The Brain on the Stand:

Neuroscience and the Law

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2019

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Overview

- Modern Neuroimaging Technology
- Modern Brain Computer Interfacing
- Neurodiversity: Not all brains are born equal
- Review of some peculiar neurodiverse individuals
- How to decode a brain
- What reading Harry Potter tells us about brain location
- Neuroscientific data in the legal system
- The “My Brain made me do it” defense
- What about juror’s brains?
- What about adolescent brains?
- What does Officer Krupke have to do with any of this?
- Memory and lie detection
- Kent Kiehl and his hunt for psychopaths

Disclaimer

- I am a neuropsychologist
- I am not a lawyer
- This lecture is the result of my ongoing concern about issues in our legal system and my belief that neuroscience needs to have more impact on the US justice system.
- It reviews what is happening in neuroscience that is relevant to our legal system

Unpredictable Future

- In a 2002 editorial published in The Economist, the following warning was given:

- "Genetics may yet threaten privacy, kill autonomy, make society homogeneous and gut the concept of human nature."

- “But neuroscience could do all of these things first.”

New terminology to learn about

The New Neurosciences:

- Neuropolitics
- Neuromarketing
- Neuroethology
- Neuroeconomics
- Neurotheology
- Neuroethics

And, of course, Neurolaw

Question:

What are the ultimate legal implications of our expanded knowledge of brain functioning and human cognition

What is Neurolaw

- Neurolaw is the area of medical jurisprudence concerned with the medical and legal aspects of the relationship of brain to human behavior.

- It can address questions of criminal responsibility, contract law & dementia, adolescents and the death penalty, etc.

- As we learn more about human brain functioning, will we have to redefine our most basic ideas of justice?

- Currently legal responsibility for behavior is a legal conclusion, not a scientific finding.

Can Pigs be legally guilty?

- 1994 film The Advocate (The Hour of the Pig), a period comedy
- 1452, Colin Firth pays role of a Medieval age legal advocate.
- He defends a man and a donkey who were found guilty of bestiality.
- The man is executed, but the donkey is spared at the last minute because it could not be proved that she consented to the act.
- He then needs to defend a pig who is accused of murdering a child.

History of Animal Legal Responsibility

- Animals were once thought to have moral responsibility.
- Numerous instances in which nonhuman animals, like pigs and moles, have been put on trial and sentenced for crimes of various sorts.
- *The Criminal Prosecution and Capital Punishment of Animals*, by E.P. Evans, described more than two hundred such trials from 824 AD to 1906, spanning Europe and many other parts of the world, including the United States.
- Such a moral and legal concept is now incomprehensible.

A legal prototype of change: Tourette's

- **Robert Sapolsky**: the example of Tourette's syndrome, a condition involving physical and verbal tics, including, most dramatically, coprolalia
- 500 years ago, they might have been burned at the stake.
- 200 years ago, people with those symptoms would have been arrested;
- Now we know it is a neurological disease and we do not blame, punish, arrest, or convict Tourette's patients for this behavior.
- But we still blame and imprison people with ASD for their behavior, as well as brain damaged individuals.

But we have a ways to go legally: ASD deficits

- Autism Spectrum Disorder:
- Deficits in social communication and social interaction
  - Social-emotional reciprocity
  - Nonverbal communicative behaviors – no eye contact, body language, poor use of gestures
  - Developing, maintaining, & understanding relationships

ASD in the legal system

- ASD behavior may lead to:
  - Behaviors considered crimes by legal systems
  - Misunderstandings that raise the suspicion of guilt: gazing down, not understanding what “put your hands up” means, not looking at jury, looking emotionally cold – behaviors all seen as signs of guilt
  - Increased risk of being the victim of crimes
  - ASD in prison: 4% in Midwest max security; 36% in one London jail

My own philosophy

- Criminal law is about society attempting to regulate the behavior of many people.
- Until we understand how to scientifically prevent criminality, we need to differentiate between who we are angry at and who we are afraid of.
- Retribution should not be the goal of the law. Criminals who we are angry at (drug crimes, etc.), need to be sent to rehabilitation.
- Society needs to be safe. Criminals we are afraid of (psychopaths, murderers), need to be in prison (until there is another scientifically justified method of treating them).

Neuroscience

- Neuroscience is still in its infancy.
- Functional magnetic resonance imaging (fMRI) only came on the scene in the 1990s, but has since revolutionized research in human brain functioning.
- The very fundamental insight of the last 40 years of neuroscience, entails that with every discovery we will be better able to predict future actions. We will get better at predicting future actions by studying the brain

Historical legal assumptions

- 1 - All men are created equal
- 2 – You are innocent until proven guilty
- 3 – You are responsible for your actions
- 4 – People are rational
- 5 - People have some awareness of their options and that they will intentionally choose the option which they believe best.
- 6 – People’s brains are legally equivalent

Neurodiversity

- Neurodiversity is an international civil rights movement
- Its mission is to redefine the perception of brain-based disorders by reconsidering the nature of atypical perceptual and cognitive performance.
- It challenges oppressive social norms, stigma and rejection, and points to a need to modernize our justice system

Neurodiversity

- Individuals with ASD refer to us as <u>neurotypicals.</u>

- <u>Neurodiversity</u> often refers to the diversity of human brains and minds, including ASD, gender-variant, ID, etc. We need to consider all individuals with non-neurotypical brains.

- New scientific data implies that there is a large neurodiverse population in our societies

- These neurodiverse individuals are highly vulnerable and marginalized

- They are involved with the justice system at higher rates than the general population

Neurodiversity: Types of non-normal brains

- Neurodiverse brains (NDD):
  - Autism spectrum disorder (ASD)
  - ADHD
  - Bipolar Disorder
  - Dementias
  - Dyslexia
  - Epilepsy
  - Tourette’s syndrome
  - Substance abuse
  - Traumatic Brain Injury (25-87% of criminal inmates report having experienced a TBI)
  - Schizophrenia
  - Growing up in early poverty
  - Born with low IQ
  - Major Depression & PTSD
  - Psychopaths
  - Pedophilia
  - Personality Disorder

- All pose legal risk factor

NDD in prisons: school to prison pipeline

- Death Row prisoners are all abnormal: nearly all Death Row inmates suffer from brain damage due to illness, trauma, or poverty. Most have also experienced histories of severe physical and/or sexual abuse.

- 85% of juvenile inmates have learning and/or emotional disability

- 31% have speech and reading difficulties (2004 state & federal inmate survey)

- 43% reported taking special education classes

(US National Council of Disability report: 2015 School to Prison Pipeline)

Need to recognize neurobiological diversity

- Brain neurodiversity raises legal issues

- Key legal concepts in criminal law become extremely tricky when applied to neurodiverse individuals, including:

  - Competency
  - Capacity
  - Sentencing
  - Admissibility of scientific evidence in trial

Dark Past for neurodiversity

- Efforts to identify normal and abnormal brains have been responsible for some of the darkest movements in the history of science and technology, from phrenology to eugenics.

- In 1949 a Portuguese neurologist named Egas Moniz won the Nobel Prize in medicine and physiology for his invention of a procedure that came to be known as the prefrontal lobotomy. Within twenty years, his discovery was viewed as barbaric and its use nearly stopped, but, while it was popular, between about 1938 and 1962, about 35 to 40 thousand Americans, and uncounted others, were lobotomized.

- Dr. Walter Freeman, traveling in a VW bus modified as a clinic, lobotomizing Southern women who were not obedient to their husbands

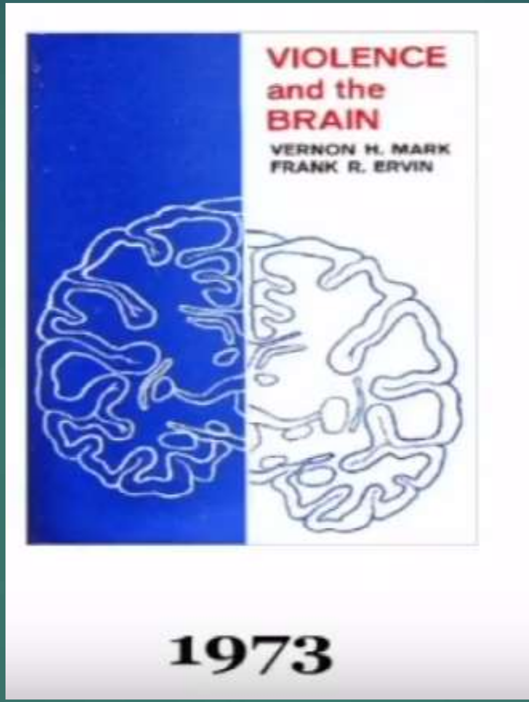
Prefrontal Lobotomy

A pair of Watts-Freeman lobotomy instruments circa 1950

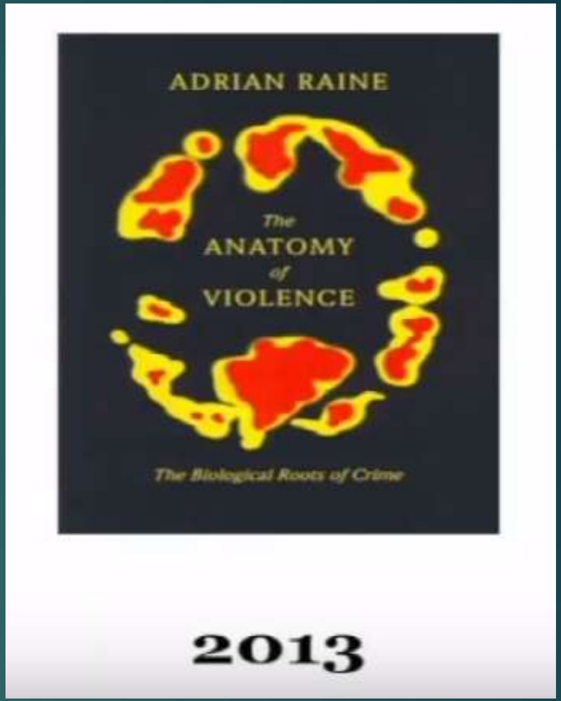
A historical lesson in neurological methods without scientific evidence.

Past History of Brain Science

Egas Moniz: Only Nobel Prize for Psychiatry:
Device for frontal lobectomy



Mark & Ervin: Brain Basis of violence;
DBS to trigger violence



Raine: Murderers are anatomically different

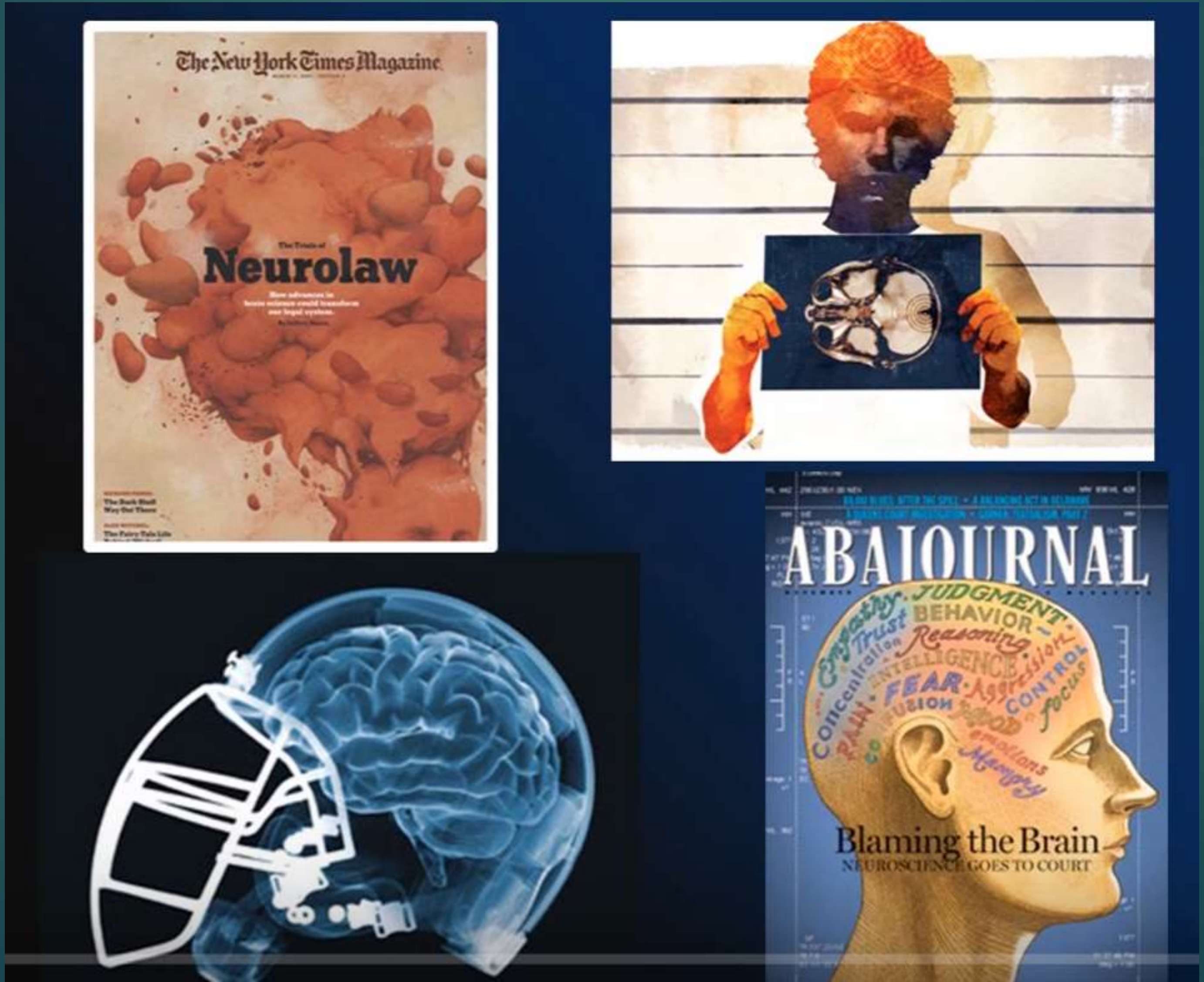
Dark History of science and law

- During the last century, the law embraced science in ways that were inhumane and harmful—and eventually were discredited.

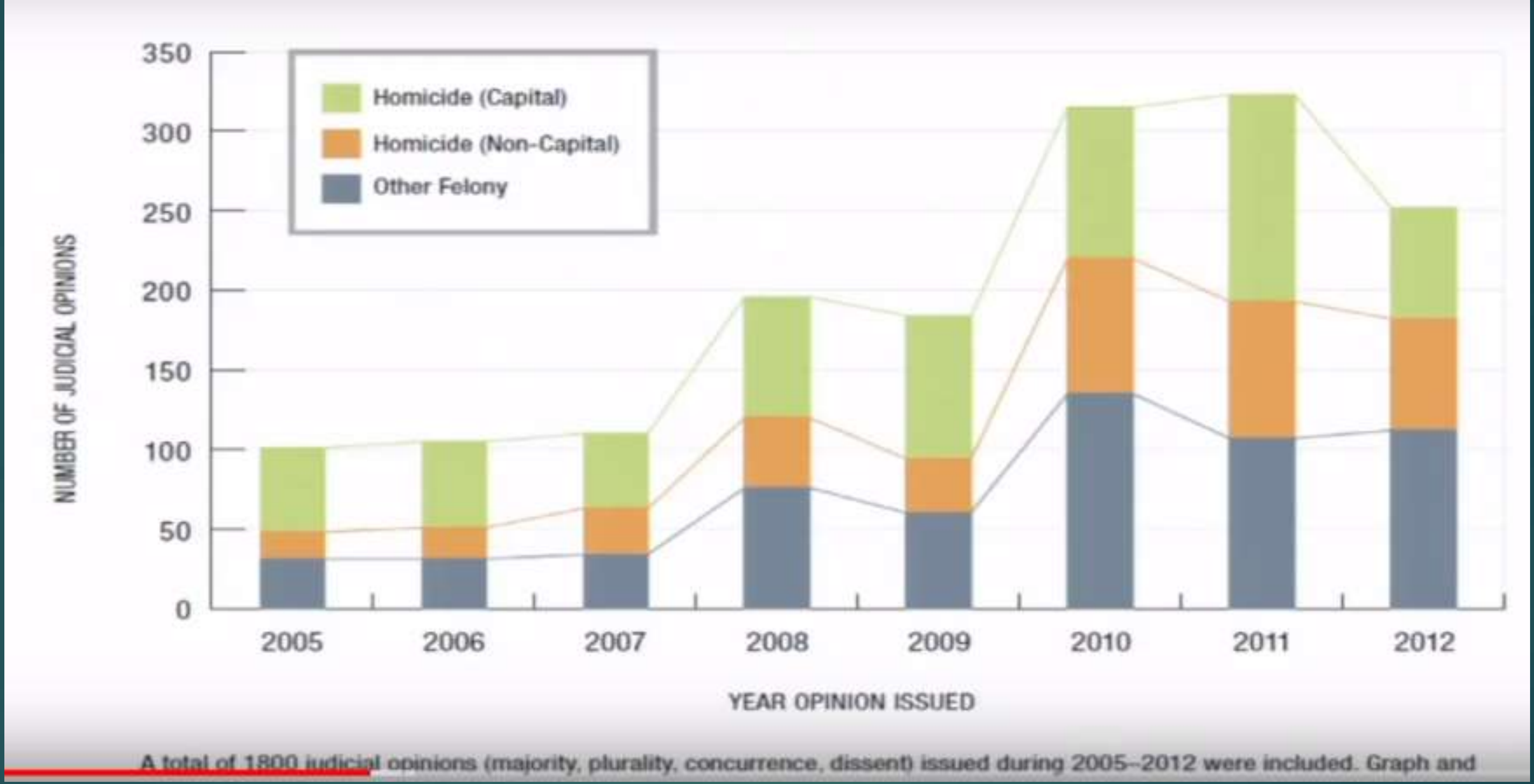
- For example, eugenics—the theory that humans could employ selective breeding and sterilization to improve genetic makeup and create better people—was once practiced in the United States.

- In fact, state laws allowed the forced sterilization of women, and the U.S. Supreme Court upheld the practice in 1927. It took Hitler's popularization of eugenics for critics to finally be heard, and it eventually fell into disfavor. Hitler studied CA laws. Not outlawed in CA until 1963.

The Present:
References to the Brain science is everywhere, including courts

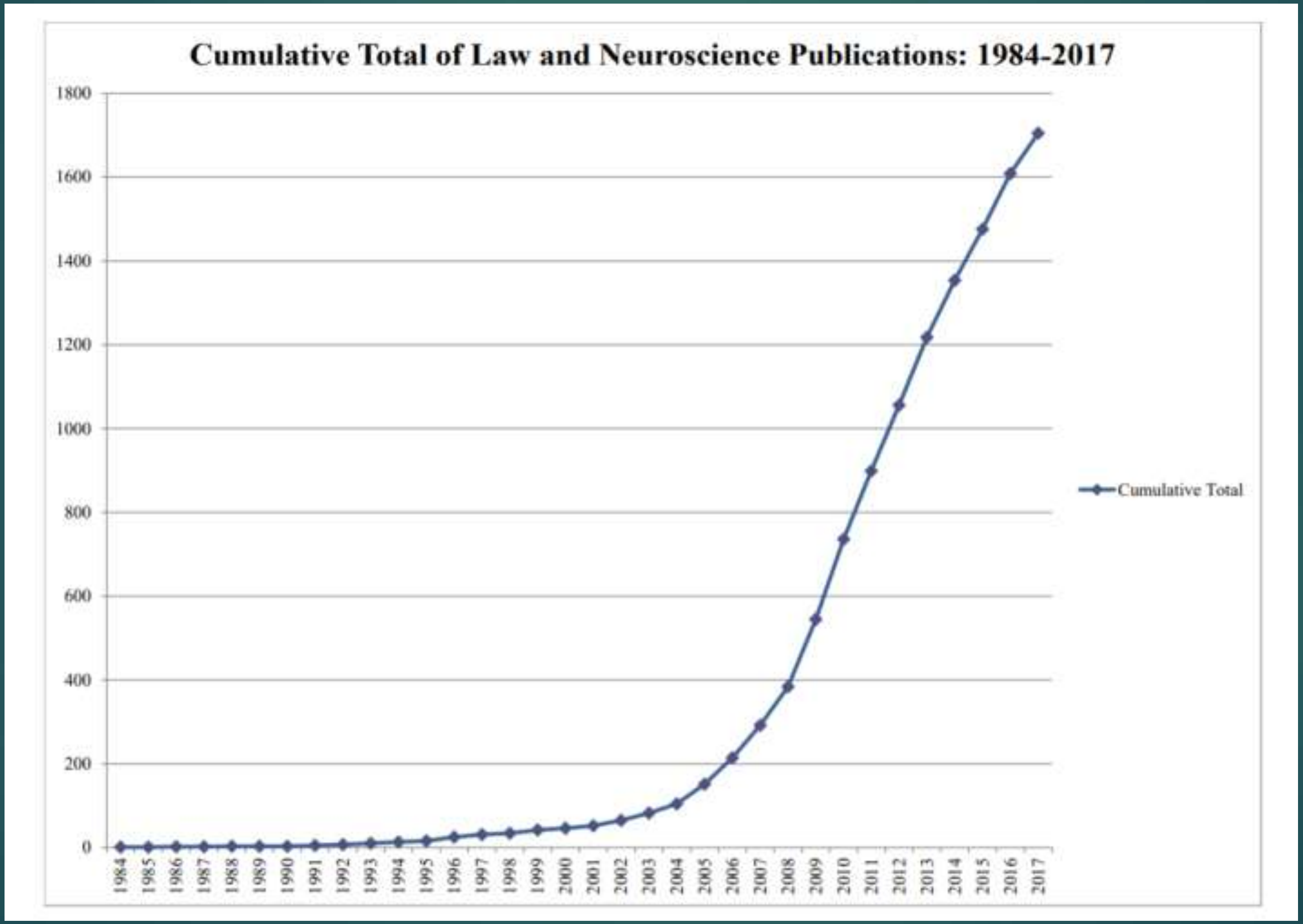


Neuroscientific Evidence in Court is on the rise



Nita Farahany, 2014

In Legal scholarship: Neuroscience & the law publications, 1984-2017



Implication: by 2042 everyone in US will have published a NS article

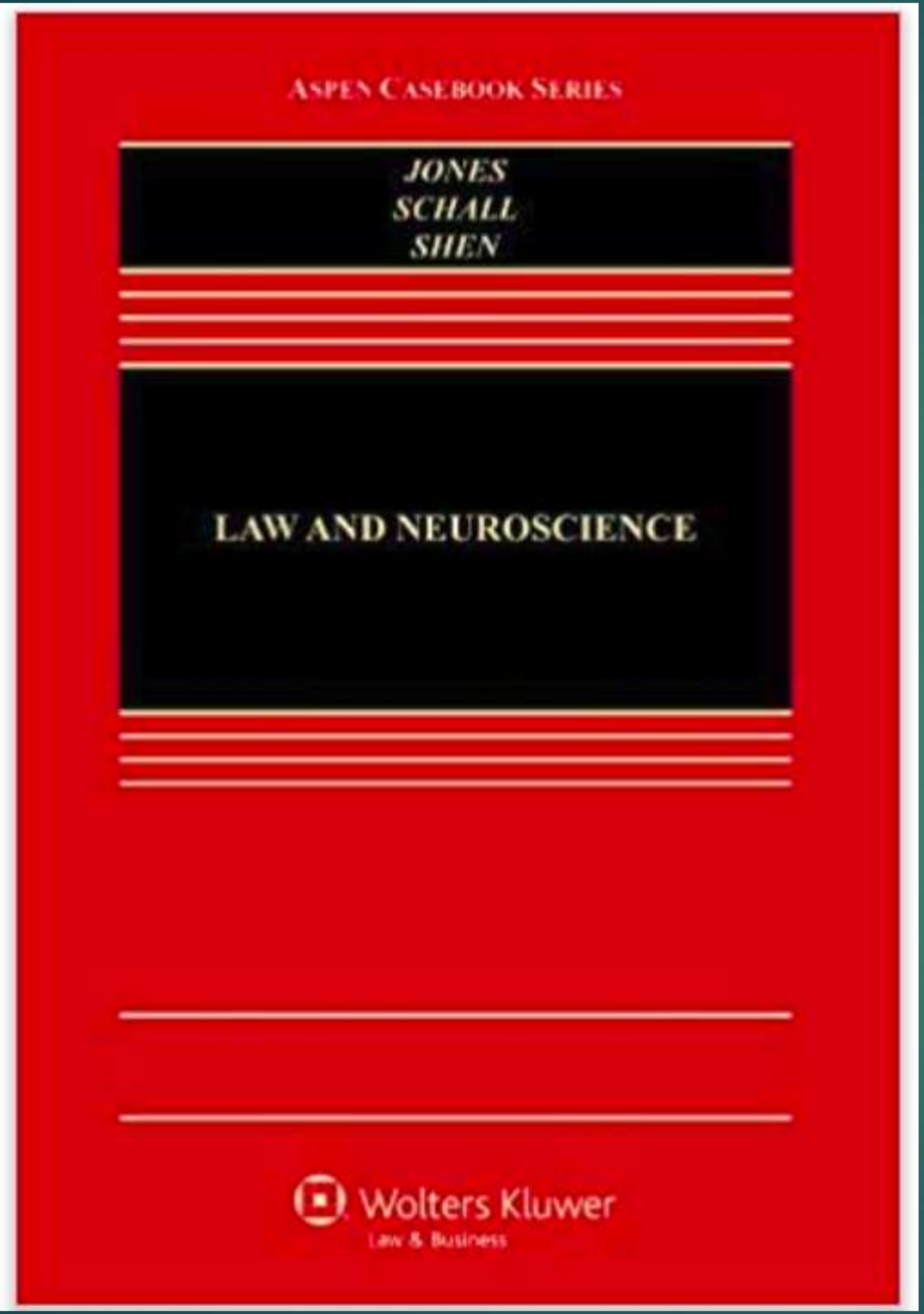
http://www.lawneuro.org/bibliography.php

In legislatures…

Topics covered by brain bills

Alzheimer's * Autism * Brain Death * **Brain Injury** * Civil Commitment * Crime Victims * Criminal Defense * **Early Childhood** * Education * End of Life * Foster Care * **Health Care** * **Juvenile Justice** * **Mental Health** * Military Veterans * Neonatal * Parkinson's * Parole * Post Traumatic Stress Disorder * Privacy * Sex Offenders * Shaken Baby Syndrome * Special Education * **Sports Concussions** * Toxins * Veterans Courts

Currently science used to support prior political opinions: fetal pain-capable laws support anti-abortion legislation



First Law and Neuroscience textbook, 2014

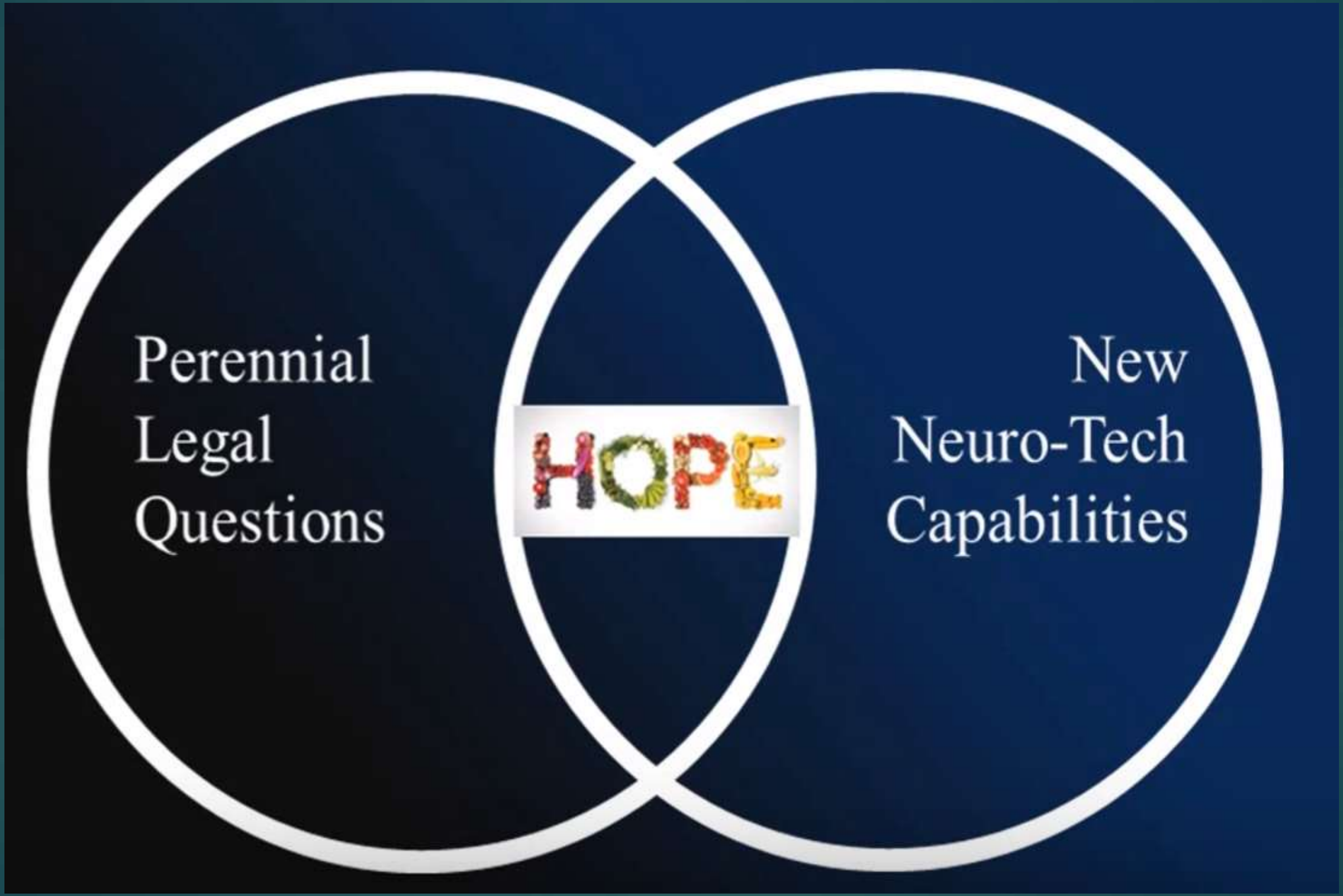
86% of the publications and cases included in the book were published only since 2000

60% published between 2008-2013.

Published in 2014 ... and already in need of a 2nd edition!

Why the intersection of NS and Law?

> "… a lot in law hinges on how brains work."

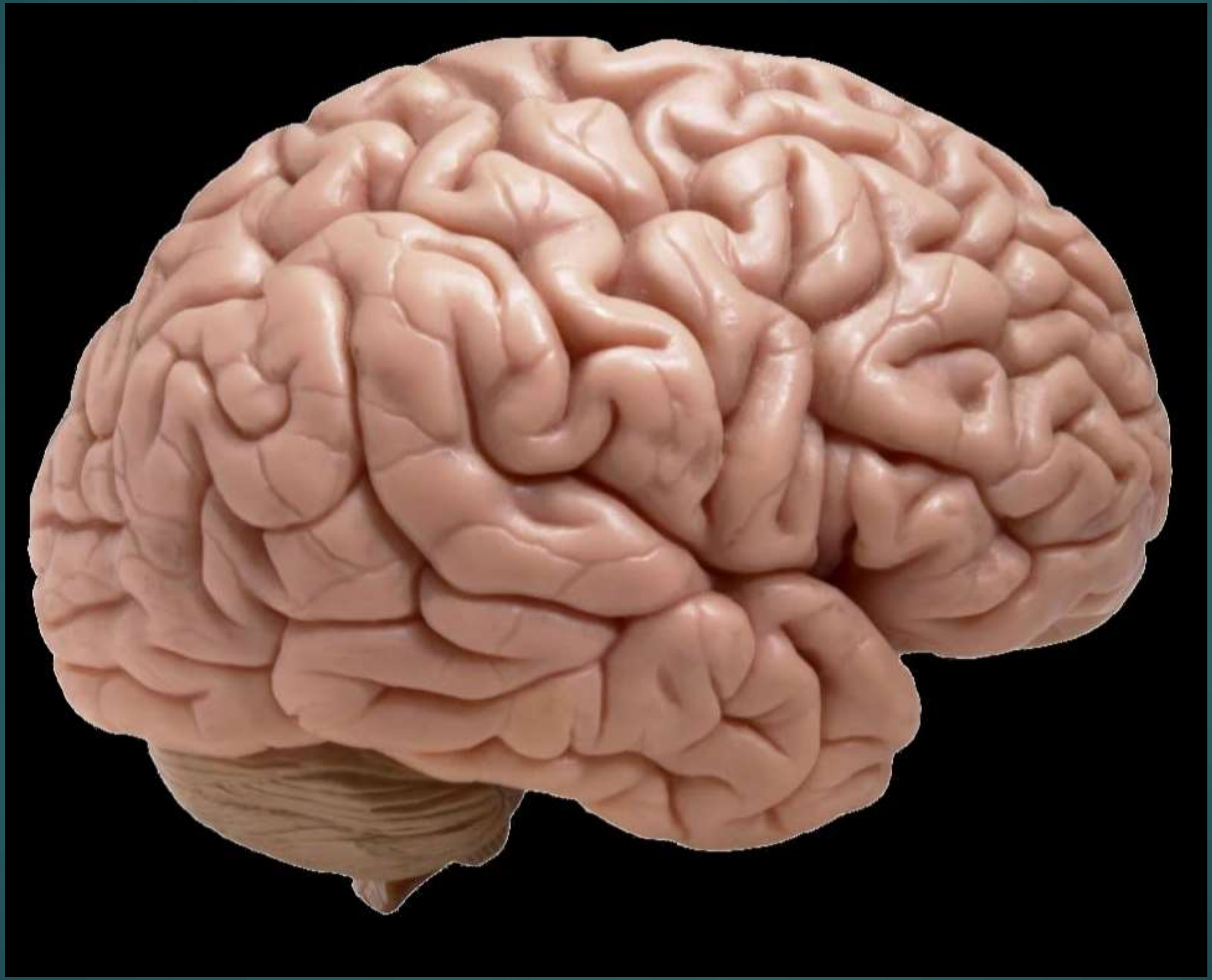

Perennial Legal Questions
HOPE
New Neuro-Tech Capabilities

Perennial Legal Questions: What was happening in his head?

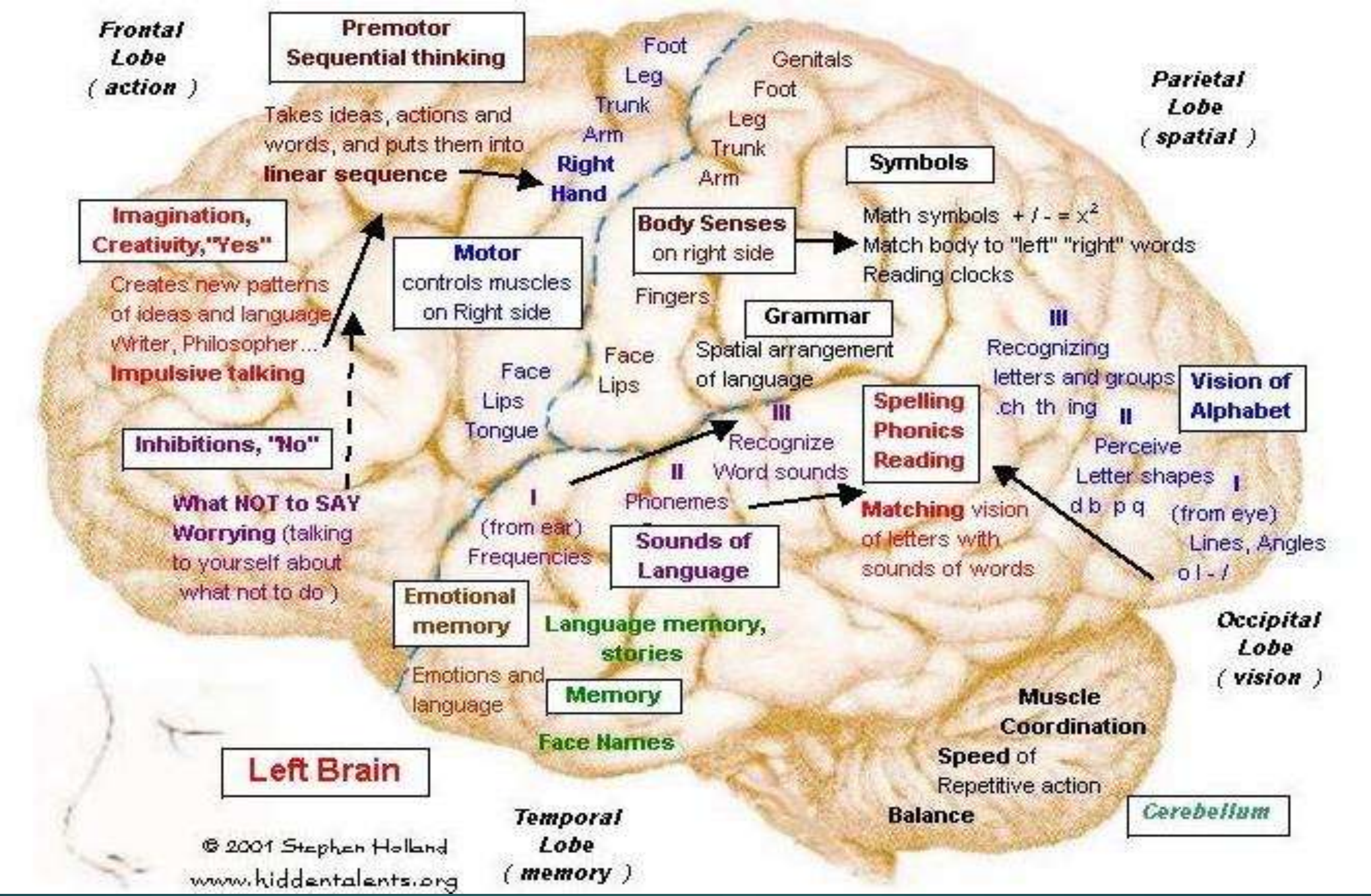
Ye Olde Questions

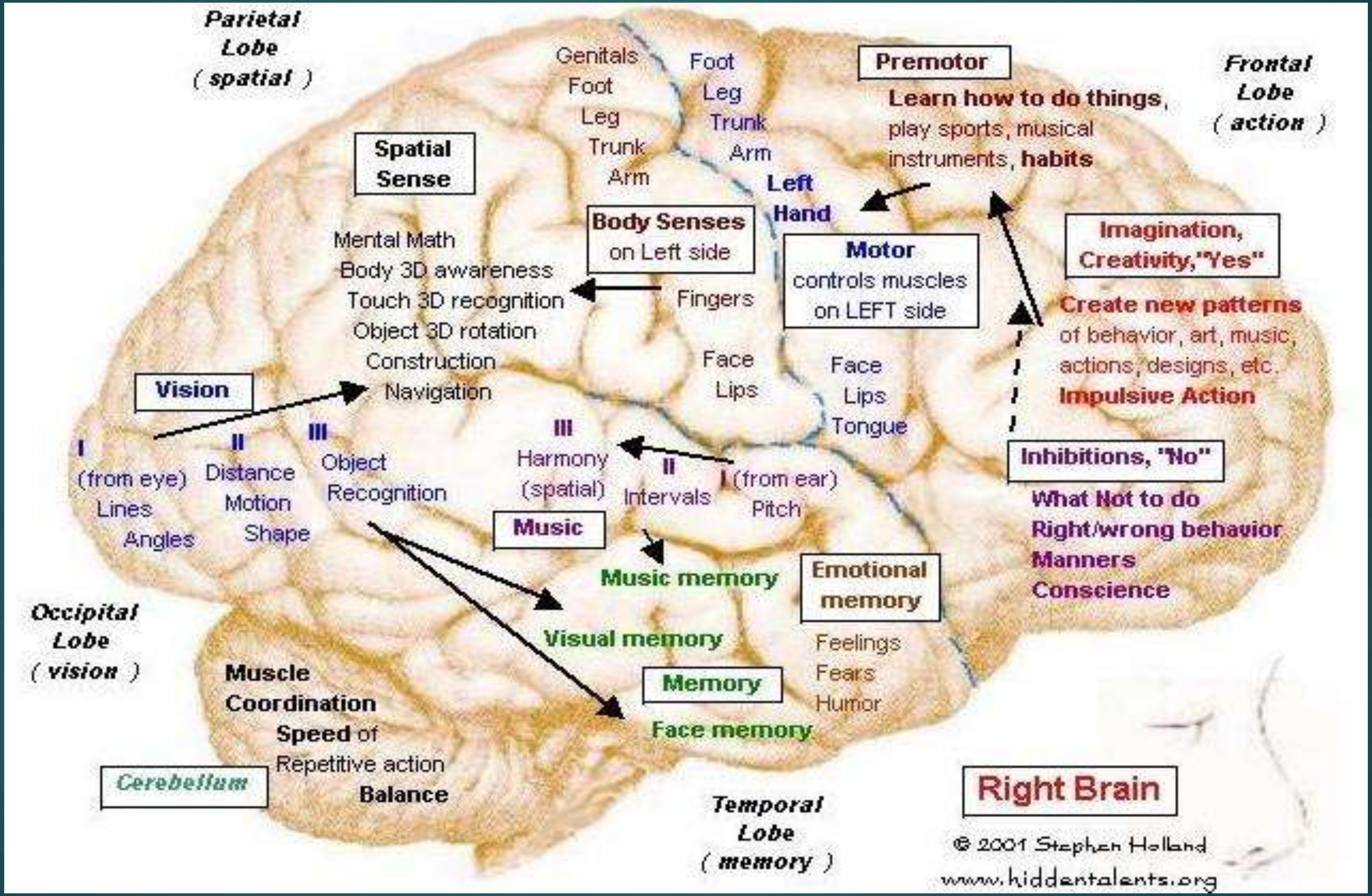
- Is this person responsible for his behavior?
- What was this person's likely mental state?
- How competent is this person?
- Is this person lying?
- What does this person remember?
- How accurate is this person's memory?
- How can we improve juror and judge decisions?

