

Impact of Trauma on Early Brain Development

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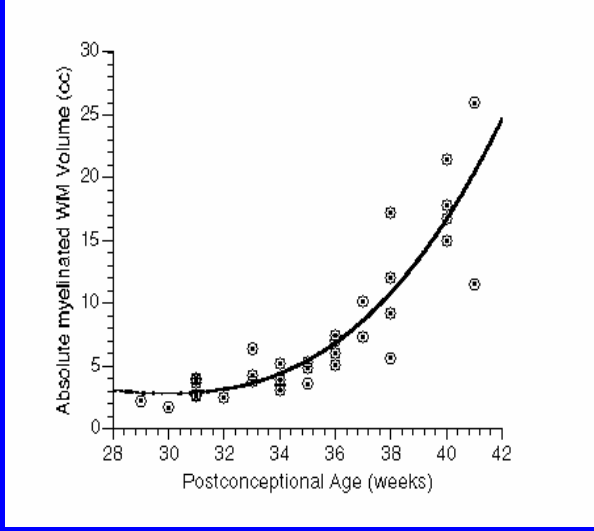
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What Promotes Healthy Development of the Human Brain?

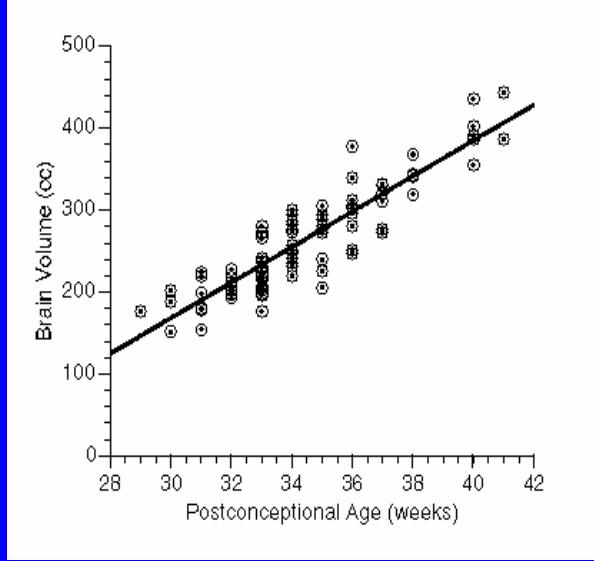
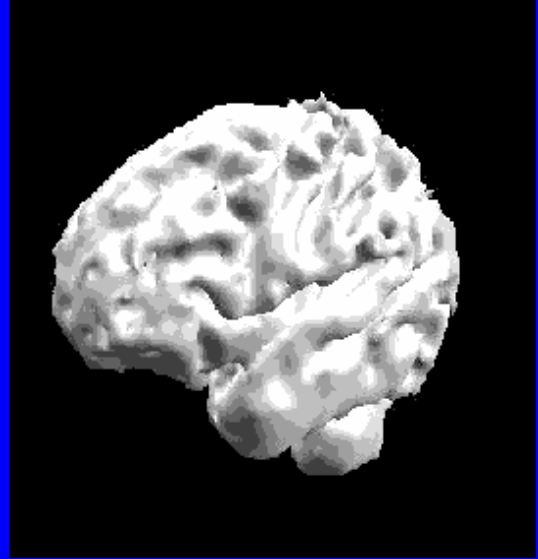
- Good nutrition
- A stimulating environment
- Healthy relationships with loving caretakers

Brain Development Accelerates Dramatically after Birth

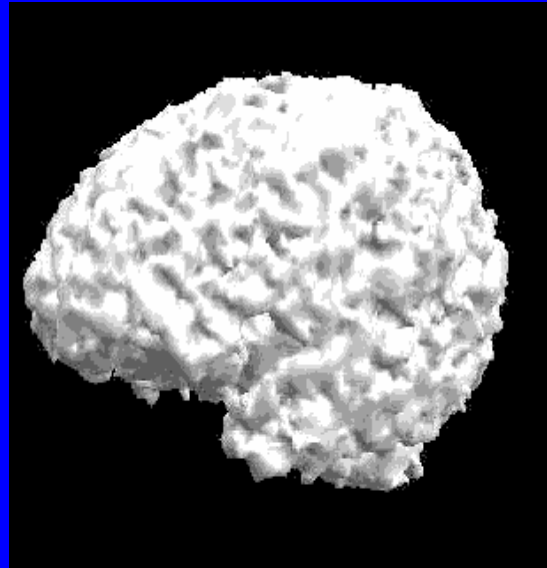
Measures of Brain Development from Huppi et al., 1999



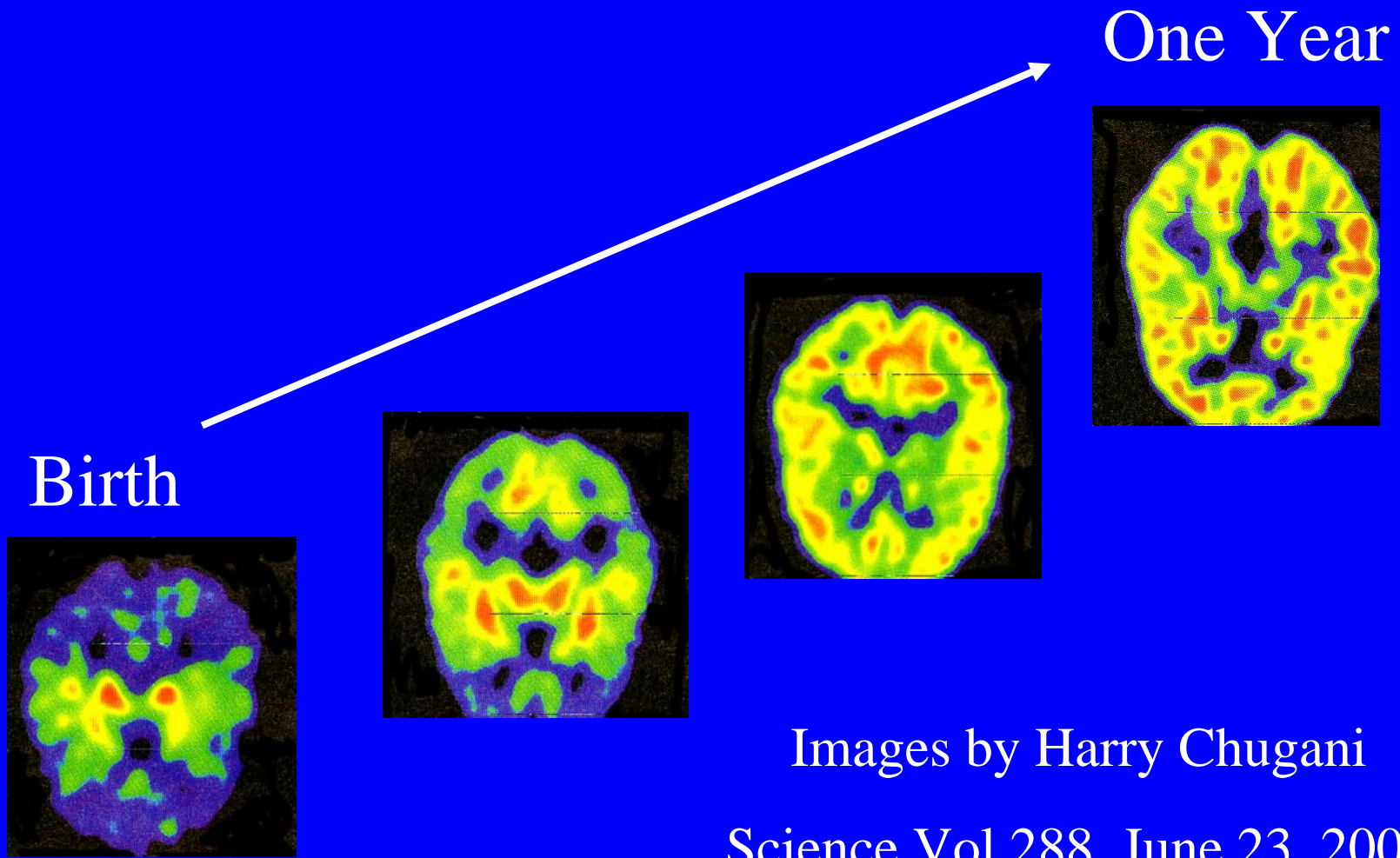
PreTerm Infant (31 Weeks)



