

# Neuroplasticity and the family: an evidence-based approach to strengthening preschool



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House Committee On Early  
Childhood and Family  
Supports

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# Brain Development Lab

- More than 30 years studying **neuroplasticity**



- **Helen Neville**, Director Emerita  
– Retired July 1



# Main points

- The developing brain is very plastic
  - Neuroplasticity is a “double-edged sword”
    - Vulnerable to experience (e.g., early adversity)
    - Enhanceable (e.g., high-quality preschool)
- Engaging parents and home environment can strengthen preschool
- High-quality early childhood education is good investment

# Outline

- Neuroplasticity to intervention
  - How we study the brain in children
  - **Vulnerability**: effects of **early adversity** on brain development
    - Language and stress/self-regulation
  - **Enhanceability**: development and assessment of evidence-based **two-generation** intervention
  - **Investment**: cost/benefit analyses of early childhood education

# Mechanism of brain development

Conel (1939~1963)

Birth



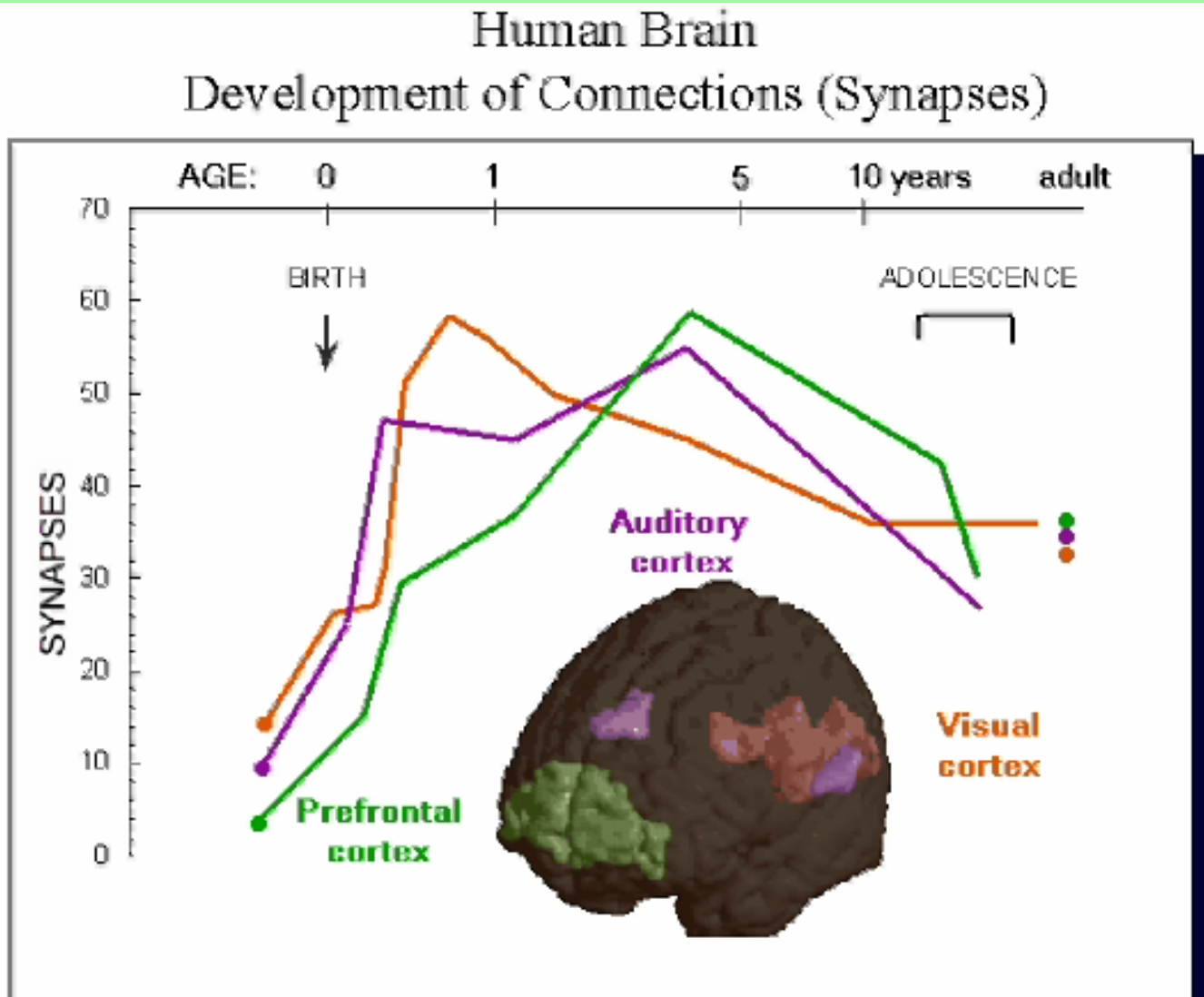
6 years



14 years



# Mechanism of brain development



Adapted from P. Huttenlocher et. al. (1979-1997)

# Different profiles of plasticity

- Constrained
  - E.g., central vision, hearing
- Modifiable by, and dependent on, experience during particular time periods (multiple)
  - E.g., **attention, language**: grammatical and phonological processing
- Modifiable throughout life
  - E.g., **language**: semantic processing

# **HOW WE STUDY THE BRAIN**

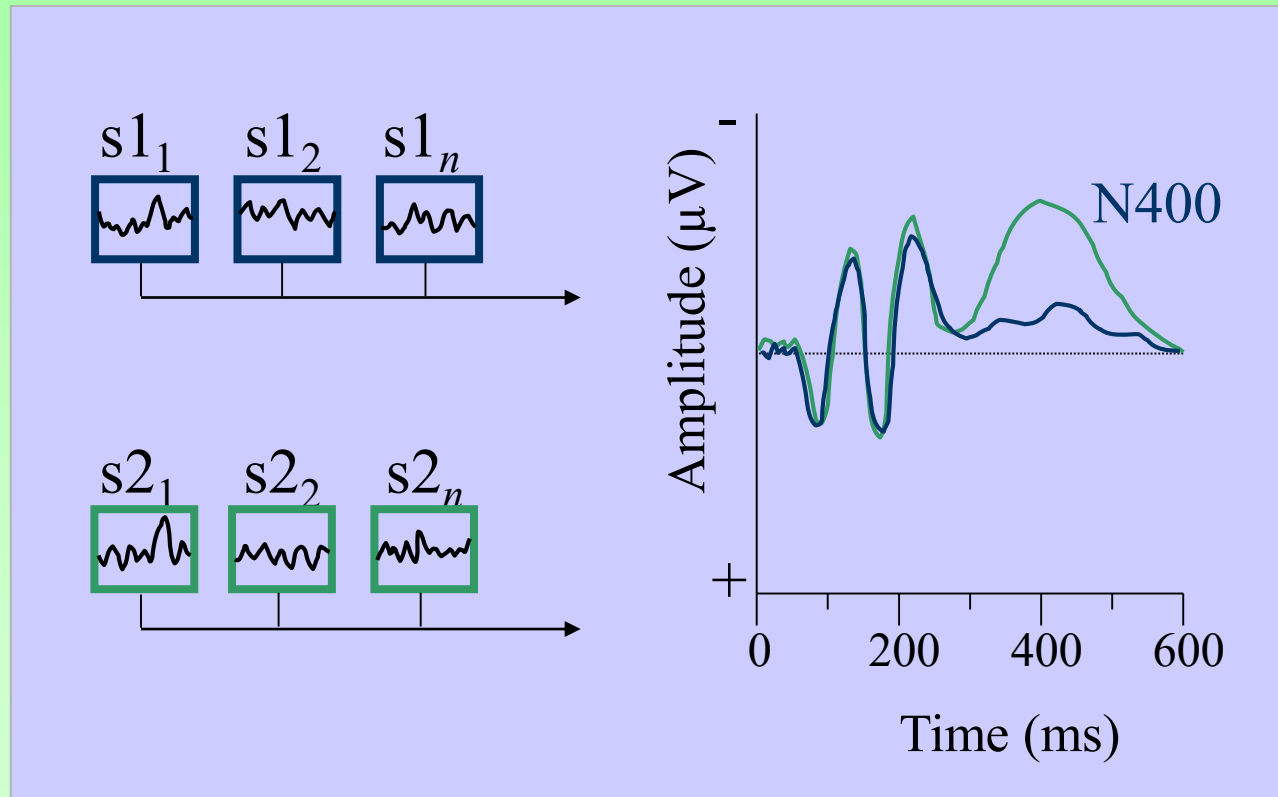


# Event-related potentials





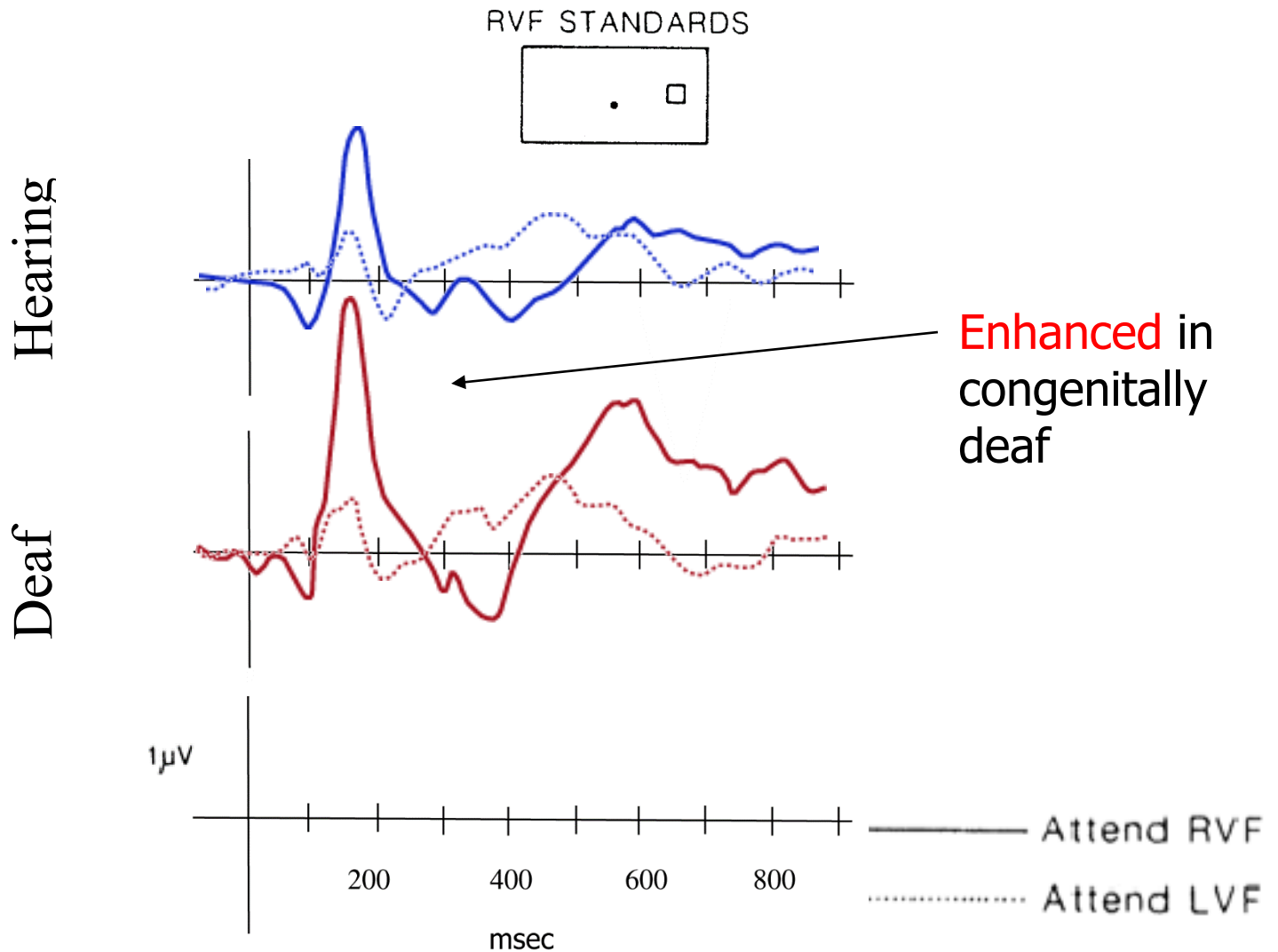
*The babies won't drink the **milk** from their bottles.*  
*The babies won't play the **milk** from their bottles.*



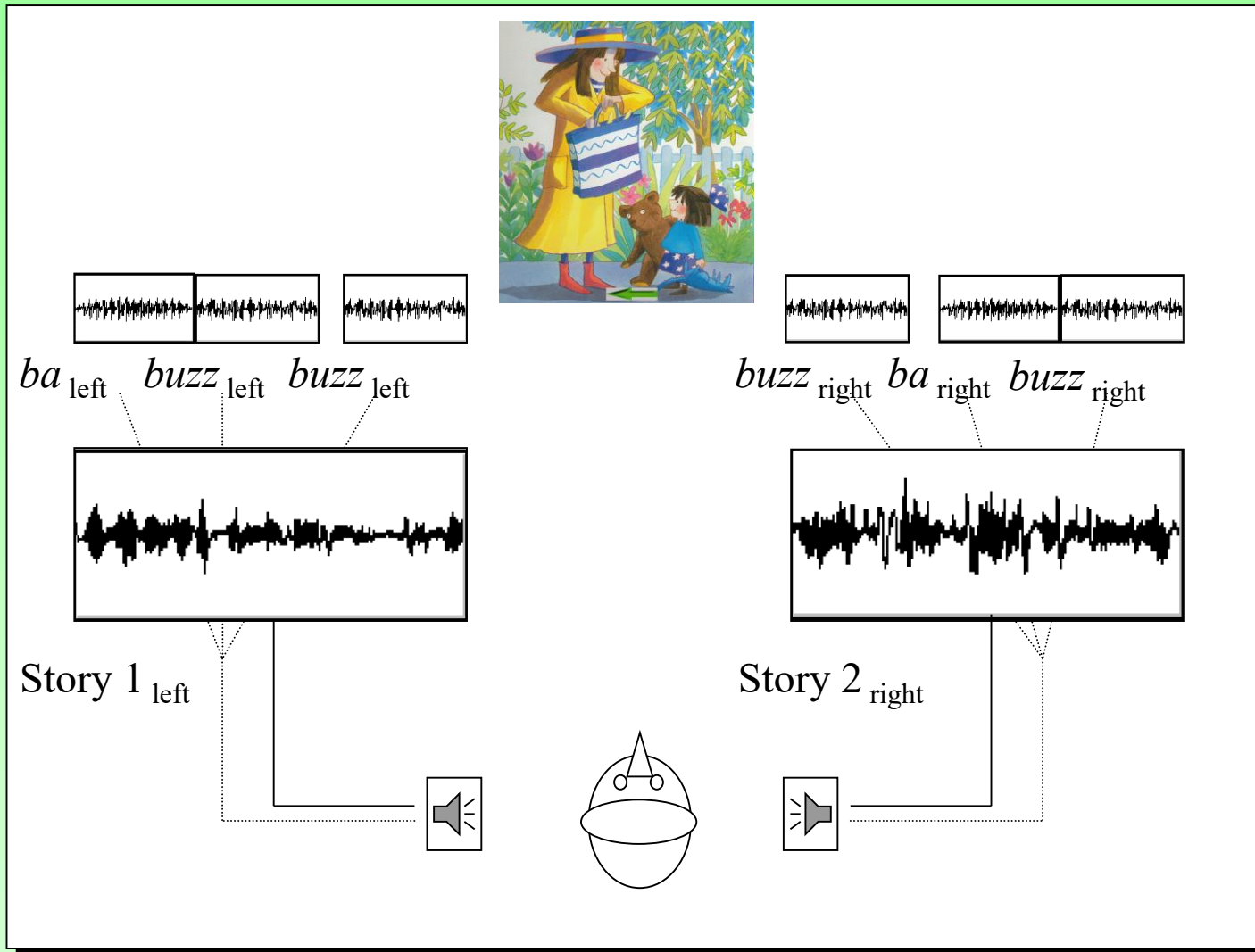
# Attention

Everybody knows . . .

