

# How Early Experiences Affect Brain Development

Dimitri Christakis, MD MPH  
George Adkins Professor of Pediatrics  
University of WA  
Director, Center for Child Health,  
Behavior & Development  
Seattle Children's Research Institute

# My Lab's Mission

*To determine modifiable factors in children's early environment that can positively impact their cognitive, social, and emotional development and to develop actionable strategies to optimize them*

Digital Native

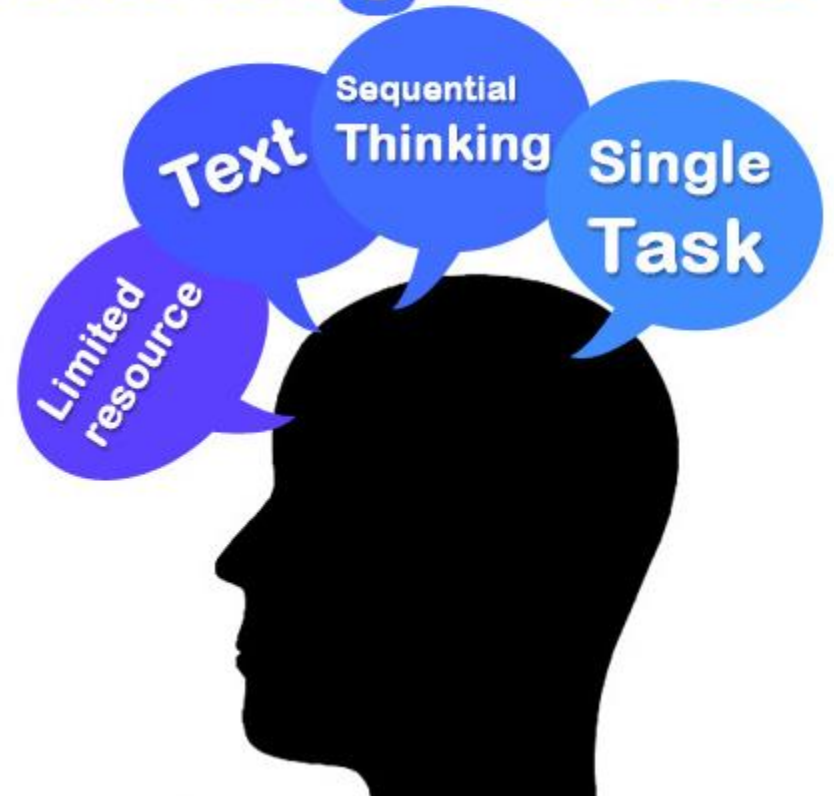


Digital Immigrant



# Digital Native

# Digital Immigrants



# Three Concurrent Phenomena of Early Childhood

- Brain Growth
- Executive Function Development
- Media Exposure

# Brain Growth





**Newborn  
Brain**

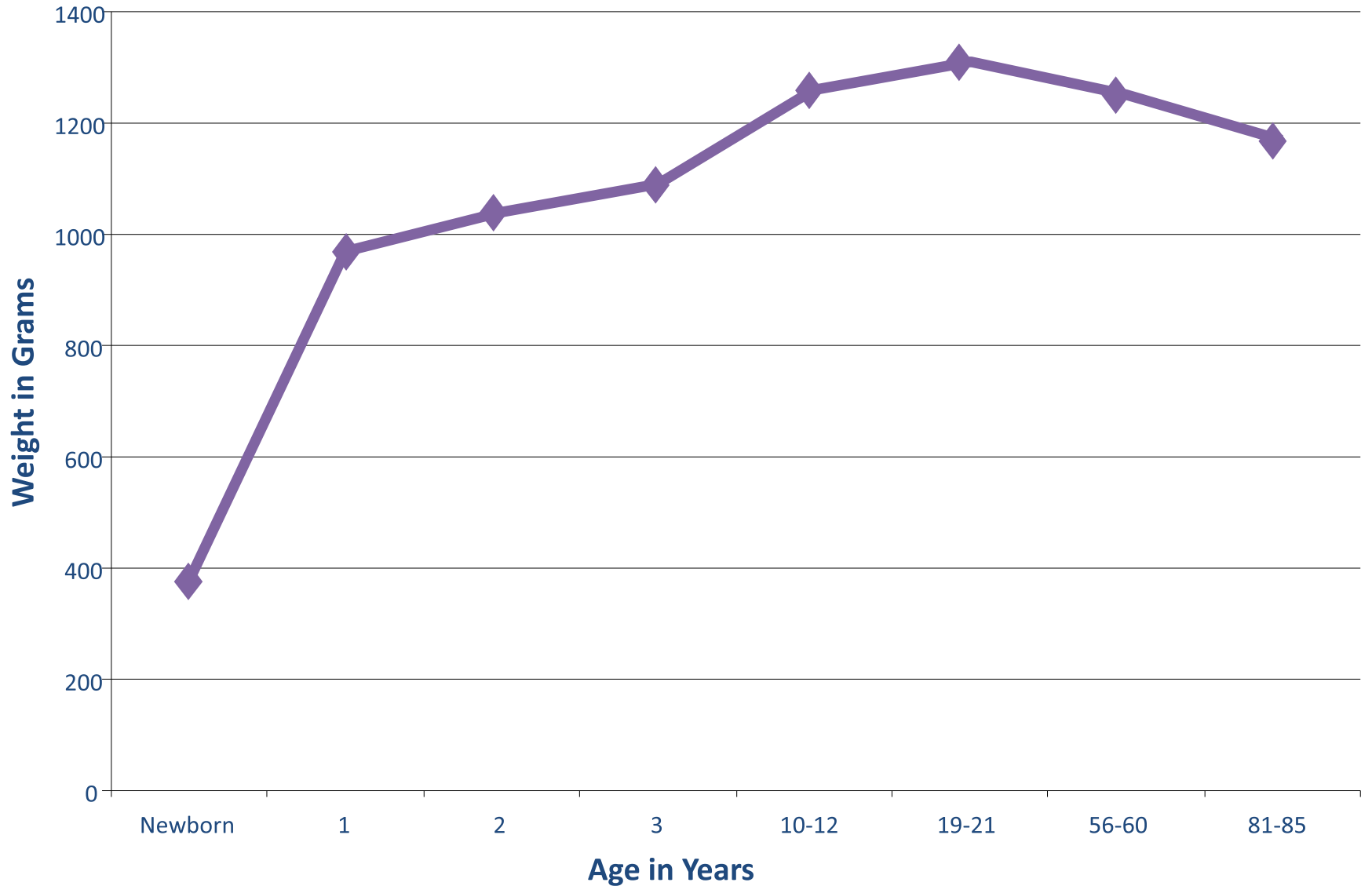
Average weight  
333 grams



**2 Year Old's  
Brain**

Average weight  
999 grams

# Brain Growth over the Lifespan





Born with  
lifetime supply  
of neurons

**Birth**

Synapses form  
based on early  
experiences

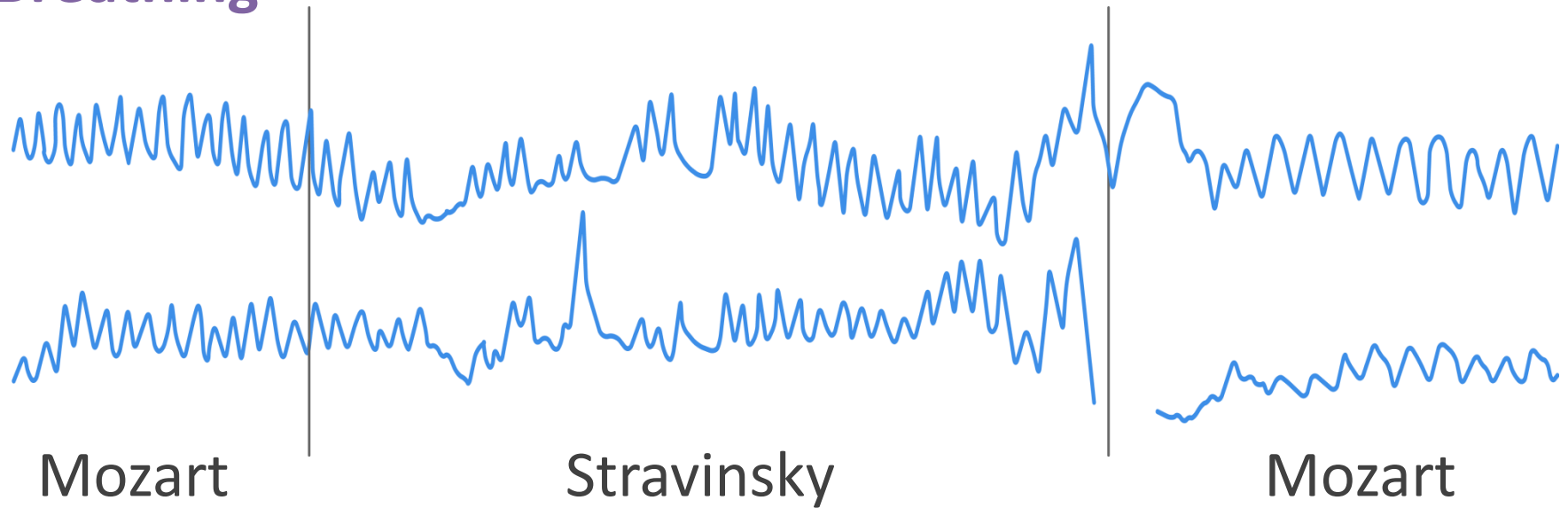
**3 Years**

Mind is fine  
tuned  
to the world  
children inhabit

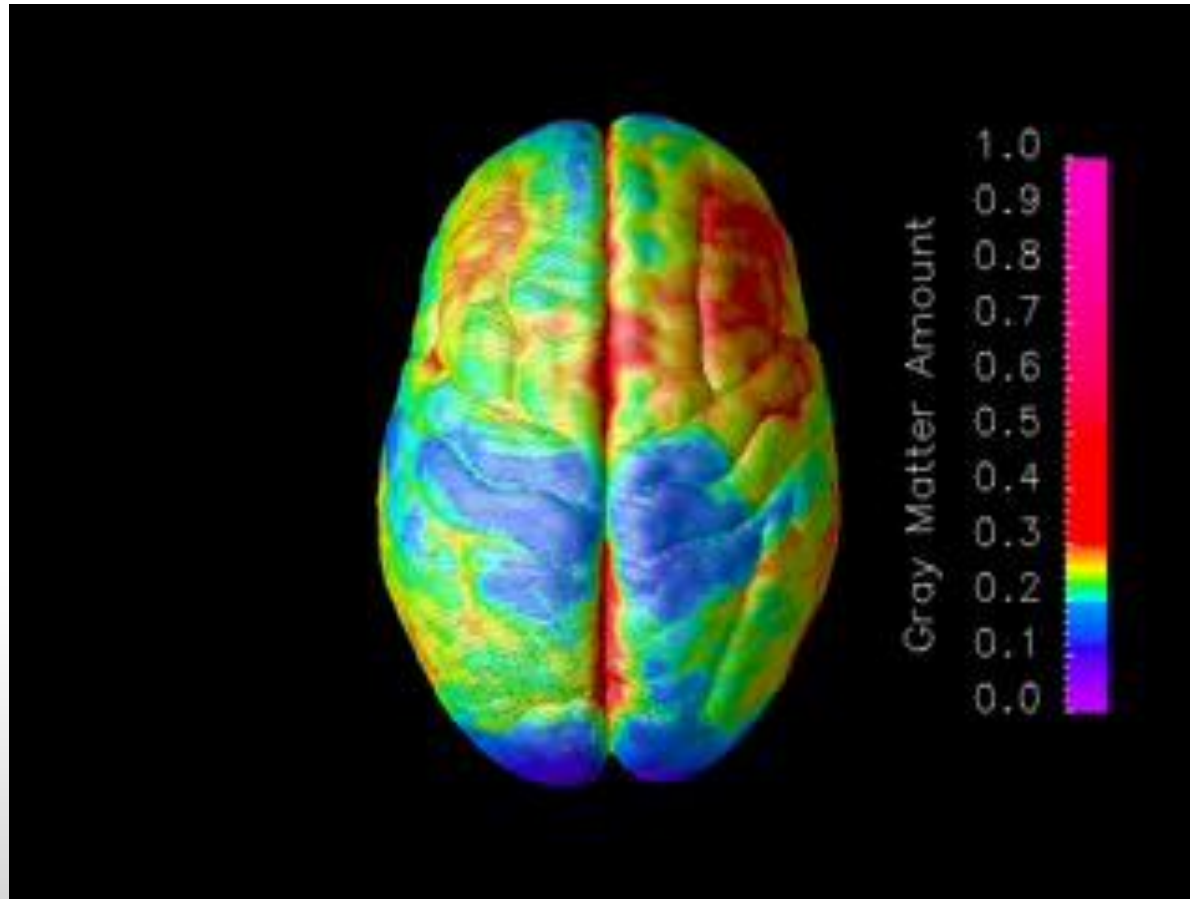
**15 Years**

# Breathing of a one day old infant listening to music

Breathing



