The Neuroscience of Nurture:
Impacts on Brain & Language Development

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1

I have no financial conflicts of interest and nothing to disclose.

2

The Neuroscience of Nurture
How Nurture Affects Infant Brain Development

- To nurture is to give tender care and protection
  - To nurture a new plant
    - We water it and handle it gently
    - We protect it from any harm
    - To help it grow to become a beautiful flower, bush, or tree

  - To nurture a new baby
    - We feed it and handle it gently
    - We protect it from any harm
    - To help it grow to become a beautiful child and adult
    - New babies also need LOVE in order to thrive

3

Bonding & Attachment
Important Mechanisms for Nurturing Babies

- Bonding
  - The emotional connection of a parent/caregiver towards their baby/child - Parent -> Baby
- Attachment
  - The emotional connection of a baby/child towards its parent/caregiver – Baby -> Parent
- Both bonding & attachment are necessary
  - For babies and children to thrive

4

4

Nurturing Infants & Children

- Parent-infant bonding and attachment
  - Strong influence on health & wellbeing of infants & children
  - Long-lasting effects – even into adulthood
- Medical Education
  - Little information is taught about bonding and attachment
  - Often considered "soft" science or even optional
- Clinical Practice
  - Physical survival and treatment are prioritized
    - Little attention given to mental health or emotional development
    - Good mental health can determine the quality of our lives

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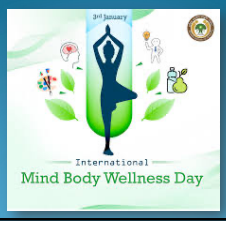
Integration of Mind & Body

- We cannot separate the wellbeing of the mind & body
  - They are intricately connected
  - Emotional & psychological health impact physical health



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Term Human Infants are Born Neurological Immature

- "At birth, the human infant is the least neurologically mature of all primates..."

McKenna

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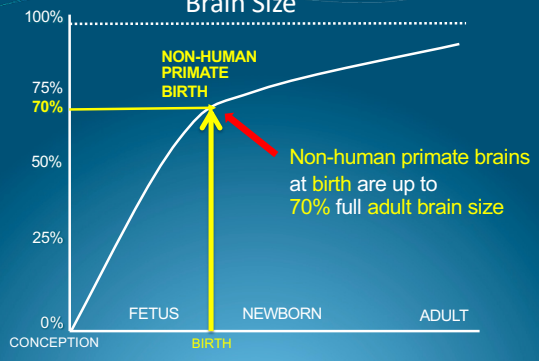
Immature Human Brain Newborn Human are More Vulnerable

- Other primates can actively cling to mother as she moves about & swings through the trees
- Human newborns are much more helpless at birth

8

Brain Size



N. Bergman

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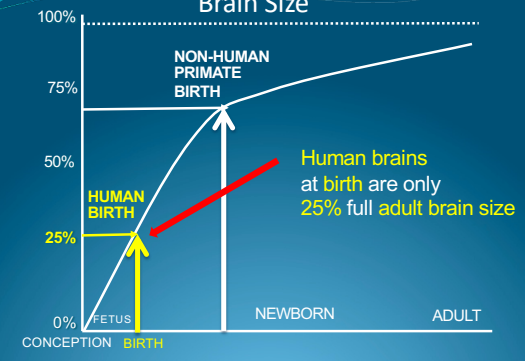
Brain Size



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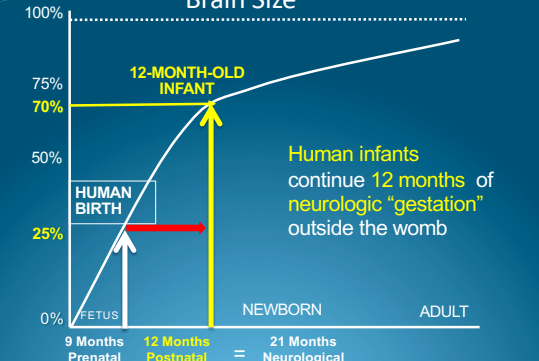
Brain Size



