

### The Interplay between Early Brain and Behavior Development

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May 30, 2011





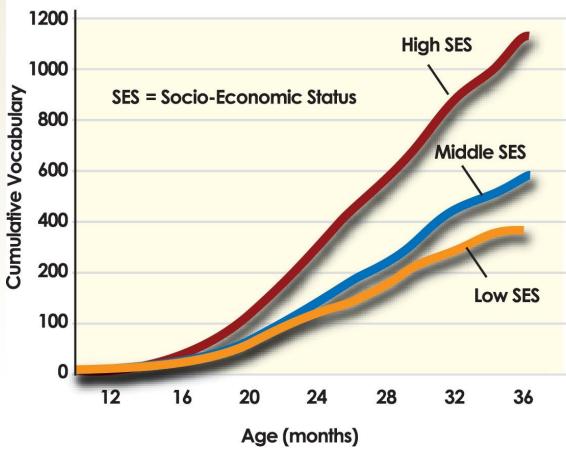


# The Importance of Viewing the Needs of Children in a Broad Context

The healthy development of all children benefits all of society by providing a solid foundation for economic productivity, responsible citizenship, strong communities, and a secure nation.



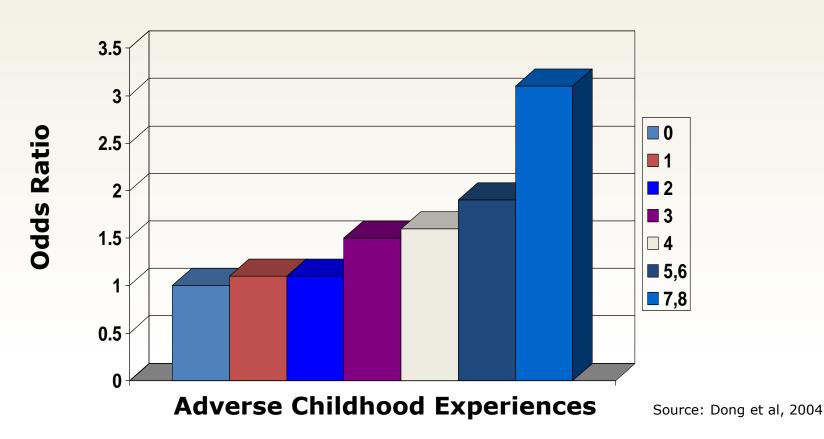
#### Disparities in Early Vocabulary Growth



Source: Hart & Risley (1995)



### Adverse Childhood Experiences and Adult Cardiovascular Disease





# Building an Integrated Science of Early Childhood Development

Convergence of findings from neuroscience, developmental psychology, molecular biology, economics, and program evaluation research.



#### Concept #1:

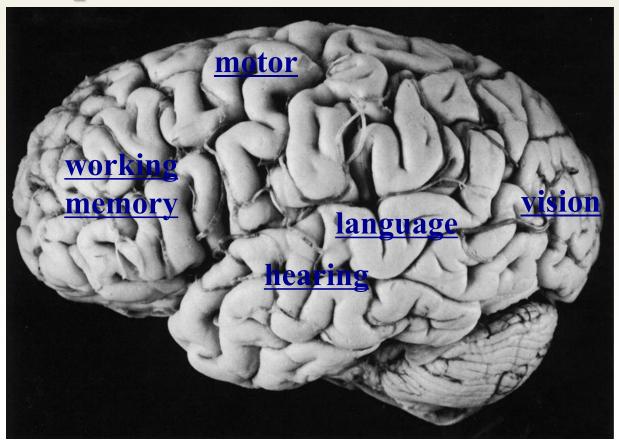
#### **Brains and Skills Are Built Over Time**

• The early years of life matter because both early experience and genes affect the architecture of the maturing brain.

