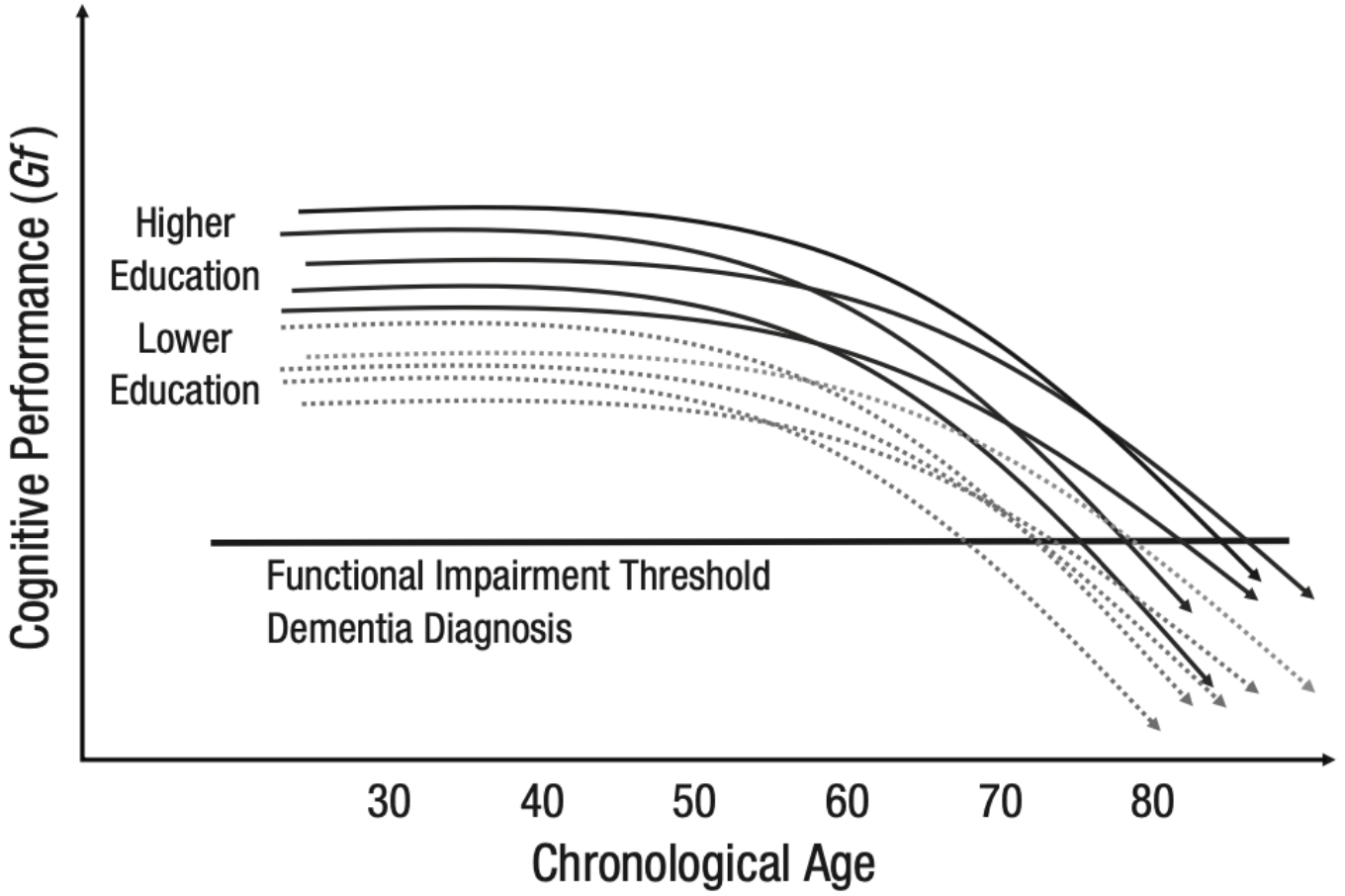
- Education and the peak and age of cognitive function


Guerra-Carrillo *et al.*, PLoS One 2017

# Education

- Greater cognitive stimulus for longer during childhood
  - Higher peak of cognitive function
  - Lasts your entire lifetime




