Understanding sexual offending and the brain: From the basics to the state of the art

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Remember: MRI is painless

Basics
Vocabulary (for people who don’t tweet, vlog, or sext)
Brief history: classic, neuropsych., early imaging
Phallometry
Sensitivity/specificity of diagnostic tests
Physics (for folks over 40)
CT, PET, MRI vs fMRI
How MRIs are analyzed statistically

The state of the art
MRI results
MRI results...explained?
fMRI results
fMRI results...explained?
Sensitivity/specificity
Issues & implications
Sexual offending and the Brain: History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tbody>
<tr>
<td>1886</td>
<td>Founding of modern sexology</td>
</tr>
<tr>
<td>1900–2000</td>
<td>Large scale studies of forensic samples</td>
</tr>
<tr>
<td>1980–1999</td>
<td>Neuropsych testing, early imaging (CT) studies</td>
</tr>
<tr>
<td>1999</td>
<td>First neuroimaging study of sexual arousal</td>
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<tr>
<td>2000–</td>
<td>Large-scale studies of homogeneous samples</td>
</tr>
<tr>
<td>2007–2008</td>
<td>High-resolution studies of pedophilia published</td>
</tr>
<tr>
<td>2007</td>
<td>First fMRI studies of pedophilia published</td>
</tr>
</tbody>
</table>

Richard von Krafft-Ebing (1840–1902)

*Psychopathia Sexualis* (1886)

Sexual anomalies are a “diseased condition of the central nervous system” (p. 61).
Eight decades of IQ testing

Meta-Analysis of all reports, 1931–2004

- 75 reports with IQ data
- 236 non-overlapping samples
- 25,146 cases (7,045 sexual offenders and 18,101 controls)

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IQ of adult samples by victims’ age group

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IQ by Definition of “Child” Victim

Cutoff Defining “child”

$\rho = .005$

$\text{r (29)} = .50$

Mean IQ

Samples’ Mean IQ

1886
1900–2000
1980–1999
1999
2007–2008
2007

Sexual offending and the Brain: History

Founding of modern sexology
Large scale studies of forensic samples
Neuropsych testing, early imaging (CT) studies
First neuroimaging study of sexual arousal
High-resolution studies of pedophilia published
First fMRI studies of pedophilia published
Frontal Lobe vs. Temporal Lobe Theories

Halstead-Reitan Battery
Yeudall (1977)  Rapists
Yeudall et al. (1979)  Heterogeneous
Langevin et al. (1985)  Sadists
Langevin et al. (1988)  Sexual killers, aggressives
Langevin et al. (1989)  Exhibitionists

Luria-Nebraska Battery
Graber et al. (1982)  Heterogeneous
Scott et al. (1984)  Offenders vs. children, adults
Hucker et al. (1986)  Pedophiles
Hucker et al. (1988)  Sadists, sexual aggressives
Langevin et al. (1988)  Sexual killers, aggressives
Galski et al. (1990)  Heterogeneous

Neuropsychological Batteries
Neuropsychological Batteries

Halstead-Reitan Battery

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Indications of general impairment.  No reliable localization.

Luria-Nebraska Battery

Graber et al. (1982)  Heterogeneous
Scott et al. (1984)  Offenders vs. children, adults
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Hucker et al. (1988)  Sadists, sexual aggressives
Langevin et al. (1988)  Sexual killers, aggressives
Galski et al. (1990)  Heterogeneous

Individual neuropsychological tests

Trail-Making
Bowden (1987)
Cohen et al. (2002)
Dolan et al. (2002)
Knox-Jones (1994)
Langevin et al. (1989)
Stone & Thompson (2001)
Tarter et al. (1983)
Yeudall et al. (1987)

Wechsler Memory Scale
Dolan et al. (2002)
Knox-Jones (1994)
Langevin et al. (1989)
Rubenstein (1992)
Tarter et al. (1983)

Stroop
Cohen et al. (2002)
Dolan et al. (2002)
Stone & Thompson (2001)
Gillespie & Mckenzie (2000)