Older view of The Human Brain as an unknowable black box

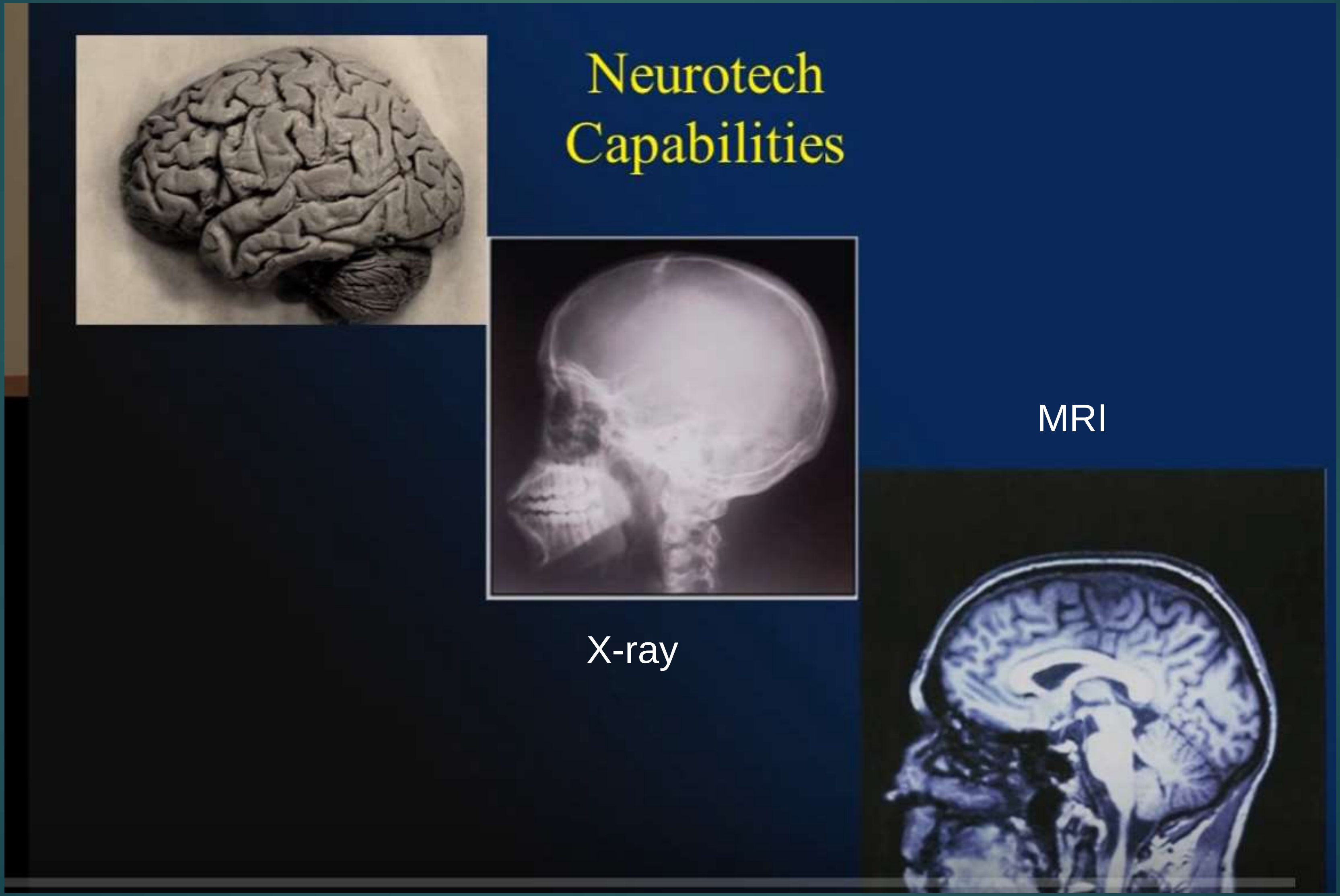


Brain is now understood to be highly and specifically organized

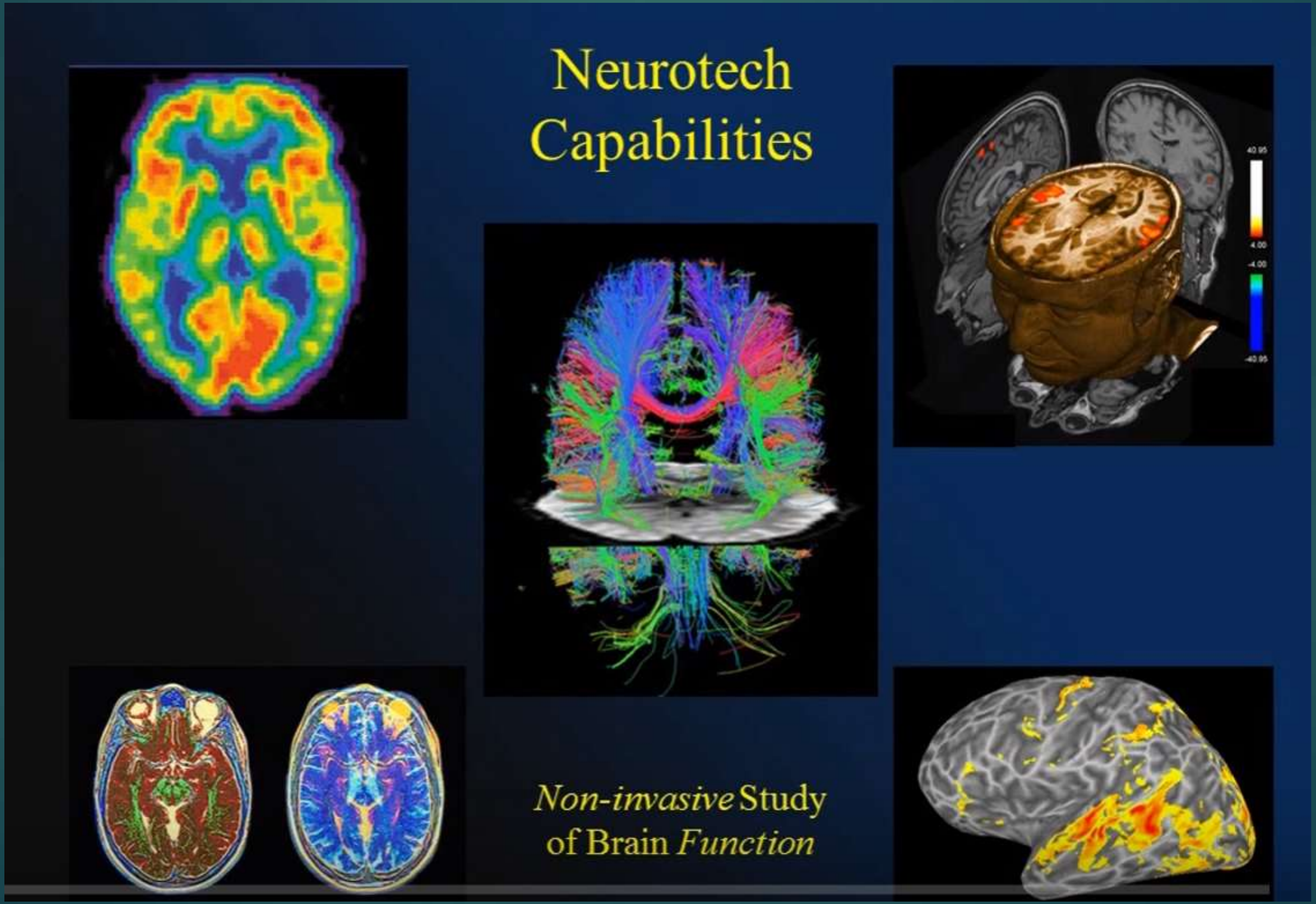



Parietal Lobe (spatial)
Frontal Lobe (action)
Occipital Lobe (vision)
Temporal Lobe (memory)
Genitals
Foot
Leg
Trunk
Arm
Foot
Leg
Trunk
Arm
Left Hand
Premotor
Learn how to do things, play sports, musical instruments, habits
Spatial Sense
Mental Math
Body 3D awareness
Touch 3D recognition
Object 3D rotation
Construction
Navigation
Body Senses on Left side
Fingers
Face
Lips
Motor controls muscles on LEFT side
Face
Lips
Tongue
Imagination, Creativity,"Yes"
Create new patterns of behavior, art, music, actions, designs, etc.
Impulsive Action
Inhibitions, "No"
What Not to do
Right/wrong behavior
Manners
Conscience
Vision
I (from eye) Lines Angles
II Distance Motion Shape
III Object Recognition
III Harmony (spatial)
II Intervals
I (from ear) Pitch
Music
Music memory
Emotional memory
Feelings
Fears
Humor
Visual memory
Memory
Face memory
Muscle Coordination
Speed of Repetitive action
Balance
Cerebellum
Right Brain
© 2001 Stephen Holland
www.hiddentalents.org

Have gone from structural understanding of brain: brain on a slab

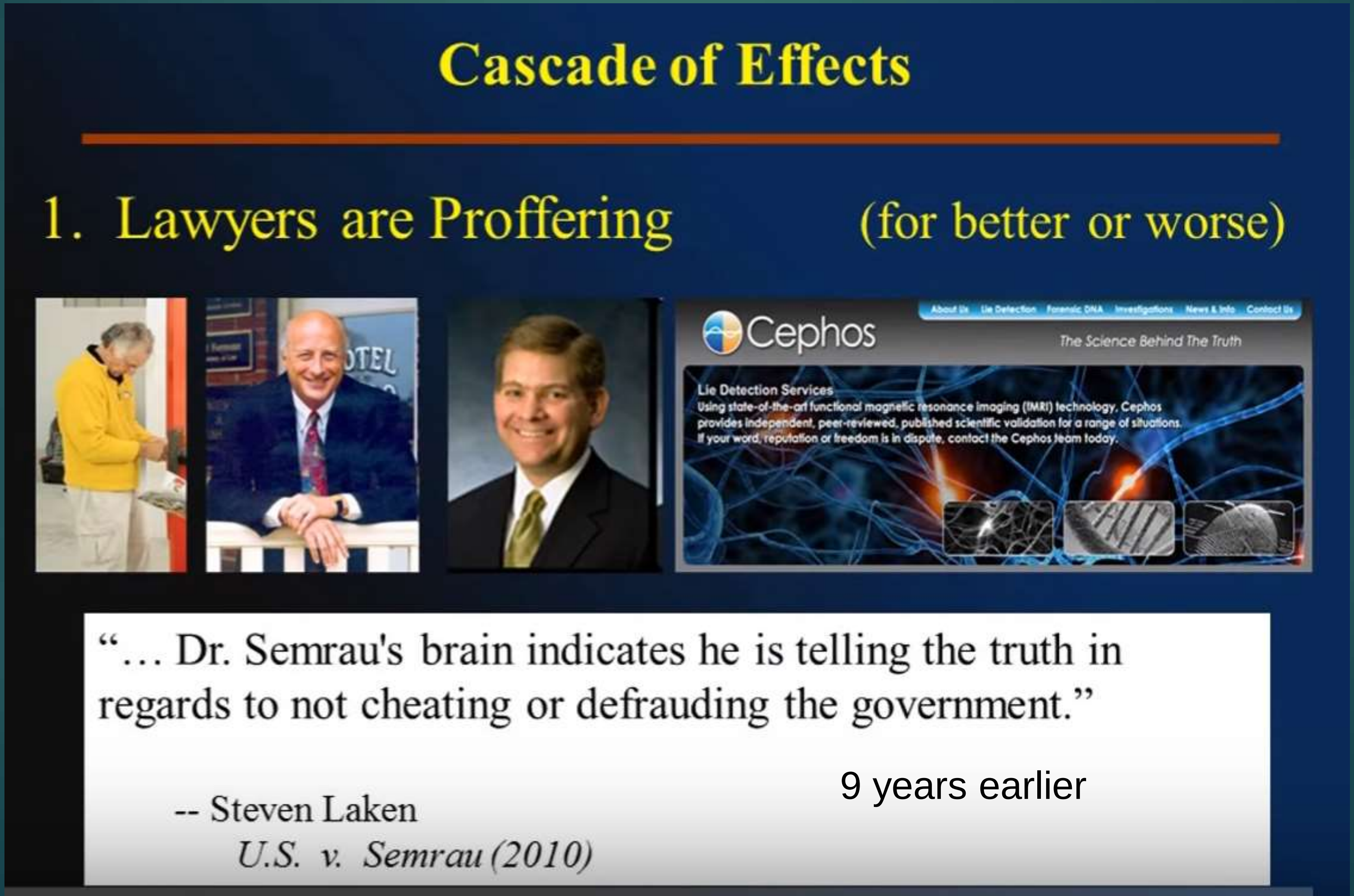


To the ability to study brain function in live, awake, people non-invasively

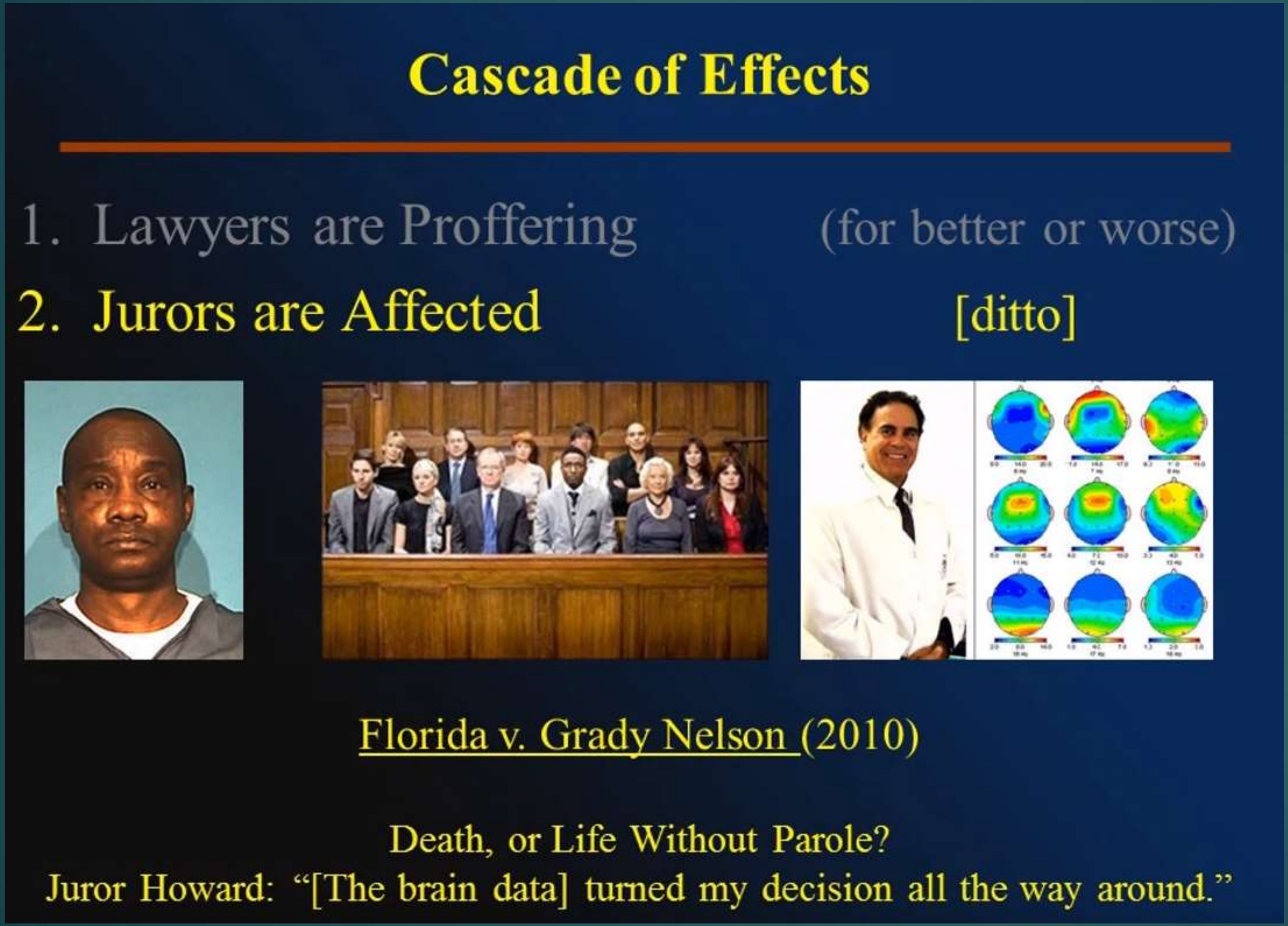


New Hope of improving the fairness and effectiveness of our Legal System

Lawyers are now bringing NS evidence into court:
case of Medicare fraud & introduction of lie detection methodology

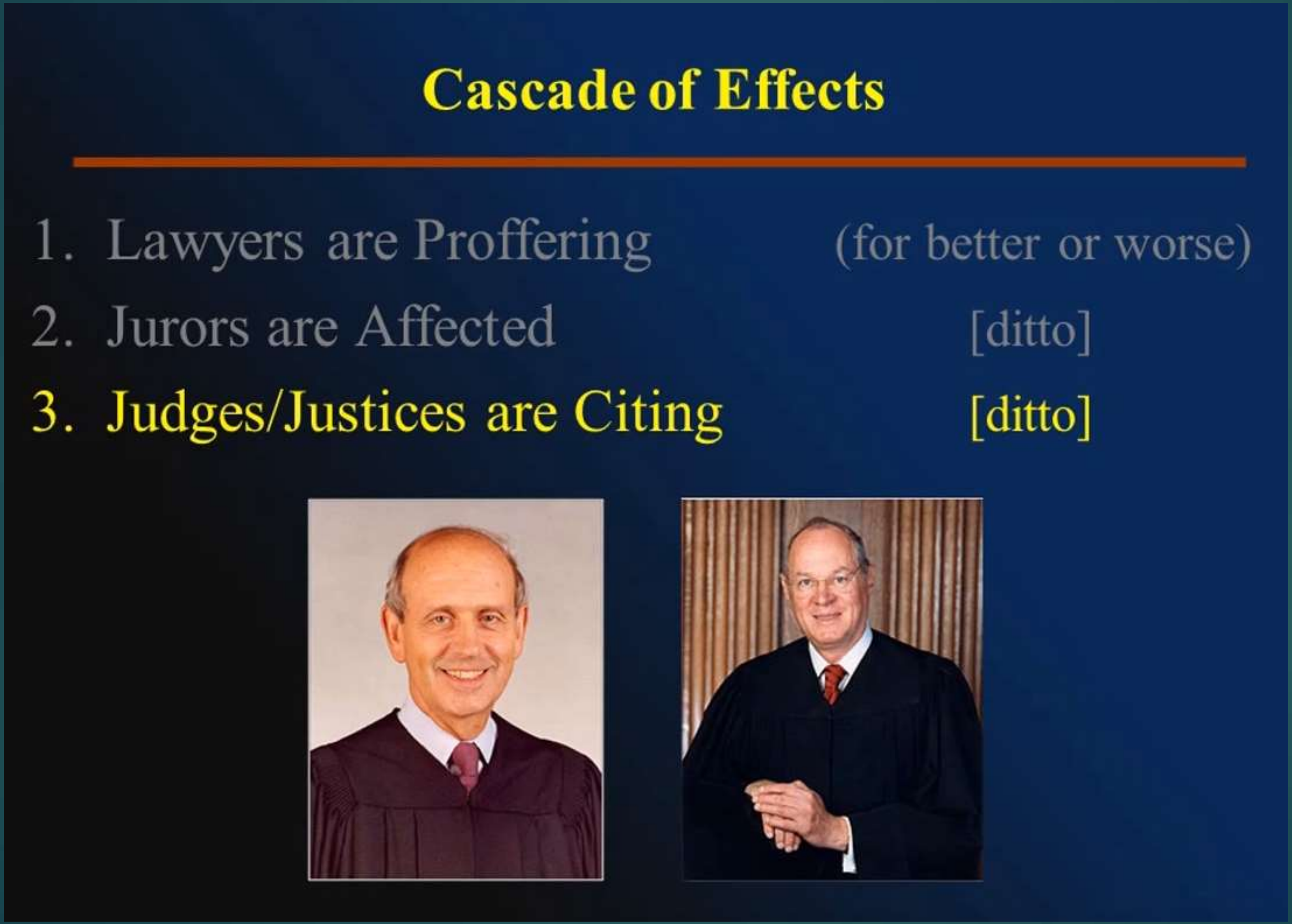


Jurors are affected by NS data



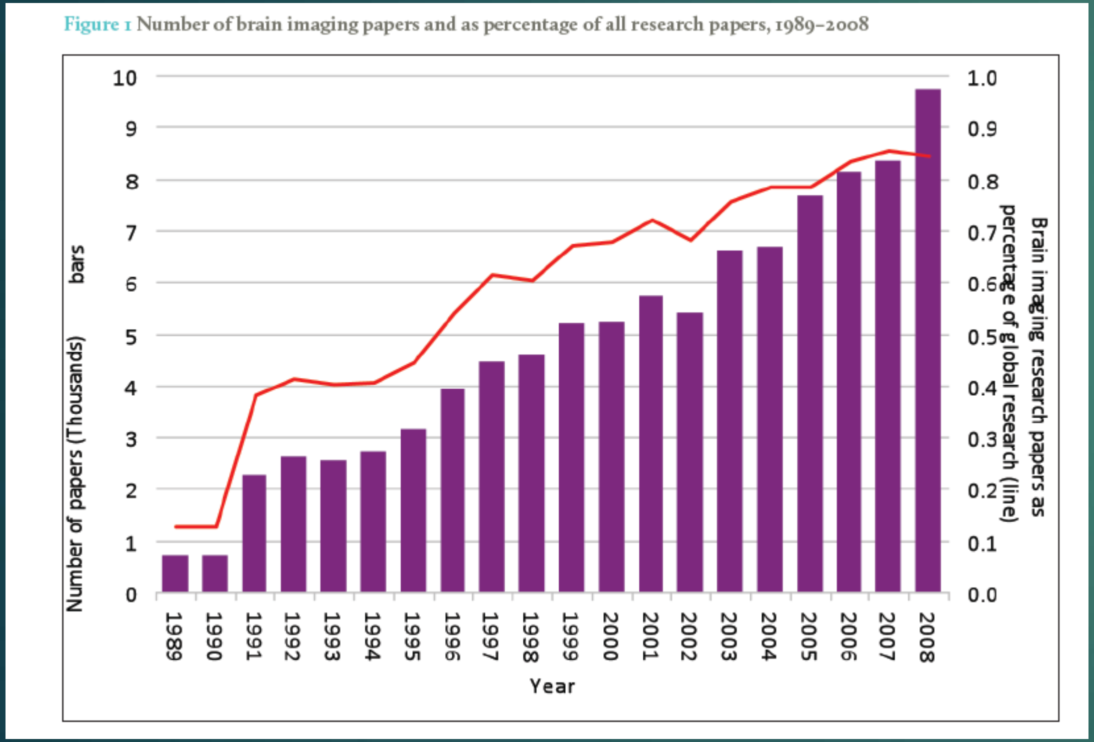
- Grady Nelson stabbed his wife 67 times; 2 children; hx sexual assault
- QEEG data: brain sufficiently broken that he should not be executed

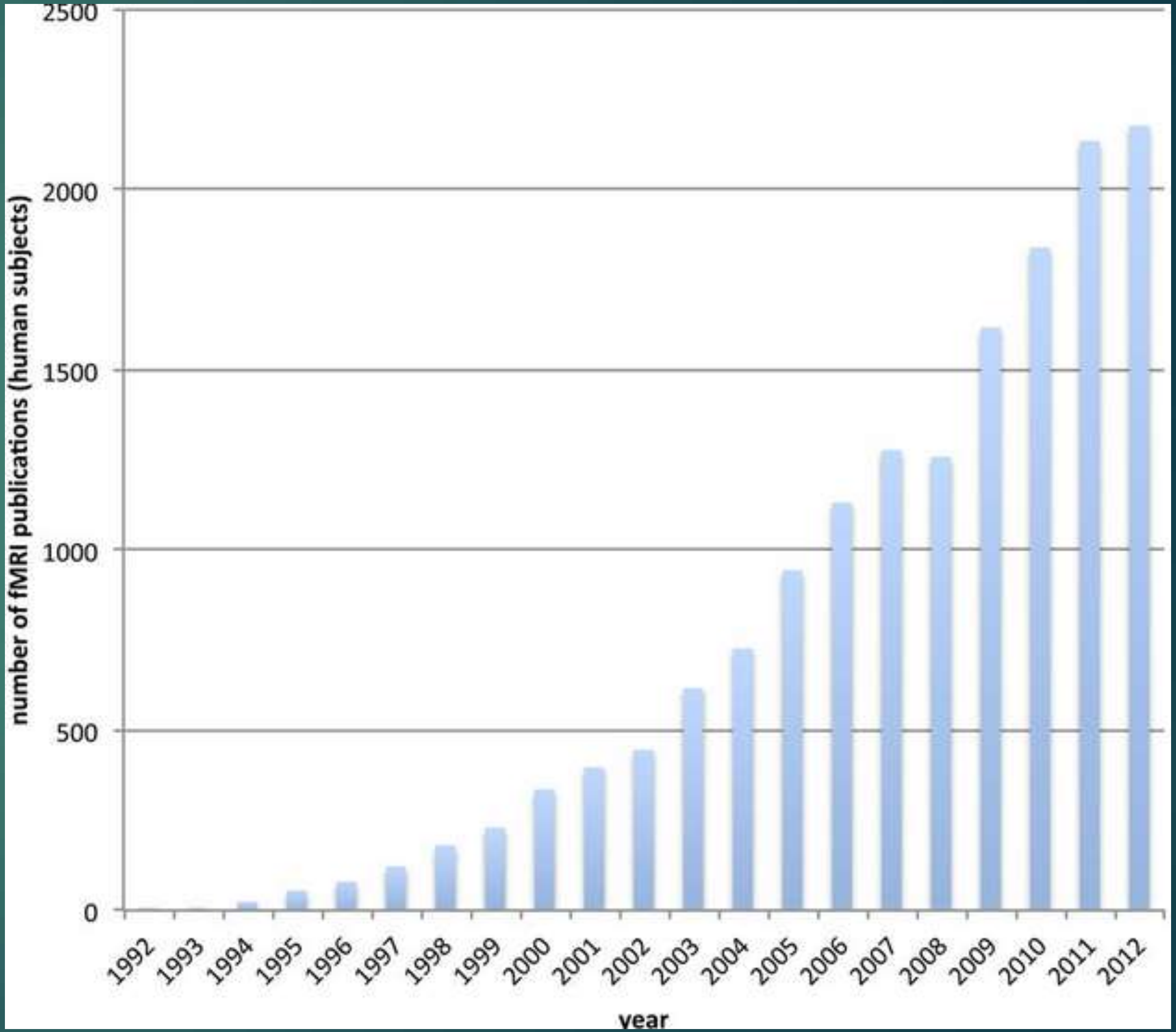
Judges are citing NS data



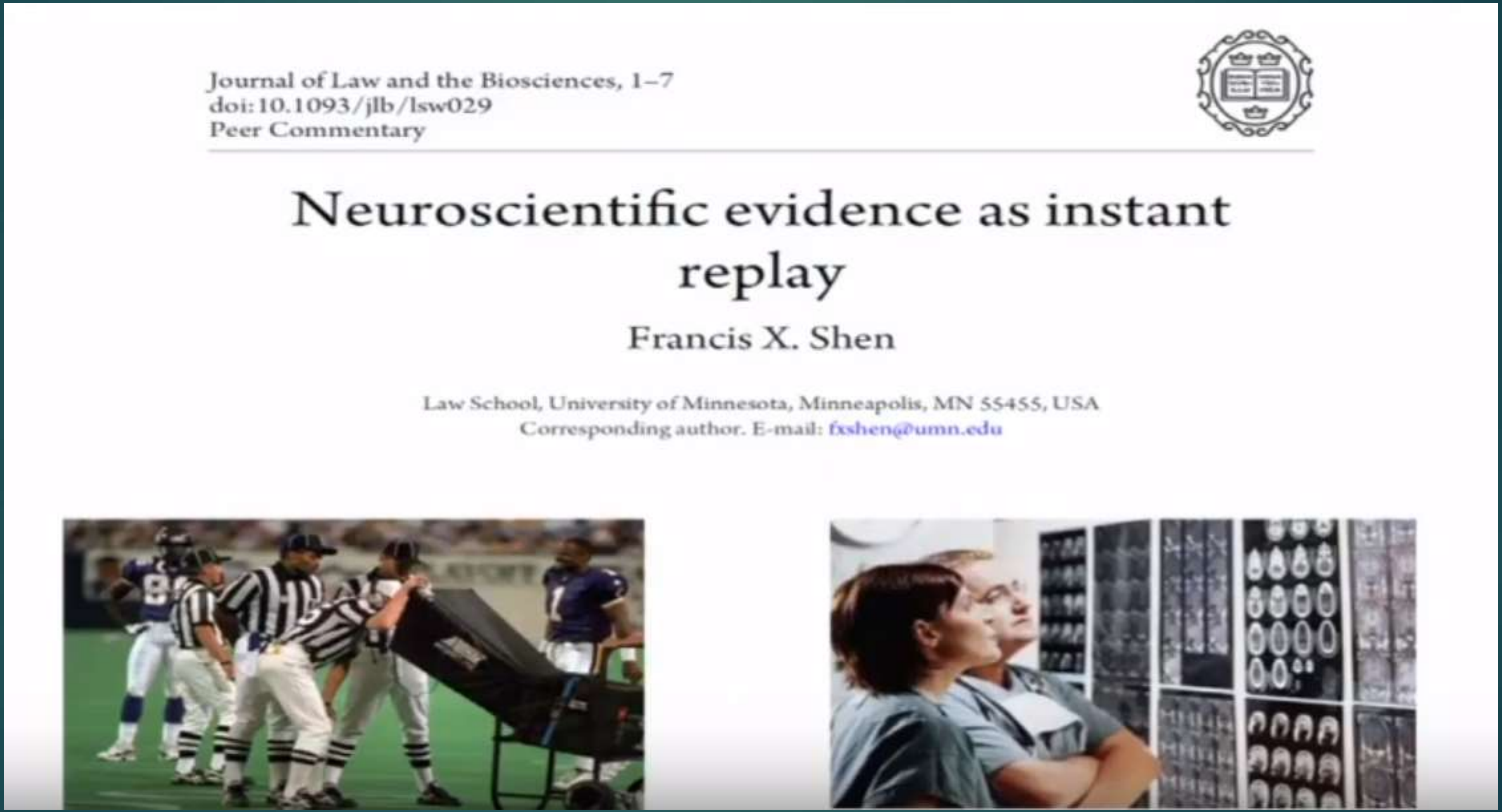
Supreme Court has heard NS data In Amicus briefs Related to adolescent culpability

Number of neuroimaging papers: 1989-2012





Need to remember that NS data has been only recently available: like instant replay methodology in sports



Journal of Law and the Biosciences, 1–7
doi:10.1093/jlb/lsw029
Peer Commentary

Neuroscientific evidence as instant replay

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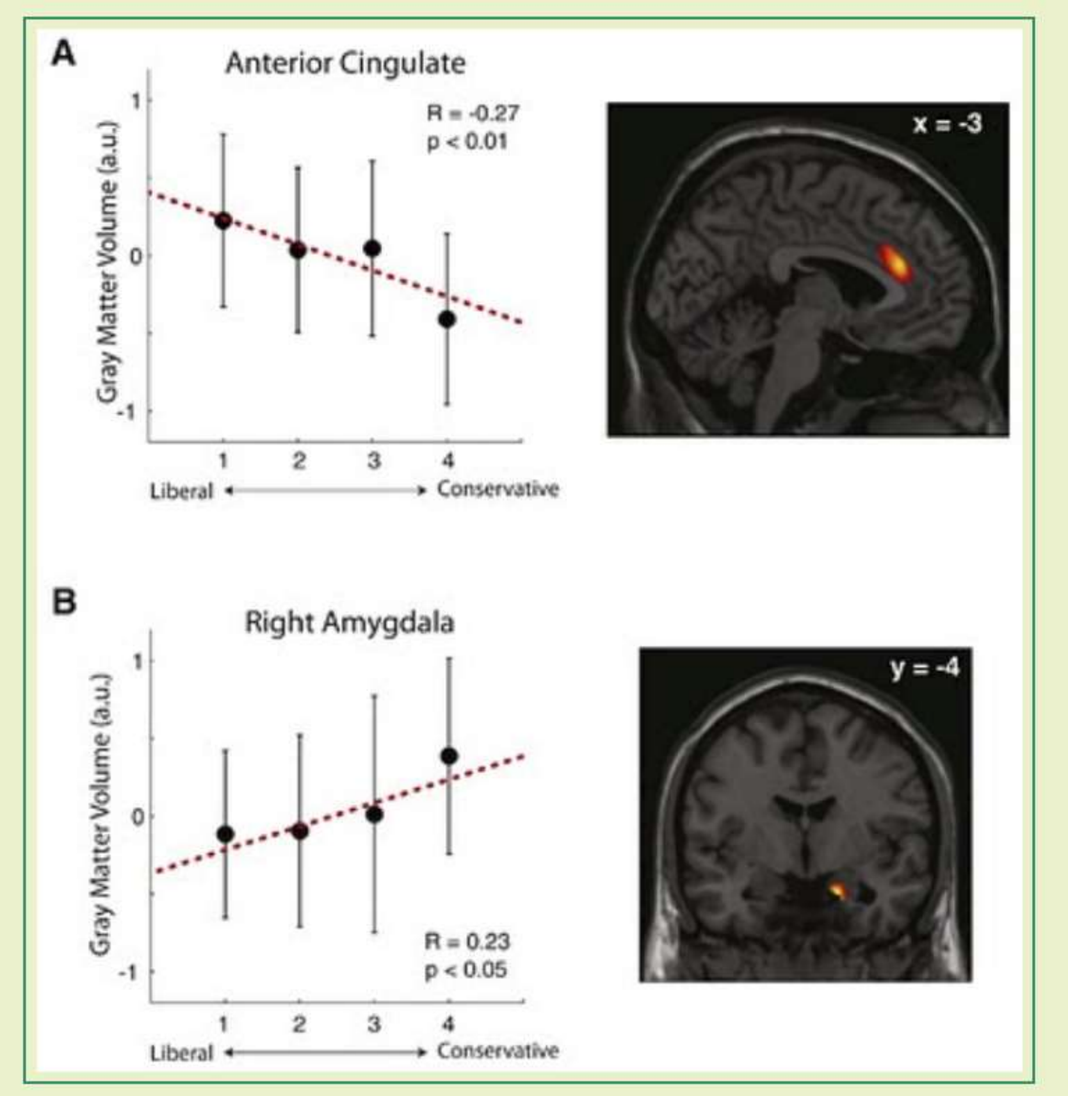
How do we grapple with these issues in the right way?

- We need sober evaluation of:
  - Legal relevance of NS evidence
  - Be able to make legitimate inferences from NS data
  - Evaluate abilities of these new technologies
  - Understand the limits of these technologies

We are a long way from fMRI airport security

Liberalism

Conservatism

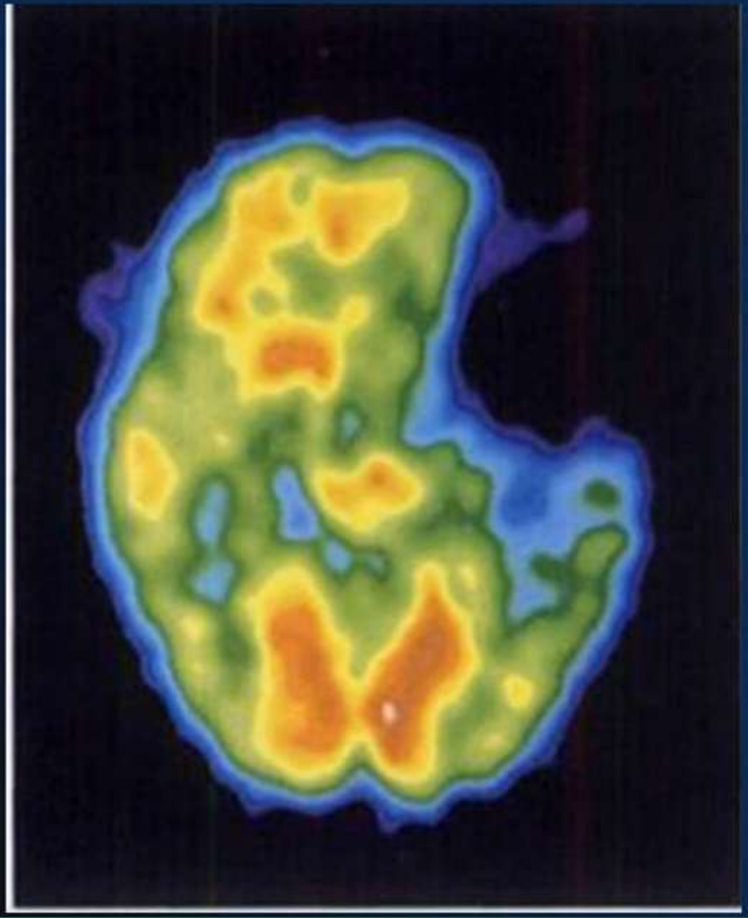


NS uses

- Liberals Are Conflicted and Conservatives Are Afraid:
  - Greater liberalism was associated with increased gray matter volume in the anterior cingulate cortex,
  - Greater conservatism was associated with increased volume of the right amygdala
  - but cause or effect?
  - London Taxi Cab study; Learning how to juggle; both increase brain volume
- Jesuits motto: Give me the child until he's seven and I'll give you the man. Theory that the brain is product of experience, not genetics
- We now know the latter is not the full picture.

(Ryota Kanai, et al., 2011)

Case example: Herbert Weinstein in 1991

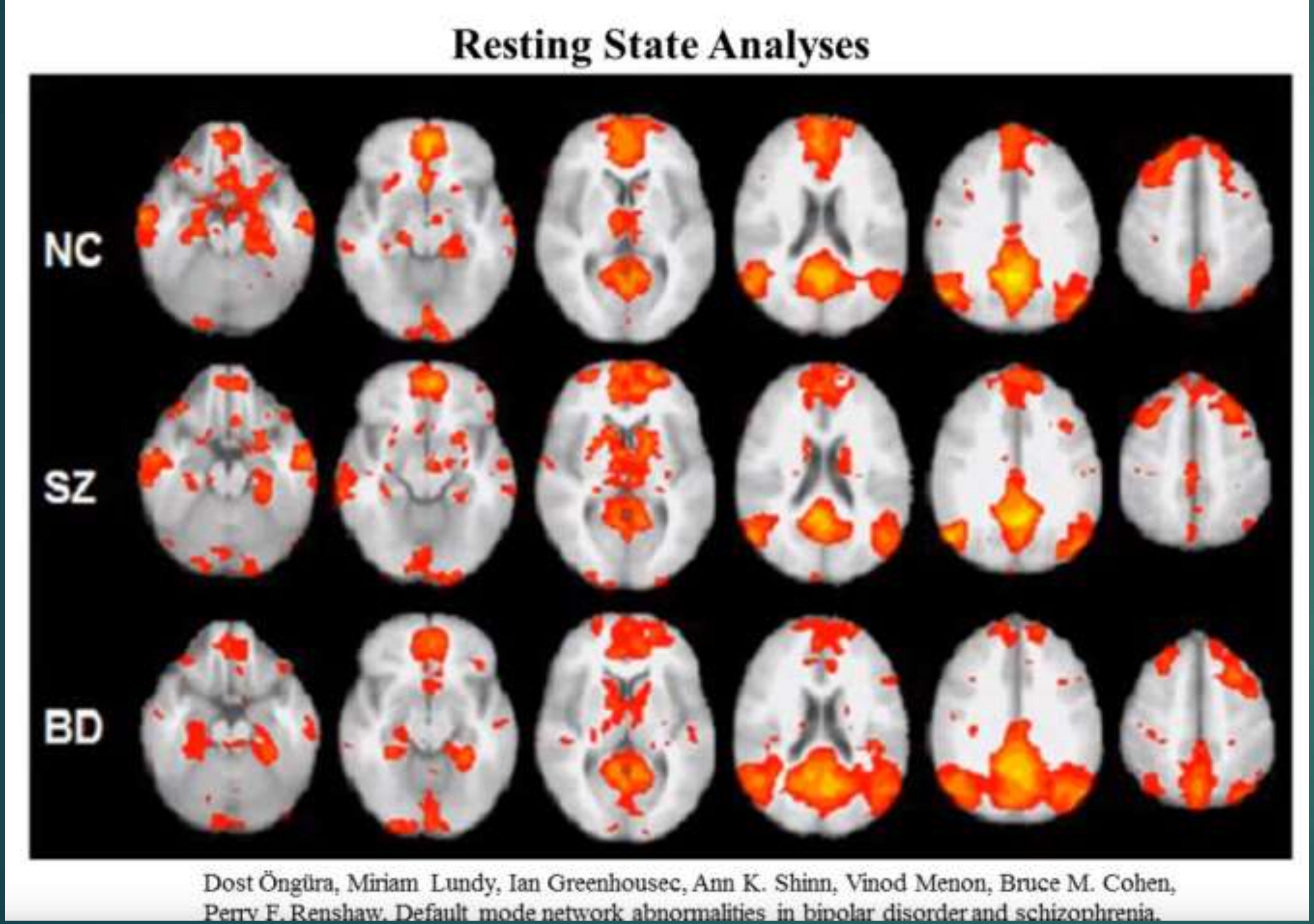


- Calm, cool, man
- Came home
- Strangled his wife
- Threw her out of 12th story apt.

Do you cut him some slack in sentencing?

We do not have base rate of how many have this condition & how often they murder.

fMRIs use Group average data:
group average scans of NC, Schiz, Bipolars



Pretty fMRI pictures are statistically averaged data

- For the Defense: My client looks like this one and should be considered mentally ill.

- For the Prosecution: How do you move from group average data to its relevance to highly individual subject.

- Do juries understand these concepts?

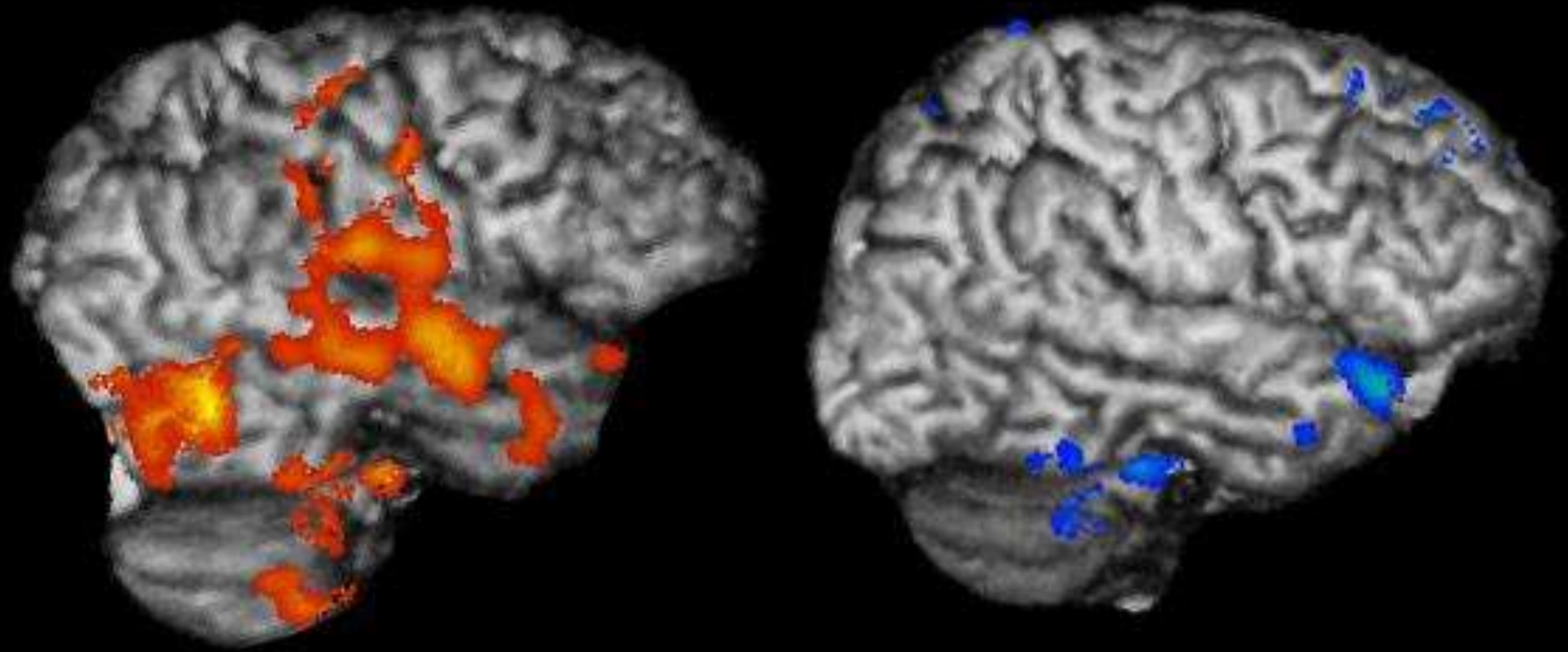
The Neurosciences

- There has been an increasing awareness of the remarkable rate of technological progress in the neurosciences.

