It’s more than the milk: Breastfeeding, Oxytocin and the Maternal Brain

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Texas Children’s Hospital
Child Abuse and Neglect

- In the United States, there are 900,000 confirmed cases of child abuse and neglect each year
- ~60% of children reported for neglect
- Highest rate of victimization in children <1 year
- Neglect accounts for 30% of all maltreatment fatalities

In over 60% of cases, the biological mother is identified as the perpetrator
Defining Neglect

- **Failure** to provide for a child’s intrinsic needs
- **Retrospective study** (Dube, 2003)
  - 10% of the population experienced physical neglect
    - >50% of these also experienced emotional neglect
  - 15% emotional neglect
Physical Neglect

- Food
- Clothing
- Shelter
- Medical care
- Educational provision

Emotional Neglect

- Comfort
- Protection
- Love
- Discipline
- Encouragement
Consequences of Child Neglect

- Language delays
- Increased risk of childhood aggression
- Internalizing and externalizing behavior problems (Mills, *Child Abuse & Neglect*, 2013)
Benefits of Breastfeeding

- In human and animal studies, breastfeeding is associated with:
  - Blunted maternal stress reactivity (e.g. blood pressure and cortisol levels)
  - Reduced maternal anxiety and perceived stress
  - More attuned maternal caregiving – improved “mother-infant bonding”?

Could breastfeeding help to protect against maternally perpetrated child abuse and neglect?
I. Breastfeeding and Child Neglect
Questions

- Does *breastfeeding* help to *protect* against child abuse and neglect?
- What *biological systems* may be important in child neglect?
- Are there *individual differences* in how mothers respond to their infants?
Study Design and Population

- Mater-University of Queensland Study of Pregnancy (MUSP)
- Prenatal cohort of public hospital patients enrolled at the Mater Mothers’ Hospital, Brisbane, Australia between 1981 and 1984
- 7292 term infants (95% of cohort)
Sample Size

- 8556 consecutive mothers attended first antenatal clinic visit
- 8458 mothers (98.9%) enrolled in the study, completing 1st antenatal clinic questionnaire
- 7636 mothers (89.2%) delivered at the Mater Mothers’ Hospital
**Mater-University of Queensland Study of Pregnancy (MUSP)**

| Description                                                      | No.  | % of prenatal cohort | % of birth cohort |
|*******************************************************************|
| Consecutive women seen at 1st antenatal visit                   | 8556 | 100                  |                  |
| Women enrolled in study                                        | 8458 | 98.9                 |                  |
| **Birth cohort (3-5 days post-birth)**                         |      |                      |                  |
| Complete breastfeeding (at 6 months) and maltreatment data      | 6621 | 77.4                 | 91.7             |
| Complete breastfeeding, maltreatment and covariate data         | 5890 | 68.8                 | 81.5             |
Breastfeeding Data

- Breastfeeding data collected from mother at 6 month assessment
- Duration of breastfeeding assessed
  - Not at all
  - 2 weeks or less
  - 3-6 weeks
  - 7 weeks to 3 months
  - 4-6 months
  - > 6 months
Controlled Variables - Prenatal

- Parental factors
  - Maternal age
  - Marital status – single, married, unmarried cohabitation
  - Race
  - Cigarette / alcohol consumption
  - Maternal anxiety
  - Maternal depression
  - Partner conflict
  - Pregnancy ambivalence

- Maternal education
- Employment
- Income

- Child factors
  - Birth weight
  - Sex
  - Prematurity
  - Neonatal complications
Outcome Measures

- Database linked to child maltreatment reports, from Child Protective Services
- Included reports from 1981 to Sept 2000
- Confidential ID number preserved anonymity of families reported
- CPS report of any type of child maltreatment (neglect or physical, emotional, sexual abuse)
- Substantiation of report
- Intervention received (child protection follow-up, court orders)
RESULTS
Incidence of Maltreatment