N. Bergman

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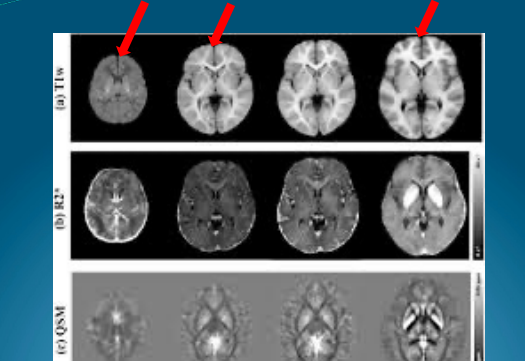


12

Term Human Infants are Born Neurologically Immature

- "At birth, the human infant is the least neurologically mature of all primates…
- And the human infant is the most reliant for physiological regulation by the caregiver for the longest period of time."

13

Mother is the Newborn's "Physiological Regulator"

14

A Newborn Has a Biological Need To Be in Contact with Mother

15

Skin to Skin with Mother

The Newborn Mammal's Natural Habitat

16

Skin to Skin with Mother

Where All the Well, Term Newborn's Basic Needs Are Met

Warmth, Nutrition, Safety

& continued

Neurological Development





17

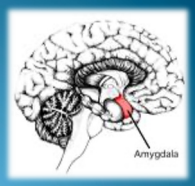
A Critical Period A Window of Opportunity

A "critical period" is a "window of opportunity" in early life when an infant or child's brain is specifically primed to receive sensory input in order to develop more advanced neural systems

18

Newborn Brain Development

- Areas of the amygdala...
  - Are in a "critical period" of maturation
  - In the first two months after birth
- Amygdala - Limbic System
  - Emotional learning
  - Memory modulation
  - Activation of sympathetic nervous system



19

Touch & Brain Development

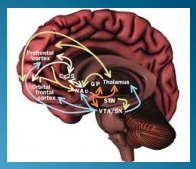
- Skin-to-skin contact
  - Sends nerve impulses to the brain that activate the amygdala, helping it to develop normally
- "Because the amygdala is in a critical period of development at the time of birth,
- In early postnatal life,
  - Getting enough tactile input...
  - Is very important for normal brain development."

Schore, *Infant Mental Health Journal*, 2001

20

Touch & Brain Development

- The senses of touch, proprioception, and smell
  - Are well developed by the 3rd trimester of pregnancy
- "These senses connect directly to the amygdala via the prefrontal-orbital pathway.
- This pathway is an essential part of an efficiently regulated and organized right brain."



Schore, *Infant Mental Health Journal*, 2001

21

Brain Development

- Why do mothers cradle babies on their left?

- Over 80% of right- and left-handed females cradle babies on the left.

Sieratzki, *Lancet*, 1996

22

Brain Development

- Males have no preference...until they become fathers.

- Over 80% of fathers cradle their babies on the left.

23

23

Right Brain Development

- "In the left cradling position, maternal signals are given to the infant's free left ear and processed by the right hemisphere...which is more advanced at this stage of development."

Sieratzki, *Lancet*, 1996

- Baby's signals entering mother's left side are processed by mother's right brain.

24

Maternal Bonding

- "When a baby is born, a mother is born"
  - Mother is usually focused on her baby

Winnicott

- Neuronal mechanisms (in the mother's brain)
  - Stimulate maternal behavior:
    - To care for and bond with her newborn baby
  - Located in the medial preoptic area of the hypothalamus
    - With projections to the meso-cortico-limbic dopaminergic system

Diaz-Rossello NeoReviews 2008

25

Maternal Bonding

- Maternal bonding is biologically primed
  - Important for survival of the newborn
  - Nature has not left it to chance
- Biochemical activators in our brain's reward circuitry
  - Trigger maternal caregiving by increasing
    - Estrogen, Progesterone
    - Prolactin, Vasopressin
    - Dopamine, Oxytocin
- All of these biochemical activators
  - Are increased by skin-to-skin contact