- This includes awareness of key new tools of cognitive neuroscience:
  - provide unprecedented insights into how human minds and brains work,
  - unique opportunities to try to 'read out' from neural signals what a person is perceiving, thinking, or remembering; decoding the mind

- These are cutting-edge tools — brain imaging methods such as positron emission tomography (PET), functional magnetic resonance imaging (fMRI)), and data analytic methods such as machine learning,

fMRI: a brain study of alcohol craving



Pre-treatment **After four treatment sessions**

Functional magnetic resonance imaging indicates significantly less craving-related activation in the brain after treatment. (The different colors highlight changes between pre- and post- but have no meaning beyond that.)

Brain Imaging is a powerful New Science

- Stroke location prediction
- Distribution of brain chemicals
- Myelination
- Drug effects
- Brain tumors
- Aging effects
- Tracking beta amyloid in Alzheimer’s

- A powerful diagnostic tool

Example of NS findings: Disgust in the brain

Mutilation images activate disgust related brain areas:

Activation of the occipitotemporal cortex, the amygdala, insula, and the orbitofrontal cortex

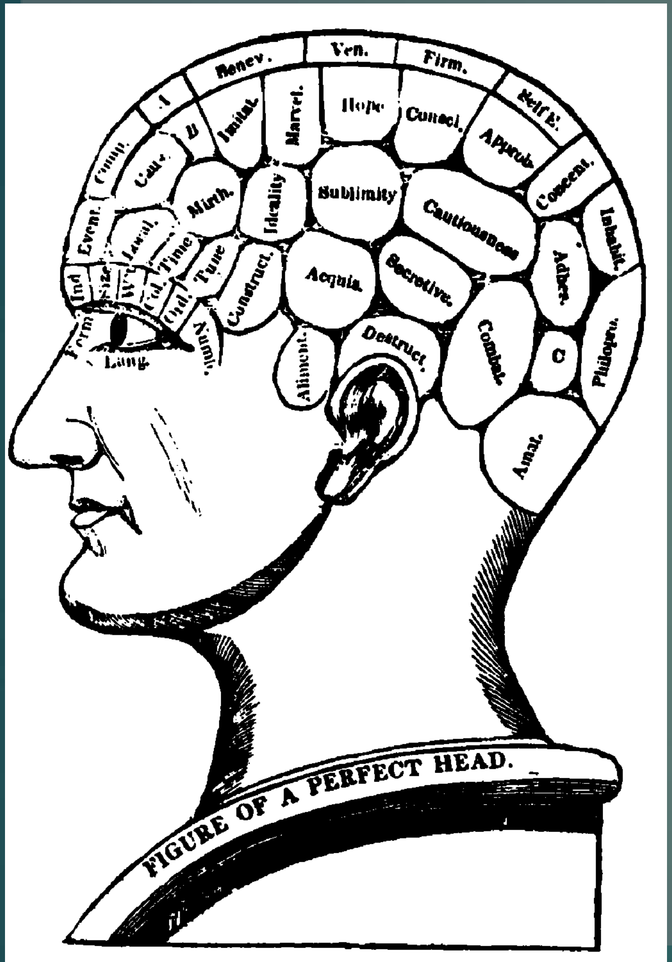
Liberals and conservatives reacted in wildly different ways to repulsive pictures:

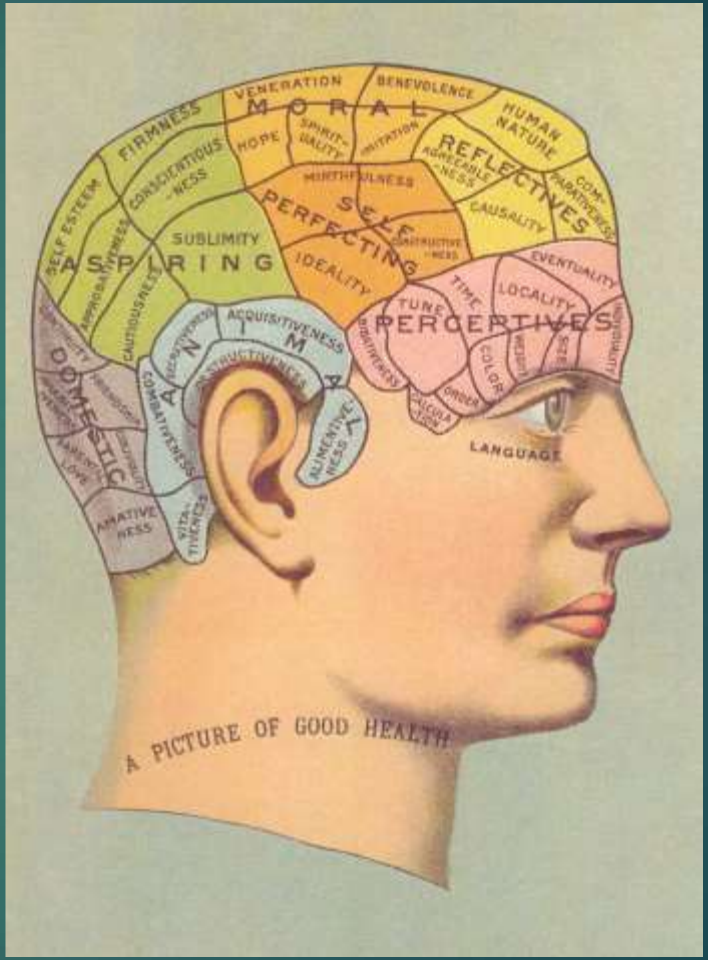
95 percent accuracy whether they were liberal or conservative: conservatives are more reactive

Disgust sensitivity correlated with a conservative ethos in 121 countries; evolutionary fear of contagion?

Brief tour of neuroimaging and some peculiar neurological cases

Phrenology: Bumps make the Man in 18-19th century





Advanced Neuroimaging circa 1905:

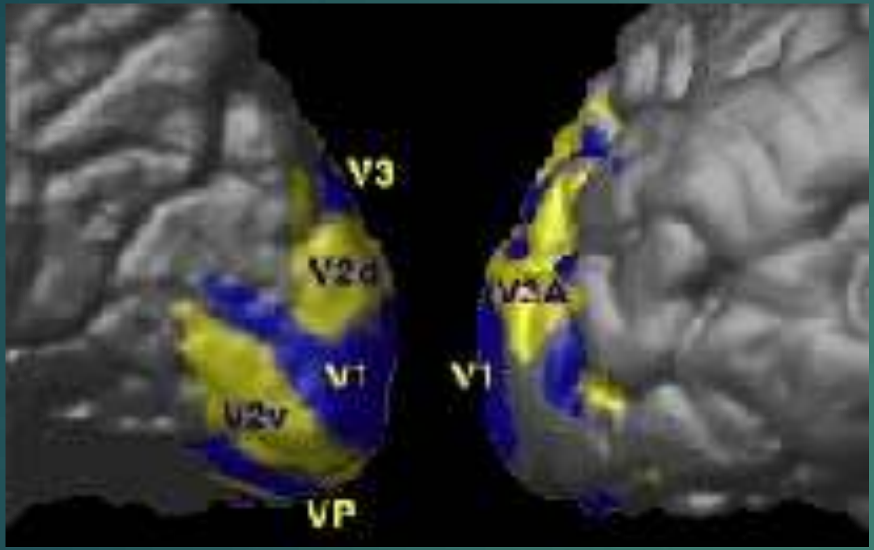
Phrenology “MRI”

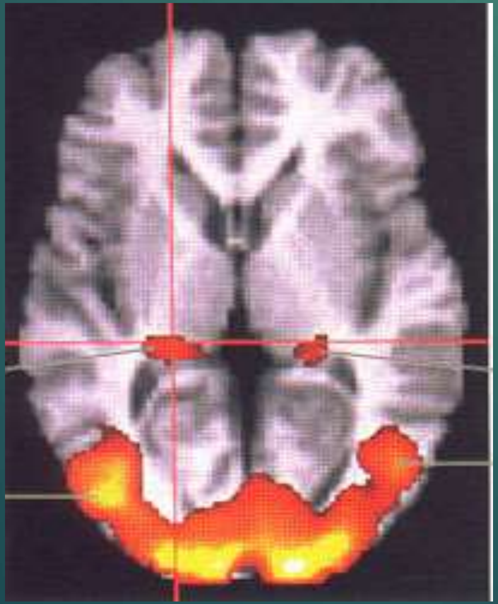
Measured head at 32 points on a five-point scale ranging from “Deficient” to “Very Superior.”

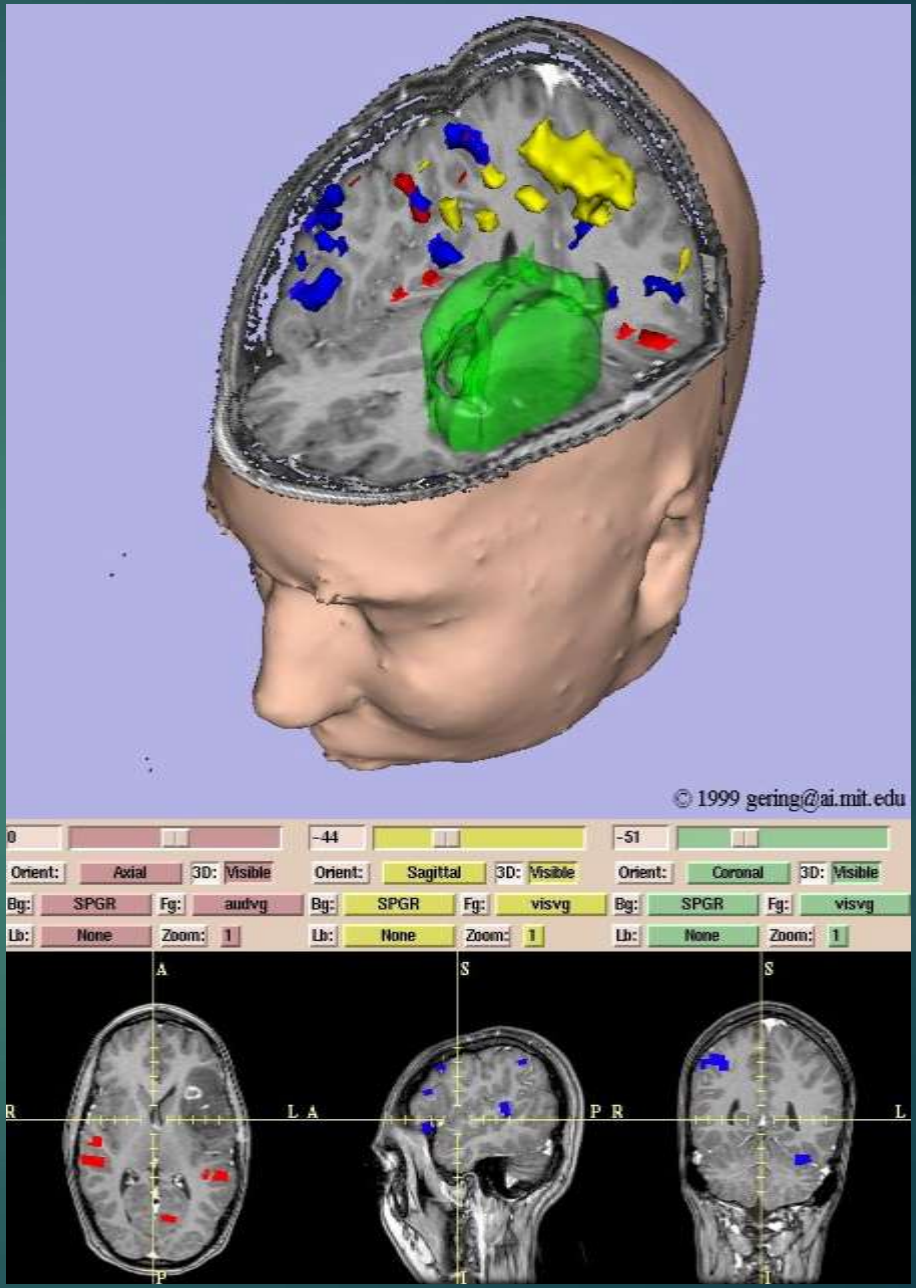
It produced a printed tape that evaluated the character of the person whose head had been poked at.

Cautionary Tale: Many “current” theories are eventually discredited

Modern Phrenology ?







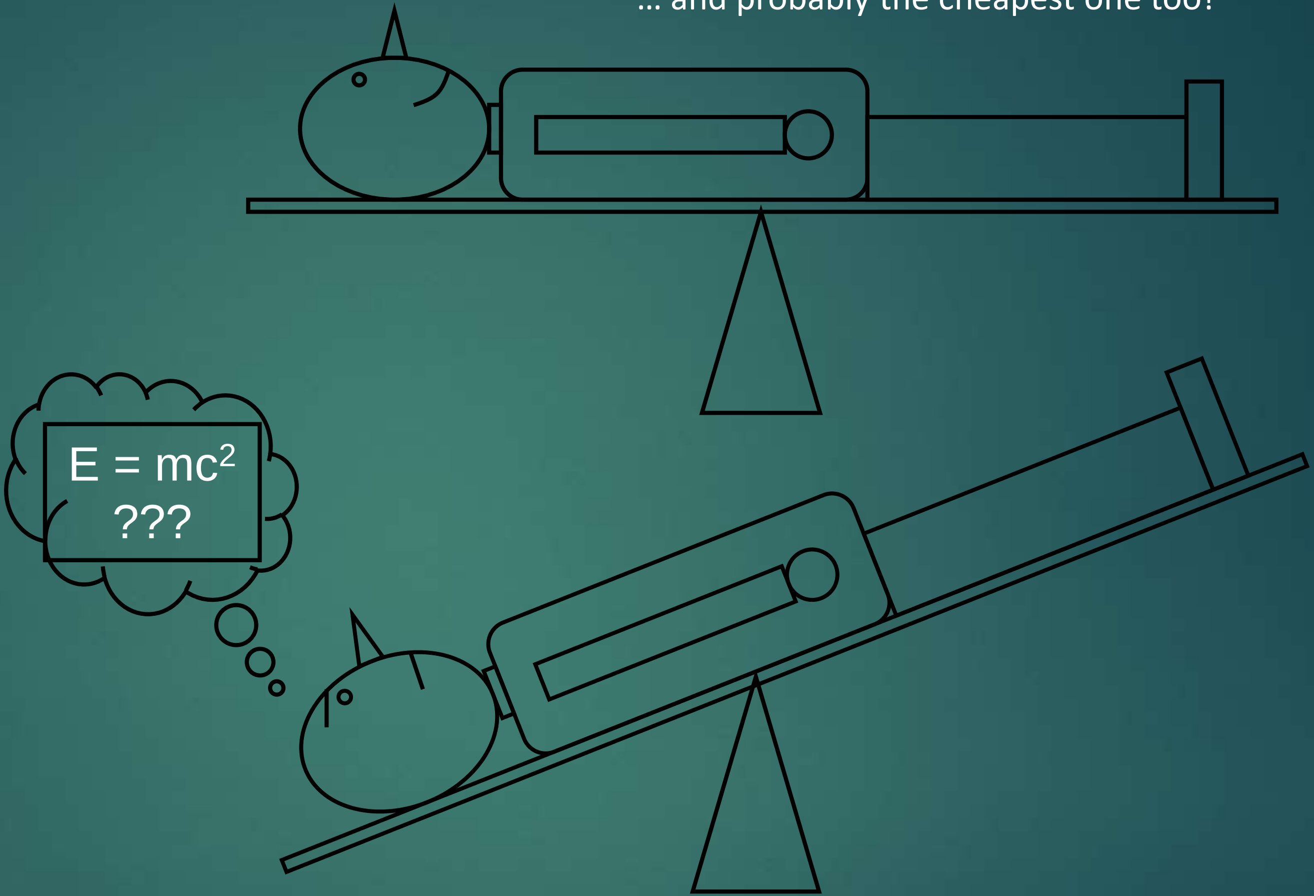
Wilhem Konrad Roentgen, 1845-1923

1895: X-ray

1901: The First "Brain Imaging Experiment"

… and probably the cheapest one too!

Angelo Mosso
Italian physiologist
(1846-1910)

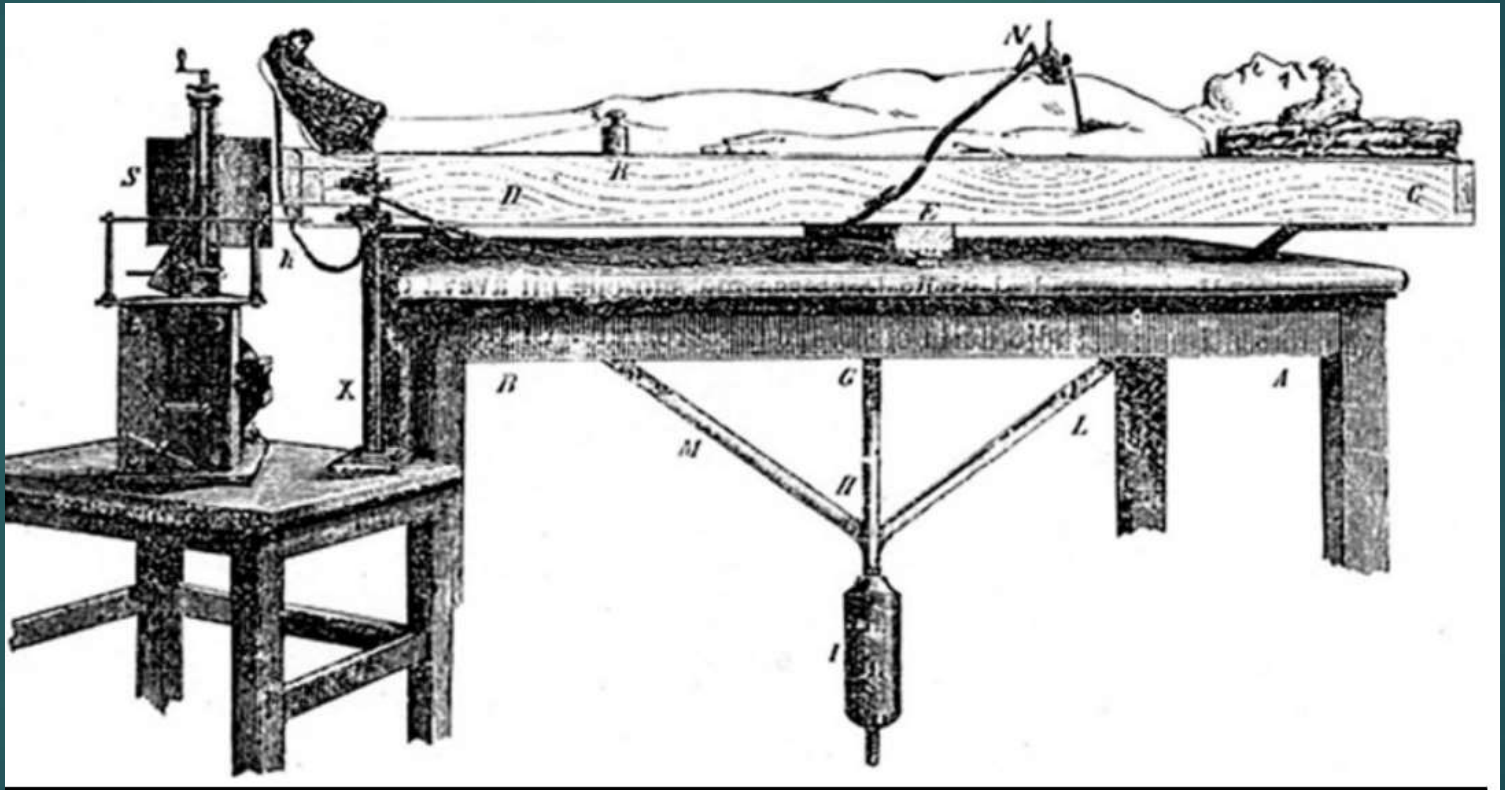


"[In Mosso's experiments] the subject to be observed lay on a delicately balanced table which could tip downward either at the head or at the foot if the weight of either end were increased. <u>The moment emotional or intellectual activity began in the subject, down went the balance at the head-end, in consequence of the redistribution of blood in his system</u>."

-- William James, *Principles of Psychology* (1890)

Angelo Mosso in 1901: 1st Brain Activity Device

First Hemodynamic Brain Imaging: rush of blood to brain



BALANCING ACT In the 1880s, Angelo Mosso used the human circulation balance illustrated here to measure the movement of blood to the brain during

Reading math text tips balance more than reading newspaper

1907 Fluoroscope (constant xray)

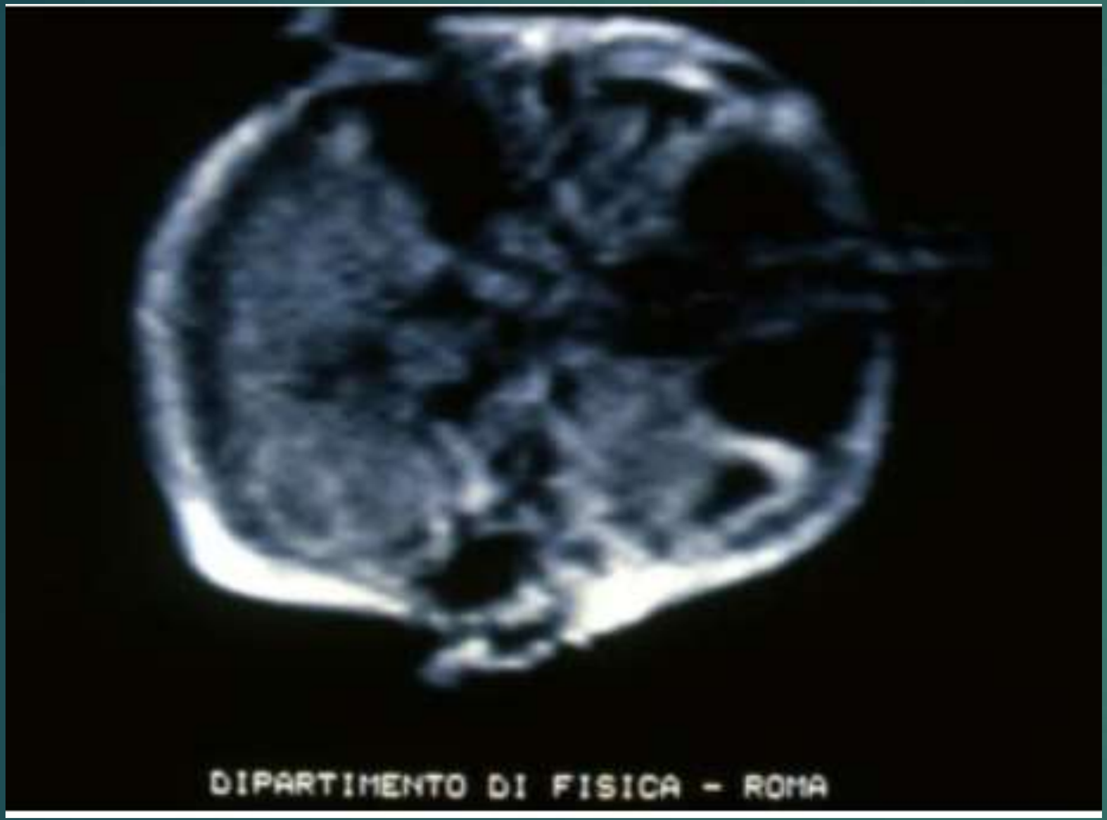
Risks that we do not originally understand

Ill fitting shoes on Charlie more dangerous than x-rays!

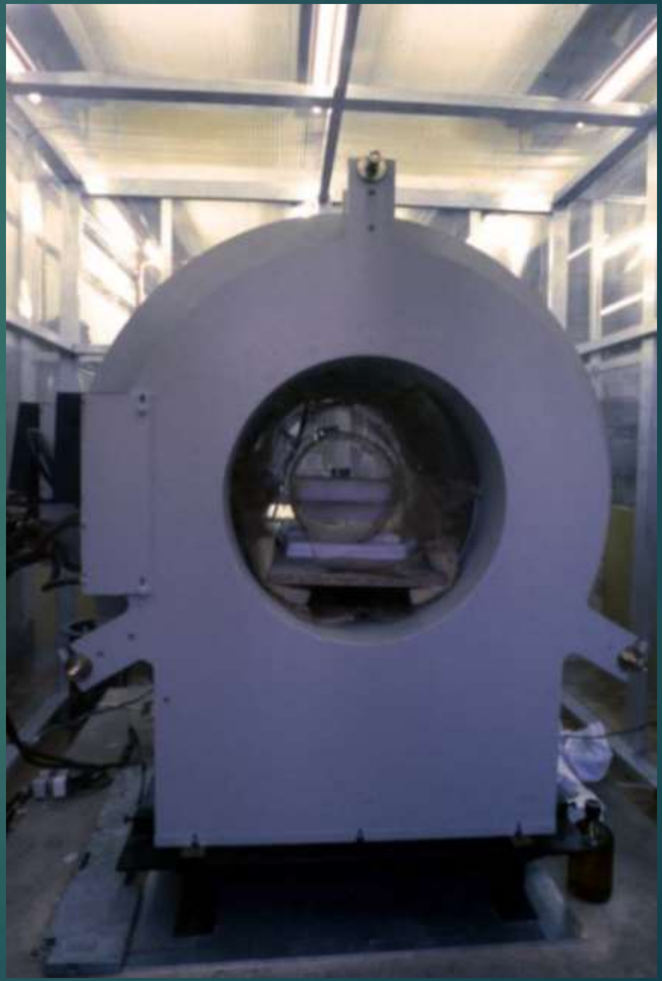
Buster Brown Shoe Stores in 1950s:
Fluoroscope for shoe fitting
Charlie's first x-ray.

Average of 13 roentgen (r) for 20 seconds
10,000 in USA ; Shoe salesman higher exposures; FDA bans in 1953

First NMR of Human Brain 1983, Rome



First NMR image (of a mouse) was in 1974



Brain Imaging

Structural	Functional
	Direct measures of neural activity:
CT - Computed tomography	EEG - Electroencephalography
MRI - Magnetic resonance imaging	MEG - Magnetoencephalography
VBM - Vox-based morphometry	
DTI - Diffuse Tensor Imaging	Indirect measures of neural activity:
Hybrid modalities:	PET - Positron-emission-tomography
PET-CT	SPECT - Single Photon emission computed tomography
MRI-PET	fMRI - Functional magnetic resonance imaging
fMRI-EEG/MEG	NIRS - Near infrared spectroscopy
PET-SPECT	
CT-SPECT	

Computed Tomography (CT): X-ray

New Couples fMRI Machine:
Brain areas sync when we interact

Friends: basal ganglia
Lovers: pCC

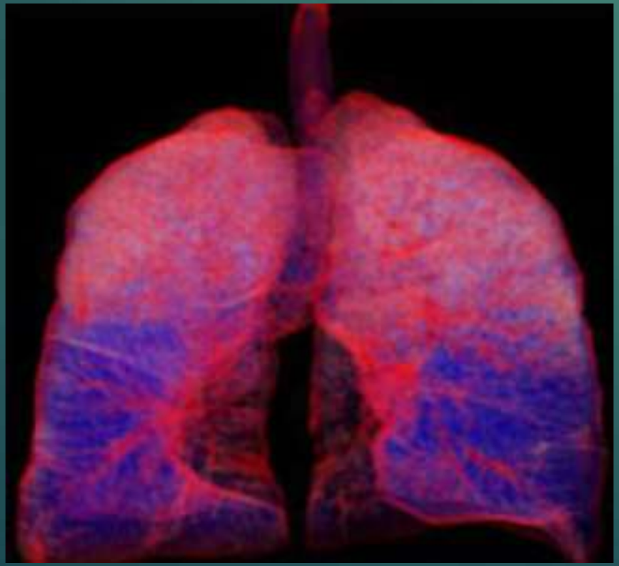
When touched:
toucher's motor and somatosensory cortex couples to the other person's STS and somatosensory cortex.

When people communicate: activates mPFC, TPJ, ACC

Ray Lee at Princeton University

MRI:
Video
Individual slice

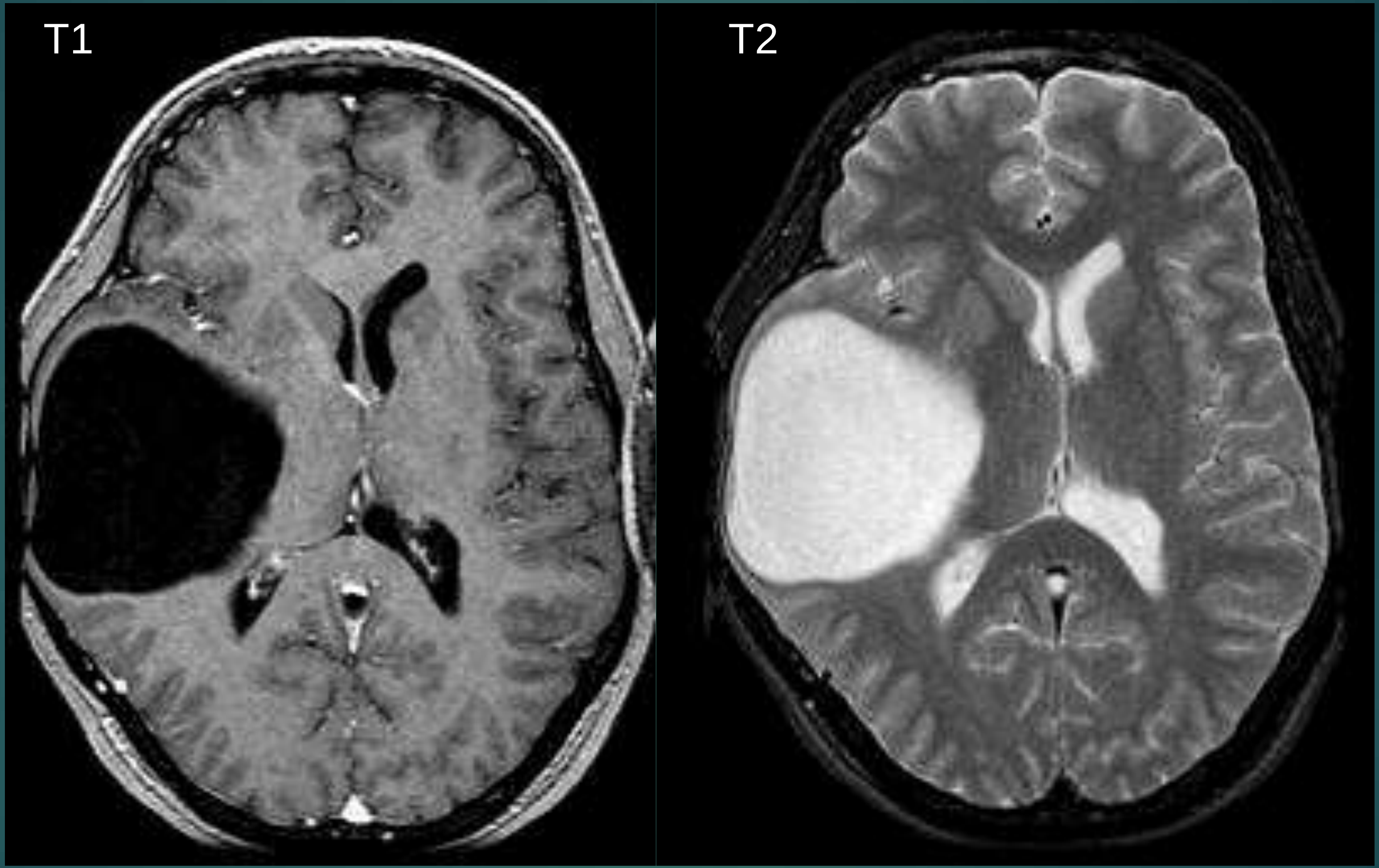
CT - Multidetector Imaging



Currently 3 Tesla machines; but soon 10.5 Tesla at U of Minnesota

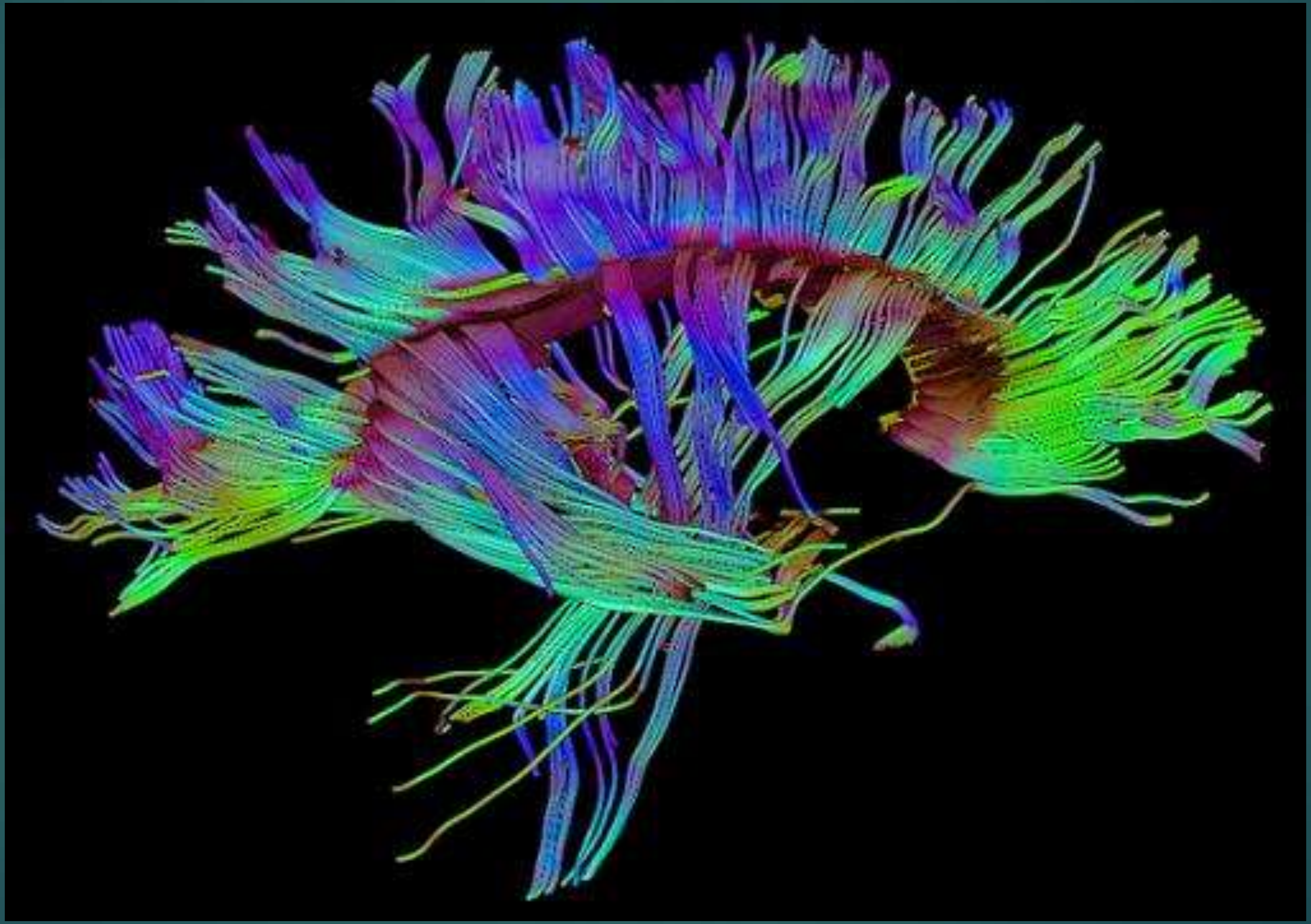
Prof. Kamil Ugurbil: 7-Tesla resolution = cubic millimeter, or about 80,000 neurons. 10.5-Tesla = down to tenths of a cubic millimeter.

Magnetic Resonance

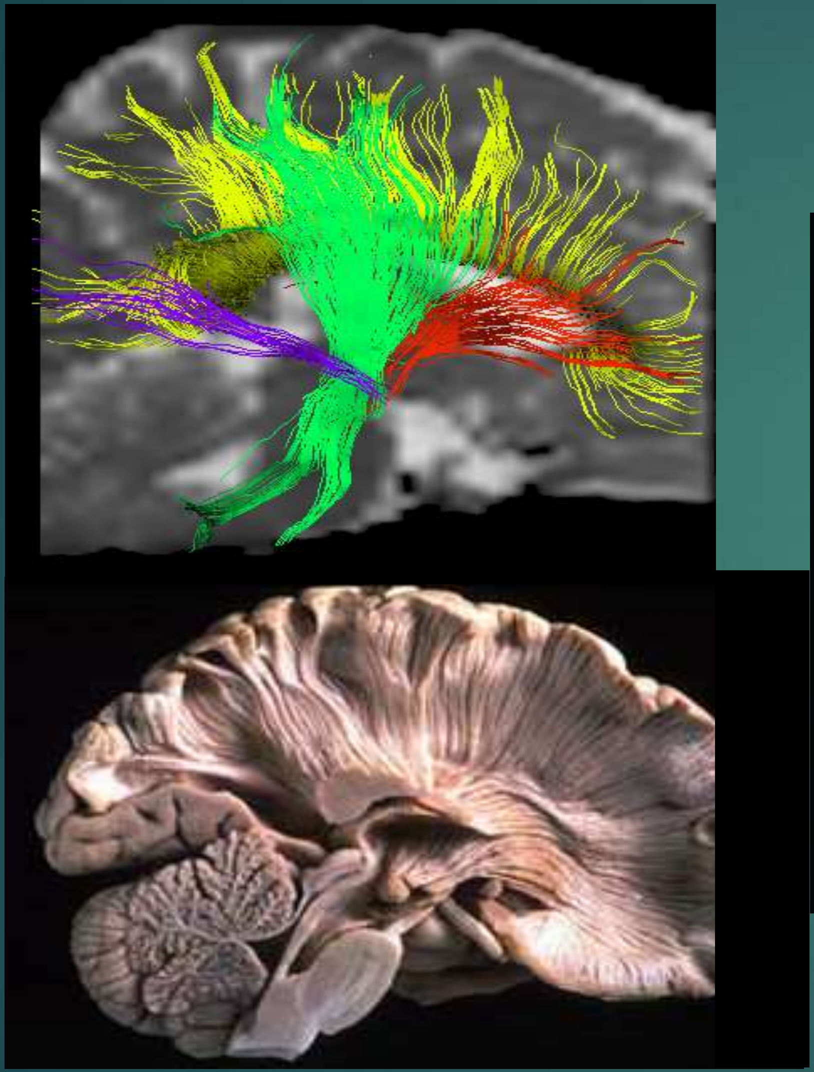


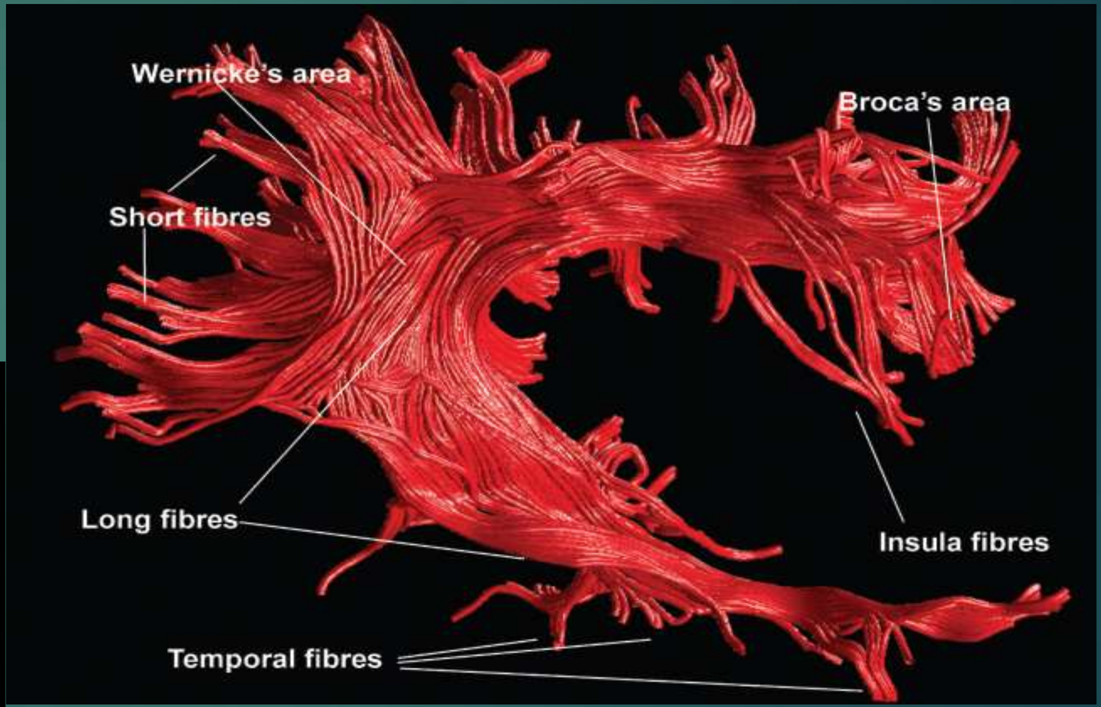
Arachnoid Cyst: water is bright on T2

DTI: Diffusion Tensor Imaging – White Matter analyze Direction of water molecules



