

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

James M. Cantor, PhD, CPsych

Psychologist & Head, CAMH Law & Mental Health Research Section  
Associate Professor, University of Toronto  
Editor-in-Chief, *Sexual Abuse*  
[http://individual.utoronto.ca/james\\_cantor](http://individual.utoronto.ca/james_cantor)



## 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

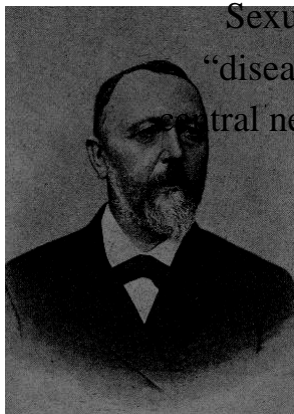
Issues & implications

## Sexual offending and the Brain: History

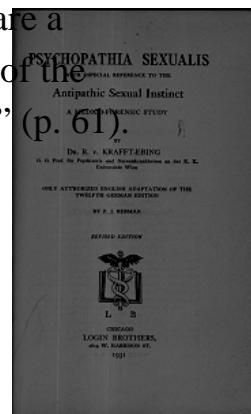
1886	Founding of modern sexology
1900–2000	Large scale studies of forensic samples
1980–1999	Neuropsych testing, early imaging (CT) studies
1999	First neuroimaging study of sexual arousal
2000–	Large-scale studies of homogeneous samples
2007–2008	High-resolution studies of pedophilia published
2007	First fMRI studies of pedophilia published

## Richard von Krafft-Ebing (1840–1902)

*Psychopathia Sexualis* (1886)



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



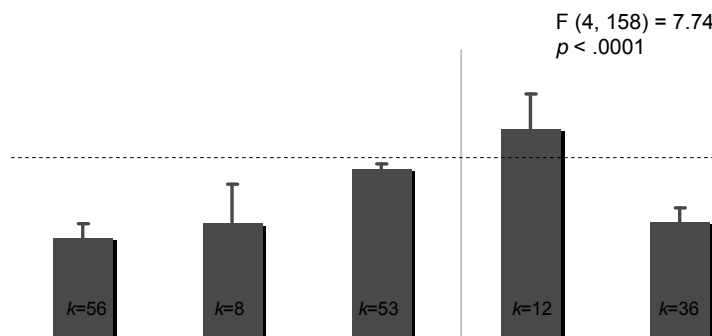
## Eight decades of IQ testing

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)

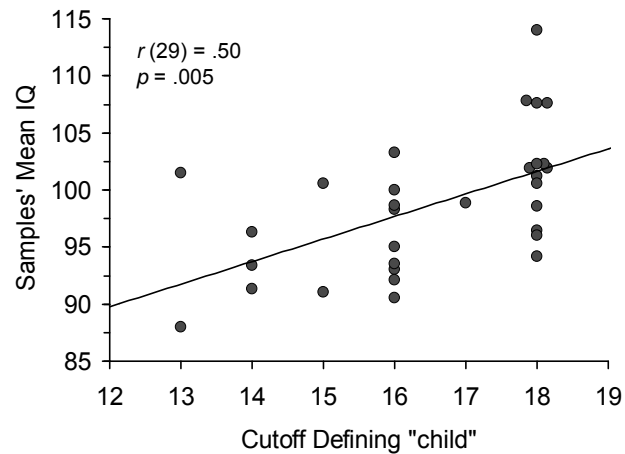
—Cantor, Blanchard, Robichaud, & Christensen (2005). *Psychological Bulletin*, 131, 555–568.

## IQ of adult samples by victims' age group



—Cantor, Blanchard, Robichaud, & Christensen (2005). *Psychological Bulletin*, 131, 555–568.

## IQ by Definition of “Child” Victim

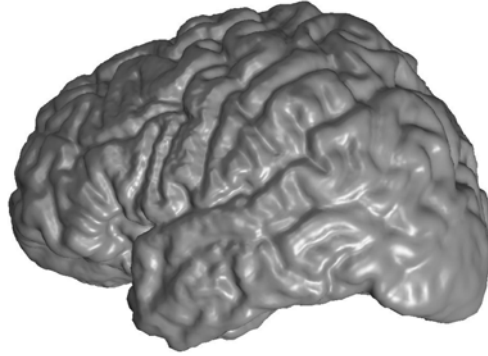


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## Sexual offending and the Brain: History

1886	Founding of modern sexology
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## Frontal Lobe vs. Temporal Lobe Theories



## Neuropsychological Batteries

### 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

### Halstead-Reitan Battery

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Indications of general impairment.

No reliable localization.

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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)

### 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)

### Wechsler Memory Scale

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

### 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)

### Stroop

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

### Bender Gestalt Test

Lewis et al. (1979)  
Yeudall et al. (1986)

## Individual neuropsychological tests

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

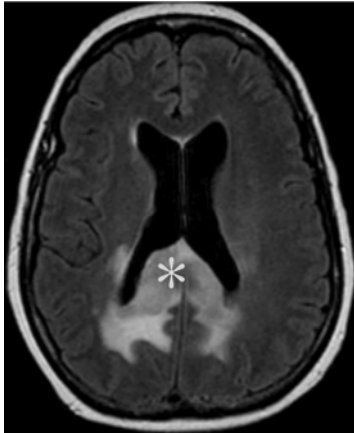
## Early brain imaging

### CT studies

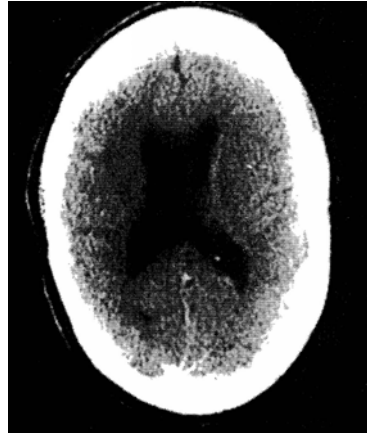
Graber et al. (1982)	Offenders vs. women, children
Langevin et al. (1985)	Sadists, nonsadistic offenders
Hucker et al. (1986)	Pedophiles
Hendricks et al. (1988)	Offenders vs. children
Hucker et al. (1988)	Sadists, nonsadistic vs. women
Langevin et al. (1988)	Incest offenders
Langevin et al. (1989)	Pedophiles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

## Early brain imaging

### CT studies



<http://knol.google.com/k/brain-ct-mri#>



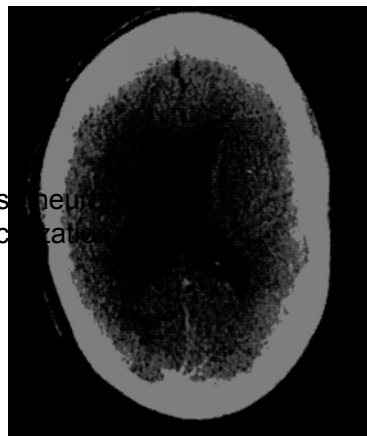
Langevin et al. (1988)

## Early brain imaging

### CT studies



<http://knol.google.com/k/brain-ct-mri#>



Langevin et al. (1988)



## 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)

LNNB/HRB

function

Neuropsych testing

CT scans

Consistent but only general  
indications of poor brain

## 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

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.