26

Oxytocin
The Love Hormone

- Contracts uterus
  - Decreasing postpartum hemorrhage
- Releases breast milk
  - Letdown reflex
- Increases maternal
  - Caregiving behaviors
  - Protective behaviors
  - Facial recognition
  - Relaxation

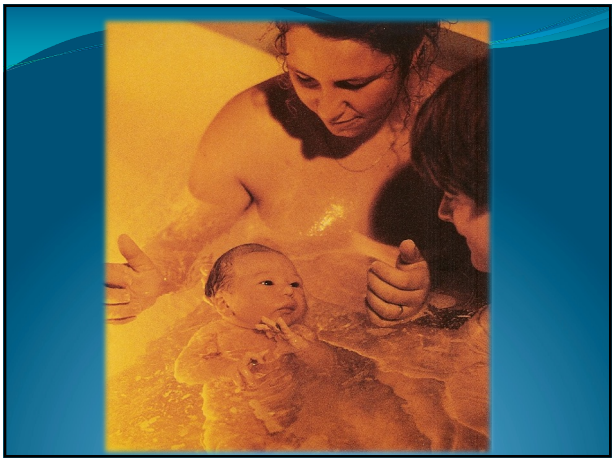
- All these functions are critical for survival of the newborn
  - Which is why they are important aspects of maternal bonding

27

Human Full-Term Newborns are Born
Ready to Connect

Klaus

28



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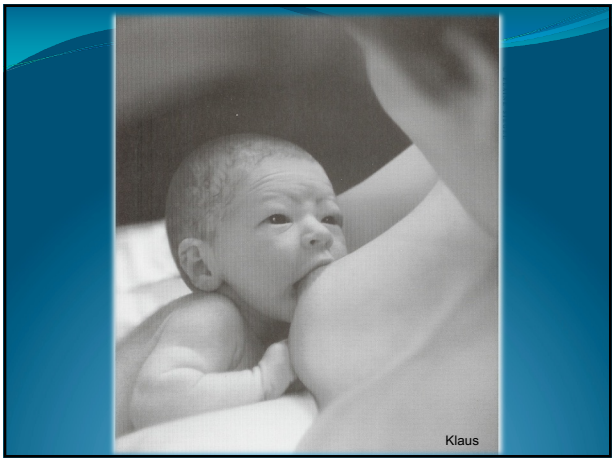

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38

Attachment and Regulation

- Infant attachment relationships are so important because they facilitate development of the newborn brain's self-regulatory mechanisms.

Schore, 2001; Fonagy & Target, 2002, Ovt-scharoff, 2001.

39

Mother is Baby's Regulator

- "The interaction between the newborn and the mother constantly controls and modulates the newborn's exposure to environmental stimuli…

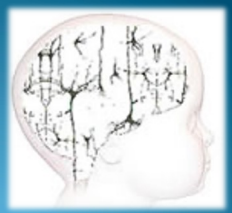
…and by doing so, the mother serves as a regulator of the developing individual's internal homeostasis."

Ovt-scharoff, *Neuroscience*, 2001

40

Attachment and Regulation

- The regulatory function of the newborn-mother interaction helps to establish
  - Synaptic connections
  - Functional brain circuits
- This may be the mechanism by which infants learn self-regulation



Ovt-scharoff , *Neuroscience*, 2001

41

What about premature infants?

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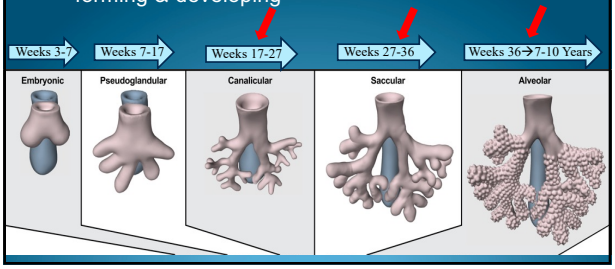
Prematurely born infants are still in fetal stages of development.