DTI – Tractography

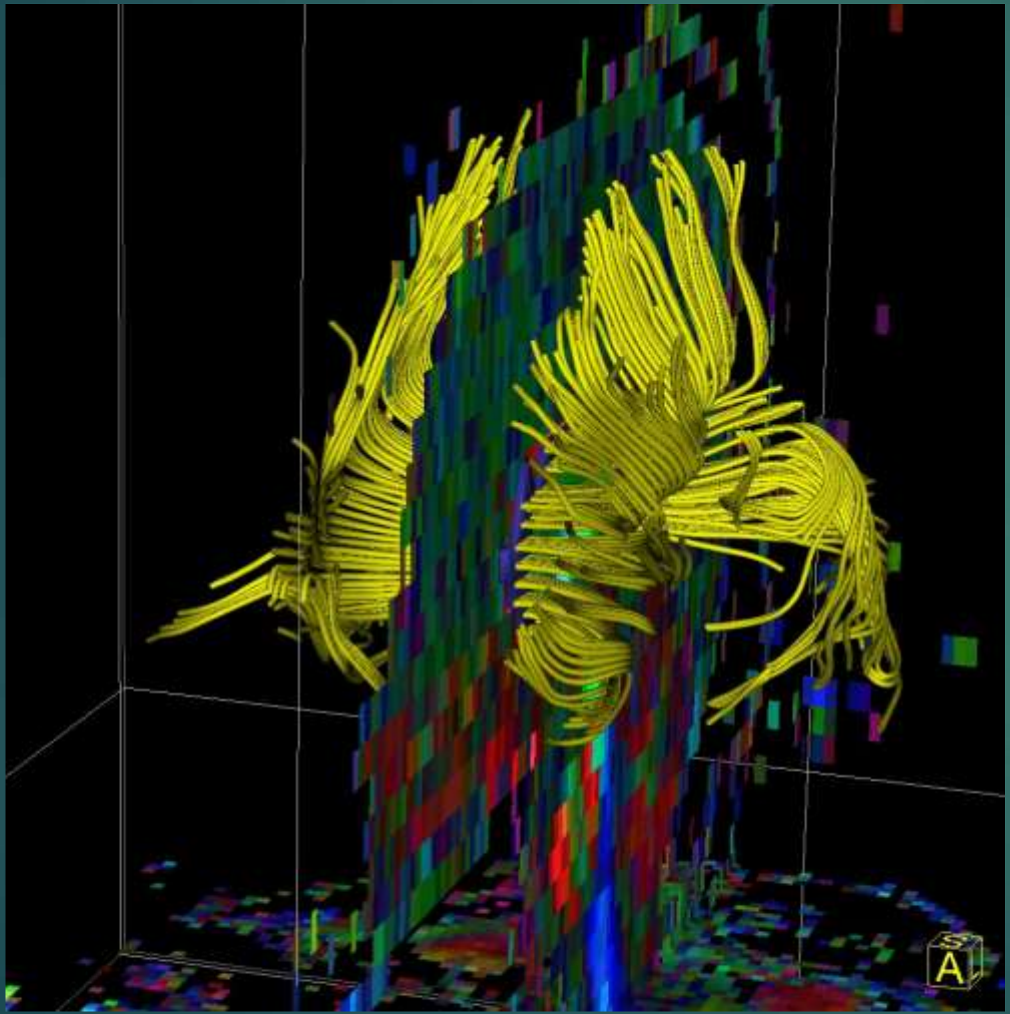


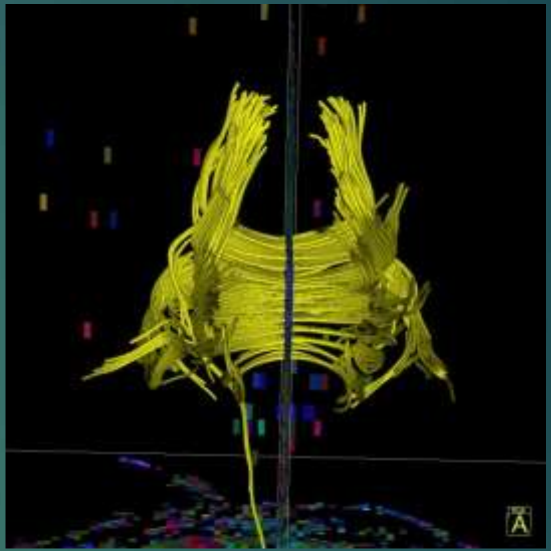


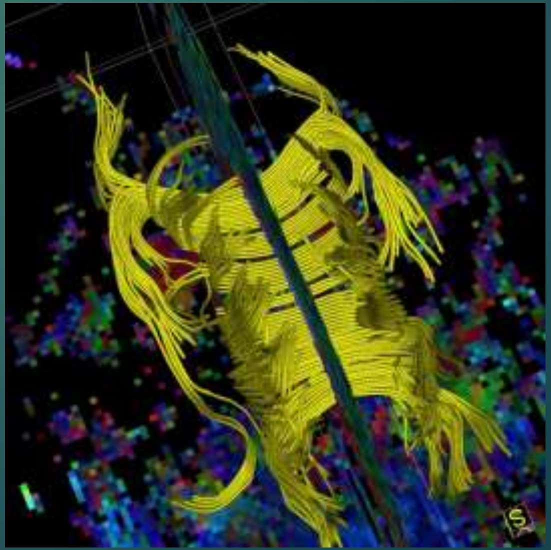
D. Jones – U Nottingham, UK

S. Mori - JHU

DTI-Tractography: Corpus Callosum

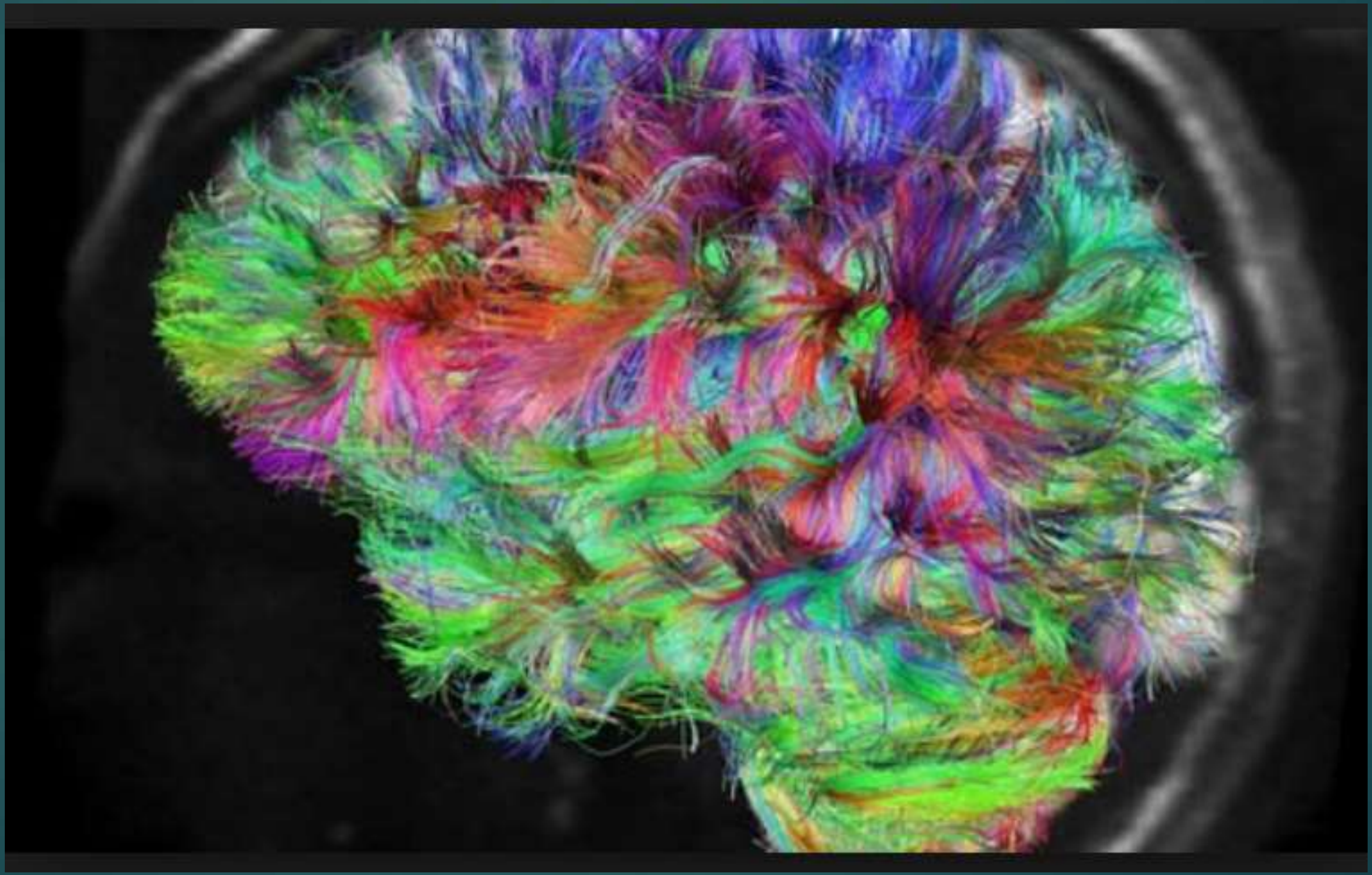




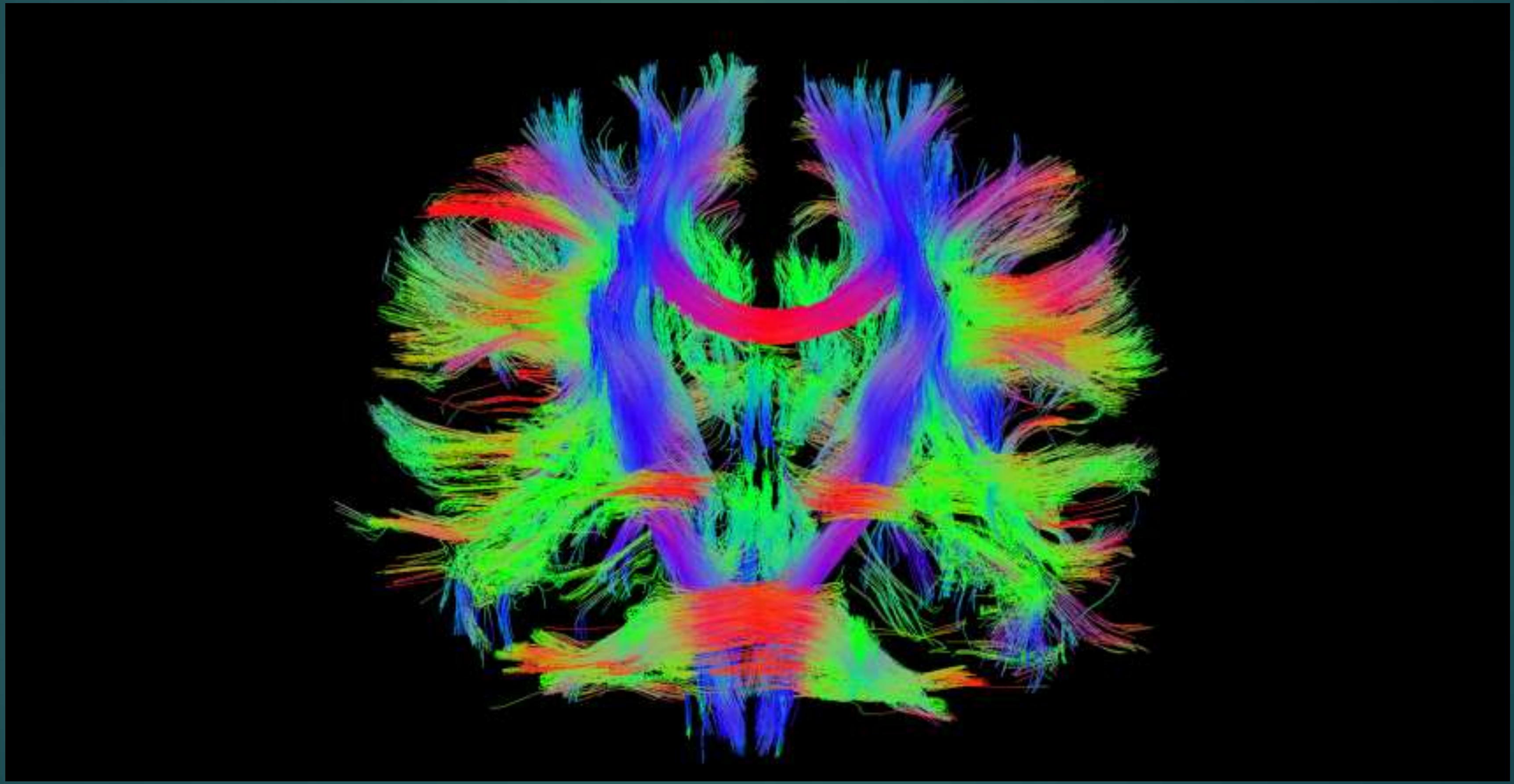


W.Zhan et. al.

Diffuse Tensor Imaging: your neural networks of axons

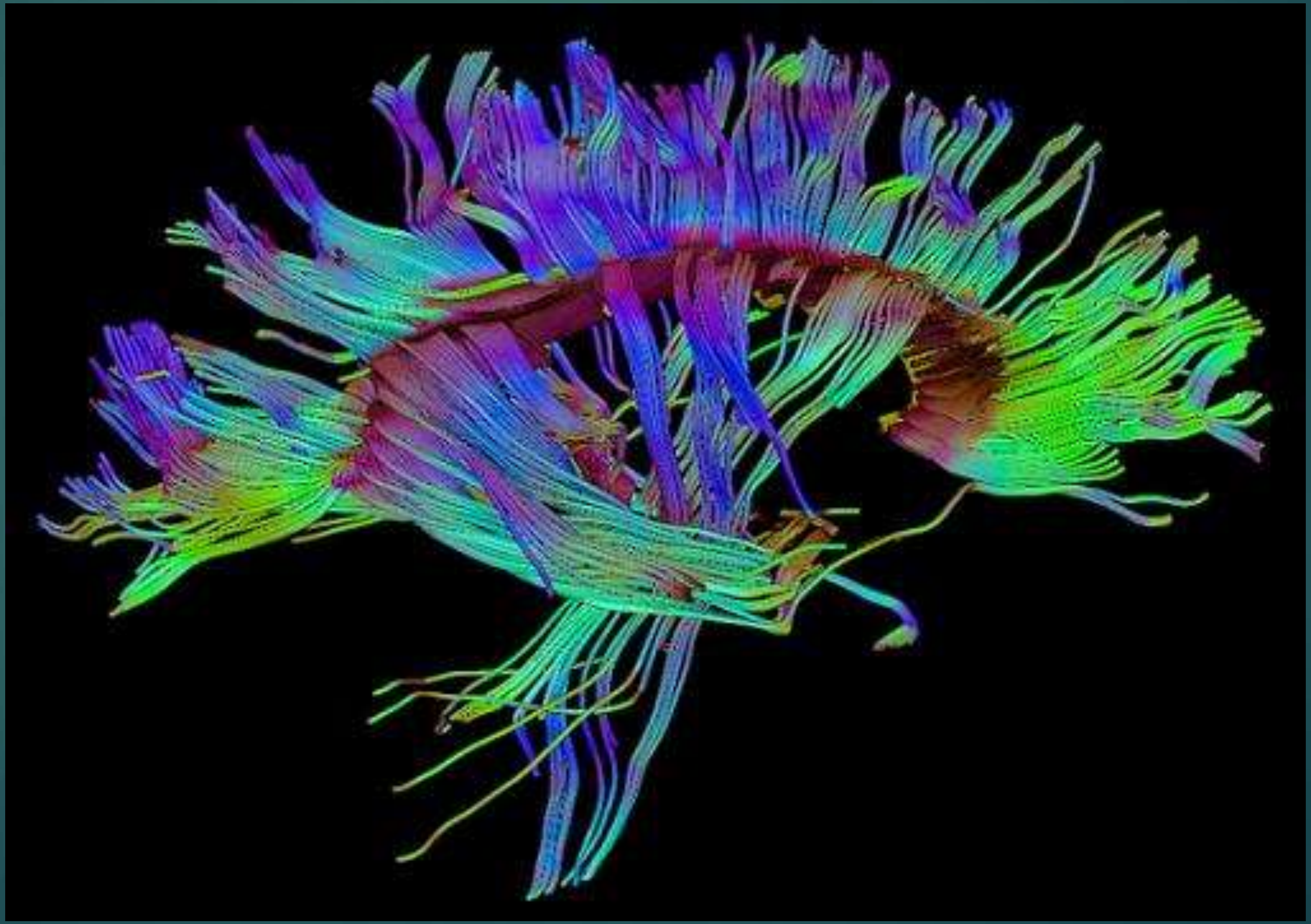


Diffusion MRI

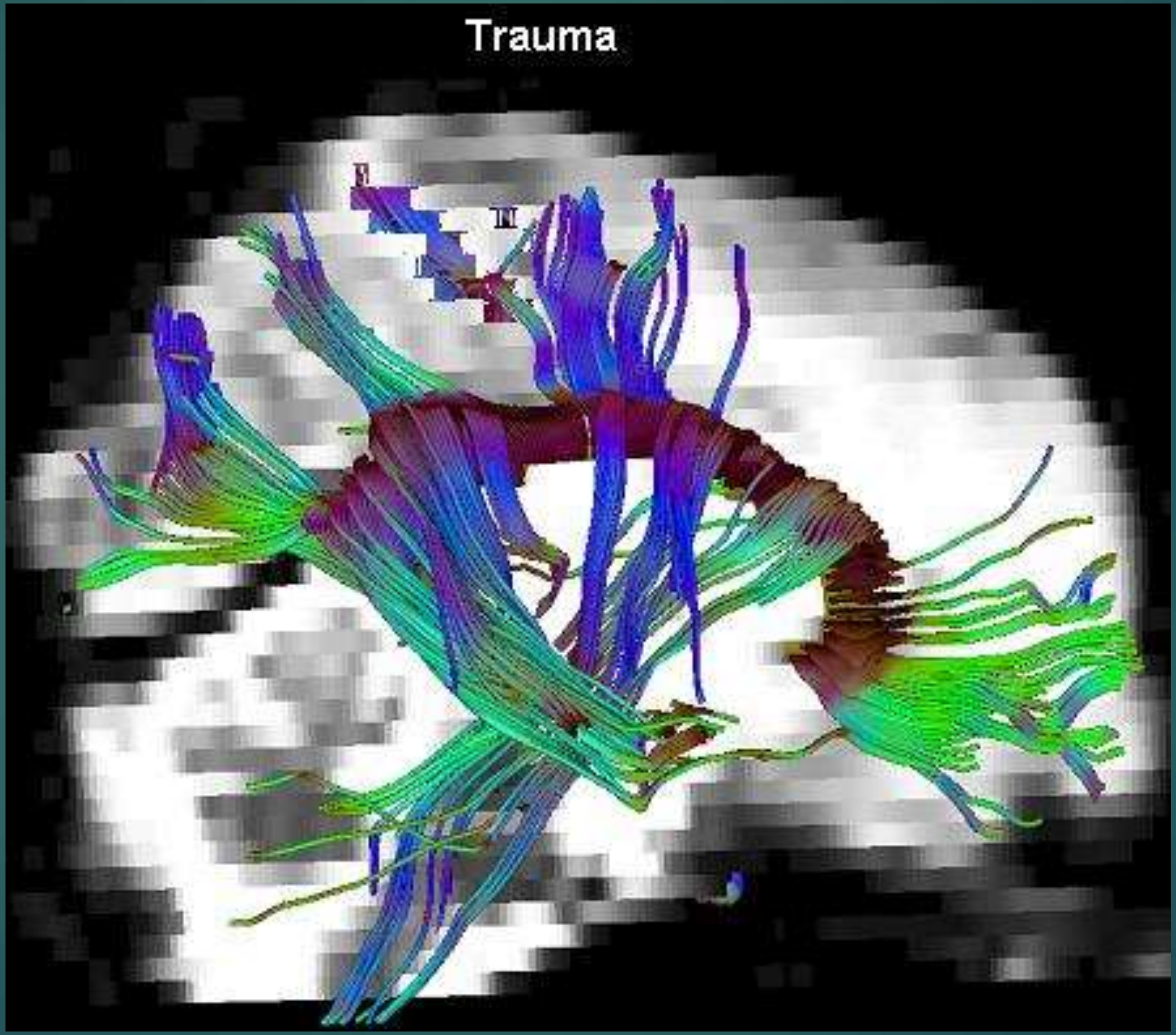


White Matter: Diffusion Tensor MRI in Traumatic Brain Injury

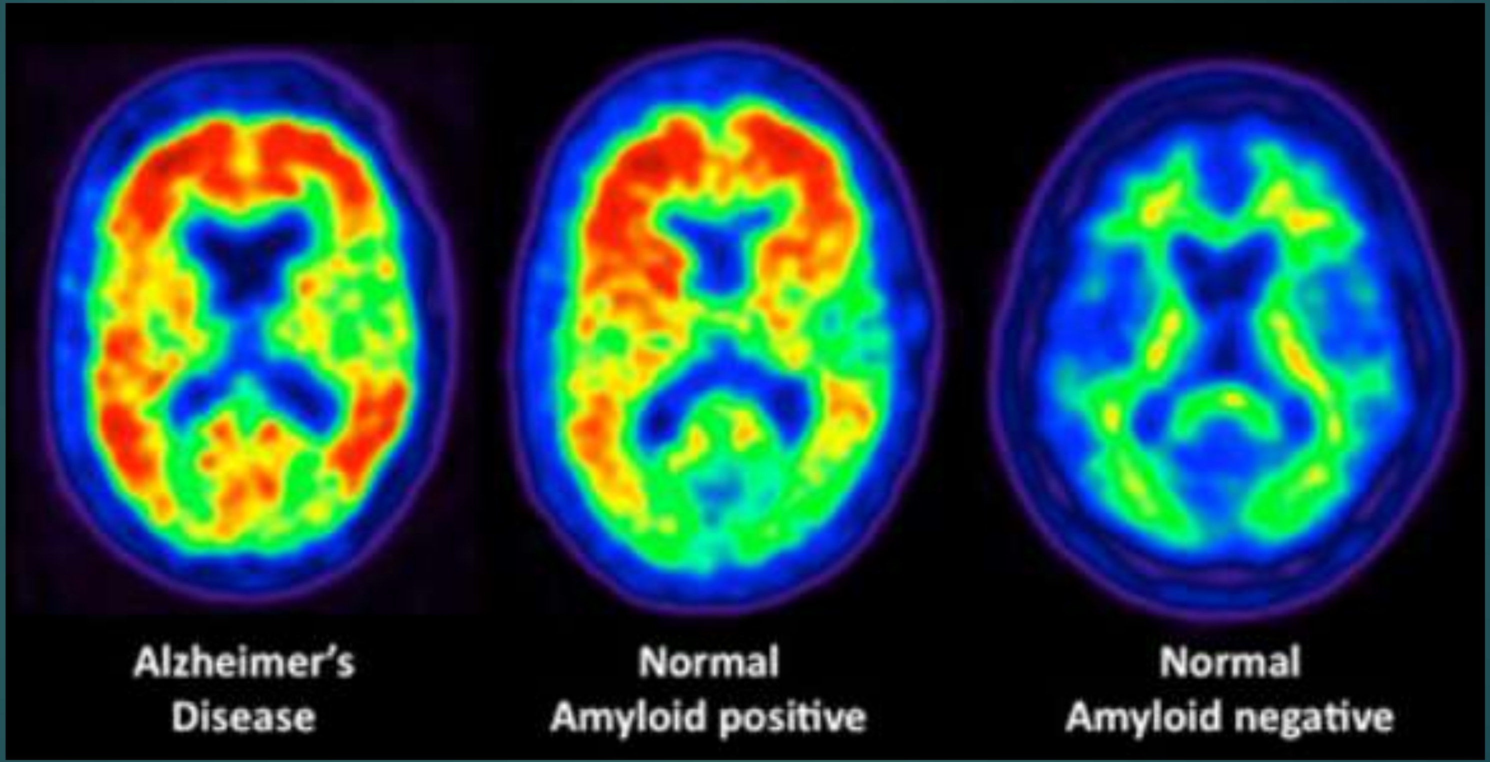
If a man commits a crime after a serious TBI, what would you think of this evidence?



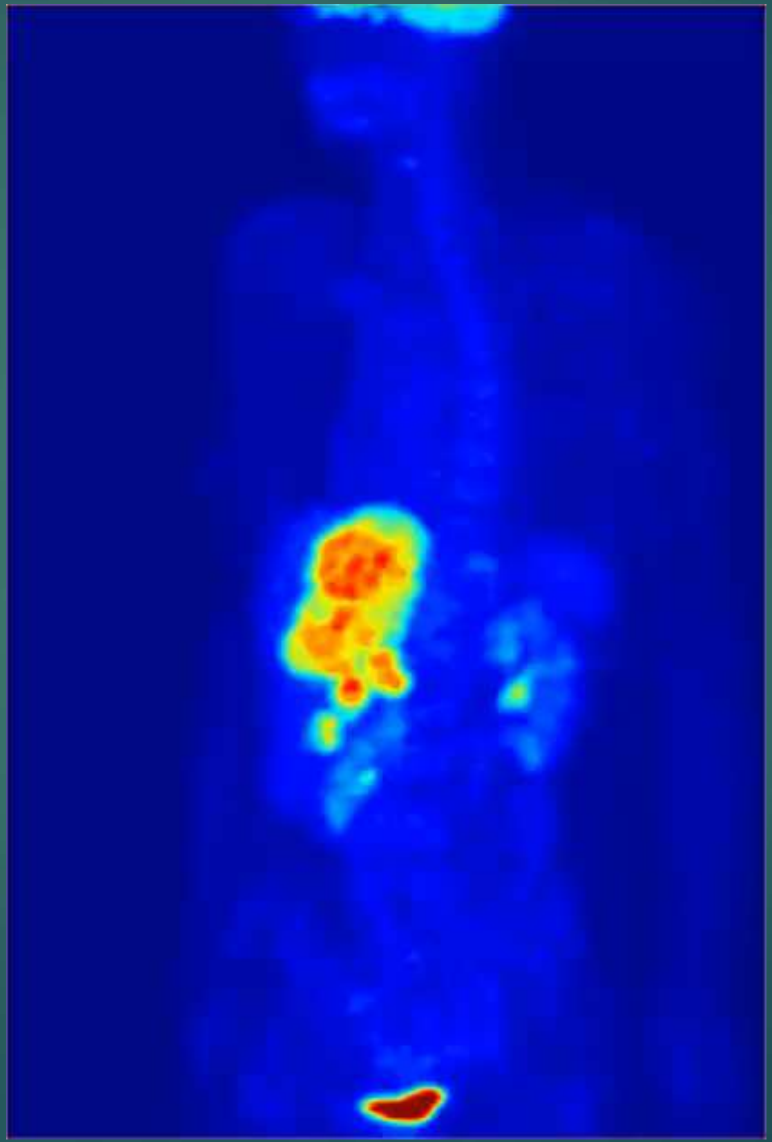
Or for this person with TBI?



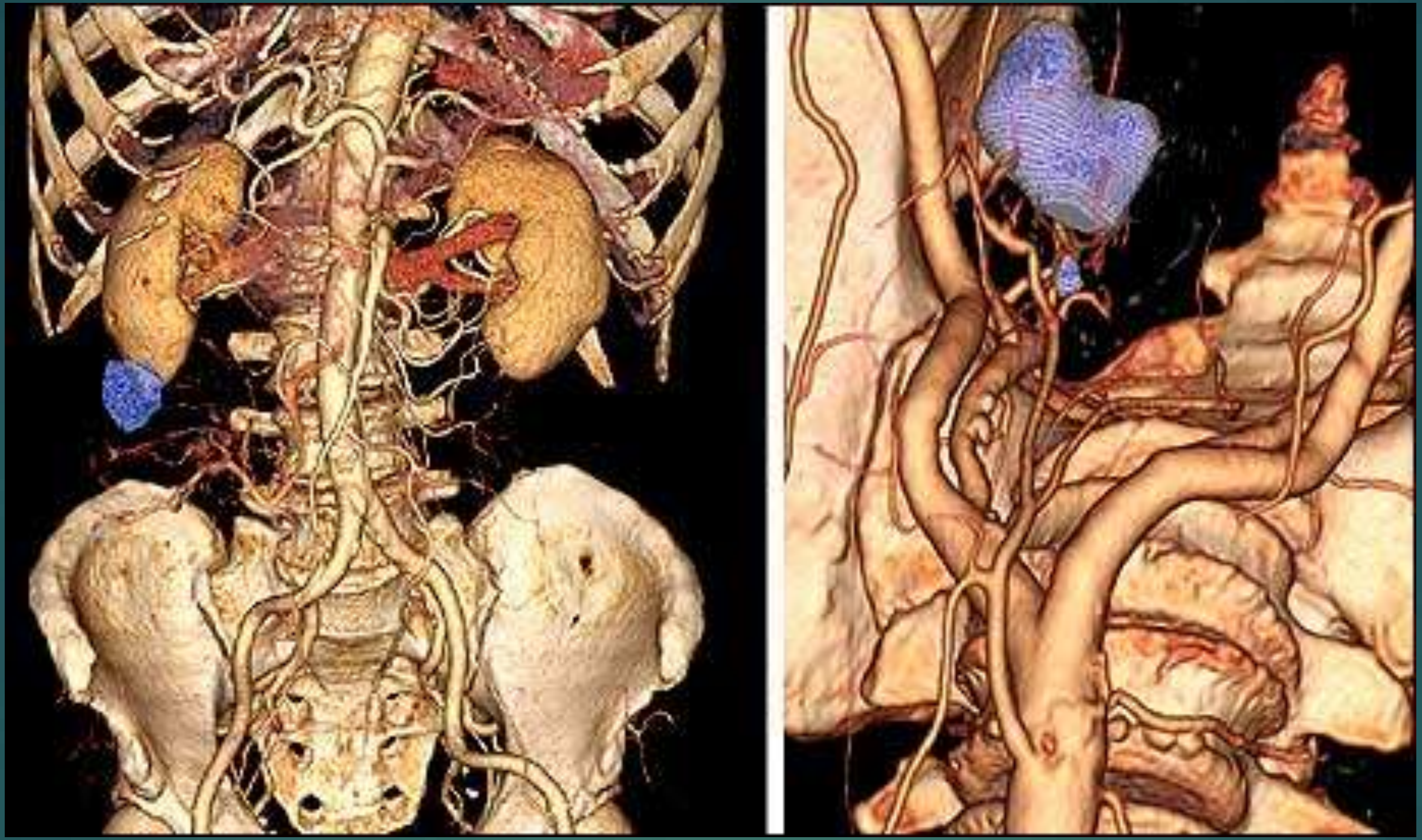
PET: beta amyloid binding



Whole-body PET scan using 18F-FDG to show liver metastases of a colorectal tumor



PET and surgery



Both colon cancer scans. The fused volume rendering of a PET/CT angiography (above left) provides vascular and metabolic visualization for surgical planning. In the zoomed view (above right), the surgeon is able to better understand the blood supply and vascular involvement of the tumor in advance of surgery.

SPECT of Epileptic Focus:

A: ictal increased metabolism; B: normal hypometabolism

Seizure

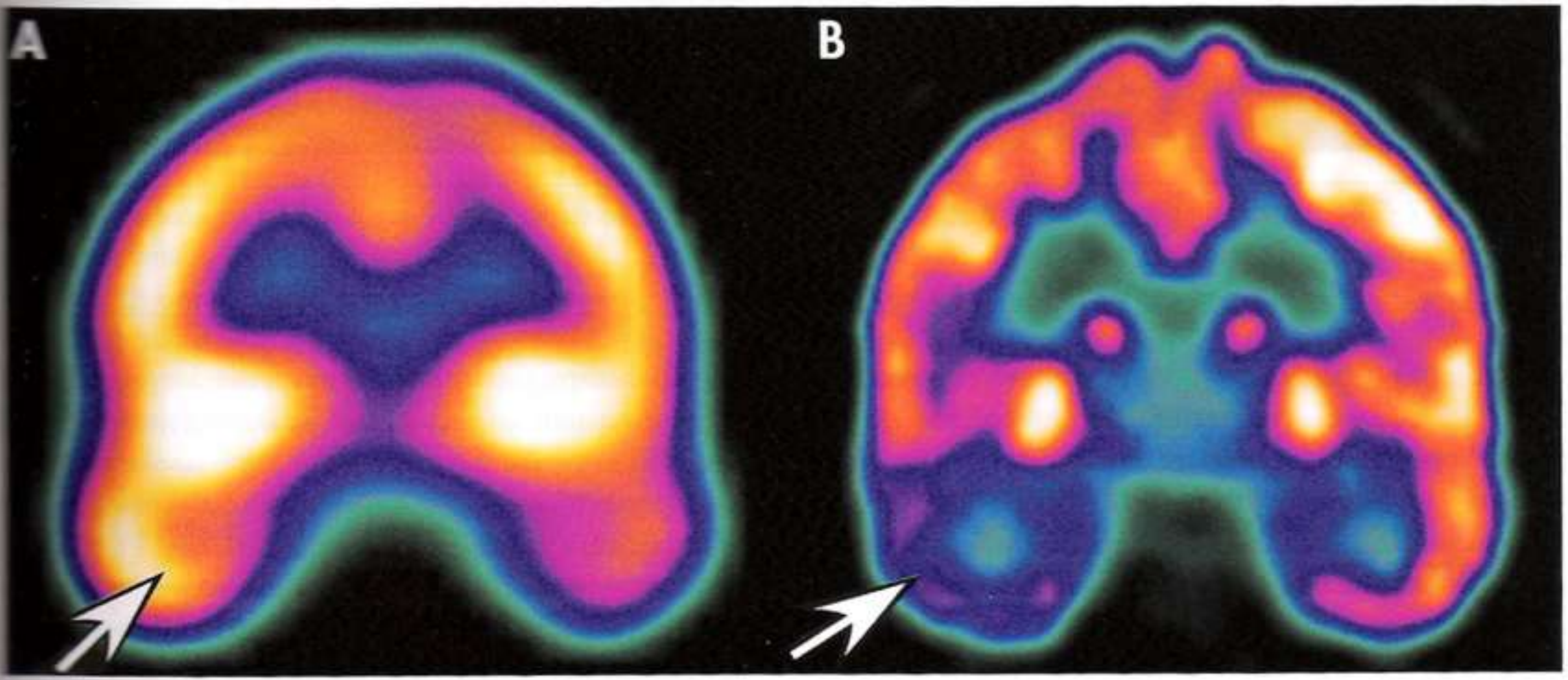


FIGURE 7–27. Nuclear medicine imaging is useful for visualizing the area of an epileptic focus. (A) Scans obtained during a seizure (ictal scan) will show increased perfusion or metabolism, as illustrated here with a coronal single-photon emission computed tomographic image of cerebral blood flow (*arrow*). (B) Scans obtained in the absence of seizure will show decreased perfusion or metabolism, as illustrated here with a coronal positron emission tomographic image of cerebral metabolism (*arrow*).

Metabolism between seizures

(Cummings and Mega, 2003)

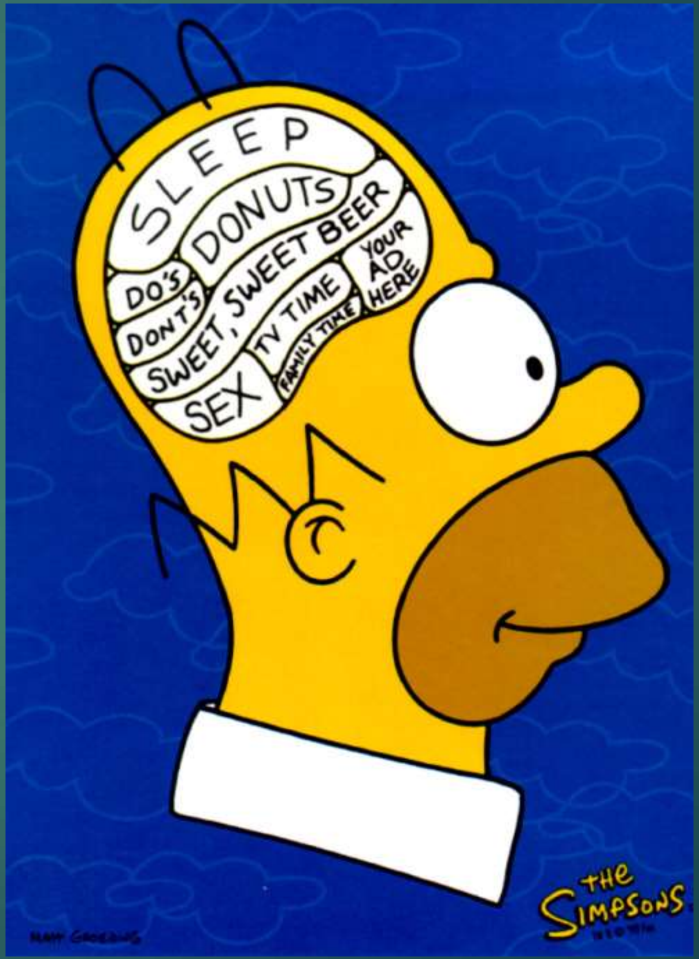
MEG: Magnetoencephalography
“Hairdresser from Mars”

Temporospatial resolution of MEG surpasses that of all other neuroimaging techniques, in real time; direct measure of neuronal activity; magnetic equivalent of EEG.

MRI vs. fMRI

MRI studies brain <u>anatomy</u>.

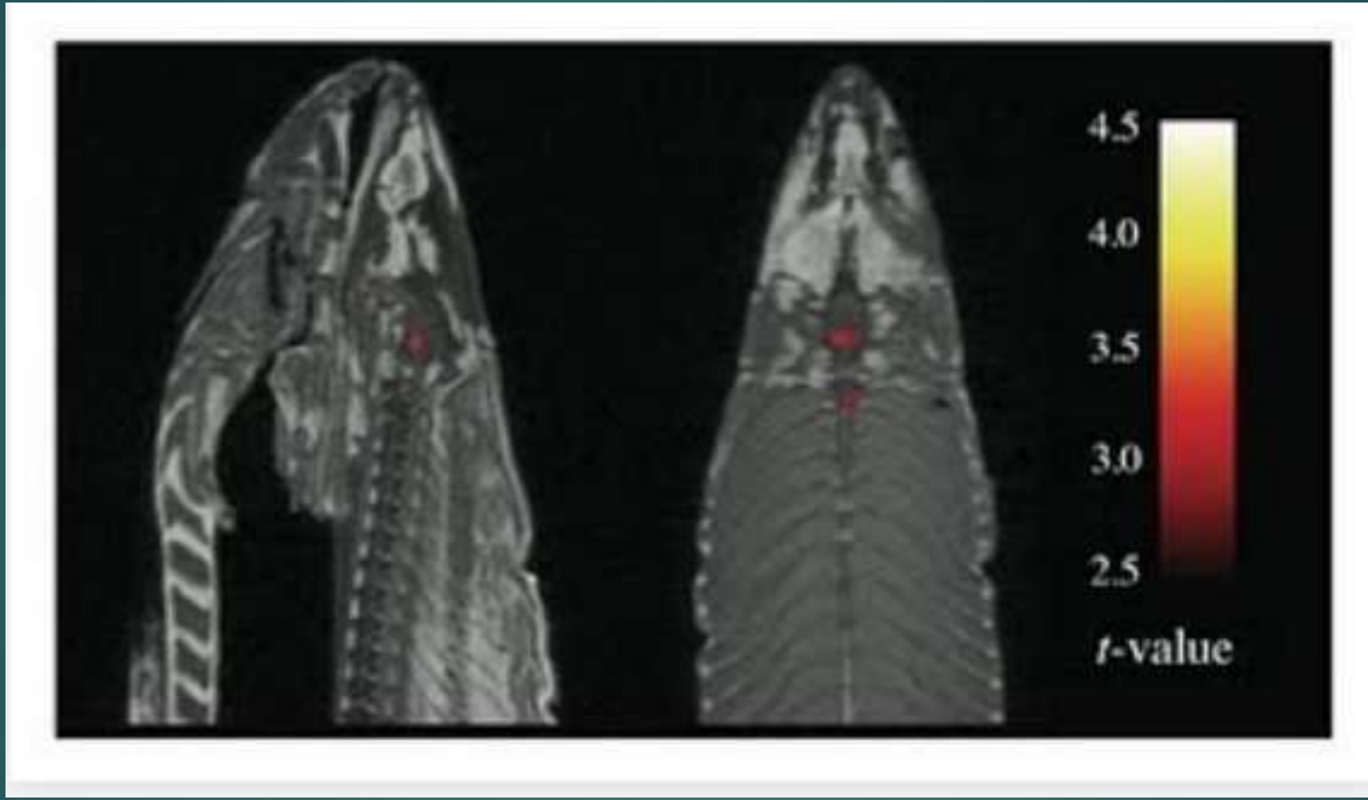
fMRI studies brain <u>function</u>.