# Attention

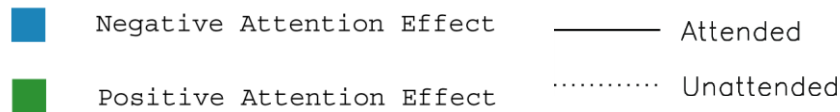
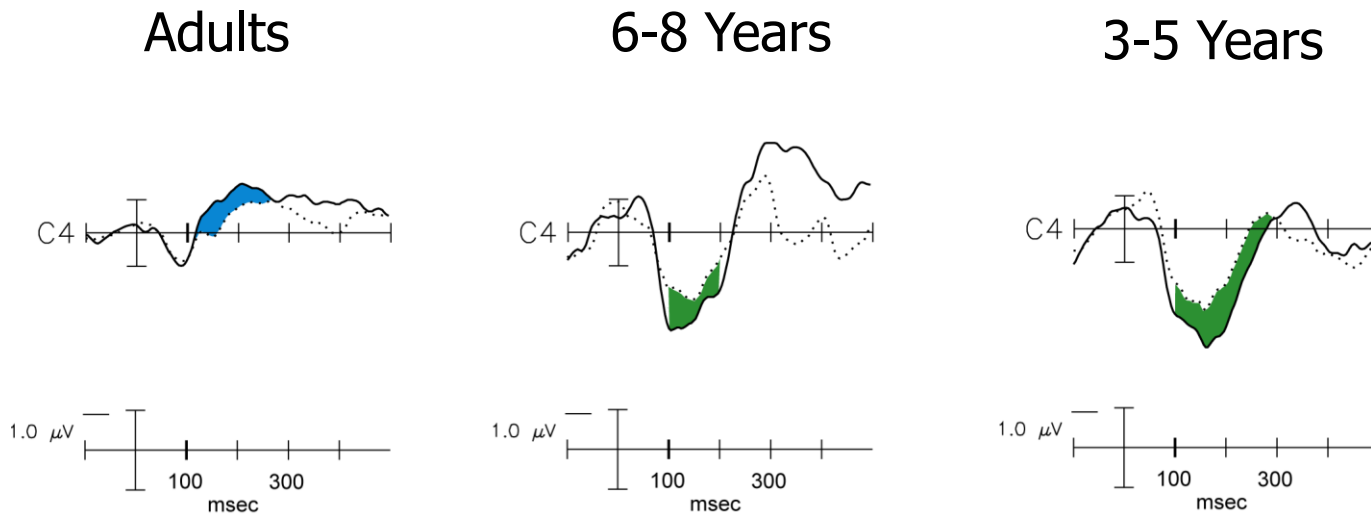


# Attention



# Attention

## Selective Auditory Attention



### Attention:

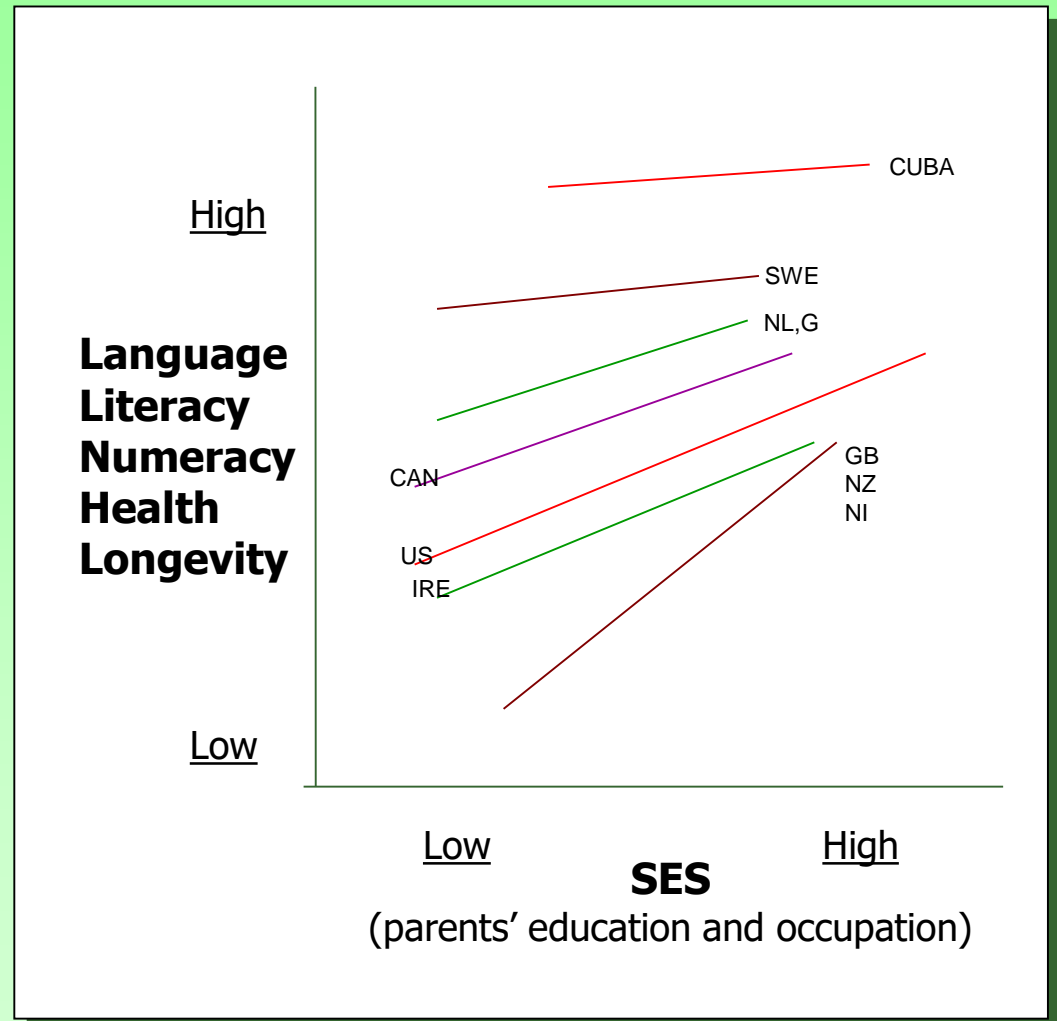
- Enhanced in deaf and blind
- ? Vulnerable in development
- ? Trainable in development

# **VARIABLE ENVIRONMENTS**



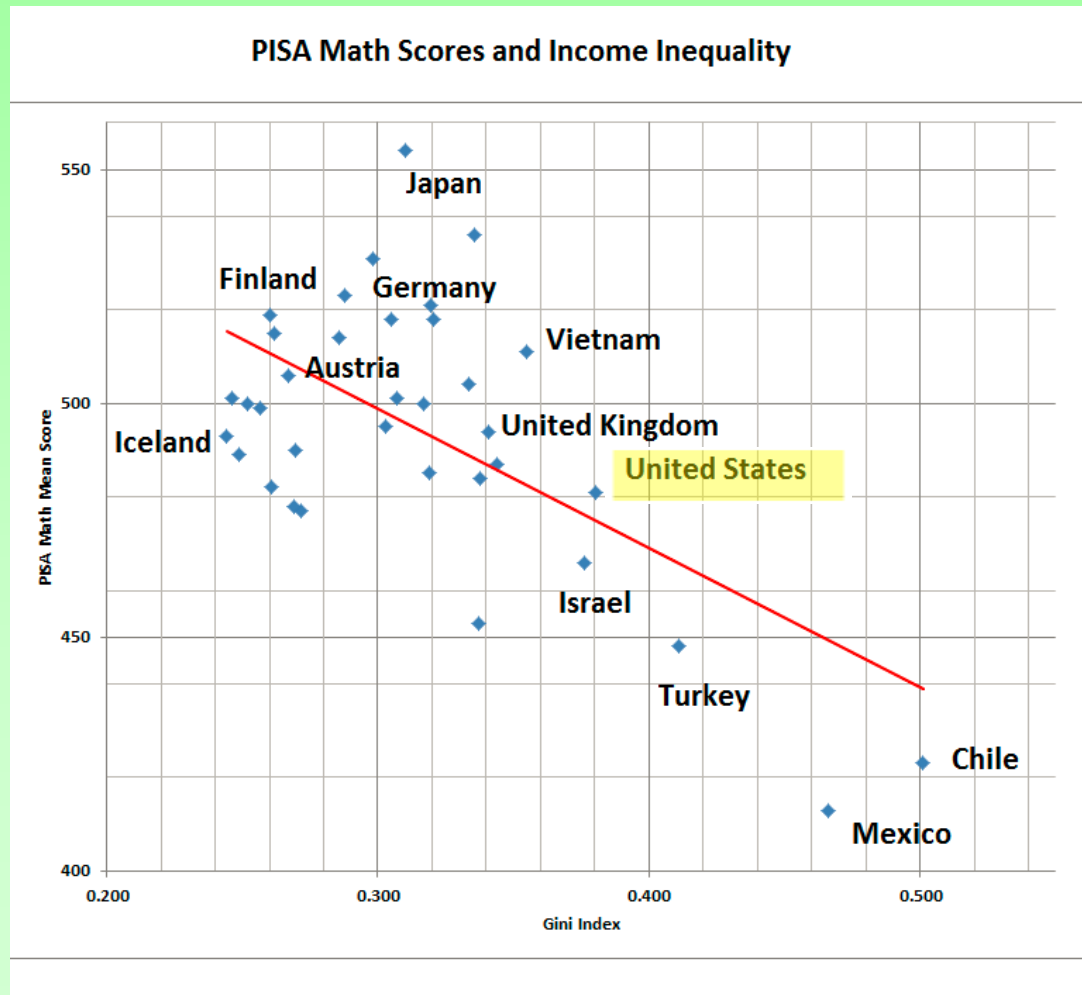
# Socioeconomic status gradients

- Steepness of gradient (degree of inequality) predicts differences in outcomes
- Entire society affected (more equal societies do better)



# Inequality

- 27 countries have higher math scores (age 15) and lower inequality than the US



# Unpacking SES

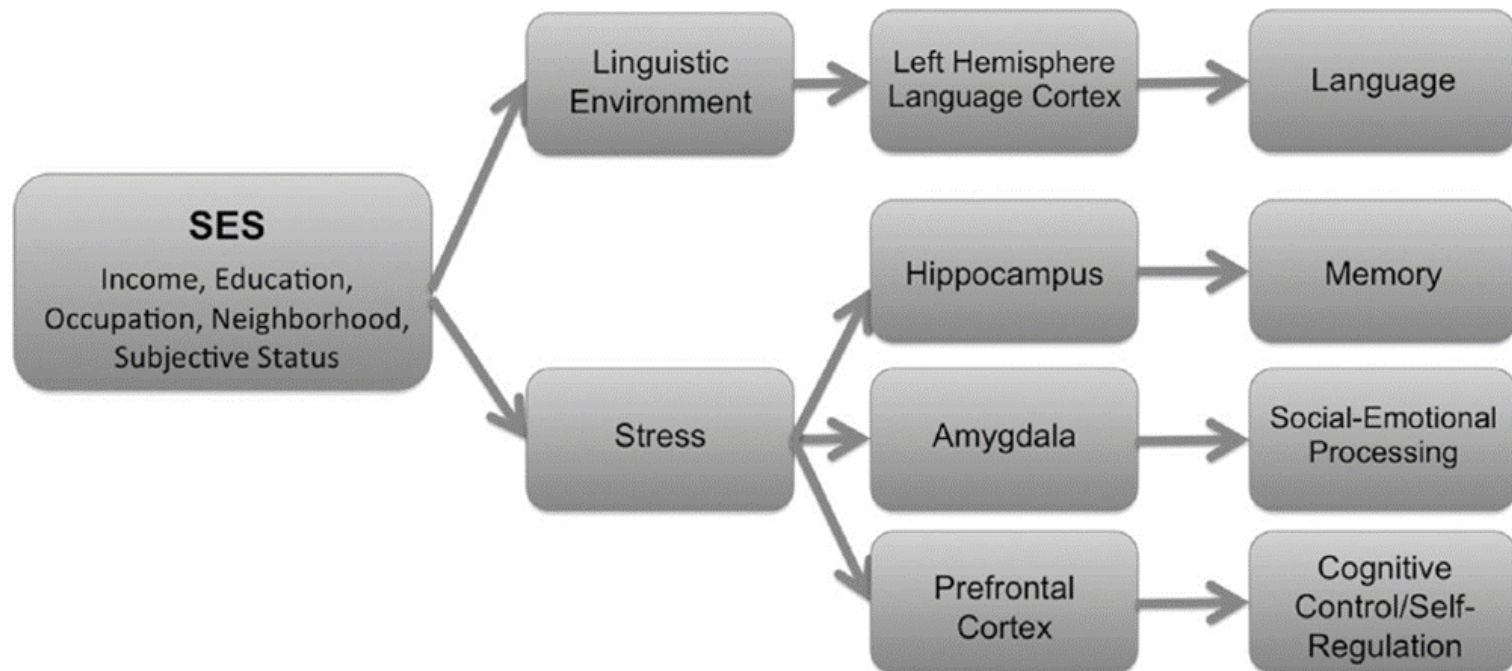
-High and low “typical families” differ in:

Stress	Perception of inequality
Prenatal care	Parental education
Drugs	Parental attitudes
Depression	Social support
Nurturance/neglect	Nutrition
Income	TV time
Arts education	Books
Schools	

-Our studies: extensive questionnaire to try to “unpack” SES

# Unpacking SES

- Two primary mechanisms: **language** and **stress/self-regulation**
  - **Foundational skills** important for school readiness, participation in economy, health



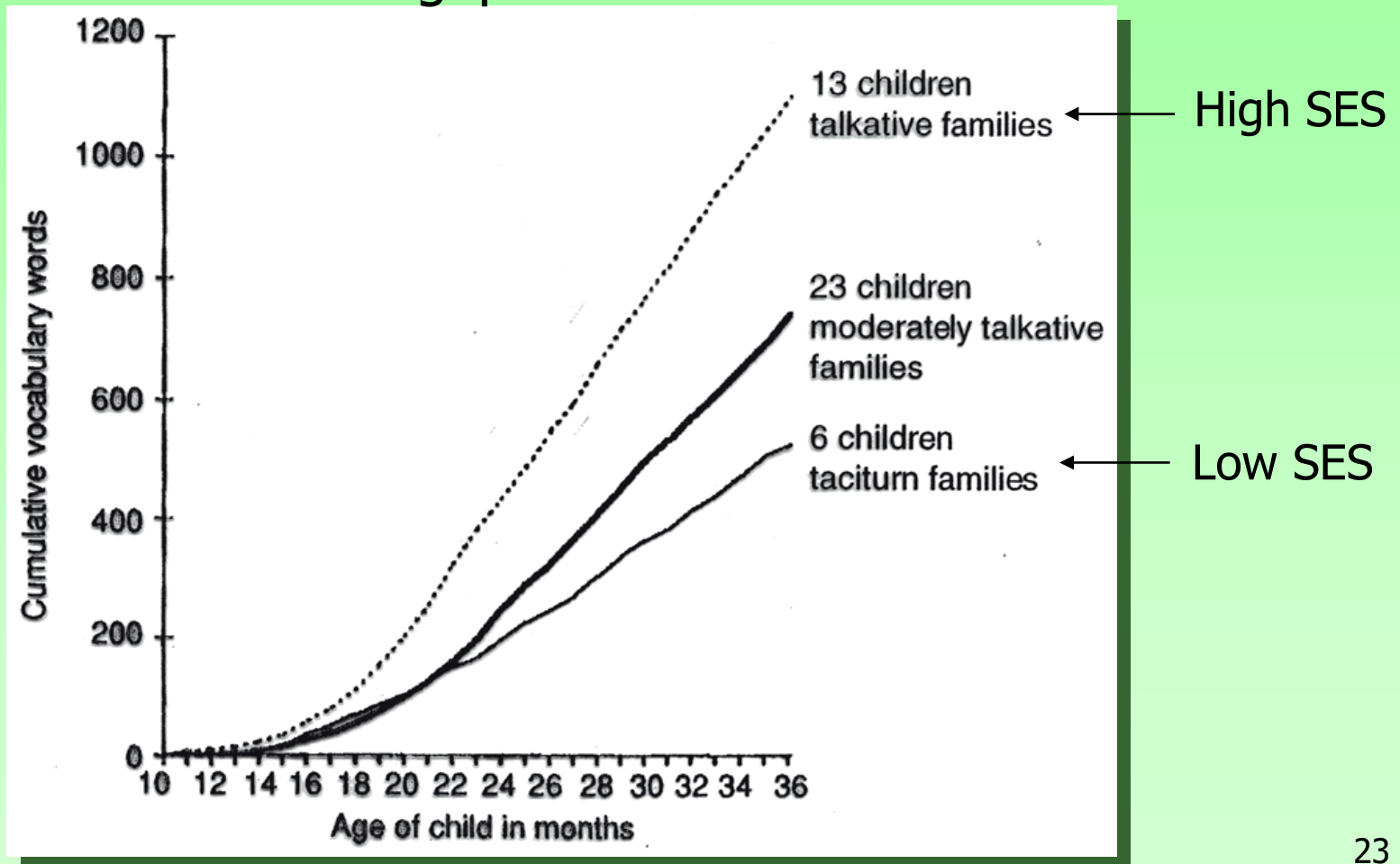
# **LANGUAGE**

# SES and language

- Differences in **language environment** as a function of SES:
  - Amount and variety of vocabulary
  - Syntactic complexity
  - Child-directed speech
  - Purpose of speech (conversation vs. directing child)
  - Use of questions vs. directives
  - Sharing books (and elaborating on content)