# Brain Development– Child to Adult



**Early Childhood to Adult**

Abstract thought,  
reasoning, judgement,  
Regulation of emotion



frontal lobe

**4 months**

Sensory & motor  
integration  
Inhibition of primitive  
reflexes



parietal lobe

**Birth**

Audio &  
Visual  
Processing



occipital  
lobe

**Birth**

Smooth  
movements  
Coordination



cerebellum

**Birth**

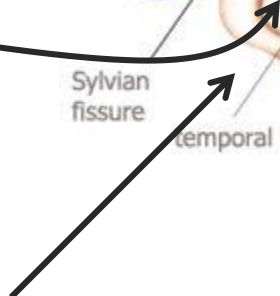
Vital  
functions  
Swallowing



pons

**18-24 months**

Processing  
Sound &  
Language



temporal lobe

**10-12 Months**

Limbic System  
(deep)  
Emotions



Sylvian  
fissure

central sulcus

frontal lobe

parietal lobe

occipital  
lobe

Sylvian  
fissure

temporal lobe

pons

medulla

cerebellum

frontal lobe

central sulcus

parietal lobe

occipital  
lobe

Sylvian  
fissure

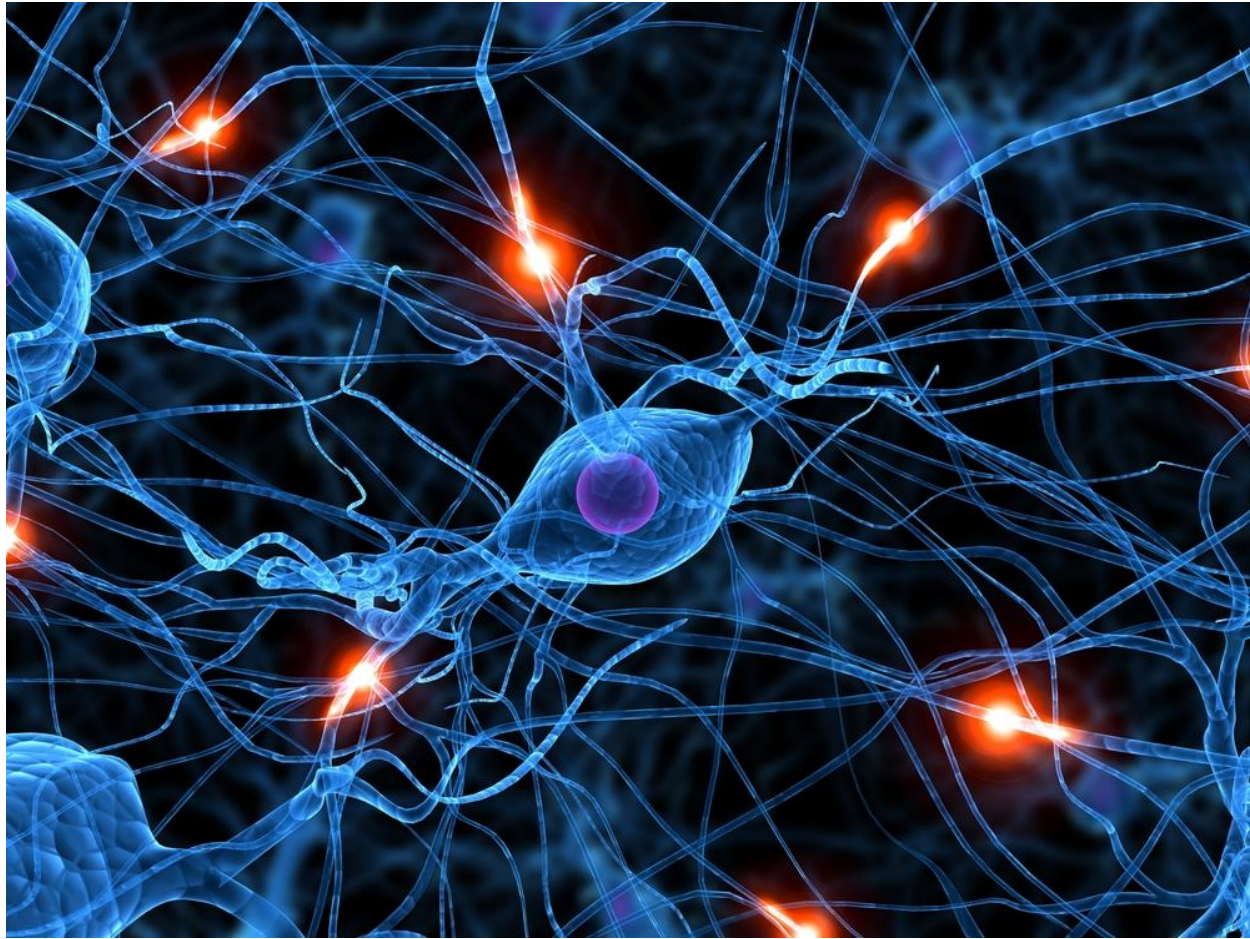
temporal lobe

pons

medulla

cerebellum

# Executive Function



# Three Components



## **Self-Control**

The ability to stay focused and resist temptation



## **Working Memory**

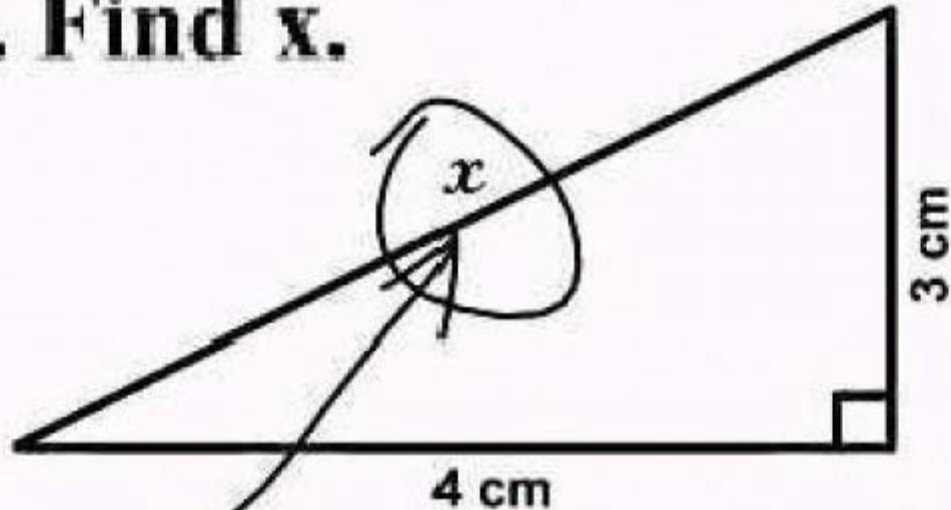
The ability to hold information in mind while mentally working with it



## **Cognitive Flexibility**

The ability to apply something learned in one context to another and to modify it accordingly