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

## 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.
- 
- Pedophile: Attraction to *pre* pubescent children.
- Hebephile: Attraction to *pubescent* children.
- Teleiophile: Attraction to *adults*.
- Gerontophile: Attraction to *the elderly*.

## 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



## Phallometry



## Phallometry



## Phallometry



## Phallometry

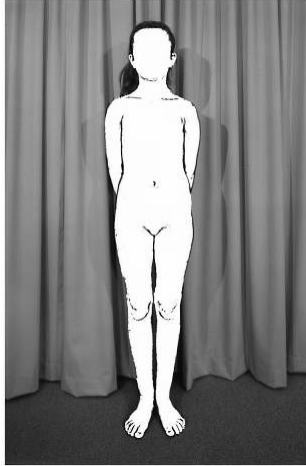


## Phallometry



## 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...”*

## Phallometric Stimuli

Stimulus categories:

prepubescent girls

pubescent girls

adult women

prepubescent boys

pubescent boys

adult men

neutral stimuli

## Phallometry

Men with >3 female adult victims



## Phallometry

Men with >3 female child victims





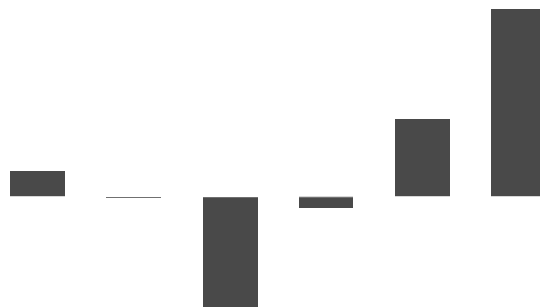
## Phallometry

Men with >3 male child victims



## Phallometry

Gay men (no victims)

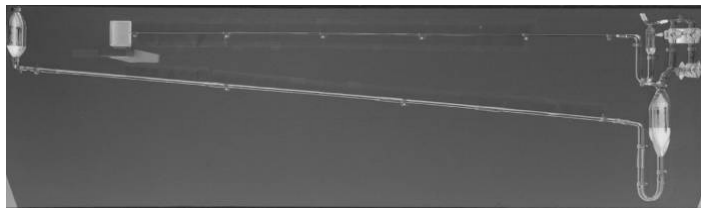


## Phallometry

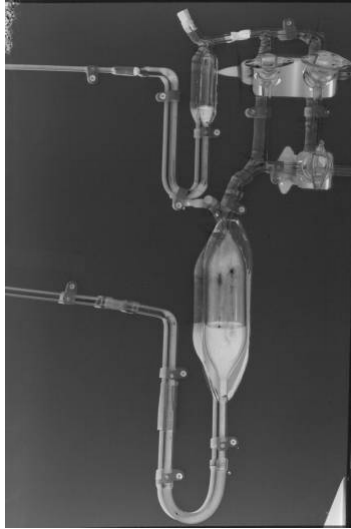


Kurt Freund  
(1914–1996)

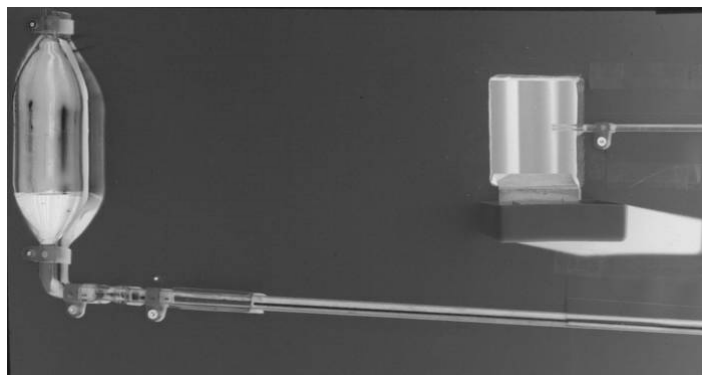
## Phallometry



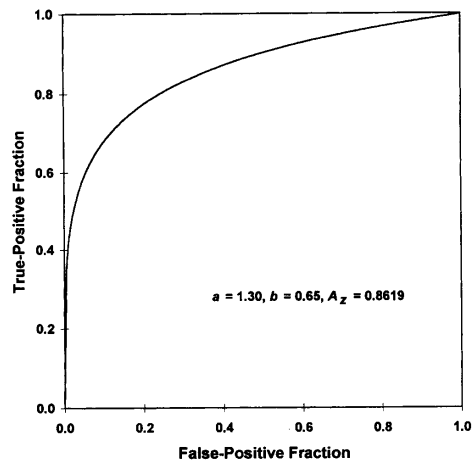
## Phallometry



## Phallometry

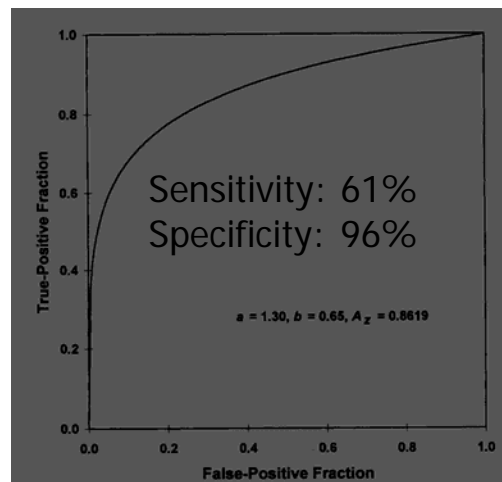


## Validity of Phallometry



—Blanchard, Klassen, Dickey, Kuban, & Blak (2001). *Psychological Assessment*, 13, 118–126.