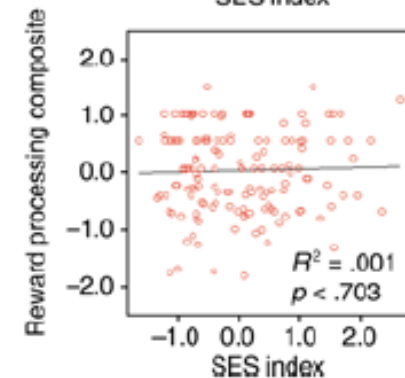
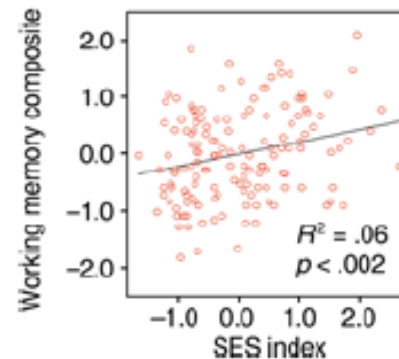
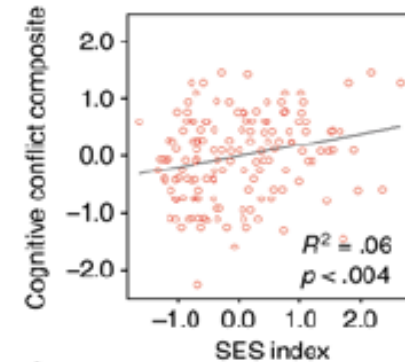
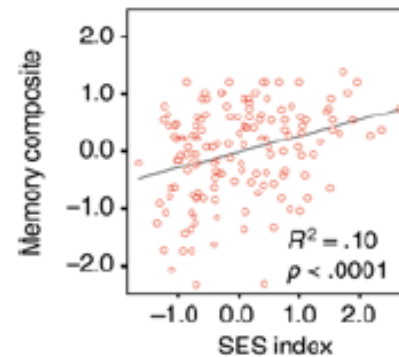
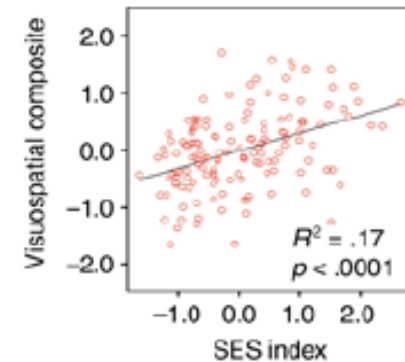
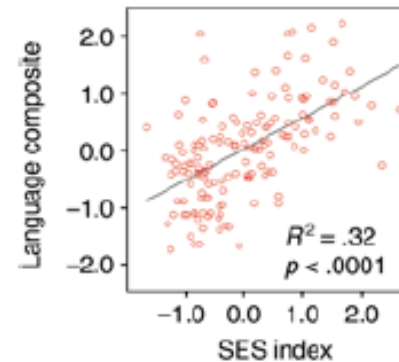
# SES and language

- Differences in **language input**: vocabulary
  - The “30 million word gap”



# SES and cognition

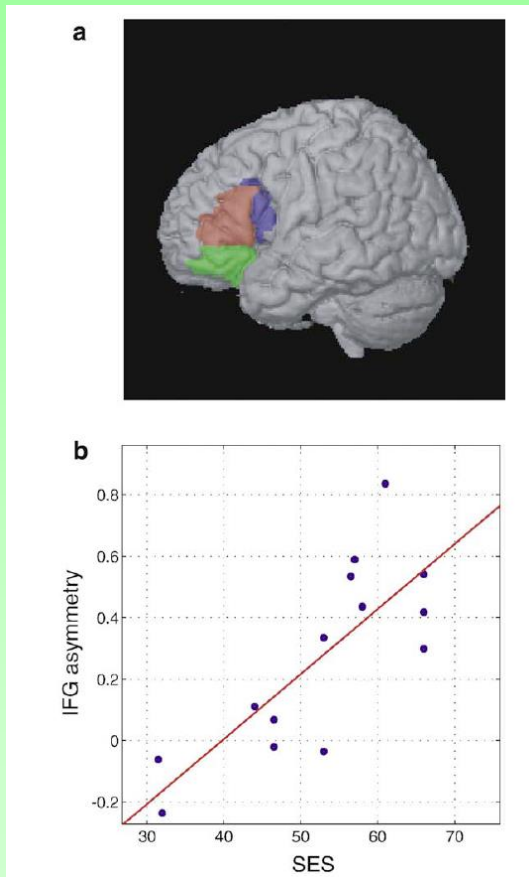
- SES related to multiple measures of cognition
  - Language one of strongest and most consistently documented relationships with SES



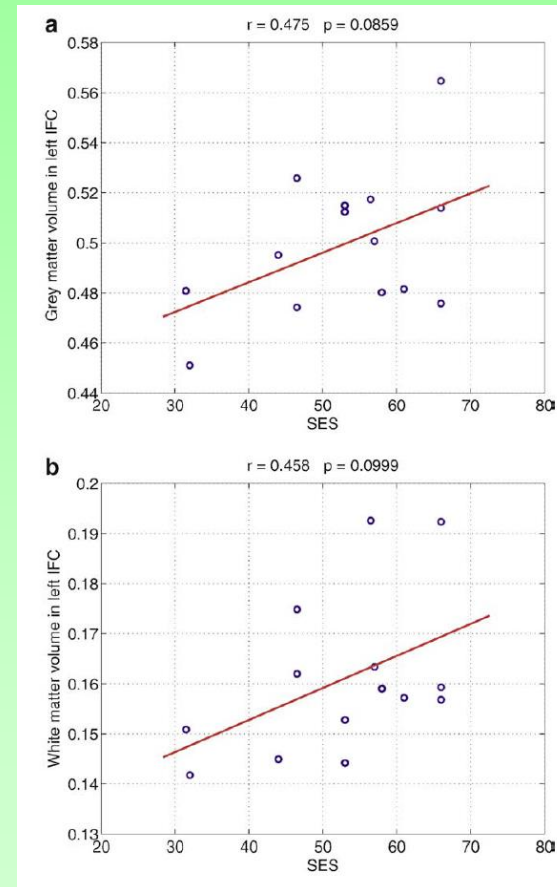


# SES and language

- Left inferior frontal gyrus (LIFG): language processing



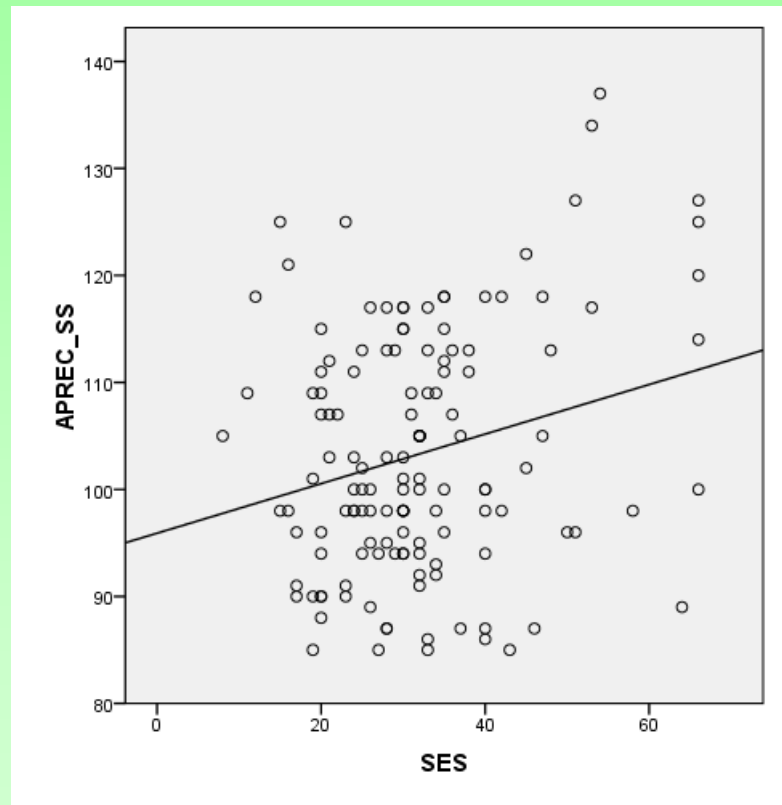
LIFG asymmetry in rhyming task in 5 year-olds



LIFG grey and white matter volume in 5 year-olds

# SES and language: 3-5 year-olds

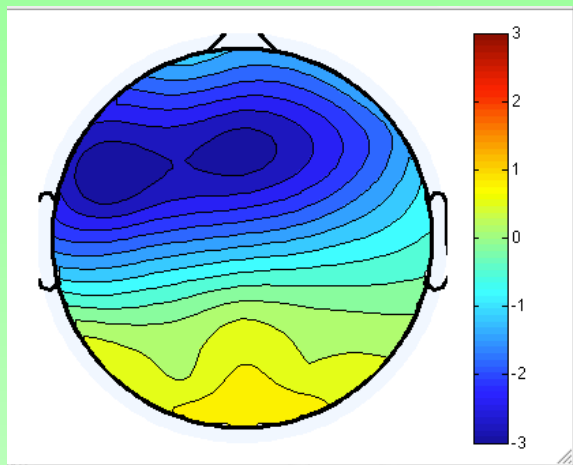
- Receptive language and SES



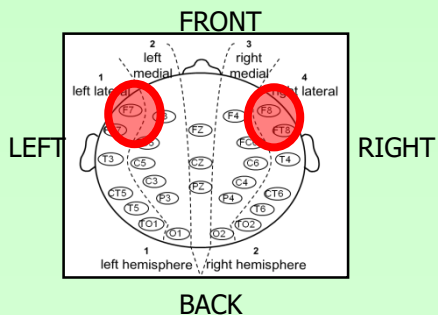
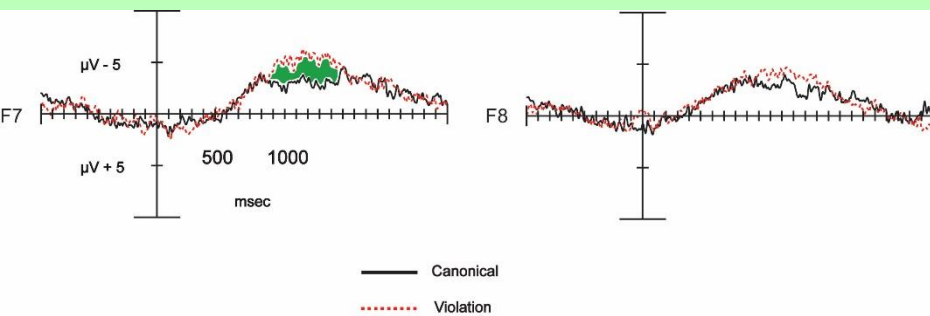
SES and receptive language:  $N = 142$ ,  $r = .243$ ,  $p < .003$

# SES and language: 3-5 year-olds

Higher SES

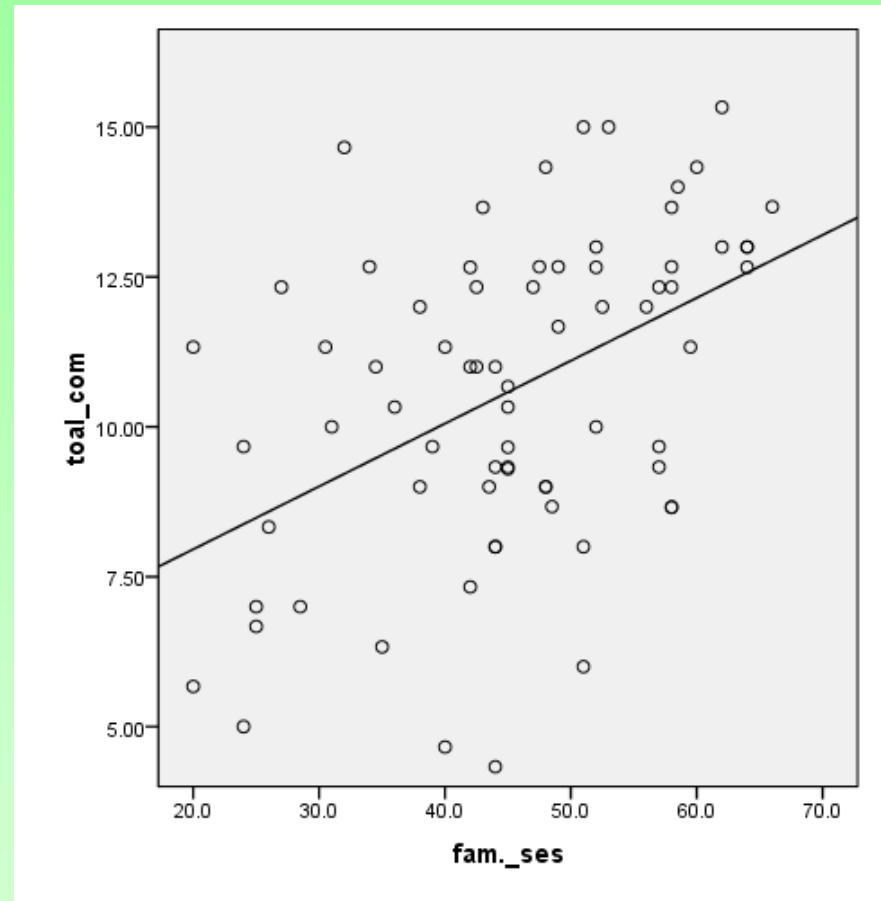


1000-1500 ms



# SES and language: adults

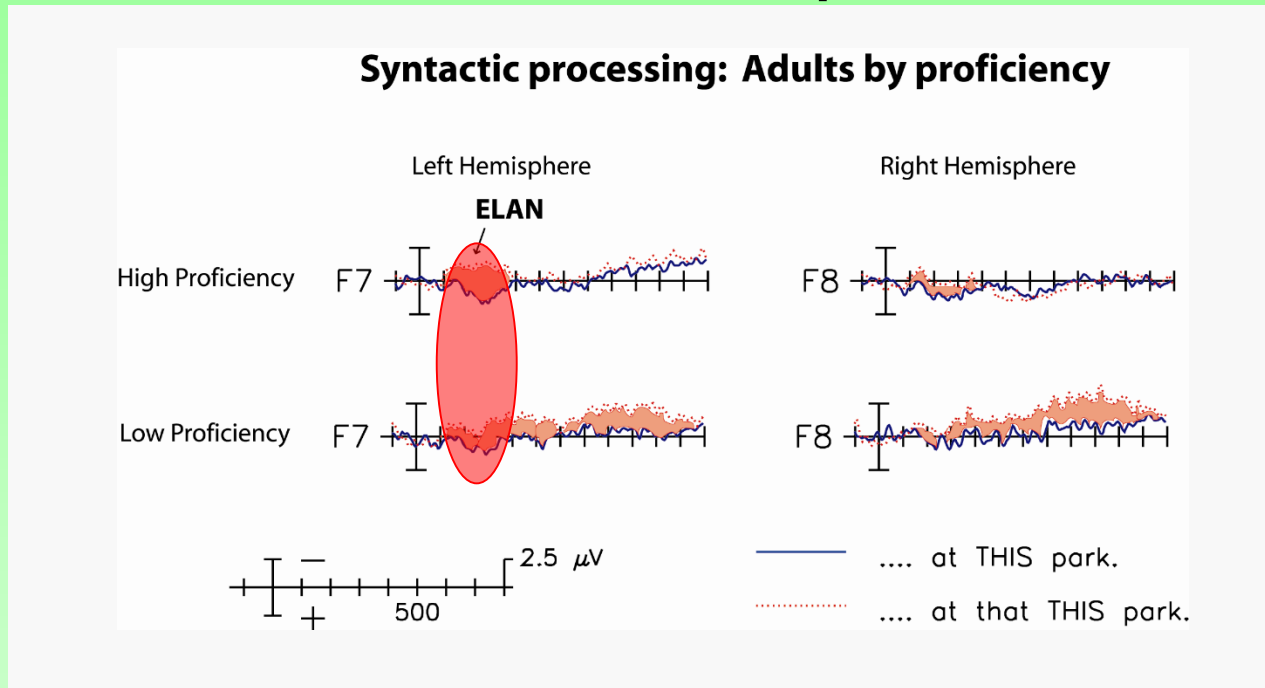
- Do SES differences endure into adulthood?
  - Significant correlation: childhood SES and language abilities in adulthood