43

The Preterm Infant's Lung Development Is Not Complete

- Bronchi, bronchioles, & alveoli are still forming & developing



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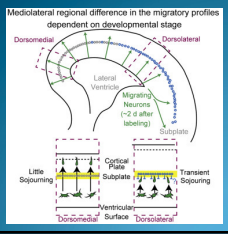
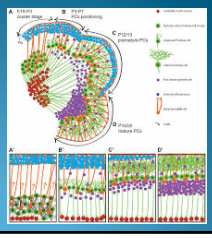
The Preterm Infant's Brain Development Is Not Complete

- New neurons are forming & migrating from the germinal matrix to their destination in the brain





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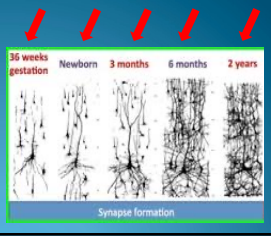
The preterm infant's brain development is not complete

- New synaptic connections are forming
  - Both the full-term baby and the pre-term baby



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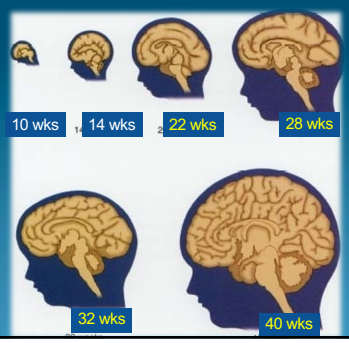
Fetal Brain Development



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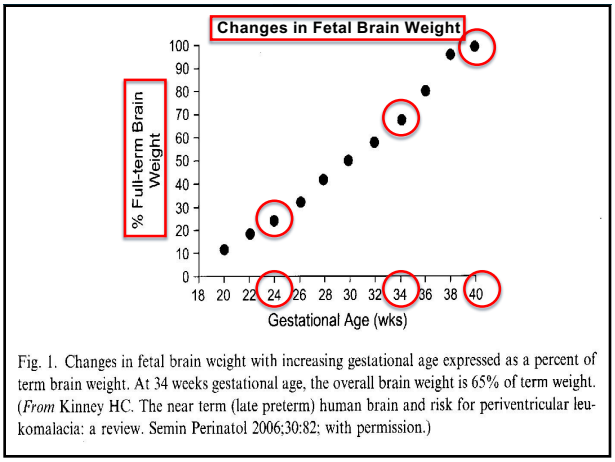
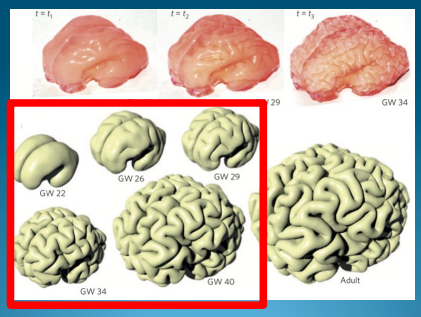


Fig. 1. Changes in fetal brain weight with increasing gestational age expressed as a percent of term brain weight. At 34 weeks gestational age, the overall brain weight is 65% of term weight. (*From* Kinney HC. The near term (late preterm) human brain and risk for periventricular leukomalacia: a review. Semin Perinatol 2006;30:82; with permission.)

48

The Preterm (Fetal) Brain Development



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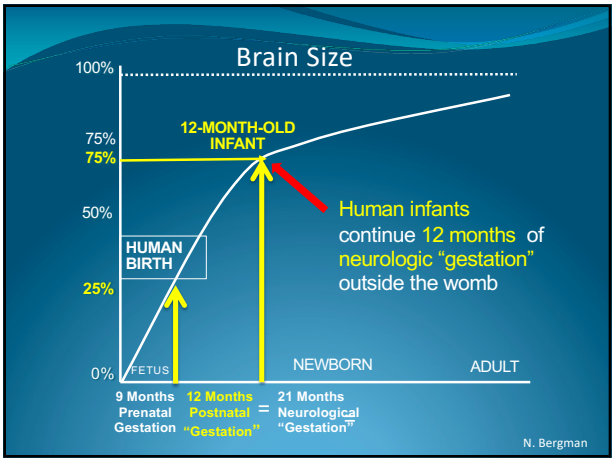