Lövdén *et al.*, Psych Sci Pub Int 2020

# Music and the developing brain

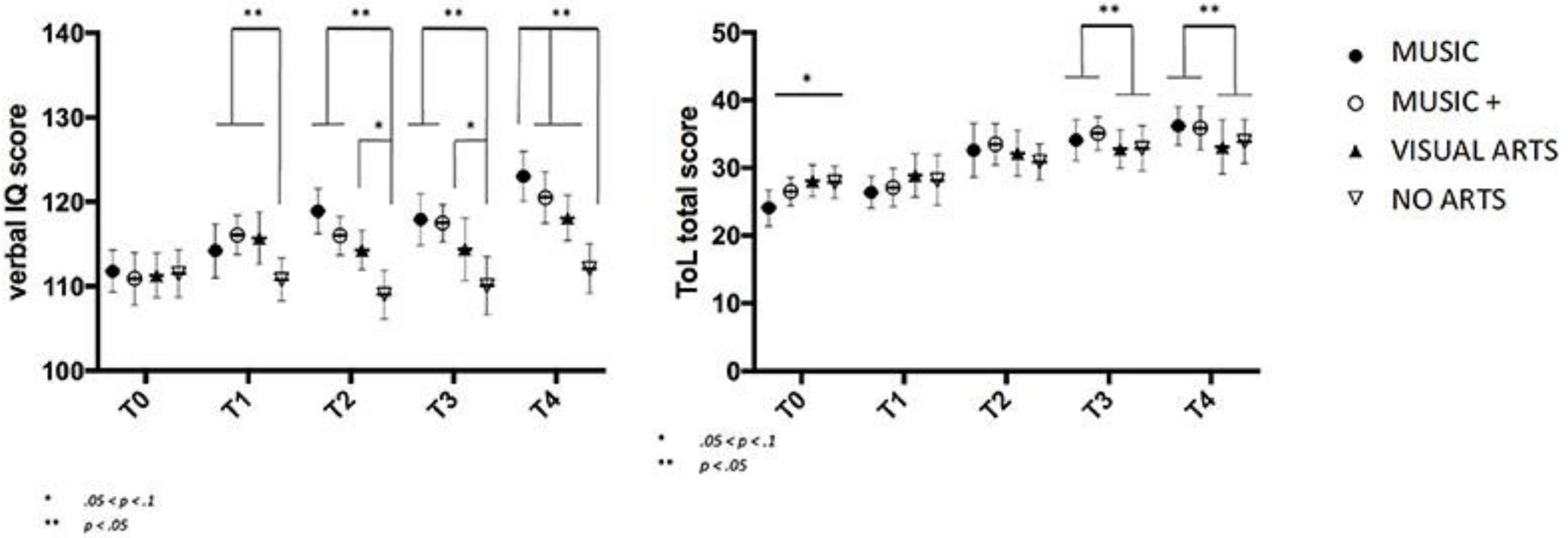
- Randomized studies show music lessons improve:
  - Working memory
  - Decision making
  - Cognitive flexibility

- Benefits all age groups
  - 3 year-olds up to young teens
  - May be better started earlier
  - Higher benefit in those who are less socioeconomically advantaged

Román-Caballero *et al*., Education Research Review 2022; Le *et al*., Frontiers in Psychology 2025

# Music in primary school children

- One hundred and forty-seven primary school children
- Four groups over 2.5 years
  - Control, art, and two music groups
  - 1–2 h lessons weekly. Collective music making, singing and improvising.




Jaschke *et al.*, Frontiers in Neuroscience 2018

# Languages and brain development

- Bilinguals often outperform monolinguals in executive function
  - Better inhibitory control
  - Split-second decision making
  - Due to the brain having to constantly control language output

- Recent report by the British Academy/UCL suggests foreign language learning can improve creativity

- Foreign language learning in childhood is associated with improved maths skills

Stocco *et al*. International Journal of Bilingualism 2012; Woll and Wei British Academy 2019; Nucett *et al*., Bilingualism: Language and Cognition 2024