SES and language proficiency:  $N = 72$ ,  $r = .460$ ,  $p < .0001$

# SES and language: adults

- SES differences in brain response at 100 ms



- Partial correlation: SES and amplitude of early left anterior effect

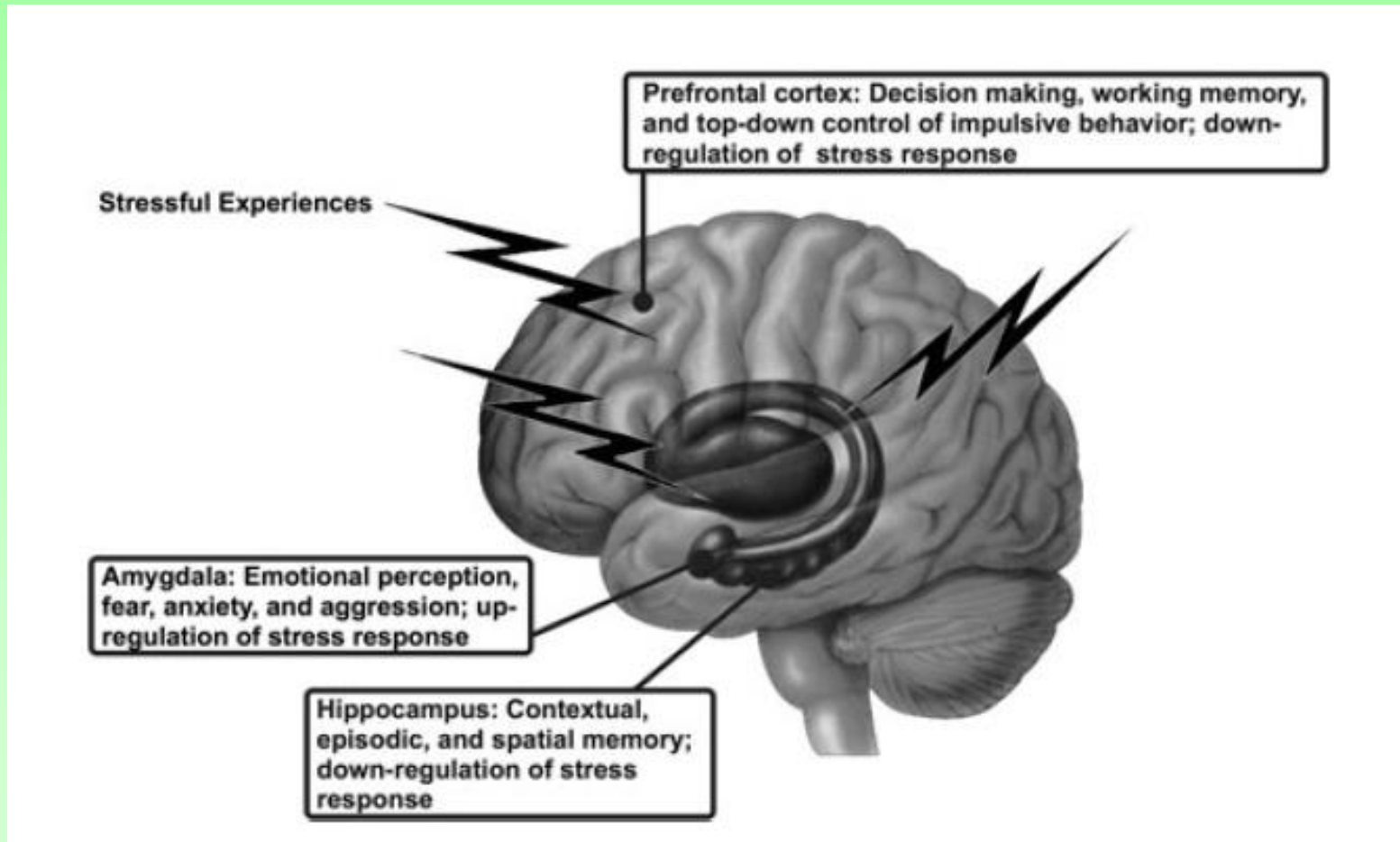
$$N = 72, r = -.217, p < .05$$

-controlling for proficiency, WM, adult educational attainment

# **STRESS AND SELF-REGULATION**

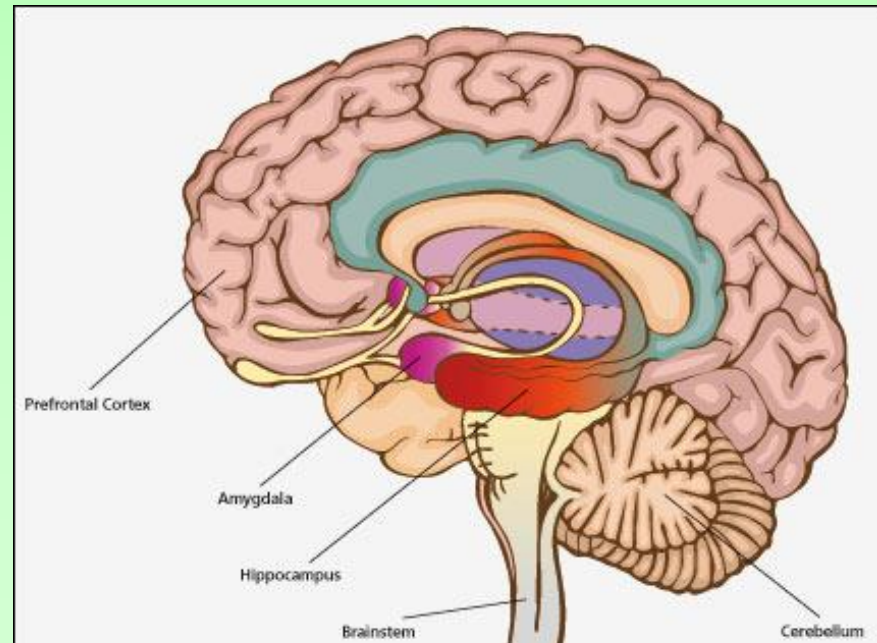
# Stress and the brain

- Prefrontal cortex, hippocampus, amygdala: sensitive to **chemical effects of stress**



# Prefrontal cortex

- **Self-regulation** (attention, executive function):
  - Judgment and decision making
  - Impulse control
  - Working memory
- **Foundational skills** important for school readiness
  - More predictive than IQ
- **Down-regulation** of stress response



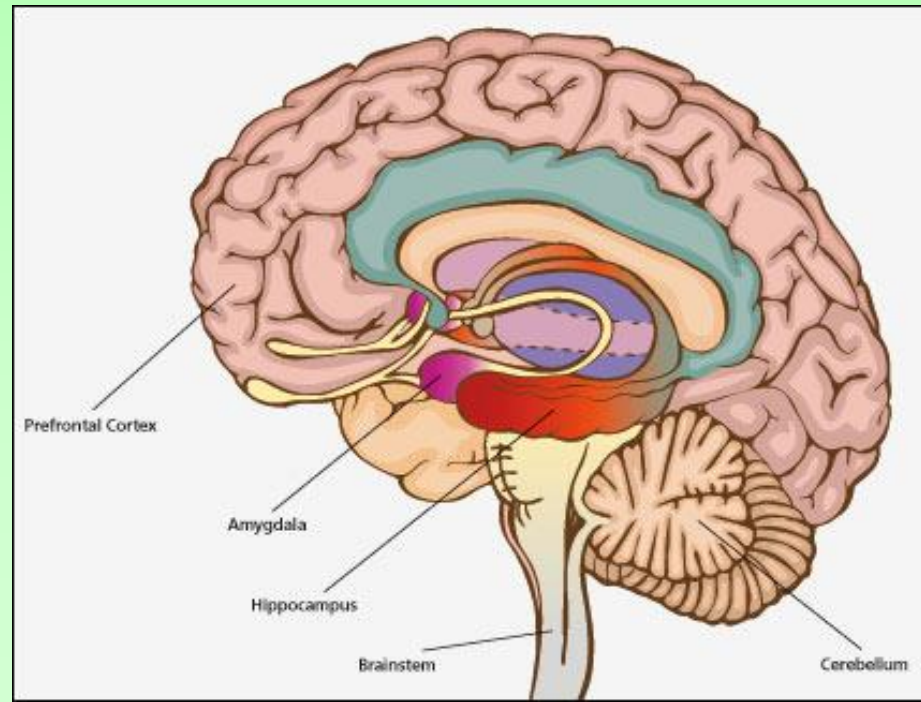


# Hippocampus



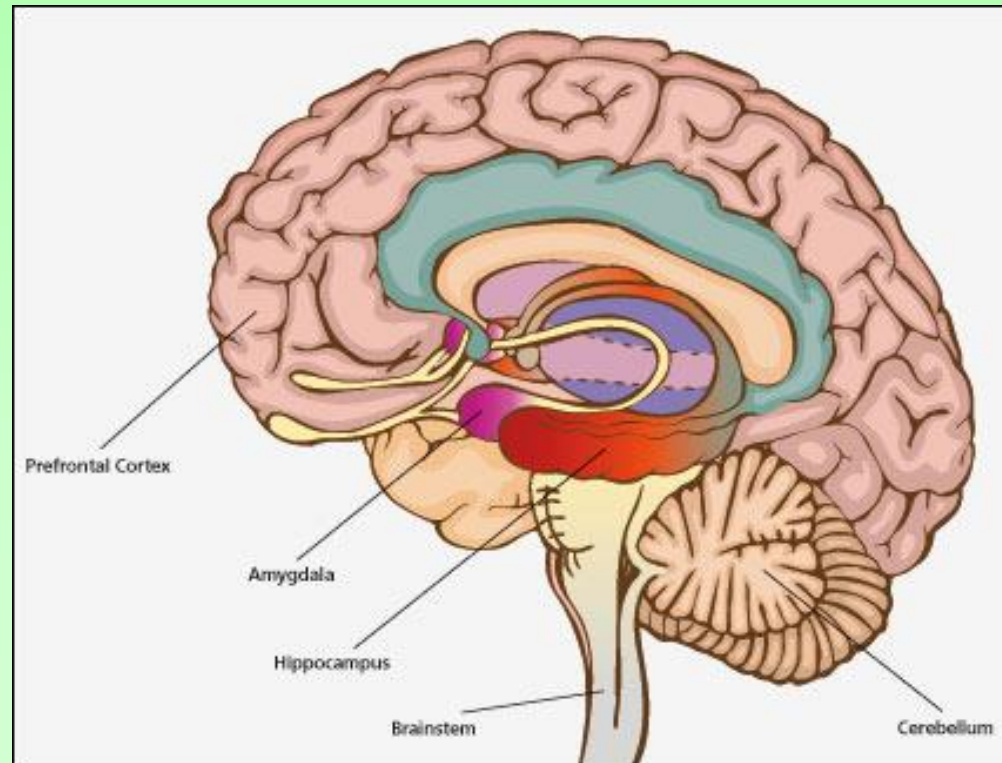
- Memory
  - Formation/consolidation of new memories
  - Memory retrieval

- Down-regulation of stress response



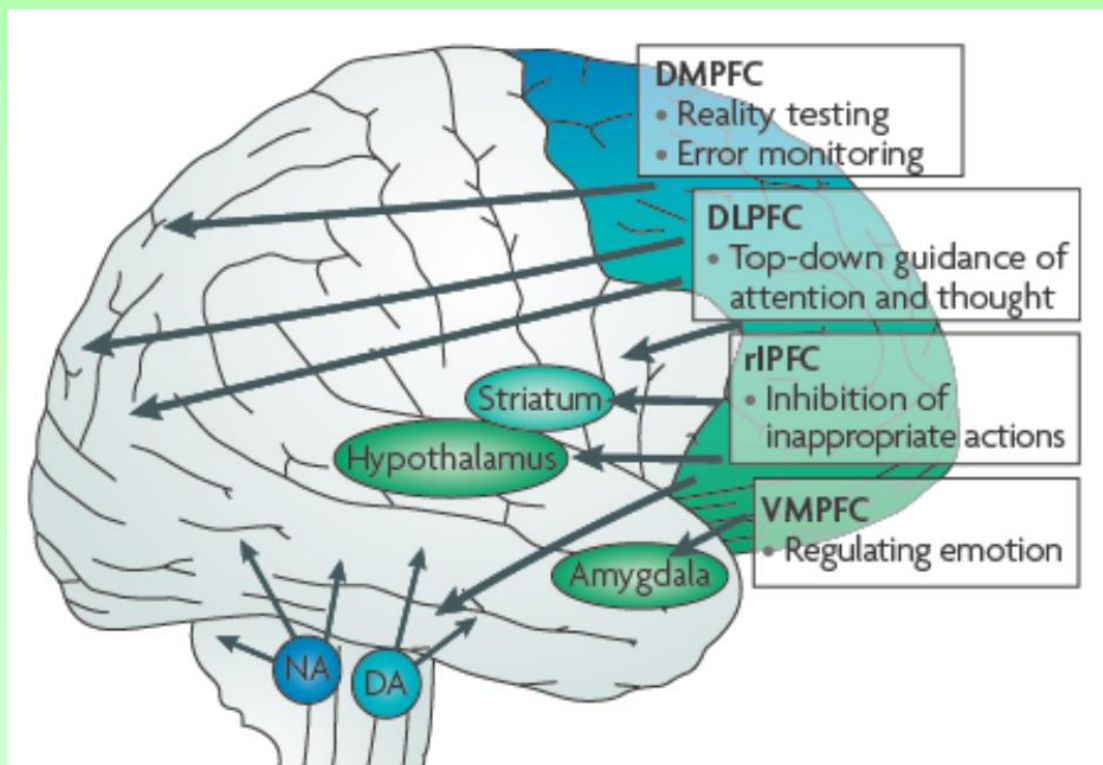
# Amygdala

- Emotional processing
  - Emotional regulation and learning
  - **Perception** of potential threat
  - Fear, anxiety, aggression
  
- **Up-regulation** of stress response



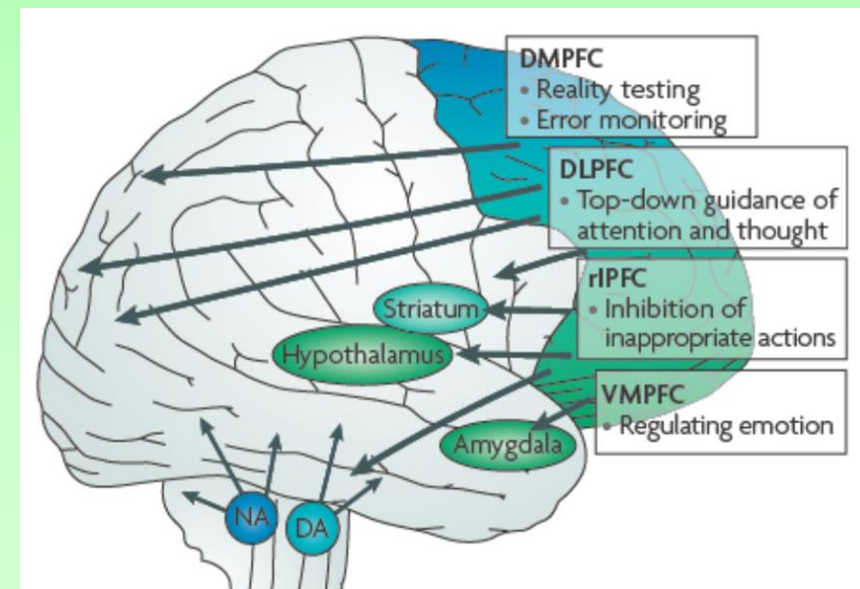
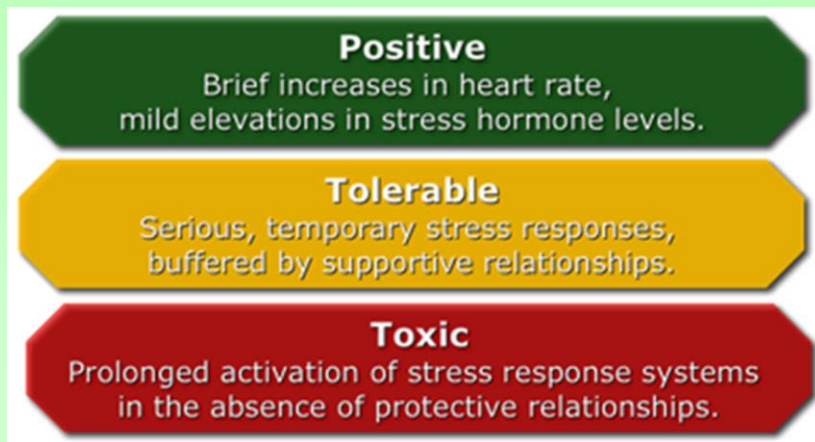
# Prefrontal regulation