Term Infant (40 Weeks)



PET Scans Showing Increasing Brain Metabolic Activity: Birth to One Year of Age



Images by Harry Chugani

Science Vol 288, June 23, 2000

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Brain Growth

- From Birth to 6 Yrs - dramatic brain growth
- Yet, 1/2 to 2/3's of neurons born in fetal development will die programmed deaths!
- Growth due to elongation of axons, expansion of dendrites as synapses form, and myelination
- Although pure cognitive functions are established by midadolescence, emotional components mature well into adulthood

Brain Growth



Newborn

6 Year old

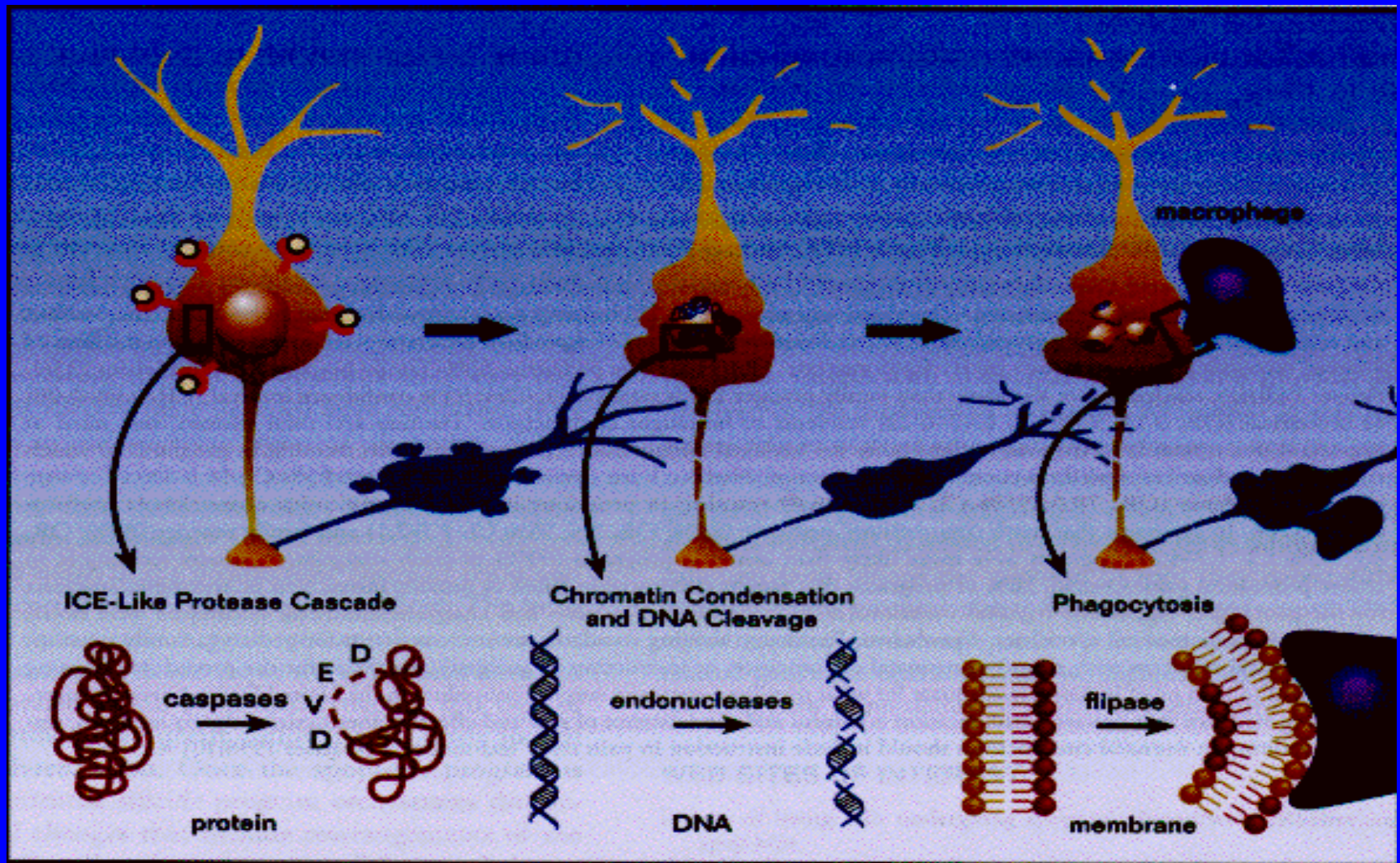
Newborn

6 Year old

Selective Neuronal Death Shapes the Developing Nervous System

- Half of all neurons & glial cells die during development
- Only neurons with the right synaptic connections will survive
- Growth factors responsible for survival (repress 'neuron suicide')

Apoptosis (Neuron Suicide)

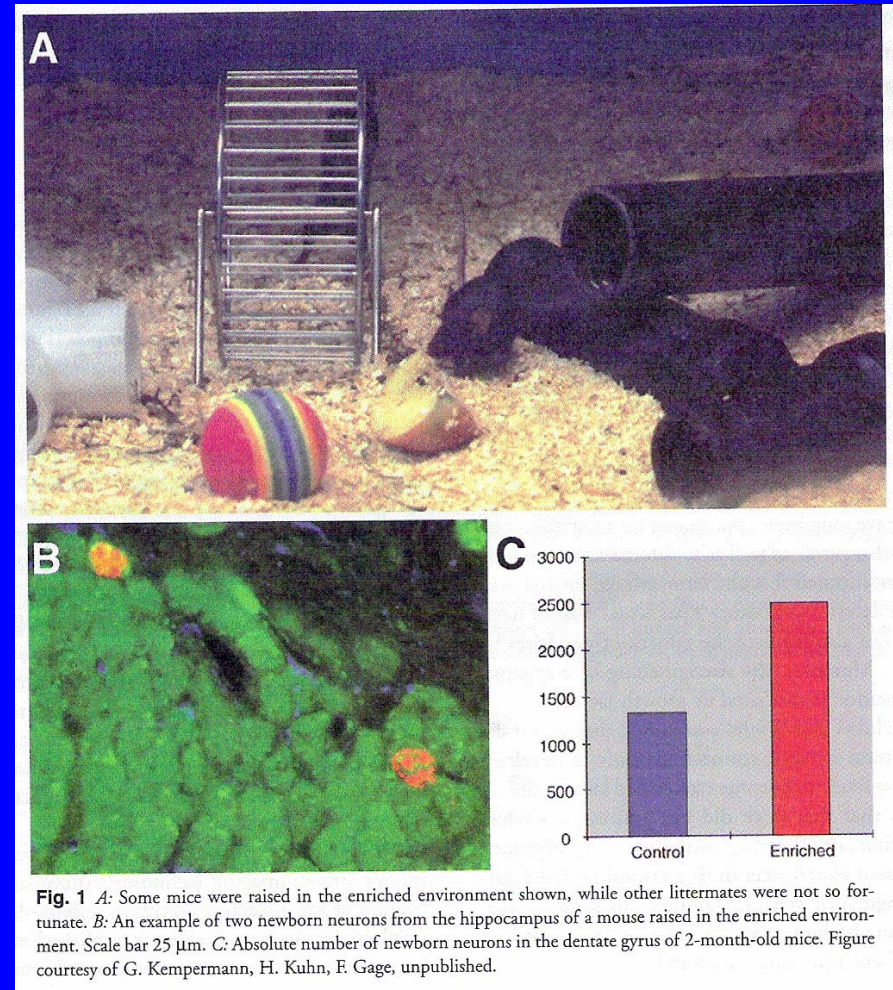


Experience Alters Brain Development

Hubel & Wiesel (kittens) -
visual input important for
proper segregation of
fibers & visual function

Kemperman (mice) -
enriched environments
increased brain size and
ability to learn new tasks