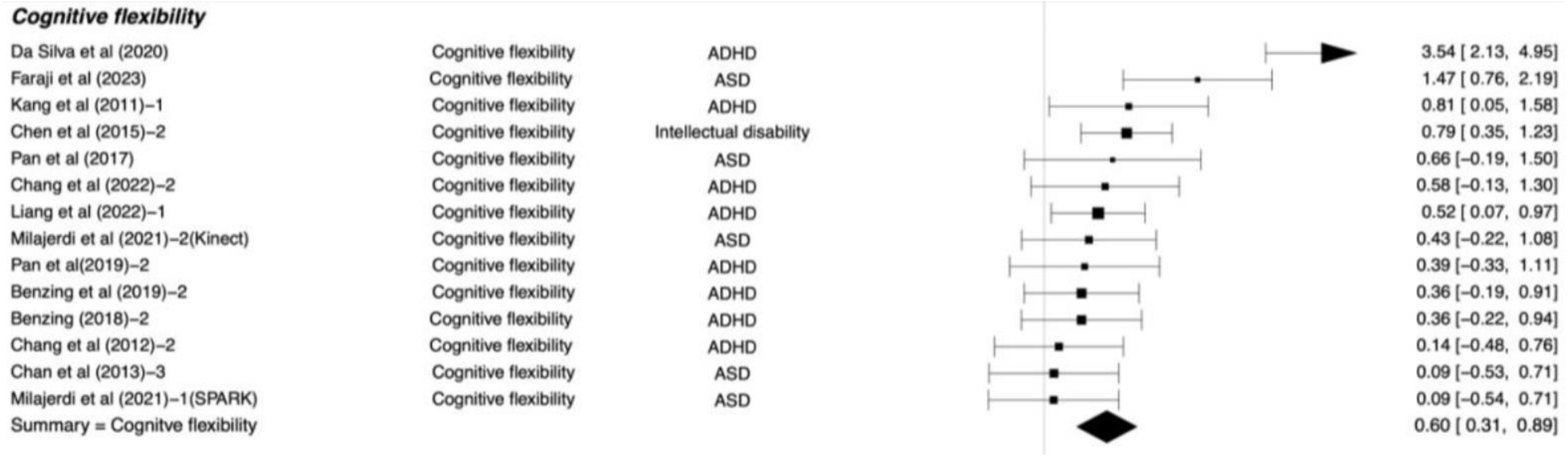
# Physical activity

- Multiple studies show that physical activity improves:
  - Focus/attention
  - Executive function
  - Academic performance
- Physical fitness and strength are associated with better academic performance
- Similar benefits seen in children with neurodevelopmental disorders
  - Dose-dependent effects

Educating the Student Body 2013; Robinson *et al*, Sports Med 2023; James *et al*., Children 2023; Liu et al., Preventive Medicine 2025

# Exercise in neurodevelopmental disorders

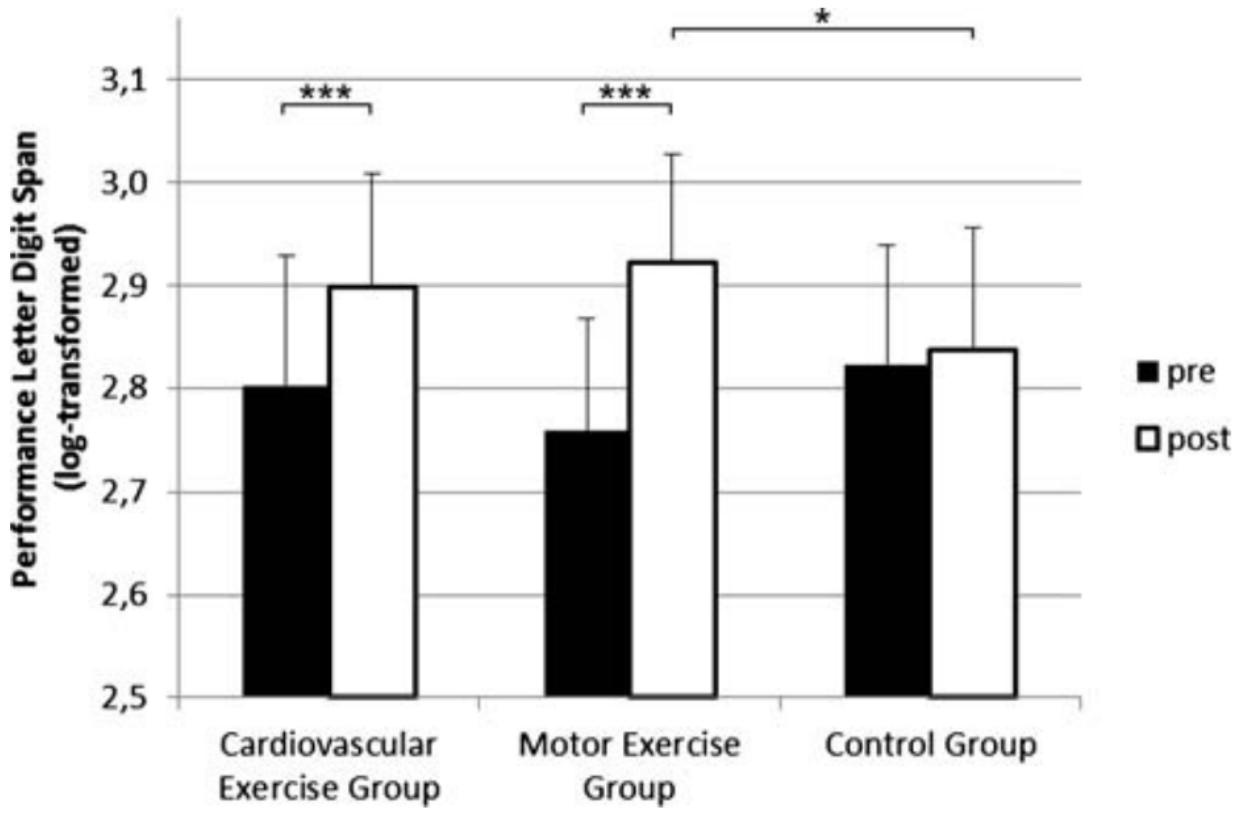
- Meta-analysis of 35 studies
  - Beneficial interventions included
    - Swimming
    - Racquet and ball sports (table tennis, football)
    - Running
    - Martial arts