Controlled Oral Word Assoc.
Cohen et al. (2002)
Dolan et al. (2002)
Gillespie & Mckenzie (2000)
Knox-Jones (1994)
Rubenstein (1992)
Stone & Thompson (2001)
Yeudall et al. (1987)

Wisconsin Card Sort
Cohen et al. (2002)
Dolan et al. (2002)
Miller (1997)
Rubenstein (1992)
Stone & Thompson (2001)
Westergren (2002)
Yeudall et al. (1987)

Williams Verbal Learning Test
Abracen et al. (1991)
Baker (1985)
O’Carroll (1989)
Yeudall et al. (1986)

Finger-Tapping
Knox-Jones (1994)
Langevin et al. (1989)
Tarter et al. (1983)
Yeudall et al. (1986)

Bender Gestalt Test
Lewis et al. (1979)
Yeudall et al. (1986)
Individual neuropsychological tests

Indications of general impairment.
(Methodological confound?)
No reliable localization.

Early brain imaging

CT studies
- Graber et al. (1982)
- Langevin et al. (1985)
- Hucker et al. (1986)
- Hendricks et al. (1988)
- Hucker et al. (1988)
- Langevin et al. (1988)
- Langevin et al. (1989)
- Wright et al. (1990)
- Offenders vs. women, children
- Sadists, nonsadistic offenders
- Pedophiles
- Offenders vs. children
- Sadists, nonsadistic vs. women
- Incest offenders
- Pedophiles
- Offenders vs. women, pedophiles, incest offenders, nonsex offenders
Early brain imaging

CT studies


Indications of diffuse neuropathy. No reliable localization.
Methological Issues

Very small samples.
Heterogeneous offender types.
Poorly validated (or not-validated) instruments.
Excessive “data-mining.”
Lack of control samples.
Very selective citation of findings.

What do I need to remember?

1886–1999

IQ (global functioning)  Consistent but only general indications of poor brain function
LNNB/HRB
Neuropsych testing
CT scans
**Pedophilia**

Child molester: An adult who engages in sexual *behavior* physically involving one or more children.

Pedophile: An adult whose primary sexual *attraction* is towards prepubescent children.

- Not all child molesters are pedophiles.
- Not all pedophiles are child molesters.
- Behavior versus attraction.
- Definitions use *primary* sexual attraction.

- Pedophilia *differs* from child molestation.
- Pedophilia *motivates* child molestation.
### Pedophilia

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<th>Description</th>
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<tr>
<td>Hebephile</td>
<td>Attraction to <em>pubescent</em> children.</td>
</tr>
<tr>
<td>Teleiophile</td>
<td>Attraction to <em>adults</em>.</td>
</tr>
<tr>
<td>Gerontophile</td>
<td>Attraction to <em>the elderly</em>.</td>
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### Phallometry

Psychophysiological technique for assessing erotic interests in males.

Examinee’s penile blood volume is monitored while he is presented with a standardized set of laboratory stimuli depicting a variety of potentially erotic activities or objects.

Examinee’s penile blood volume increases are taken as an index of his relative attraction to the different classes of stimuli.
Phallometry

[Image of phallometry equipment]

Phallometry

[Image of phallometry equipment]
Phallometry

[Image of a phallometry device in use]
Phallometric Stimuli

Stimulus modality: Audiotaped narratives, slides of nudes

Sample narrative:
“You are watching a late movie on TV with your neighbours’ 12-year-old daughter. You have your arm around her shoulders, and your fingers brush against her chest. You realize that her breasts have begun to develop...”

