The Forgotten Parent: The Importance of Fathers and Their Experience on the Brain Development of their Children

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Take Home Messages?

Paternal experience affects brain development and future environmental challenges the offspring. Paternal interaction with children supports healthy brain development.

Prevention- by providing parents and families with Support we can avoid many situations that undermine brain development.

MECHANISMS? Experience alters gene expression and changes the brain

Why do we care about brain?

YOU ARE YOUR BRAIN

* Brain is responsible for both physical and mental health
  • BUT- Your brain is not just produced by your genes
  • Your brain is sculpted by a lifetime of experiences

• The most important time in brain development is the first few years of life and the prenatal period.
  • What about prior to conception?
Why does the brain change?

• Brain plasticity offers an adaptive advantage. We can “learn” from our experiences and that should allow us to engage more appropriate behavioural responses in future situations

  • Brain changes                  Behavioural changes

      Experience (Environment)

• But - Not all brain plasticity is positive! (Think of habits)

Nature/ Nurture

• No longer a debate

• Environment leaves its mark on our genome and can modulate future gene expression in a sometimes heritable fashion

• The study of how environment leaves its footprint on the genome falls into the domain of Epigenetics

Harry Harlow - early work on surrogate mothers
How We Derive Our Genome: Nature

Determination of gender. The gender of the offspring depends on whether the sperm cell that fertilizes the ovum carries an X or a Y chromosome.

Sex Chromosomes

X and Y chromosomes display their different characters in this electron micrograph.
Each gene contains a unique set of instructions that is carried out if endorsed (signed) by the environment. This is what is known as the “signature effect”

Epigenetics- “The Signature Effect”

Is the process of using environmental signature approvals to enact the instructions contained within the genes in our DNA.

• It is possible for the “approval” to be transmitted to future generations.

• It is also possible for the heritable change to be reversed

• This provides the basis of environmental adaptation.
Methylation

**Human aggression and the MAO-A gene** Buckholtz & Meyer Lindenberg, 2008

<table>
<thead>
<tr>
<th>MAOA genotype</th>
<th>Developmental 5-HT</th>
<th>Circuit-level effects</th>
<th>Early-life experience</th>
<th>Behavioral outcome</th>
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<td>MAOA-H</td>
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Brain and Human Development

Nature

Genes → Epigenetics ← Stimulation & Nutrition

Nurture

Gene Function

Neurobiological Pathways

Physical Health → Mental Health ← Behaviour → Learning & Cognition

The Sensible Guide to a
HEALTHY PREGNANCY

All For Women:

- Government of Canada
- Prenatal Nutrition
- Folic Acid
- Alcohol and Pregnancy
- Physical Activity and Pregnancy
- Smoking and Pregnancy
- Oral Health
- Emotional Health
The Placenta As a Site of Parental Conflict

• Paternal genes enhance placental development ensuring fetal growth and nutrition

• Maternal genes reduce placental development to reserve resources for mother use

• Balance of conflict results in healthy pregnancy

Mothers and...

IUGR

– pre-pregnancy weight and nutritional status

– poor weight gain during pregnancy

– poor nutrition

– anemia

– alcohol and/or drug use

– Smoking

– recent pregnancy

– pre-gestational or gestational diabetes
Paternal Alcohol Exposure

“The germ plasma itself- that vital spark which continues on through countless centuries- is so affected by alcohol that the children for generations to come suffer from the sins of the fathers.

(from poster issued by US National Education Association in the 1920’s)

Cynthia Daniels- Exposing Men

Can it be too gross to suppose that the organs of generation must equally suffer in both sexes, from frequent intoxication… (Thomas Trotter, English Physician campaigning against the use of alcohol consumption 1813)

Cynthia Daniels- Exposing Men

Fetal alcohol children born to alcoholic fathers, mothers abstainers (Lemoine et al., 1968) 20-25% of sons of father alcoholics and 5% of daughters become alcoholics themselves (Cotton, 1979)

Paternal Smoking

Fathers who have history of early onset of smoking have a higher incidence of obese sons (Pembrey et al., 2006)


Daughters hit menopause earlier (Fekunda, Fertility and Sterility, 2011)

Paternal Marijuana Use (Human)

Paternal use of marijuana in preconception Increased incidence of SIDS

– Not associated with Maternal Use
Exposure to Pesticides (Human)

- DBCP-1,2-Dibromo-3-chloropropane
- Soil fumigant

Dow suspended distribution in 1978 except for use on pineapples (1985). Effects on male reproduction were first documented in 1961. Birth defects, fetal growth restriction, childhood cancers, chromosomal damage

Paternal Preconception Military Duty

- Higher incidence of congenital abnormalities in veterans of Vietnam (Erickson et al., 1984) and Cambodian Wars
- Sailors on Norwegian missile torpedo boats in 1990’s had higher incidence of stillborn children and children with congenital birth defects (Mageroy et al., Occup Environ Med, 2006)

Paternal Age (Human)