Source: Jody Culham's fMRI for Dummies web site

Cautionary Tale: Post-Mortem Atlantic Salmon: false positives in MRI phantom data

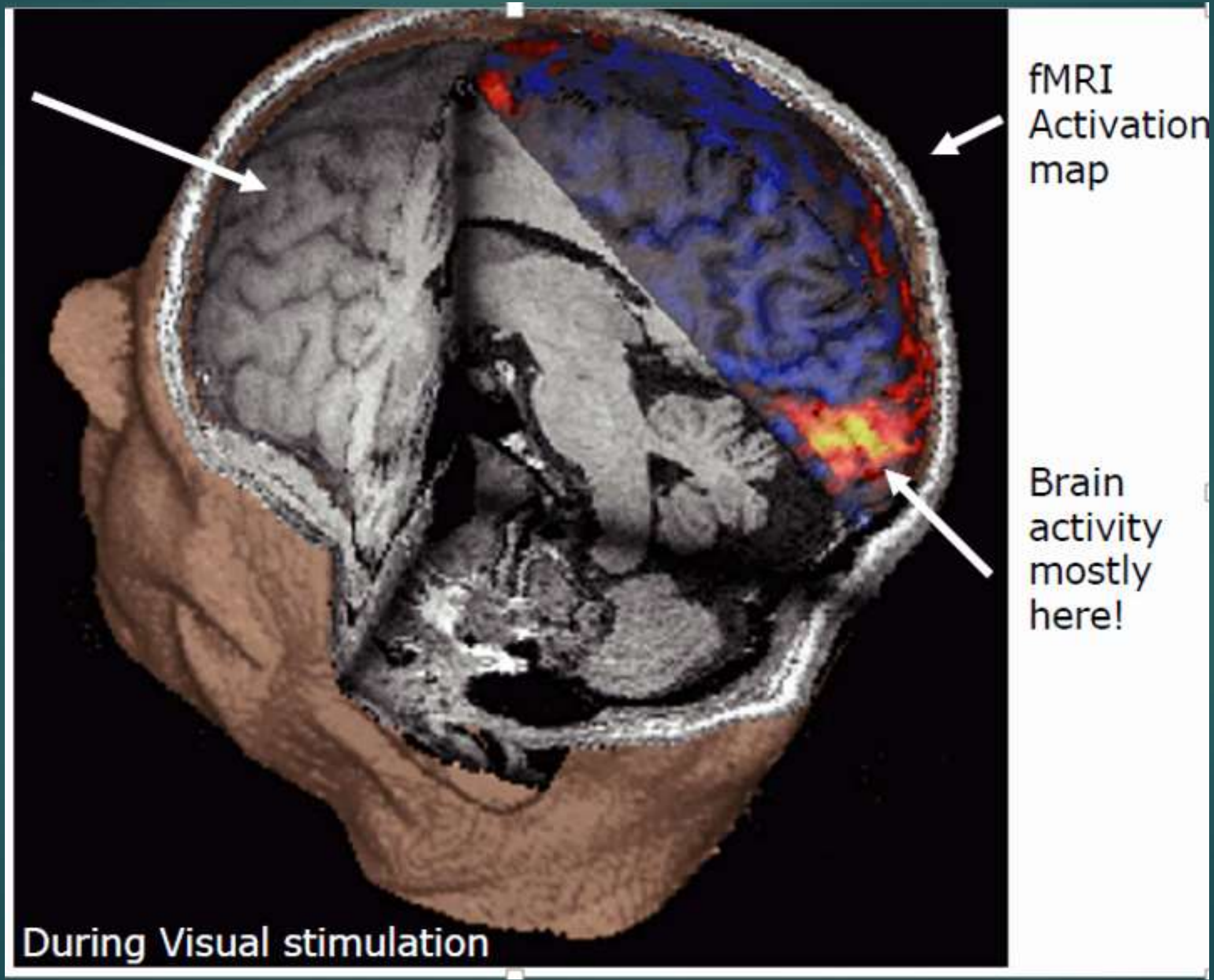
Neural correlates of interspecies perspective taking in the post-mortem Atlantic Salmon: An argument for multiple comparisons correction



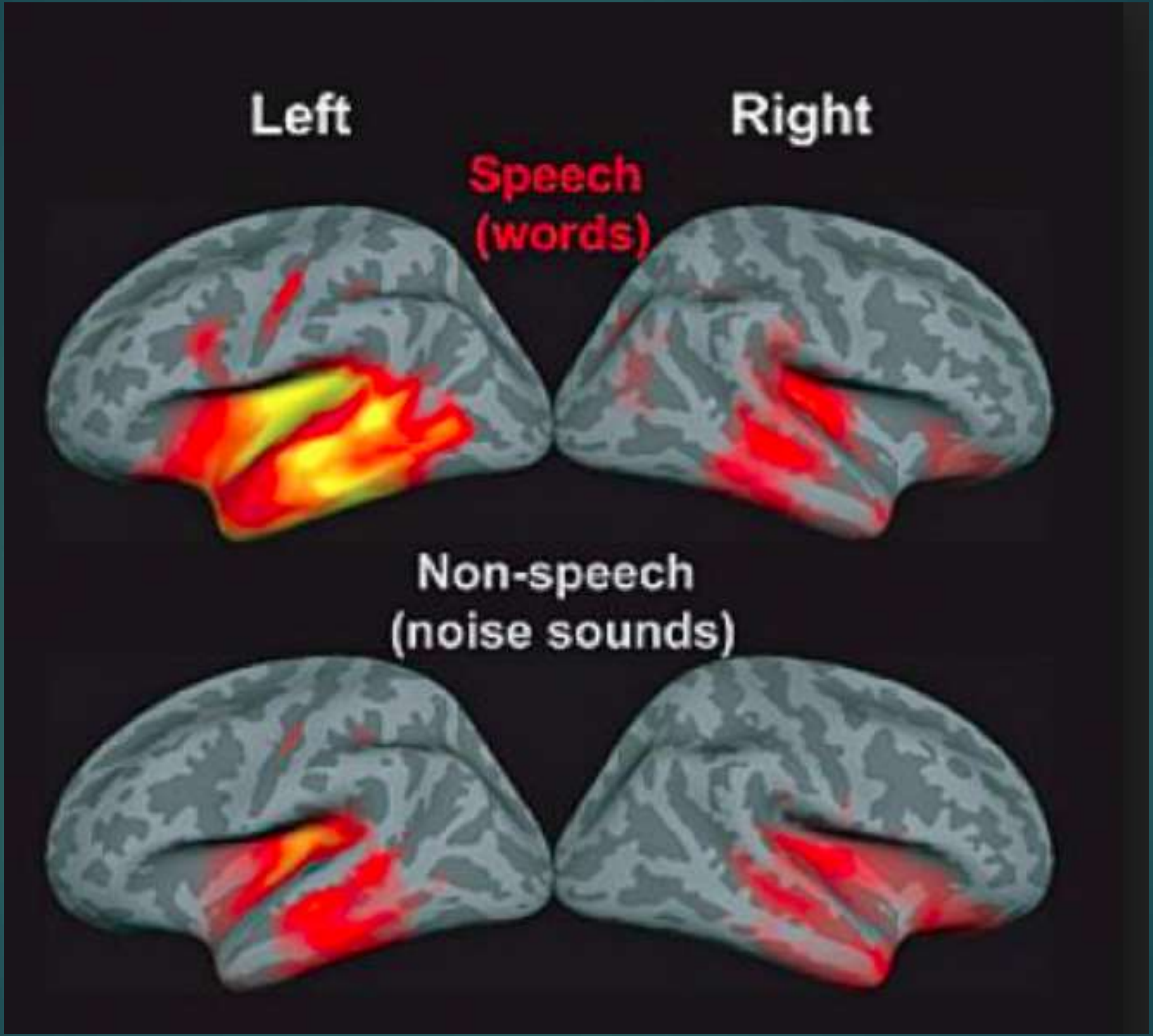
Bennett, 2009

This is a lesson in statistics, not in fMRI. Which is why this was never published in a peer-reviewed journal. It is a lesson about how probability indicates that you certainly can get activation in a dead salmon by chance, and that if you only have one salmon and no corrected threshold in 2 million samples, you will get about 100,000 false positives.

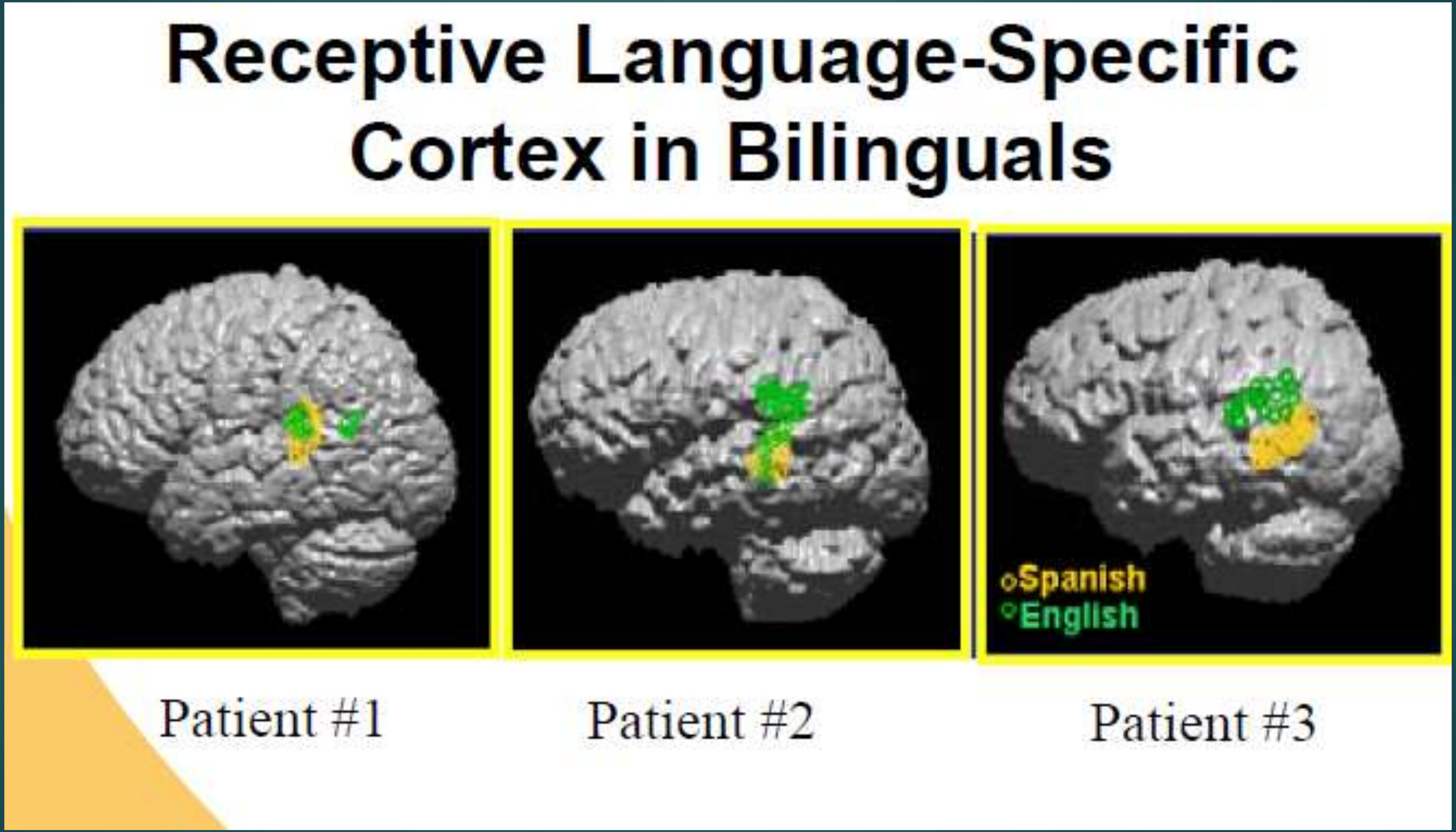
FMRI during visual task



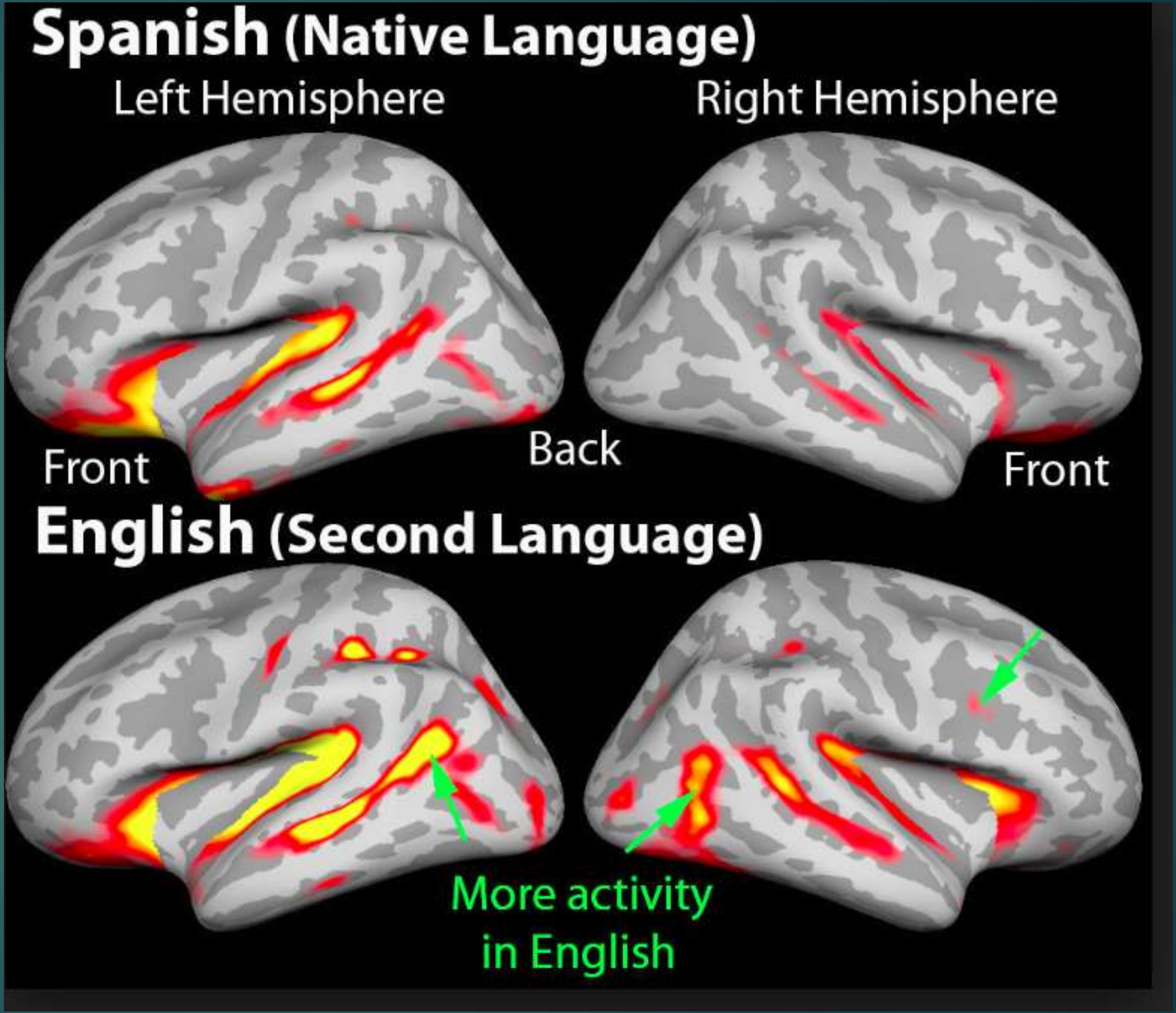
Speech



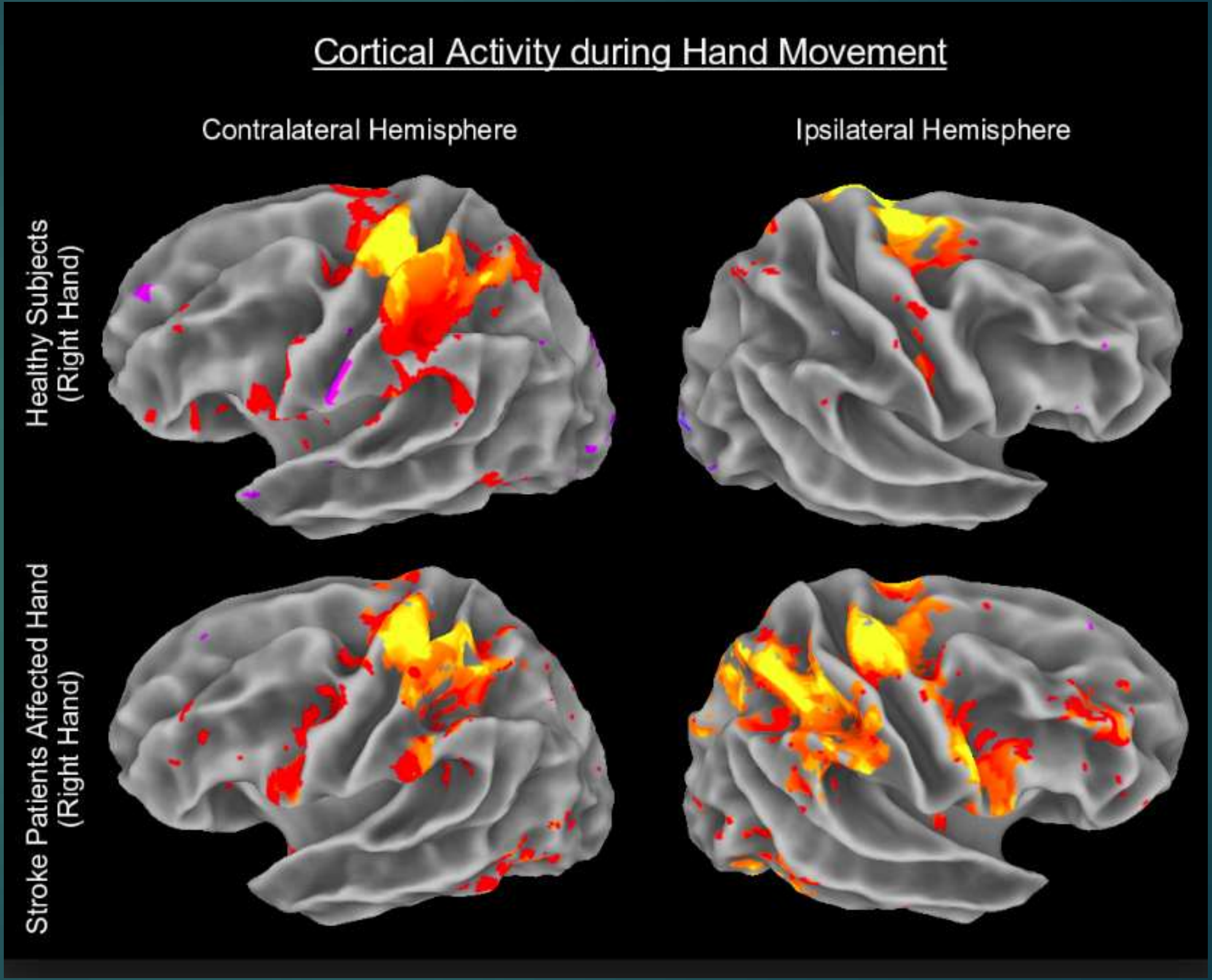
MEG: Bilinguals – Location of each language

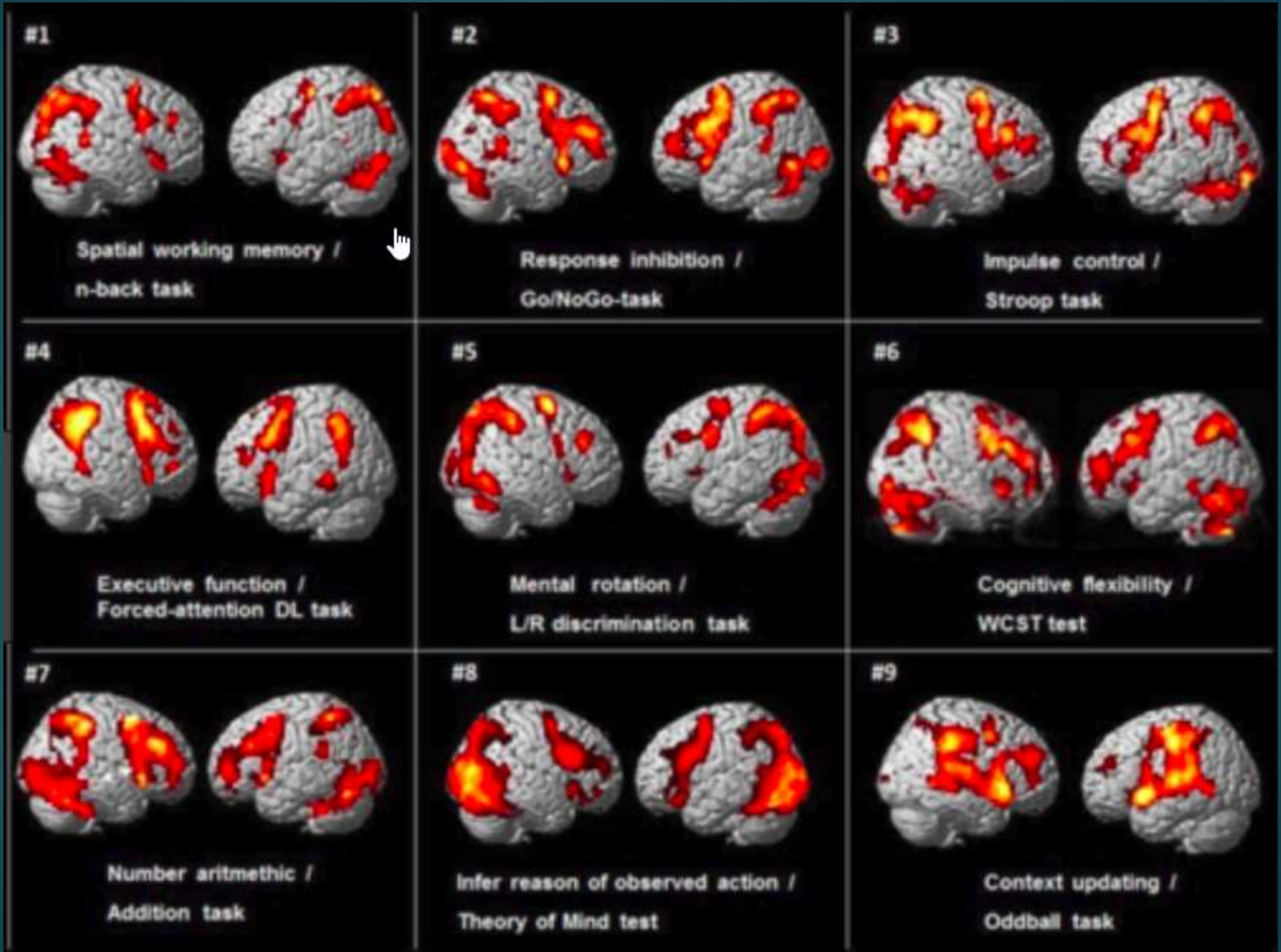


Spanish
and English as
second language



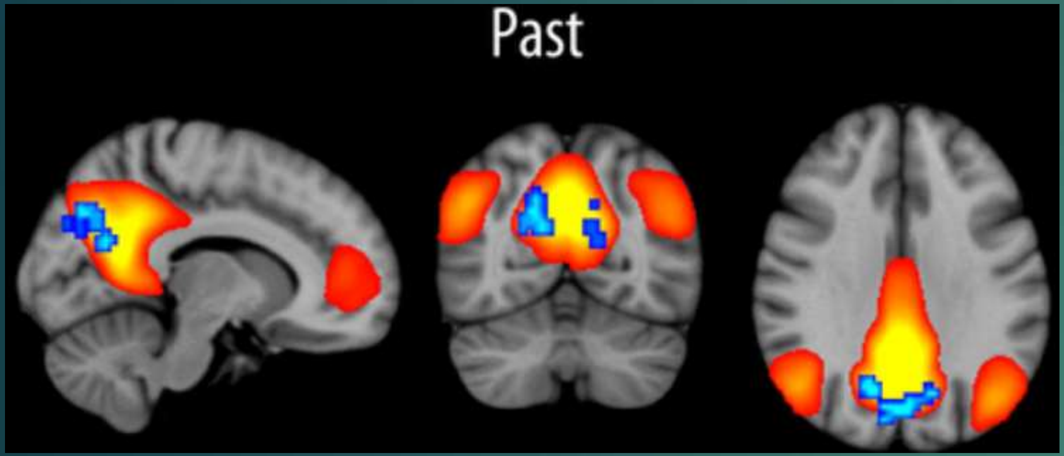
Hand Movement



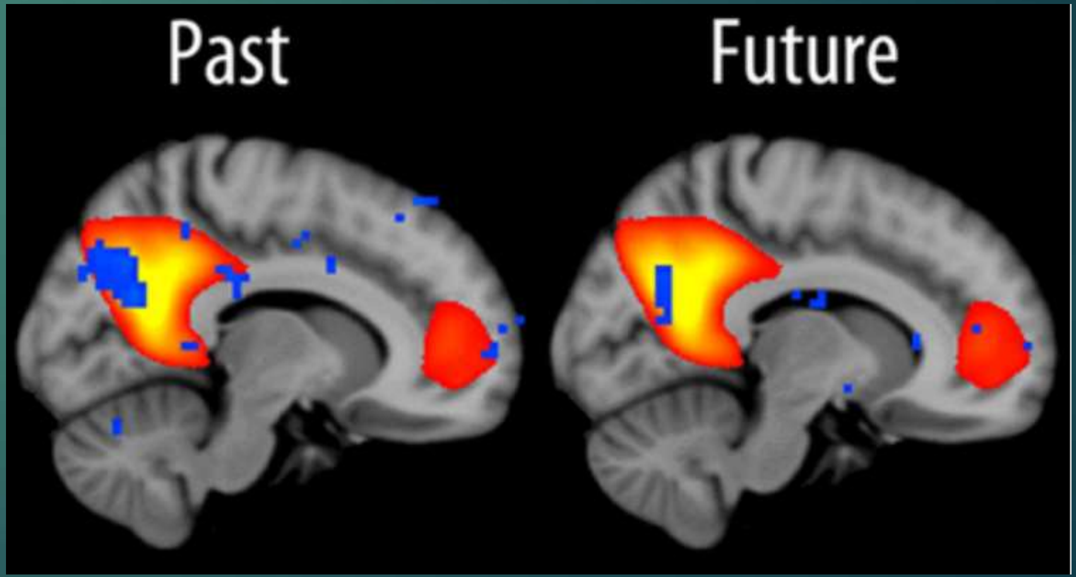

#1
Spatial working memory /
n-back task
#2
Response inhibition /
Go/NoGo-task
#3
Impulse control /
Stroop task
#4
Executive function /
Forced-attention DL task
#5
Mental rotation /
L/R discrimination task
#6
Cognitive flexibility /
WCST test
#7
Number aritmethic /
Addition task
#8
Infer reason of observed action /
Theory of Mind test
#9
Context updating /
Oddball task

Default Network: Mental Time Travel

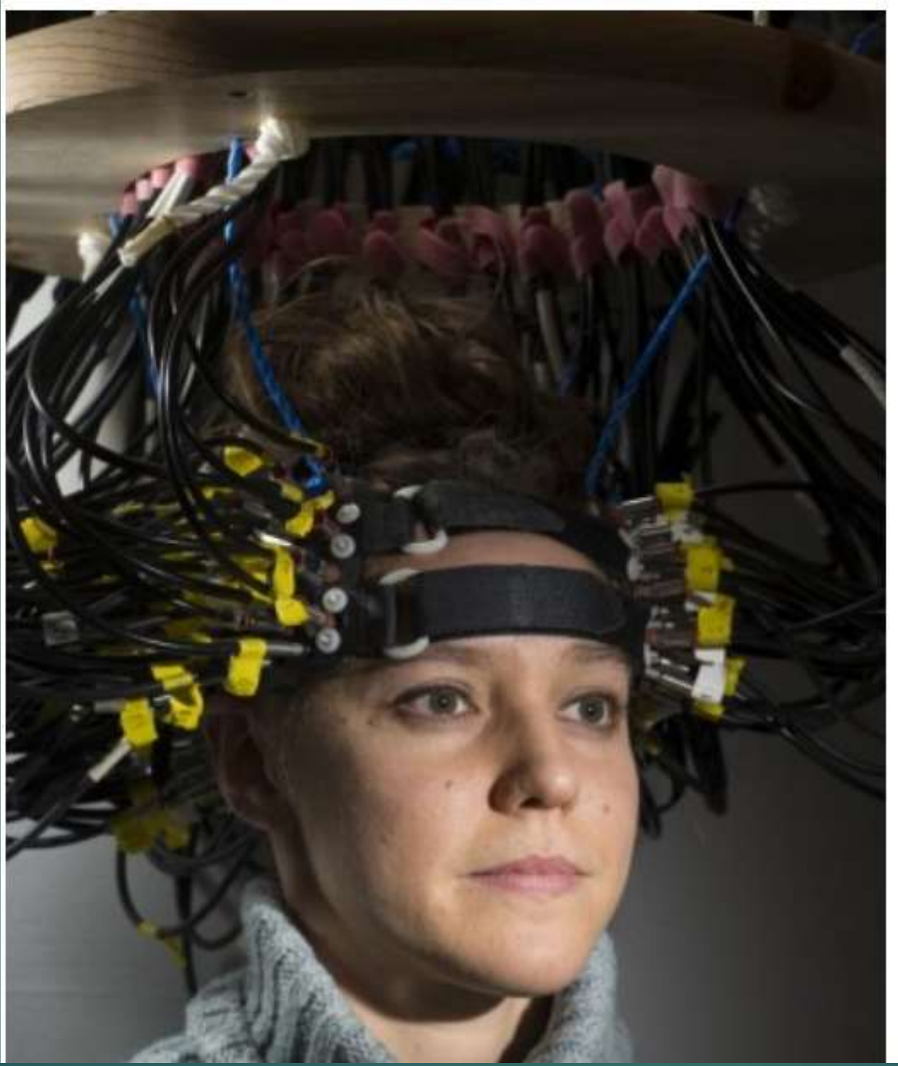
Remembering the past



Imaging the future



Diffuse optical tomography

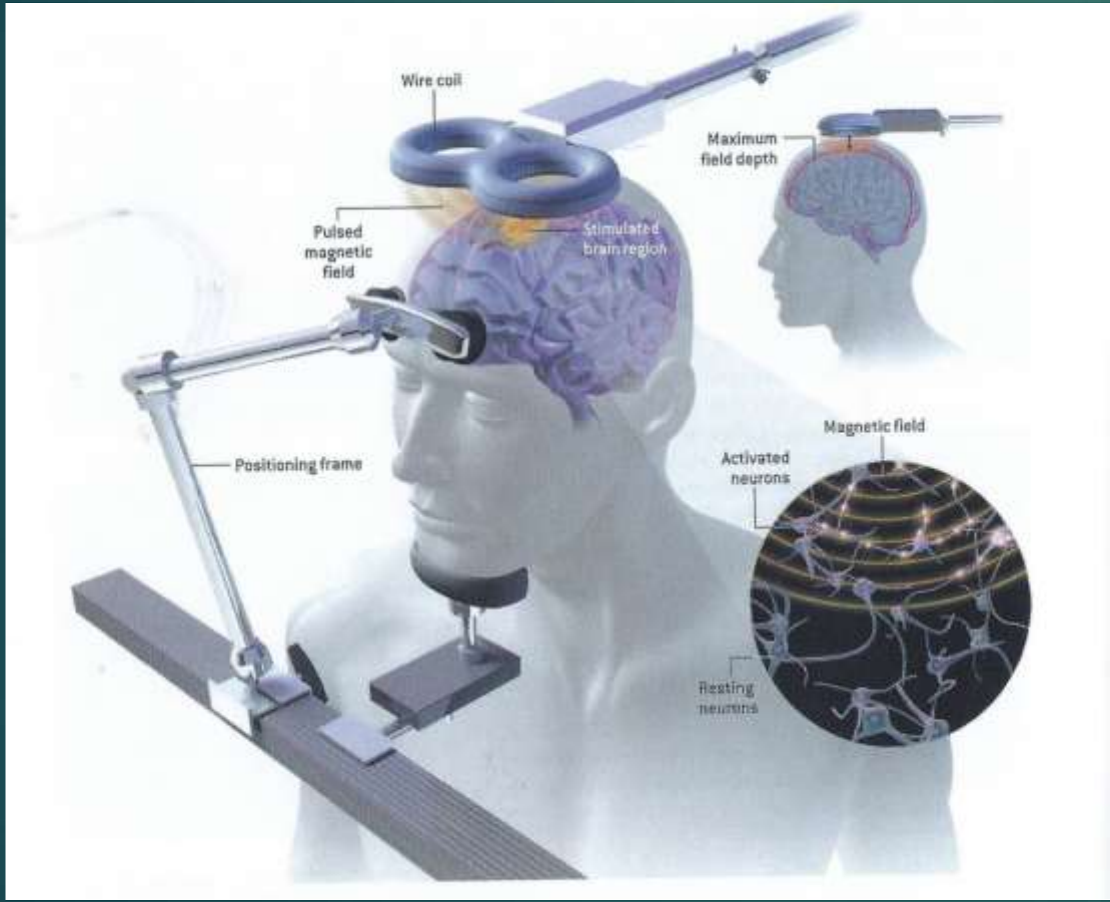


Shining LEDs into the subject's head; latest system able to monitor up to two-thirds of the head at once. Can only reliably image the brain down to a depth of about one centimeter.

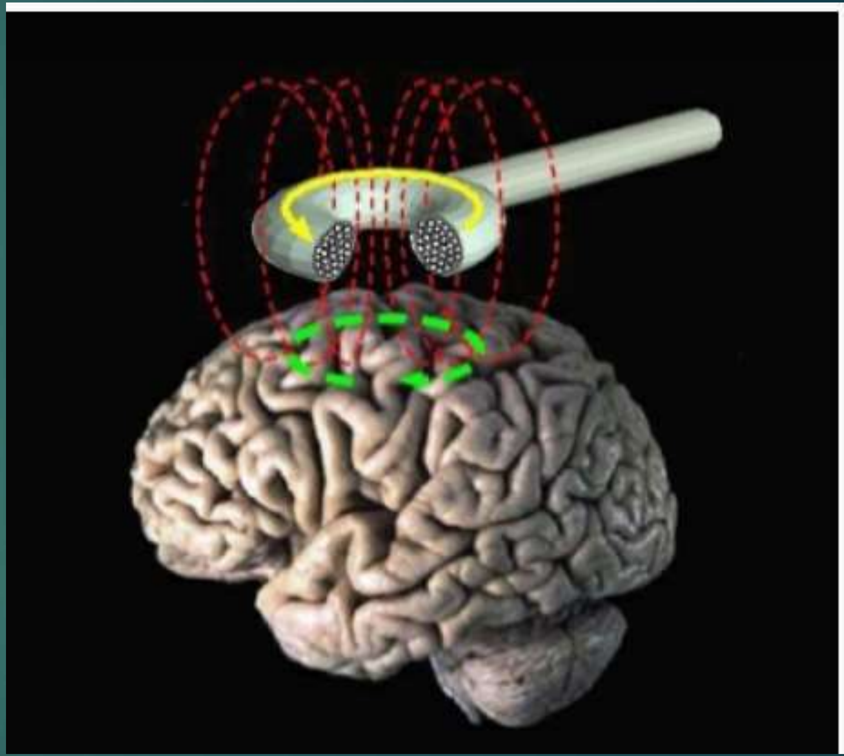
Has done four hierarchical language tasks and multiple resting-state networks including the dorsal attention and default mode networks.

Future: Hitachi Walkman-style mobile optical (laser) brain scanner

Transcranial Magnetic Stimulation (TMs): Depression Tx and Brain Area knockout



Can momentarily render a brain area dysfunctional



Up to 2.5 tesla
(strength of a magnetic field)

EEG scanner for gaming control

Major Neuroscience projects

- 1. Human Connectome Project: 9 institutions, neural pathways that underlie brain function and behavior, using <u>diffusion MRI</u>, n = 1200; <u>contributions of genes and environment to the wiring of the brain</u>
- 2. Bigbrain Project: highest resolution <u>3D digital model of the human brain</u>, down to 20 microns; based on 7,400 slices of <u>a 65-year-old woman's brain</u>
- 3. Brain Nanotechnology: build <u>circuits that mimic brain functions</u>, for brain prostheses or even synthetic brains; use of <u>nanotubes</u>
- 4. Optogenetics: use of <u>optics and genetics to control neurons</u>; Genes are inserted that are responsive to light, then the host cells can be controlled via fiberoptic; have restored vision in blind mice; control mice behavior

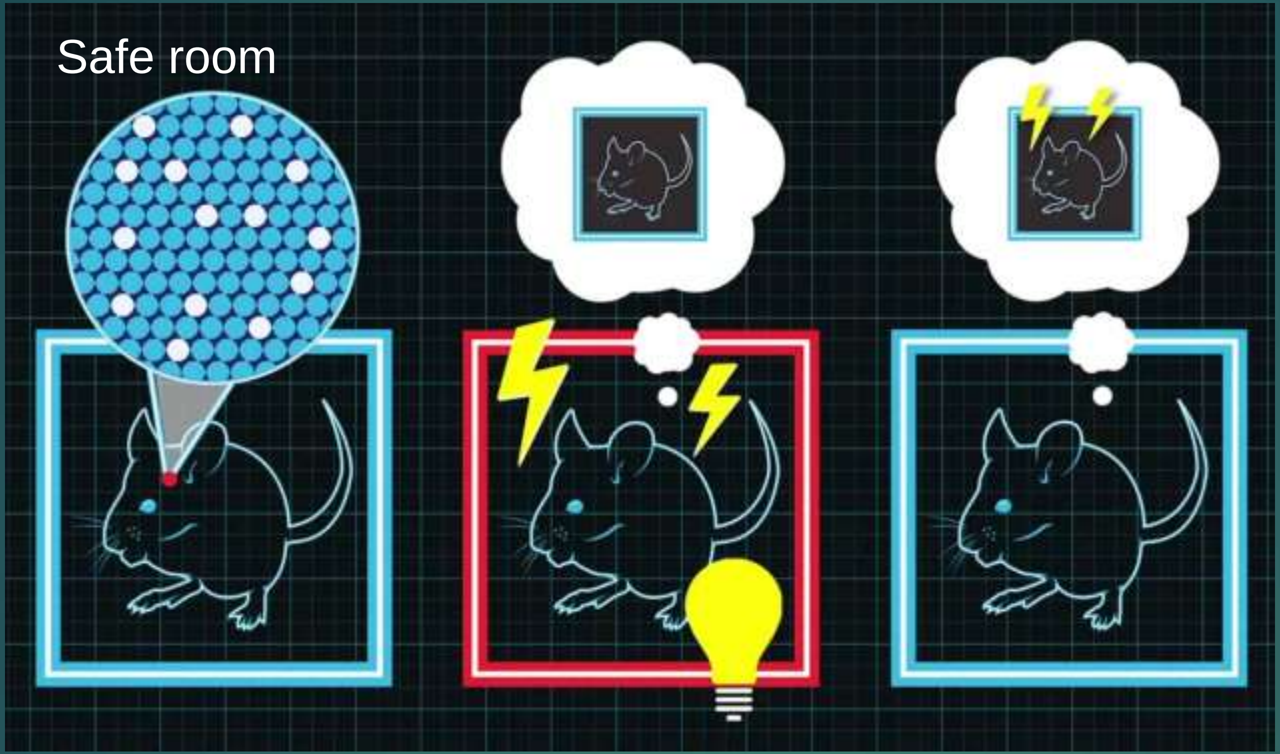
Optogenetics, 1971:
Walther Stoeckenius and Dieter Oesterhelt,

- By inserting opsin genes into neurons; act as miniature solar panels, enabling the cells to convert illumination into electrical signals.
- Can use flashes of light to trigger firing by specific neurons on command. Use light to determine the precise role of those neurons in freely moving animals.
- The discovery of channelrhodopsin2 (ChR2) from the unicellar alga Chlamydomonas reinhardtii was the starting point for the optogenetic approach.
- When transfected into mammalian cells and activated by blue light ChR2 acts as an inwardly rectifying cation channel, thus depolarizing the cells.

Let There Be Light for New and Better Mind Control (in Mice)

- There is an LED system that turns on and off optogenetically modified neurons with pulses of light. Inserted into deep regions of the mouse brain to precisely illuminate specific groups of cells.
- Scientists clone genes for light-sensitive channels into specific groups of neurons and then polarize or depolarize those cells with the flick of a switch
- Researchers successfully trained the animals to prefer maze solution without offering them a food treat and also manipulated anxiety behavior
- Potential uses: brain study, mind control, addiction

Can now create a false memory in a mouse via Optogenetics

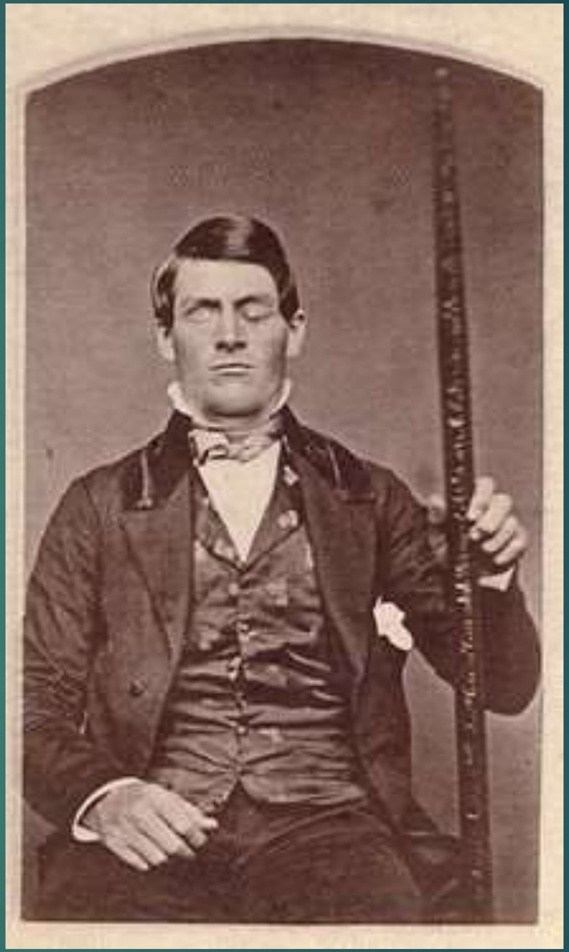



Optical fibres implanted in a mouse's brain activated memory forming cells

- Three steps to plant a fake memory in a mouse.
- First, let the mouse build a real memory of a safe room (left).
- Second, put the mouse in a room with an electrified floor. Shock the mouse — but add the memory of the shock to the memory of the first room.
- Third, put the mouse back in the safe room — which the mouse brain now incorrectly "remembers" as dangerous.

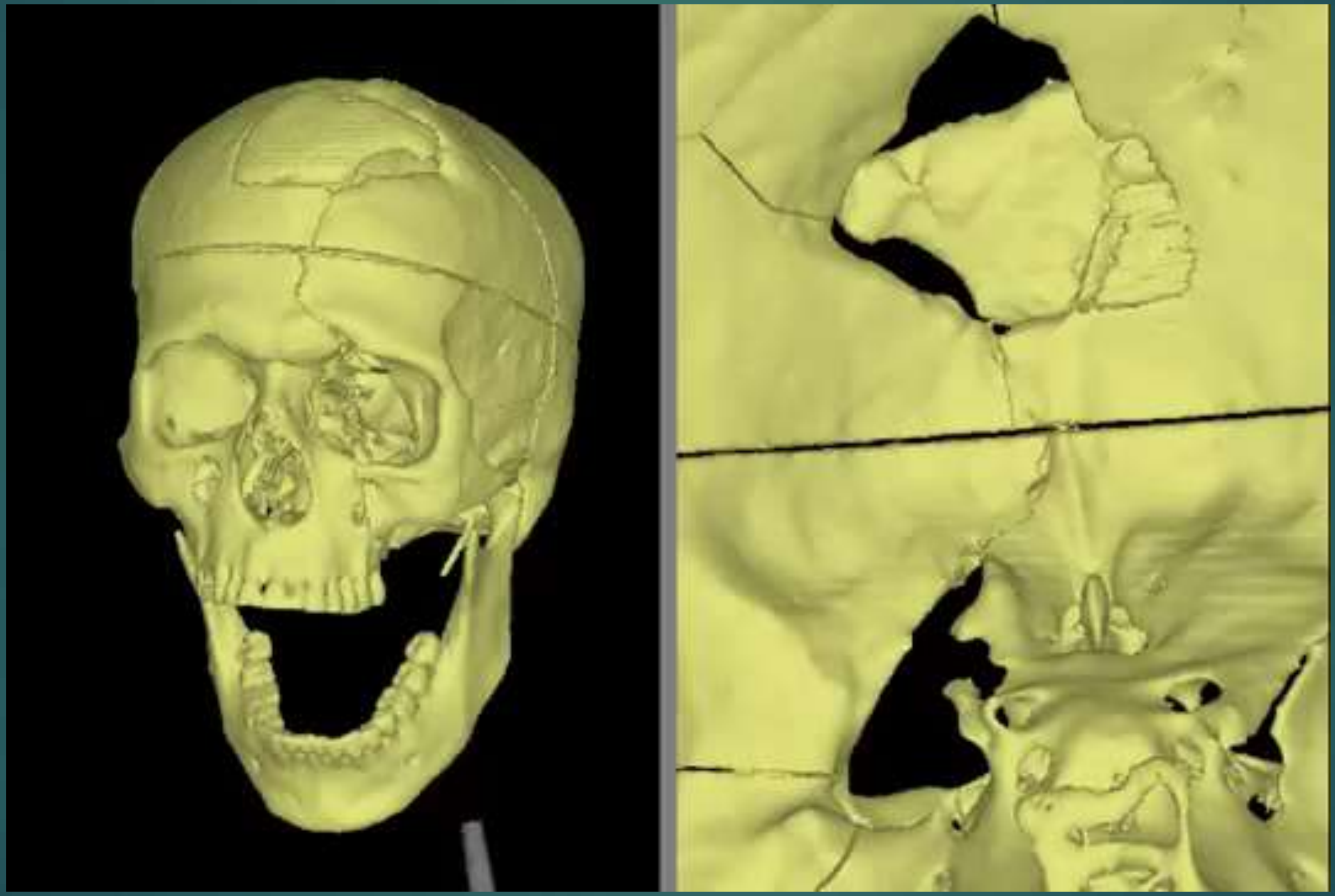
Future of Criminal Control?

Who is this handsome gentleman?