Liu et al., Preventive Medicine 2025

# Exercise and focus/memory

- 9-10 year-old children
- Running vs complex skills
  - 45 minutes 3x per week for 10 weeks
    - Playful balance, coordination, ball games, skipping ropes etc




Koutsandréou *et al*. Med Sci Sports Exerc 2016

# Brain-boosting effect of coordinative exercise

- 12 males in their 20's-30's, cross-over study
  - 400m track with/without obstacles for 60 min
  - Pace constant to maintain similar exertion
  - Both types increased BDNF
    - Obstacles > Normal running

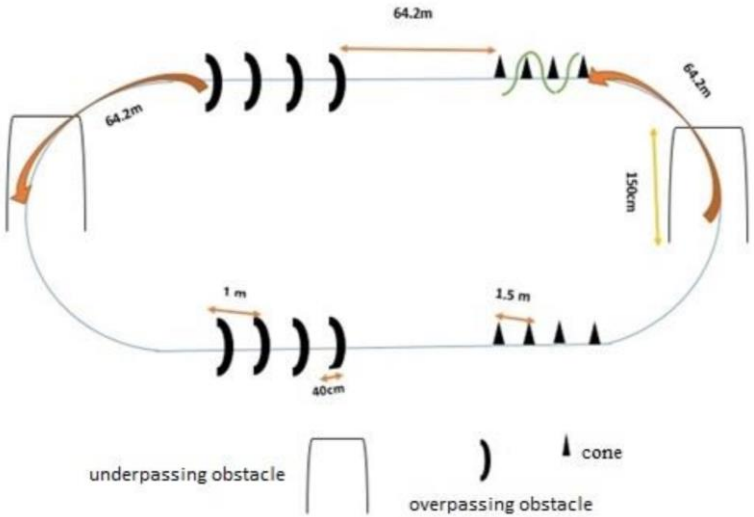



**Table 1.** Mean and SD of study variables in pre and post-time for normal and enriched environments.

| | Normal | | | Enriched | | |
|---|---|---|---|---|---|---|
| | Before 95% CI | After 95% CI | ES | Before 95% CI | After 95% CI | ES |
| BDNF (ng/ml) | 8.33 ± 0.71 [7.87-8.78] | 8.85 ± 0.71* [8.29-9.20] | 0.59 | 8.39 ± 0.64 [7.98-8.79] | 9.46 ± 0.71*¥ [9.01-9.91] | 1.60 |
| IGF-1 (ng/ml) | 333.06 ± 45.81 [303.95-362.16] | 338.82 ± 40.96* [312.79-364.84] | 0.13 | 341.30 ± 37.95 [317.19-365.41 | 379 ± 31.96*¥ [359.25-399.86] | 1.09 |
| VEGF (ng/ml) | 121.91 ± 25.97 [105.41-138.41] | 131.41 ± 25.81* [115.01-147.80] | 0.37 | 130.91 ± 28.48 [112.81-149.00] | 168.03 ± 29.31*¥ [149.41-186.65] | 1.28 |

* Significantly different from pre-intervention ($p \leq 0.001$).
¥s Significantly different from normal environment ($p \leq 0.001$).

Bahramnejad *et al*. IJES 2023

# The importance of play and risk

- Increasing mental health problems in children
  - Inability to deal with stressful situations
  - Decreased outdoor/adventurous play and increased indoor time

- Outdoor/adventurous play associated with
  - Less anxiety and fear
  - Better mental health during Covid-19 lockdown

- Increased ”risky” play improves a kid’s ability to assess risk

- Restrictive parenting increases risk-seeking behavior later

Dodd *et al*. Child Psych Hum Dev 2022; Loebach et al., J Outdoor Envir Educ 2023; Hansen and Breivik, Personality and Individual Differences 2001