3. Find  $x$ .



*Here it is*

# SIMPLICITY

The simplest solutions are often the cleverest  
They are also usually wrong

# Stanford Marshmallow Test

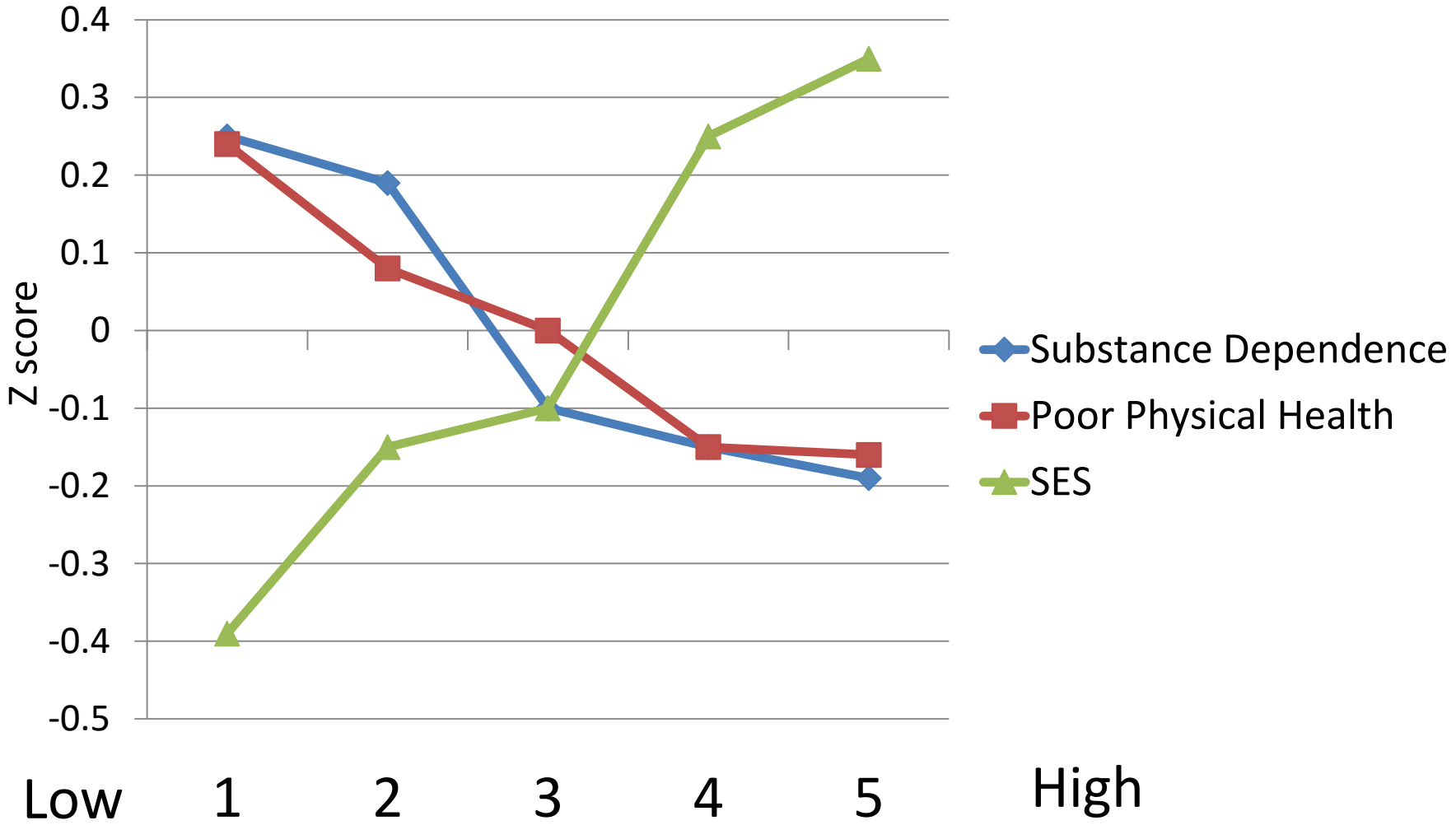




# Moffitt et al– PNAS 2011

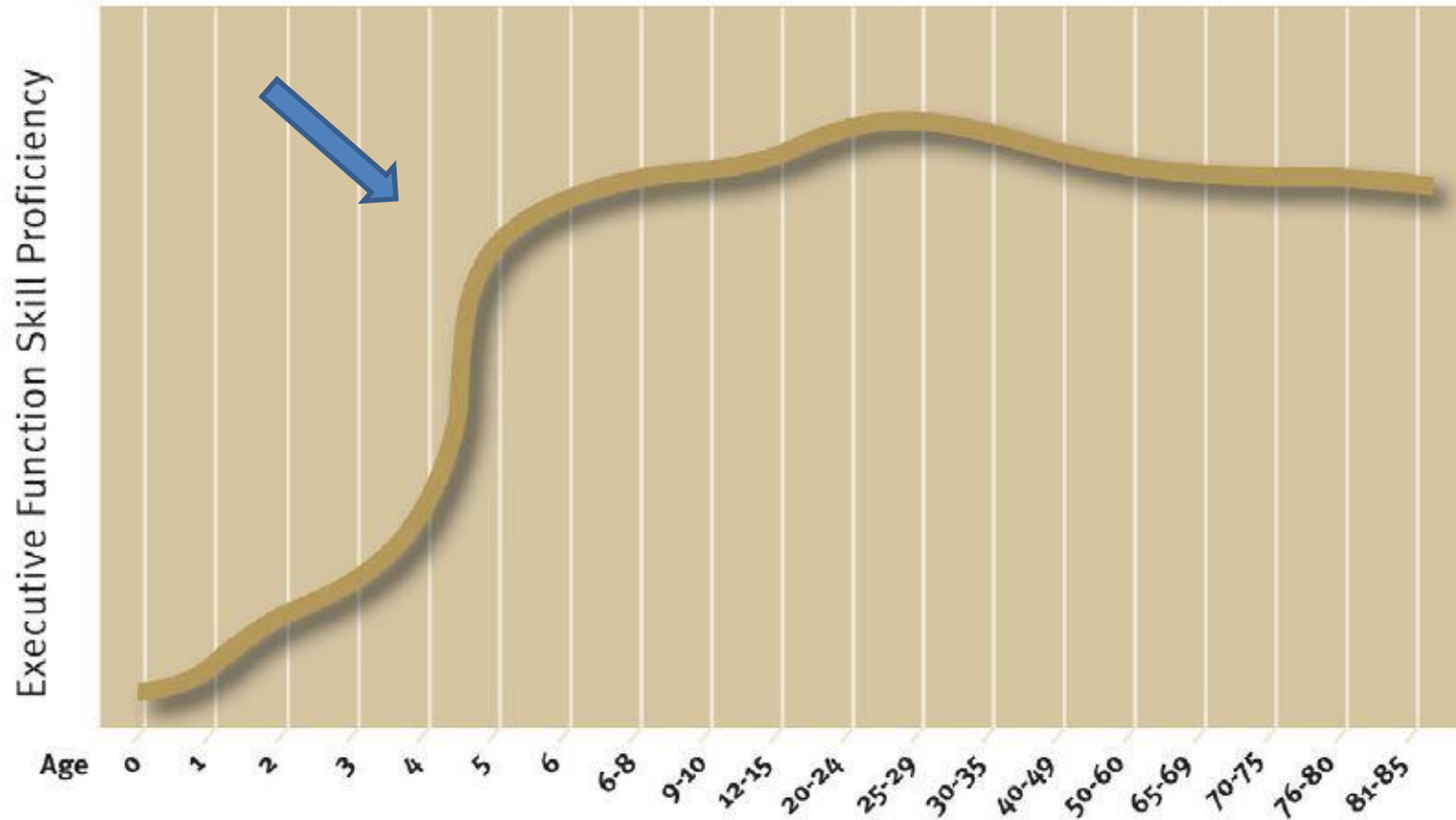
- Dunedin longitudinal data
- 1000 children followed from birth to 30 years
- Observational but very well controlled
- Excellent follow-up

# Adult Health Outcome



Childhood Self-control in Quintiles

## Executive Function Skills Build Into the Early Adult Years

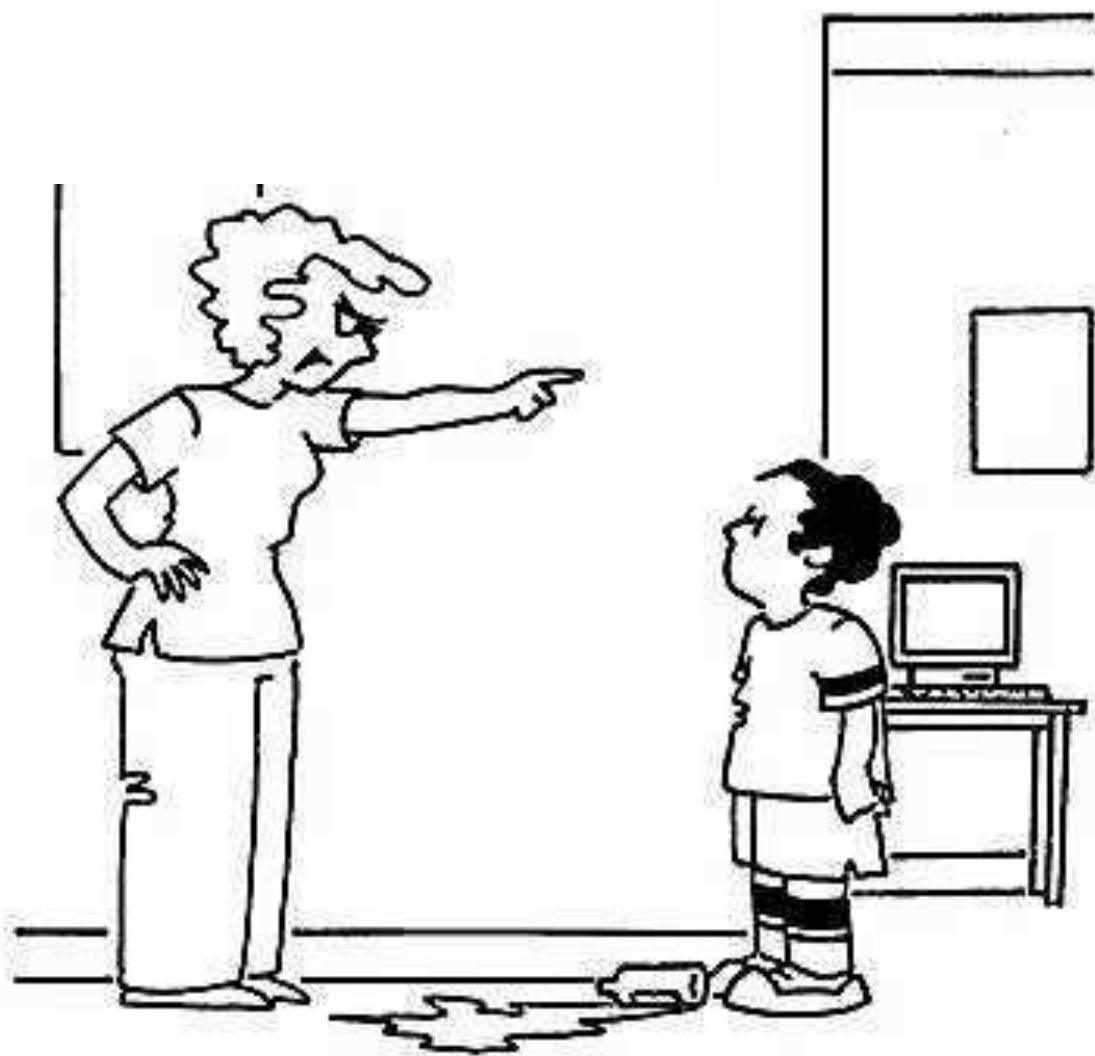


Center on the Developing Child at Harvard University (2011).



# Media Exposure





"Go to your chat room!"