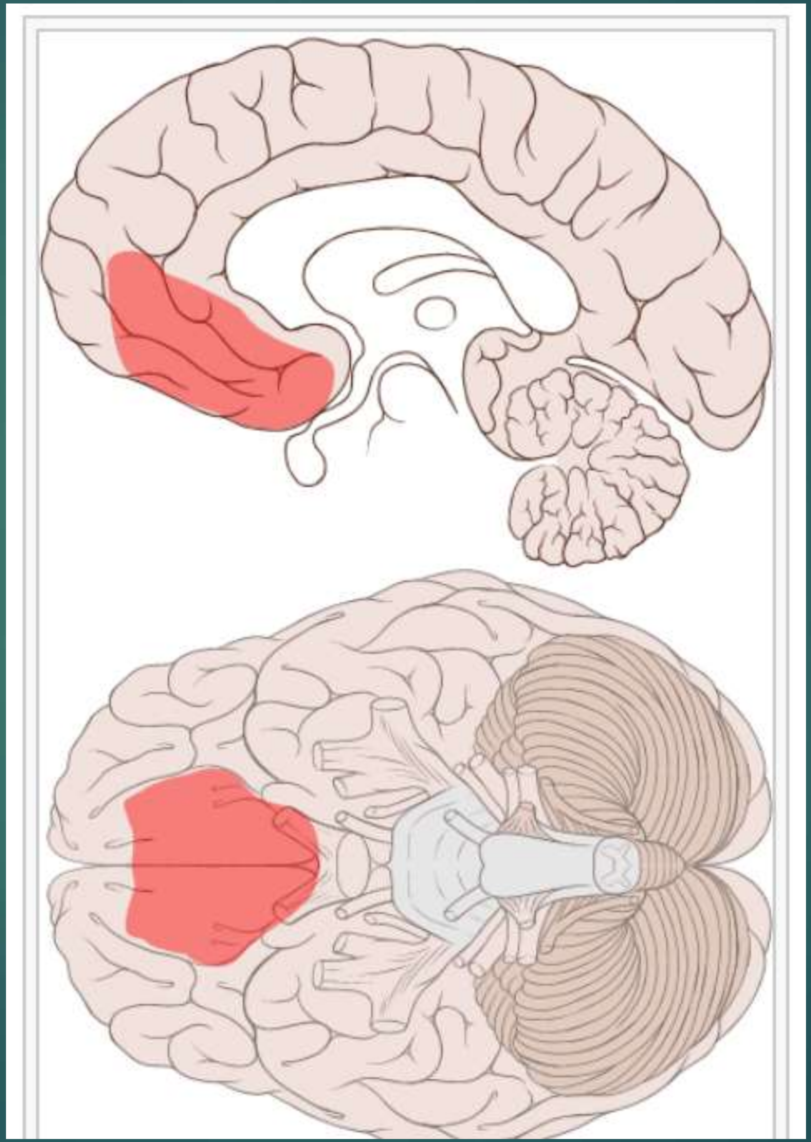
Phineas Gage, ~ 1848

The Phineas Gage Event: Railroad foreman who tapped a metal rod into a hole in a rock filled with black powder

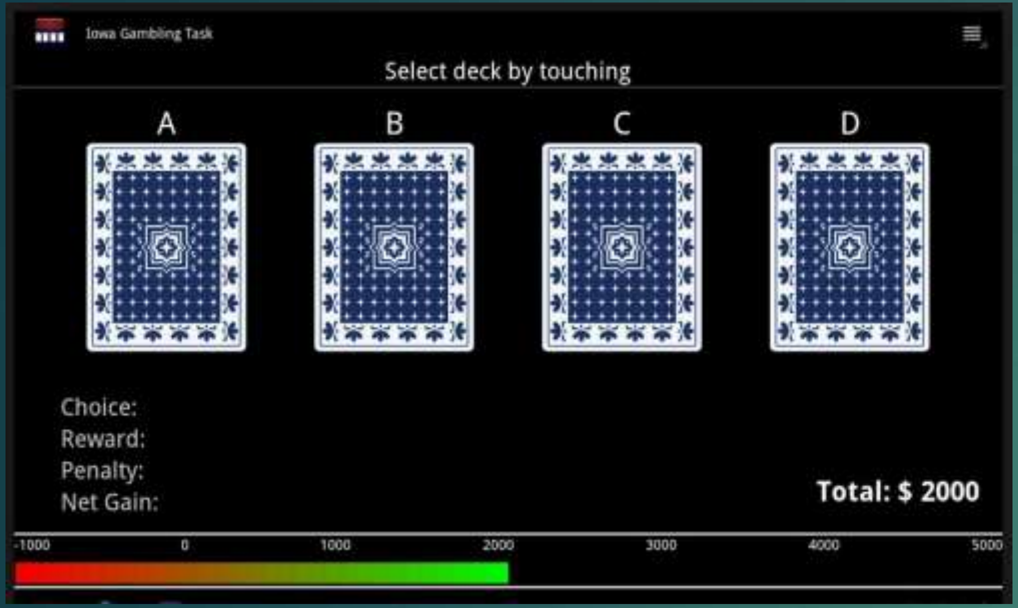


One of first scientific hints that brain damage effects brain in specific ways

Why do you need the orbital (ventromedial) frontal lobes?



Iowa Gambling Task & OFC



IGT: Participants are presented with 4 virtual decks of cards on a computer screen. They are told that each time they choose a card they will win some game money. But some decks lose money.

<u>VM prefrontal deficits</u>; *oblivious to the future consequences of their actions*, respond to immediate prospects only

- Normals: <u>after about 40-50 selections are fairly good at sticking to the good decks</u>.
- Patients with <u>OFC dysfunction</u>, continue to choose the bad decks,
- <u>GSR</u> shows that healthy participants show a <u>"stress" reaction to hovering over the bad decks after only 10 trials</u>, before conscious awareness that the decks are bad.

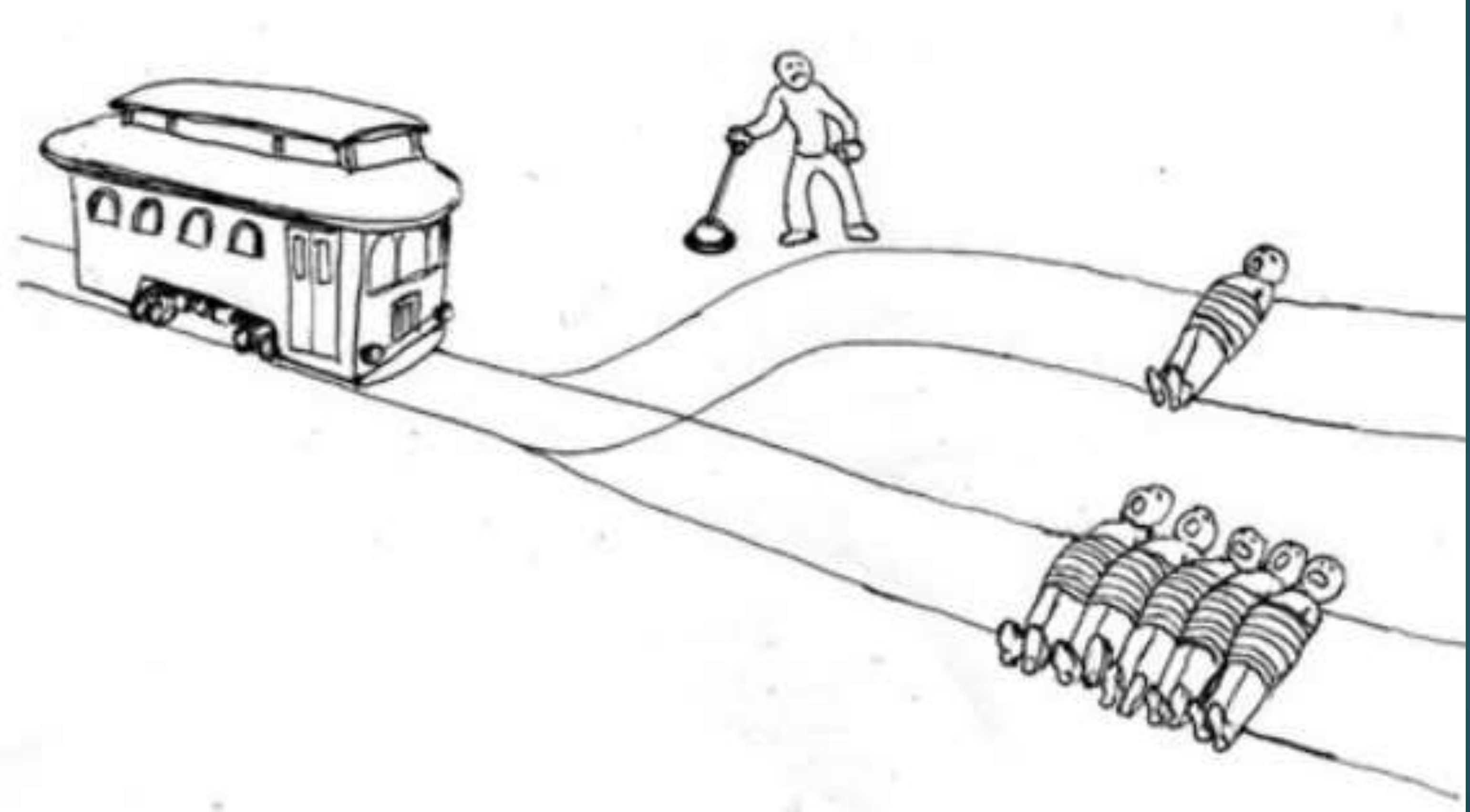
	Bad Decks		Good Decks	
	A	B	C	D
Gain/Deck:	$100	$100	$50	$50
Loss/10 cards:	$1250	$1250	$250	$250
Net/10 cards:	-$250	-$250	$250	$250
Rewards/10 cards:	5	1	5	1

Medial Orbital Frontal Cortex Tumor:
Is Mr. Spock's rationality the ideal

- 1982: Pt. E.: model father, corporate manager, 97%tile IQ
- Then behavior changed; considered a "malingerer"; fired from job, wife divorced him.
- He walked into neurologist Antonio Damasio's office: he had a bilateral <u>mOFC tumor</u> diagnosed & removed
- <u>Now: No emotional reaction (no GSR) to scenes of mutilation</u>
- Now: pathological indecision: whether to use a blue or black pen; where to park
- Discovery: <u>human decision making requires emotions to function correctly</u>
- <u>Damasio's Somatic Marker Theory</u>: emotional processes can guide (or bias) behavior, particularly decision-making.

A. R. Damasio, Tranel, & Damasio, 1990; Eslinger & Damasio, 1985

Trolley Problem 1: Do you throw the switch?
Dorsolateral PFC active



9 of 10 people confronted with this scenario say it's O.K. to kill 1 to save 5.

Trolley Problem 2: Do you push the fat man off the bridge? vmPFC active

9 of 10 people say it's <u>not O.K</u>. to kill one person to save five;
Individuals with vmPFC damage 3x more likely to push the person off.

vmPFC Damage

- VMPFC damage: strongest predictor of empathic deficits
- 3 x more likely to advocate throwing a person to certain death in front of a runaway train to keep it from killing five other people.
- 5 x more likely to advocate smothering one's baby to save others

Damasio, 2007; Amitai Shenhav and Joshua D. Greene, 2010

FMRI of Trolley Problem

- Dorsolateral prefrontal cortex activates in first trolley hypothetical, in which most of them made a utilitarian judgment about how to save the greatest number of lives.

- By contrast, emotional centers activate the second trolley hypothetical, in which they tended to recoil at the idea of personally harming an individual, even under such wrenching circumstances.

- Moral judgment uses multiple brain centers: intuitive emotional responses vs. cognitive responses

Driverless cars need ethical programming

- This type of choice is becoming more important.
- How do we make autonomous cars choose correct solutions. May need to have a minor accident in order to prevent a more serious one.

Self Driving Cars: Moral choices – Machine ethics

- Do you program car to save pedestrian if the people in car get hurt?

- In 2016 study: ethical paradox about self-driving cars: in surveys, people said that they wanted an autonomous vehicle to protect pedestrians even if it meant sacrificing its passengers

- But also that they wouldn't buy self-driving vehicles programmed to act this way.

- Who would you spare in an unavoidable collision in which some combo of passengers and pedestrians are killed; online quiz had recorded 40 million decisions made by people from 233 countries.

- People from relatively prosperous countries with strong institutions were less likely to spare a pedestrian who stepped into traffic illegally.

Rahwan, 2018

Autonomous cars

- Most people spared humans over pets, and groups of people over individuals

- US and Europe: a stronger preference for sacrificing older lives to save younger ones

- Country with significant economic disparity — chose to kill the lower-status person.

- Cultural nuances that governments and makers of self-driving cars must take into account if they want the vehicles to gain public acceptance.

Ethics in machines

- Autonomous military drones or killing droids who may be able to make autonomous decisions to create civilian casualties to take out a valued target.

- We will need to have an algorithm for how to value human life relative to a greater good.

“Kevin”: A case of new behavior at age 40

- What does the following legal case tell you about the origins of human behavior?

- How should we incorporate these findings into legal decision making?

“Kevin”: A case of new behavior at age 40

- A 40-year-old married schoolteacher began to have an increasing interest in pornography, including child pornography seemingly out of the blue. He had a preexisting strong interest in pornography dating back to adolescence, although he denied a previous attraction to children and had never experienced related social or marital problems as a consequence.
- Throughout the year 2000, he acquired an expanding collection of pornographic magazines and increasingly frequented Internet pornography sites. Much of this material emphasized children and adolescents. He also solicited prostitution at "massage parlors," which he had not previously done.
- The patient went to great lengths to conceal his activities because he felt that they were unacceptable. However, he continued to act on his sexual impulses, stating that "the pleasure principle overrode" his urge restraint.

Burns JM , Swerdlow RH, Arch Neu, 2003

New sexual urge 2

- He began making subtle sexual advances toward his prepubescent stepdaughter, which he was able to conceal from his wife for several weeks. Only after the stepdaughter informed the wife of the patient's behavior did she discover with further investigation his emerging preoccupation with pornography, and child pornography in particular.
- The patient was legally removed from the home, diagnosed as having pedophilia, and prescribed medroxyprogesterone. He was found guilty of child molestation and was ordered by a judge to either undergo inpatient rehabilitation in a 12-step program for sexual addiction or go to jail.
- Despite his strong desire to avoid prison, he could not restrain himself from soliciting sexual favors from staff and other clients at the rehabilitation center and was expelled. The evening before his prison sentencing, he went to a hospital emergency department complaining of a headache. A nonphysiologic cause was suspected, and the psychiatry service admitted him with a diagnosis of pedophilia, after he expressed suicidal ideation and a fear that he would rape his landlady.

New sexual urge 3

- The day after his admission he complained of balance problems, and a neurologic consultation was obtained
- The patient's medical history was notable for a closed head injury 16 years earlier that was associated with a 2-minute loss of consciousness and no apparent neurological sequelae, a 2-year history of migraines, and hypertension. He was without a previous psychiatric or developmental history and had exhibited no prior deviant sexual behavior.
- There was no family history of psychiatric disease. He had worked as a corrections officer prior to completing a master's degree in education in 1998, at which time he became a schoolteacher. He was currently in his second marriage, which prior to his developing sexual preoccupations had been stable for 2 years.
- During a neurologic examination, he solicited female team members for sexual favors. He was unconcerned that he had urinated on himself.

A new sexual urge 4

- MRI scan revealed the teacher had a large, egg-sized orbitofrontal tumor (an aggressive meningioma). Surgeons removed the tumor and his criminal behavior ceased.
- He successfully participated in a Sexaholics Anonymous program. Seven months later, he was believed not to pose a threat to his stepdaughter and returned home.
- One year later, he developed a persistent headache and began secretly collecting pornography again. MRI showed tumor regrowth, and surgery was redone.
- Two days after this surgery, his examination results were normal. His MMSE was perfect. Results of clock-drawing and figure copy tests were normal, and his writing was legible.
- Throughout these events the patient was unable to control his urges, but he was always aware his behavior was wrong.

Right Orbitofrontal Tumor With Pedophilia Symptom and Constructional Apraxia Sign

Arch Neurol. 2003;60(3):437-440. doi:10.1001/archneur.60.3.437

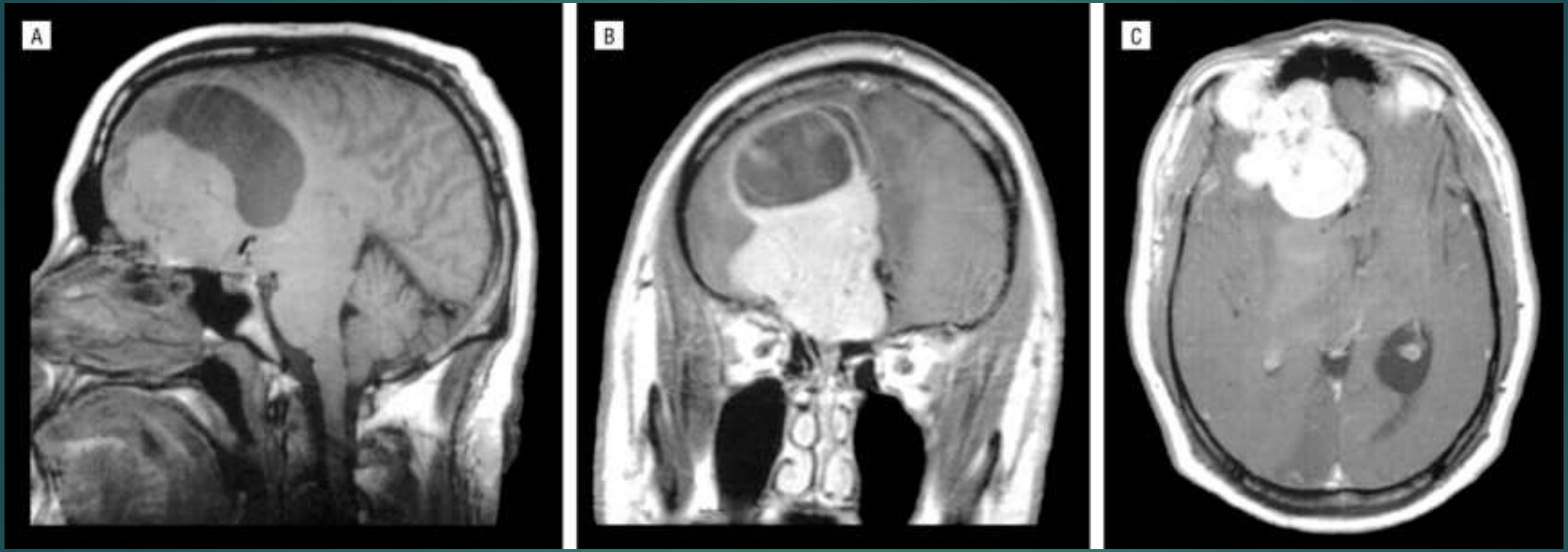


Figure Legend:

Magnetic resonance imaging scans at the time of initial neurologic evaluation: T1 sagittal (A), contrast-enhanced coronal (B), and contrast-enhanced axial (C) views. In A and B, the tumor mass extends superiorly from the olfactory groove, displacing the right orbitofrontal cortex and distorting the dorsolateral prefrontal cortex. The tumor is capped by a large cystic portion.

Before surgery

After surgery

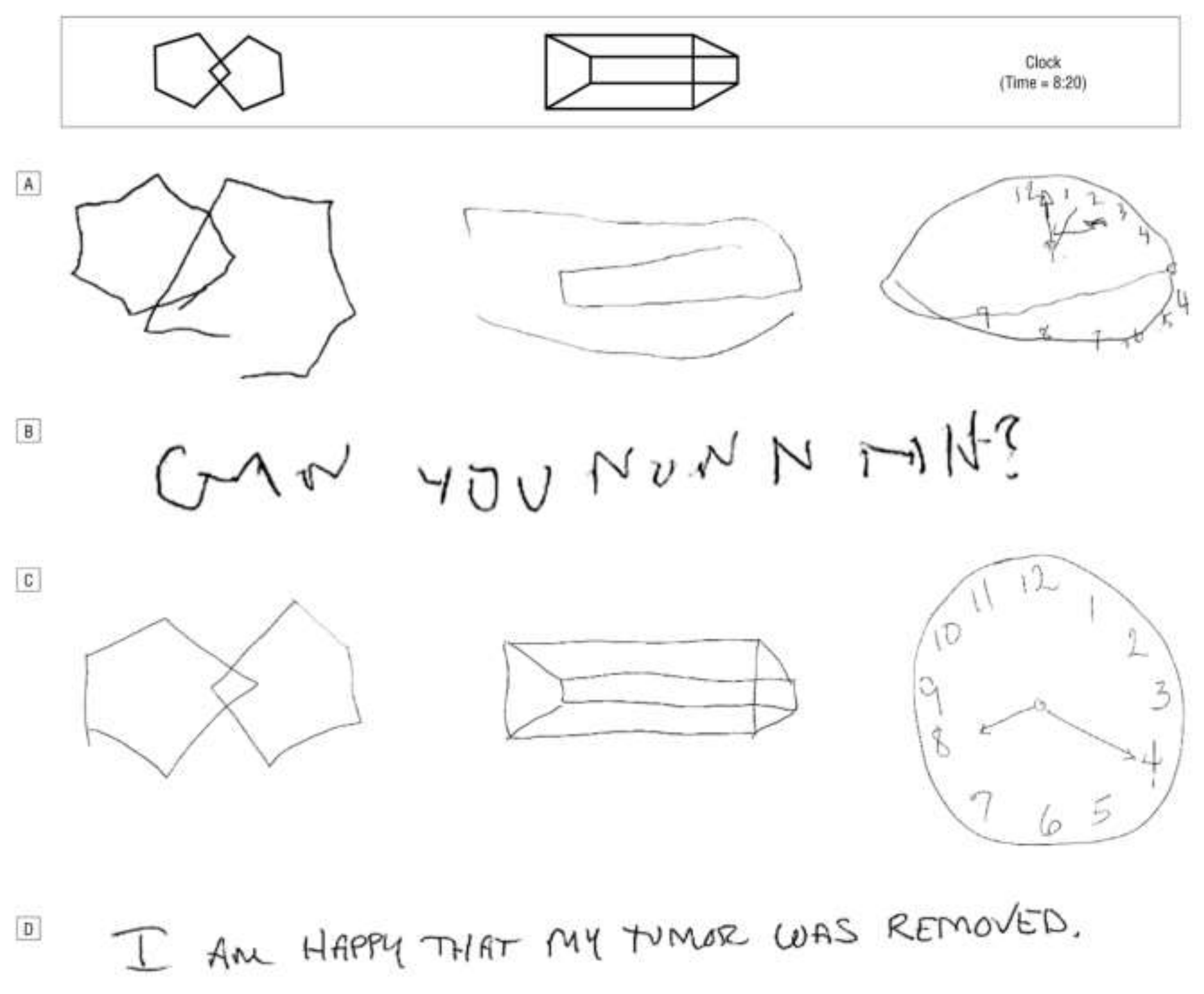


Figure Legend:

Constructional apraxia and pseudodysgraphia in our patient with a right orbitofrontal tumor. A, Impaired copy drawing and free drawing at the initial evaluation. B, Pseudodysgraphia at the initial evaluation. C, Resolution of constructional apraxia after tumor resection. D, Resolution of pseudodysgraphia after tumor resection.

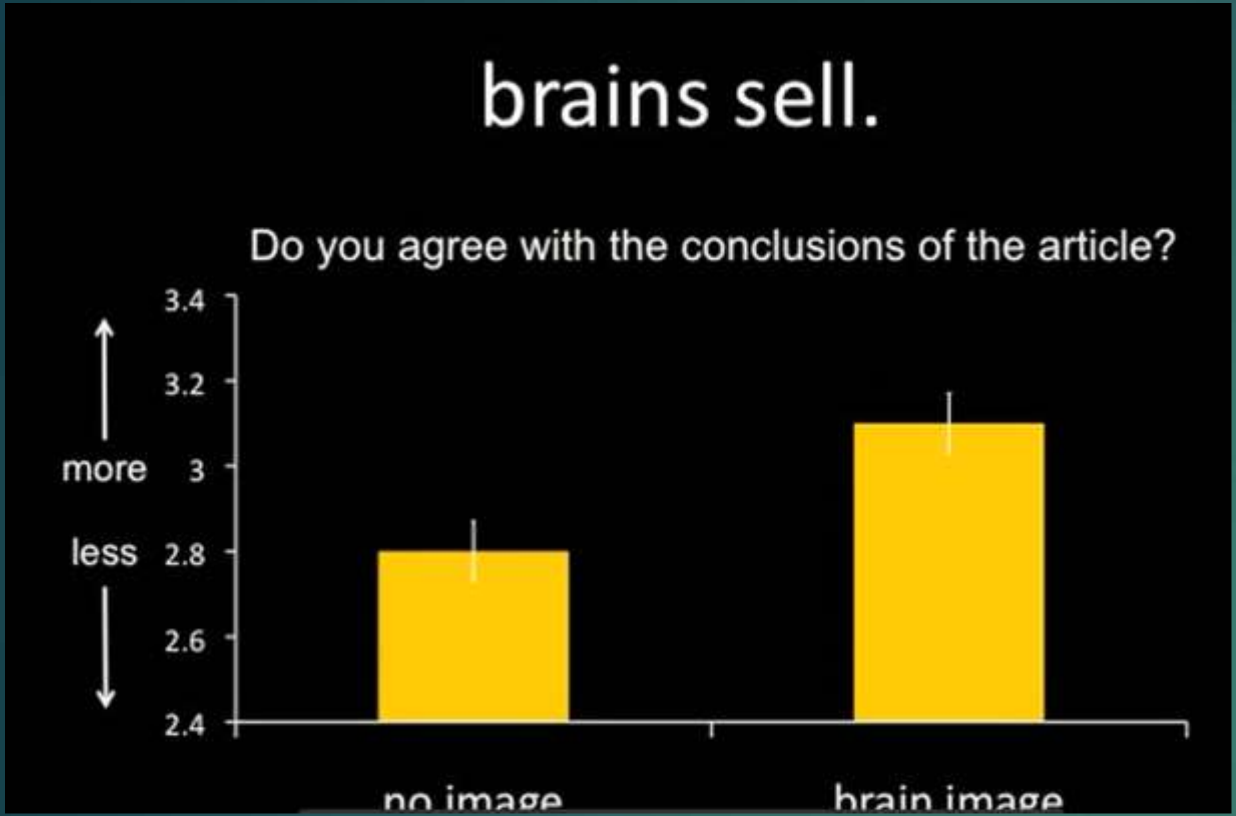
Neuroscience

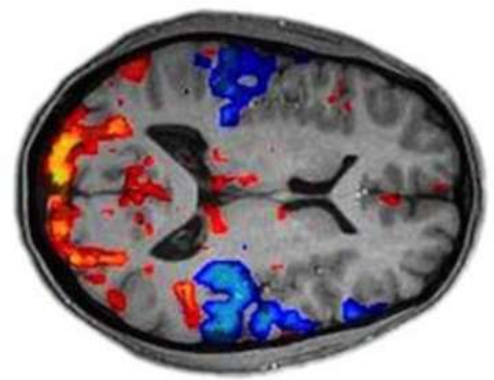
1st third

- Cases like this one, reported in the *Archives of Neurology*, raise the issue off how advances in neuroscience are shaping our understanding of moral and legal choices.

- There are many ethical, legal, and social issues raised by our neuroscience knowledge.
- Major issues:
  - Brain imaging can effect our understanding of causes of human behavior
  - Brain imaging can be used and misused by lawyers (intentionally or unintentionally)
  - NS data can be misunderstood by judges and jurors.

Neurobunk





People perceive articles with images of brains that summarizing cognitive neuroscience research more scientifically credible than articles with no images or images other than brains.

McCabe, D. P., & Castel, A. D. (2008).

Brain Scans: Visual Illusions

- Brain scan images are not what they seem. They are not photographs of the brain in action in real time.

- Scientists can't just look "in" the brain and see what it does.

- Those beautiful colored images are actually representations of particular areas in the brain that are working the hardest – as measured by increased oxygen or blood consumption – when a subject performs a task such as reading a passage or reacting to a picture of face.

- Computer transforms changes in oxygen levels into the familiar colored images indicating the brain regions that become especially active during the subject's performance.

Decoding the Brain

- With its implied promise of decoding the brain, it is easy to see why brain imaging is being used in many ways:
  - politicians hoping to manipulate voter attitudes,
  - agents of the law seeking an infallible lie detector,
  - marketers trying to learn what consumers really want to buy,
  - addiction researchers trying to gauge the pull of temptations,
  - defense attorneys fighting to prove that their clients lack malign intent or even free will.

NS research can be error prone

- Just prior to 2008 presidential election season was gearing up, a team of UCLA neuroscientists sought to solve the riddle of the undecided, or swing, voter.
- Did fMRIs of swing voters as they reacted to photos and video footage of the candidates.
- Together with three political consultants, they presented their findings in the *New York Times* in an op-ed titled, “This is Your Brain on Politics.”
- Tested images of Hillary Clinton, John Edwards, Rudy Giuliani, and other candidates. Revealed in these activity patterns, the authors claimed, were "some voter impressions on which this election may well turn".
- Two candidates had utterly failed to "engage" with swing voters: John McCain and Barack Obama, the two eventual nominees for president.

A don't-blame-me-blame-my-brain theory of crime?

- Still, <u>if biological roots can be identified </u>– and better yet, captured on a brain scan– it is too <u>easy for non-professionals to assume that the behavior under scrutiny must be "biological" and therefore "hardwired", involuntary or uncontrollable. </u>

- <u>Criminal lawyers</u> are increasingly drawing on <u>brain images supposedly showing a biological defect that "made" their clients commit murder</u>.

Neurocentrism

- “Neurocentrism" – the view that human experience and behavior can be best explained from the predominant or even exclusive perspective of the brain.

- From this popular vantage point, the study of the brain is somehow more "scientific" than the behavioral study of human motives, thoughts, feelings and actions. By making the hidden visible, brain imaging has been a spectacular boon to neurocentrism.

- The key problem with neurocentrism is that it devalues the importance of psychological explanations and environmental factors, such as familial chaos, stress and widespread access to drugs in sustaining addiction.

- Remember actor Robert Downey Jr., the poster child for drug addiction.

Exposure to Neuroscience = more leniency

- Understanding how much our brain controls our behavior consciously and unconsciously increases our moral leniency.

- Exposure to brain-based accounts of behavior, seems to decrease people’s support for retributive punishment

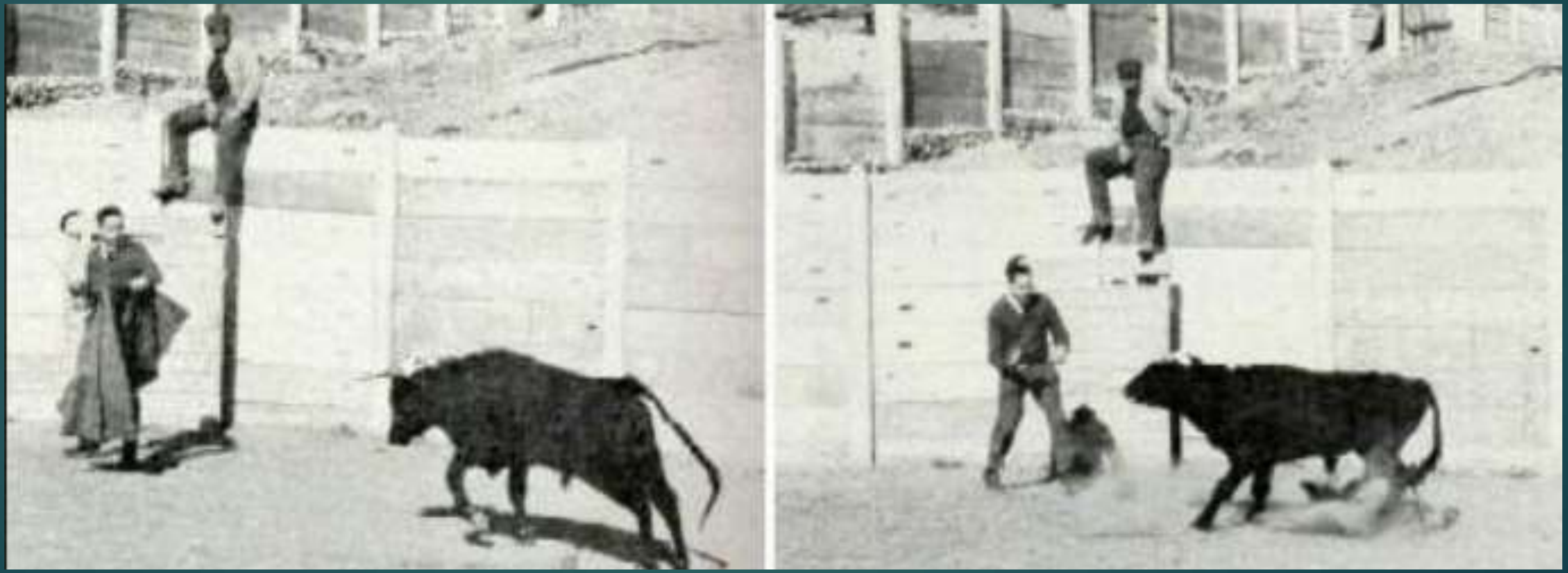
- Those who either by reading a magazine article or through undergraduate coursework, learn about brain science, propose less severe punishment for a hypothetical criminal; they saw the criminal as less blameworthy.

Shariff et al, 2014

Old Science: The bull that stopped

- In the 1960s, for example, neuroscientist Jose Delgado inserted devices into the brains of animals that he used to control their actions.
- In one dramatic episode, a bull charged at Delgado until, moments before the anticipated impact, Delgado pressed a button on a radio transmitter that activated a device in the bull's brain and caused it to stop.
- One of first NS interventions in behavior.

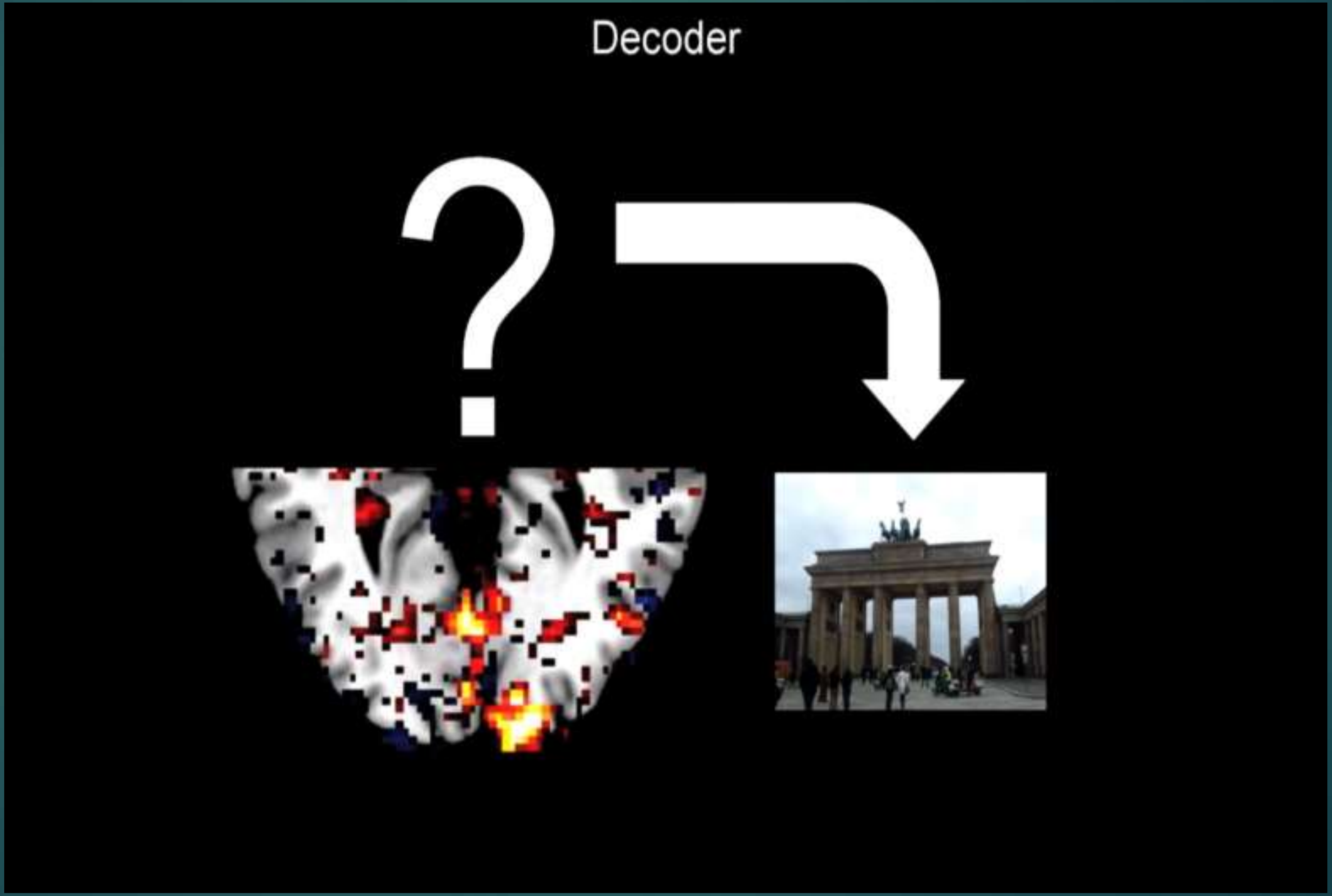
1965: Stopping a bull



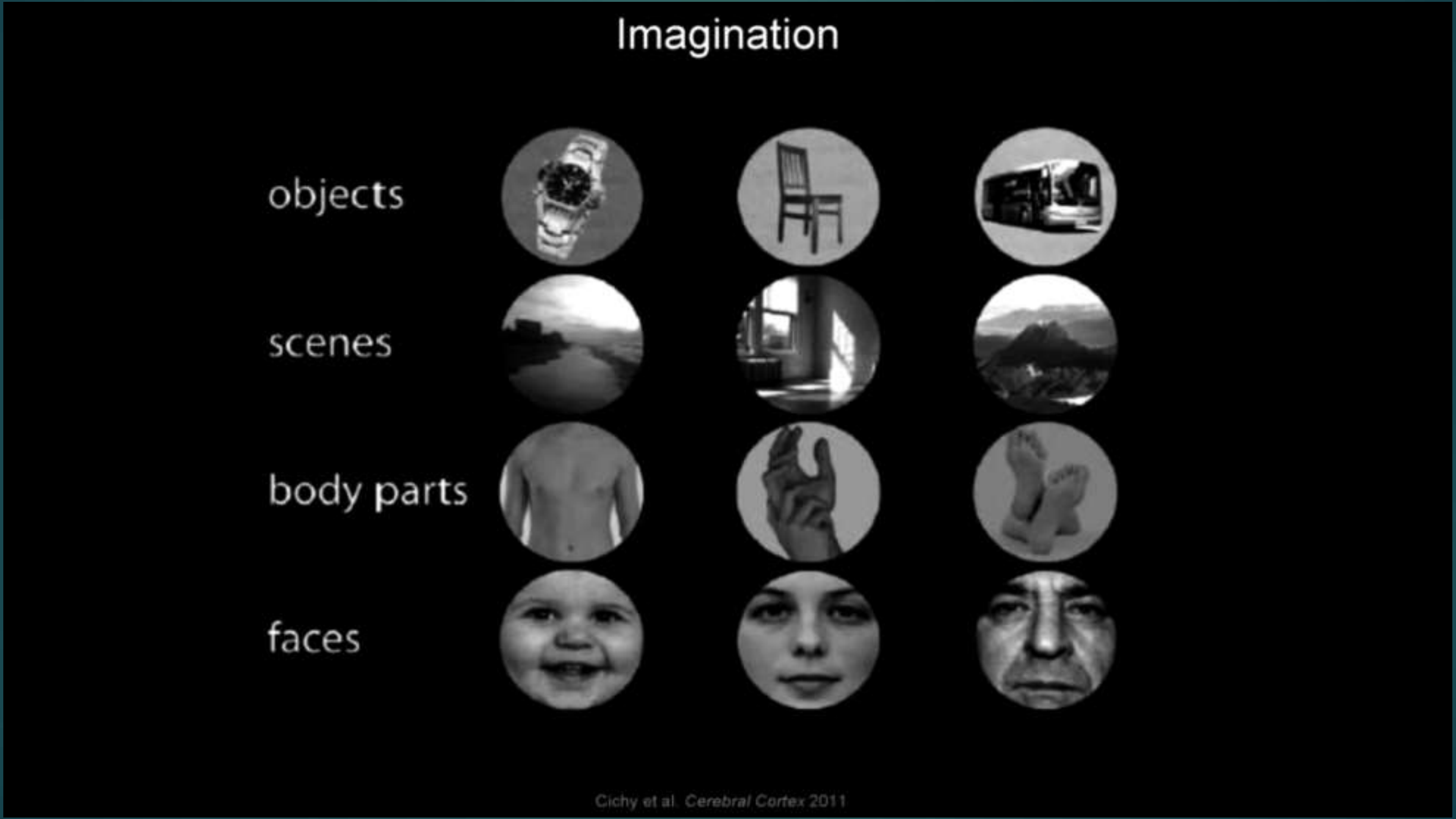
We are in the era of brain decoding technology.

Do we need new laws to protect our cognitive liberty?

Brain decoding via fMRI: scan a brain while person is doing an activity: arrive at a brain scan which is the equivalent of the activity



Can even use a person imaging an activity or object



Current Neuroscience Brain Decoding Achievements

- Brain decoding: Reconstruct images of faces or video a person has seen
- Probe the content of sleepers' dreams (60% accurate object detection)
- Ability to extract personal info: ATM PIN code, month of birth, bank location and the type of debit card used.

- NeuroScout program: Identify the type of baseball pitch and decide whether to swing; identify which baseball players will be good hitters

- Emotiv and NeuroSky make consumer BCI gaming headsets
- Goal: universal brain decoders

Current Neuroscience Projects

- Brain Computer Interfaces (BCI): Latest EEG headsets and computer algorithms can translate neuronal signals into specific actions that control a variety of mechanical devices, including wheelchairs, prostheses and now flight simulators.

- Ability to move robotic arms or cursors by thought alone via eeg or electrodes (lots of practice req.) (J. Donahue, Cybernetics, BrainGate chip)

- Ability to move paralyzed legs by thinking

- Ability to control a drone by thinking alone.

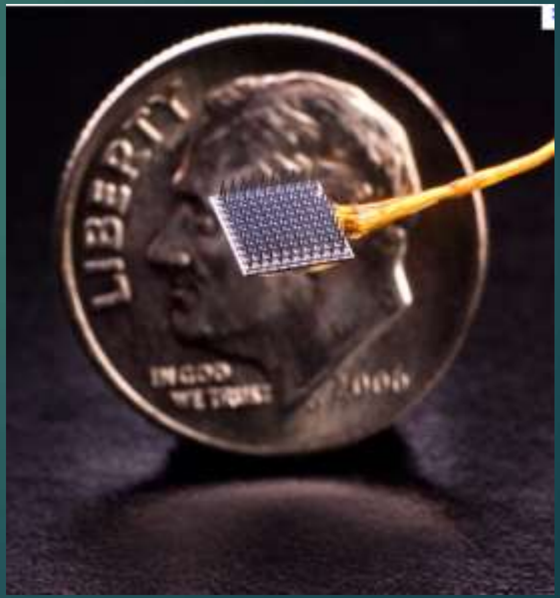
Brain Computer Interface: BCIs

- Facebook's Mark Chevillet described the company's "thought to typing" BCI research as being guided by one question: "What if you could type directly from your brain?"

- Facebook and others envision similar technology facilitating consumer products that translate thoughts into text messages and emails. No typing or Siri necessary.

