Experience-based Brain Development in Early Life and Mental Health and Behaviour Problems

By J. Fraser Mustard
The Founders’ Network

November 26, 2007
CIAR - History

- Population Health
- Human Development
- Experience-based Brain and Biological Development
HEALTH
Socio-Economic Gradient and Mortality – Men UK

SMR – Standardized Mortality Rate
U.K. CIVIL SERVICE Mortality - All Causes

Cumulative Mortality

Year of Follow-up

Other
Clerical
Professional/Executive
Administrative
<table>
<thead>
<tr>
<th>Civil Service Grade</th>
<th>Non-Adjusted</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HIGH</td>
<td>LOW</td>
</tr>
<tr>
<td>Work</td>
<td>1.00</td>
<td>1.18</td>
</tr>
<tr>
<td>Risk Factors</td>
<td>1.00</td>
<td>1.30</td>
</tr>
<tr>
<td>Fully</td>
<td>1.00</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Marmot, BMJ, 1997

Age Adjusted Odds Ratios
CHD - Whitehall Study
Life Cycle and Health

In Utero - Barker et al
Early Years - Power and Hertzman
Adult Life - Marmot et al

Biological embedding in the early years (Epigenetics)
<table>
<thead>
<tr>
<th>Adult Health</th>
<th>Number of Adverse ECD Circumstances*</th>
<th>Odds - Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Physical</td>
<td>0 1 2 3 4</td>
<td>1 1.39 1.54 2.08 2.66</td>
</tr>
<tr>
<td>Circulatory</td>
<td>1 1 2 3 4</td>
<td>1.56 1.53 2.91 7.76</td>
</tr>
<tr>
<td>Mental</td>
<td>1 1 2 3 4</td>
<td>1.78 2.05 3.76 10.27</td>
</tr>
</tbody>
</table>

* Economic, family size, broken family and family dissention

Health Problems Related to Early Life

- Coronary Heart Disease
- Non-insulin Dependent Diabetes
- Obesity
- Blood Pressure
- Aging and Memory Loss
- Mental Health (depression)
- Behaviour (addiction, ADHD)

Bruce McEwen
"Follow up through life of successive samples of birth has pointed to the crucial influence of early life on subsequent mental and physical health and development."

Acheson, Donald - *Independent Inquiry into Inequalities in Health*, 1998
Human Early Experience & Development
# Substance Abuse and Childhood Abuse

<table>
<thead>
<tr>
<th>Exposure to Child Abuse*</th>
<th>Odds Ratios for Drug and Alcohol Use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Drugs</td>
</tr>
<tr>
<td>0</td>
<td>1.0</td>
</tr>
<tr>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>3</td>
<td>3.6</td>
</tr>
<tr>
<td>4+</td>
<td>4.7</td>
</tr>
</tbody>
</table>

* Scale: 0 none 4 intense

Felitti, V.J.
Early Learning and Criminal Behaviour

"Significant correlation with registered criminality (teenage) appeared for language development at 6, 18, and 24 months

Stattin, H. et al *Journal of Abnormal Psychology* 102; 369, 1993
J. Douglas Willms, "Literacy Skills of Canadian Youth"
### Document Literacy
1994 – 1998, Ages 16 to 65

<table>
<thead>
<tr>
<th>Country</th>
<th>Level 1 and 2</th>
<th>Level 4 and 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>23%</td>
<td>34.0%</td>
</tr>
<tr>
<td>Canada</td>
<td>42%</td>
<td>23.0%</td>
</tr>
<tr>
<td>Australia</td>
<td>43%</td>
<td>17.0%</td>
</tr>
<tr>
<td>United States</td>
<td>48%</td>
<td>18.0%</td>
</tr>
<tr>
<td>Chile</td>
<td>85%</td>
<td>3.0%</td>
</tr>
<tr>
<td>Mexico</td>
<td>84%</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

OECD
Socioeconomic Gradients for Document Literacy Scores

Mean Scores

Parents’ Education (years)

U.S.

U.S.

Canada

Finland

Sweden

Australia

Intern’l Mean

OECD, 2000
Sociocultural Gradients for Language Scores By Country (grade 3)

Parents' Education (Years)

Language Score

Cuba
Argentina
Brazil
Colombia
Mexico

Willms, 2002
Literacy Levels for the Total Population – USA

- Prose
- Document
- Quantitative

NALS, p. 17, 2002
Literacy Levels by Physical, Mental or Other Health Conditions – USA (Quantitative)

Health Problems
Mental or Emotional Problems
Long-term Illness

NALS, p. 44, 2002
“How do social experiences get under the skin?”