## Validity of Phallometry



—Blanchard, Klassen, Dickey, Kuban, & Blak (2001). *Psychological Assessment*, 13, 118–126.

## Validity of Phallometry

### Risk Prediction

Hanson & Bussière (1998)

Meta-analysis of 61 follow-up studies

$n = 28,972$  sexual offenders

## Validity of Phallometry

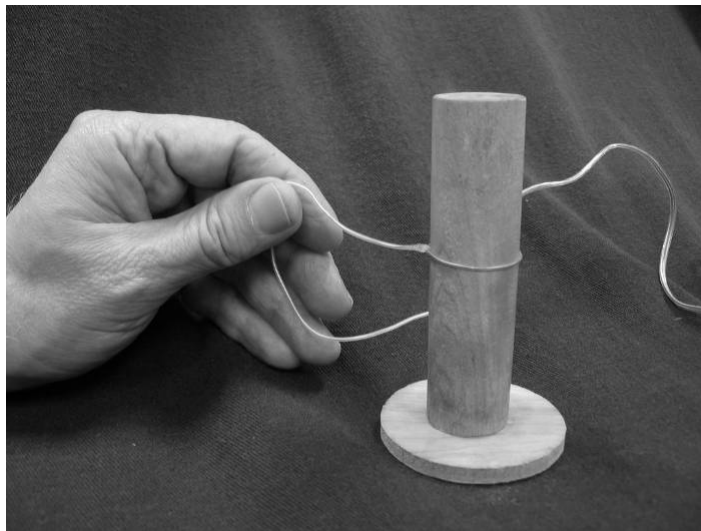
<u>Strongest predictors of sex recidivism:</u>	<u><math>r</math></u>
phallometric assessment ( <i>children</i> )	.32
MMPI scale 5 (M–F scale)	.27
severe psychological maladjustment	.25
prior sex offenses	.19
failure to complete treatment	.17
negative relationship with mother	.16
any personality disorder	.16

Hanson & Bussière (1998). *J Consult Clin Psych*, 66, 348–362.

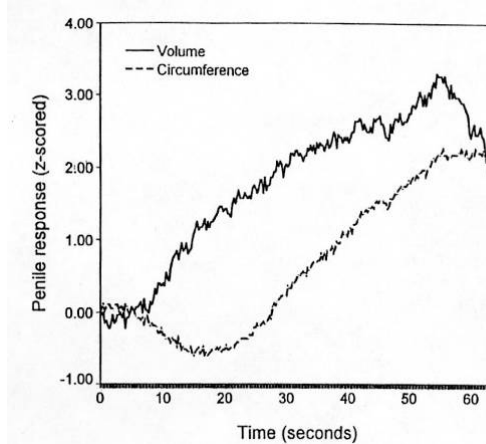
## Differences Betw. Laboratories

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



## Differences Betw. Laboratories



—Kuban, Barbaree, & Blanchard (1999). *Archives of Sexual Behavior*, 28, 245–359.

## Contemporary neuropsychology and biometrics

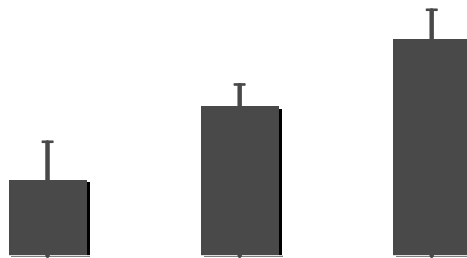
### Needs fixing!:

- 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

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

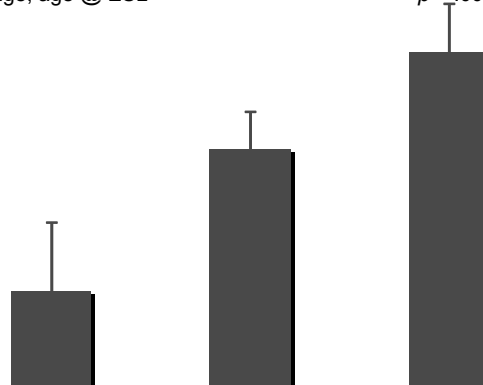


From: Cantor, Blanchard, Christensen, Dickey, et al. (2004). *Neuropsychology*, 18, 3–14.

## Verbal memory by phallometric group

Covariates:  
age, age @ ESL

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



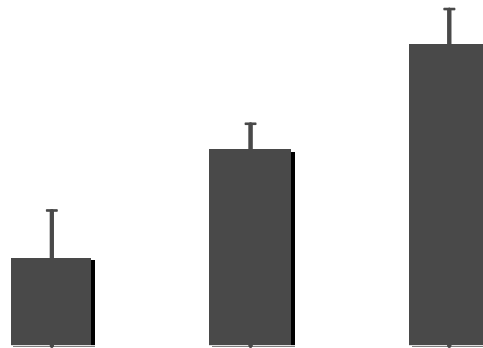
—Cantor, Blanchard, Christensen, Dickey, et al. (2004). *Neuropsychology*, 18, 3–14.



## Visuospatial memory by phallometric group

Covariates:  
age, age @ ESL

$F(2, 255) = 6.51$   
 $p = .002$

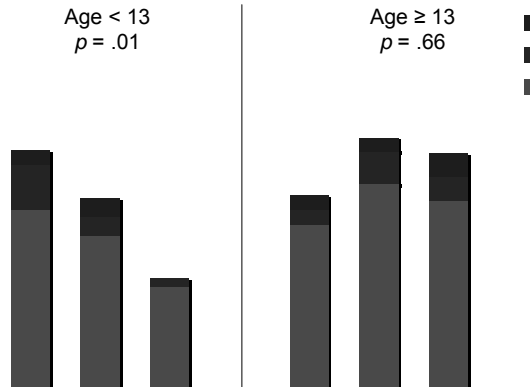


—Cantor, Blanchard, Christensen, Dickey, et al. (2004). *Neuropsychology*, 18, 3–14.

## Accidents causing unconsciousness

Age < 13  
 $p = .01$

Age ≥ 13  
 $p = .66$

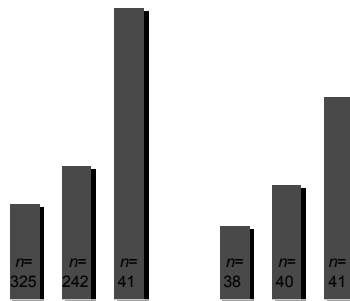


—Blanchard, Kuban, Klassen, Dickey, Christensen, Cantor, & Blak. (2003). *Archives of Sexual Behavior*, 32, 573–581.