# Technologizing Childhood

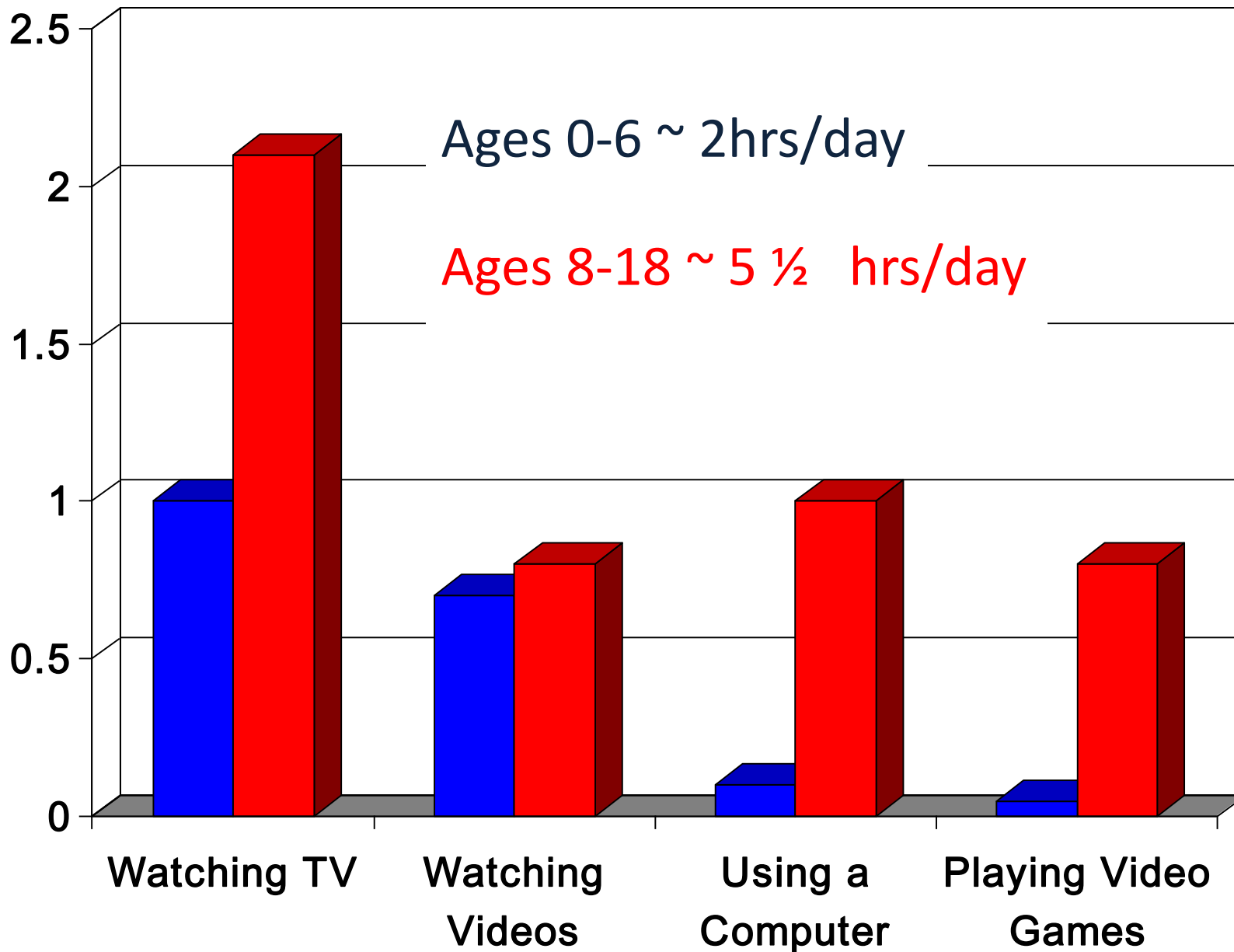
1970



Today

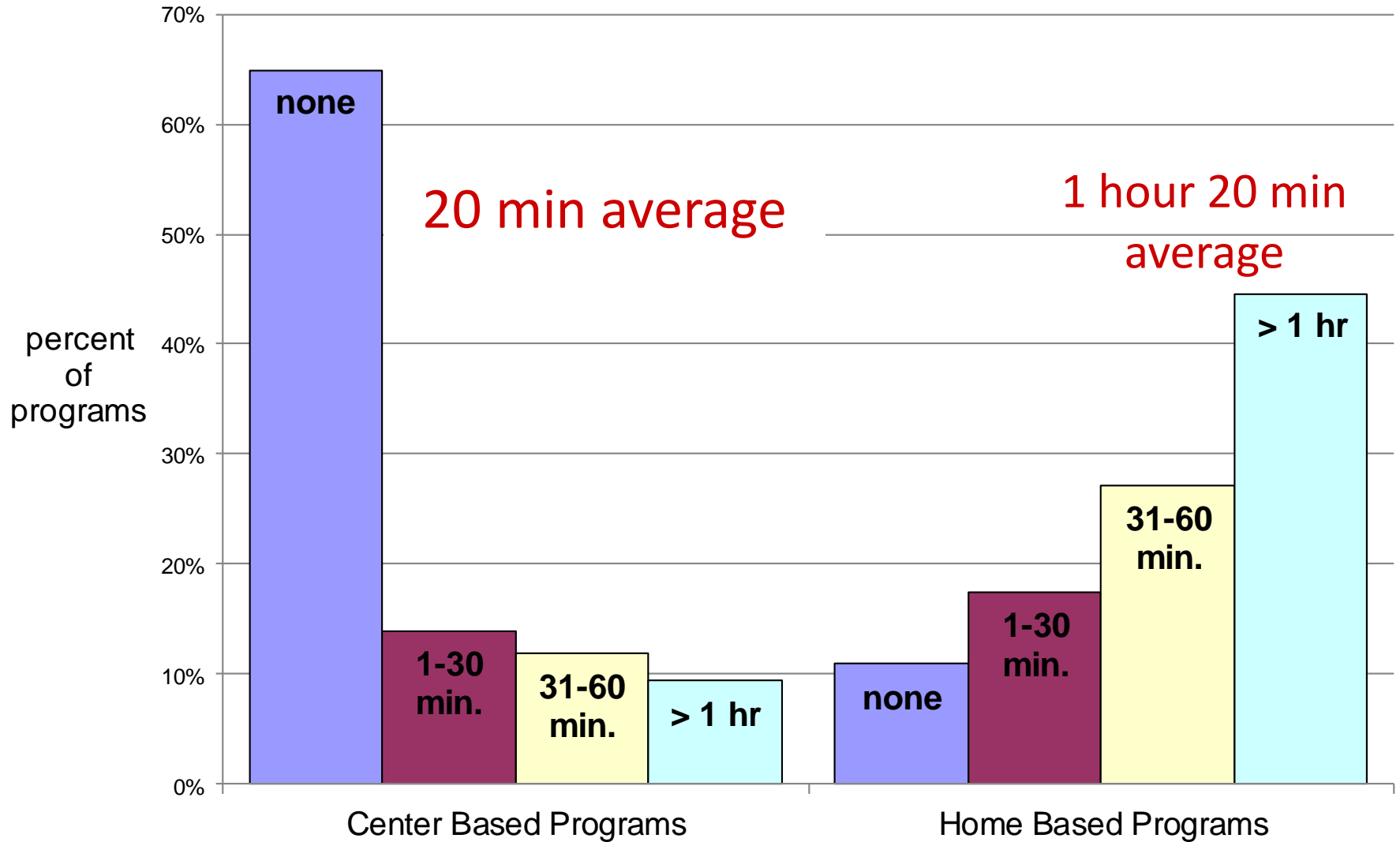


# Children's Daily Media Usage

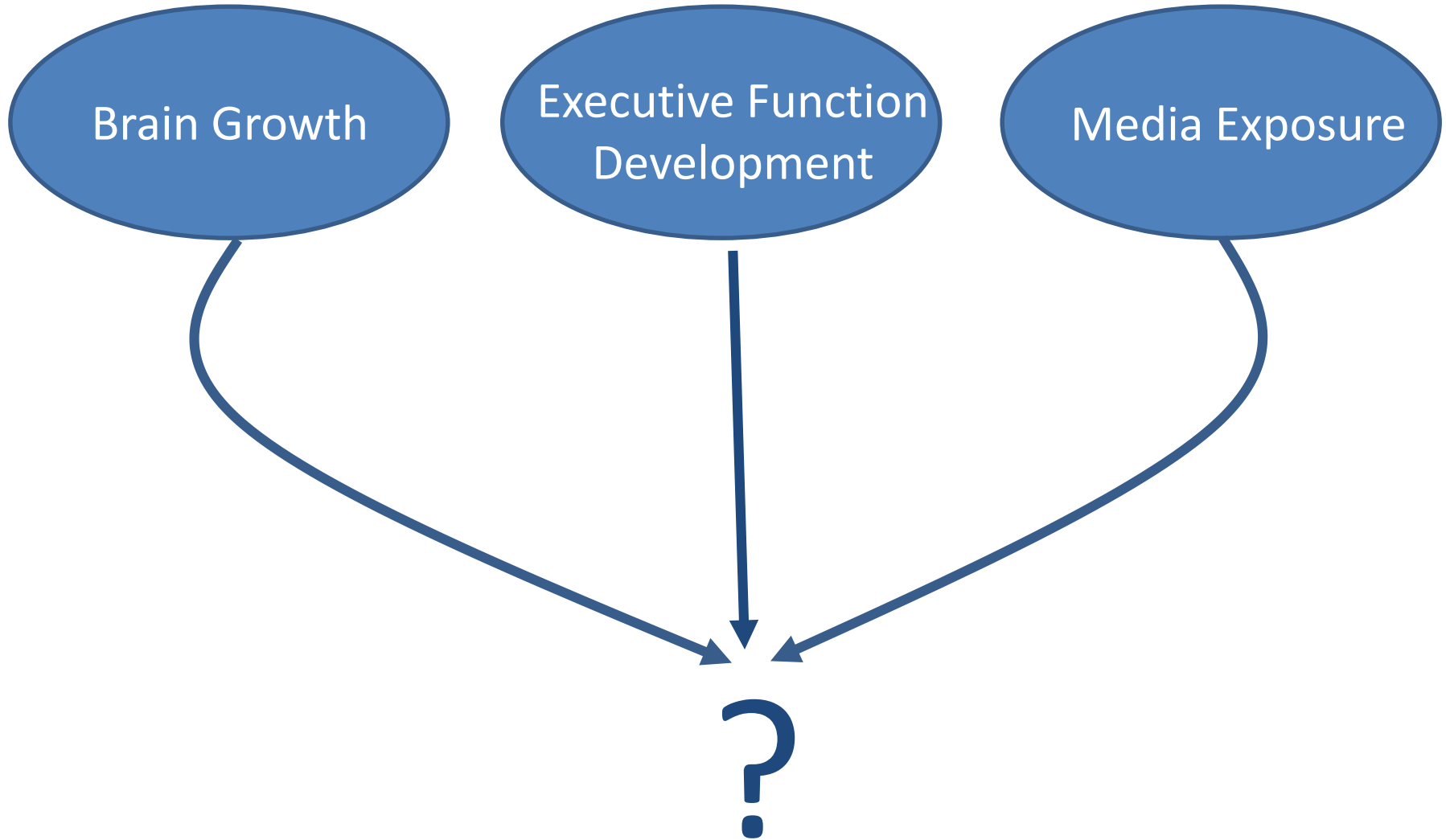




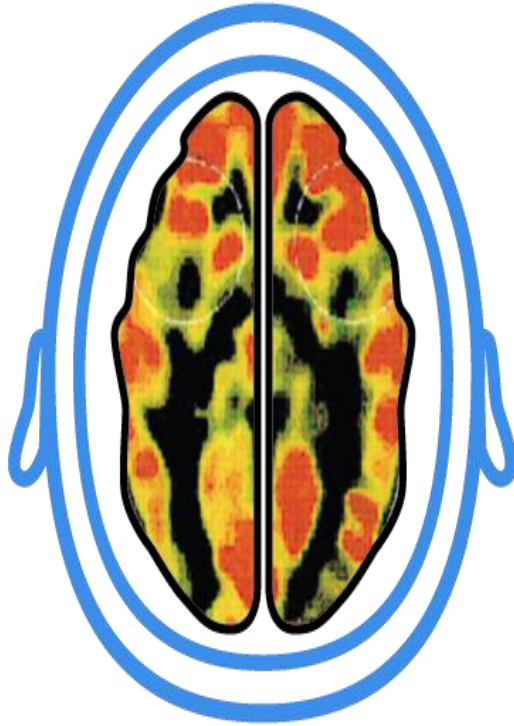
# TV viewing in childcare settings



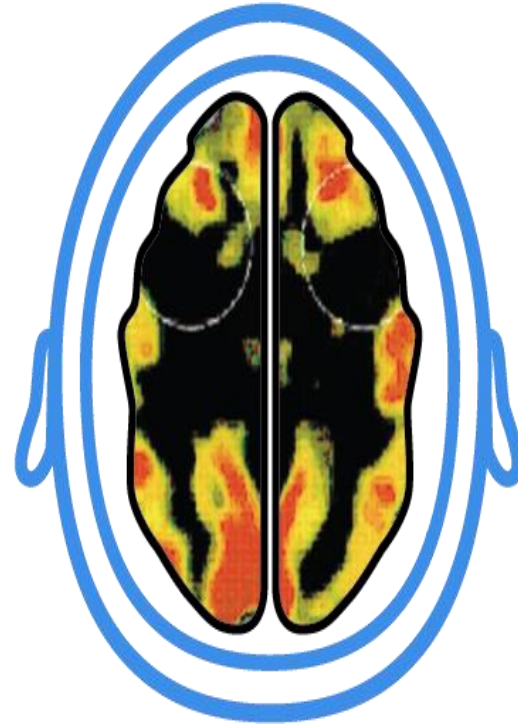
# Three Concurrent Phenomena



# Too Little Stimulation Is Bad But What About Too Much?



**Normal**

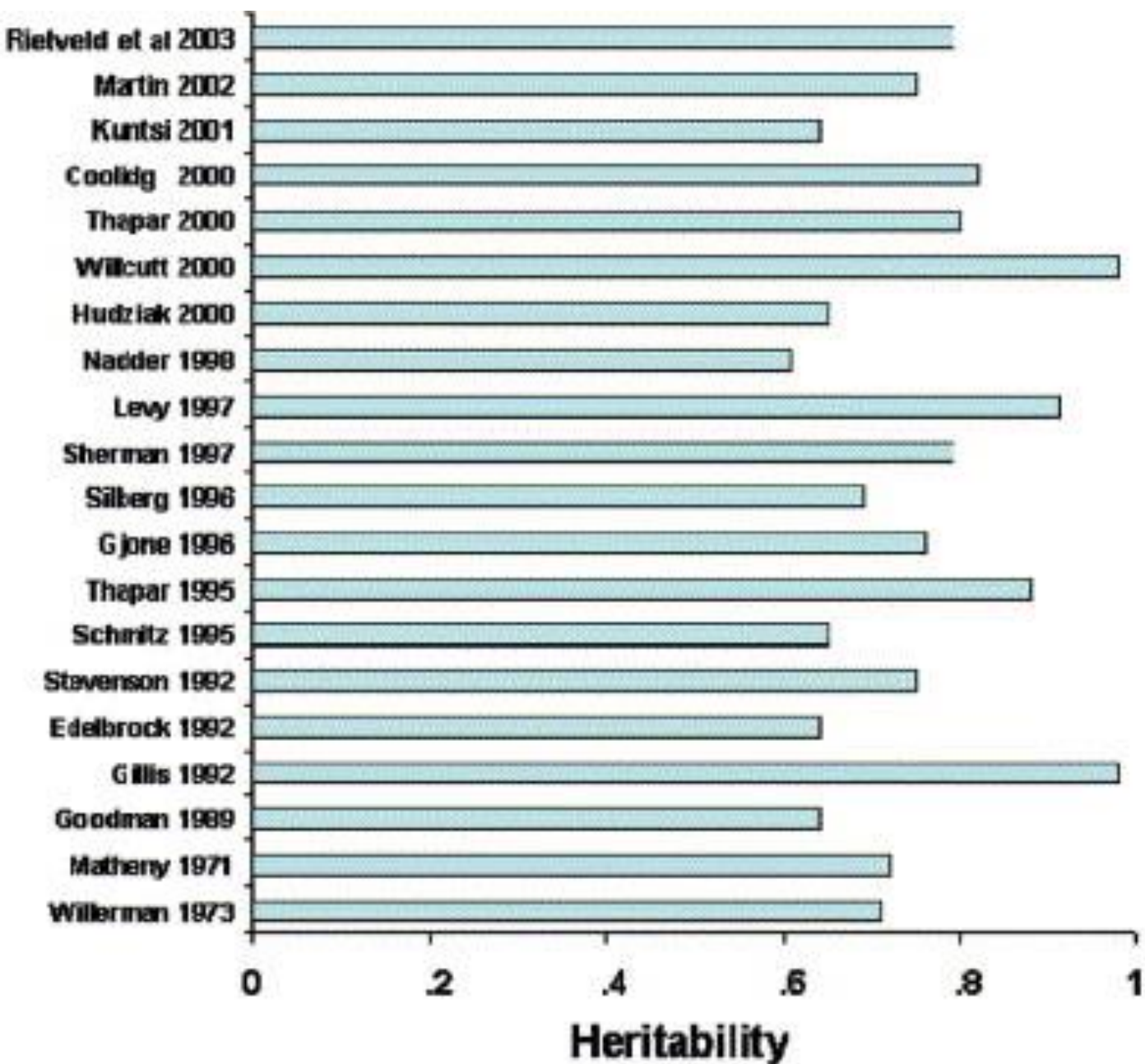


**Sensory-Deprived**



# “Rise” of ADHD

- Characterized by impulsivity, inattention, hyperactivity (ie ↓EF)
- ~10% US Children
- 30% more common today than 20 years ago



**Heritability around 75%**

# GENES

## Dopamine

SLC6A3/DAT1

DRD5 DRD4

## Noradrenaline

SLC6A2/NET

ADRA2C ADRA2A

## Serotonin

SLC6A4/5HTT

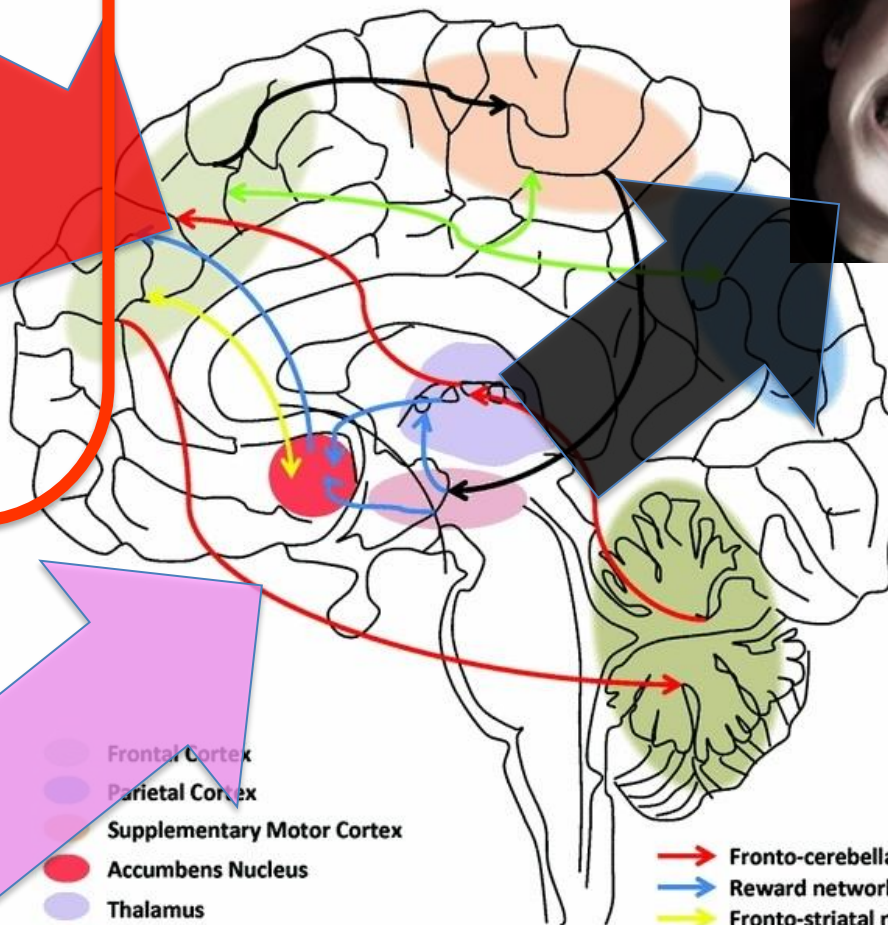
TPH-2 HTR1B

(Nicotinic  $\alpha 4$ ) CHRNA4

(NMDA2A), GRIN2A,  
SNAP 25, BDNF