Ron Barr
Experience-Based Brain Development in the early years of life sets neurological and biological pathways that affect:

- Health
- Learning
- Behaviour
Economist Magazine

- September 21, 2006 – Learning Without Learning (Epigenetics)
- October 7, 2006 – A Survey of Talent
- December 23, 2006 – A Survey of the Brain
- June 14, 2007 – RNA - Really New Advances (microRNA)
Two Neurons

Axon

RECIPIENT NEURON

Synapse

Dendrite

SIGNAL-SENDING NEURON
SENSING PATHWAYS
- Sound
- Vision
- Smell
- Touch
- Proprioception
- Taste
Eye cataracts at birth prevent normal development of vision neurons in the occipital cortex (Hubel and Wiesel)

Cochlear defects at birth impair hearing development (Rauschecker and O’Donoghue)
Brain Pathways

- “Higher levels of brain circuits depend on precise, reliable information from lower levels in order to accomplish their function.

- Sensitive periods for development of lower level circuits ends early in life.

- High level circuits remain plastic for a longer period.”

Knudsen 2004
Early Child Development and Language

- Starts early – first 7 months
- Sets capability for mastering multiple languages
- Sets literacy and language trajectories
Vocabulary Growth – First 3 Years

Vocabulary

Age - Months

High SES
Middle SES
Low SES

B. Hart & T. Risley, Meaningful Differences in Everyday Experiences of Young American Children, 1995
Human Brain Development – Language and Cognition

Sensing Pathways (vision, hearing)

Language

Higher Cognitive Function

Early Brain Development and Criminal Behaviour

Significant correlation with registered criminality (teenage) appeared for language development at 6, 18, and 24 months

Stattin, H. et al - *Journal of Abnormal Psychology* 102; 369, 1993
Stress

Limbic HPA Pathway
Limbic HPA Pathway - Stress

**Cortisol – Over Production**

Behaviour, depression, diabetes, malnutrition, cardiovascular disease, memory, immune system, drug and alcohol addiction

**Cortisol – Under Production**

Chronic fatigue syndrome, fibromyalgia, immune system (autoimmune disorders) rheumatoid arthritis, allergies, asthma
Stress Pathway and Sensory Stimuli

Touch in the Early Period is Critical

- Rats – Mothers licking pups
- Monkeys – Peer vs mother rearing
- Humans - Attachment
Individual differences in stress reactivity of the adult are determined by maternal behaviour during infancy.

Development of Stress Reactivity

HIGH LG

Modest Stress Reactivity
Reduced Risk for Disease

LOW LG

Increased Stress Reactivity
Increased Risk for Heart Disease, Type II Diabetes, Alcoholism, Affective Disorders, Brain Aging, etc.

M. Szyf
Environment Affects Gene Function

- Epigenetics
- MicroRNAs
- Candidate Genes
Epigenetics
(heritable without changes in DNA sequence)

- Methylation of DNA (cytosine)
- Histone acetylation
Hippocampal GR(1γ) Region 16 (5’ NGFI-A RE) Methylation Timeline

Mean C-Methylation

Age

Embryo
Day 20

Birth
Day 1

Pup
Day 6

Weaning
Day 21

Adult
Day 90

Licking Low

Licking High

M. Szyf
Rhesus Macaque Monkeys – Serotonin Transporter Gene

Poor nurturing in infancy

- Long allele, no behaviour problems
- Short allele, significant behaviour problems and alcohol addiction
“Maltreatment at an early age can have enduring negative effects on a child's brain development and function.”

Martin Teicher
Scientific American, 2002
"The aftermath … can appear as depression, anxiety, suicidal thoughts or post-traumatic stress - or as aggression, impulsiveness, delinquency, hyperactivity or substance abuse."

Martin Teicher
Scientific American, 2002
Serotonin Transporter Gene Experience in Early Life - Depression

Depression Risk

Age 26

S = Short Allele
L = Long Allele

No Abuse Moderate Abuse Severe Abuse

Early Childhood

## Romanian Adoption Project

Scores at 10.5 Years

<table>
<thead>
<tr>
<th></th>
<th>CB</th>
<th>EA</th>
<th>RO</th>
</tr>
</thead>
<tbody>
<tr>
<td>IQ</td>
<td>108</td>
<td>99</td>
<td>85</td>
</tr>
<tr>
<td>Language Score</td>
<td>106</td>
<td>99</td>
<td>88</td>
</tr>
<tr>
<td>Behaviour</td>
<td>13%</td>
<td>9%</td>
<td>43%</td>
</tr>
</tbody>
</table>