- 11% of birth cohort reported for suspected child abuse or neglect
- 7% of birth cohort had at least one substantiated episode of maltreatment
- Over 60% of children with substantiated maltreatment had at least one episode of maternally-perpetrated abuse or neglect
Breastfeeding Duration

- Breastfed >=4mth: 35% (2655)
- Breastfed <4mth: 34% (2638)
- Not breastfed: 19% (1481)
- Missing data: 12% (n=6774)
Duration of Breastfeeding and Severity of Neglect

- Not Breastfed: 1329
- Breastfed <4mth: 2452
- Breastfed >=4 mth: 2564

- No reported neglect: 52, 88, 55
- Unsubstantiated neglect: 59, 60, 29
- Substantiated neglect (no CPS intervention): 41, 38, 24
- Substantiated neglect + CPS intervention: 7

$p < .001$
## Breastfeeding and Substantiated Neglect

<table>
<thead>
<tr>
<th>Breastfeeding duration</th>
<th>Unadjusted OR (95%CI) Substantiated Maltreatment</th>
<th>Adjusted OR (95%CI) Substantiated Maltreatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>Non-maternal</td>
</tr>
<tr>
<td><strong>Any maltreatment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 or more months</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Less than 4 months</td>
<td>1.0</td>
<td><strong>1.8 (1.2-2.8)</strong></td>
</tr>
<tr>
<td>Not at all</td>
<td>1.0</td>
<td><strong>1.7 (1.0-2.8)</strong></td>
</tr>
<tr>
<td><strong>Neglect</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 or more months</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Less than 4 months</td>
<td>1.0</td>
<td><strong>0.9 (0.3-2.6)</strong></td>
</tr>
<tr>
<td>Not at all</td>
<td>1.0</td>
<td><strong>2.3 (0.9-6.0)</strong></td>
</tr>
</tbody>
</table>
Breastfeeding and Emotional and Physical Abuse

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<thead>
<tr>
<th>Breastfeeding duration</th>
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<tr>
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<td>1.0</td>
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<tr>
<td>Less than 4 months</td>
<td>1.0</td>
<td>1.3 (0.7-2.5)</td>
</tr>
<tr>
<td>Not at all</td>
<td>1.0</td>
<td>1.5 (0.7-3.2)</td>
</tr>
<tr>
<td><strong>Physical Abuse</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 or more months</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Less than 4 months</td>
<td>1.0</td>
<td>2.1 (1.2-3.8)</td>
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<tr>
<td>Not at all</td>
<td>1.0</td>
<td>2.3 (1.2-4.4)</td>
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## Adjusting for Maltreatment Subtypes

<table>
<thead>
<tr>
<th>Breastfeeding Duration</th>
<th>Adjusted OR (95%CI) for Substantiated Maltreatment</th>
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<tbody>
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<td></td>
<td>None</td>
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<tr>
<td><strong>Neglect</strong></td>
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Maternal Risk Factors for Substantiated Neglect

- Emotional Abuse: Adjusted Odds Ratio (log) = 7.7
- Aboriginal Race: Adjusted Odds Ratio (log) = 2.6
- Physical Abuse: Adjusted Odds Ratio (log) = 2.5
- Anxiety: Adjusted Odds Ratio (log) = 2
- Low Education: Adjusted Odds Ratio (log) = 2
- Young Age: Adjusted Odds Ratio (log) = 1.7
- Unemployment: Adjusted Odds Ratio (log) = 1.6
- Not Breastfed: Adjusted Odds Ratio (log) = 3.8
II. Biological Mechanisms
Questions

- Does *breastfeeding* help to *protect* against child abuse and neglect?
- What *biological systems* may be important in child neglect?
- Are there *individual differences* in how mothers respond to their infants?
Oxytocin and maternal caregiving

- Oxytocin is a peripheral hormone important in childbirth and lactation
- Breastfeeding/suckling stimulates its production
- It also has important central effects in the brain to help prepare for long-term child rearing
- “Calm and connection” effect
In animal models of maternal care, oxytocin is critical for the initiation of maternal care.