Knudsen (barn owls) -
enriched environments
increase auditory-visual
neuronal adaptation to
altered visual input



Enriched Environment Triples Window of Opportunity to¹⁰ Re-Wire Visual-Auditory Brain Pathways (Knudsen's Barn Owl Chicks)

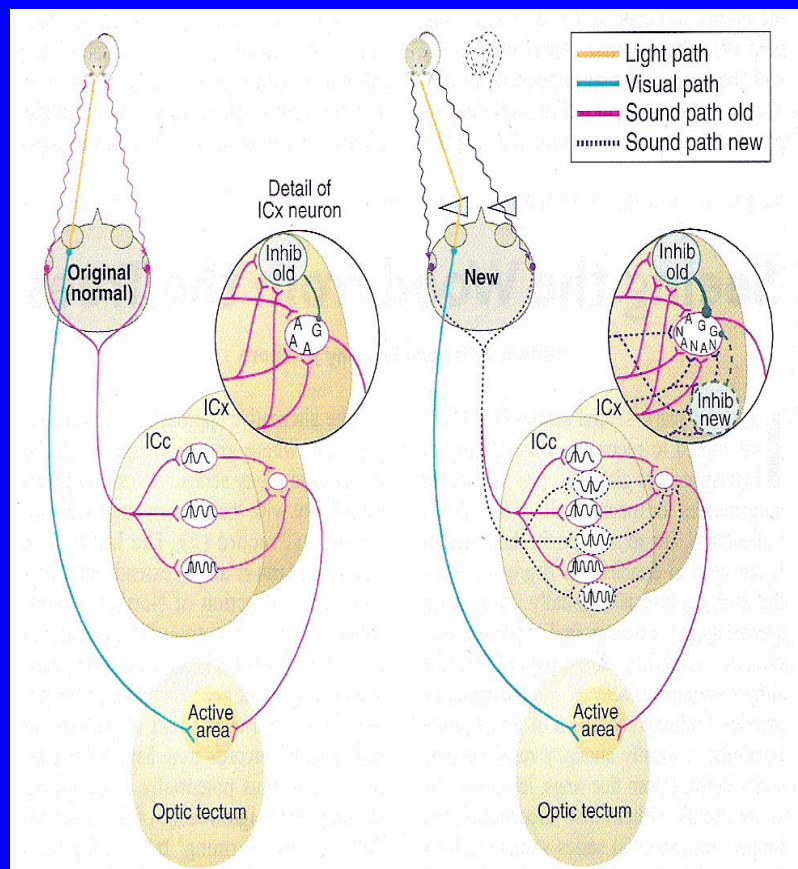


Image: Science 279 6 March 1998, p 1451

Image: Science 284 7 May 1999, p 925

Experience Affects Brain Development

- Childhood is a time for learning (languages, music, motor skills most easily acquired)
- Number of synapses increases dramatically after birth
- Environment-stimulated neuronal activity is critical for elaboration of synaptic territories and 'proper' connections

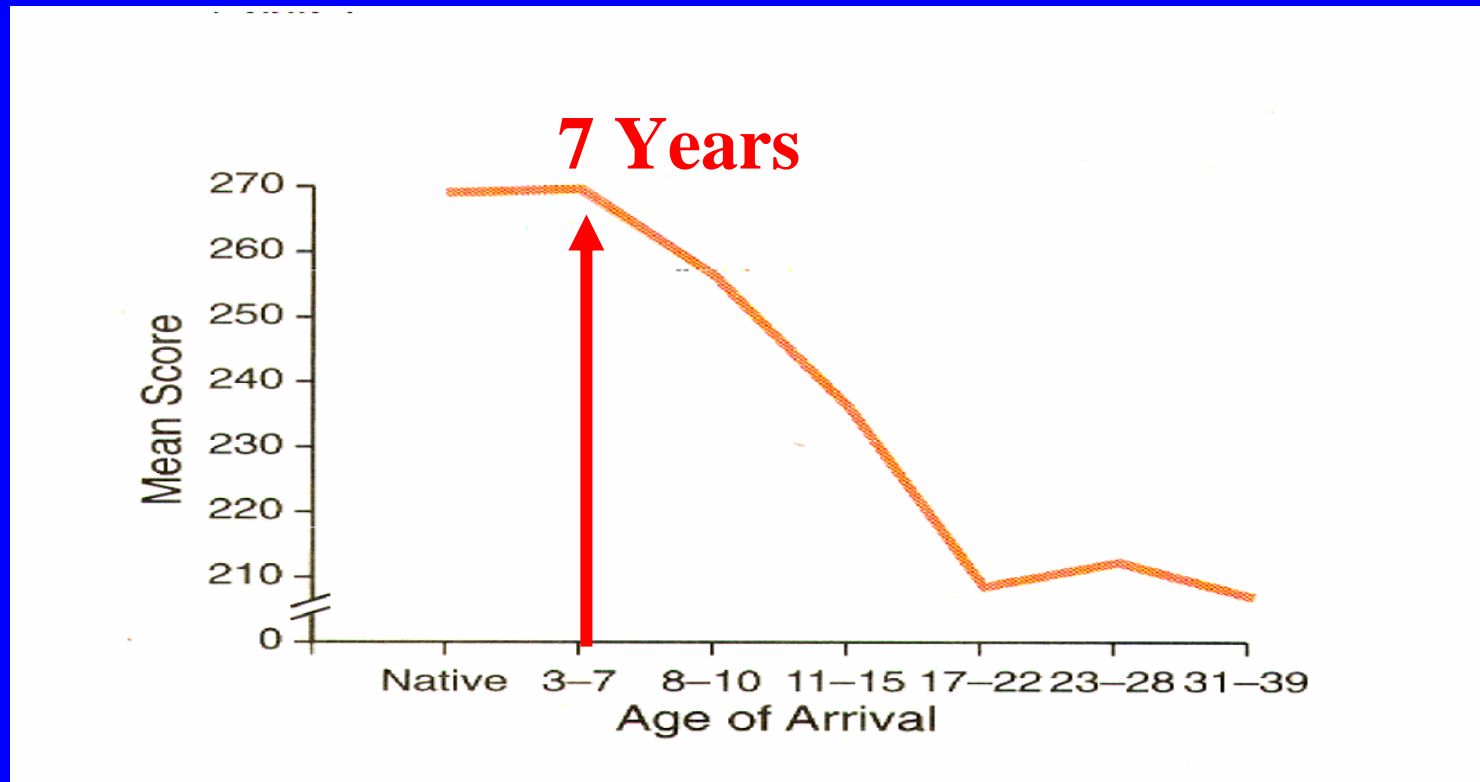
Growth of the Human Brain from birth to 20 years



FIGURE 1.1. Growth of whole brain compared when mature weight is taken at 12.5 years and at 20 years. Note the accelerated growth in the first 2 years. (From Himwich,

Sensitive Period for a Second Language Declines after Age 7 and Ends by Late Adolescence

Immigrant scores on a language test decline with the age at which they were first immersed in English