# Risk ≠ Danger

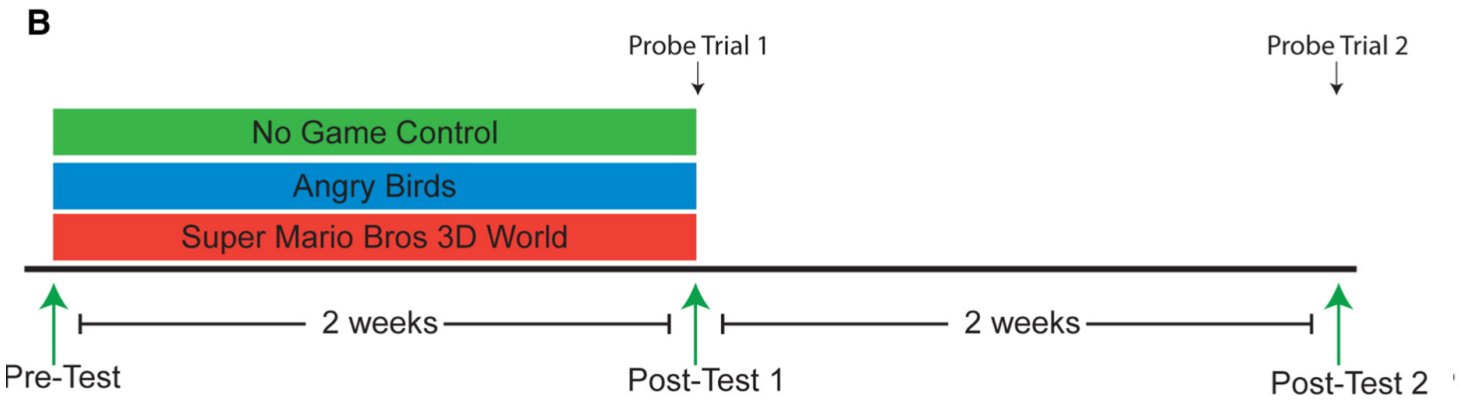
- Beneficial risky play
  - Play with heights or high speed (climbing, running, jumping)
  - Rough-and-tumble play
  - Risk of getting lost (within reason)

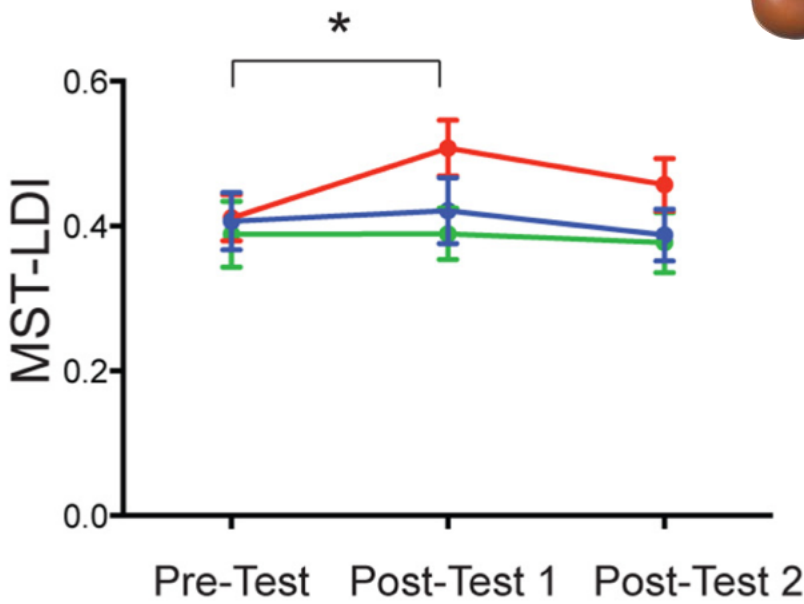
- Principles of beneficial risky play
  - Attempting things above current skill level
  - Requires concentration and determination
  - Requires control and thought to prevent injury
  - Failure comes with a risk of minor injury

# Are video games good for your brain??

- Large US study of 2,217 9-10 year-old children
  - Gamers (~3h per day) vs non-gamers (0h per day)
  - Gamers had slightly better reaction times and decision making

- Several studies in adults show benefit of computer games
  - Complex movement/puzzle solving in new environments
  - Usually Super Mario




Charaani *et al*. JAMA Network Open 2022; Clemson and Stark, J Neurosci 2105

# Video games in context

- Video games can be a beneficial stimulus for the brain

- As long as it doesn't prevent you doing other important things:
  - Eating a nutritious diet
  - Sleep
  - Learning
  - Time outside
  - Doing physical activity/sports
    - Replacing physical activity with screen time increases depression risk
  - Spending time with *real* people

# The importance of recovery

- Recovery and sleep is how you get stronger and smarter

- Sleep is when:
  - You save memories
  - The brain makes new connections
  - Your brain cleans itself

- Sleep deprivation results in:
  - Lower cognitive function
  - Decreased empathy
  - More negative emotional responses
  - Impaired decision making