- Alert, non-stress “default” condition:
  - Prefrontal regulation of attention, thought, emotion
  - Inhibition of inappropriate actions



# Moderate stress and self-regulation

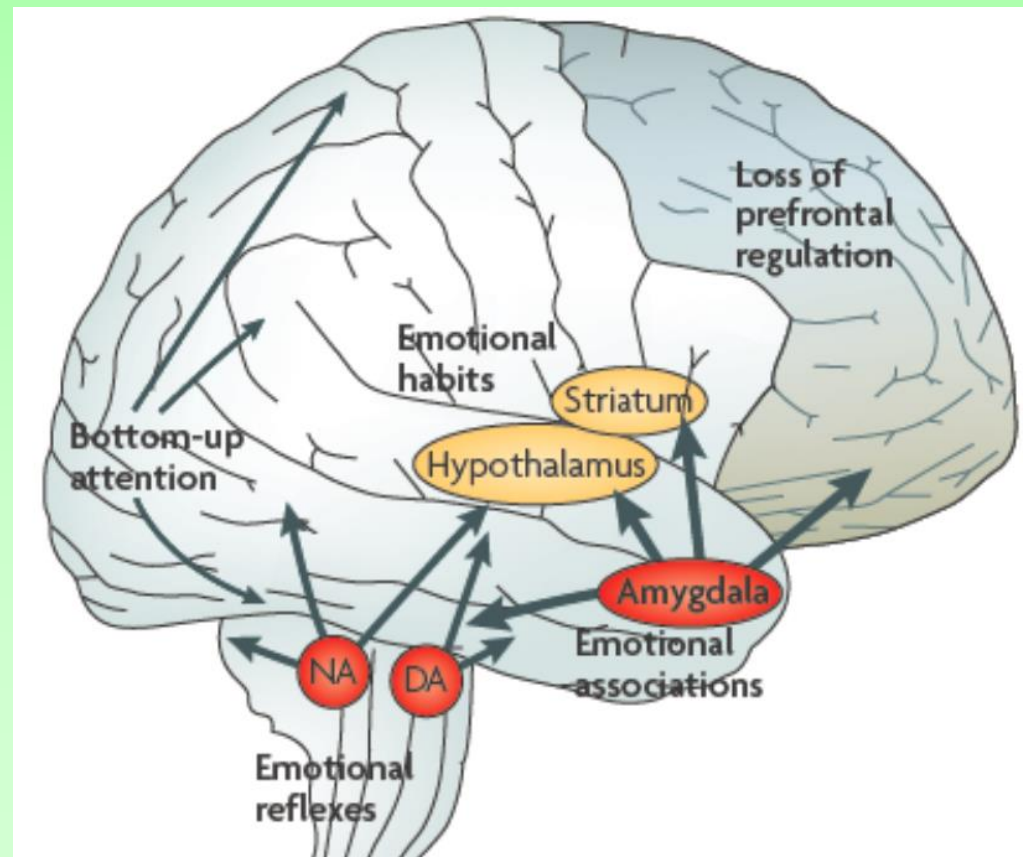
- **Moderate** increases in stress: attention/ self-regulation **maximized**
  - Rise above moderate levels: shift to more **reactive** response to experience



# Stress

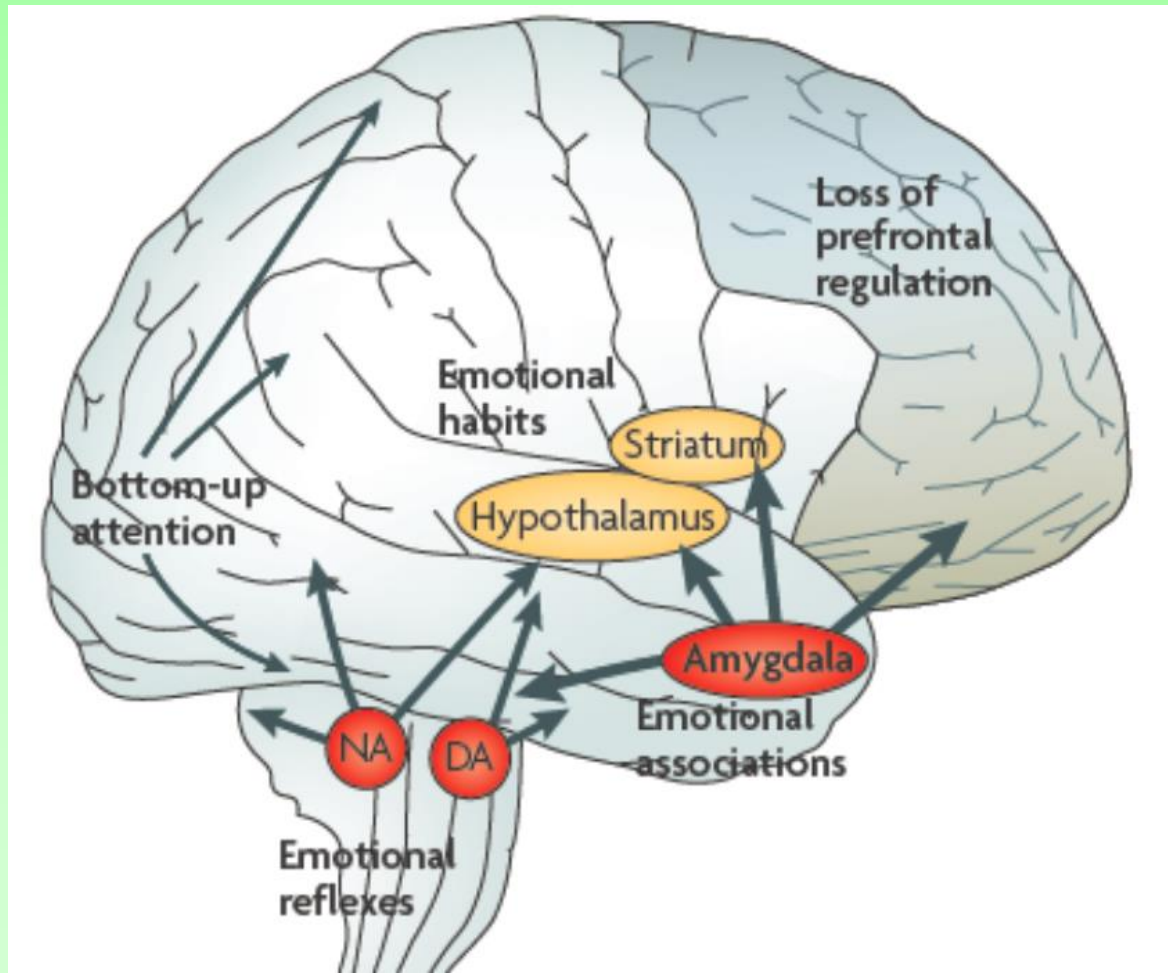
- **Amygdala** activates stress pathways
  - PFC regulation **impaired**
  - Amygdala function **strengthened**

- Regulation switches from **reflective** (“top down”) to **reactive** (“bottom up”)



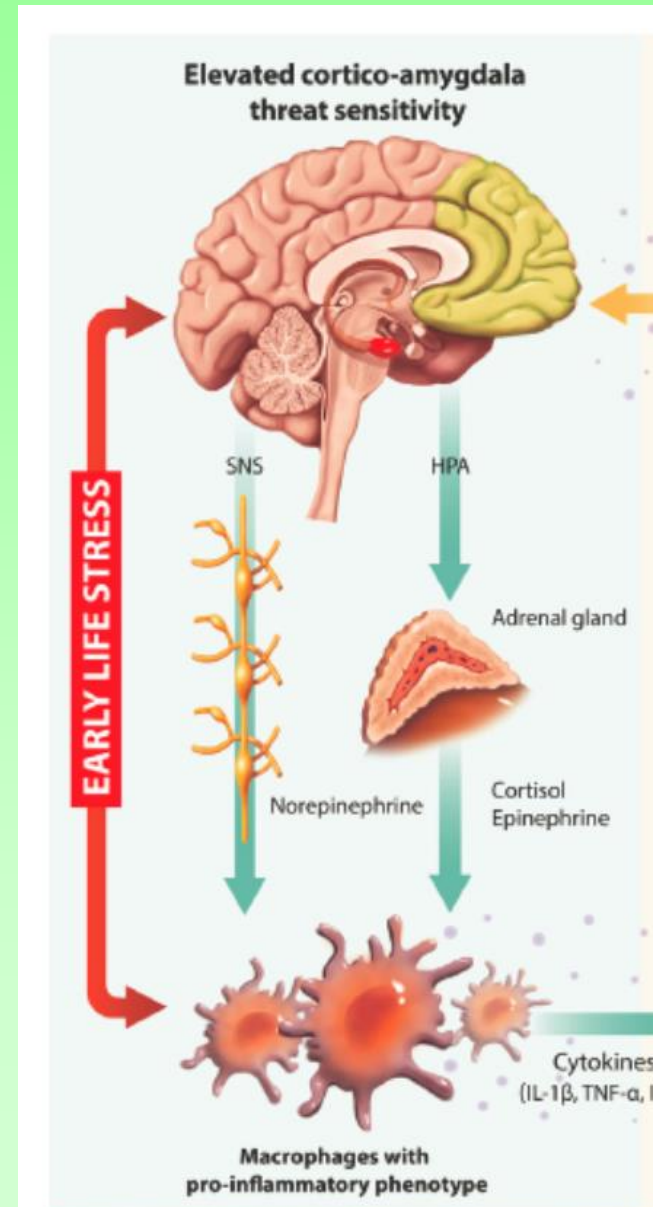
# Stress

- **Amygdala** activates stress pathways
  - What happens when stress is **chronic**?



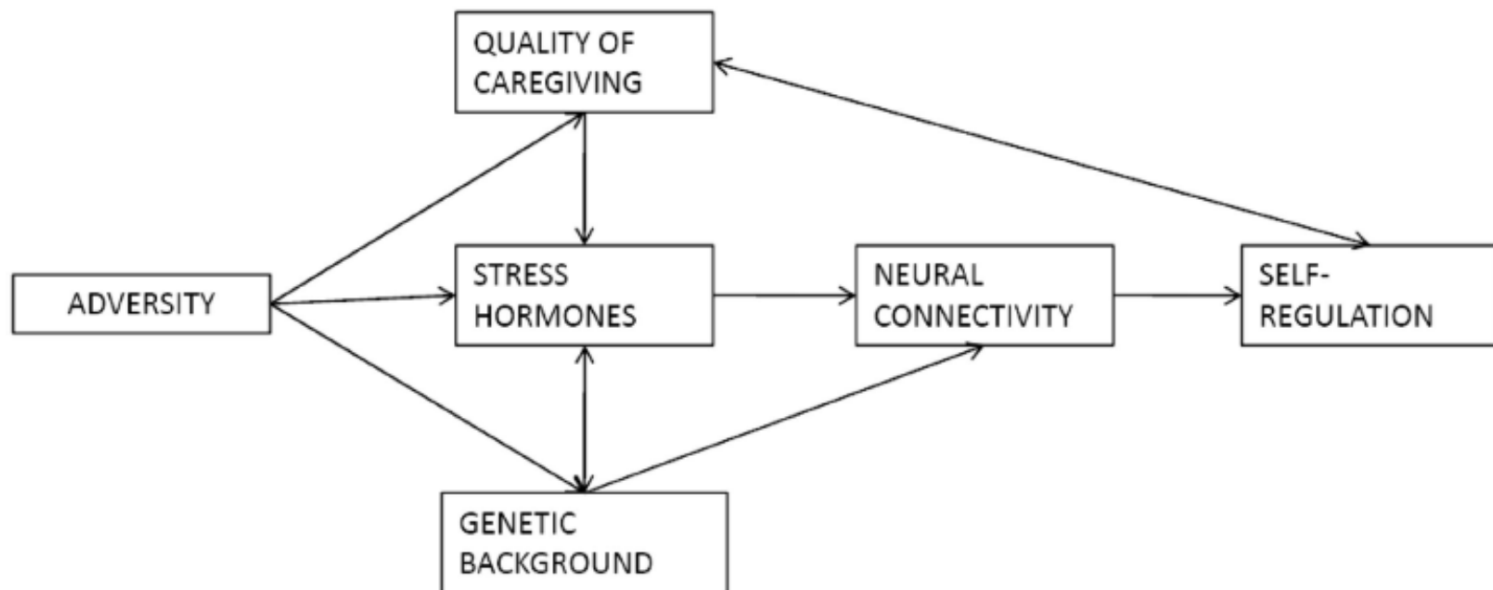
# Threat sensitivity

- How would chronic stress affect the PFC-amygdala connection?
  - More **reactive** amygdala
  - Less regulated by PFC
- **Hyper vigilance** / sensitivity to threat



# Self-regulation and environment

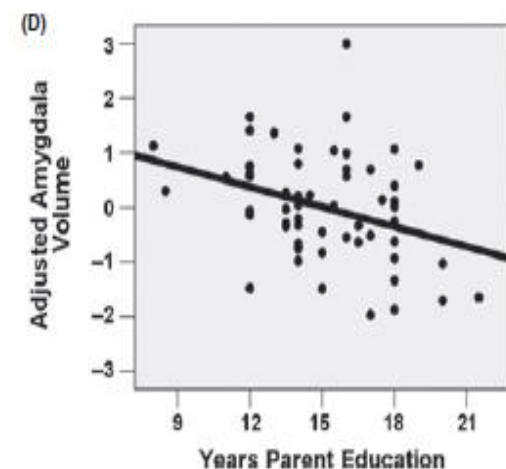
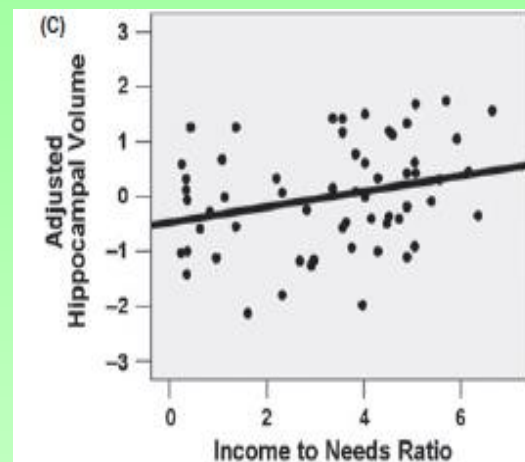
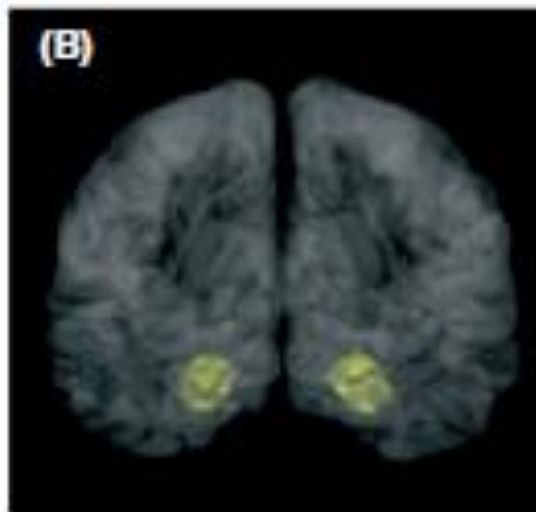
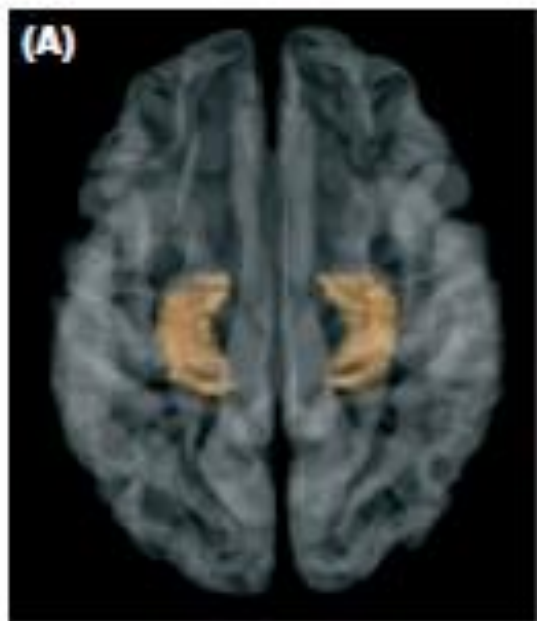
- Not just deficit – **adaptation** to environment
  - Shaped by biology and experience
- **Hypervigilance** – more **reactive** profile
  - Adaptive for more threatening environment
  - But **classroom environment?**