Cell division, cell adhesion,  
neuronal migration,  
Plasticity, K<sup>+</sup>-channels

# ADHD



## Environment

Psychosocial stress

Low social class

Maternal stress, Marital

Conflicts, large families

Delivery complications

Prenatal exposure  
to nicotine or alcohol

Frontal Cortex  
Parietal Cortex  
Supplementary Motor Cortex  
Accumbens Nucleus  
Thalamus  
Basal Ganglia  
Cerebellum

Fronto-cerebellar network  
Reward network  
Fronto-striatal network  
Executive function network  
Attentional network



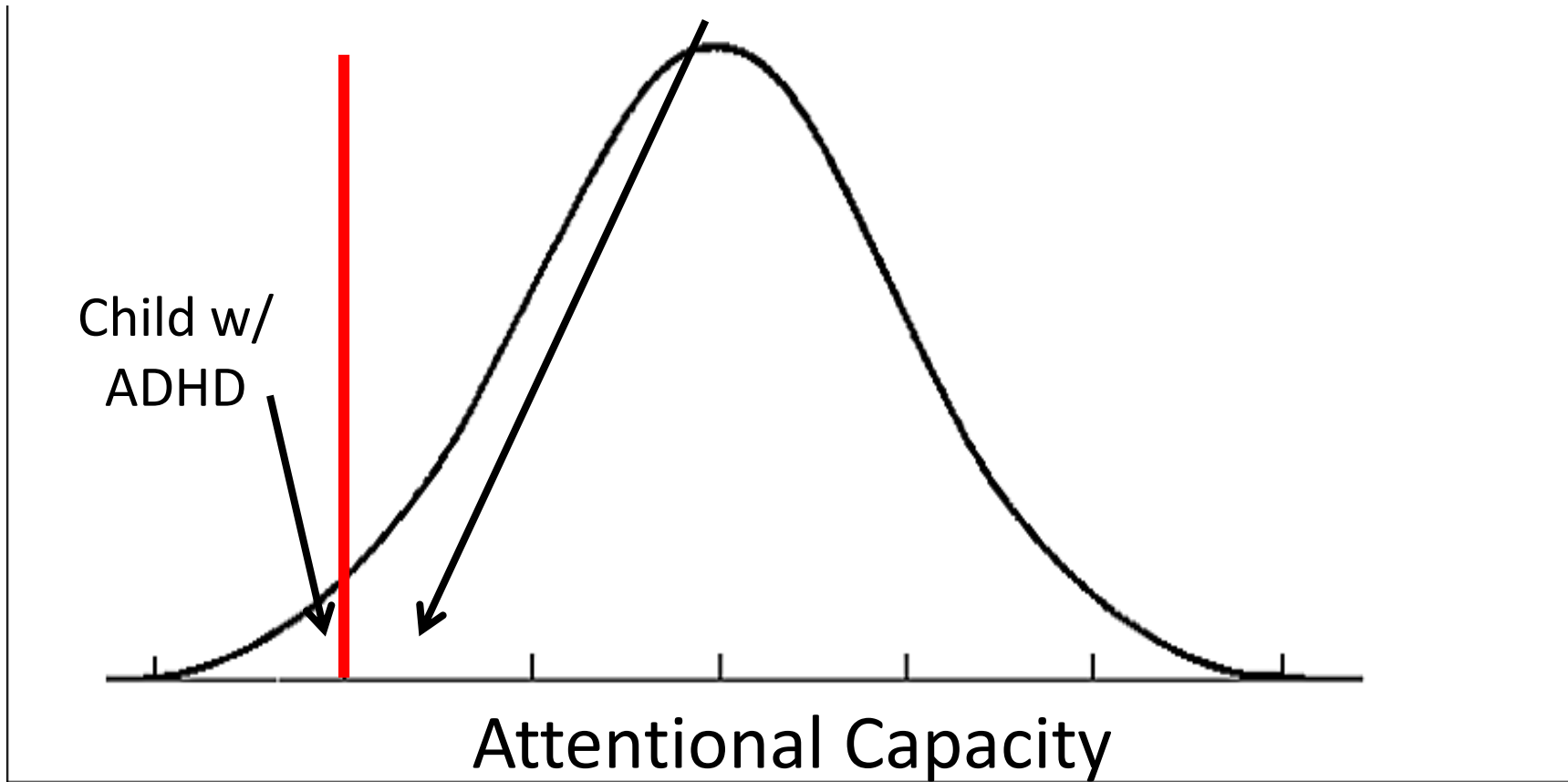
*“For most children with ADHD, the overall effects of these gene abnormalities appear small, suggesting that non-genetic factors also are important”*

*--Surgeon General Report (1999)*

Child w/ Attentional Challenges

Child w/  
ADHD

Attentional Capacity



# Overstimulation Hypothesis

Prolonged exposure to rapid image change during critical period of brain development