# Sleep and academic performance

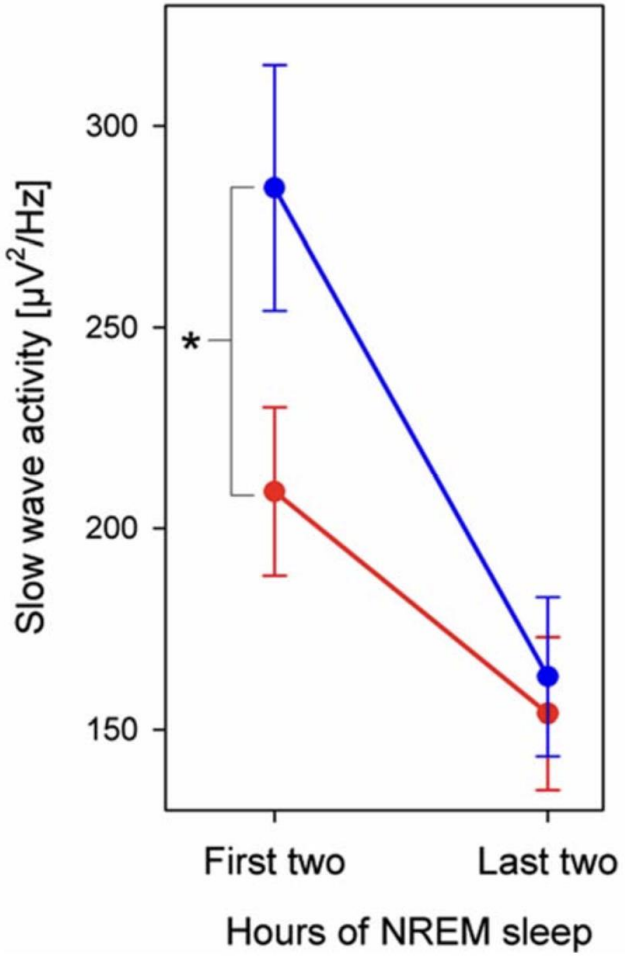
- Seattle Sleepmore study
  - All schools started an hour later
  - Kids slept 34 minutes longer on average
  - 4.5% Higher grades
  - Higher attendance and more graduates

- Two important factors for sleep in children/teens
  - Caffeine
  - Screen time
  - Both also relevant to adults(!)

# Caffeine

- Children who consume caffeine sleep less well
  - Study of 10-16 year-olds
  - Caffeine consumers:
    - Fall asleep ~1 hour later
    - Spend an hour less in bed
    - Get less deep sleep

- Afternoon caffeine impairs sleep
  - Last strong coffee ~12h before bed
  - Last Coca-cola ~8-9h before bed
  - Small amounts of caffeine in tea is OK

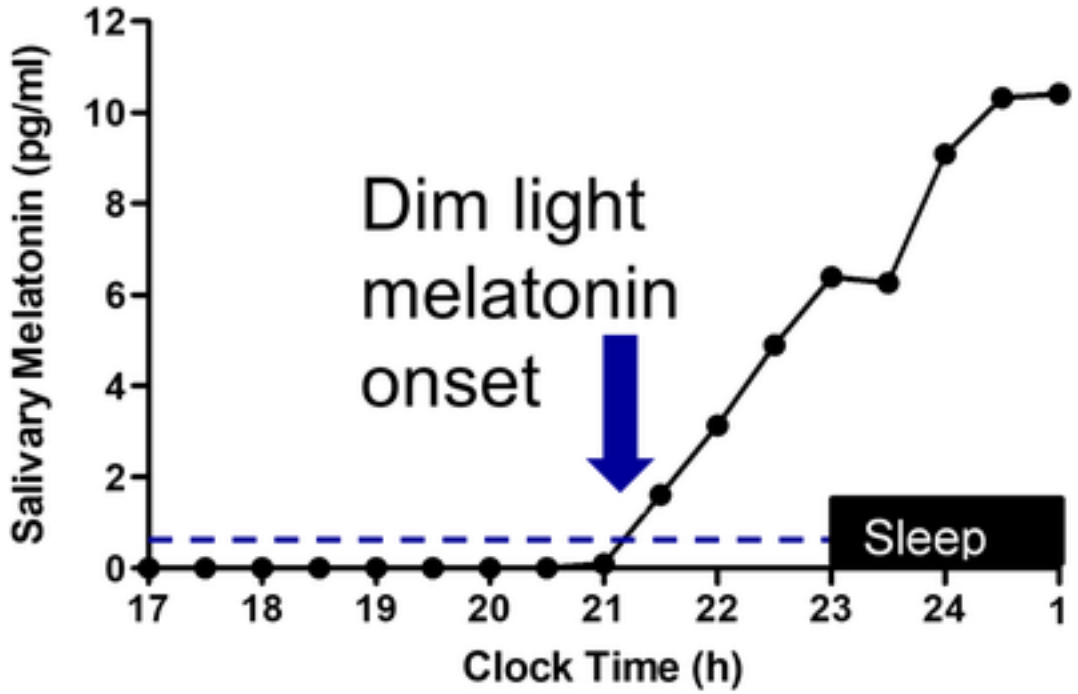



Aepli *et al*. Brain Scinces 2015; Gardiner et ali., Sleep Medicine Reviews 2023

# Screens

- Sleep is initiated by the hormone melatonin
  - Starts to increase ~2h before sleep