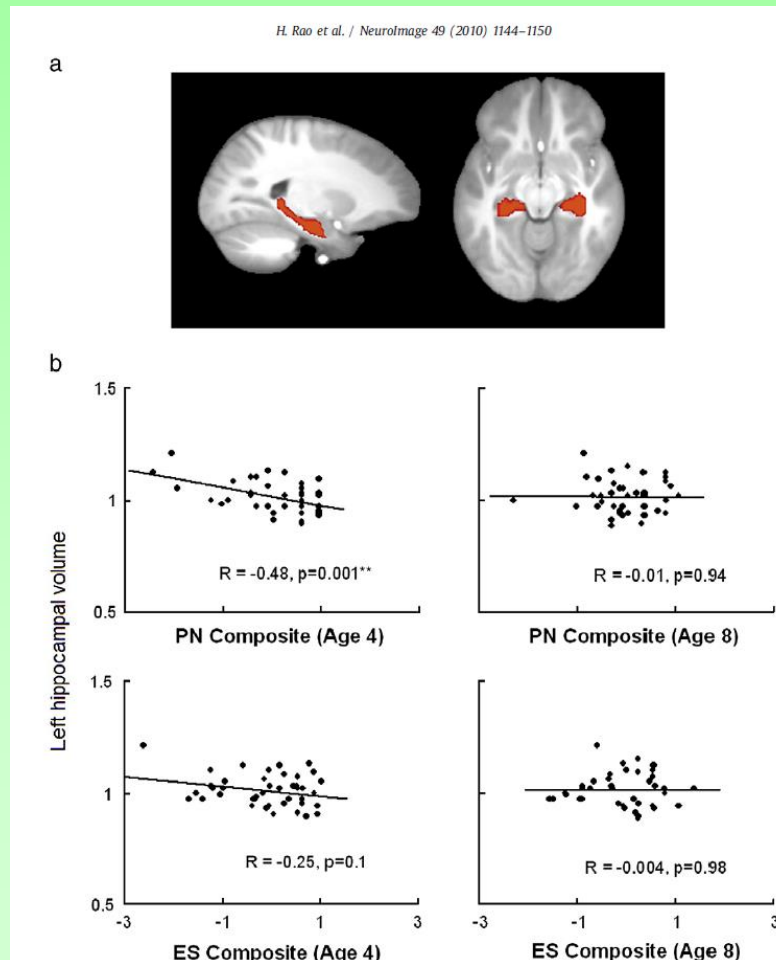
# SES and brain structure

- SES correlated with amygdala and hippocampus volume



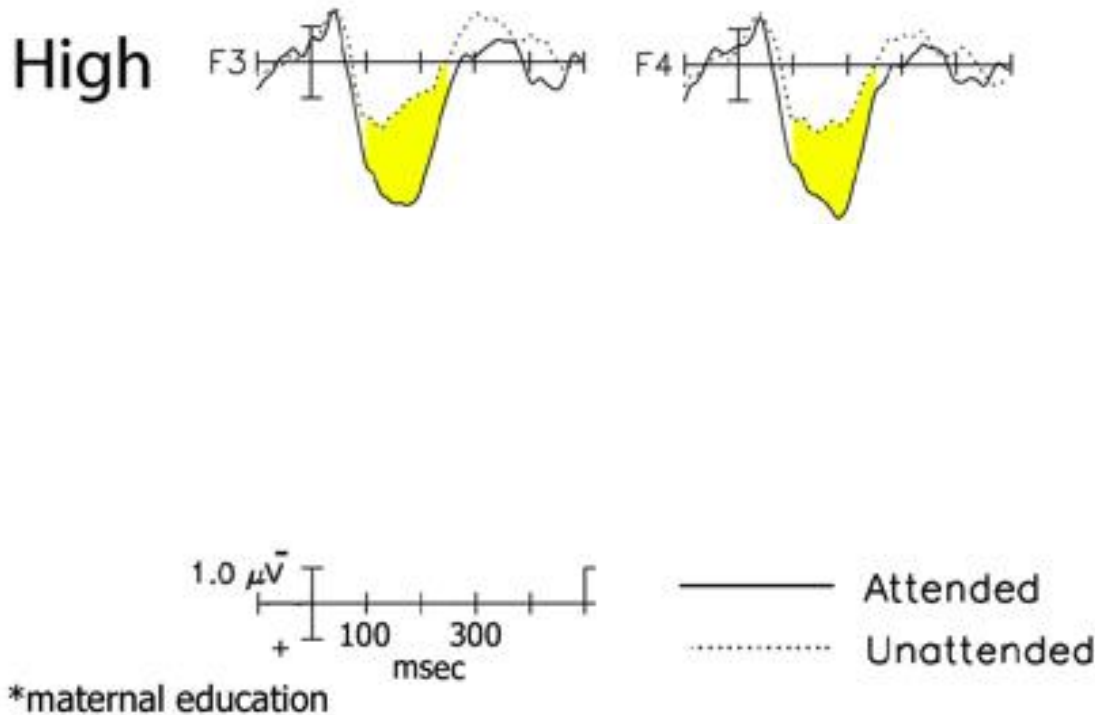
# SES and brain structure

- Effects of **parental nurturance** on hippocampus volume at age 4 but not age 8:



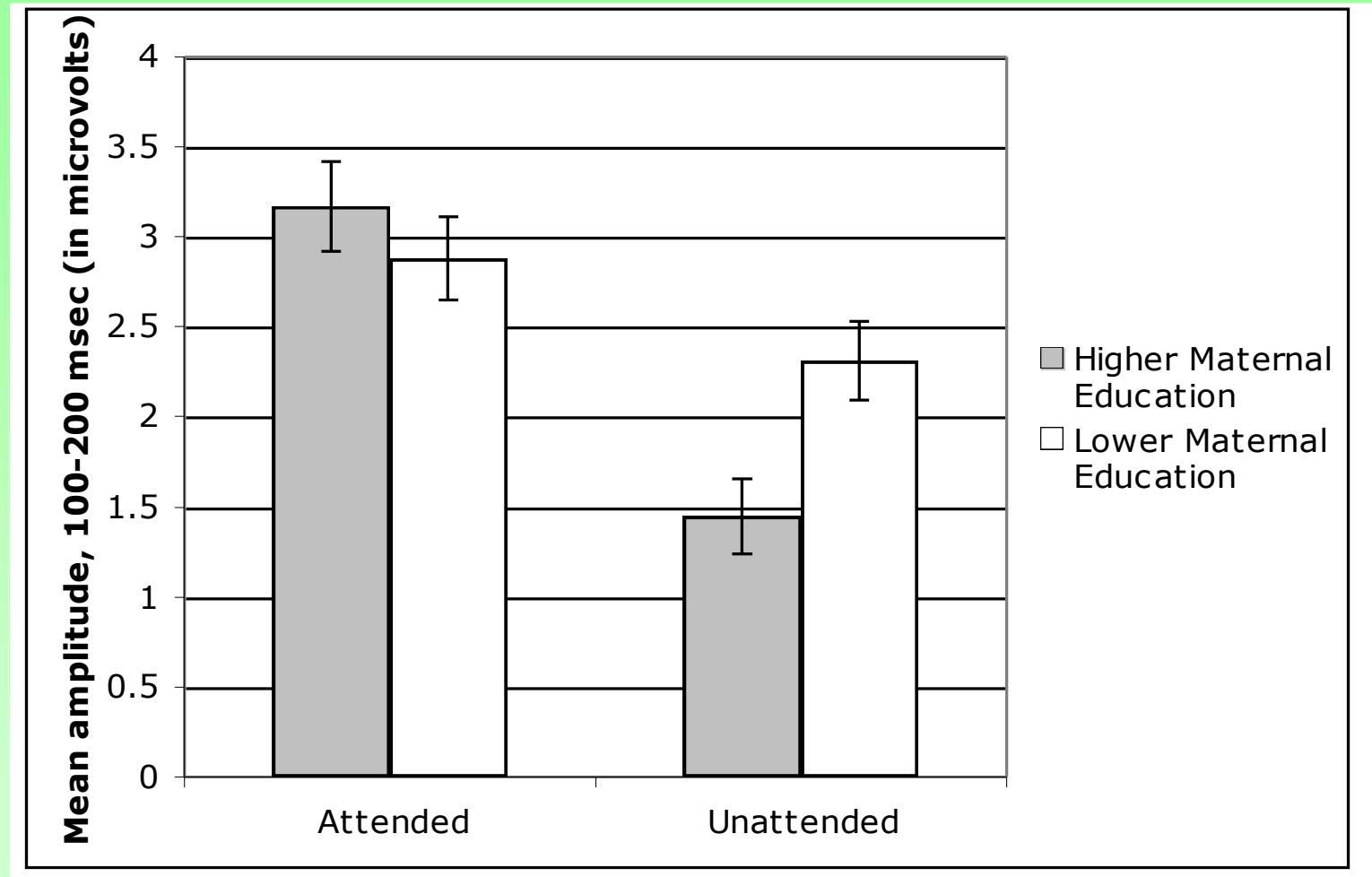
# SES and attention

## SES\* and Attention 4-7 Years



Vulnerable in  
lower SES  
children

# SES and attention

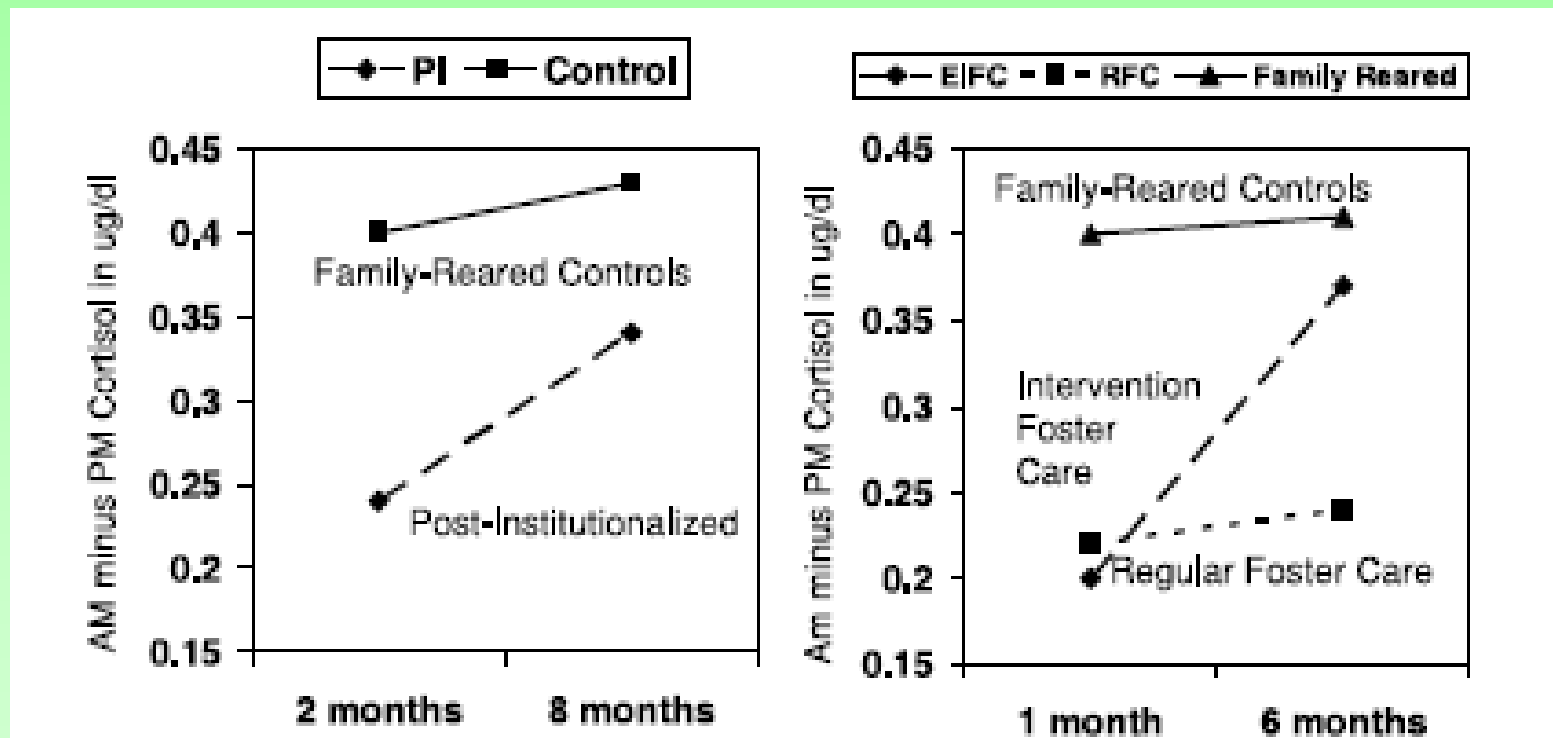


Mean Amplitude from 100-200 ms of Responses to Unattended and Attended Probes

# **ENHANCEABILITY**

# Adoption/intervention and cortisol

- Adoption and intervention (foster parenting) can regularize stress hormone (cortisol)



# Intervention studies

- Older studies of high-quality preschool with random assignment and long-term follow-up
- Perry Preschool Project (1962-64)
  - Comprehensive program for 3-5 year olds
  - 5 Days per week, 2.5 Hours per day
  - Included education, health, and family support
- Abecedarian Project (1972-77)
  - Intensive intervention from infancy-kindergarten
  - \$42,871 average cost per child
  - Full-day, full-year, supplemented by home visits

# Intervention studies

- Changes in children randomly assigned to intervention groups in Perry and Abecedarian Projects:
  - **Short-term:** cognitive benefits (some fade-out)
  - **Long-term** predictive of:
    - Increases in high school graduation
    - Increases in employment and income
    - Decreases in welfare
    - Decreases in incarceration



# **PARTNERSHIP WITH EDUCATION**

# Partnership with Head Start of Lane County



- All children living at or below the poverty level
- Participating families **randomly assigned** to a control group or one of several training programs
- Over 800 participants to date
- 3- to 5-year-old children

# Two-generation intervention

- Parents and Children Making Connections – Highlighting Attention (**PCMC-A**)
- Weekly **child training**
  - “Brain Train”
  - 50-min. sessions
- Weekly **parent training**
  - Combination of OSLC and unique components

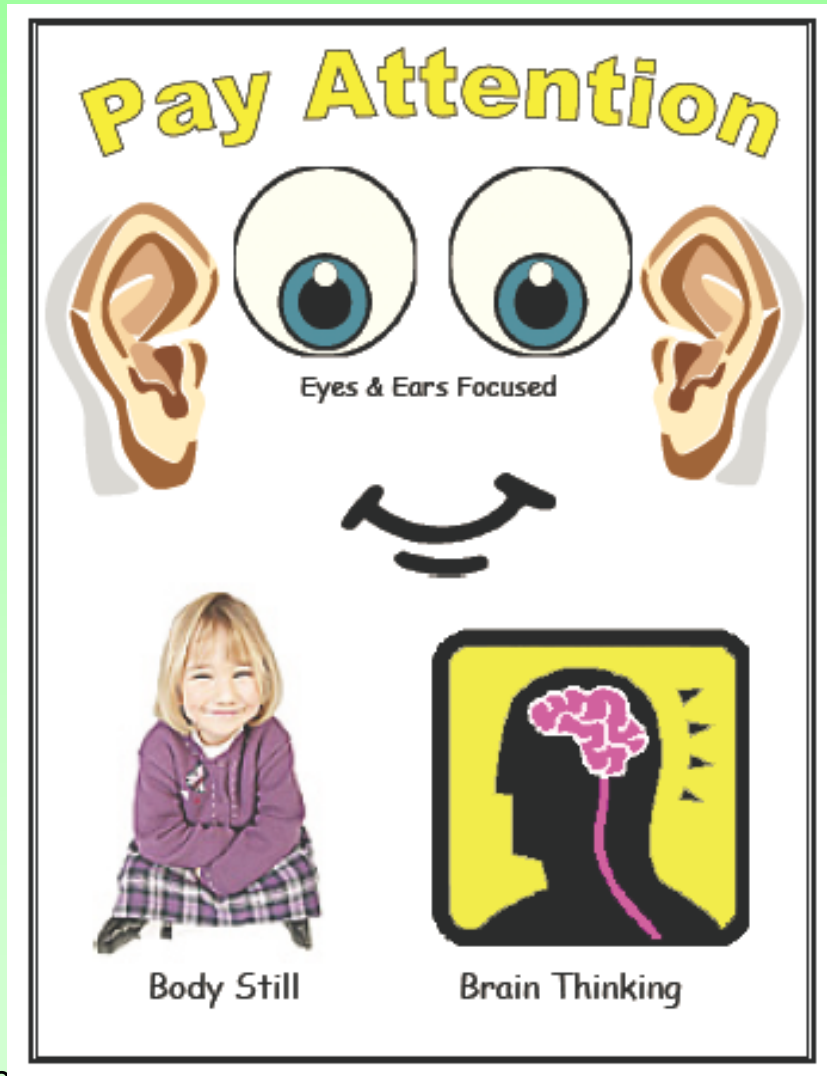


# Child attention training: “Brain Train”

- Engaging activities targeting core components:
  - Positive social interaction
  - Metacognitive awareness
  - Self-regulation
  - Focused attention
  - Dealing with distraction