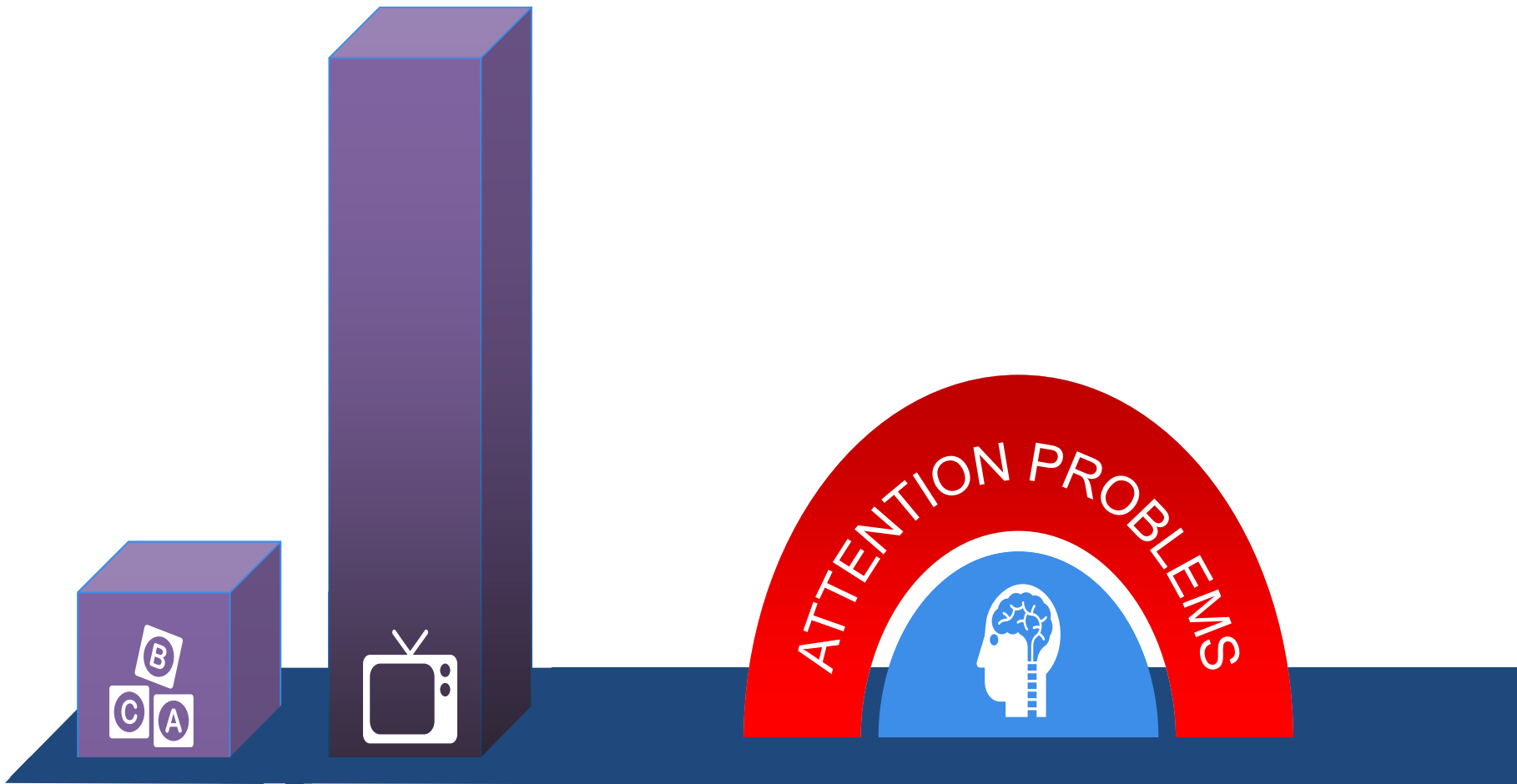


Precondition mind to expect high levels of stimulation



Inattention in later life





AGE 3

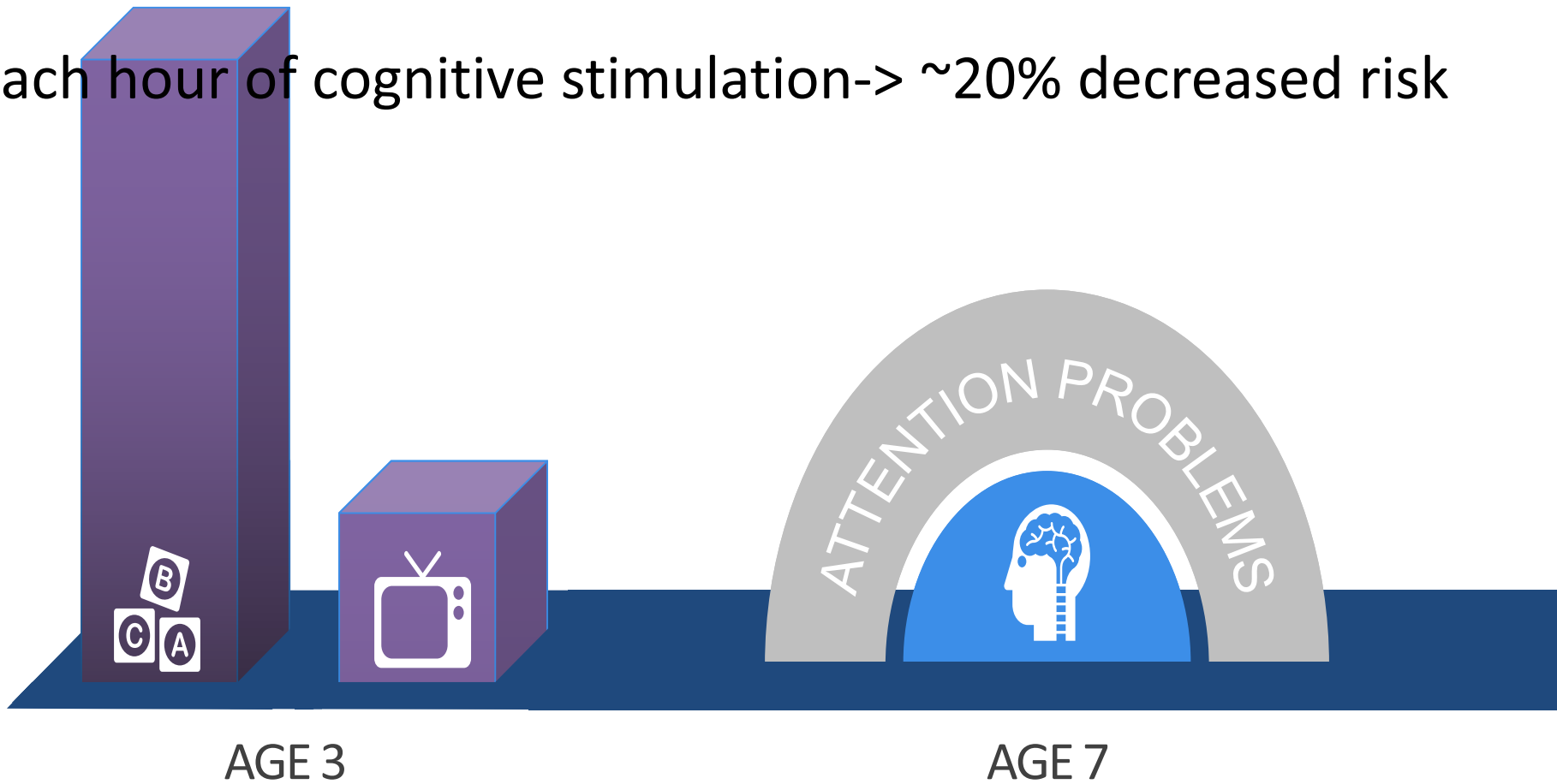
AGE 7

**MORE**  
Television

**MORE** likely to  
have  
attention  
problems

Each hour of TV -> ~10% increased risk of attention problems

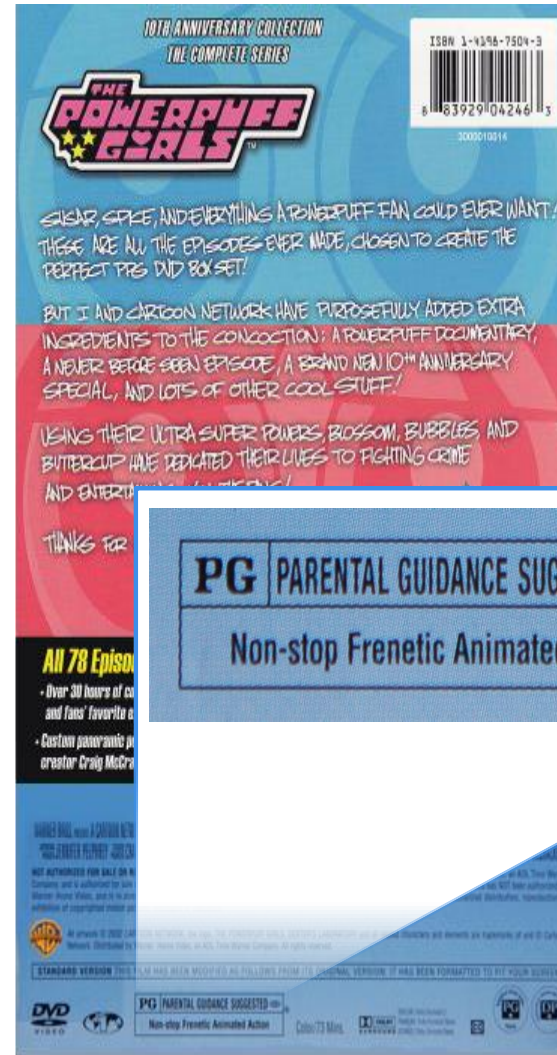
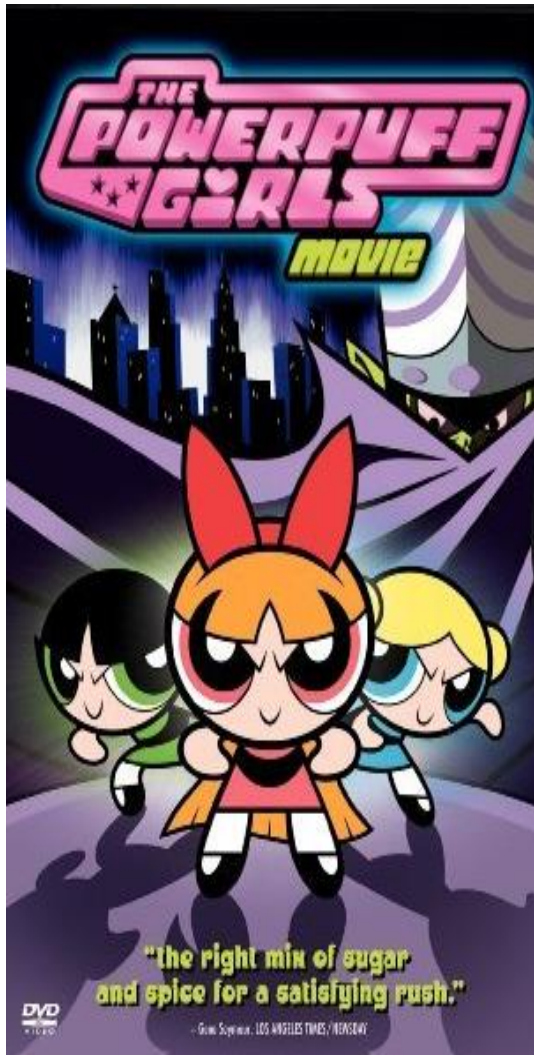
Each hour of cognitive stimulation-> ~20% decreased risk