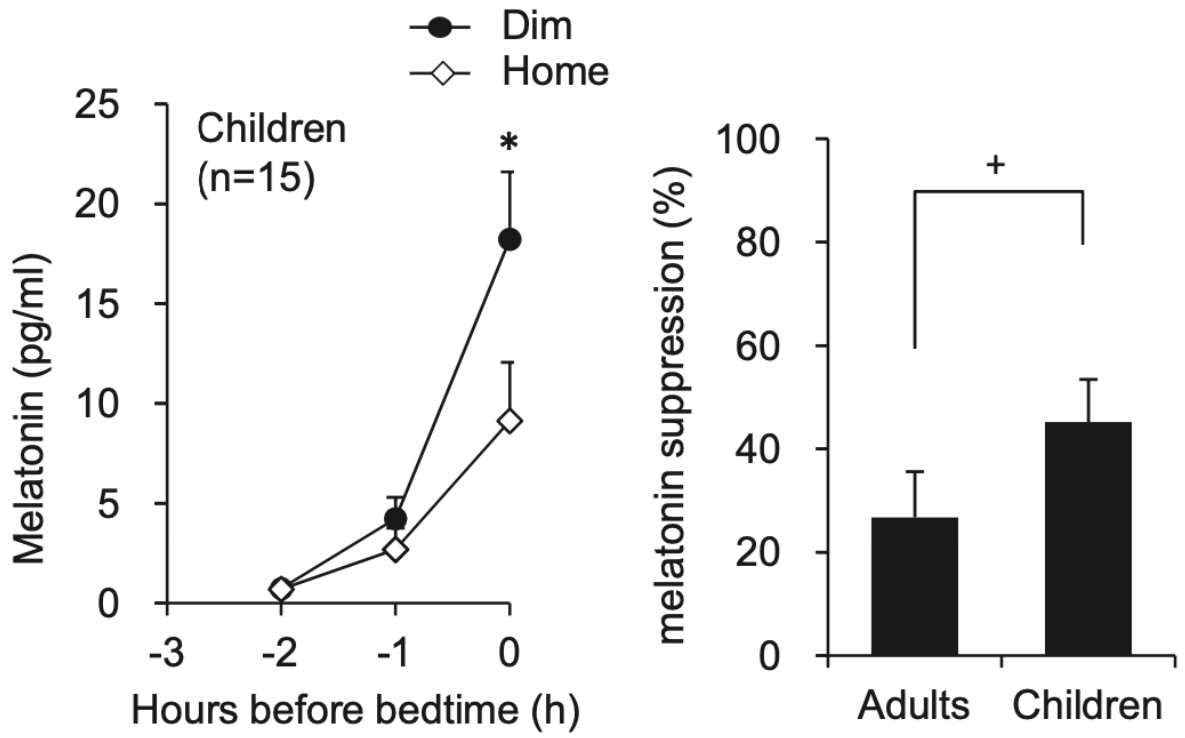
- Melatonin production is decreased by bright light




Klerman *et al*. Clin Transl Med 2022

# Melatonin in children

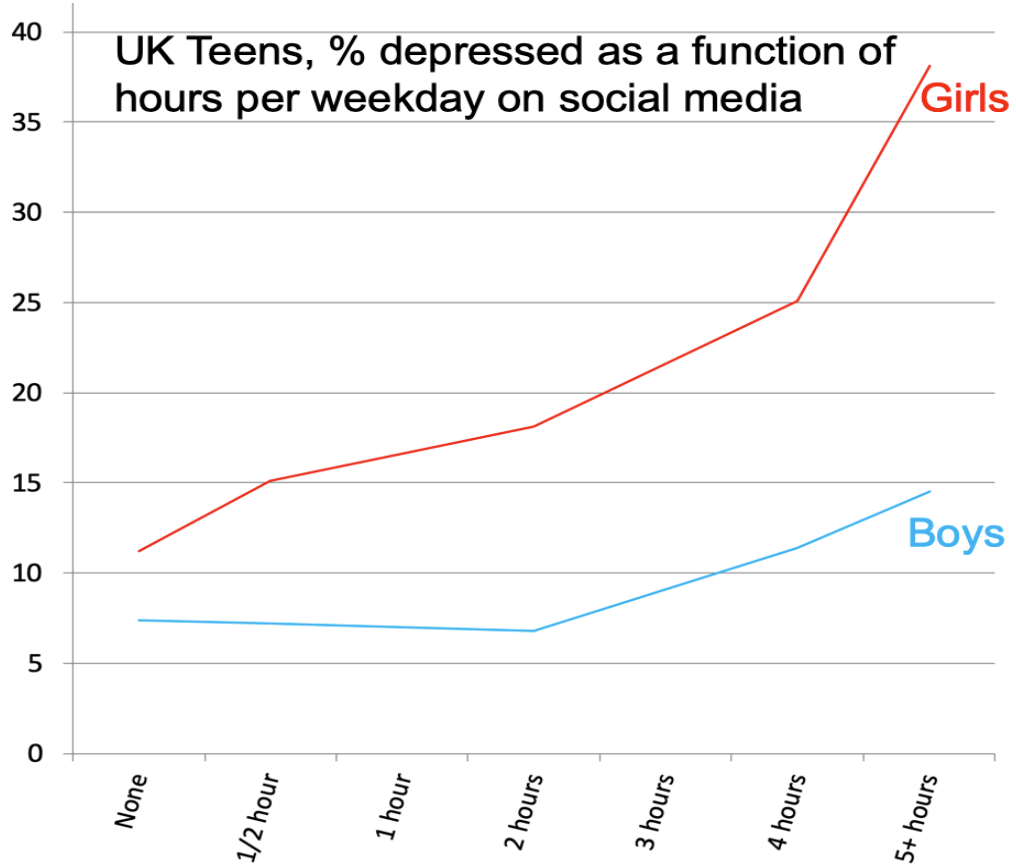
- Children are much more susceptible to light than adults
  - 9-10 years-old children have about twice the melatonin suppression
  - Minimise bright overhead lights in the evening
  - Stop screens at least 1-2h before you want to fall asleep