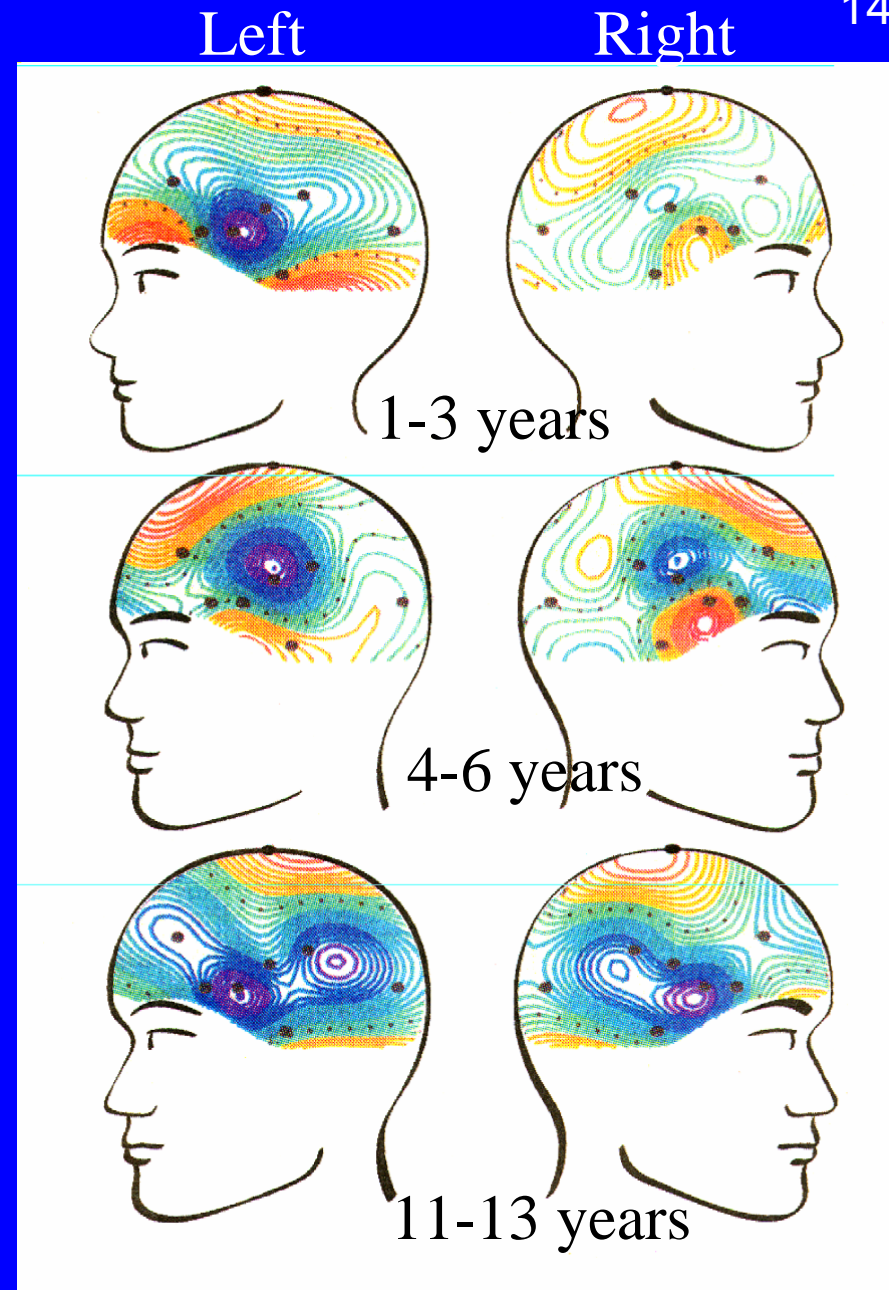
Science, Vol 288, 23 June 2000, p 2119

Sensitive Periods

Switching Sides

As subjects learn a new language at older ages, there is an increasing amount of right hemispheric activity.

Science, Vol 288, 23June2000, p 2117

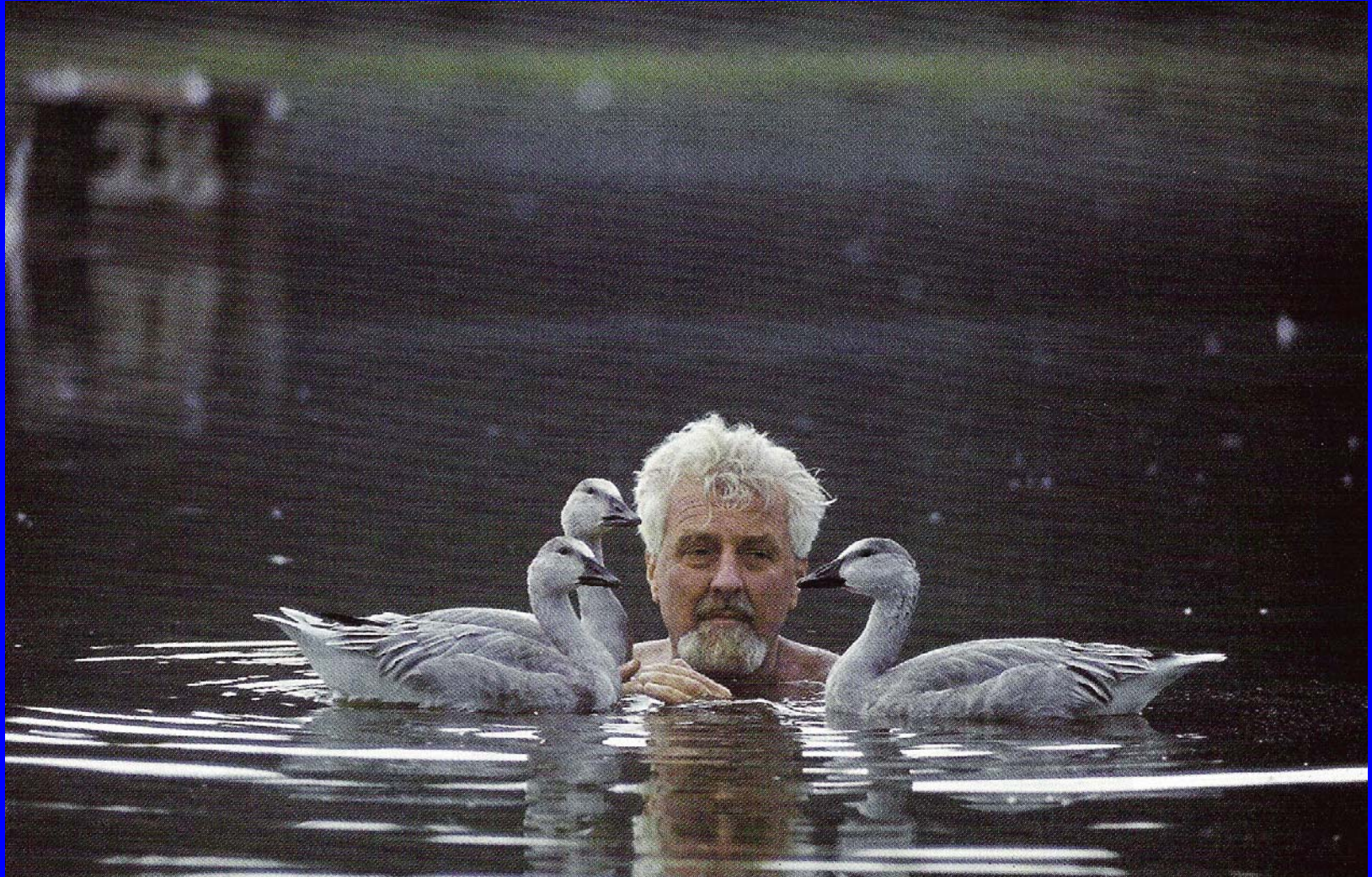


Neurodevelopmental Windows of Opportunity

Domain	Sensitive Period
Emotional Intelligence	0-48 Months
Motor Development	0-24 Months
Vision	0-24 Months
Early Sounds	4-8 Months
Music	0-36 Months
Second Language	0-60 Months

“Imprinting” – The Biological Substrate for “Attachment”

(Konrad Lorenz, 1903-1989)



Attachment



Attachment

- Attachment refers to the organization of behavior within an infant-caretaker relationship
- In human infants, attachment is at the core of the regulation of emotional experience
- Four major patterns of attachment (secure, anxious-avoidant, anxious-resistant, and disoriented-disorganized (type D))

Key Features of Infant Social and Emotional Development

- Infants are born with remarkable faculties. They can imitate facial expressions, learn to manipulate their environments, and show preferences for caregivers.
- Infants have a need to seek out interaction with others (e.g., “still-face” paradigm).
- Infants can elicit social and emotional responses from caregivers.