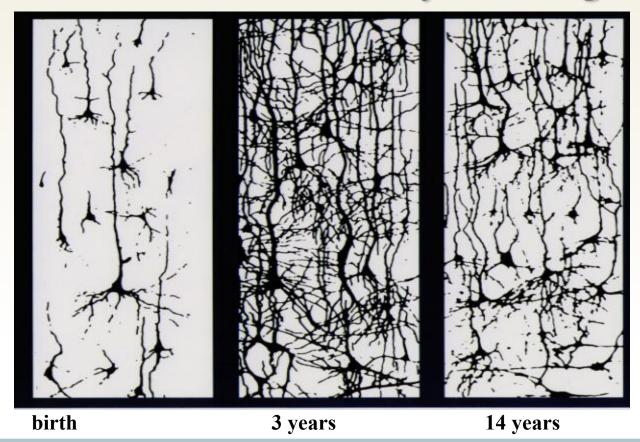
 As it emerges, the quality of that architecture establishes either a sturdy or weak foundation for all the learning and behavior that follow.



## Brain Architecture is Organized into Specialized Functional Areas



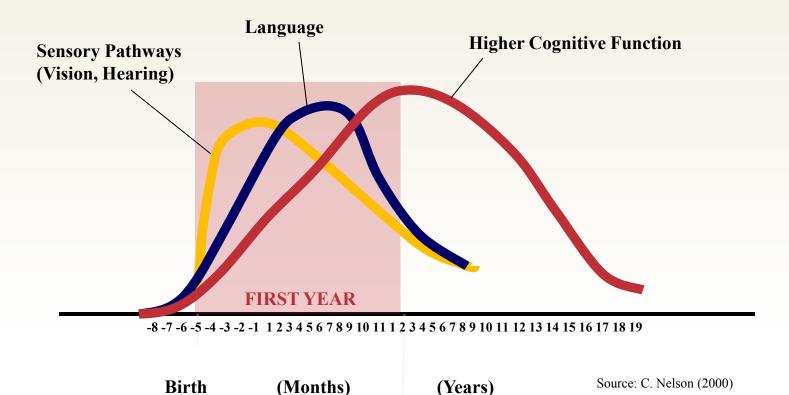
### **Experience Shapes Brain Architecture by Over- Production Followed by Pruning**





## Neural Circuits are Wired in a Bottom-Up Sequence

(700 synapses formed per second in the early years)





#### Concept #2:

### Brain Architecture and Skills Are Built in a "Bottom-Up" Sequence

- Neural circuits that process basic information are wired earlier than those that process more complex information.
- Higher circuits build on lower circuits. Adaptation at higher skill levels is more difficult if lower level circuits are not wired properly.
- Advanced skills build on basic skills in all aspects of development.



### **After Prism Experience Normal** ICC ICC TCX OT TCX OT Knudsen et al. 2007



#### Concept #3:

"Serve and Return" is a key ingredient in the learning process

 Social interactions are important. Children learn best when an attentive adult is engaged with them in the learning process.



### **Brains and Skills are Built Over Time**



#### There Are No Magic Bullets Relationships Matter

Positive relationships and quality learning experiences can be promoted both at home and through a range of **evidence-based** parent education, family support, early care and education, and intervention services.

A balanced approach to emotional, social, cognitive, and language development will best prepare children for success in school and later in the workplace.