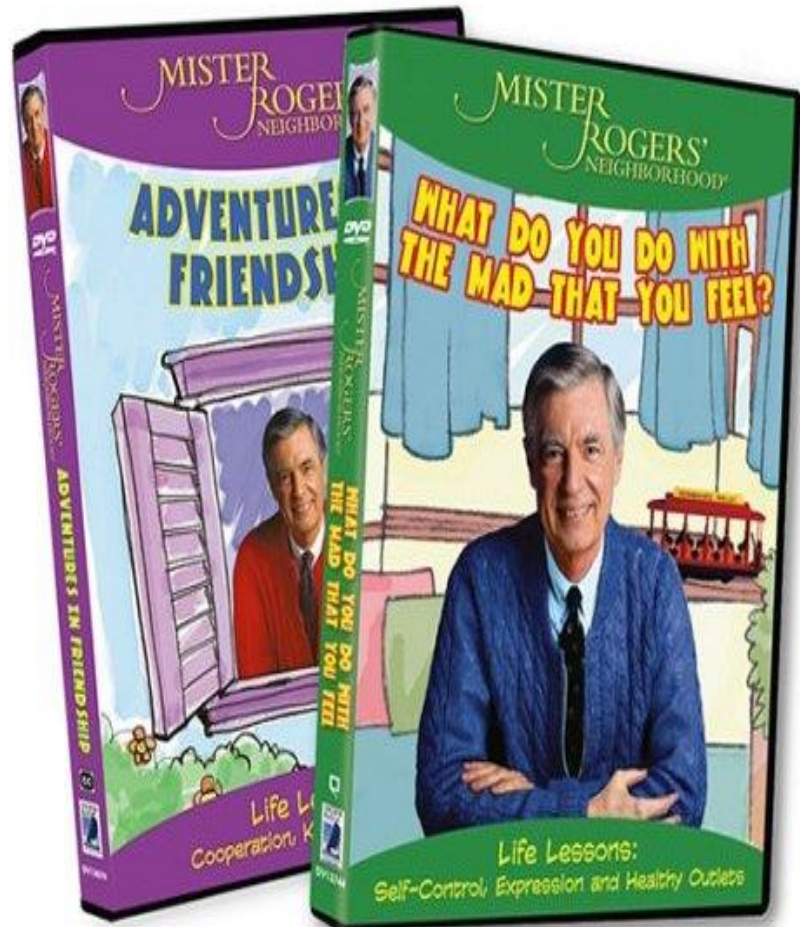


**MORE**  
Cognitive Stimulation

**LESS** likely to have  
attention problems

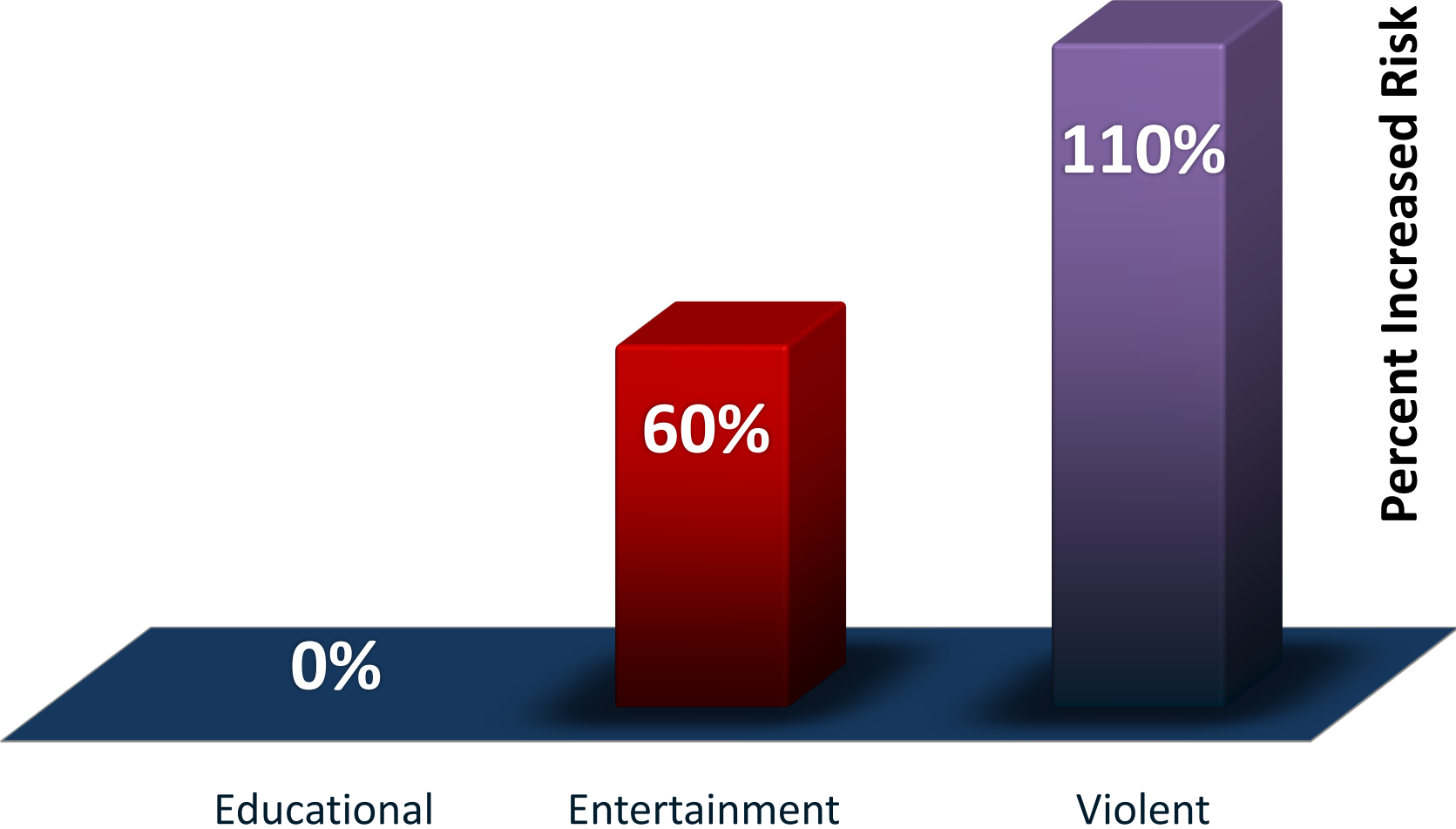
**CONTENT MAY BE KEY**







# Content viewed at 0-3 and risk of attention problems at school age



# **BUILDING A MOUSE MODEL**



# Exposure

Starting at 10 days of life, mice were overstimulated

- 6 hours daily
- 42 days



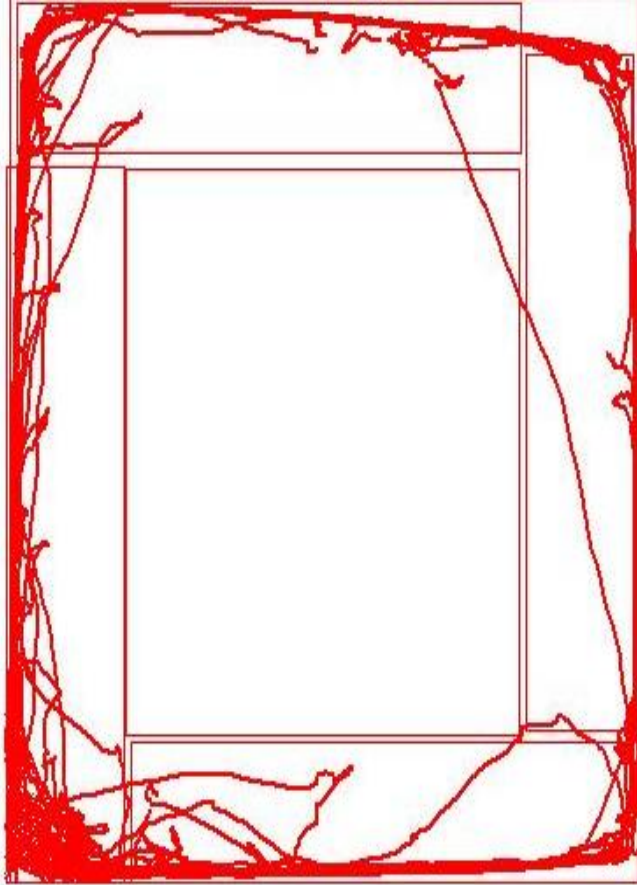
10 days later we assessed behavior

# **ACTIVITY/RISK TAKING**

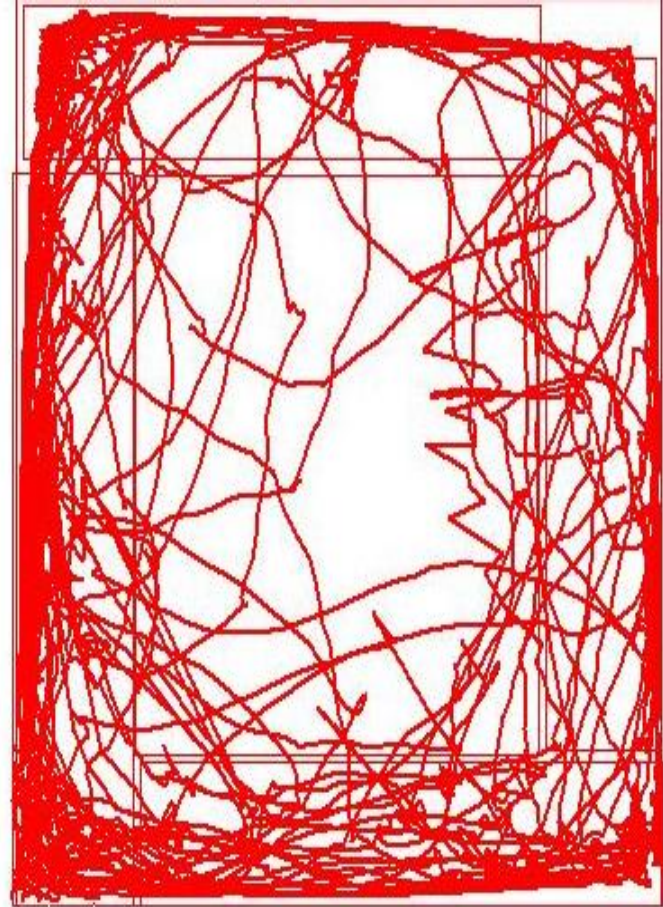


# OPEN FIELD TEST

# Open Field: Travel Pathway

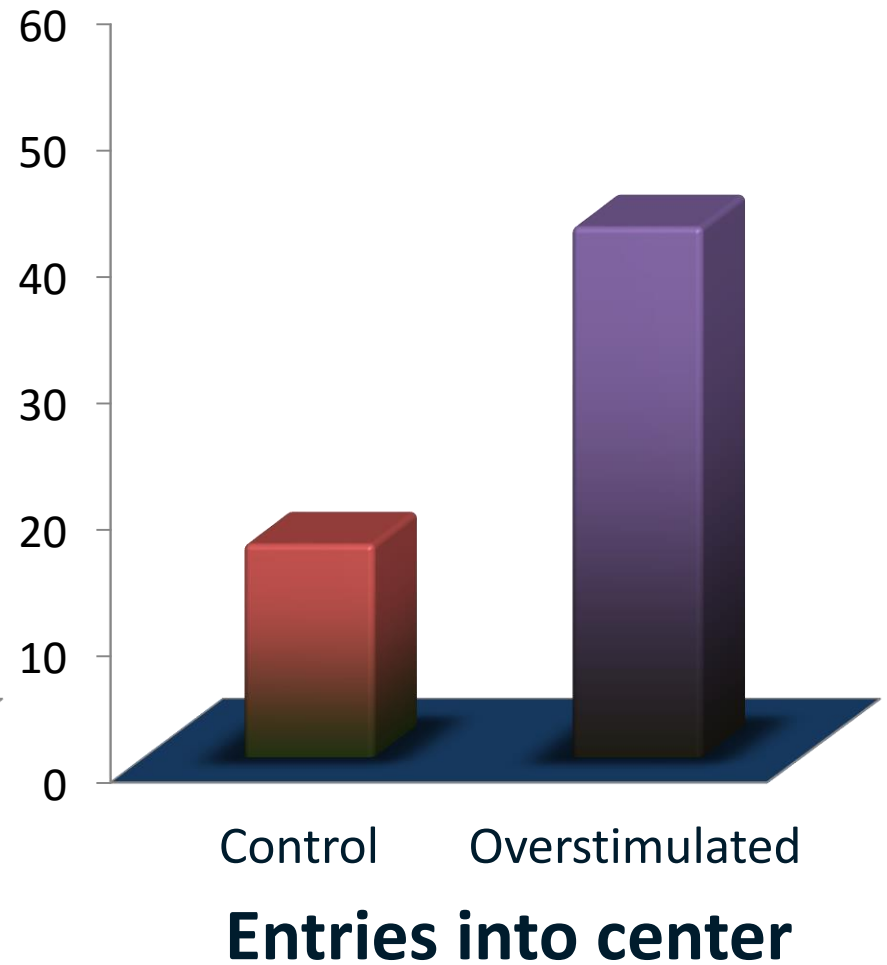
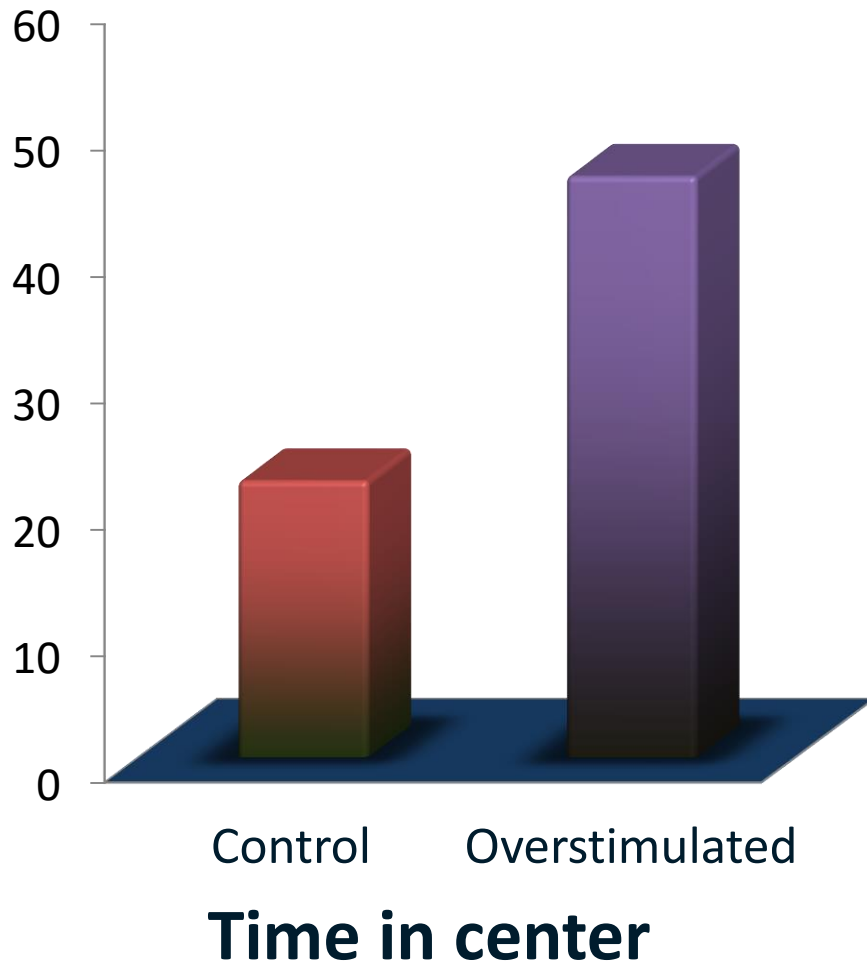


**NORMAL**

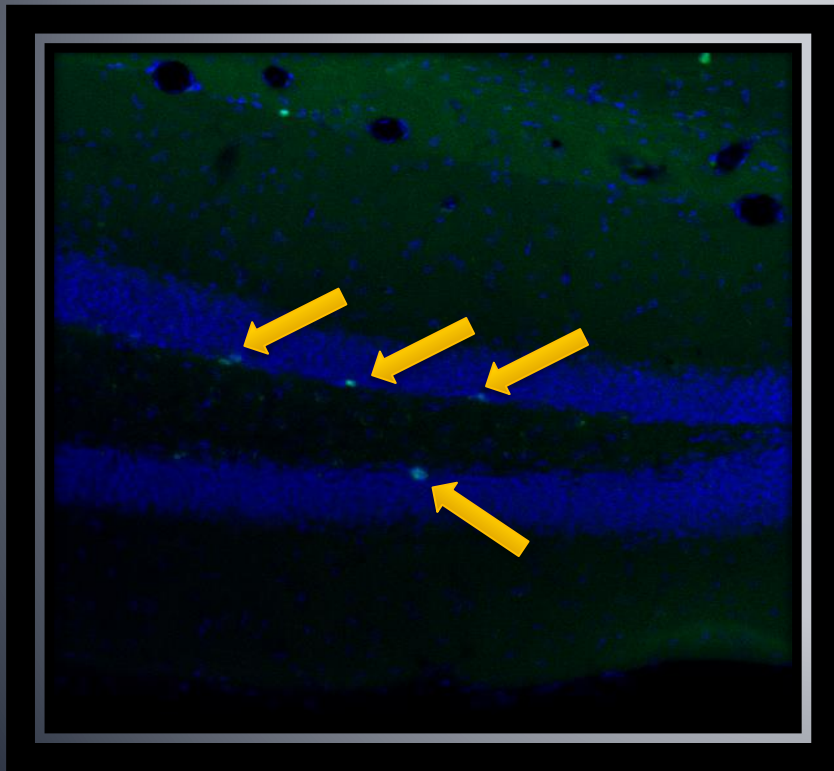


**HYPERACTIVE/RISK TAKING**

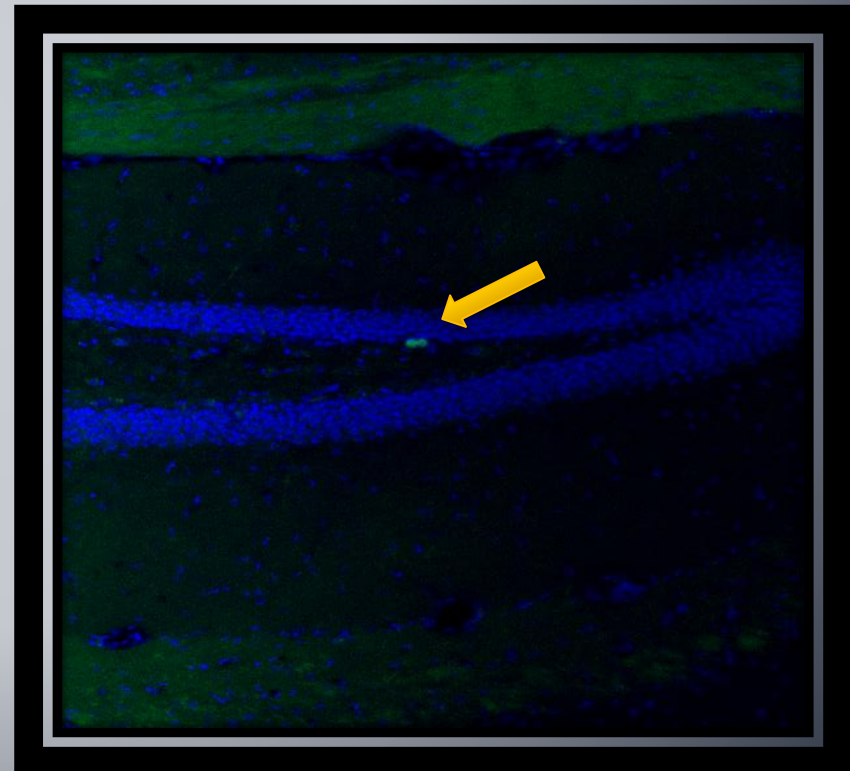
# Open Field: Overstimulation



# Histology on Adult Mice – Ki67 Antibody Staining



Control