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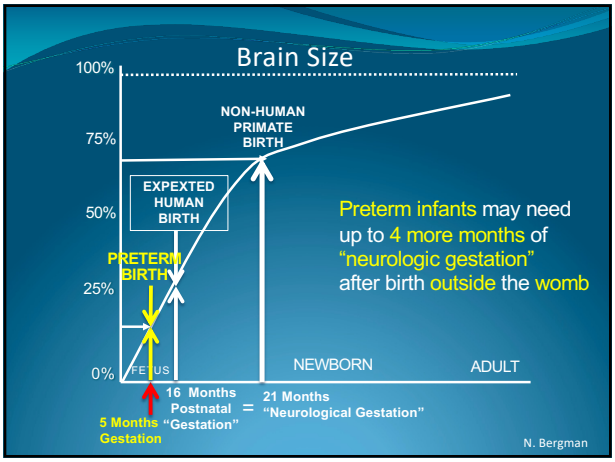


51

In the NICU we have a "Window Into the Womb"

52

Hands to Face

In the Womb

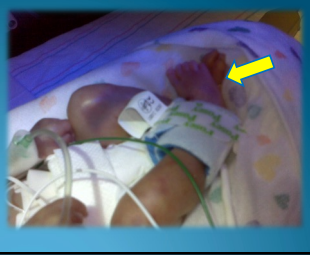
In the NICU

53

Foot Planting

In the Womb

In the NICU

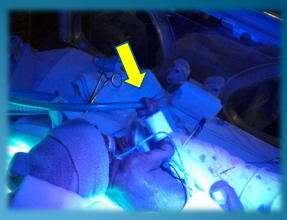


54

Grasping

In the Womb

In the NICU



55

Brain development is an active process

that depends on individual experiences

- The brain of baby who spends the 3rd trimester in the NICU will develop very differently from
- The brain of a baby who spends the 3rd trimester inside the protective environment of the womb

(Schore, 2001)

56

Review of Part 1

Born too soon!

- No matter how small or how premature babies are,
  - They can still be aware of, and react to, their surroundings
- How we care for them can make a big difference in their outcomes

57

Preterm babies have their own feelings & experiences

58

Preterm babies have their own individual responses

59

Nurturing Baby in the Womb

60

Nurturing Baby in the NICU

61

Nature has prepared parents to nurture their own babies

62

Creating Emotional Connections Is How We Nurture Our Babies & Children

- Maternal bonding comes first
  - Comes first - before infant attachment
  - Can begin well before birth

63

Even Preterm Infants are Born Ready for Connections

64

65

66

67

68

Mother-Preterm Baby Bonding in the NICU

Uvnas-Moberg, 2003, Tessier et al., 1998, Kirsten, Bergman, 2001, Conde-Agudelo, et. Al., 2003

69

Father-Preterm Baby Bonding in the NICU

70

Bonding & Attachment In the NICU

- We actively support bonding and attachment between NICU parents and their preterm babies
  - Encourage and support parental presence
  - Facilitate early, frequent & prolonged skin-to-skin contact (Kangaroo Care)
  - Encourage softly talking or singing to preterm babies

71

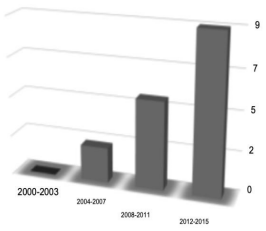
Talking to babies in the NICU

72

REVIEW ARTICLE

Systematic review of maternal voice interventions demonstrates increased stability in preterm infants

Manuela Filippa (manuela.filippa@gmail.com)[1], Costantino Panza[2], Fabrizio Ferrari[3], Rossella Frassoldati[3], Pierre Kuhn[3], Sara Balduzzi[4], Roberto D'Amico[4]



Number of studies on Maternal Voice Interventions and Preterm Infants from 2000 to 2015.