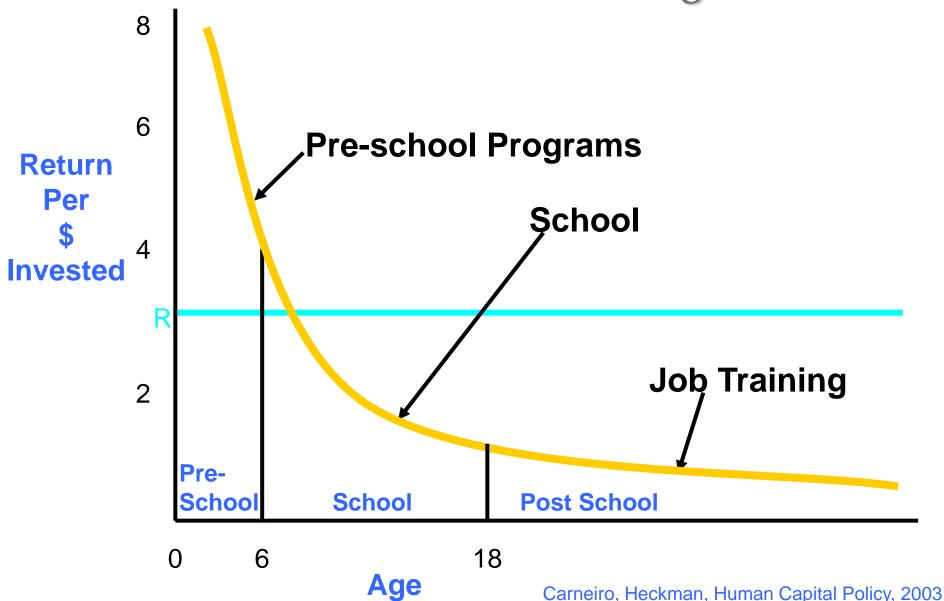
### Concept #4:

### Brain Plasticity - The Ability to Change Behavior Decreases Over Time

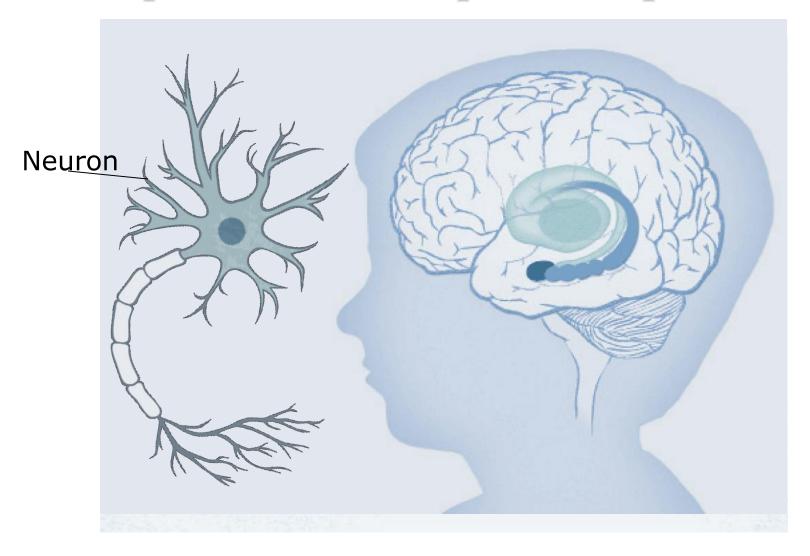
- Brain circuits stabilize with age, making them increasingly more difficult to alter.
- The window of opportunity for development remains open for many years, but the costs of remediation grow with increasing age.
- It is more efficient, both biologically and economically, to get things right the first time than to try to fix them later.



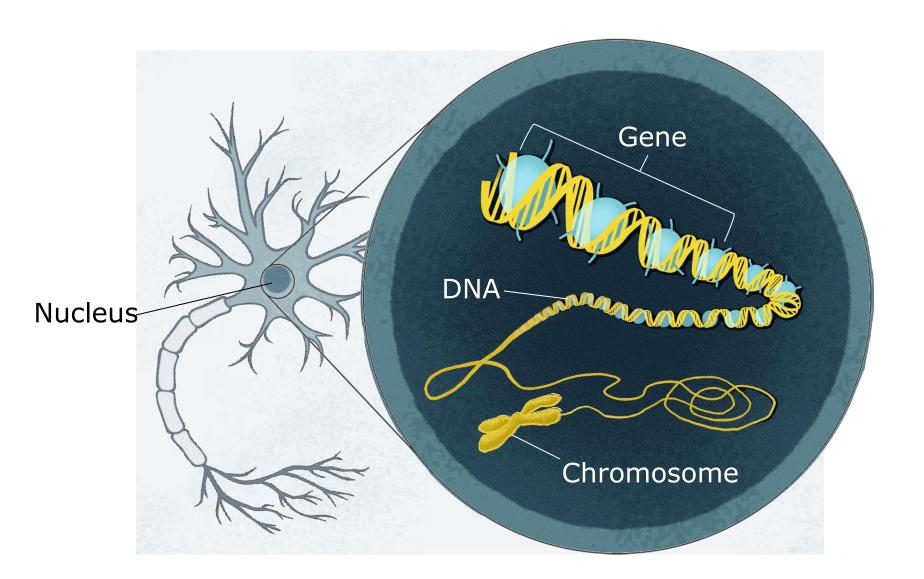
### Rates of Return to Human Development Investment Across all Ages