In ewes, oxytocin results in selective bonding with the lamb.

Oxytocin neurons may also connect with the brain’s dopamine “reward” system, resulting in changes in “long-term conditioned preferences”.

Champagne, 2003
Possible Mechanisms Underlying Breastfeeding / Neglect Connection

- Areas of known significance
  - Oxytocin “affiliation” pathways
    - Pituitary gland
    - Hypothalamus (MPOA, PVN)
  - Dopamine “reward” pathways
    - Ventral striatum
    - Medial prefrontal cortex
- The development of these systems appears to be strongly influenced by early maternal care
Study Outline

Visit 1: Pregnancy
- 3rd trimester
- BIRTH

Visit 2: Videotaping
- 7 mths
- 20 min: Mother-infant separation 1
- 5 min: “Free play” interaction
- 6 min: Mirror-based interaction
- Blood draws
  - Oxytocin
  - Cortisol
  - Adrenaline
  - Noradrenaline

Visit 3: Scanning
- 10 mths
- 20 min: Mother-infant separation 2
- • PANAS (2)
  - IBQ
  - PSI
- • WTAR
  - Breastfeeding duration
  - Hours separated per week

Visit 4: Follow-Up
- 14 mths
- • Bayley Scales of Infant Development
  - Strange Situation Procedure

Data Collected
- AAI
- Demographics
- PDQ
- BDI
- PANAS (1)
- Demographics
- ATQ
- Infant face images
- PANAS (2)
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- PSI
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**Visit 1: Pregnancy**

**Study Timeline**

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  - 3rd trimester
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- Strange Situation Procedure

**Strathearn L, et al. Neuropsychopharmacology. 2009.**
Visit 2: Videotaping

Visit 1: Pregnancy
- 3rd trimester

Visit 2: Videotaping
- 7 mths
  - Mother-infant separation 1
  - "Free play" interaction
  - Mirror-based interaction
  - Blood draws (Oxytocin, Cortisol, Adrenaline, Noradrenaline)
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  - Demographics
  - ATQ
  - Infant face images

Visit 3: Scanning
- 10 mths
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Visit 3: fMRI Scanning

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**Study Timeline**

14 mths:
- Mother-infant separation 2
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Three Affective States

Crying  Neutral  Smiling
<table>
<thead>
<tr>
<th>STIMULUS TYPES</th>
<th>IDENTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own Infant</td>
<td>Unknown Infant</td>
</tr>
<tr>
<td>Happy</td>
<td>OH</td>
</tr>
<tr>
<td>Neutral</td>
<td>ON</td>
</tr>
<tr>
<td>Sad</td>
<td>OS</td>
</tr>
</tbody>
</table>

2–6 sec random inter-stimulus interval
Functional Magnetic Resonance Imaging (fMRI)

- fMRI allows for the time course of human brain activity to be imaged.
The Hemodynamic Response

Neural pathway → Hemodynamics → MR scanner

Figure adapted from Chein & Schneider
Initial Findings

Amygdala
Cingulate Cortex
VTA
Ventral striatum
Substantia nigra

n=28, p<0.001 (uncorr.)
A. Dorsal striatum

B. Substantia nigra
A. Dorsal striatum

B. Substantia nigra
III. Individual Differences in Maternal Responses
Questions

- Does breastfeeding help to protect against child abuse and neglect?
- What biological systems may be important in child neglect?
- Are there individual differences in how mothers respond to their infants?
Attachment Theory

- Originally formulated by John Bowlby in 1969
- Innate biological system to ensure protection and reproduction
- Individual differences in attachment “security” are associated with maternal care and infant social/emotional development
Group Comparisons