## Handedness in Pedophilia and Hebephilia

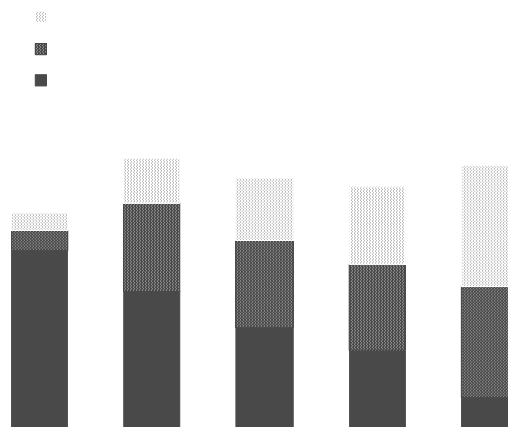
Covariates:  
IQ, parental ed.,  
age, age @ ESL

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



—Cantor, Klassen, Dickey, Christensen, Kuban, Blak, et al. (2005). *Archives of Sexual Behavior*, 34, 447–459.

## Proportions failing or in spl. ed. by birth decade

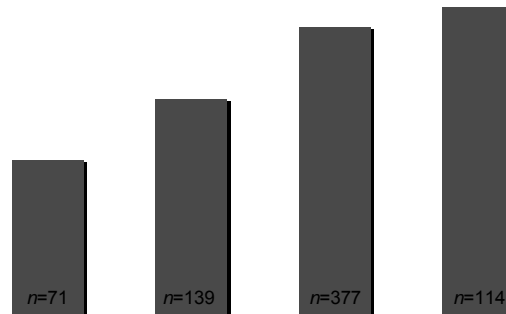


—Cantor, Kuban, Blak, Klassen, Dickey, & Blanchard. (in press). *Archives of Sexual Behavior*.

## Proportions failing or in spl. ed. by group

Co-variates:  
IQ, parental edu.  
age, age @ ESL

Wald = 16.72  
 $p = .001$

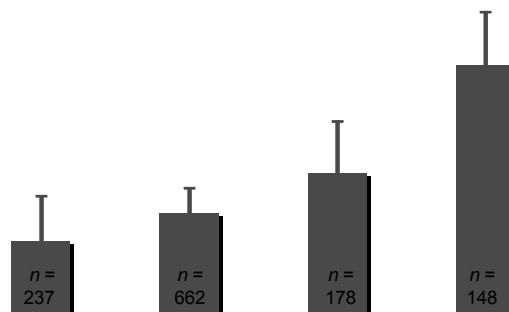


—Cantor, Kuban, Blak, Klassen, Dickey, & Blanchard. (in press). *Archives of Sexual Behavior*.

## Physical Height

Covariate:  
age

$F(4, 1220) = 4.11$   
 $p = .003$



From: Cantor, Kuban, Blak, Klassen, Dickey, & Blanchard. (2007). *Sexual Abuse*, 19, 395–407.

## 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

CT



PET



MRI



fMRI



Also: MEG, SPECT, DTI

## Current brain imaging technologies

CT



PET

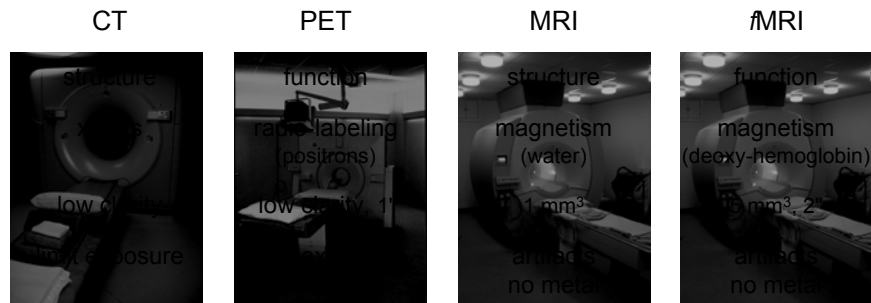


“Open MRI”



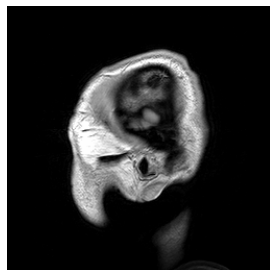
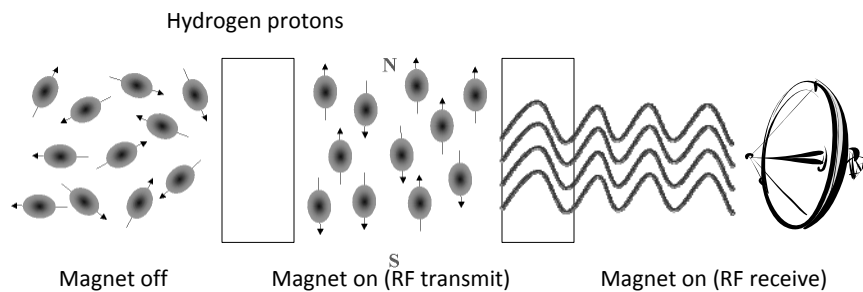
Also: MEG, SPECT, DTI

## Current brain imaging technologies



Also: MEG, SPECT, DTI

## MRI Physics



[http://cal.man.ac.uk/student\\_projects/2000/mmmr7gjlw/technique3.htm](http://cal.man.ac.uk/student_projects/2000/mmmr7gjlw/technique3.htm)

## Structural MRI studies of pedophilia

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>	<u>Subjects</u>	<u>VBM Analysis</u>
Schiltz et al. (2007)				
Schiffer et al. (2007)				
Cantor et al. (2008)				

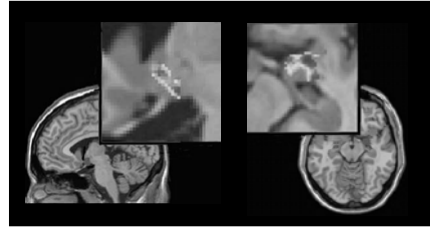
## Schiltz et al. (2007)

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>	<u>Subjects</u>	<u>VBM Analysis</u>
Schiltz et al. (2007)	limbic	"temporal"	15 pedophiles 15 community controls	small volume corrected
Schiffer et al. (2007)	OCD/ impulsivity	frontal		
Cantor et al. (2008)				