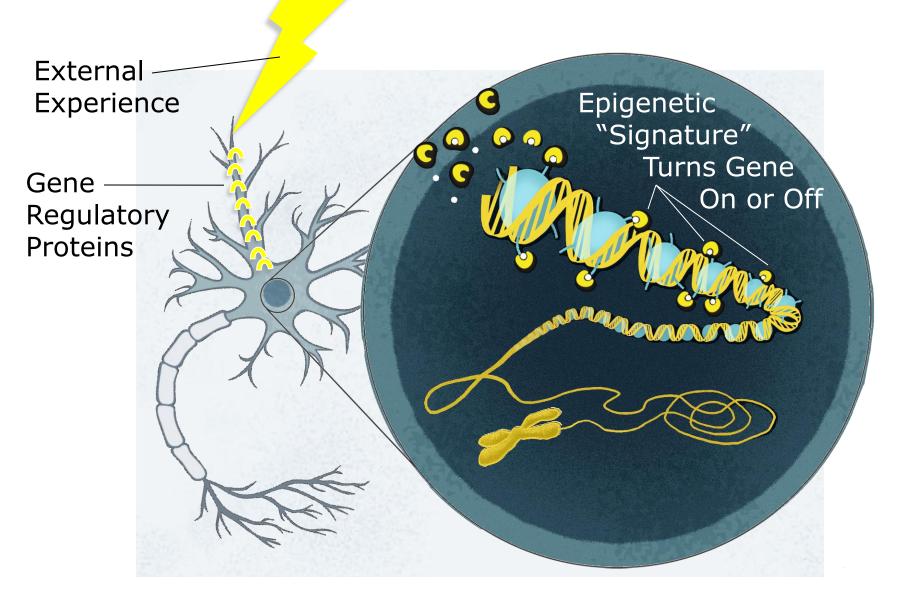
## How Early Experiences Alter Gene Expression and Shape Development