Overstimulated





# Joint Attention



- LENA system
  - Digital Language Processor
  - Worn in the pocket
  - Records everything child says/could hear
  - Audio data analyzed by software



# LENA decodes

- Adult word count (Male & Female)
- Child vocalizations (Includes prespeech)
- Conversational turns (Adult/Child exchanges)
- Television

# Analysis

- Conditional Regression
- Each child served as own control
- Compared times when TV was audible to times when it was not





# April 3<sup>rd</sup> 2010



Question

**I did it!!!!!!**









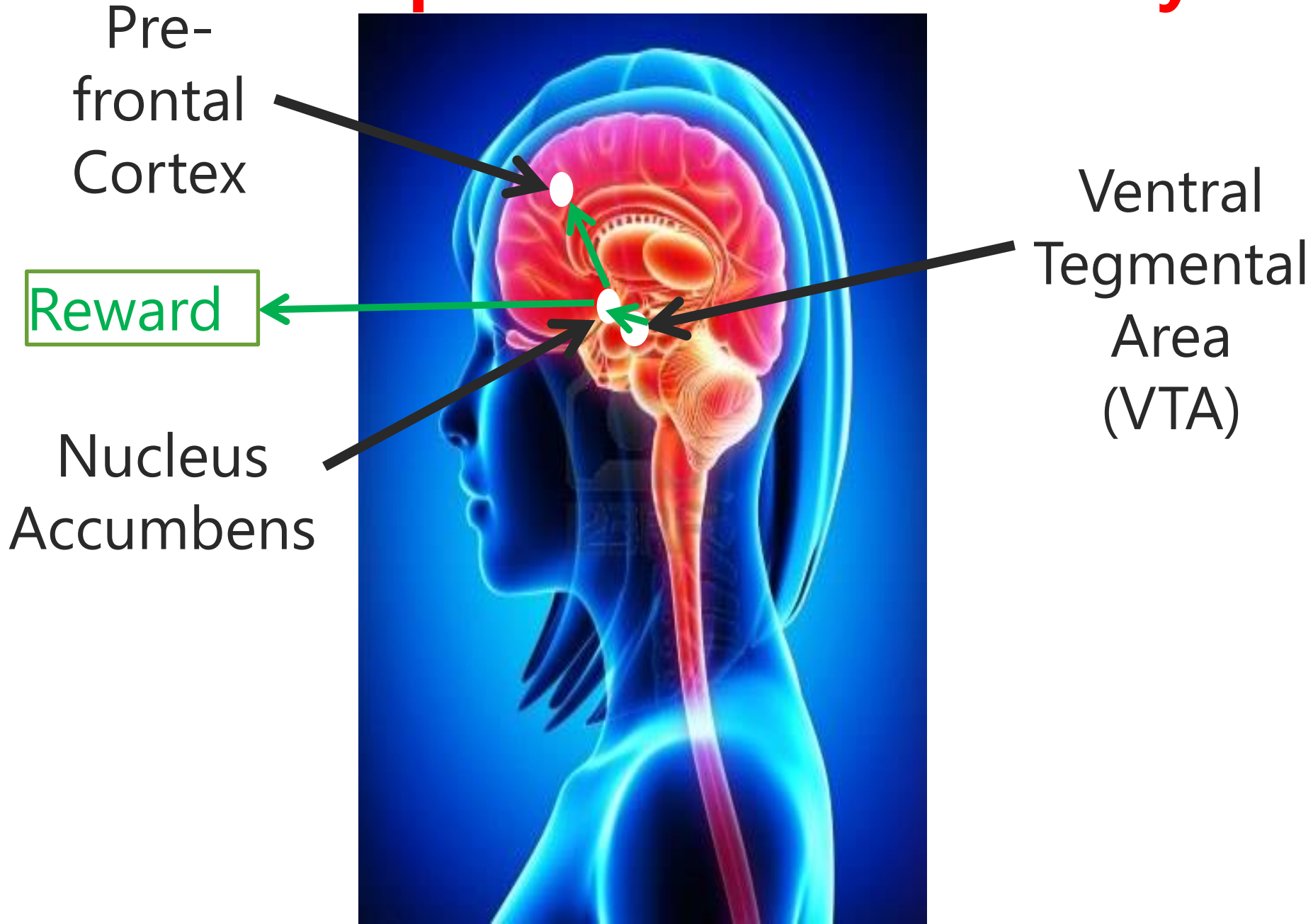








# Dopamine Reward Pathway





# B F Skinner





Early childhood  
for children  
(and mice)  
is critical to  
their  
development

More real time  
play; less fast-  
paced media

Change the  
beginning and  
you change  
the whole story!