Stimulus categories:
- prepubescent girls
- pubescent girls
- adult women
- prepubescent boys
- pubescent boys
- adult men
- neutral stimuli
Phallometry

Men with >3 female adult victims

Phallometric Response

Men with >3 female child victims

Phallometric Response
Phallometry

Men with >3 male child victims

Phallometric Response

Gay men (no victims)

Phallometric Response
Validity of Phallometry

Sensitivity: 61%
Specificity: 96%

Validity of Phallometry

Risk Prediction
Hanson & Bussière (1998)
Meta-analysis of 61 follow-up studies
n = 28,972 sexual offenders

Strongest predictors of sex recidivism:  

<table>
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<th>r</th>
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<td>phallometric assessment (children)</td>
<td>.32</td>
</tr>
<tr>
<td>MMPI scale 5 (M–F scale)</td>
<td>.27</td>
</tr>
<tr>
<td>severe psychological maladjustment</td>
<td>.25</td>
</tr>
<tr>
<td>prior sex offenses</td>
<td>.19</td>
</tr>
<tr>
<td>failure to complete treatment</td>
<td>.17</td>
</tr>
<tr>
<td>negative relationship with mother</td>
<td>.16</td>
</tr>
<tr>
<td>any personality disorder</td>
<td>.16</td>
</tr>
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Differences Betw. Laboratories

- Circumferencial vs. volumetric measures
- Visual vs. auditory stimuli
- Video clips vs. still pictures
- Numbers and duration of pictures shown
- One vs. many of each stimulus shown
- Validation of interpretation methods
Differences Betw. Laboratories


Contemporary neuropsychology and biometrics

Needs fixing:

Very small samples.
Heterogeneous offender types.
Poorly validated (or not-validated) instruments.
Excessive “data-mining.”
Lack of control samples.
Very selective citation of findings.
**Intelligence Quotient (IQ)**

Covariates: age, age@ESL

F (2, 293) = 6.77
p = .001

Mean (SE) Full-Scale IQ

- Pedophiles (n=47)
- Hebephiles (n=158)
- Teleiophiles (n=93)


---

**Verbal memory by phallometric group**

Covariates: age, age @ ESL

F (2, 297) = 5.08
p = .007

Mean (SE) HVLT-R Total Recall

- Pedophiles (n=47)
- Hebephiles (n=161)
- Teleiophiles (n=94)

---

Visuospatial memory by phallometric group

Covariates:
age, age @ ESL

\[ F (2, 255) = 6.51 \]
\[ p = .002 \]

Pedophiles (n=43)
Hebephiles (n=138)
Teleiophiles (n=79)

Mean (SE) BVMT-R Total Recall

Accidents causing unconsciousness

Age < 13
\[ p = .01 \]

Age ≥ 13
\[ p = .66 \]


Handedness in Pedophilia and Hebephilia

Covariates:
- IQ, parental ed.,
- age, age @ ESL

- age: Wald = 14.25, p = .0008
- sex: Wald = 0.64, p = .43

Proportions failing or in spl. ed. by birth decade

Special Education Only
Repeated Grade and Special Education
Repeated Grade Only


Are Brain Differences Observable *Directly*?

Magnetic Resonance Imaging (MRI)

How we are going to attack this. In English.

- Little math or physics, some fancy slides
- Vocabulary that you really can use
- Clearing up some common confusions
Current brain imaging technologies

Also: MEG, SPECT, DTI
Current brain imaging technologies

CT
- structure
- x-rays
- low clarity
- limit exposure

PET
- function
- radio-labeling (positrons)
- low clarity, 1 mm³
- limit exposure

MRI
- structure
- magnetism (water)
- 1 mm³
- artifacts
- no metal

fMRI
- function
- magnetism (deoxy-hemoglobin)
- 5 mm³
- 2 mm³
- artifacts
- no metal

Also: MEG, SPECT, DTI

MRI Physics

Hydrogen protons

Magnet off
Magnet on (RF transmit)
Magnet on (RF receive)

# Structural MRI studies of pedophilia

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<td>OCD/ impulsivity</td>
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Junk data or blind monks?
### Structural MRI studies of pedophilia