## Schiltz et al. (2007)

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>
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Schiltz et al. (2007)	limbic	"temporal"
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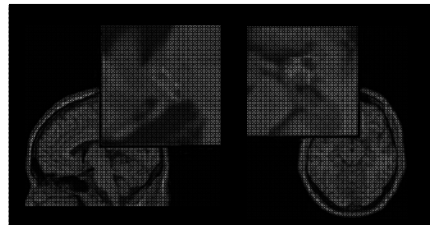
Schiffer et al. (2007)	OCD/impulsivity	frontal
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Cantor et al. (2008)		
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## Schiffer et al. (2007)

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>
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Schiltz et al. (2007)	limbic	"temporal"
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Schiffer et al. (2007)	OCD/impulsivity	frontal
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18 pedophiles  
24 community controls

small volume corrected

Cantor et al. (2008)		
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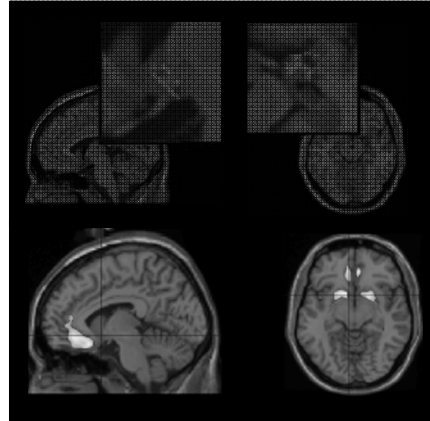
## Schiffer et al. (2007)

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>
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Schultz et al. (2007)	limbic	"temporal"
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Schiffer et al. (2007)	OCD/ impulsivity	frontal
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Cantor et al. (2008)		
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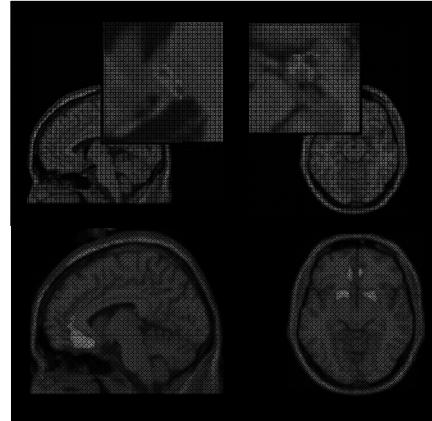


## Junk data or blind monks?



## Structural MRI studies of pedophilia

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>
Schiltz et al. (2007)	limbic	"temporal"
Schiffer et al. (2007)	OCD/impulsivity	frontal
Cantor et al. (2008)		



## Cantor et al. (2008)

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>	<u>Subjects</u>	<u>VBM Analysis</u>
Schiltz et al. (2007)	limbic	"temporal"	15 pedophiles 15 community controls	small volume corrected
Schiffer et al. (2007)	OCD/impulsivity	frontal	18 pedophiles 24 community controls	small volume corrected
Cantor et al. (2008)	atheoretical	unbiased	65 pedophiles 62 nonsexual offenders	whole brain volume corrected

## 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

## Subjects

Characteristic	Patients	Controls	Comparison	$p$
Age	36.4 (13.5)	36.9 (9.4)	$t(125) = -0.23$	.82
Full-Scale IQ	96.2 (15.3)	96.3 (11.5)	$t(125) = -0.03$	.98
Education	12.2 (3.0)	12.1 (2.8)	$t(125) = 0.20$	.84
CAGE alcohol screen	1.1 (1.4)	2.1 (1.6)	$t(125) = -3.8$	.0003
% non-right-handed	23.1%	14.5%	$\chi^2(1) = 1.52$	.22

## Procedures

### Sexological Measures

Self-report,  
offense history

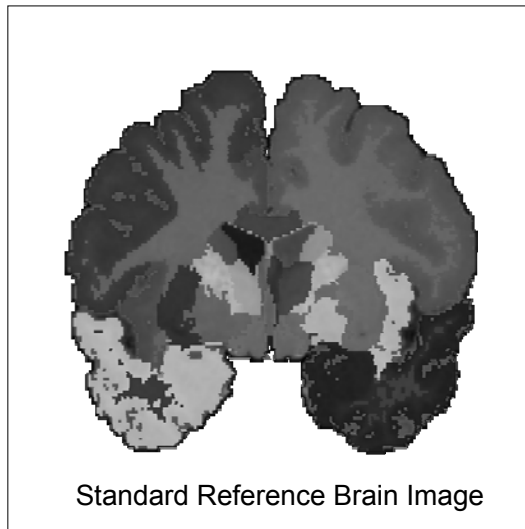
Phallometry

### MRI Measures

Automated parcellation

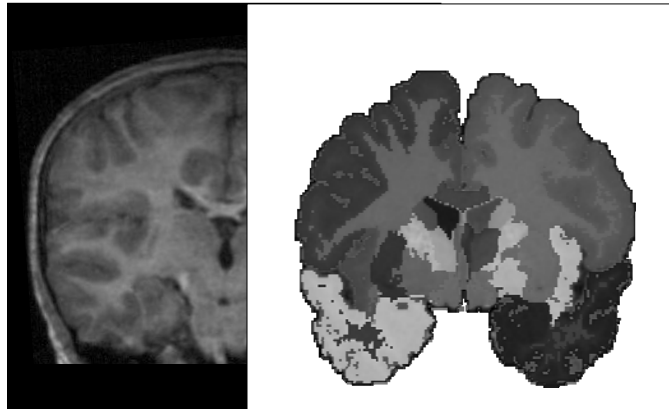
Voxel-based morphometry  
(VBM)

## Automated Parcellation



Standard Reference Brain Image

## Automated Parcellation



Standard Reference  
Brain Image


## Image Acquisition & Processing

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

## Phallometric Pedophilia Index

### Stimulus categories:

prepubescent girls      pubescent girls            adult women  
 prepubescent boys      pubescent boys           adult men  
 neutral stimuli

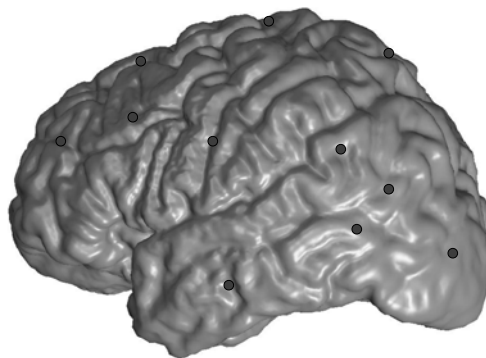
## Parcellated Volumes with Pedophilia Index