- Comparison of 15 “secure” mothers and 15 “insecure/dismissing”
- No significant group differences were seen, with respect to:
  - Maternal SES, race, education or IQ
  - Self-reported parenting stress
  - Pre- or post-natal depression or psychopathology risk
  - Mother or infant temperament
  - Infant development at 14 months
  - Breastfeeding duration
## Secure vs. Insecure/Dismissing

<table>
<thead>
<tr>
<th>Secure</th>
<th>Insecure / Dismissing</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Medial PFC</td>
<td></td>
</tr>
<tr>
<td>- Orbitofrontal cortex</td>
<td></td>
</tr>
<tr>
<td>- Ventral striatum</td>
<td>- Dorsolateral PFC</td>
</tr>
</tbody>
</table>
Own Happy Faces: Secure vs. Insecure Attachment

Bilateral Ventral Striatum

Right Medial PFC

(secure = 1.0, t=3.0, p=0.006)

(secure = 0.4, t=3.1, p=0.005)
## Secure vs. Insecure/Dismissing

<table>
<thead>
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<th>Secure</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Medial PFC</td>
<td>Dorsolateral PFC</td>
</tr>
<tr>
<td>Orbitofrontal cortex</td>
<td></td>
</tr>
<tr>
<td>Ventral striatum</td>
<td>Dorsolateral PFC</td>
</tr>
<tr>
<td>Ventral striatum</td>
<td>Anterior insula</td>
</tr>
</tbody>
</table>
Own Sad Faces: Secure vs. Insecure Attachment

- R Ventral Striatum
- R Insula

- Insula: (se=0.4, t=3.1, p=0.005)
- Insula: (se=1.0, t=3.0, p=0.006)

- Own Sad Faces: Secure vs. Insecure Attachment

- Secure: % Signal Change
- Insecure/Dismissing: % Signal Change
Change in peripheral oxytocin with mother-infant interaction

Serum oxytocin (pg/ml)

- Type B (Secure)
- Type A (Insecure/Dismissing)

* $P<0.05$

Mann-Whitney U
Own > Unknown Faces: Oxytocin Response

Hypothalamus/Pituitary Region

\[ r_s = 0.60, \quad P = 0.001 \]

R Sq Linear = 0.297
Oxytocin Response and Ventral Striatum Activation

Brain Activation (beta weights) vs. Change in Oxytocin (%)

- Type B (Secure)
- Type A (Insecure)
- Fit line for Total

R Sq Linear = 0.258
In Summary

- Breastfeeding beyond 4 months may have a protective role in preventing child neglect
- Oxytocin may play a critical role in strengthening the mother-infant bond and activating brain reward mechanisms
- Mothers with insecure attachment patterns may be at higher risk for neglect
Preventing Neglect: Where to from here?
Future Research Directions

- Better understand neural processes involved in attachment in high-risk populations
  - e.g. cocaine exposed new mothers in residential treatment
- Randomized controlled trial of intranasal oxytocin in mothers
Future Research Directions

**Risk for Emotional Neglect**

- Insecure/Dismissing Adult Attachment

**Effects of Intranasal Oxytocin**

1. Brain
   - Functional MRI
   - Eye gaze tracking
2. Behavior
   - Videotaped free play
   - Modified Still-Face paradigm

**Maternal Responses to Infant Cues**

- Reduced brain reward activation to infant faces
- Reduced eye gaze when viewing sad infant faces
- Reduced maternal sensitivity
- Reduced contingent responses to infant cues

**Indirect Measures of Maternal Emotional Neglect**

- Dopamine and oxytocin
Supporting New Mothers and Babies

- Promotion and support for breastfeeding from the time of conception
  - Prenatal breastfeeding counseling
  - Baby Friendly Hospital Initiative
Acknowledgements

- Dr Michael O’Callaghan, Prof Jake Najman and the Mater-University Study of Pregnancy
- Families, Youth and Community Care Queensland, Australia
- Read Montague, Samuel McClure at the Human Neuroimaging Laboratory, Baylor College of Medicine
- Peter Fonagy, University College London