Higuchi *et al*. J Clin Endocrinol Metab 2014

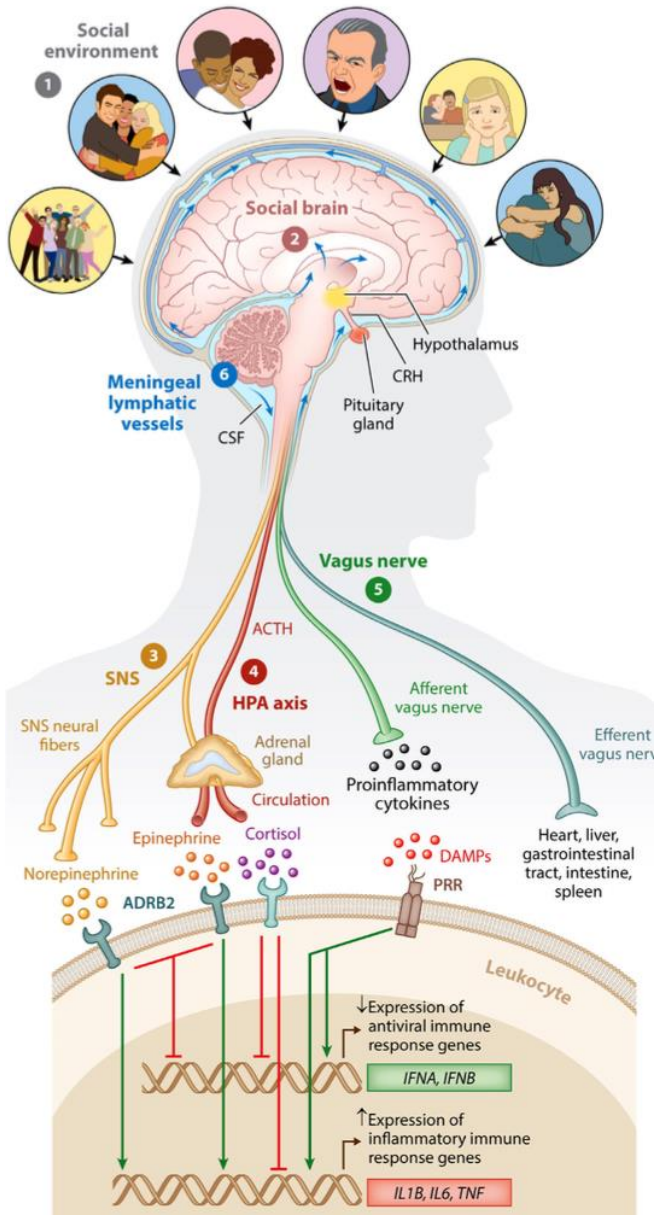
# Social media – the opposite of rest

- Increasing social media use is associated with higher depression
  - Greater risk in girls
  - Many schools banning smartphones




Social Median and Mental Health: Haidt, Lausch and Twenge

# Social media can drive stress




- We've evolved to be social animals
- Loneliness causes stress/inflammation
  - Survival response
- Similar response to "social stress"
  - Being left out
  - Being bullied
  - Seeing people who are "better" than you

Slavich et al., Lifestyle Medicine 2022

# Active bodies and minds

- Function of the brain is driven by learning and challenge

- Critical to provide children with a variety of demanding stimuli
  - Music
  - Languages
  - Physical activity (especially with a coordinative component)
  - Social interaction
  - Play and risk taking
    - The developing brain will go looking for limits if they are denied

- Support stimulus with adequate rest and recovery

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