The distribution evidences an increasing number of studies on maternal voice, both recorded and live, as early interventions with preterm infants in NICUs

Filippa, M., Panza, C., Frassoldati, R., Kuhn, P., Ferrari, F., Balduzzi, S., D'Amico. (2017). Systematic review of maternal voice interventions demonstrates increased stability in preterm infants. *Acta Paediatrica*. Young Investigator Award

73

73

Research About Talking to Babies in the NICU

- Provenzi L, Broso S, Montirosso R. Do mothers sound good? A systematic review of the effects of maternal voice exposure on preterm infants' development. Neurosci Biobehav Rev, 2018 May;88:42-50.
- Filippa, Kuhn, Westrup. Early Vocal Contact and Preterm Infant Brain Development: Bridging the Gaps Between Research and Practice. Springer US. 2017.

74

74

Fetus Response to Maternal Speech

- Fetal response to auditory stimuli
  - Noninvasive functional brain imaging (fMRI)
- A fetus at 33-34 weeks gestation can distinguish between:
  - Maternal voice (MV)
  - Unfamiliar female voice (UFV)
  - Sounds (S)
- Increased brain activity in auditory centers of brain:
  - Upper bank of the temporal lobe showed specific sensitivity to speech ($p < 0.001$)
  - Lower bank of the temporal lobe was more active during exposure to MV than to UFV ($p < 0.007$)

Jardri R, Houfflin-Debarge V, Delion P, Pruvo JP, Thomas P, Pins D. Assessing fetal response to maternal speech using a noninvasive functional brain imaging technique. Int J Dev Neurosci. 2012 Apr;30(2):159-61.

75

Fetal Heart Rate Responses to Recurrent Maternal Speech

- Unborn babies can recognize familiar word sequences
  - Mothers recite a child's rhyme daily in the last few weeks of pregnancy
  - Unborn baby begins to have changes in fetal heart rate when they hear their mother recite the now-familiar rhyme

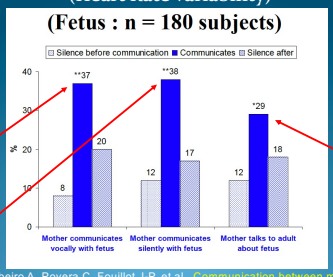
DeCasper J, et al., Fetal reactions to recurrent maternal speech. Infant Behav and Dev. April-June 1994;17(2):159-164.

76

Communication Between Mother and Fetus

(Heart Rate Variability)

(Fetus : n = 180 subjects)



Mother Communicates WITH the Fetus Vocally

Silently

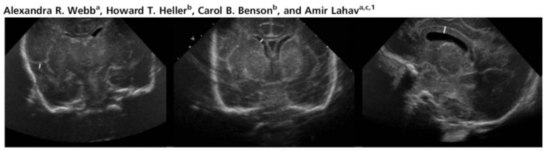
Mother Communicates ABOUT the Fetus Vocally

Busnel M-C, Volff T, Ribeiro A, Povera C, Fouillot J-P, et al.. Communication between mother and infant (fetus or newborn). World Association of Infant Mental Health - WAIMH Congress, 2006, Paris, France. Infant Mental Health Journal, 27 (3A), pp.738, 2006, Supplement to the Infant Mental Health Journal. (hal-01598660)

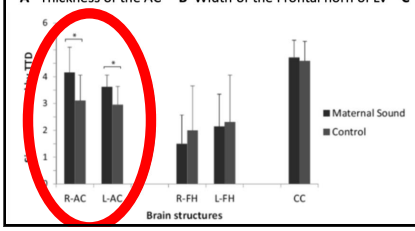
77

Mother's voice and heartbeat sounds elicit auditory plasticity in the human brain before full gestation

Alexandra R. Webb[a], Howard T. Heller[b], Carol B. Benson[b], and Amir Lahav[a,c,1]



A Thickness of the AC B Width of the Frontal horn of LV C Width of the body of the Corpus Callosum



- 40 VPT Newborns
- GA 29 wks
- Mother's sound 3 hr/day during 30 d
- Cr US at 30 DOL