### **Genes Carry Instructions that Tell Our Bodies How to Work**



# Early Friences Leave Lasting Chemical C

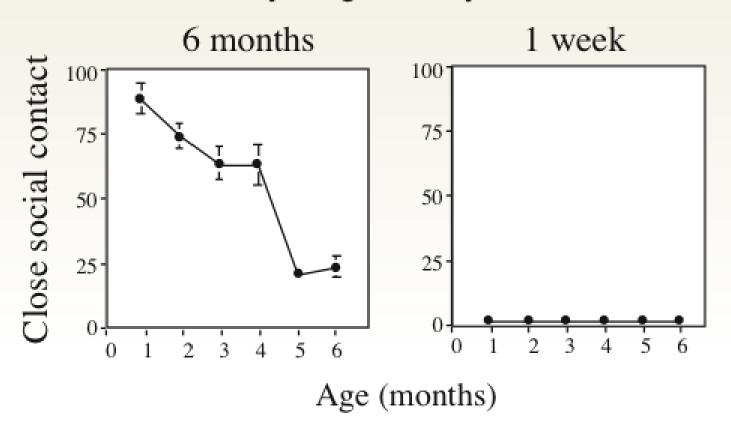


# Studies in monkeys show that early life experiences have lasting effects on brain development

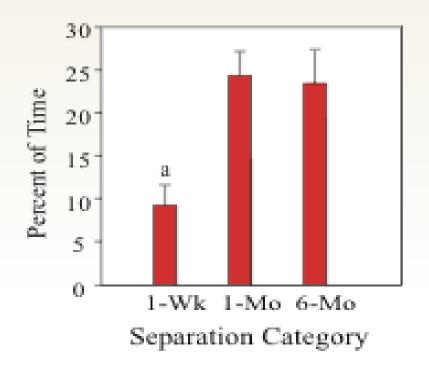




### Mother removed from social group when young monkey was:



### Social Behavior Remains Decreased in Adulthood





#### **Amygdala Microarray Studies**

#### ctrl wk mo gene description

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I (2.2) NW_BI2462 / "HOMO SAPTEMS ETMC PTMOSER PROTEIN 261 (EMP261), MRINA"
I (I S) NW GS1635 / ""ROWO SAPIENS ARACHIDONATE CIPOTYODRASE 3 (ACOTES), MISHA ""
E (1 4) NO 36 1929 / "HONO SUPERS EVE EVENSKEPPED HONED BOX ROWDOOD I (DEGERALE OND) EVEN I BEN'A
SIG (1 6) NOV 025261 / ""FROMO SAPTENS DEC PROTEIN (DEC), MIRIKA "
1 9 (2 0) NOV 015000 C TROMO SAPTONS ROOK I PROTEIN BROOK I J. MRINA ***
1 E (1 E) NW BESSES / " FROMO SAPEDYS GRANGE MUCUSOFIDE BENDEVO PROTEEN AS PROTEEN, ACPEA I 1 (90 CLASS) (SWA I 1), MR.MA "
2 F (1 4) PM B 16532 / TROMO SAPEDYS SKEP FOR SKELETAL MUSCLE AND KENEY ENRICHED MOSTICL PROSPRATASE (COCS) 7631 MB/M
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14 (1 6) MY_007151 / "ROMO SAPENS MITOGENACTIVATED PROTEN KINASE KINASE KINASE KINASE KINASE (1 MAPAKI), NRMA ""
14 PLY) NO BELLED . THOMO SAPENS CALCED CANCED CONTROL PROTEIN KINASE (CAN KINASE) TRETA (CANKIB), MRNA ...
1 1 (1 5) NW 016231 / "ROWO SAPTENS RIF TYPE C OCYCOPROTEIN (RIFICOL WRINA "
$ 1 (1.4) NOV 981172 / "HONO SAPENS AROPASE THE BARROLL MUCLEAR OSIS SICCOPIO MITOCHONDRIAL PROFESS ABOVA "
S S (I 1) MAC BS I BEB 4 .... HOMO SAPREMS DISABLED FROMOCOG I (DROSOPFITA) (DABI ), MRIKA ..
12 H STRAY BERT 2 / " FROMO SAPTEYS GAMMA ANALYGROTTER'S ACTO (SABATA RECEPTOR, BETA I (SABERITA MERA "
1 2 (1 5) CHASAN - " HONO SAPERS (CLONE HITT-1) C.TYPE YOUTAGE.CEPERGER CALCED CHARRES, AT SUBURIT BRITTHERIA, CONFLETE CDS "
I M 33 NW 085596 (""RONG SAPENS NUCLEAR FACTOR YO INFIB.) MRNA"
E B (E 2) POK BE 4897 / ""ROMO SAPTONS KWABODA PROTEIN (KWABODA), MRMA ""
ER ES 4) PAR RELIES 2 · THOMO SAPER'S SLAV (SAREVONIC CETTIAL, ARNORMAL VISION, DROSOPHILA) LIKE 4 (HU ANTIGER D) (SLAVLA), MRNA **