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<td>frontal</td>
<td>18 pedophiles 24 community controls</td>
<td>small volume corrected</td>
</tr>
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<td>Cantor et al. (2008)</td>
<td>atheoretical</td>
<td>unbiased</td>
<td>65 pedophiles 62 nonsexual offenders</td>
<td>whole brain volume corrected</td>
</tr>
</tbody>
</table>
Subjects

Patients
n = 65 sexology patients
Recruited from the Kurt Freund Laboratory (CAMH, Toronto)

Controls
n = 62 nonsexual offenders
Recruited from federal and provincial parole/probation offices

Exclusion criteria
<18 years age
>300 lbs weight
Ever suffered traumatic brain injury
Ever diagnosed with schizophrenia
Ever employed grinding metal
Any other metal object in body, counterindicating MRI

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Patients</th>
<th>Controls</th>
<th>Comparison</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>36.4 (13.5)</td>
<td>36.9 (9.4)</td>
<td>t (125) = −0.23</td>
<td>.82</td>
</tr>
<tr>
<td>Full-Scale IQ</td>
<td>96.2 (15.3)</td>
<td>96.3 (11.5)</td>
<td>t (125) = −0.03</td>
<td>.98</td>
</tr>
<tr>
<td>Education</td>
<td>12.2 (3.0)</td>
<td>12.1 (2.8)</td>
<td>t (125) = 0.20</td>
<td>.84</td>
</tr>
<tr>
<td>CAGE alcohol screen</td>
<td>1.1 (1.4)</td>
<td>2.1 (1.6)</td>
<td>t (125) = −3.8</td>
<td>.0003</td>
</tr>
<tr>
<td>% non-right-handed</td>
<td>23.1%</td>
<td>14.5%</td>
<td>χ² (1) = 1.52</td>
<td>.22</td>
</tr>
</tbody>
</table>
## Procedures

<table>
<thead>
<tr>
<th>Sexological Measures</th>
<th>MRI Measures</th>
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<td>Self-report, offense history</td>
<td>Automated parcellation</td>
</tr>
<tr>
<td>Phallometry</td>
<td>Voxel-based morphometry (VBM)</td>
</tr>
</tbody>
</table>

### Automated Parcellation

![Standard Reference Brain Image]
Automated Parcellation

124 images/subject were acquired in the coronal plane using a 3-dimensional, inversion-prepped, radio-frequency fast spoiled-gradient recalled-echo sequence on a 1.5-Tesla MRI system.

- Time to inversion: 300 ms
- Time to repetition: 12 ms
- Time to echo: 5 ms
- Flip angle: 20°
- Field of view: 20 cm
- Matrix resolution: 256 × 256 pixels

Correct intensity non-uniformity: Sled & Pike (1998)
Normalization: MNI-Talairach space
Resampling: 1.0mm isotropic voxels
Tissue classification: GM, WM, or CSF
Non-brain tissue removal: Automated, manual check

Image Acquisition & Processing
Phallometric Pedophilia Index

Stimulus categories:
- prepubescent girls
- pubescent girls
- adult women
- prepubescent boys
- pubescent boys
- adult men
- neutral stimuli

Parcellated Volumes with Pedophilia Index

<table>
<thead>
<tr>
<th>Brain Region Families</th>
<th>Multiple Regression</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortical Grey Matter</td>
<td>$R = .260$, $F(12,95) = 0.58$</td>
<td>.86</td>
</tr>
<tr>
<td>(12 regions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcortical Grey Matter</td>
<td>$R = .263$, $F(11,96) = .65$</td>
<td>.79</td>
</tr>
<tr>
<td>(11 regions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Matter</td>
<td>$R = .473$, $F(11,96) = 2.51$</td>
<td>.008</td>
</tr>
<tr>
<td>(11 regions)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebrospinal Fluid</td>
<td>$R = .274$, $F(5,102) = 1.66$</td>
<td>.15</td>
</tr>
<tr>
<td>(5 regions)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Mean (SD) White Matter Volumes by Group