- Problem: today's brain electrodes last only a few years, meaning people would need repeated brain surgery, and current BCI systems, while OK in a lab, aren't reliable enough for real-world use,

Robotic Connections



She is able to move external robot arm just by thinking; (2012: BrainGate system)

Wearable devices: EEG skull caps

- Have been used to control wheelchairs, drones and humanoid robots
- Used by 2 people to communicate using only their brains: 5000 kms apart (India & France) using codes like move hand or foot (by Starlab & Axilum Robotics)
- Used by AI to recreate seen faces
- Microsoft patent: device that uses EEG brain signals to open and control apps

Proposed NS techniques

- Facebook: near infrared spectroscopy (near infrared light through skull) to reveal blood flow in brain: type as fast as thought
- MIT: AlterEgo device (sensors on face to pick up muscle movements when thinking of a word): used to do Google search by thinking of asking a question
- Elon Musk: Neuralink –ultra thin mesh on top of brain for picking up brain signals

Brain to brain communication

- In 2015, Andrea Stocco and his colleagues at the University of Washington in Seattle used this gear to connect two people via a brain-to-brain interface. The people then played a 20 questions–type game.

- An obvious next step is to allow several people to join such a conversation, and Stocco announced they have achieved this using a world-first brain-to-brain network. The network, which they call BrainNet, allows a small group to play a collaborative Tetris-like game.

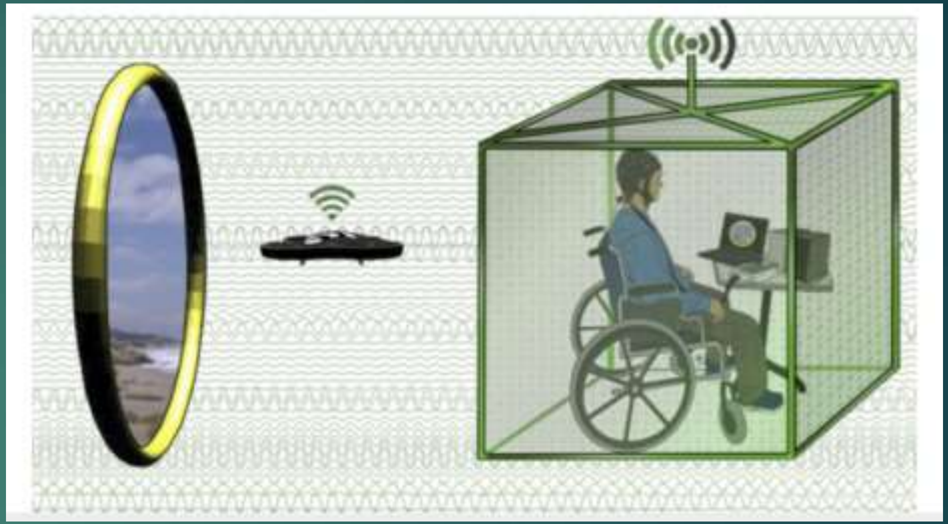
Think and walk

Back on his feet (Image: University of California, Irvine)

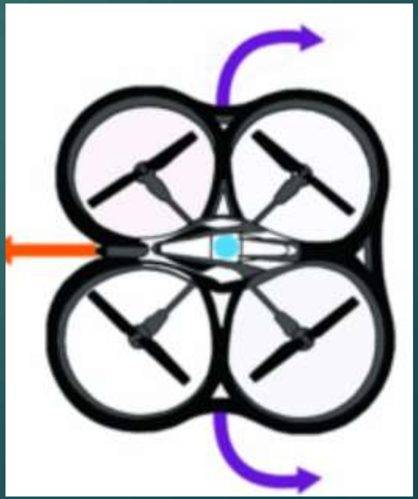
A 26-year-old man who is paralysed in both legs has walked for the first time in five years – just by thinking about it. He is the first person to have his brain activity recorded and used to control a muscle-stimulating device in his legs.

Robotic Quadcopter by Thought

2013: Brain–computer interface (BCI): BCI controlling a robotic quadcopter in three-dimensional (3D) physical space using noninvasive scalp electroencephalogram (EEG) in human subject.



Five human subjects were trained to modulate their sensorimotor rhythms to control an AR Drone navigating a 3D physical space



What about the military?

- Fly a plane via brain waves:
- Ability to control and land a plane by nonpilots in a flight simulator using EEG (Tim Fricke of the Technical University of Munich)

Human makes rat tail move via thought & another person hit a computer key

- Person wearing an EEG headset was paired with an anesthetized rat. When a participant decided to move the rat's tail, that person's corresponding brain activity triggered an ultrasonic pulse that entered the rodent's brain. About two seconds later the rodent's tail lifted and then fell.

- Thru a computer, 1 person moved the hand of another person using EEG & TMS equipment. The receiver did not register the received motor impulse consciously, but his right hand moved anyway. The stimulation caused his hand to lift, and when it fell it hit a keyboard and fired the cannon in the game. For the first time, a human brain had communicated an intention directly to another human brain, allowing the two brains to jointly complete a task.

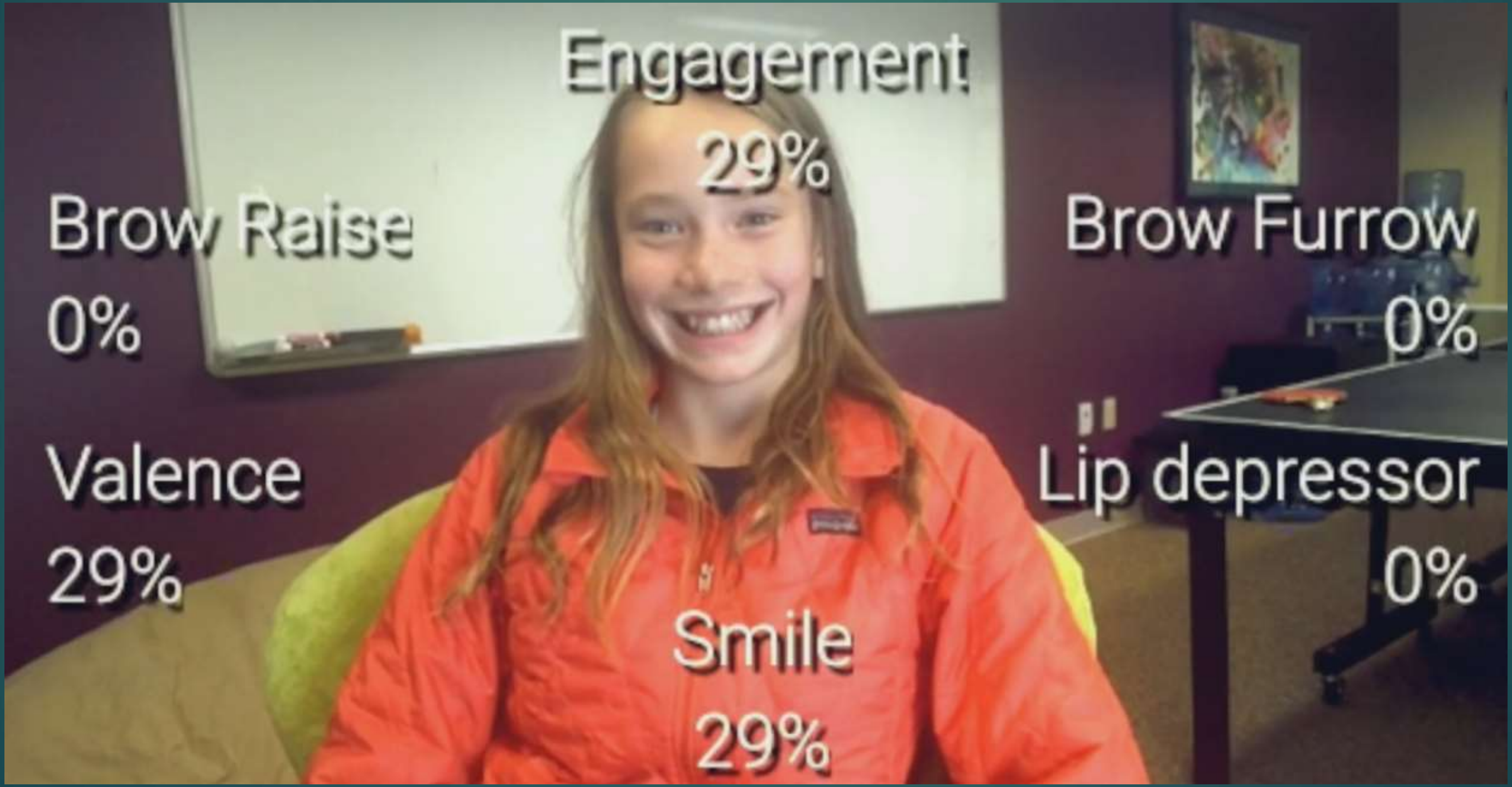
Reading emotions: Potential Benefits and Risks for abuse

- Emotion reading software, now with database of 12 billion facial emotions from 75 countries; quantifies emotion

Affectiva's technology can enable applications to use a webcam to track a user's smirks, smiles, frowns and furrows, which measures the user's levels of surprise, amusement or confusion.
The technology also allows a person's heart rate to be measured from a webcam without the person wearing anything. This is done using color changes in the person's face, which pulse each time the heart beats.
Can test advertising (when you get bored), movie evaluation (what pulls emotions, engages you), political polling

Frowns

Emotion tracking:
Can analyze your…



Technology that could help autistics

Or your refrigerator senses you are stressed and autolocks itself!

Brain scans can now…

- Decode imagery directly from the brain, such as:
  - what number people have just seen
  - what memory a person is recalling
  - reconstruct videos of what a person has watched based on their brain activity alone

- Identify which protagonist/personality is being imagined based solely on activity patterns in the medial prefrontal cortex

Mind reading: via AI

- Ability to <u>predict which video you just watched</u> (of 3 short videos just watched) (E. Maguire) (R and L anterior & posterior hippocampus activate for episodic memory)

- Computer <u>program translates brain waves into individual words with 80-90% Accuracy (vs. 7% by chance)</u>

- Ability to <u>guess which of 1000 pictures you just viewed</u> (J. Gallant)

- <u>Computer ability to recreate what you are watching as you watch it </u>(as you watch man in white shirt, computer spits out a white torso) (J. Gallant)

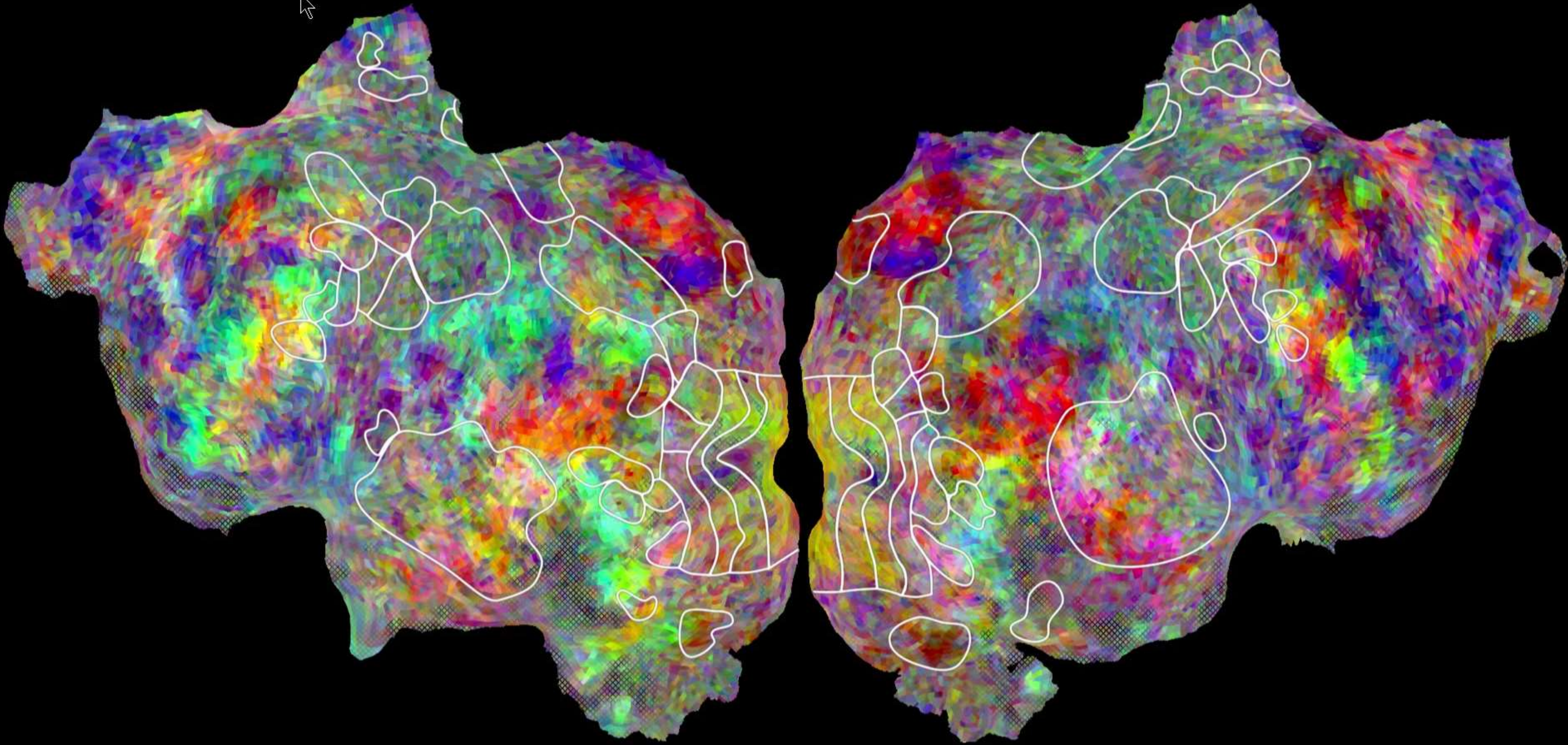
Decoding Brains: Jack Gallant

- J. L. Gallant, UCB: Predictive models of brain activity are the gold standard of computational neuroscience

- Using EEG, fMRI for voxel analysis ; statistical analysis, esp. regression; & theoretical modeling: how each element of the visual system encodes information

- Models can then be inverted in order to *decode* brain activity, providing a direct way to do "brain reading", and to build brain-machine interfaces (BMI) and neural prosthetics.

- Lab has been able to make videos of what people see, what people are semantically thinking about



Cortical maps of semantic representation

First ever photograph, 1826

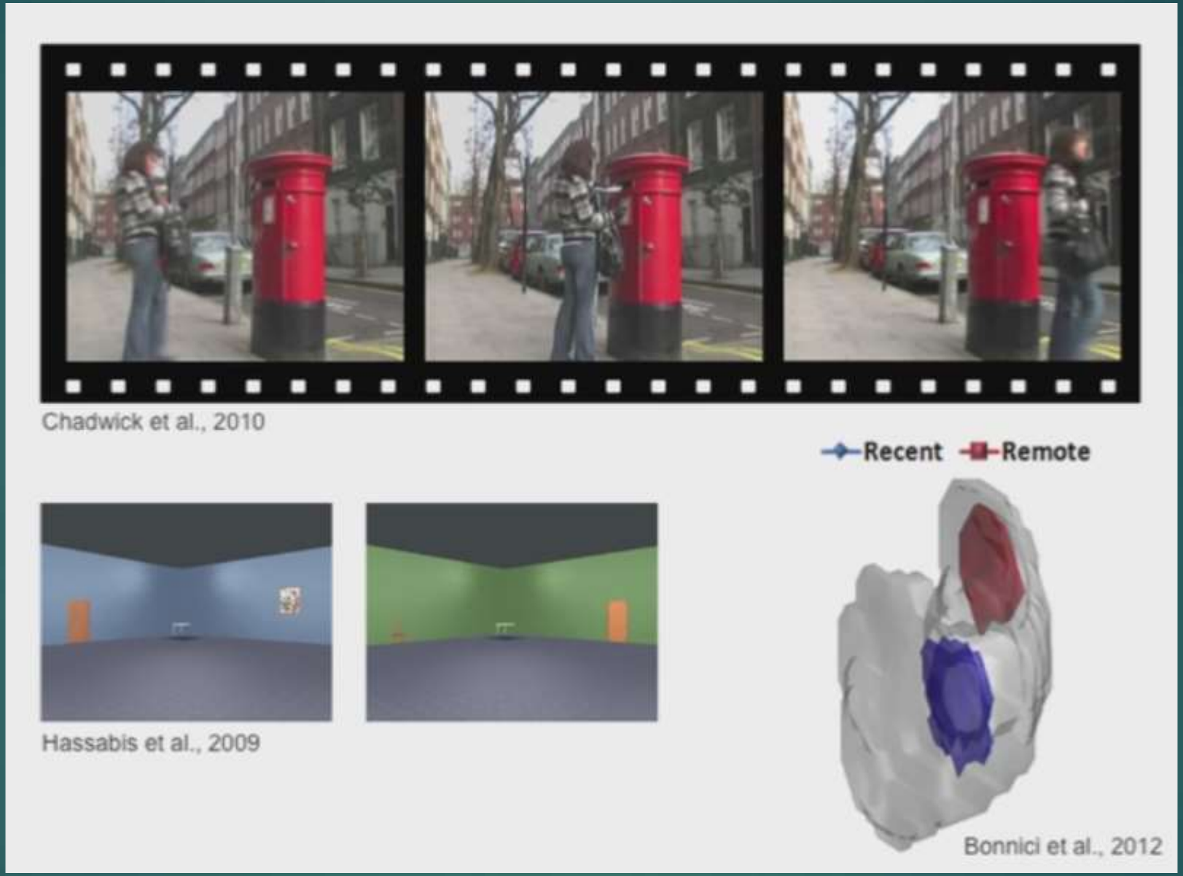
Brain Decoding: videos of people's mental images

AI trained on millions of frames of YouTube clips & brain scans of people watching them

Other research: 10 years until telepathy?

- Marcel Just: AI able to guess content of a sentence someone is reading from brain scan: use of machine learning algorithms with brain imaging technology to "mind read”.
- Yukiyasu Kamitani: possible to train AI to detect content of someone’s dreams: predicting whether or not the 20 objects occurred in dreams with 75 percent accuracy.
- Michal Kosinski: AI can detect whether people are gay or straight based on photos; 91% for men and 83% with women
- Kosinski predicts facial identification systems will be able to predict IQ, political affiliation, tendency toward violence
- Mary Lou Jepsen: 10 years until telepathy – thinking cap as powerful as MRI: technology to be able to both read and to output your own thoughts, as well as read the thoughts of others

fMRI activations can tell where someone is located in virtual reality environment



- Based on activations in the hippocampus
- Also what specific memory a person is recalling, which previous recalled autobiographical memory, or movie

Which tool or building you are thinking about

- 2008 study: <u>showed people primitive line drawings of objects</u>.
- The objects were:
  - <u>five different tools—a drill, a hammer, a screwdriver, pliers, and a saw</u>
  - <u>five different buildings—an igloo, a hut, a house, a castle, and an apartment.</u>
- The group was able, with about <u>80 percent accuracy</u>, to tell <u>not just when each subject was seeing a tool or a building</u>, but <u>which tool and which building the subject was thinking about.</u>

Jack Gallant:

- Within 20-50 years, will <u>have cheap, portable, mobile brain decoders</u>
- We currently use thumbs to translate messages to iPhone
- <u>Decoders will allow direct messaging from brain to your devices.</u>

Only an eyeblink

- Imagine you are in an accident. You suffer serious brain damage that leaves you with eye blinking as your only voluntary movement for communicating with the outside world.
- in time you might perfect this new form of communication, and eventually you might even write a good novel, with sufficient blinking and heroic patience
- Jean-Dominique Bauby (Mathieu Amalric), editor-in-chief of French fashion bible Elle magazine, has a devastating stroke at age 43. The damage to his brain stem results in locked-in syndrome, with which he is almost completely paralyzed and only able to communicate by blinking an eye. Bauby painstakingly dictates his memoir via the only means of expression left to him
- 200,000 blinks of his left eye in response to a recited alphabet

Locked in syndrome: 12 years a ghost

- Consider the story of Martin Pistorius of Johannesburg, South Africa, author of the 2011 book *Ghost Boy*.
- At age 12, he fell into in a coma after an infection. Doctors told his family his brain was permanently compromised and he would never recover.
- When he was a teen, his brain woke up, but his body did not. No one around him knew he was mentally aware as they fed, bathed and cared for him, and once, in a trying moment, told him they hoped he would die.
- He lived locked in this way for 12 years before he was finally able to move.
- “I couldn’t make a sign or a sound to let anyone know I’d become aware again,” Pistorius wrote in a 2015 *Daily Mail* article. “I was invisible.”
- He eventually began to communicate with his eyes, then learned how to use a computerized voice.
- Today, he is married and working as a freelance web designer.

Communication with patient in vegetative state via fMRI

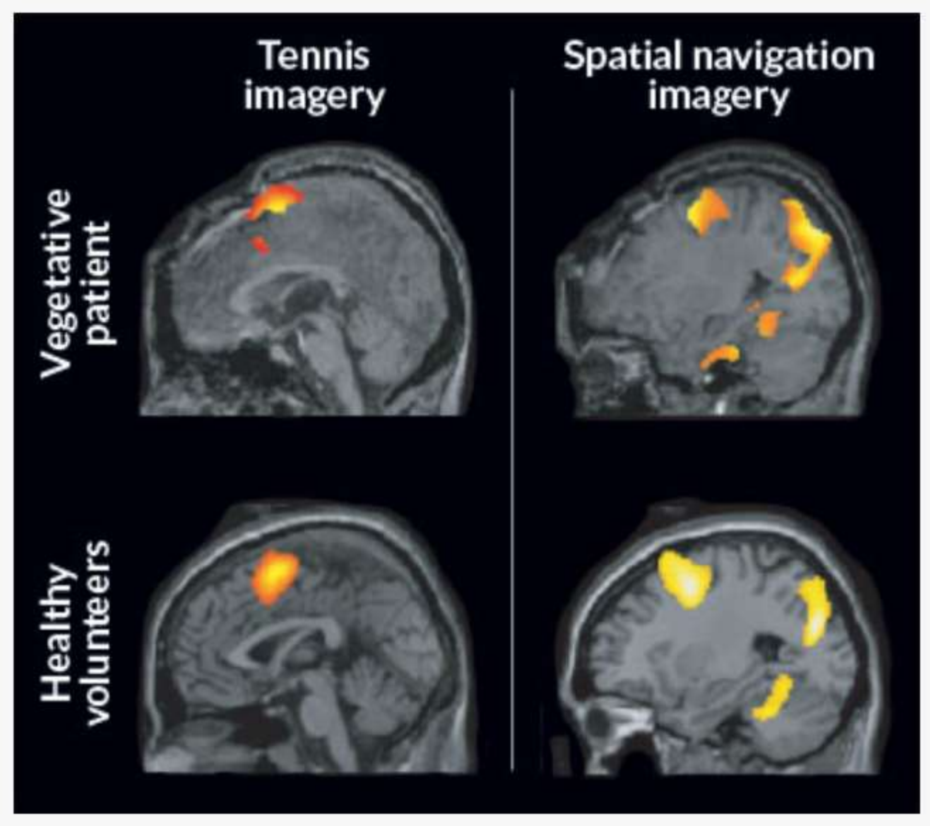
- In 1997 a patient in a vegetative state was shown a picture of a familiar face, her brain on fMRI lit up.
- It was June 2006. Wimbledon was on, and in a headline-stealing study, Dr. Adrian Owen took fMRI scans of a 23-year-old woman in a vegetative state while he asked her to imagine playing tennis and walking through the rooms of her house. When healthy, conscious adults imagine playing tennis, they consistently show activation in a region of the motor cortex called the supplementary motor area, and when they think about navigating through a house, they generate activity in the parahippocampal gyrus, right in the center of the brain.
- The woman, who had been unresponsive for five months after a traffic accident, had strikingly similar brain activation patterns to healthy volunteers who were imagining these activities, proving, in Owen's mind, that she was conscious.
- Next study: Patient 23 was only 24 years old when his life was devastated by a car accident. Alive but unresponsive, he had been languishing in what neurologists refer to as a vegetative state for five years, when Adrian Owen, a neuro-scientist then at the University of Cambridge, UK, put him into a functional magnetic resonance imaging (fMRI) machine in 2010 and started asking him questions.

Communication with patient in vegetative state via fMRI

- Incredibly, he provided answers. A change in blood flow to certain parts of the man's injured brain convinced Owen that patient 23 was conscious and able to communicate. It was the first time that anyone had exchanged information with someone in a vegetative state. researchers asked patient 23 to use that capability to answer yes-or-no questions: imagine playing tennis for yes, navigating the house for no.
- Can ask asking patients whether they feel pain. Still, he shies away from asking patients the toughest question of all — whether they wish life support to be ended
- There are 10s of thousands of people in vegetative states; 20% of them are capable of communicating; a population of totally locked-in patients
- Use of EEG can allow team to ask up to 200 questions in 30 minutes
- Another method: Sucking a lemon, for example, can produce a pH-level change in the mouth and a recognizable brain signal.

Brain response, rather than speech: Talking to the unconscious

Yes =
Playing tennis:
Suppl. Motor Area



No =
Walking your house:
parahippocampal gyrus (memory),
posterior parietal cortex (planning movements)
lateral pre-motor cortex

In a 2006 landmark experiment, researchers asked a woman who suffered a brain injury and was in a seemingly vegetative state to imagine herself playing tennis or moving around the rooms of her house. Same as healthy adults asked to imagine doing the same tasks. Answered 5 of 6 questions correctly

Eyewitness Testimony

- Eyewitness misidentifications are known to have played a role in 70 percent of the 349 wrongful convictions that have been overturned based on DNA evidence (so far).
- Jury Trial: witness points to defendant and says "It's him."
- Eyewitness testimony, especially if confident, has disproportionate effect on belief by jurors
- But memory can be altered by presenting misdirecting questions
- Answering the question "How fast was the white sports car going when it passed the barn while traveling along the country road?" increases witnesses' later reports of having seen a nonexistent barn in an earlier video (Loftus, 1975, p. 566).

Eye witness testimony

- Earlier Studies: Convincing evidence that eyewitness testimony is poor.
- Newer studies:
  - ID made early on are accurate
  - a high-confidence ID is highly accurate; suspect identifications made with high confidence were, on average, 97 percent accurate!
- Legal system nonetheless habitually relies on unreliable (contaminated) eyewitness evidence from later IDs.

Nancy Kanwisher at MIT: Brain's localization specialist

Reading minds: a face or a place

- Kanwisher was able, with nearly perfect accuracy, to tell when the people in fMRI were seeing pictures of faces and when they were seeing pictures of places by examining whether the subjects' brains showed activation in the fusiform face area.

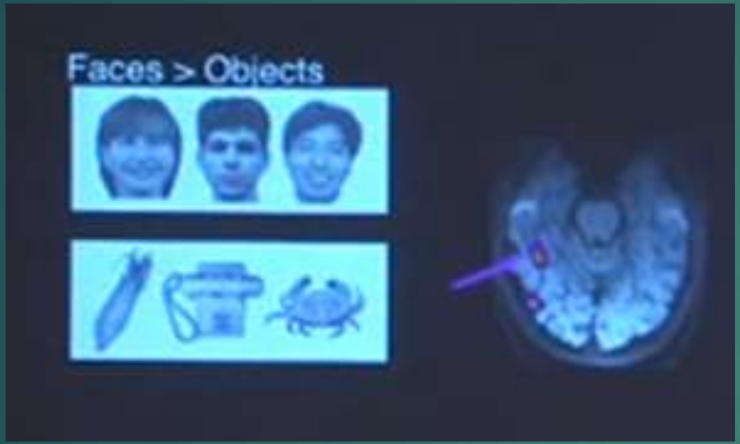
- She also identified what she calls the parahippocampal place area, which is differentially activated when people see places

- 80 percent accuracy in predicting whether a person was visualizing—was thinking about—a face or a place

- Way to talk to locked in syndrome: yes = place; no = face

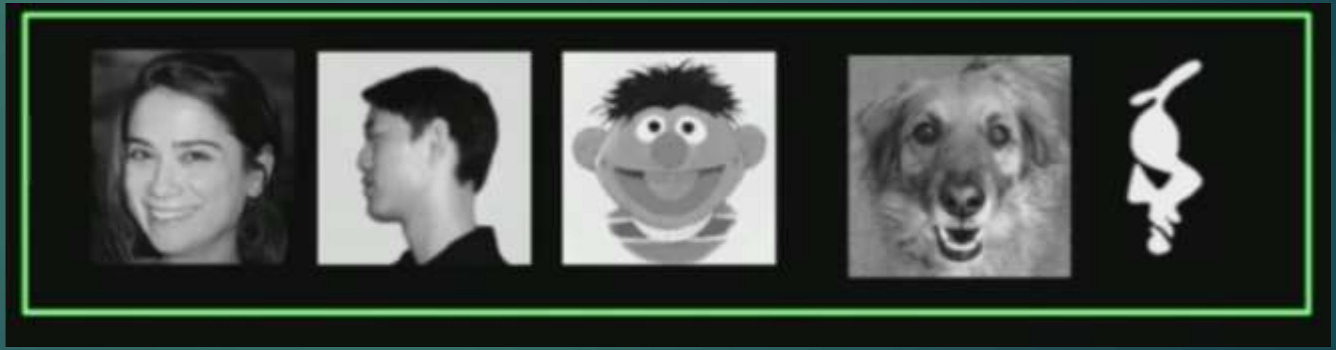
Fusiform Face Area (FFA): Face Recognition

Brain regions for face vs. object recognition



<u>Genetic</u>: Face perceptual abilities are inherited

No correlation between IQ & face recognition



Confirmed in epileptic pt with 2 electrodes on FFA

Nancy Kanwisher at MIT

Capgras Syndrome: The trouble with disconnections:
I know your face, but you are not familiar

- When wife walks into the room, husband, with Capgras, is convinced that she is an impostor. When wife calls him on the phone and he hears her voice, he instantly recognizes her.

- Capgras Syndrome: you are an imposter
  - FFA Visual Recognition ok;
  - amygdala/Hippocampus familiarity circuits ok;
  - but 2 are disconnected

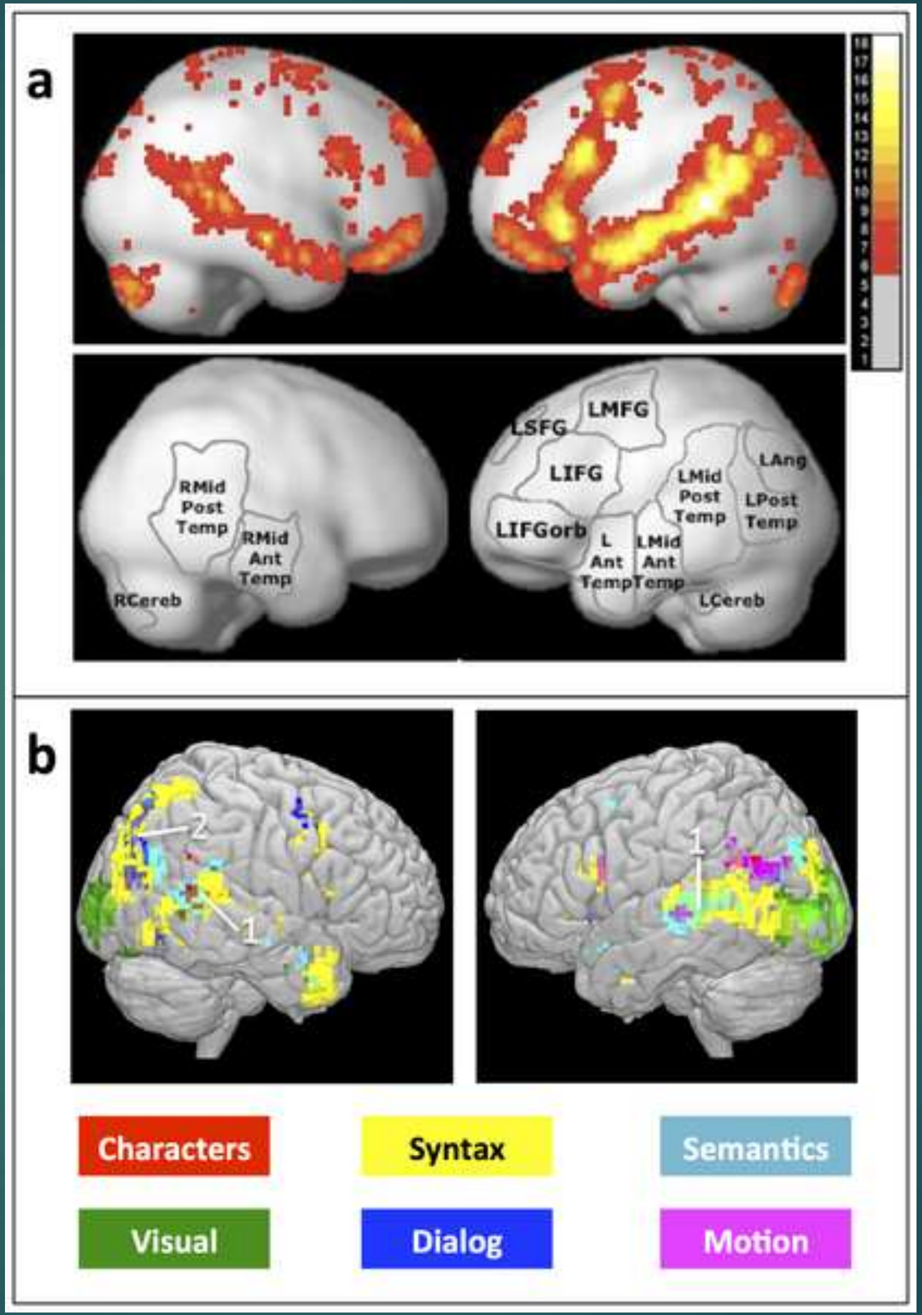
- V. S. Ramachandran: syndrome due to a disconnection between the FFA (visual face recognition↑↑) and the limbic system (amygdala and hippocampus) (emotional familiarity↓↓); auditory recognition normal

Reading Harry Potter

- Model is able to classify which of two novel passages of the story is being read with an accuracy of 74% based on neural activity while reading.
- Brain areas involved:
  - Angular Gyrus: lexical semantics (bilateral); <u>physical motions of story characters</u>
  - Inferior frontal: high level word integration (right); semantics of individual words (left); <u>Physical motions of story characters</u>; <u>dialog among story characters</u> (right)
  - Inferior temporal, Fusiform Gyrus, Precentral Gyrus, Precuneus, Supplementary Motor Gyrus
  - Middle temporal: semantics of individual words (bilateral), <u>identities of different story characters</u>
  - Superior temporal: sentence length (L), syntax (R); semantics of individual words (R); Physical motions of story characters; identities of different story characters, <u>protagonist's perspective</u> (right)
  - Temporal pole: high level word integration (bilateral); Occipital: word length (left Visual Word Form Area)
  - Temporal Parietal Junction: sentence length/syntax (left & esp. right); dialog among story characters (right); Bilateral temporal: both semantic and syntactic meaning

Reading Harry Potter:

Map of the patterns of representation: regions involved in sentence processing:
which information process they represent.



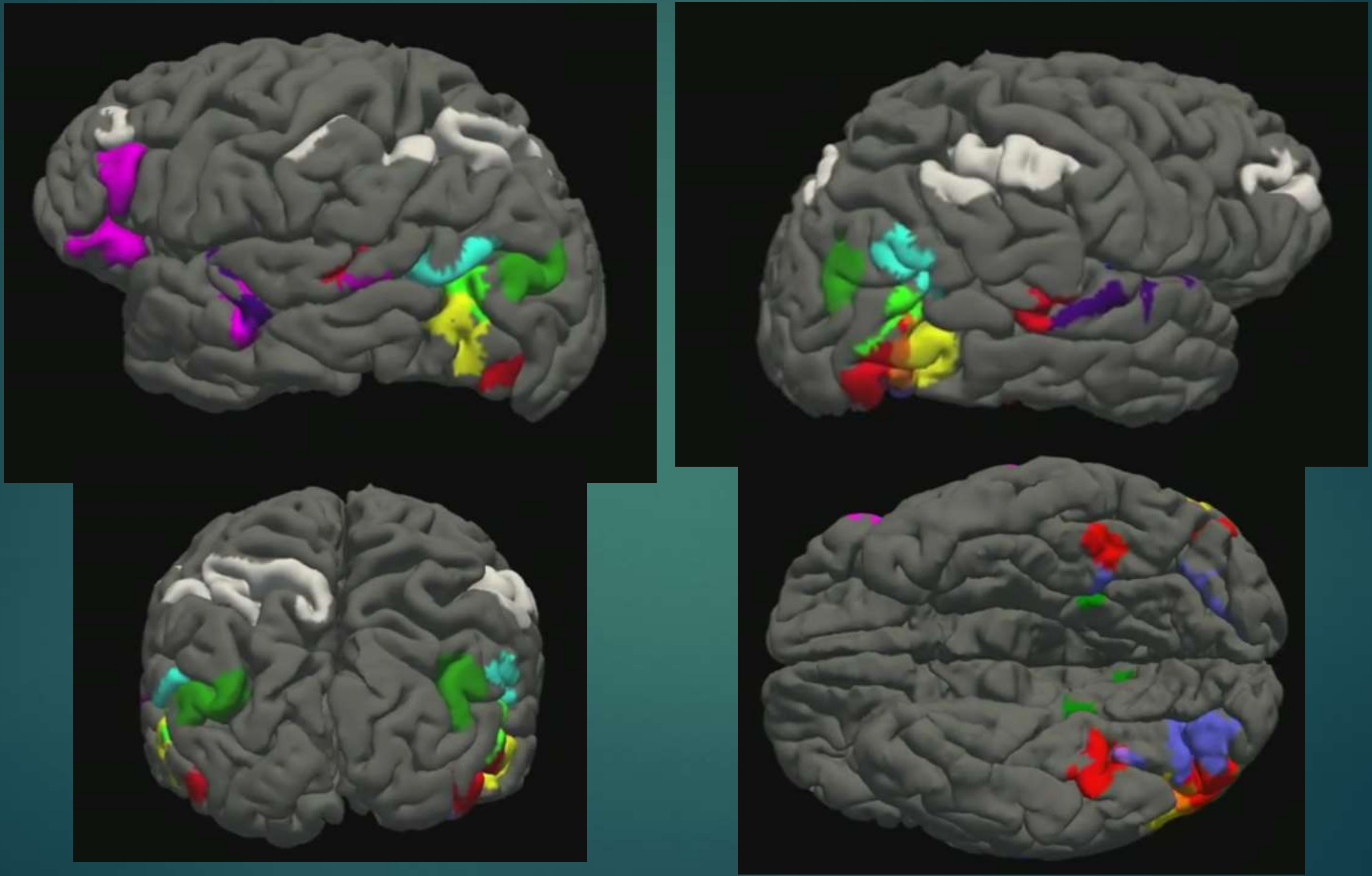
Wehbe L, Murphy B, Talukdar P, Fyshe A, et al. (2014) Simultaneously Uncovering the Patterns of Brain Regions Involved in Different Story Reading Subprocesses. PLoS ONE 9(11): http://www.plosone.org/article/info:doi/10.1371/journal.pone.0112575

In brain, Perception/Seeing = Imaging

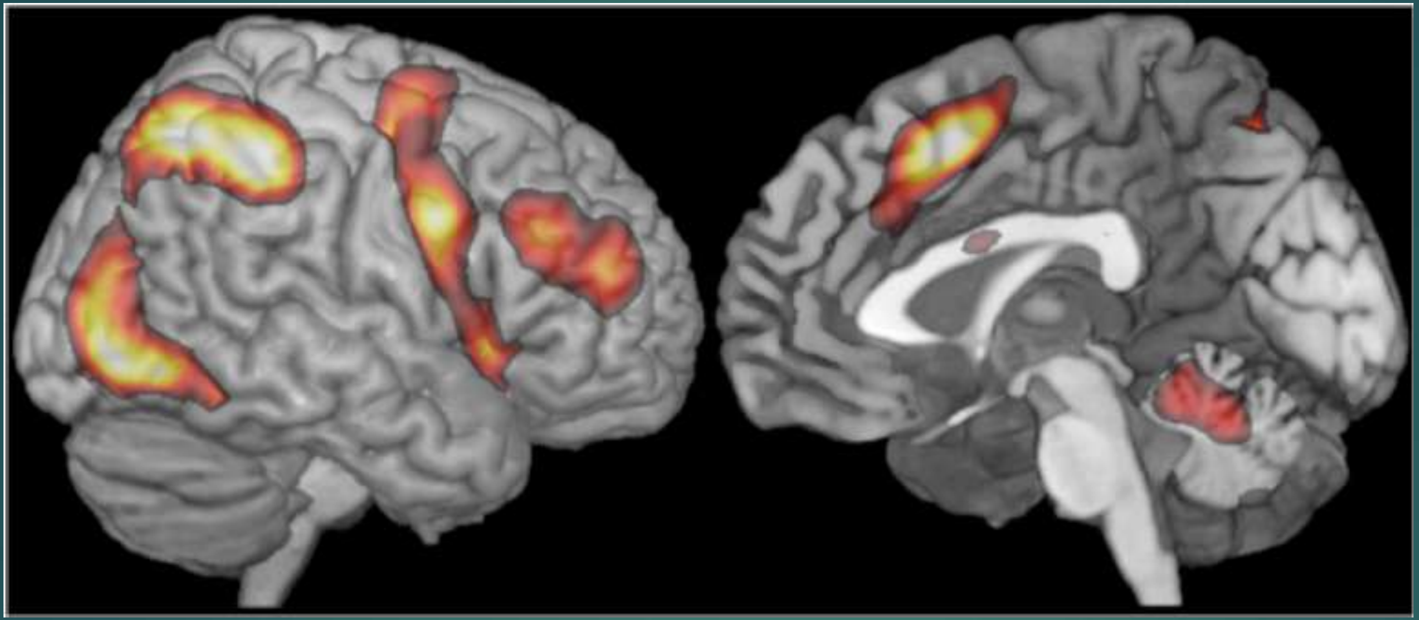
- Same areas are active when you are imagining faces and places, with no physical perception, as when they are actually looking at faces and places.

- It’s not just what you are physically seeing, but what you are consciously aware of that is processed by these areas.