Brain Region Families	Multiple Regression	<i>p</i> -value
Cortical Grey Matter (12 regions)	$R = .260, F(12,95) = 0.58$	.86
Subcortical Grey Matter (11 regions)	$R = .263, F(11,96) = .65$	.79
White Matter (11 regions)	$R = .473, F(11,96) = 2.51$	.008
Cerebrospinal Fluid (5 regions)	$R = .274, F(5,102) = 1.66$	.15

## Mean (SD) White Matter Volumes by Group

Region	Volume (cc <sup>3</sup> )	Correlation with Pedophilia Index	<i>p</i>
R. Frontal	89.0 (10.4)	– .16	.10
L. Frontal	93.8 (10.3)	– .17	.07
R. Temporal	52.3 (5.6)	– .31	.001
L. Temporal	50.2 (5.5)	– .25	.008
R. Parietal	49.2 (6.8)	– .32	.0008
L. Parietal	46.3 (6.4)	– .33	.0005
R. Occipital	19.2 (4.0)	– .08	.42
L. Occipital	15.8 (4.0)	.02	.84
R. Fornix	0.9 (0.2)	– .06	.56
L. Fornix	0.9 (0.2)	.04	.72
Corpus callosum	16.4 (2.8)	– .19	.05

## What's a *Voxel*?



## Voxel-Based Morphometry (VBM)

### SPM2

Nonlinear registration:

Ashburner & Friston (1999)

Custom templates:

All-subject averages

Modulation

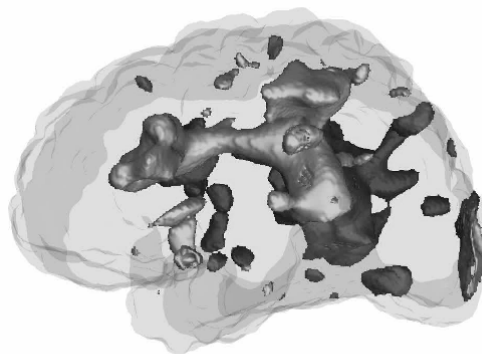
Smoothing:

10mm full-width-half-maximum,  
Gaussian blurring kernel

Voxel-wise analyses (GLMs):

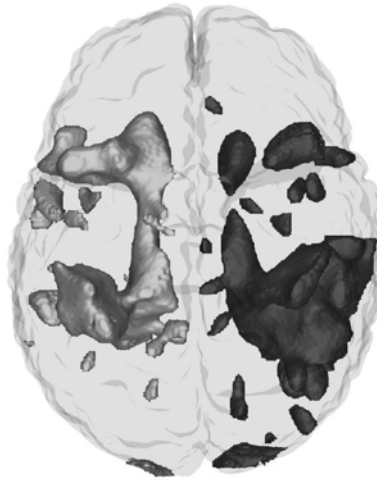
Indep  $t$  s, correlations

## VBM of Pedophilic vs. Nonsexual Offender Men

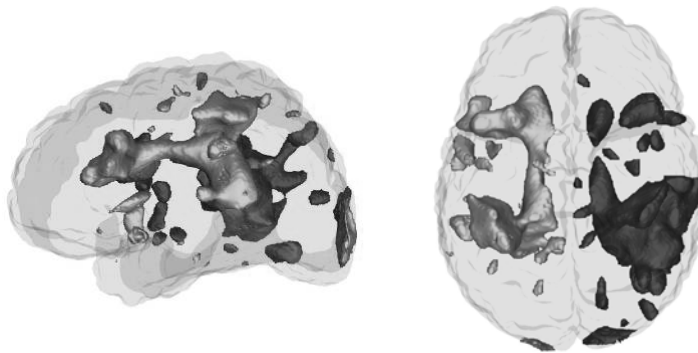




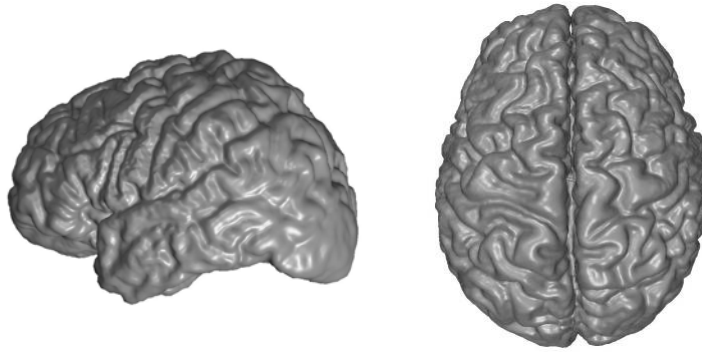
## VBM of Pedophilic vs. Nonsexual Offender Men



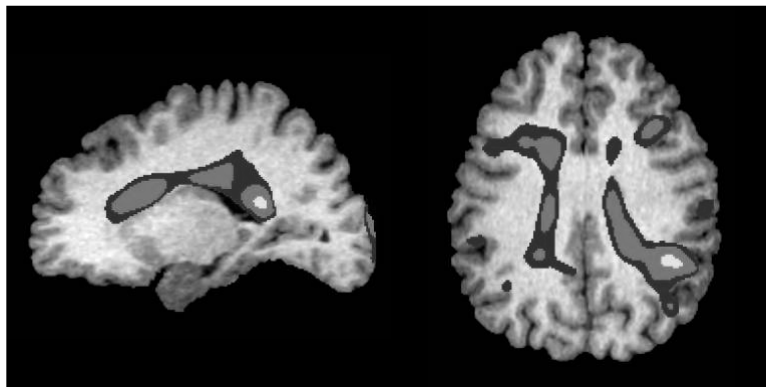
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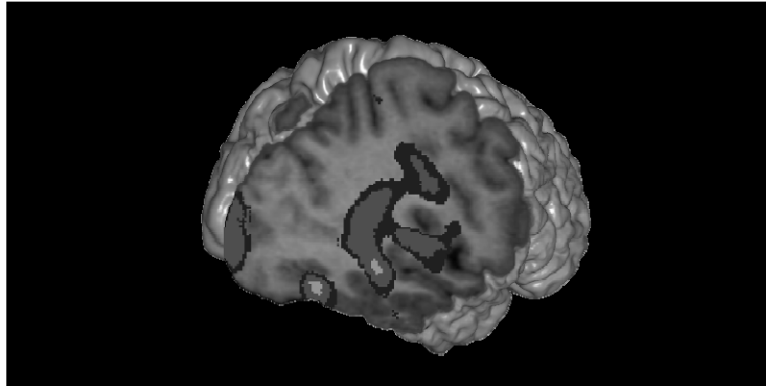
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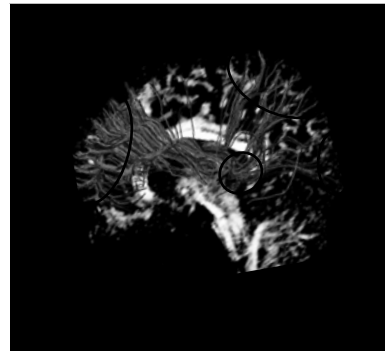
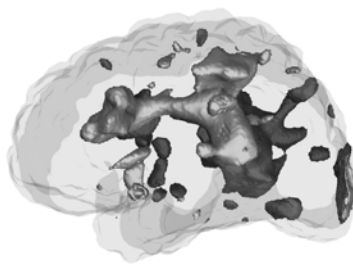
## Superior Occipitofrontal Fasciculus