9 (2.2) PAG 486475 - " HONO SAPIENS OSTEOBLAST SPECIFIC FACTOR 2 (FASCICUM LUKE) (OSF-2), MRHA "
9 (1 2) NN 914344 *** WONG SAFENS PUTATIVE SECRETED CHAND HONOLOGICUS TO FIXT (FIXT), HENA ***
9 (1 8) YOU BESTAS / "RONG SAPERS TYL ASSOCIATED FACTOR 3 (YAFY), MENA
 $ (2.7) HOW DELIGHAY "" BOND SAPPENS SINC PROSES PROTEIN 145 (PRISSE) (SHE145), MISHA"
 4 (1.1) NAV. 8 (4 (1.1) 2 · · · · BOARD SAFERYS TRICKFORKER/OPERALANGEAL SYMPERIOR TORRIS (TRPS ). MR.MA · · ·
B 2 (1 B) NW BB2728 / THOMO SAPTONS ANYTHE ONDASE, COPPER CONTAINING 2 (VASCULAR ADMESTER PROTEIN 1) (ACC), MENA ***
A 7 ID VINNY BIRANDE !"" HONO SAPRING HYPOTHETICAL PROTEIN FULIBRING PULIBRING MRINA!
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I S IN BLIGH BUISBE / "FROMO SAPTENS ACYT. CORNEYWE A ONTDASE 1, BRANCHED CHAIN MCONTA MRINA"
I 2 to 17 HM 100646 ( " HOMO SAPENS ANYTO I, EXCUSOSDASE, EXCUSORDASE, EXCUSONOTRANSFERASE (EXCUSOR) DEBRANCIEND EXTREM, DUYCOOSY STORAGE DEBRASE THE TOLOGY, TRANSCRET WARRING & MENA "
 I 9 to STHM BI4135 (""FIONO SAPTEMS PROBES PROTEIN (PROBESV), MRHA"
Q B B) HH BB I BB / ""HONG SAPER'S A DETITIONER AND METALLOPROTEINASE DOMAIN B NADAMEL MINA"
A B ID KERN BLAZZE C''' SICHIO SAPIDIS KWABZES ODIES PRODUCT (KWABZES) MIRKA''
2 I 80 7) AKE2445E - "HONO SAPTENS MIRHA FOR PLIEBERS PROTEIN PARTIM, CDS"
 2 F (8 E) ABBLIDATI **** FROMO SAPTEMS MENA FOR KIMATOLS PROTEIN, PARTIAL CDS**
A LIS THREE BLTTSS COMPONE SAPERS STIPPOTISTICAL PROTERY PURSUES STUDENESS MIRHA TO
Q 1 (0.8) HOV 015997 / ""HONO SAPTENS COTAL PROTETY (COCS1091), MRIKA
4 2 (6 5) MH 601993 ( "HONO SAPENS COC-LIKE KWASE 2 (CLK2), TRANSCRIPT VARIANT PRICKS, MRHA "
4 9 (0 6) X56146 / "BRAKAN XET, CODING SEQUENCE SYMBINA (COCUS DISSING) "
4 3 to 2) ABBITTLE !! HONO SAPENS MICHA FOR KWARS4S PROFEN, PARTING CDS***
2.3 (0.7) ATREETAS **** QNT FFT EXT STONG SAPTENS CONA, 3"END"
A 1 IO STABBLEFORS **** SPONG SAPEDIS MICHA FOR KIMALLIAS PROFERS PARTIAL CDS***
 4 49 7) FOLD STAND OF THE PROPERTY SOUTHER CARRIED FAMILY 37 FOLYCOROLLI PROSPECTE TRANSPORTERS MEMBER 1 (SUC37A1), MRNA ***
2.4 to 7) HAY BOLES4 / " FROMO SAPTEMS COULAGEN, TYPE XI, AUPSIA I (COULTAIL) HRIMA"
2.4 (B. E) FON BELISTER *** BROND SAPERIS GENERAL TRANSCRIPTION FACTOR TIC, POLYPEPTEDE 1 (BETA SUBUNT, 1 10KD) (OTFUC1), NEWA ***