CB - Canadian Born
EA - Early Adopted
RO - Romanian Orphanage

L. Le Mare
Evening Cortisol Levels Increase with Months of Orphanage Rearing *

Log10 Salivary Cortisol

*linear trendline

Months of Orphanage Rearing
OUTCOME MEASURES
Early Development Instrument (EDI)

- Physical health and well-being
- Social knowledge and competence
- Emotional health/maturity
- Language and cognitive development
- Communication skills and general knowledge
### EDI Results – Vancouver Districts

<table>
<thead>
<tr>
<th>District</th>
<th>Income</th>
<th>EDI Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12,000-24,000</td>
<td>34.5</td>
</tr>
<tr>
<td>2</td>
<td>24,000-37,000</td>
<td>27.5</td>
</tr>
<tr>
<td>3</td>
<td>37,000-49,000</td>
<td>21.5</td>
</tr>
<tr>
<td>4</td>
<td>49,000-62,000</td>
<td>15.0</td>
</tr>
<tr>
<td>5</td>
<td>62,000-74,000</td>
<td>8.5</td>
</tr>
<tr>
<td># of Vulnerabilities</td>
<td>% Failing Grade 4</td>
<td>% Not Passing Grade 4</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>0</td>
<td>7.5</td>
<td>12.3</td>
</tr>
<tr>
<td>1</td>
<td>11.8</td>
<td>22.2</td>
</tr>
<tr>
<td>2-3</td>
<td>18.7</td>
<td>33.8</td>
</tr>
<tr>
<td>4-5</td>
<td>27.5</td>
<td>55.6</td>
</tr>
</tbody>
</table>

Hertzman, HELP, 2006
## Vancouver EDI Reading

<table>
<thead>
<tr>
<th># of Vulnerabilities</th>
<th>% Failing Grade 4</th>
<th>% Not Passing Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>13.6</td>
<td>17.8</td>
</tr>
<tr>
<td>1</td>
<td>26.7</td>
<td>33.9</td>
</tr>
<tr>
<td>2-3</td>
<td>29.5</td>
<td>43.1</td>
</tr>
<tr>
<td>4-5</td>
<td>48.4</td>
<td>68.3</td>
</tr>
</tbody>
</table>

Hertzman, HELP, 2006
Decrease in the % of vulnerable children as a result of improved ECD in Western Australia

<table>
<thead>
<tr>
<th></th>
<th>2003</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floreat</td>
<td>47.22%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Wembley</td>
<td>47.11%</td>
<td>11.8%</td>
</tr>
</tbody>
</table>
Success by Ten
Early Child Development

- Intervene early
- Intervene often
- Intervene effectively

Ludwig and Sawhill, Brookings Institution
Components of Early Childhood Development and Parenting Centres:

- ECD & care (parental and non-parental) arrangements
- Play-based learning (problem-based)
- Resources
- Prenatal & postnatal supports
- Nutrition programs
Parental Leave

Provide 18 months parental leave with income support, followed by one day weekly leave for both parents until age three to be involved in the Early Child Development & Parenting Centre.
In Ontario and South Australia, about 25% of Children are Vulnerable at Age 5

<table>
<thead>
<tr>
<th>Country</th>
<th>Number of Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>Over 40,000</td>
</tr>
<tr>
<td>South Australia</td>
<td>Over 5,000</td>
</tr>
</tbody>
</table>
Cost of ECD-P Centres (Estimate Canada)

Age 0 to 6 Population

Universal (2,500,000 children)

Cost $18.5 Billion (1.5% of GDP)

Present Expenditure 0.25% of GDP
Cost to Individuals and Canadian Society of Poor Early Child Development (estimates)

Crime and Violence* $120 Billion/year
Mental Health and Behaviour** $100 Billion/year

* Adapted from Heckman. 2006.
** Adapted from Gnam et al. 2006.
"We cannot afford to postpone investing in children until they become adults nor can we wait until they reach school - a time when it may be too late to intervene."

Heckman, J., 2001
(Nobel Prize Economics, 2000)
Rates of Return to Human Development Investment Across all Ages

Pre-school Programs

School

Job Training

Return Per $ Invested

Age

Pre-School

School

Post School

J. Heckman
ECD

Education  Health  Social Capital  Equality

Economic Growth

Human Development

J. van der Gaag, 2000
Free Market Capitalism
Choices

- Without social accountability
- With social accountability
To download this presentation, go to:
Slides - Slide Shows

To order copies of Early Years Study 2, go to:
www.councilecd.ca