Key Features of Infant Social and Emotional Development


- Communication between mothers and infants is organized around face, voice, gesture, and gaze
- There is mutual and synergistic regulation (“a dance”)
- Secure attachment is the cornerstone of early social and emotional development
- Communication directly influences, and is influenced by, brain development and emerging physiological regulation



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FOR EVERY CHILD AND EVERY CHILDREN

Trauma and Brain Damage

Human Data

- Combat PTSD patients had 8% decrease in right hippocampal volume compared with matched controls - correlated ($r=0.64$; $p<0.05$) with memory retention deficits (Bremner et al., 1995)
- Female child abuse PTSD patients had 12% decrease in left hippocampal volume compared with controls (Bremner et al., 1997)

Trauma and Brain Damage

Human Data

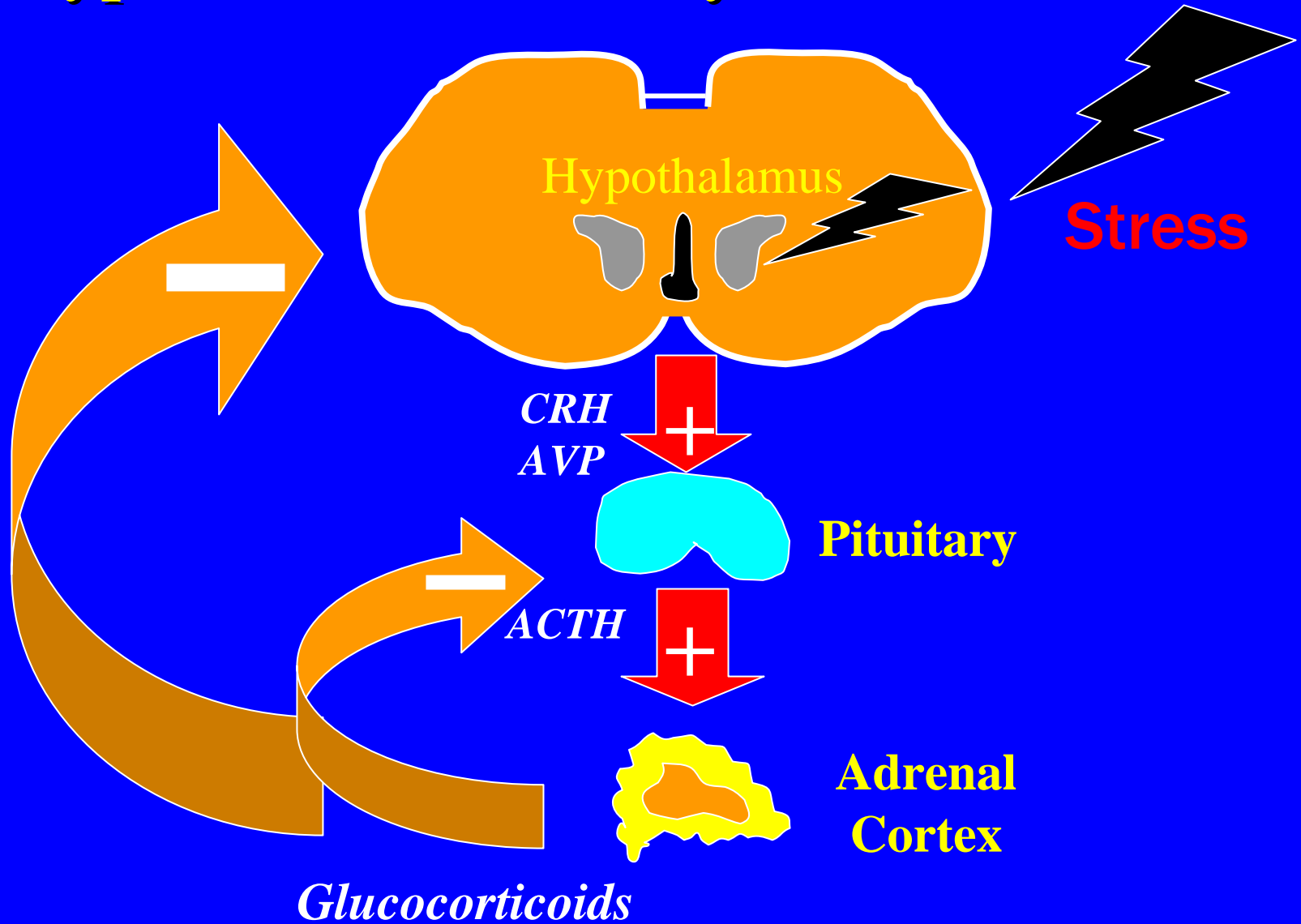
- Female abuse PTSD patients had 5% decrease in left hippocampal volume compared to matched controls - correlated ($r=0.73$) with dissociative symptoms (Stein et al. 1997)
- Many studies have demonstrated significant memory impairments in victims of trauma including autobiographical memories and explicit free recall short-term memories

Abnormal Inter-Hemispheric Connections in Maltreated Children: De Bellis et al., 1999

- Corpus Callosum - mid sagittal region and areas 4, 5, 6, & 7 were smaller in maltreated children with PTSD
- Decrease correlates with: Intrusive thoughts, avoidance, hyperarousal & dissociation
- Effects boys > girls



Hypothalamic-Pituitary-Adrenal Axis



High Levels of Glucocorticoids and Brain Damage

- Loss of dendritic branching
- Alterations in synaptic terminal structures
- Inhibition of neuronal regeneration in CA3 region of hippocampus
- Associated with memory deficits
- Mechanism thought to involve disruptions in cellular metabolism with increased vulnerability to excitatory amino acids

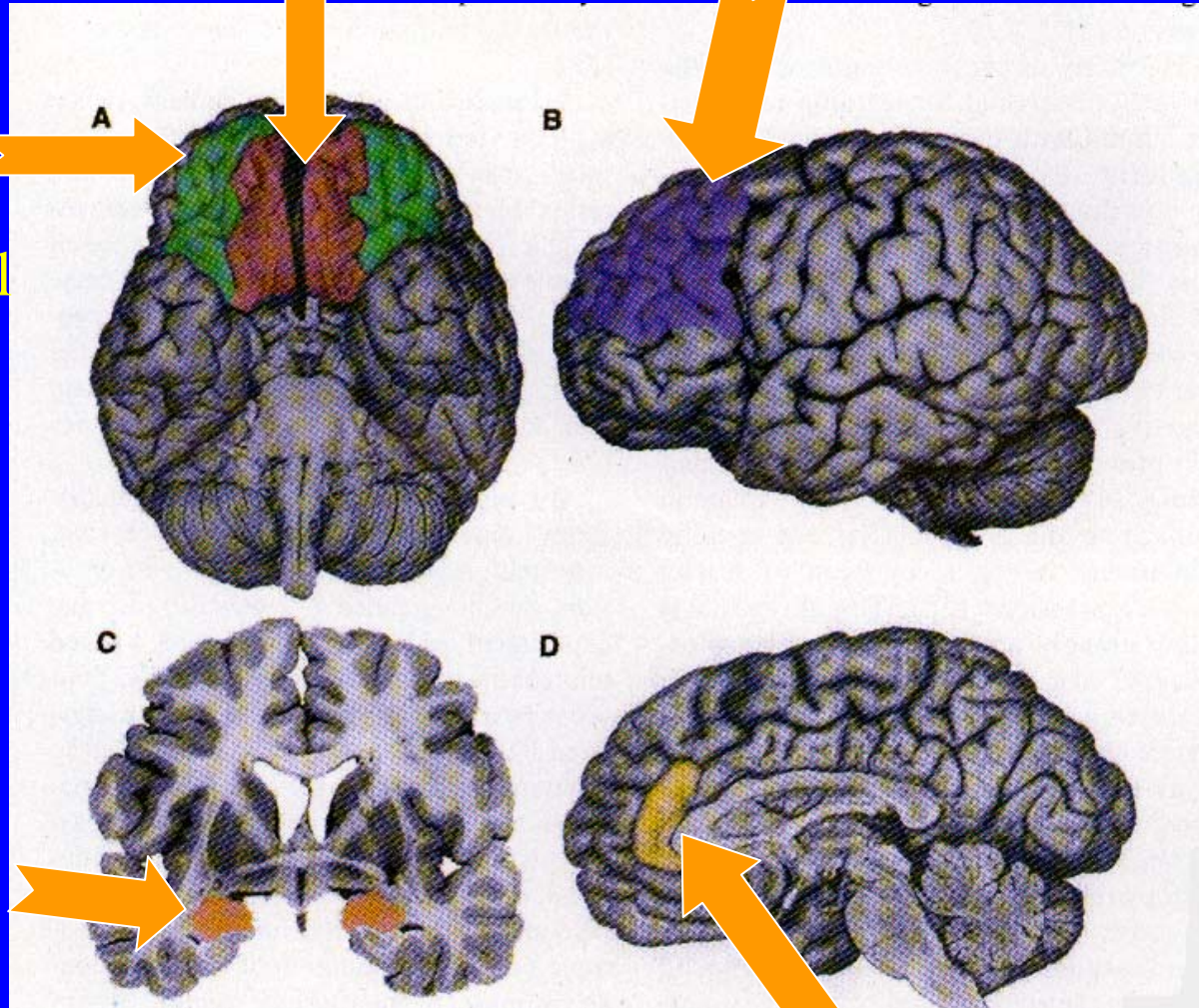
Trauma Impacts Key Structures Underlying Emotional Regulation 27