<table>
<thead>
<tr>
<th>Region</th>
<th>Volume (cc³)</th>
<th>Correlation with Pedophilia Index</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. Frontal</td>
<td>89.0 (10.4)</td>
<td>– .16</td>
<td>.10</td>
</tr>
<tr>
<td>L. Frontal</td>
<td>93.8 (10.3)</td>
<td>– .17</td>
<td>.07</td>
</tr>
<tr>
<td>R. Temporal</td>
<td>52.3 (5.6)</td>
<td>– .31</td>
<td>.001</td>
</tr>
<tr>
<td>L. Temporal</td>
<td>50.2 (5.5)</td>
<td>– .25</td>
<td>.008</td>
</tr>
<tr>
<td>R. Parietal</td>
<td>49.2 (6.8)</td>
<td>– .32</td>
<td>.0008</td>
</tr>
<tr>
<td>L. Parietal</td>
<td>46.3 (6.4)</td>
<td>– .33</td>
<td>.0005</td>
</tr>
<tr>
<td>R. Occipital</td>
<td>19.2 (4.0)</td>
<td>– .08</td>
<td>.42</td>
</tr>
<tr>
<td>L. Occipital</td>
<td>15.8 (4.0)</td>
<td>.02</td>
<td>.84</td>
</tr>
<tr>
<td>R. Fornix</td>
<td>0.9 (0.2)</td>
<td>– .06</td>
<td>.56</td>
</tr>
<tr>
<td>L. Fornix</td>
<td>0.9 (0.2)</td>
<td>.04</td>
<td>.72</td>
</tr>
<tr>
<td>Corpus callosum</td>
<td>16.4 (2.8)</td>
<td>– .19</td>
<td>.05</td>
</tr>
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**What’s a Voxel?**

![Brain Image with Voxel Markers]
**Voxel-Based Morphometry (VBM)**

**SPM2**
- Custom templates: All-subject averages
- Modulation
- Smoothing: 10mm full-width-half-maximum, Gaussian blurring kernel

Voxel-wise analyses (GLMs): Indep t s, correlations

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**VBM of Pedophilic vs. Nonsexual Offender Men**
VBM of Pedophilic vs. Nonsexual Offender Men

VBM of Pedophilic vs. Nonsexual Offender Men
VBM of Pedophilic vs. Nonsexual Offender Men

Superior Occipitofrontal Fasciculus
(right) Arcuate Fasciculus

- Middle Frontal Gyrus (Ferretti et al., 2005; Garavan et al., 2000; Gizewski et al., 2006; Karama et al., 2002; Montosori et al., 2003; Rauch et al., 2000)

- Insula and Opercula (Garavan et al., 2000; Gizewski et al., 2006; Karama et al., 2002; Park et al., 2001; Stolérus et al., 1999)

- Sup./Inf. Parietal Lobules (Beauregard et al., 2001; Bocher et al., 2001; Ferretti et al., 2005; Mouras et al., 2003; Stolérus et al., 2003)

- Occipital Cortex (Beauregard et al., 2001; Bocher et al., 2001; Ferretti et al., 2005; Garavan et al., 2000; Mouras et al., 2003; Park et al., 2001)

fMRI Studies of Sexual Arousal
But, what does this *mean*?

1. In healthy men, the cortical grey matter regions identified by fMRI studies may actually operate as a single network that serves to “recognize” stimuli as potentially sexual.

2. In pedophilic men, the white matter tissue is insufficient for that network to function accurately.

3. Because no deficit in grey matter volume was detected, the white matter volume may reflect poor myelination rather than low neuronal population.

Junk data or blind monks?

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Why didn’t Schiltz and Schiffer find white matter?

Why didn’t Cantor find grey matter?
## Structural MRI studies of pedophilia

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### Junk data or blind monks?

[Diagram showing brain structures and their relationships]
functional MRI (fMRI)

- CT
- PET
- MRI
- fMRI

functionality
magnetism (deoxy-hemoglobin)
5 mm², 2"
artifacts
no metal
**functional MRI (fMRI)**

Perform two (or more) tasks including a control task. Use statistics to subtract active tasks from control tasks.