Webb AR et al PNAS 2015

78

Talking to Preterm Babies in the NICU

- 36 preterm infants in a NICU at Brown University
- At 32 weeks and 36 weeks, researchers recorded the NICU environment for 16 hours with a Language Environment Analysis (LENA) microprocessor.
- Computer recorded and analyzed
  - Adult word count
  - Infant vocalizations
  - Conversation turns between mother and infant

Caskey M, Stephens B, Tucker R, Vohr B. Adult talk in the NICU with preterm infants and developmental outcomes. *Pediatrics*. 2014 Mar;133(3):e578-584

79

79

Observations

1. Some parents talked directly to the baby
2. Other parents simply held and rocked the babies or caressed them but didn't talk or sing much
3. Some parents were not present

- In the latter two cases, the infants did not hear many words spoken directly to them.

Caskey M, Stephens B; Tucker R Vohr B. Adult talk in the NICU with preterm infants and developmental outcomes. Pediatrics, 2014 Mar;133(3):e578-584

80

80

Results

Bailey III Developmental Evaluations were done
At 18 months CGA:

- For every increase in 100 words that adults spoke directly to the preterm infants at 32 weeks CGA, the babies had a:
  - 2-point increase in language scores
  - 0.5 increase in expressive communication score

Caskey M, Stephens B; Tucker R Vohr B. Adult talk in the NICU with preterm infants and developmental outcomes. *Pediatrics*, 2014 Mar;133(3):e578-584

81

81

Conclusions

- Premature babies had the most benefit
  - When their mothers spoke directly to them
  - Compared to:
    - If mothers only stroked their babies with no words
    - If babies were mostly with nurses who talked to other adults around them but didn't talk directly to the babies

Caskey M, Stephens B; Tucker R Vohr B. Adult talk in the NICU with preterm infants and developmental outcomes. *Pediatrics*, 2014 Mar;133(3):e578-584

82

82

Parent's Role in Language Development

Dr. Vohr said:

- "To me, it's amazing that at 32 weeks CGA
  - (eight weeks before their expected delivery)
  - The role of the parent is so powerful
    - In predicting language outcomes.
- "We can inform parents
  - They have an important role in the NICU
  - They can make a big difference for their baby
  - By being with their baby and talking to them."

83

83

Vocalizations & Conversational Turns

Study identified that preterm infants :

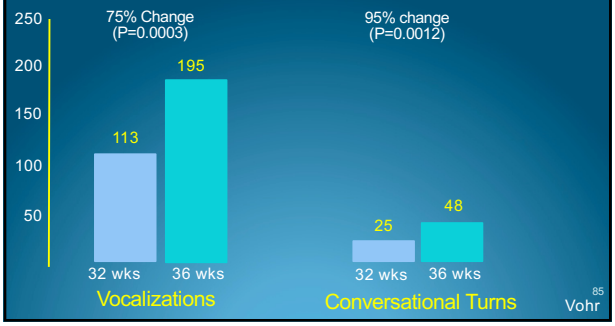
- Vocalize (make sounds) at least eight weeks before their mother's due date
- Vocalize more when their mothers are present in the NICU than when they are cared for by NICU staff"
- Have conversational turns when mothers were present
  - Words of mother and vocalizations of infant within 5 seconds

Caskey M, Stephens B, Tucker R, Vohr B. Importance of parent talk on the development of preterm infant vocalizations. *Pediatrics*. 2011;128(5):910-916. doi:10.1542/peds.2011-0609

84

84

Total Vocalizations & Conversational Turns



85

Nurture Science Program

- Martha Welch, MD & Michael Myers, PhD
  - Columbia University Medical Center in the US
- Developed a Nurture Science Program in the NICU
  - To put the neuroscience of nurture into practice
- Recognize that mother-infant separation causes emotional trauma
  - They help parents & preterm babies
  - To have an emotional connection each day
- Goal: To re-connect & relax from NICU stress
  - By using simple interventions