Ventral Prefrontal Cortex

Dorsolateral Cortex

Orbital Prefrontal Cortex

Amygdala



Science Vol 289, p 592

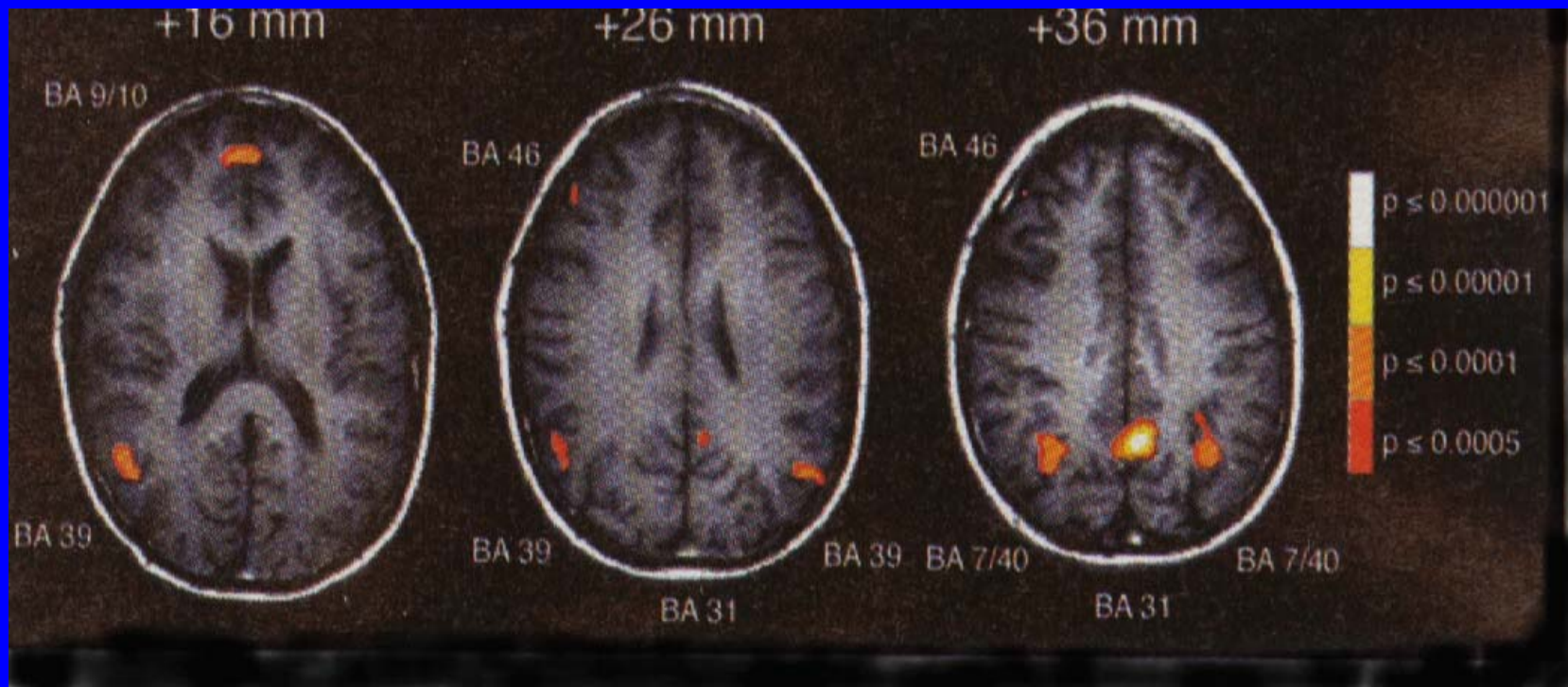
Anterior Cingulate
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Emotions and Moral Judgment

Greene et al. *Science*, 293:2105-8, 2001

Brain Areas showing differences between moral-personal vs. moral-impersonal dilemmas (e.g., runaway trolley scenario)

All areas activated by moral-personal dilemmas are associated with emotional processing



Social & Emotional Deficits in Maltreated Children

- Maltreated children have lower social competence
- Have less empathy for others
- Have difficulty in recognizing other's emotions
- Are less able to recognize their own emotional states
- Are more likely to be insecurely attached to their parents

Type D Attachment

(First described by Main & Solomon, 1990)

- Sequential or simultaneous display of contradictory behavior patterns
- Undirected, misdirected, incomplete or interrupted movements and expressions
- Stereotypies, asymmetrical movements, mistimed movements and anomalous postures
- Freezing, stilling, and slowed movement and expression

Predictors of Type D Attachment

- History of early maltreatment
- Mother with high Dissociative Experiences Scale (DES) score
- Single parenthood with parenting difficulties
- Type D attachment is **NOT** predicted by maternal medical problems, complications during pregnancy, infant anomalies, infant temperament

Attachment is a Biological Process

Heart Rate Changes by Attachment Type

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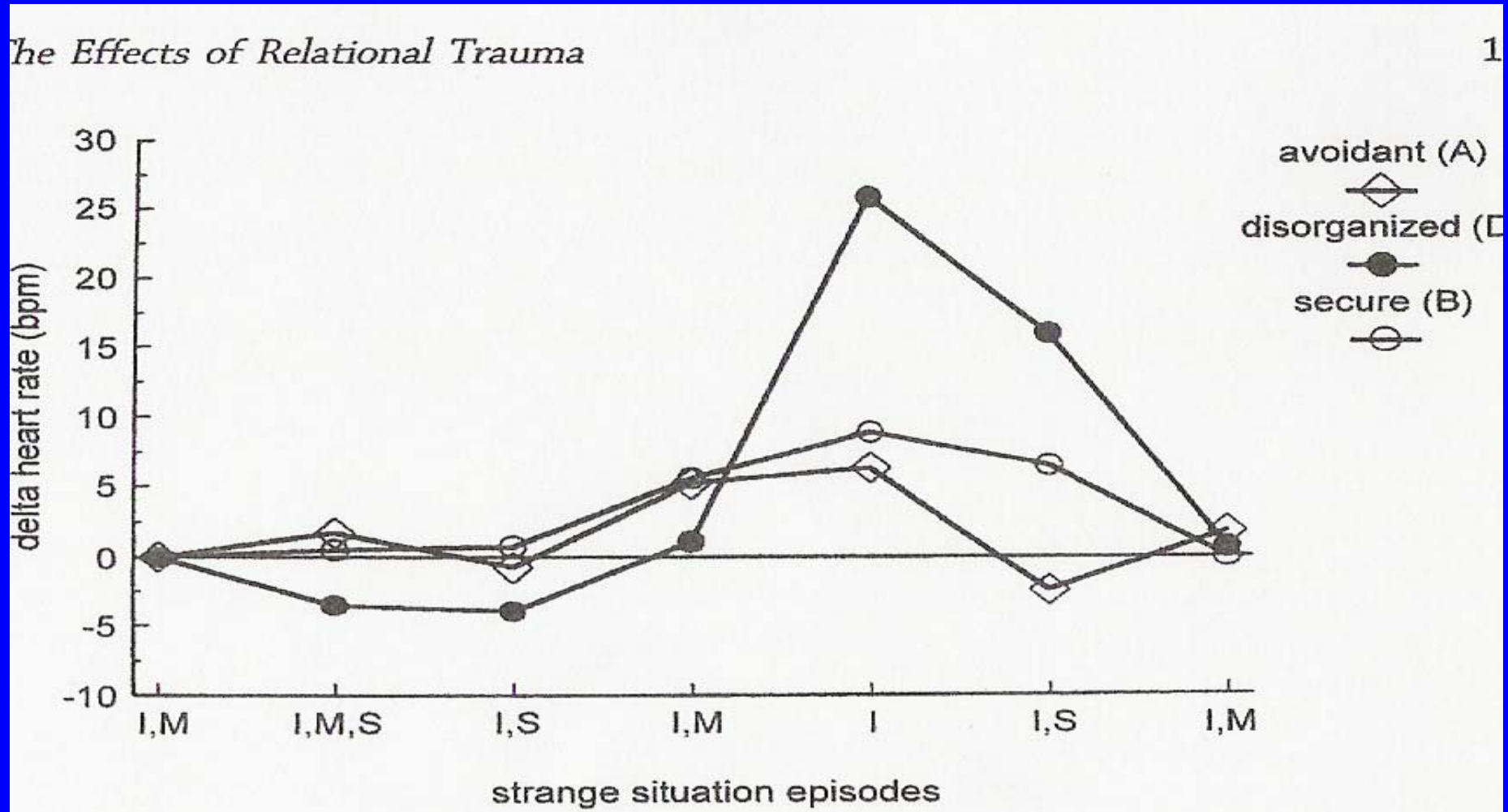