# Child attention training: "Brain Train"

- Engaging activities targeting core components:



# Parent training

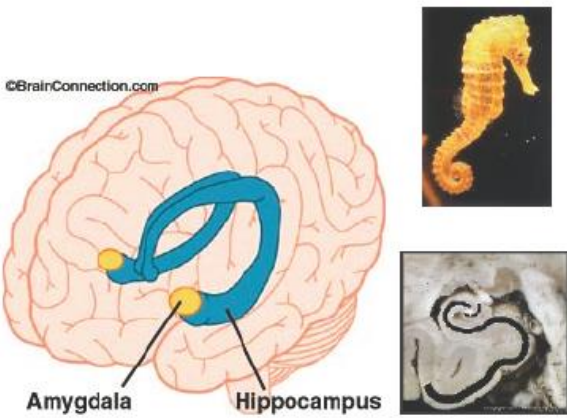
- Eight weekly two-hour meetings in interactive small-group setting
- Goals for parents include:
  - Strengthen positive relationship with child by providing high levels of **positive reinforcement** and **specific praise**
  - Monitor and improve **language** use with child to encourage high-quality interactions
  - Foster child **emotional regulation** by increasing awareness of emotional states and using strategies to support emerging regulation skills

# Parent training

- Goals for parents include:
  - Manage **family stress** by improving **consistency** and **predictability**, awareness and avoidance of **power struggles**
  - Support child **attention** and **self-regulation**
    - Strategies (e.g., giving child opportunities to **make choices** and **solve problems** in variety of situations)
    - Sharing of strategies and materials from **child attention training activities** to facilitate generalization in home

# Parent training

- Emotional saturation:



©BrainConnection.com

Amygdala Hippocampus

Emotional Saturation

The **amygdala** (yellow) helps to process emotions & the **hippocampus** (blue) helps in learning & in creating new memories.


When the **amygdala** gets saturated with emotion, it does not interact well with the **hippocampus**.

During times of high emotions attention, memory, and learning don't happen optimally.

“Optimized Attention” & “Optimized Learning” happen when emotions are calm.

**Adults can Stop Wasting Energy!**

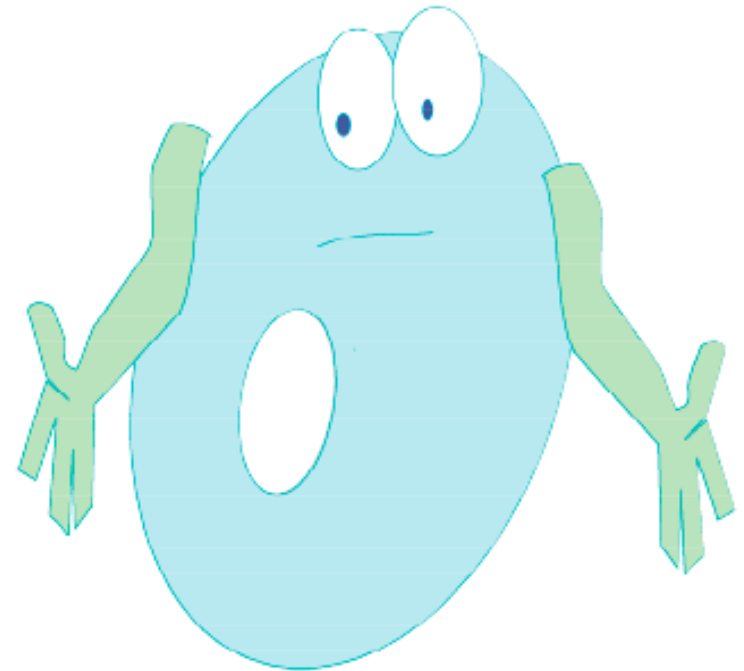
- ✓ **Short statements**
- ✓ **Model emotional control**
- ✓ **No arguing**
- ✓ **No big explanations or justifications**
- ✓ **No bribing** (“if you do this, you can have that”)
- ✓ **No threats** (“if you \_\_\_\_, you will lose going to the birthday party”)





# Parent training

- Support child self-regulation:



1. Take a deep breath and shrug your shoulders
2. Say, "Oh Well, I can..." (Think of solutions)
3. Be aware of when *you or your child(ren)* are frustrated. Model this strategy when you are upset, and cue them when they are upset.

# Evidence for PCMC-A

## -PCMC-A (N = 66)

## -Comparison groups

### -Head Start alone (HS-alone; N = 38)

- Children attended regular Head Start
- No specialized parent/family training

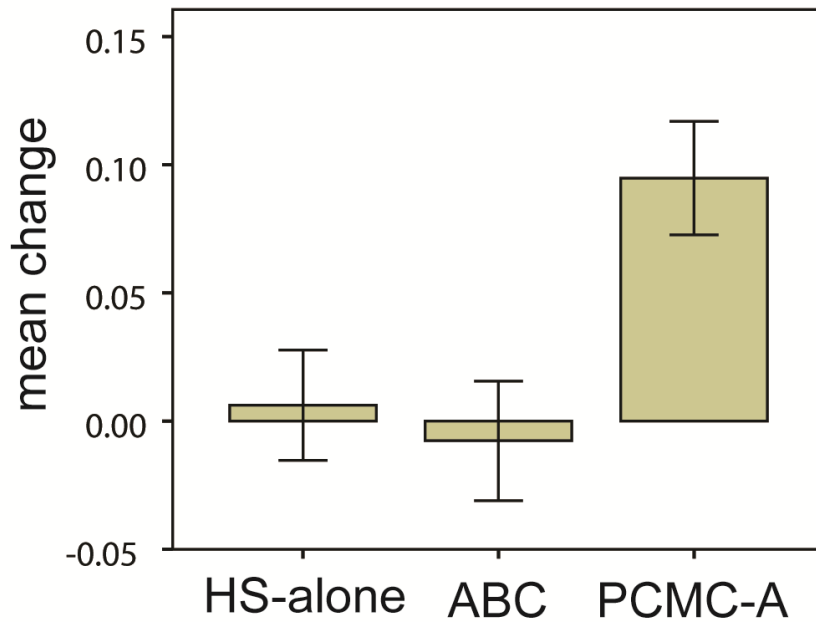
### -Attention Boost for Children (ABC; N = 37)

- Emphasis on small group child-directed training
- Child sessions: 40 minutes/day, four days per week, held as pullout sessions during the regular Head Start day.
- Parents received three small group sessions lasting 90 minutes held in alternating weeks

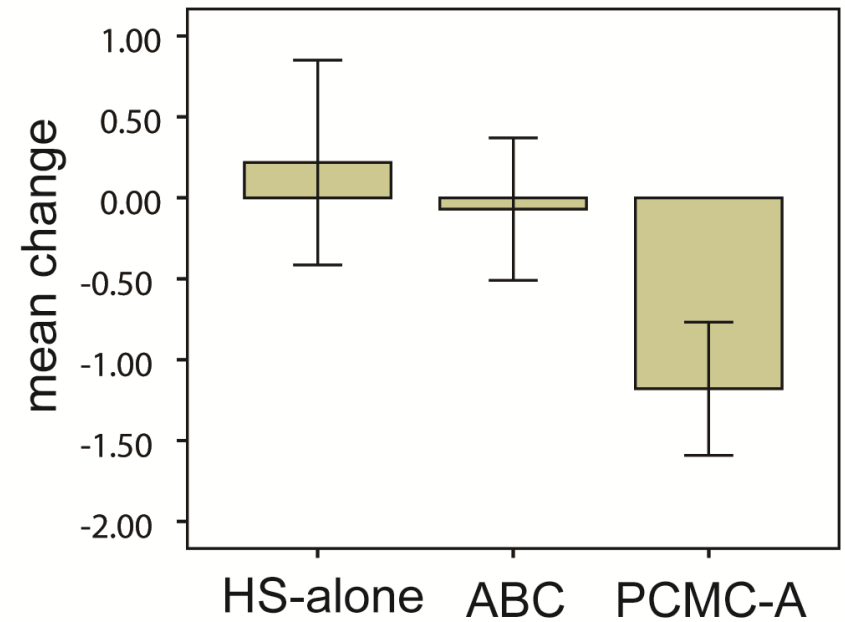
# Evidence for PCMC-A

## Changes in Parents

### Turn Taking



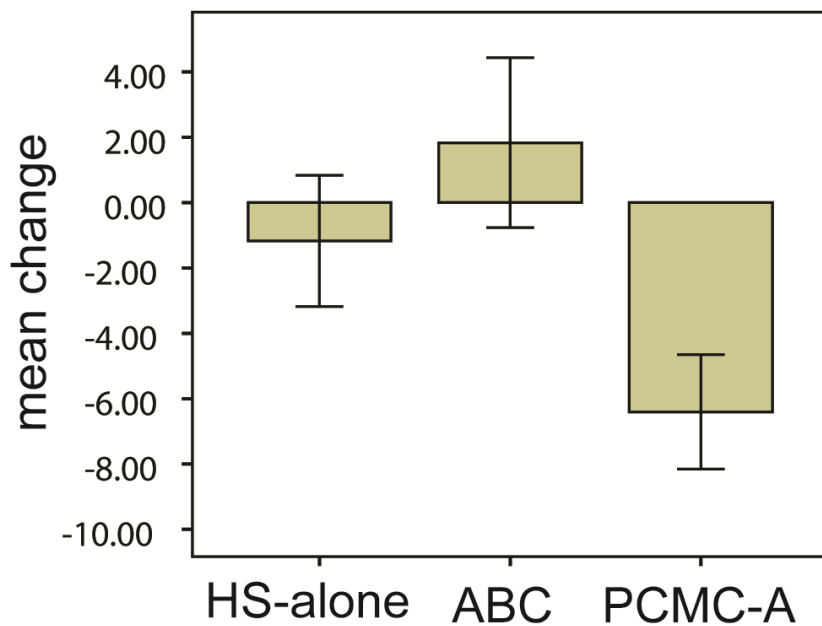
### Parent Stress



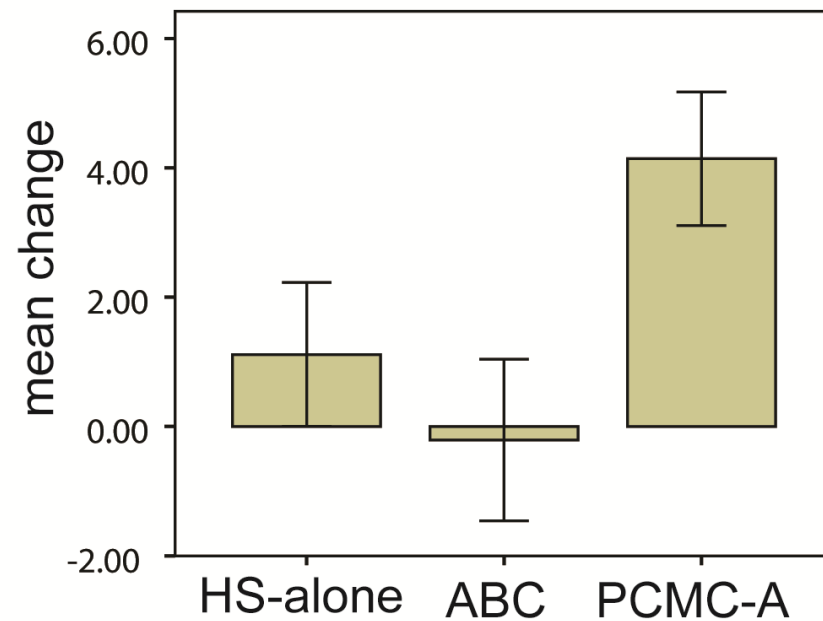
# Evidence for PCMC-A

## Changes in Child Behavior

### Problem Behavior

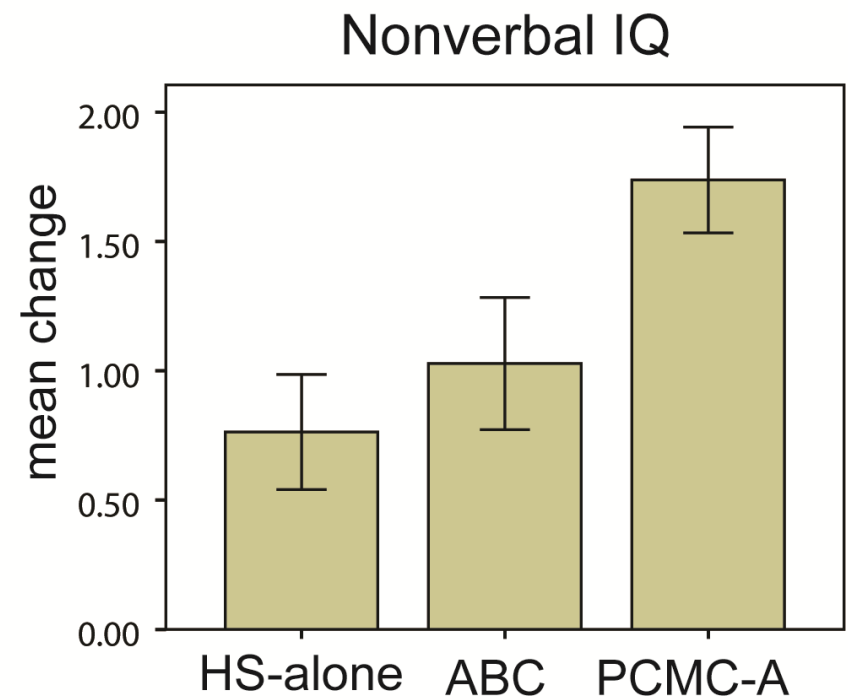
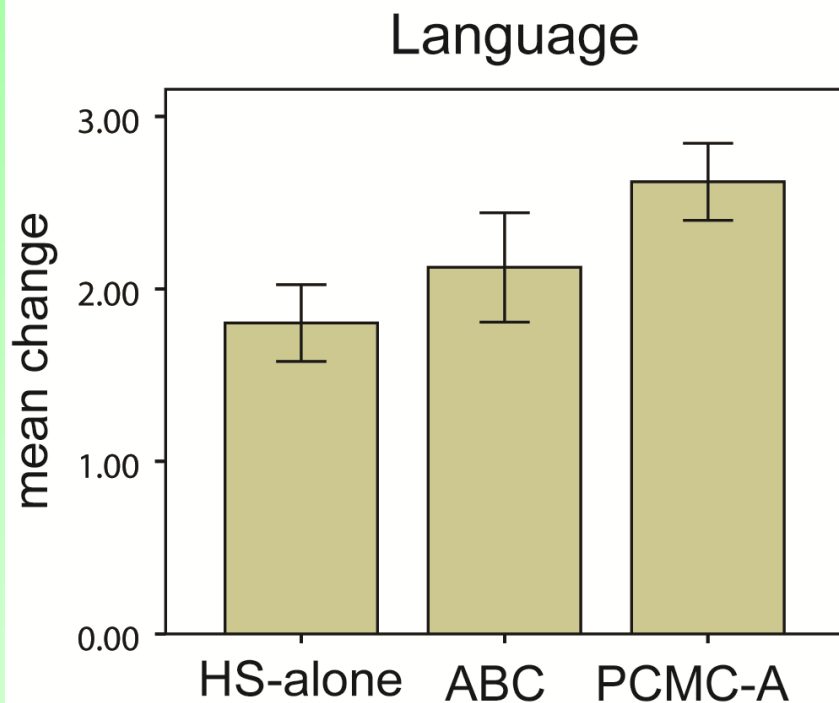