4 4 to 7) ABB228716 FTT SIGNO SAPTENS MIRKA FOR RIVADURA PROTEIN, PARTIAL CDST
 2 4 (B 5) HM - 000474 / * THOMO SAPRINS TRYET HOMOLOG (MCROCESHALOS YNDACTYLY 2, SAETHRE-CHOTZEY S YNDROME) (DROSOPHILA) (TWET), MRINA ***
2.4 pp.7) NW BBBBB / " HONO SAPTEYS OKUTAMATE DECARBOTYLASE 2 PANCREATIC EXETS AND BRATK, BSKD) (BADS), MRNA "
O 6 (B 7) AF458087 (""HONO SAPENS URBI INTERACTING PROTEIN I (UPI) MRNA, CONFLETE CDS"
 a e 🔞 7) MN_004592 x " "HONO SAPTENS SPLICTMO FACTOR, ARGININESER INSERTICH & GLIPPRESSOR OF INTELAPRICOT HONOLOG, DROGOPHILA) GERSS), MRXA " "
 S IN TIDESTIF . ""REMAIN MENA FOR KNAMEN OFFE, PARTIAL COS"
2 7 (8 6) FOY 000441 F THOMO SAPEDIS SOLUTE CARRED FAMILY 16, HEMBER 4 (SLC16A4), HRIVA
2 7 to 5) AB029000 / ""HONO SAPIENS NIKHA FOR KWAH022 PROTEIN, PARTING COS"
2 7 (0 7) W22165 / 65F1 RICHO SAPENS COKA
O S IN PLANTAGE 151 / THOMO SAPERYS COMA PLULISMO FIE. CLONE HTDR TOR TOR 2010 FINALLY SWILAR TO X111 PROTEIN!
4.5 IO B) AKBSSSEE - * HONO SAPER'S COMA PLIZIBRA PE, CLONE BULRYDIBBBBB, BIRBELY SENTLAR TO BONO SAPER'S ANCIENT USIDUITOUS 46 RDA PROTEIN AUPI NIRMA **
2 9 to 1) AKB02206 (*** HONO SAPENS CONA PLUI 1344 PE, CLONE PLACEI 0 10010, MODER ATELY SINTLAR TO ZINC PINGER PROTEIN 91*
A 9 ID ED ED ED ED ER C''' REGNAN EIDIOCHTRACONGEGNATING ENERVAL 9 MISSA, COMPLETE CDS''
 $ 2 to 5) HIV $84836 *** BONO SAPIENS COADSTATION FACTOR C BIONOLOG, COCURT (CINGLUS POLYPIENUS) (COCUR, NR.HA ***
3 2 to 7) ABB23166 (""HONO SAPTENS MIKHA FOR KNARP49 PROFEIN, PARTING COS"
 3 2 (0.7) ABBOTETI / ""FRONO SAPENS KWASHI I HRINA, COMPLETE CDS"
2 2 to 2) HAV 001421 / TRONG SAPERS PROTEIN PROSPRATASE I, RESOCUTORY (PARENTOR) SUBJUNT 128 (PPP1R 139) TRANSCRIPT VARIANT I, MRNATT
S S DE BEHAV BREESS !! HONO SAPISH'S USBOUTTH-ACTIVATING ENTINE ELLIKE DISELLE MENA!
3 7 (0.8) FOR GORSON FOR SAPERIS OLUCOSTDASE 1/90513, MRNA
4 0 (0 7) FOX 017755 / "FRONG SAPEDYS STYPOTHETICAL PROTEIN FLISBED (FLISBED), MRNA "
4 2 IB S) HIV BUT 417 / " HONO SAPERYS CADRESTIN BOF CAD SEVENPASS OF THE RECEPTOR 2 PLANTING DOMOLOG, DROSOPHILA) (CELSE 21 MR.HA "
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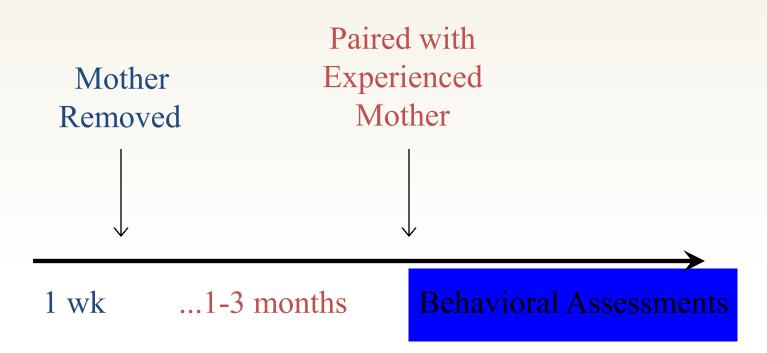
#### Intervention