## (right) Arcuate Fasciculus



## fMRI Studies of Sexual Arousal



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; Stoléru et al., 1999)

Sup./Inf. Parietal Lobules

(Beauregard et al., 2001; Bocher et al., 2001; Ferretti et al., 2005; Mouras et al., 2003; Stoléru 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)

## 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?

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>	<u>Subjects</u>	<u>VBM Analysis</u>
Schiltz et al. (2007)				
Schiffer et al. (2007)				
Cantor et al. (2008)				



Why didn't Schiltz and Schiffer find white matter?

Why didn't Cantor find grey matter?

## Structural MRI studies of pedophilia

<u>Study</u>	<u>Theory</u>	<u>Prediction</u>	<u>Subjects</u>	<u>VBM Analysis</u>
Schiltz et al. (2007)	limbic	"temporal"	15 pedophiles 15 community controls	small volume corrected
Schiffer et al. (2007)	OCD/ impulsivity	frontal	18 pedophiles 24 community controls	small volume corrected
Cantor et al. (2008)	atheoretical	unbiased	65 pedophiles 62 nonsexual offenders	whole brain volume corrected

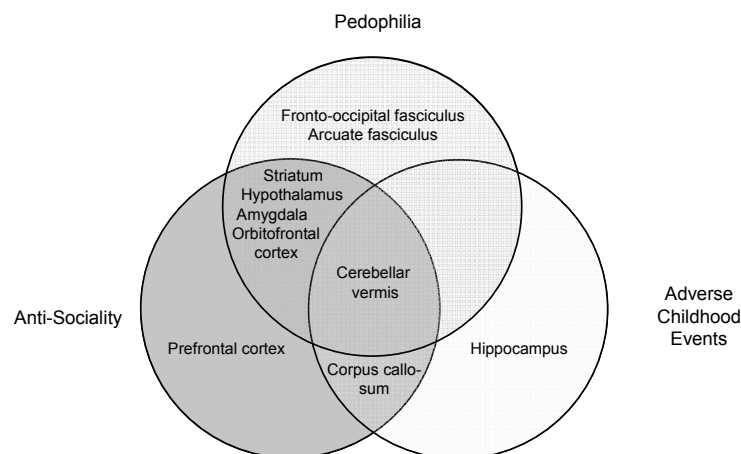
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## Junk data or blind monks?



## *functional* MRI (fMRI)

CT



PET



MRI

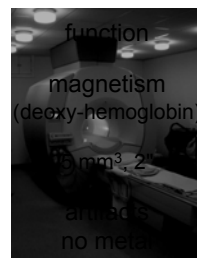


fMRI

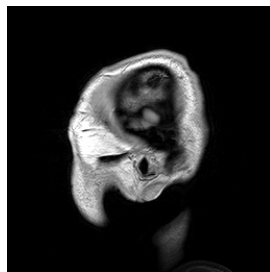
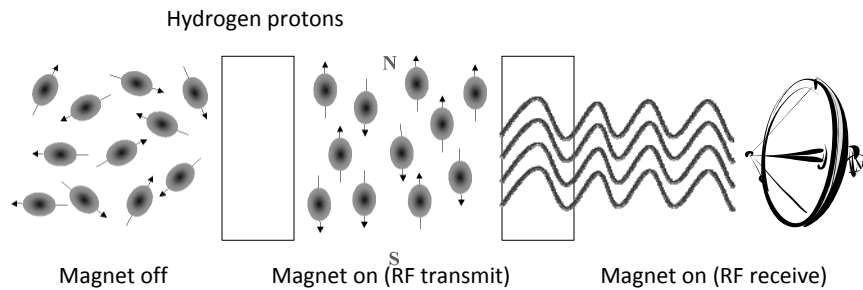


## *functional* MRI (fMRI)

fMRI



## functional MRI (fMRI)

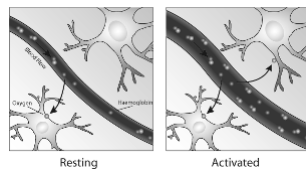


[http://cal.man.ac.uk/student\\_projects/2000/mmmr7gjlw/technique3.htm](http://cal.man.ac.uk/student_projects/2000/mmmr7gjlw/technique3.htm)

## 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



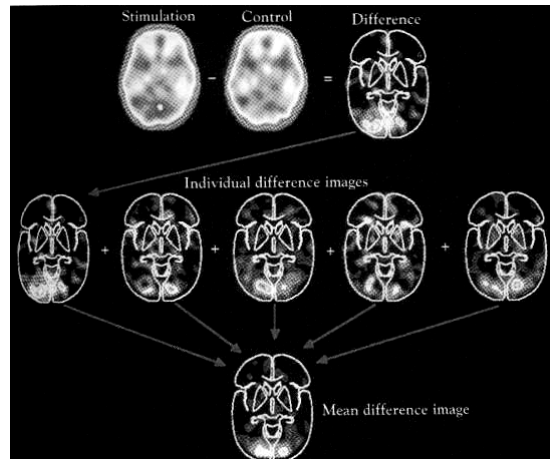
Stuart Clare, FMRI



## functional MRI (fMRI)

Subject perform two+ tasks, including a control task.