86

Family Nurture Intervention

- Trained Nurture Specialists
  - Support mother and baby in
    - 1-hour Calming Sessions every day for 6 days a week
- They use 3 simple tools:
  - 1) Kangaroo Care, 2) Talking to baby, and 3) Scent cloth
    - Scent cloth carries mother's smell and stays with the baby
- The mother and baby are thought of together as a pair
  - Interventional activities are deliberately designed to create emotional connections between them

87

Nurture Science Program Results

Randomized Controlled Trial

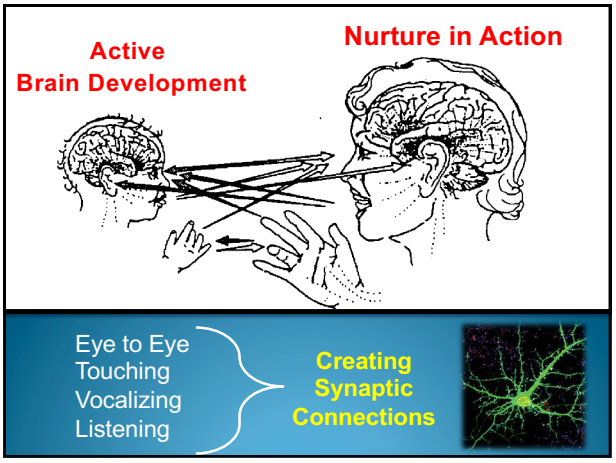
- 4 months CGA:
  - Decreased maternal anxiety and depression
- Term CGA:
  - Dramatically increased brain activity in pre-frontal cortex
- 18 months CGA:
  - Significantly increased cognition & language development
  - Significantly decrease in rates of autism
- 4-5 years:
  - Improved autonomic regulation

88

What is the purpose of bonding & attachment relationships?

- In the past, we thought:
  - Bonding & attachment relationships were
    - Mostly to create a sense of safety & security for infants & children
- Now we know that
  - Bonding & attachment relationships:
    - Have a major effect on brain organization & development
    - Even effect brain structure & function

89



90

Attachment and Brain Structure

- "Early interpersonal events can positively and negatively impact the structural organization of the brain."
- "The immature newborn brain is designed to be sculpted into its final configuration by the effects of early experiences.
- These experiences are embedded in the attachment relationship."

Schore, I*nfant Me*

91

Impact of Neglect, Trauma, & Abuse on a Child's Brain Development

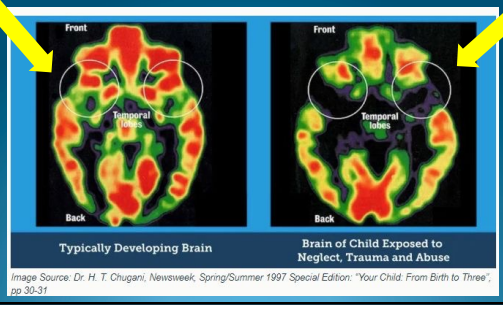


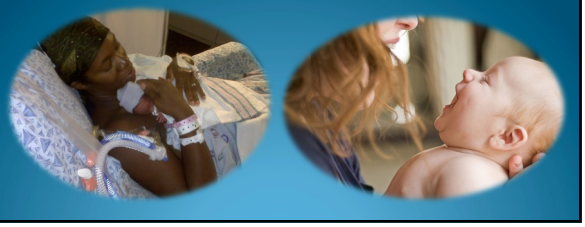
Image Source: Dr. H. T. Chugani, Newsweek, Spring/Summer 1997 Special Edition: "Your Child: From Birth to Three", pp 30-31

92

Nurturing Supports Optimal Brain Development

Premature

Full Term



93

"If we hope to create a non-violent world where respect and kindness replace fear and hatred, we must begin with how we treat each other at the beginning of life.

For that is where our deepest patterns are set. From these roots grow fear and alienation – or love and trust."

Suzanne Arms

94

Every Human Being Needs Love From the Very Beginning of Life

Klaus MH & Klaus PH. *Your Amazing Newborn*, 1998

95

Every Human Being Needs Love From the Very Beginning of Life

96

Every Human Being Needs Love

Even if the Very Beginning of Life Is in the NICU

97

98

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103