### Social Skills



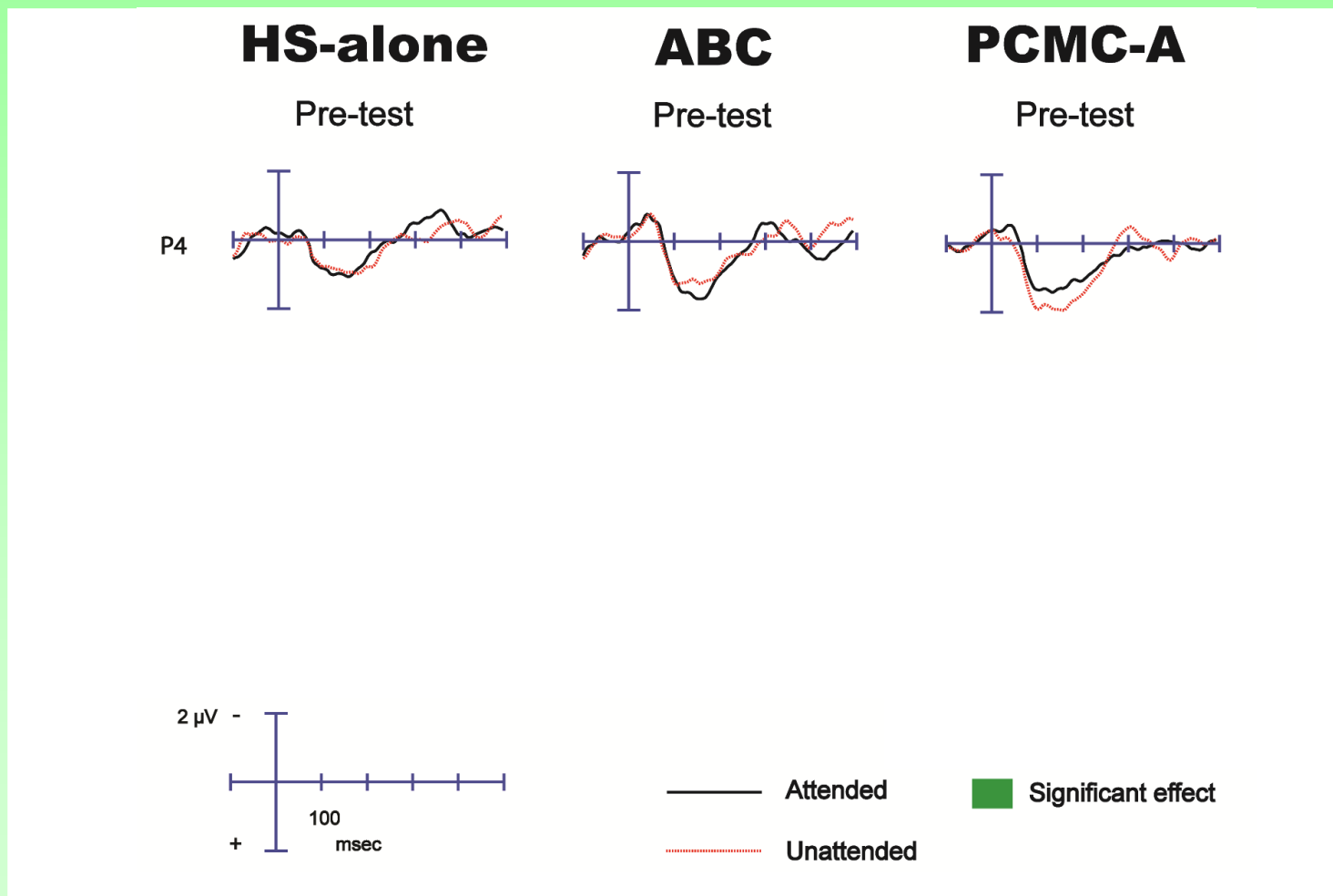
# Evidence for PCMC-A

## Changes in Child Cognition



# Evidence for PCMC-A

- Event-related potentials (ERPs): selective attention



# Current project



- Head Start University Partnerships:  
Dual Generation Approaches

- Department of Health and Human Services
- Formal partnership with Head Start of Lane County
- One of only four projects nationwide

# Current project



- Head Start University Partnerships: Dual Generation Approaches
- Goals:
  - Develop and implement delivery model
    - Integrated into Head Start services
    - Sustainable and replicable by other Head Start programs
  - Improve assessments
    - Stress and attention/self-regulation in children and parents



# Head Start University Partnership

- Develop delivery model of intervention for **broader implementation**:
  - Sustainable and replicable by other Head Start programs

## Creating Connections: Strong Families, Strong Brains



# Creating Connections

- Child component (“Brain Train”) implemented in **classrooms**
  - Integrated throughout school year
  - Also selected **parent strategies**
- Parent component delivered in eight weekly two-hour parent groups mid-year
  - Combination of **BDL interventionists** and **Head Start staff**
  - Multiple days/times at two sites



Creating  
CONNECTIONS

# Increased integration

- Creating Connections: selected **parent strategies** in classroom
  - Goal: increase consistency from **classroom** to **home environment**
- **Common vocabulary**: specific praise/noticing, clear statements, metacognitive (“thinking”) vocabulary
- **Strategies** to increase consistency: picture notes, weekly calendars



Creating  
CONNECTIONS

# Increased integration

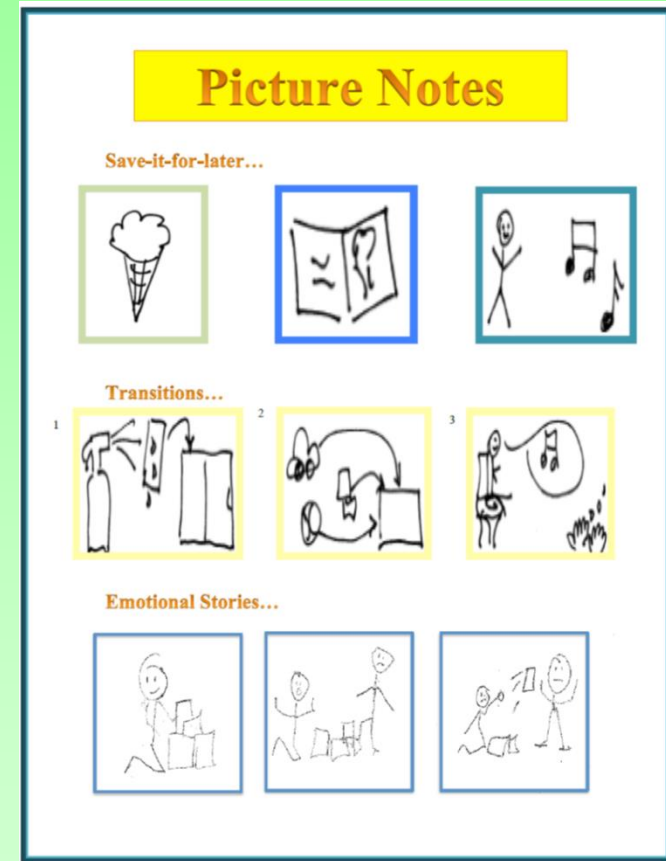
- Implementation of **parent strategies in classroom** improves integration
  - Greater **consistency** from classroom to home environment:
    - **Reduced stress** for children
    - Children familiar with strategies before parents learn – **more success for parents**
    - **Parent recruitment:** “These strategies work great! Come to the parent groups and find out more!”



Creating  
CONNECTIONS

# Increased integration

- Parenting strategies in classroom
  - Picture notes: teacher favorite
  - Weekly calendars: similar to home success charts





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Creating  
CONNECTIONS

# Hypotheses

- Targeting self-regulation **simultaneously in children and adults** can:
  - Improve **stress physiology** and **self-regulation**
    - In children **and** parents
    - Targeting self-regulation in children
    - Many parent strategies require self-regulation
  - Improve **family well-being**
    - E.g., health, education, financial decision making



Creating  
CONNECTIONS

# Head Start University Partnership

- Improved assessments of intervention
  - Stress physiology and brain function for **attention** and **self-regulation**
    - In **children and adults** pre- and post-intervention (parent component)
  - Broader outcomes related to **family well-being**
    - E.g., health, education, financial decision making



Creating  
CONNECTIONS



# Broader effects?

- Promising to target self-regulation with **two-generation** approaches (e.g., Shonkoff, 2012; Shonkoff & Fisher, 2013)
  - Protect children from consequences of early adversity (e.g., chronic stress)
    - Potential to **improve self-regulation** and school readiness in **children**
  - Simultaneously **improving self-regulation** in **adults** may lead to broader improvements
    - Self-regulation as **core capability** essential for success in home and workplace (Shonkoff, 2012)



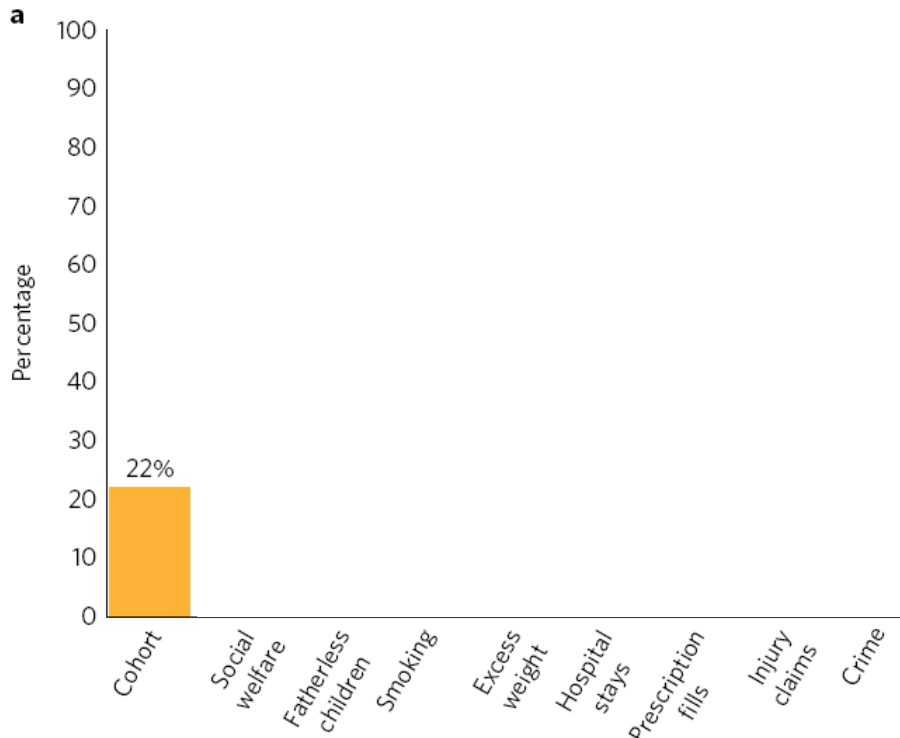
Creating  
CONNECTIONS

# Costs to society

- Costs of growing up in poverty: estimated to be equivalent to almost 4% of GDP (~ \$500 billion/year)
  - Reduced productivity and economic output (1.3% GDP)
  - Increased costs related to crime (1.3% GDP)
  - Increased direct and indirect health expenditures / value of life expectancy (1.2% GDP)

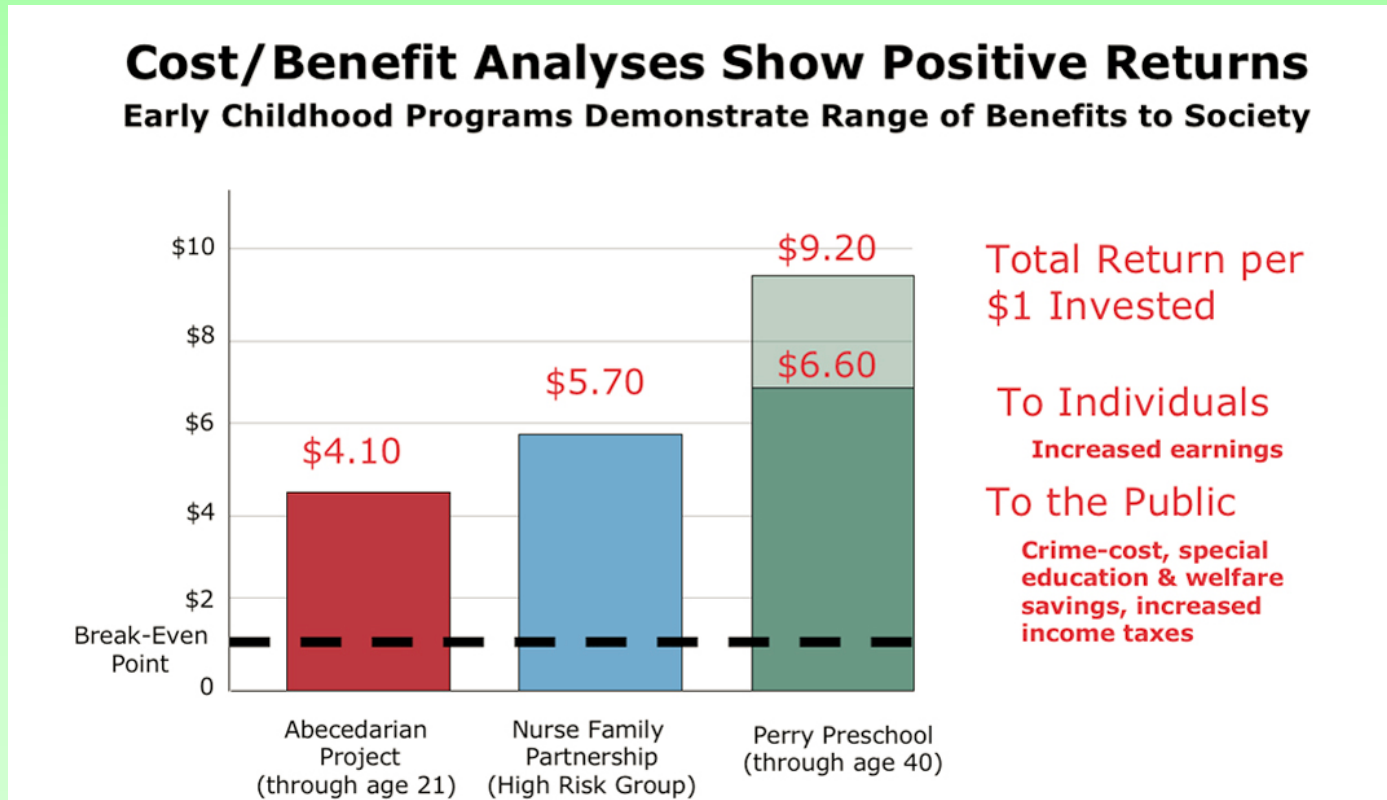
# Costs to society

- New estimation of **costs of early adversity**:
  - **Most vulnerable 22%** based on early risk factors: SES, maltreatment exposure, IQ, self-regulation
    - What % of health/social economic-burden outcomes?



# Good investment

- Long-term outcomes from early studies permit **cost/benefit analyses**
  - Evidence suggests **high return on investment**



# Good investment

- Early analysis of two-generation program
  - **Estimated** PCMC-A costs: about \$800 per student
  - **Estimated** benefits (based on previous studies):
    - Improved cognitive skills/self-esteem
    - Reduced special education, grade repetition, crime
    - Increased high school graduation, college
    - Increased employment, income (tax)
- **Estimate: at least 9:1 return on investment**
- Currently conducting updated analysis

# Main points

- The developing brain is very plastic
  - **Neuroplasticity** is a “double-edged sword”
    - Vulnerable to experience (e.g., early adversity)
    - Enhanceable (e.g., high-quality preschool)
- Engaging **parents** and **home environment** can strengthen preschool
- High-quality early childhood education is **good investment**

# CHANGING BRAINS

Effects of Experience on Human Brain Development



UNIVERSITY OF OREGON BRAIN DEVELOPMENT LAB



[changingbrains.org](http://changingbrains.org)

# Thank you



Head Start of Lane County

*Ensuring that our youngest children have a solid foundation for life.*

- Theodore Bell
- Melissa Gomsrud
- Ryan Guiliano
- Christina Karns
- Scott Klein
- Zayra Longoria
- Lauren O'Neill
- Helen Neville



- And many wonderful and dedicated RAs!



# Thank you



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