Elderly fathers have higher incidence of offspring with……

- Autism (Over 40 vs 30 year olds) grandchildren too (Frans, JAMA Psychiatry, 2013)
- Schizophrenia (Over 50 vs 25 year olds)
- Cognitive Impairment – concentration, memory, reading and reasoning skills (Harms, Mayo Clinic, 2012)
Kari Stefansson (Iceland)

- Higher paternal age increases the risk of genetic disease.
- Mothers pass on ~14 mutations to offspring.
- 20 year old Fathers ~29 mutations
- 30 year old Fathers ~49 mutations
- 40 year old Fathers ~69 mutations
- In Iceland, the average father age rose from 22 in 1980 to 28 in 2011. New mutations in newborns in Iceland increased by 17%
**Paternal Obesity (Human)**

Fathers who have increased food intake in the pre-pubertal period have increased incidence of obese grandsons (Kaati et al. 2002, 2007)

Associated with hypomethylation of IGF-2 in offspring - may impact future health status (Soubry et al. 2013, BMC)

**Paternal Use of Prescription Drugs (Human)**

- Recent studies show about 1/3 of Dads take prescription drugs in the 6 months prior to conception (Netherlands & Norway: Crijns et al., Exp Opin Drug Saf, 2012)

- Many take SSRI's (increased use up to the 3rd trimester)

- Paxil - paroxetine causes abnormal DNA fragmentation in sperm

- Otherwise little is known

**Parental Complex Housing**

![Enriched rat enclosure](image)
Paternal Stress
Elevated Plus Maze (P61)

![Graph showing the comparison between Control and Paternal Stress treatments in terms of Closed Arm (Sec.).]

Paternal Stress
Activity Box (P33)

![Graph showing the comparison between Control and Paternal Stress treatments in terms of Activity.]
Paternal Alcohol Exposure

- Motor defects and neurodevelopmental delays (Abel et al., Jamerson et al., 2004) Rat
Paternal Alcohol
Open Field (P15)

![Chart showing number of novel squares and total squares entered by male and female mice in the P15 Open Field experiment with control and alcohol groups.](chart)

Paternal Alcohol
Elevated Plus Maze (P35/P100)

![Chart showing time in closed arm by male and female mice in the Juvenile and Adult Elevated + Maze (Closed Arm) experiment with control and alcohol groups.](chart)
Paternal Obesity (Rats)


Paternal Bystander Stress

- Protocol: 30 Minute Sessions, 2 Session/Day, 5 Days (G12-19)
  - Housed with mated dam

- External stimuli can alter gene expression in the brain.

- Sphere of Influence is larger than we thought.
Mechanisms

- Sperm- motility
- Sperm- Shape
- DNA & RNA → epigenetic changes
Parenting Styles: Play

Dads (Tag, wrestling, lots of physical contact)

• Play differently-more rough and tumble
• Allow more exploration of their body
• Play is unpredictable
• Spend 40% of time with kids in interactive play

Moms (Coloring, drawing, board games, lots of control, little contact)

• Color, draw, read
• Don’t permit too much physical contact
• Play in a highly predictable fashion
• Spend about 22% of time with kids in interactive play

Scientific American, Vol.21, #2, 2010 pg.46 “Family Guy”

Parenting Style: Discipline

Dads

• Use a quick discipline style-over with and move on.
• Expect immediate results

Moms

• Soften the blow.
• Encourage change but want kids to think about it
Paternal Care

– Dads are spending more time with kids (6.5 hrs/week -2.6 hrs/week 30 yrs ago-<1 hr/week 50 yrs ago)

– Flynn effect: Steady rise in IQ over the past century- Due mostly to improvements in environment and caretaking of children

Maternal depression both pre and post partum affects up to 25% of moms

- Associated with childhood depression and other mental health issues

Paternal Depression may be higher after the birth of baby -up to 30%

- Father depression puts marital status at risk
- Reduced attachment to children
- More problems with self-regulation in children

Strong Father Attachment

• Father vocabulary (not mother’s) predicts kids literacy skills even though Dad’s speak fewer words to their kids
• Stronger interpersonal relationship skills
• Fewer teen pregnancies, less drug use, less likely to join gangs, more likely to finish high school
• Strong mother attachment predicts none of these things

Scientific American, Vol.21, #2, 2010 pg.46 “Family Guy”

A Father’s Love

- Rejection by Father often has a greater influence on the psychological well-being of children than rejection by Mom. May be related to perceived status or prestige
- Important that children receive Father’s love to develop appropriately. Mothers have been disproportionately blamed for maladjustment and behaviour problems (Khaleque and Rohner, Personality and Social Psychology Review, 2011)
- Children whose fathers are more engaged at 3 months show better behaviour at 12 months (Ramchandani et al., J Child Psych and Psychiatry, 2012)
- Fathers can be induced to be more socially engaged with their babies by nasal administration of oxytocin - Basal levels increase by 10 fold in fathers and in babies not administered the drug (Weisman et al. Biological Psychiatry, 2012)

“We underestimate our power as parents at our children’s peril”

Dr. Charles Raison, March 12/2012

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