FIGURE 7.1. Changes in heart rate during strange situation episodes for different attachment groups (M, mother; I, infant; S, stranger). (From Spangler & Grossman, 1993)

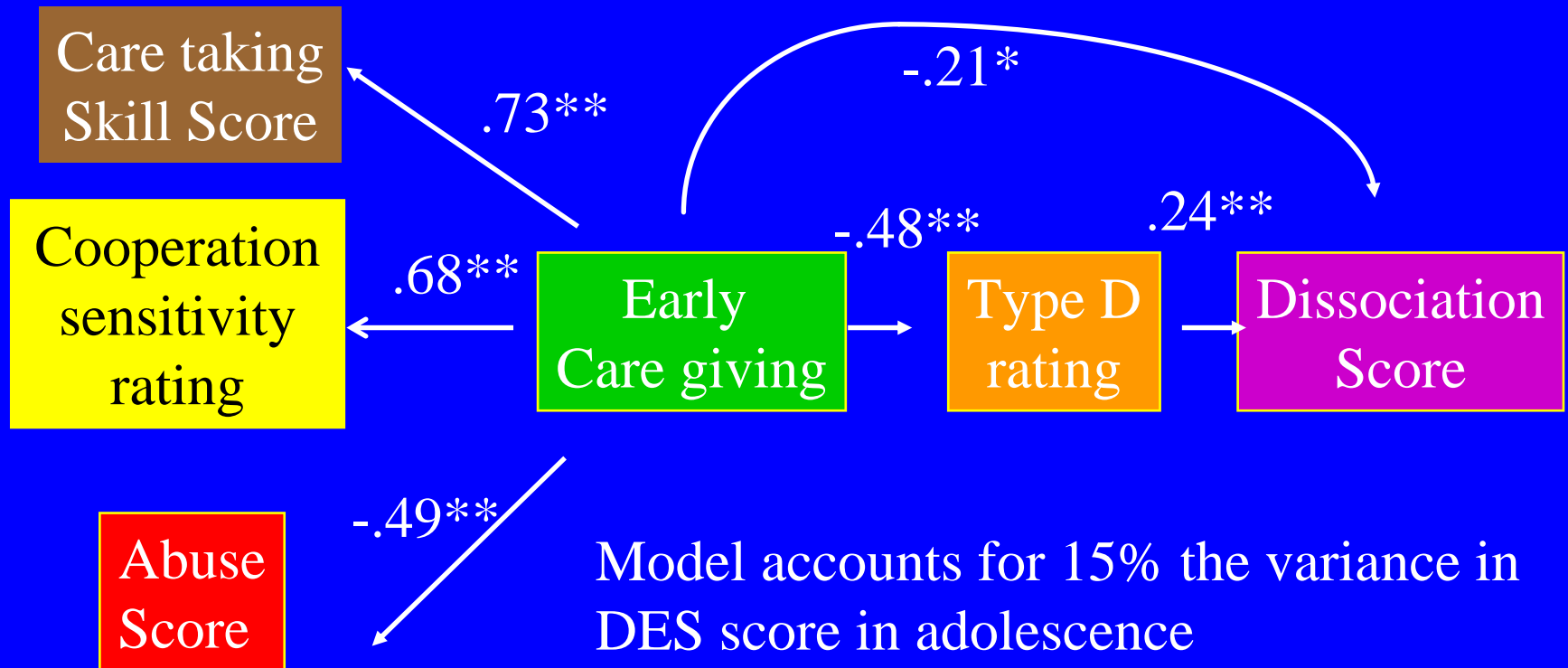
Infant Predictors of Adult Dissociation

Ogawa et al., *Development & Psychopathology*, 9:855-879, 1997

- These variables measured in infancy accounted for 30% of variance in dissociation scores at age 19 years ($N=168$, $F[3,116]=16.7$, $p<.001$)
 - 1) Type D attachment rating
 - 2) Maternal psychological unavailability
- Psychological unavailability accounted for 19% of variance in DES-T (taxon) subscale scores

Type D Attachment as a Mediator between Early Care taking and Adolescent Dissociation