Higher bloodflow = higher activity

Stuart Clare, FMRIB
Subject performs two or more tasks, including a control task. Use “subtractive” statistics to compare activity between tasks.

Study | Anatomy | Subjects | Results
--- | --- | --- | ---
Walter et al. (2007) |  |  |  |
Schiffer et al. (2008a) |  |  |  |
Schiffer et al. (2008b) |  |  |  |
Poeppl et al. (2011) |  |  |  |
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Subject performs two+ tasks, including a control task. Use “subtractive” statistics to compare activity between tasks.

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**Note:**
- fMRI (functional MRI) was used in some studies.
Subject performs two+ tasks, including a control task. Use “subtractive” statistics to compare activity between tasks.

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<td>Ponseti et al. (2012)</td>
<td>empirical subset of brain</td>
<td>diverse pedophiles, diverse controls</td>
<td>88% sensitivity and 100% specificity</td>
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**functional MRI (fMRI)**

This just in!

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### What are the ethical issues?

- Neuroethics
- Bioethics
- Neurolaw
- Legal neuroscience
What are the ethical issues?

Does our ability to detect pedophilia have implications?
What if juries buy it too much?
What if it is used to jail/commit people for their intentions?
Privacy? “mental privacy”
Basic issue: consent to assessment (like polygraph?)
Used as employment criterion?

What does this say about nature/nurture?
The Big Questions

Is it in the brain?  
Can it change?  
Are they responsible for it?  
Can we prevent it?

Can we treat it?  
Were they born with it?  
Does it run in families?
The Public’s Fears

My fears:
### My fears:

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- MRI always right
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- “Experts” with defense bias
- Unvalidated techniques

- MRI always wrong
- Individual rights always come first
- Brain tells us nothing
- Public doesn’t trust science
- “Experts” with prosecution bias
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The State of the Art

Research ➔ Clinical ➔ Screening ➔ Evidence
Validity of Phallometry

Sensitivity: 61%
Specificity: 96%

Hypothetical Validity

Sensitivity: 99%
Specificity: 99%
Hypothetical Validity

Sensitivity: 99.999%
Specificity: 99.999%

So, can fMRI detect arousal to child stimuli?

Research ⇒ Clinical ⇒ Screening ⇒ Evidence
So, can fMRI detect arousal to child stimuli?

Can we replace this:
...with this?

Future Directions

- Minor physical anomalies
- Diffusion Tensor Imaging
- Magnetization Transfer imaging
- Specificity of findings for pedophilia vs. paraphilia
- Empirical tests of childhood adversity, antisociality, vs pedophilia
- fMRI of response in abusers who deny pedophilia
My Hopes

What if…?

fMRI provides the next increment in accuracy of diagnosing pedophilia and is employed only within the bounds of contemporary professional ethics:

- Informed Consent
- Confidentiality

With continued research, we pinpoint the prenatal process that goes awry.

Perhaps: A general prenatal health factor already known to interfere with normal growth of both body and brain...
My Hopes

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fMRI provides the next increment in accuracy of diagnosing pedophilia and is employed only within the bounds of contemporary professional ethics:

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With continued research, we pinpoint the prenatal process that goes awry.

Perhaps: A *general* prenatal health factor already known to interfere with normal growth of both body and brain...

Instead of preventing a second offense, we can prevent *the first* offense.

The stakeholders

- Victim groups
- Defense experts
- Prosecution experts
- Treatment clinics
- Politically punitive
- Profiteers of hysteria
Magnus Hirschfeld (1868–1935)

“Justice through science”
Wissenschaftlich-humanitäres Komitee
(Scientific-Humanitarian Committee)

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Philip Klassen

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Hien Tran

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Robert Brown

CAMH Image Processing Lab
Noor Kabani
Kate Hanratty
Blake Richards

Kurt Freund Laboratory
Ray Blanchard
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Thomas Blak
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Nanci Lipstein

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