Can pairing a separated infant with a very attentive mother reverse the effects of early social bond disruption?

Does the timing of therapy matter?

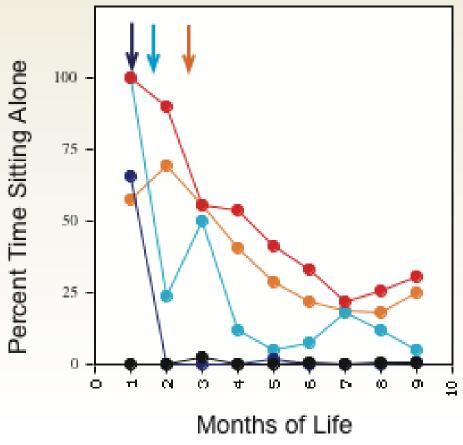


### Intervention Design





(arrows show introduction of experienced mother)



Pairing with an experienced mother is effective when <u>initiated early</u>.



### The role of early experience in shaping socialemotional development: Conclusions

The *timing* of early stressful life experience plays a critical role in determining the outcome of stress exposure on behavior.

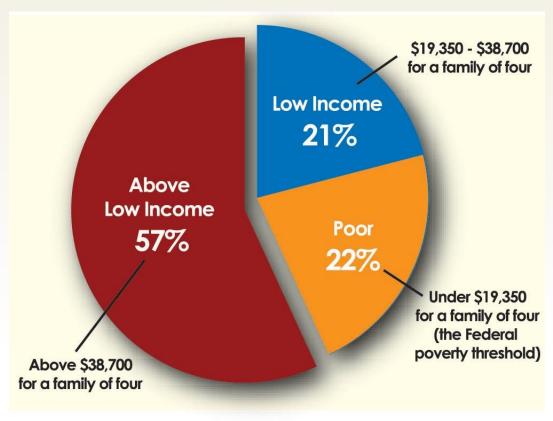
Early social bond disruption can lead to changes in *brain anatomy* and *gene* expression in the brain.

Early intervention can prevent long-term consequences of social bond disruption, but the timing of intervention is important.



### **Children in Poverty**

#### **U.S. Families with Toddlers and Infants**



Source: National Center for Children in Poverty (2006)



## Science Points Toward a Two-Tiered Approach to Reducing Disparities

Basic health services and good quality early care and education can promote healthy development and early detection of problems in all children.

HEALTH SERVICES & EARLY CARE AND EDUCATION

Targeted services for children experiencing substantial stresses early in life can reduce disruptions of the developing nervous and immune systems that lead to later problems in learning, behavior, and health.



#### **Maximizing Return on Investment**

The basic principles of neuroscience and human capital formation indicate that later remediation will produce less favorable outcomes than preventive intervention.

Low cost services that have little impact are a waste of money. Responsible investments focus on effective programs that are staffed appropriately, implemented well, and improved continuously.



#### **Further Information:**



http://www.developingchild.net

Center on the Developing Child ## HARVARD UNIVERSITY

NATIONAL SCIENTIFIC COUNCIL ON THE DEVELOPING CHILD
NATIONAL FORUM ON EARLY CHILDHOOD PROGRAM EVALUATION

Knudsen EI, Heckman JJ, Cameron JL, Shonkoff JP.

Economic, neurobioligical and behavioral perspectives on building America's future workforce.

World Economics 7: 17-41, 2006

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