E. Carlson (1998) Child Development, 69:1107-1128

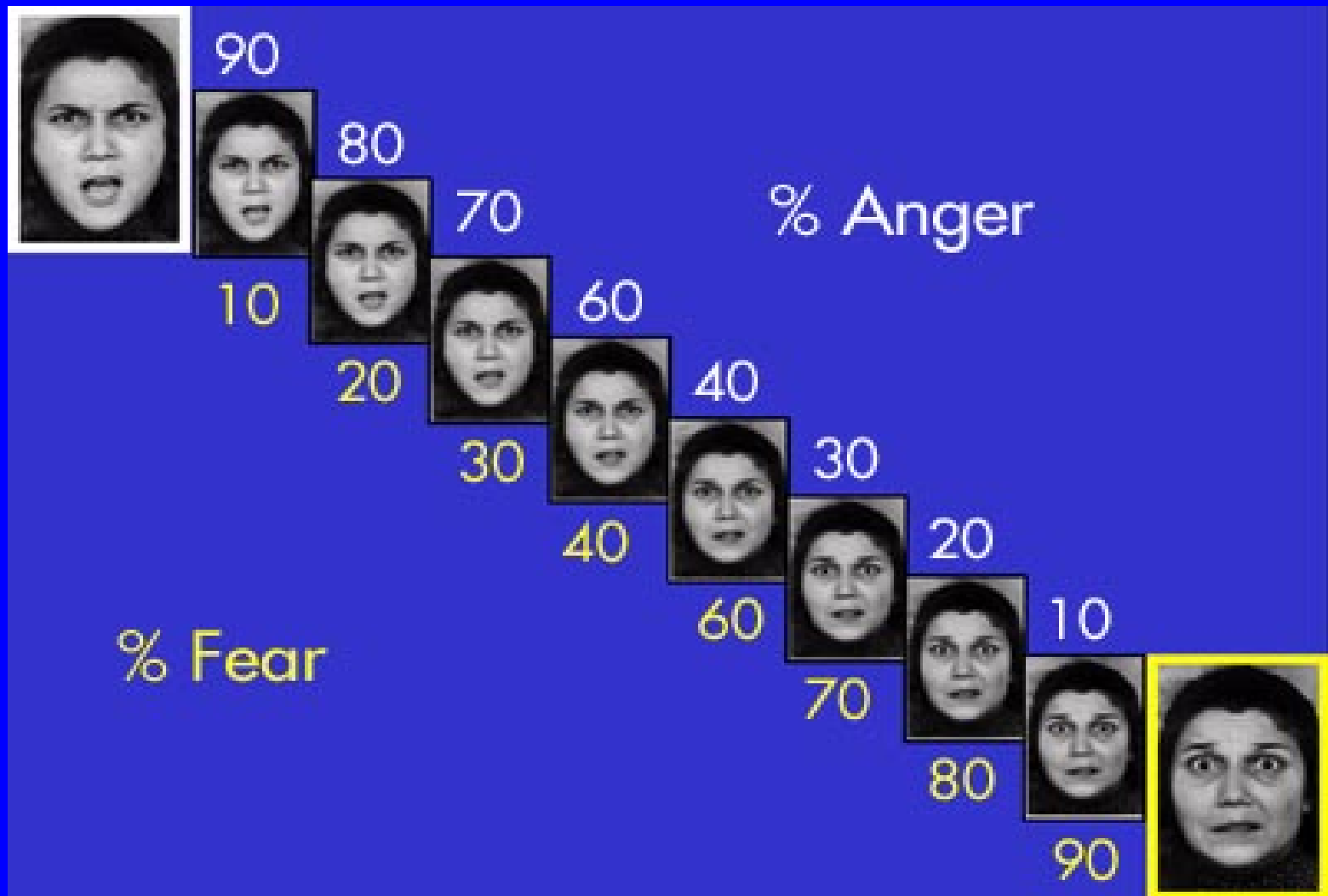


Model accounts for 15% the variance in
DES score in adolescence

N=116, * $p < .05$, ** $p < .01$

Physically Abused Children See Anger Where Others See Fear

Graphic by: Seth Pollak, courtesy PNAS



Child Maltreatment as a Risk Factor for School Problems

- Greater than 50% of abused children have significant school problems (including conduct problems)
- Greater than 25% of abused children require special education programs
- Several studies suggest CAN decreases IQ
- CAN victims 2 X's more likely to be unemployed as adults

Abuse-Related Forms of Psychopathology

- Affect dysregulation (depression, mood swings, panic attacks, affect liability)
- Cognitive & attentional problems (IQ ↓ ADHD, impulsivity, hypervigilance)
- Disturbances in sense of self and identity (suicidality, self-mutilation, low self-esteem, risk taking, alter personalities, depersonalization)

Abuse-Related Forms of Psychopathology

- Impaired stress response and somatization (sensitivity to traumatic reminders, alterations in neuroendocrine stress response systems)
- Use and abuse of substances and behaviors (e.g., self-mutilation, risk-taking) to regulate mood, sense of self, and behavior
- Interpersonal and relationship problems (attachment disorders, social withdrawal, promiscuity, antisocial behavior, spouse abuse, parenting problems)

Why Does Childhood Maltreatment Exert Such Powerful Effects?

- It occurs during sensitive neurodevelopmental periods (e.g., Synaptogenesis, Experience-Dependent Maturation of Neuronal Systems)
- It impacts on fundamental psychodevelopmental processes (e.g., Attachment, Emotional Regulation, Impulse Control, Integration of Self, Socialization)

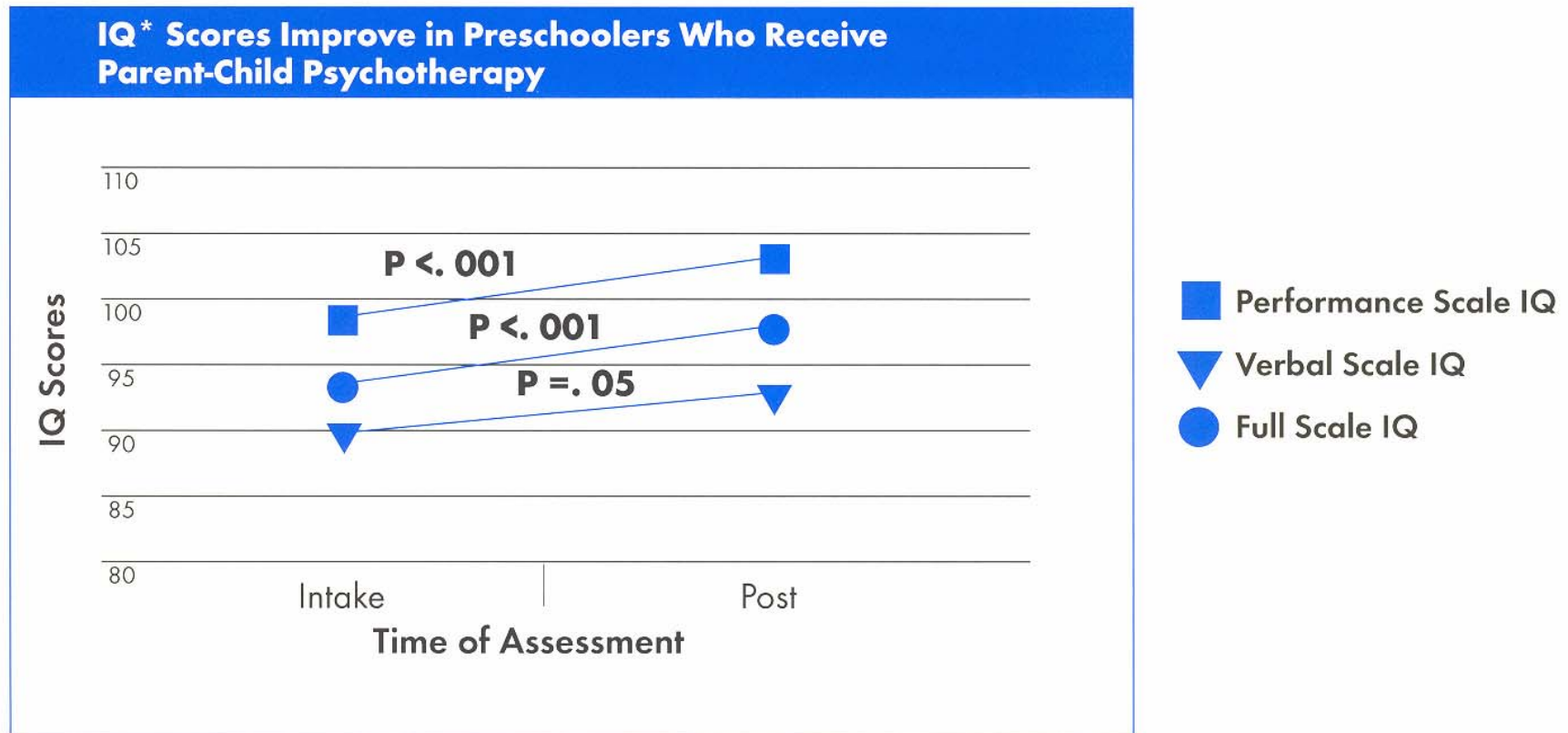
Developmental Processes Implicated in Abuse Outcomes

- Attachment
- Sensitive (Critical) Periods
- Experience-Dependent Maturation of Neuronal Systems
- Development of Emotional Regulation
- Development of Impulse Control
- Consolidation of Integrated Sense of Self
- Socialization

Are the Neurobiologic Effects of Child Maltreatment Reversible ?

- Humans are remarkably adaptable, with children showing the greatest degree of adaptability
- Psychosocial Dwarfism - a neuroendocrine inhibition of physical growth in a noxious environment is rapidly reversed when child is placed in a nurturing environment
- We do not know how reversible the brain damage and neuroendocrine abnormalities are, but it is likely that they will respond to stress reduction with increased normalization

Parent-Child Psychotherapy Improves Preschooler IQ Scores - Lieberman



*The Wechsler Preschool and Primary Scale of Intelligence is a battery of tests for young children that assesses intellectual functioning.

National Child Traumatic Stress Network. (2004). Children and trauma in America: A progress report of the National Child Traumatic Stress Network.

What Promotes Healthy Development of the Human Brain?

- Good nutrition
- A stimulating environment
- Healthy relationships with loving caretakers