Use “subtractive” statistics to compare activity between tasks.



Posner & Raichle, *Images of Mind*

## functional MRI (fMRI)

Subject perform two+ tasks, including a control task.

Use “subtractive” statistics to compare activity between tasks.

Two kinds of experiments:

How does pedophilic processing differ from teleiophilic processing?

Can fMRI serve the same function as a phallometric test?

<u>Study</u>	<u>Anatomy</u>	<u>Subjects</u>	<u>Stimuli</u>
Walter et al. (2007)	whole brain	pedophiles (type?), healthy controls	nude adult females (?)
Schiffer et al. (2008a)	whole brain	homosexual pedophiles, healthy gay men	nude/dressed boys/men
Schiffer et al. (2008b)	whole brain	heterosexual pedophiles, healthy gay men	nude/dressed girls/women
Sartorius et al. (2008)	amygdala center	homosexual pedophiles, heterosexual controls	boys, girls, men, women in swimsuits/underwear

What does this say about cause/effect?

What does this say about nature/nurture?

## 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 if...?*

Can we replace this:



...with this?



My fears:



### My fears:

MRI  
always right

Society's needs  
always comes first

Brain tells us  
everything

Public overly  
trusts science

"Experts" with  
defense bias

Unvalidated  
techniques

MRI  
always wrong

Individual rights  
always come first

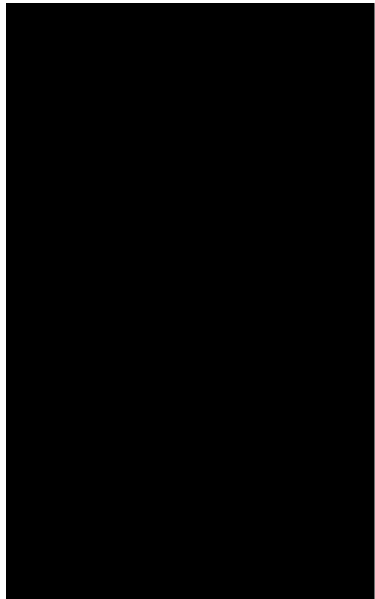
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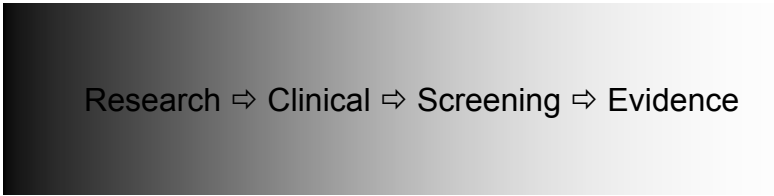
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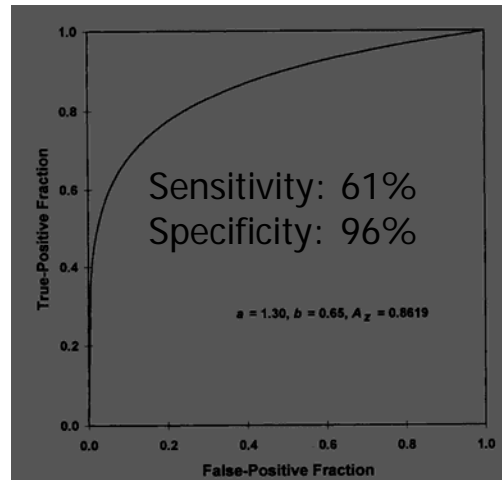
Unvalidated  
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## The State of the Art

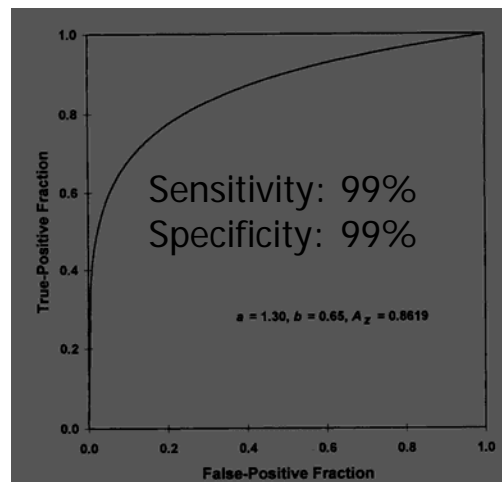


Research ⇒ Clinical ⇒ Screening ⇒ Evidence

## Validity of Phallometry

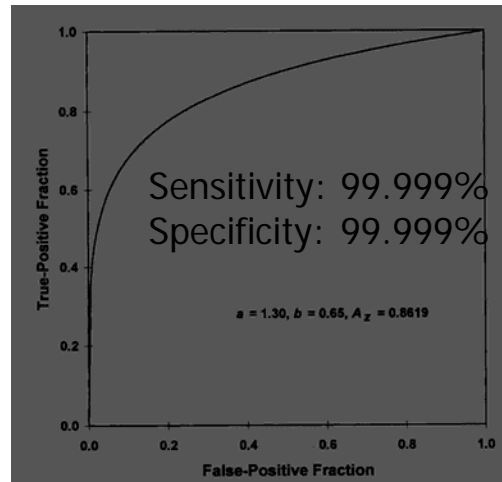


## Hypothetical Validity



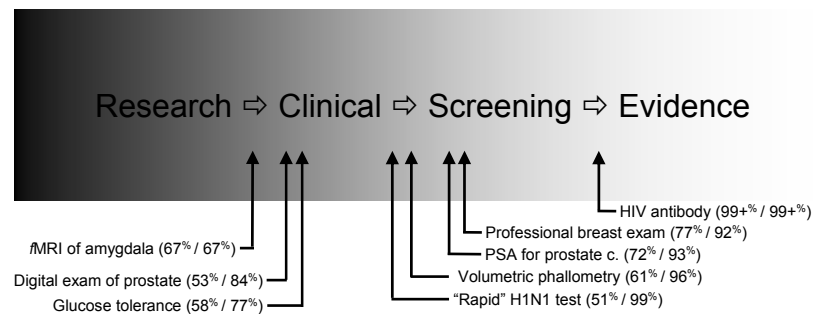


## Hypothetical Validity



## The State of the Art

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 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?



## The stakeholders

Victim groups  
Defense experts  
Prosecution experts  
Treatment clinics  
Politically punitive  
Profiteers of hysteria



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