These processors are invariant (genetic); Same places in everyone

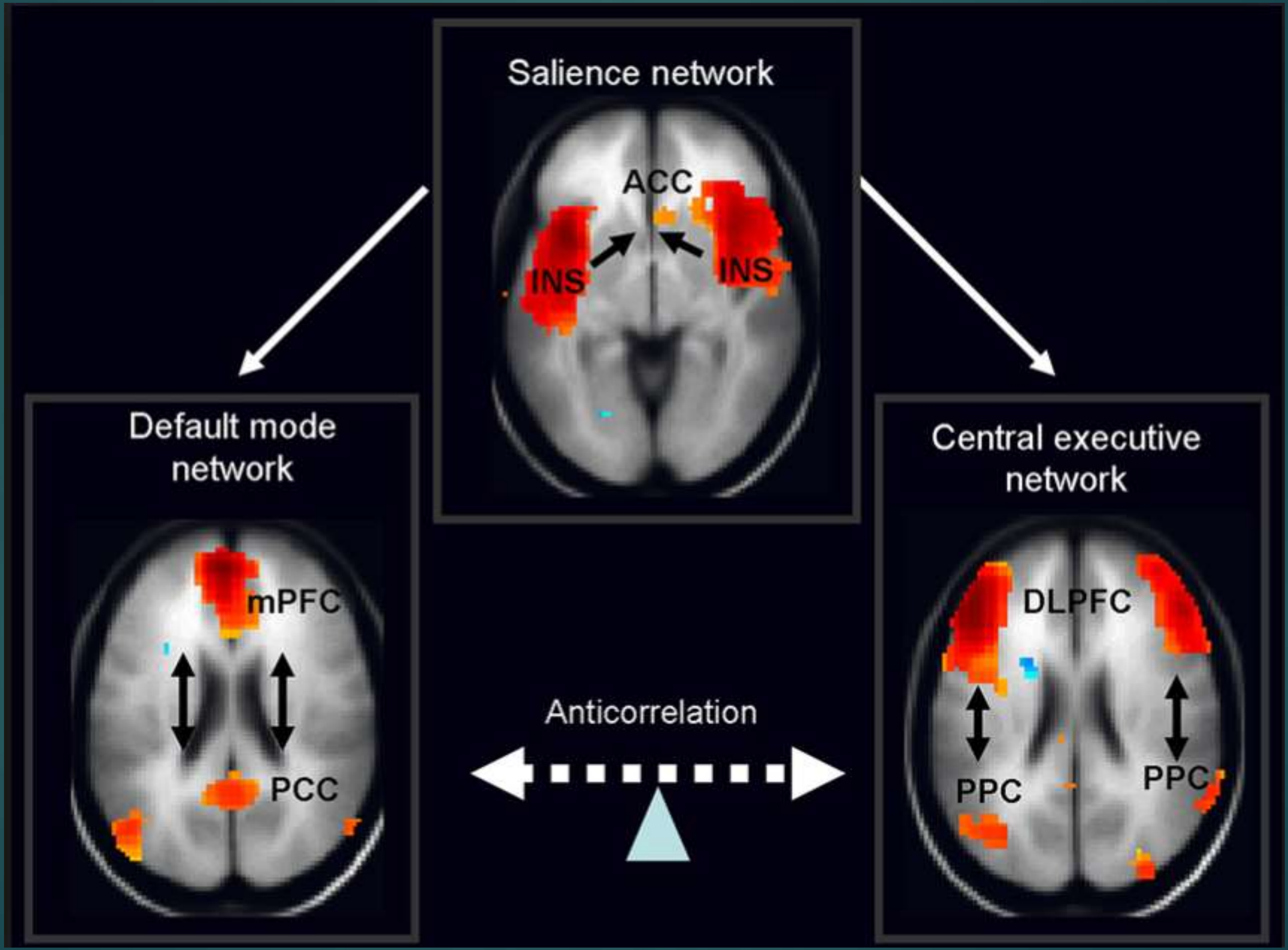


Multiple Demand Processors: 7 areas



- Problems used: Localization, math, multisource interference tasks, spatial and verbal WM, Stroop
- Opposite of DNM areas: medial temporal lobe, parts of the medial prefrontal cortex, the posterior cingulate cortex, and the precuneus

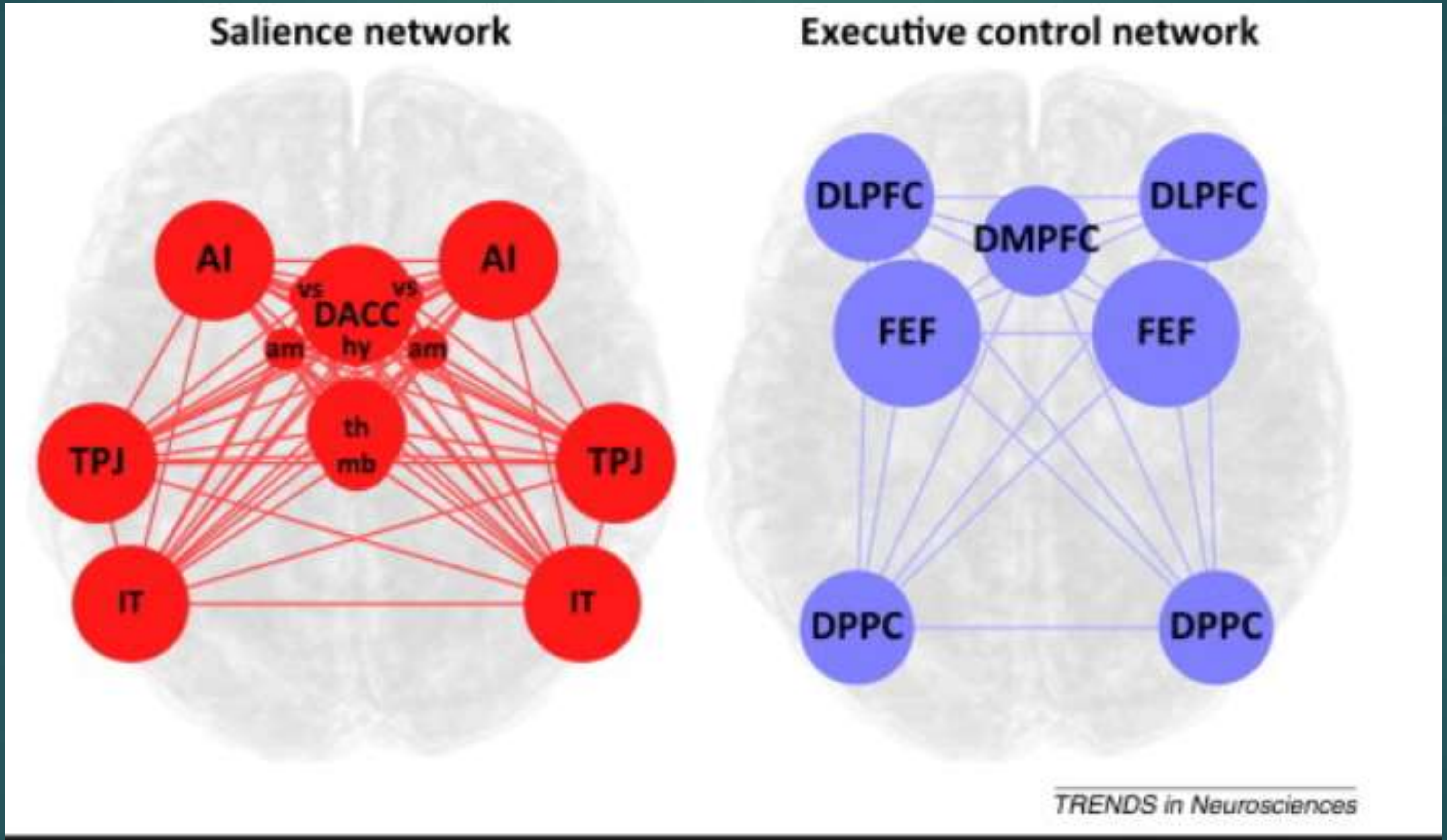
3 Major Networks



Salience & Executive Network regions

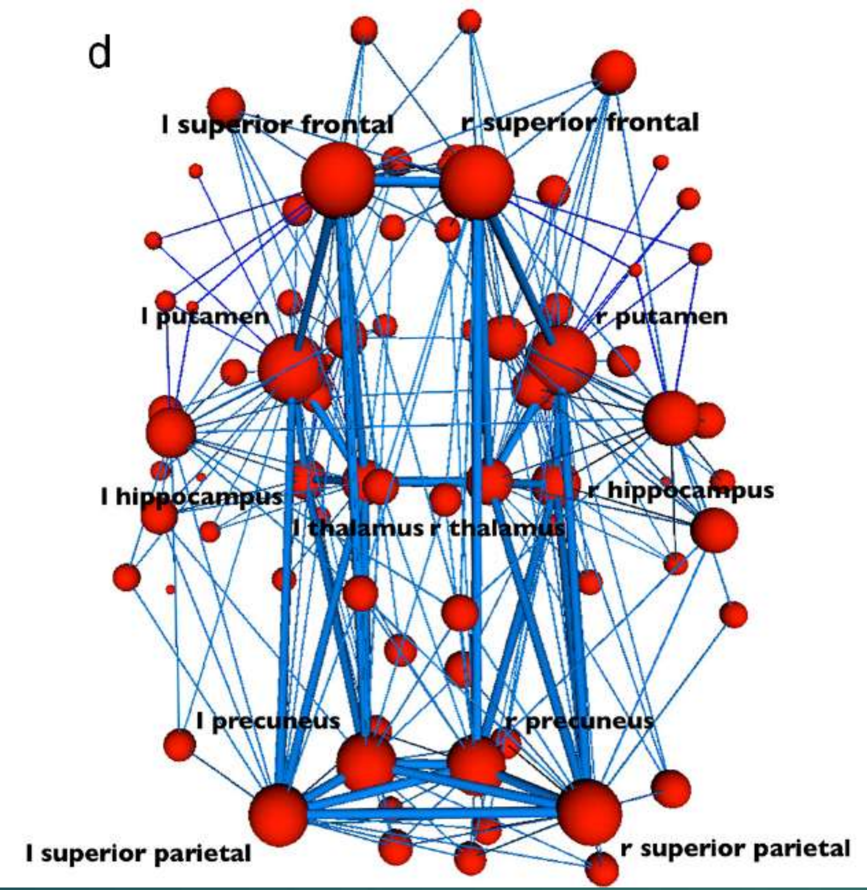
What's Important

What to do about it

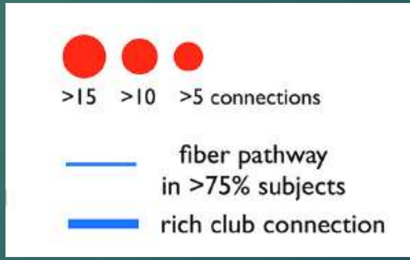


Intrinsic functional connectivity

12 Rich World Hubs

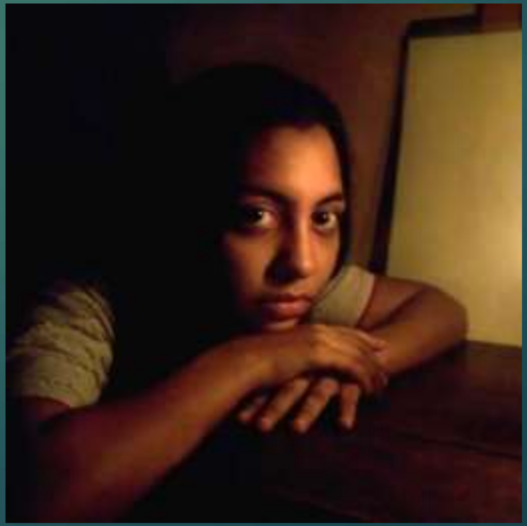


Bilateral frontoparietal regions, including precuneus, superior frontal and parietal cortex, hippocampus, thalamus, and putamen are individually central & also densely interconnected, together forming a rich club.

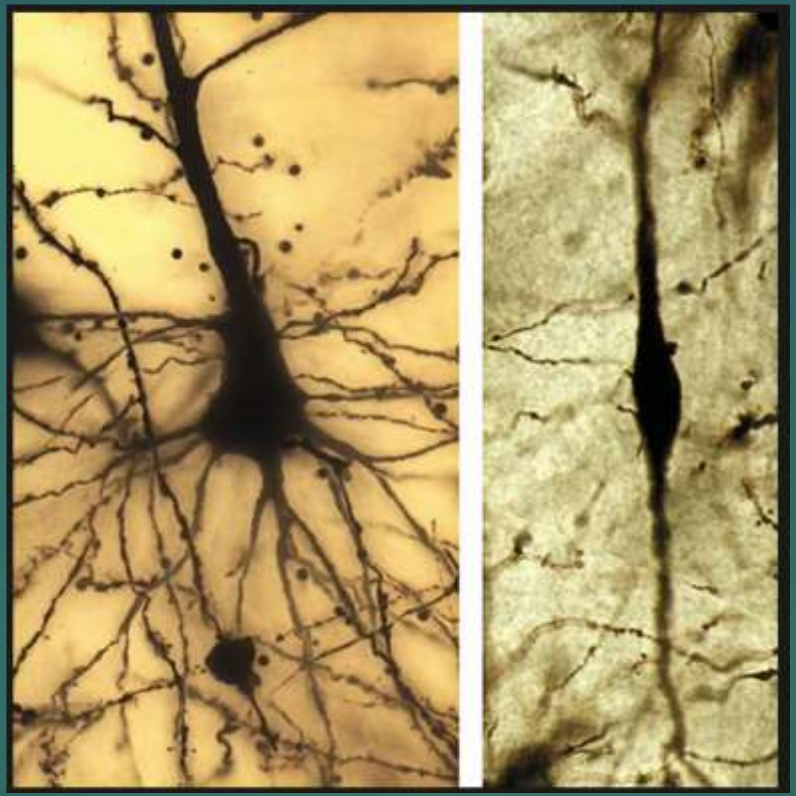


Connections between rich-club regions (dark blue) and connections from rich-club nodes to the other regions of the brain network (light blue). The figure shows that almost all regions of the brain have at least one link directly to the rich club.

What is the neuronal commonality in social animals with large brains?



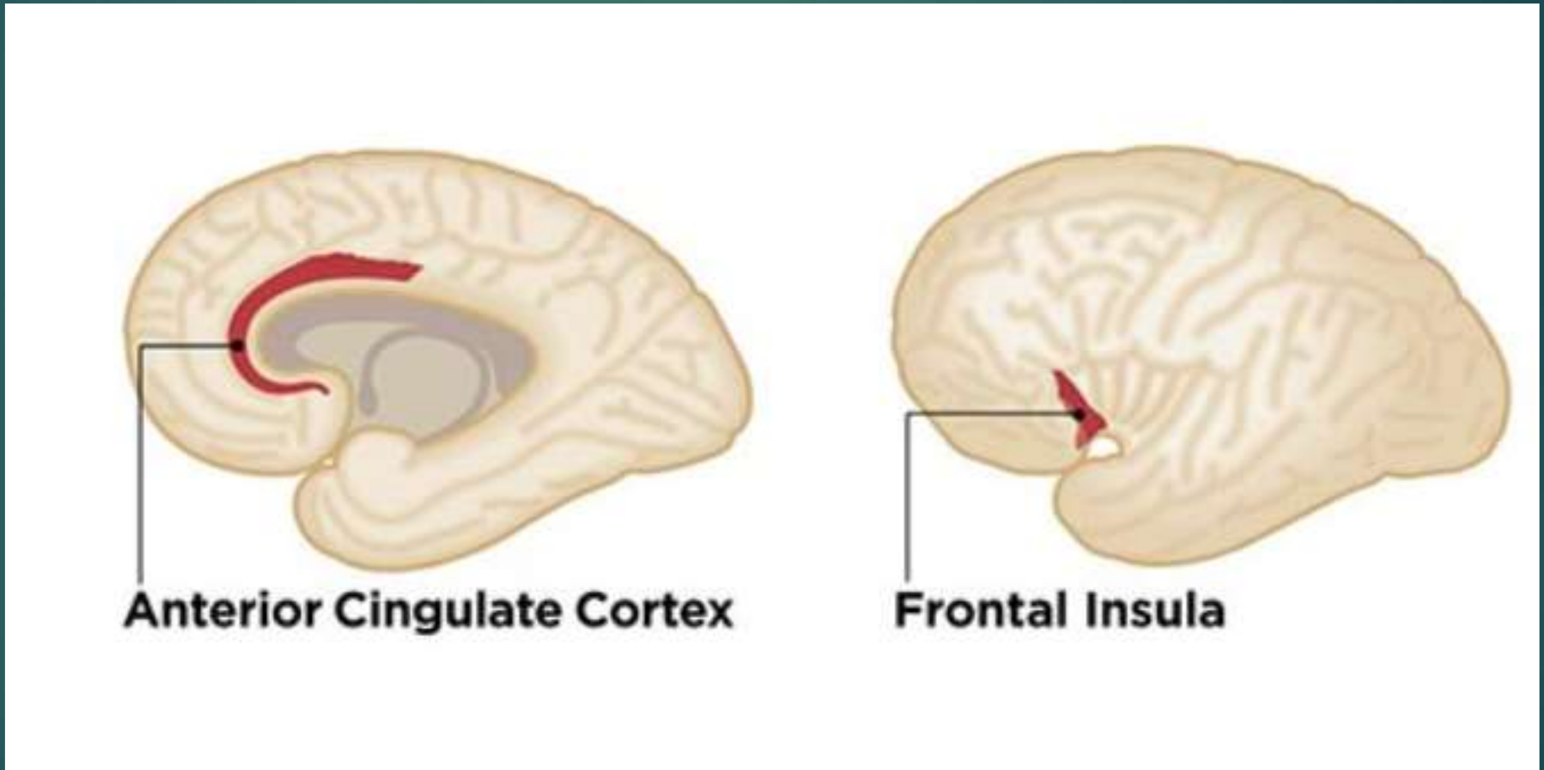
Brain Cells for Socializing? Von Economo neurons



A focal concentration of VENs in ACC and FI distinguishes large-brained, highly social mammals from other mammals.

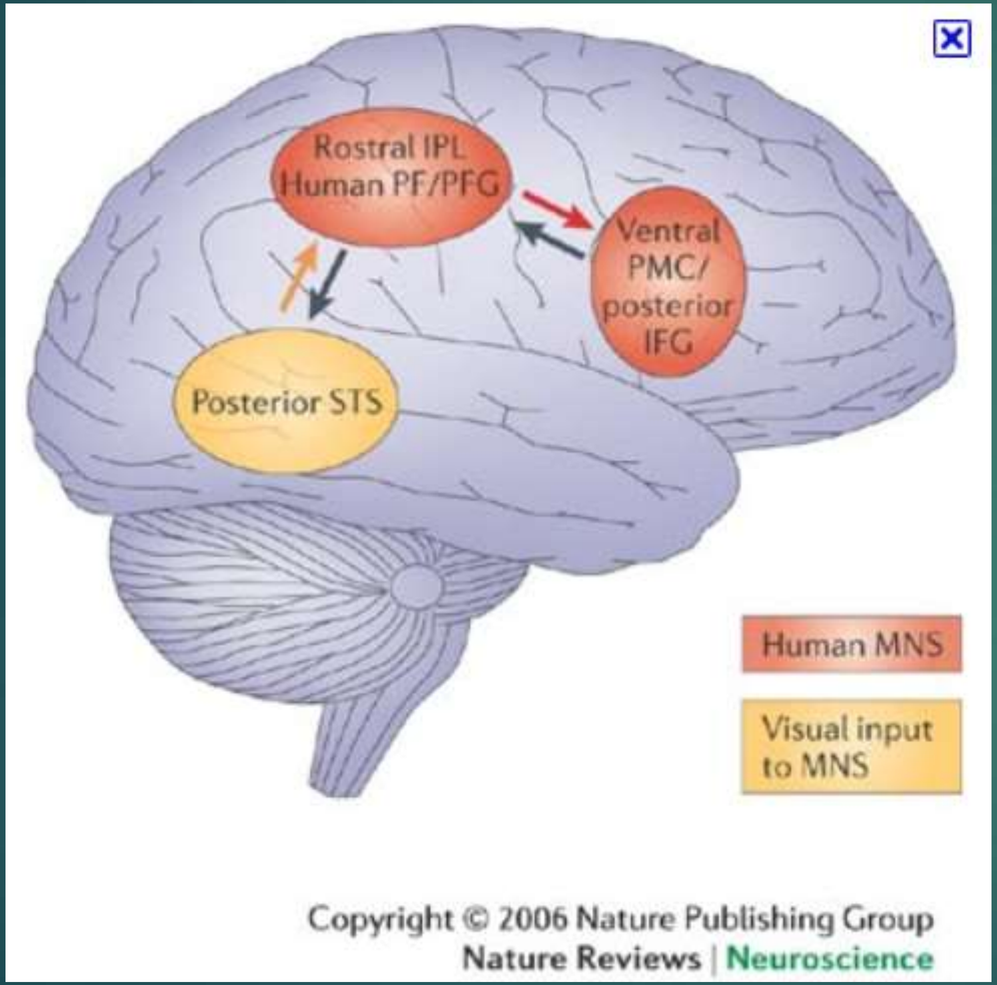
(Allman et al., 2010; Hakeem et al., 2009; Hof and Van der Gucht 2007; Nimchinsky et al., 1999; Rose 1928)

Location of VENS: ACC & FI



The FI features the other layer 5 neuron, the fork cell, which is scarcely seen in ACC.

Mirror Neurons: How we read others



STS: superior temporal sulcus

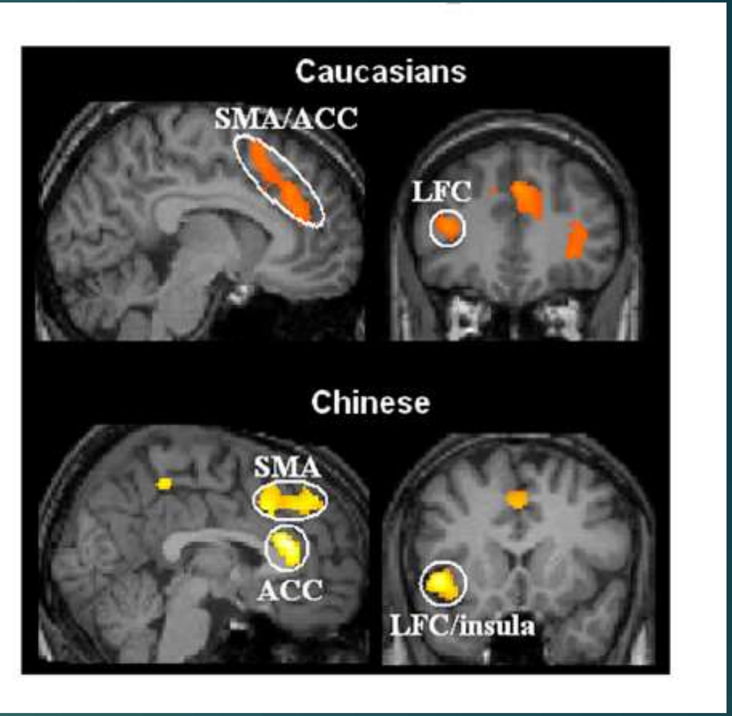
Monkey who saw researcher lift a banana

Gandhi neurons: dissolve the barrier between you and me

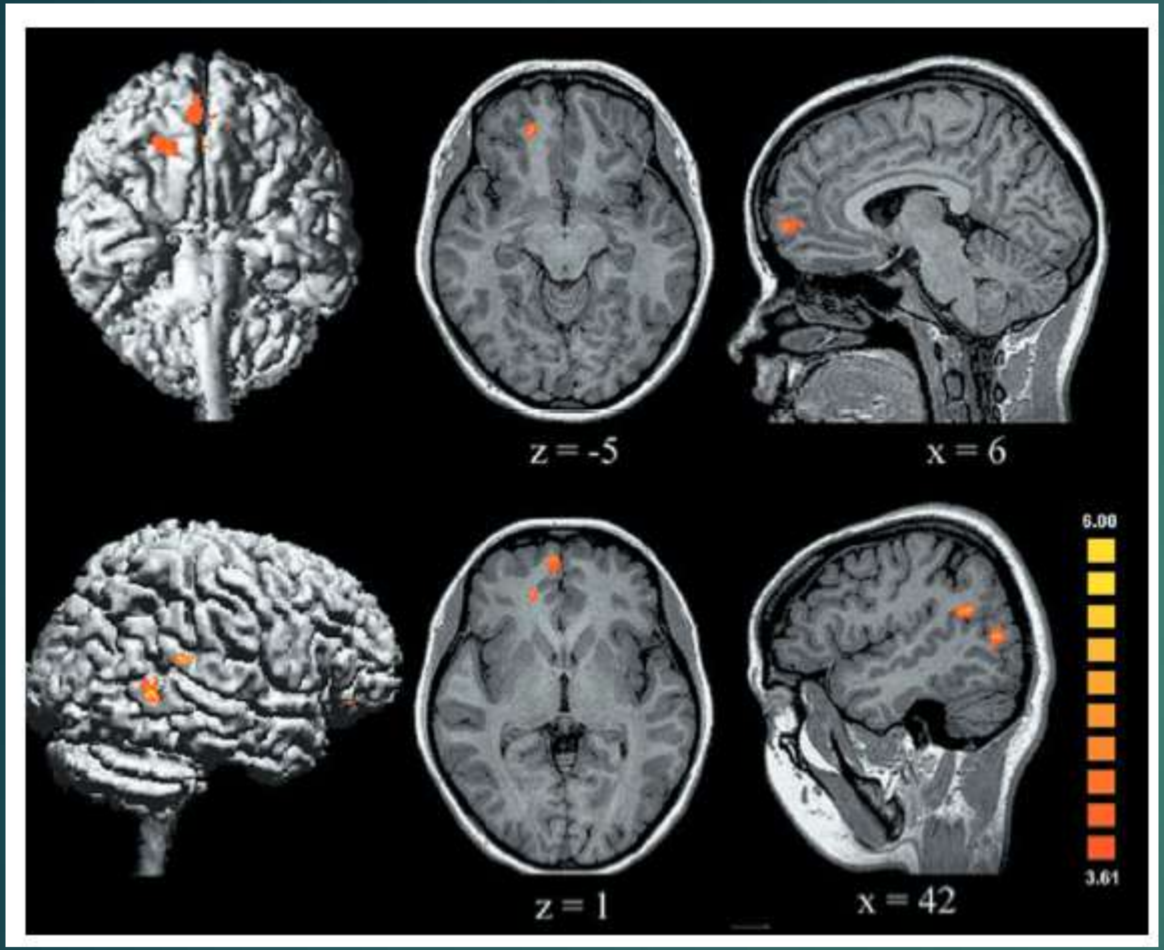
Activation in response to seeing other doing something

Loyalty & Empathy & Prejudice in the In Group:
Do You Feel My Pain?

- Inborn Prejudice: People show more empathy to our own group.
- ACC mainly contributes to the affective component of empathy
- ACC & FI activate when witnessing someone in pain
- Own-race bias in ACC activity in empathy for pain
- Those with damage in the right ACC were least likely to feel embarrassment.



Neural correlates of morality

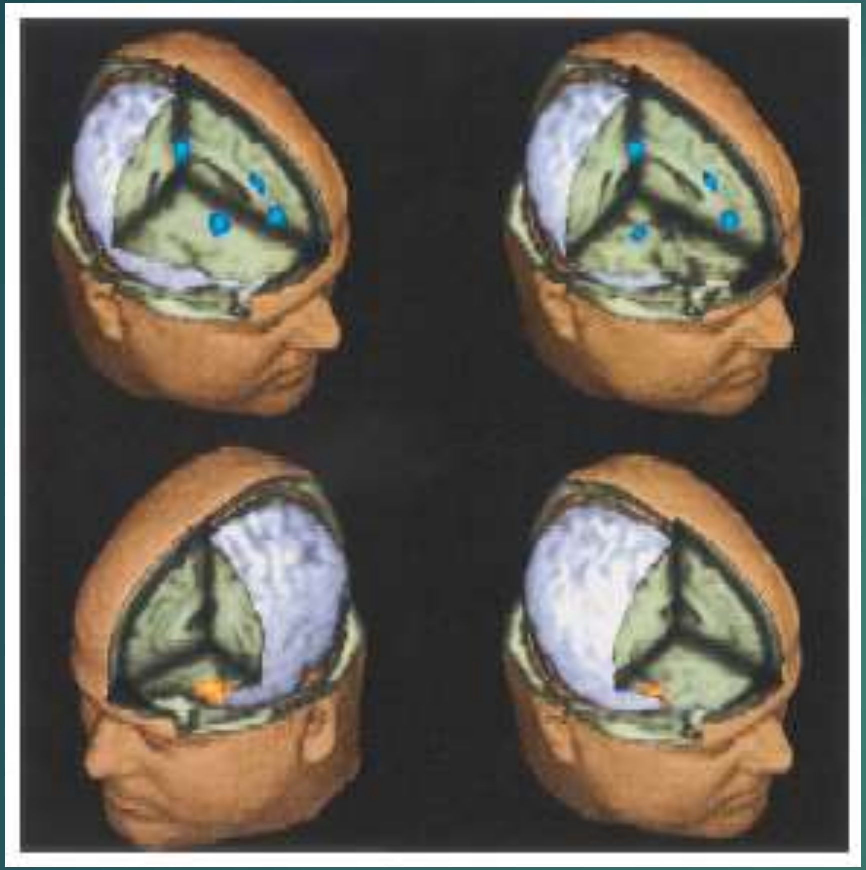


Areas shown are <u>those activated by moral versus non-moral unpleasant visual stimuli</u>. Differential activation was also seen in moral vs. neutral conditions.

(Moll et al J Neurosci 2002)

How would we interpret someone's scan that does not show this pattern of activation. Are they immoral? Amoral?

Forensic neuroimaging: violent offenders



Criminal psychopaths show different patterns of emotional-related activity compared to non-criminal control subjects (Kiehl, Biol Psychiatry 2001)

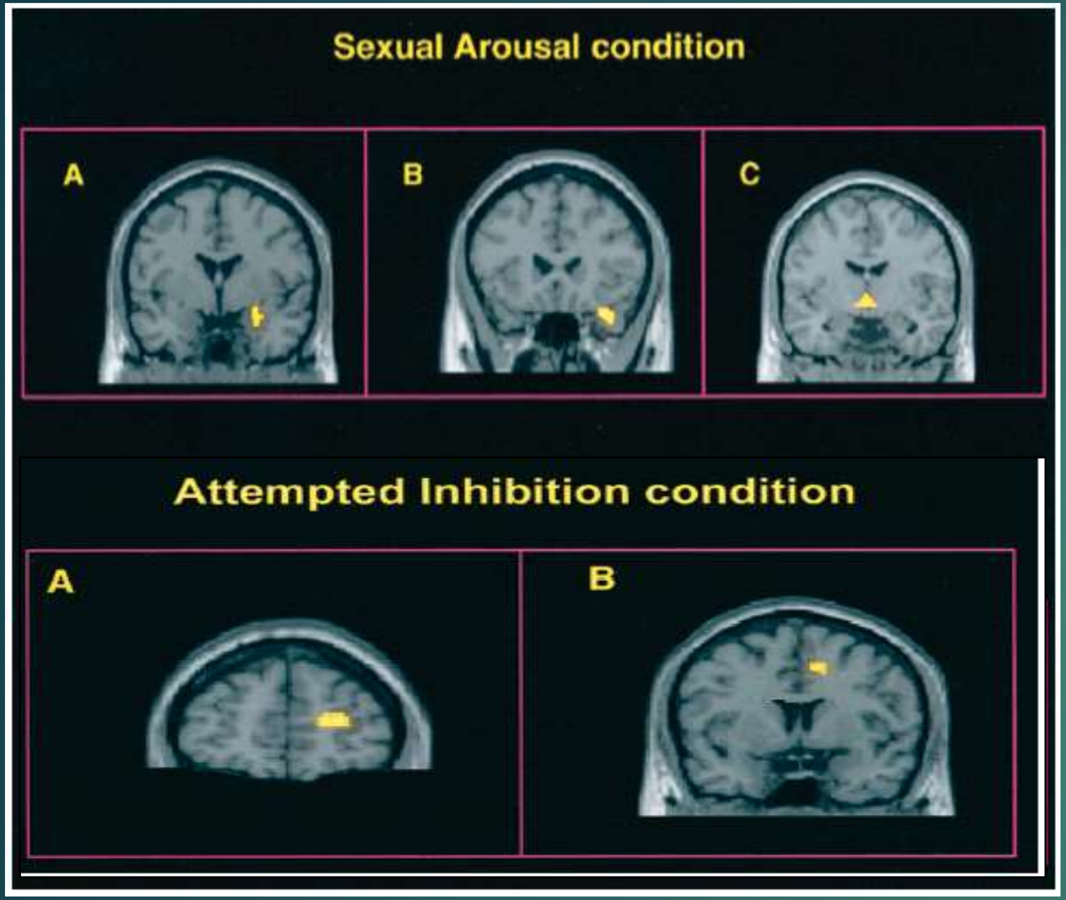
Areas of less activation

Areas of more activation

Will this change our diagnosis of "psychopathy" to a brain scan rather than observed behavior?

Would we incarcerate "brainscan-psychopaths" before they commit a crime?

Behaviour prediction: imaging inhibition



Beauregard et al, J Neurosci 2001

In noncriminal male subjects, sexual arousal in response to erotic films produced activation in limbic and paralimbic regions (compared to viewing neutral films),

but attempted inhibition of arousal was restricted to activation of right superior frontal gyrus and anterior cingulate.

If scanning shows a *lack* of inhibitory ability, are you likely to commit a sexual crime?

If one's brain cannot inhibit arousal, is one responsible for impulsive actions?

Should one be required to register with authorities or accept treatment?

Back to Neuroscience and the Law

Neuroscience and the Law

- Cognitive neurosciences aim is to explain the psychological and neurobiological mechanisms that give rise to thought and action.
- The remarkable neuroscientific advances made in recent decades have not gone unnoticed by the legal community.
- Increasingly, lawyers are offering neuroscientific evidence during litigation.
- In the civil (non-criminal) domain, for example, one core issue of the NFL concussion litigation concerns the neurological effects of repetitive impacts to the head

NS and the Law

- Neuroscience appears in contexts as varied as medical malpractice litigation, on one hand, and suits seeking disability benefits, on the other.

- In the criminal domain, many defendants now offer evidence of brain abnormalities — such as tumors, cysts, or unusual features — to argue during the sentencing phase of a trial that they should receive a lesser punishment than would someone who acted identically, but with a "normal" brain.

- Former mayor of San Diego Maureen O'Connor, for instance, claimed that a tumor contributed to her gambling addiction, which in turn led to the embezzlements of which she was convicted

NS and the Law

- Over the past decade, more than 1,000 judges have participated in training sessions on the NS and the law
- Neurolaw publications numbered barely 100 in 2005, but swelled sixteen-fold over the next decade, to over 1600 today.
- Across the same time span, over 150 law and neuroscience conferences and symposia were hosted, a variety of law and neuroscience societies formed around the globe, and a number of law schools and other departments started offering neurolaw courses,
- A multi-part television program, various radio documentaries and interviews, a complimentary electronic newsletter (Neurolaw News) and more than 50 neurolaw video lectures (at https://www.youtube.com/user/lawneuroorg).

The Law

- The law takes a non-determinist approach which presumes that individual actions are the end result of an individual's volitional decisions and choices—not merely the mechanistically determined outcomes of genes, brain circuitry, or anything else.

- This is why criminal punishment hinges on whether or not a defendant had the requisite *mens rea* ('guilty mind' including consideration of premeditation and intent), and not on whether the crime was causally predetermined by the laws of nature or a certain Gene x Environment variable.

Perennial questions of legal system

- Is this person responsible for his or her behavior?
- What was this person’s likely mental state at the time of the act?
- How competent is this person? Is this person lying?
- What does this person remember? How accurate is this person’s memory?
- Is this person really in pain, and – if so – how much?
- How can we improve juror and judge decisions?

- Can NS resolve these issues?

Science and the Law

- The domains of science and law have very different goals.

- Science attempts to uncover truths and the law attempts to fairly and effectively govern the behaviors of large populations.

- In the court, explanation isn’t legal justification.

- Advances in the cognitive neurosciences effectively guarantee a future in which the law increasingly interacts with neuroscientific evidence.

- Gradual shift from nearly exclusive reliance on structural brain evidence (in cases involving any brain evidence) to increasing reliance on functional neural assays.

Daubert ruling: Admission of Experts

- Case that determined the standard for admitting expert testimony in federal courts
- In *Daubert v. Merrell Dow Pharmaceuticals*, the Supreme Court ruled that scientific evidence need not be 100 percent reliable to be admitted in trial.
- Supreme Court has ruled against the admissibility of polygraph evidence, even when the accuracy is as high as 95 percent.
- In *Daubert*, the justices provided judges greater leeway in accepting or rejecting admission of such evidence.
- Although relevant, general scientific acceptance is no longer a necessary precondition. Instead, consideration may include whether a procedure or theory has been peer reviewed, has an error rate, and whether there are accepted standards for the technique.

M’Naughten Case: Insanity Defense

- Since the celebrated M'Naughten case in 1843, involving a paranoid British assassin, English and American courts have recognized an insanity defense only for those who are unable to appreciate the difference between right and wrong: did the accused know that what he was doing was wrong when he did it.

- This is consistent with the idea that only rational people can be held criminally responsible for their actions.

- Used in less than 1% of criminal proceedings and is only successful in 25% of those cases.

- The defendant has the burden of proving the defense of insanity by clear and convincing evidence.

Neuroscientific evidence

- <u>Influence of neurolaw is clearly growing.</u>

- <u>Neuroscientific evidence</u> has <u>persuaded jurors to sentence defendants to life imprisonment rather than to death penalty</u>

- <u>Courts have also admitted brain-imaging evidence during criminal trials </u>to support claims that defendants like John W. Hinckley Jr., who tried to assassinate President Reagan, are insane.

Areas of Application of legal NS

- Questions of guilt / responsibility.
- Detection of lies / hidden prejudices.
- Prediction of future criminal behavior
- Selecting ‘unprejudiced’ jurors based on their brain activity patterns
- Legal culpability
- Sentencing effect
- Family and child custody

Categories of Relevance of NS to Law

- There are at least seven contexts in which neuroscience can be relevant to law (Jones, 2013).

- *Buttressing*: Neuroscientific evidence, most commonly perhaps, can be used to buttress other – typically behavioral – evidence.

- For example, suppose a criminal defendant has raised an insanity defense. If there is behavioral evidence consistent with insanity, those data will be the most salient evidence. If it turns out that there is also evidence of an acute abnormality in brain form or function, then the latter will buttress the former. But still need behavioral evidence.

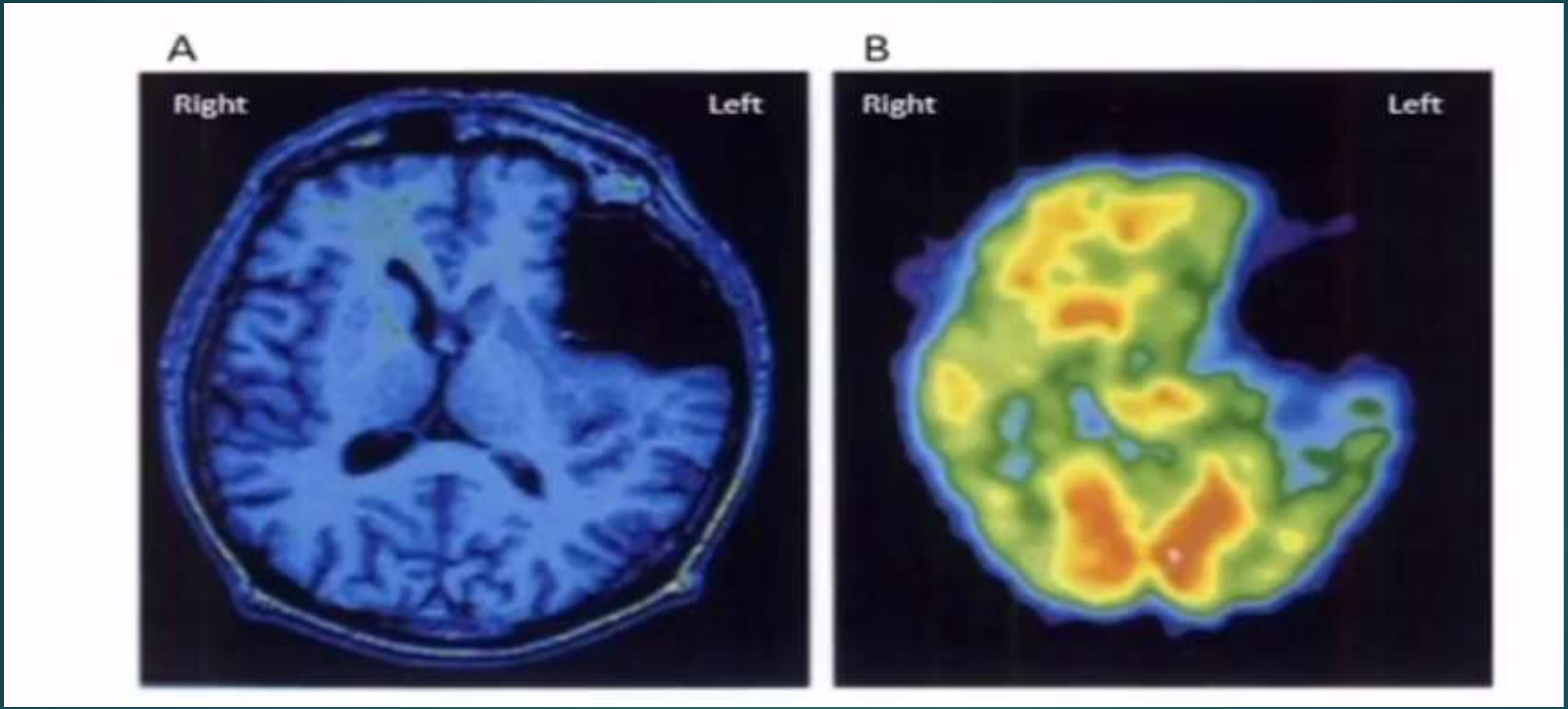
Detection and Classification of Mental States

- Generally speaking, the government must prove, in order to get a criminal conviction, both that a defendant performed a prohibited act ("actus reus") and that he did so in one of several defined states of mind ("mens rea")
- In most courts, cannot have a criminal act without a guilty mind resulting in a guilty action.
- The "Model Penal Code": By its taxonomy, culpable mental states include: purposeful, knowing, reckless, and negligent — in descending sequence of severity, each with importantly different sentencing results
- Study: combination of fMRI and machine-learning algorithms has (under laboratory conditions) predicted with high accuracy whether a subject was in knowing versus in reckless frames of mind. This was the first proof of concept that it is possible to read out a law-relevant mental state of a subject, in a scanner, in real time (Vilares et al, 2017).

NS Uses -- Detecting: Case of Herbert Weinstein's Cyst

- 1992 Case in which neuroscience began to transform the American legal system
- The case involved Herbert Weinstein, a 65-year-old ad executive who was charged with strangling his wife, Barbara, to death and then, in an effort to make the murder look like a suicide, throwing her body out the window of their 12th-floor apartment on East 72nd Street in Manhattan.
- Before the trial began, Weinstein's lawyer suggested that his client should not be held responsible for his actions because of a mental defect -- namely, an abnormal cyst nestled in his arachnoid membrane.
- To suggest that criminals could be excused because their brains made them do it seems to imply that anyone whose brain isn't functioning properly could be absolved of responsibility.

Weinstein’s Brain, 1991: basis of insanity defense?



Weinstein 2

- The prosecution at first tried to argue that evidence of Weinstein's arachnoid cyst shouldn't be admitted in court.
- One of the government's witnesses, a forensic psychologist named Daniel Martell, testified that brain-scanning technologies were new and untested, and their implications weren't yet widely accepted by the scientific community.
- Ultimately, on Oct. 8, 1992, Judge Richard Carruthers issued a Solomonic ruling: Weinstein's lawyers could tell the jury that brain scans had identified an arachnoid cyst, but they couldn't tell jurors that arachnoid cysts were associated with violence.

Weinstein 3

- Even so, the prosecution team seemed to fear that simply exhibiting images of Weinstein's brain in court would sway the jury.
- Eleven days later, on the morning of jury selection, they agreed to let Weinstein plead guilty in exchange for a reduced charge of manslaughter.
- Legal example of allowing brain images to be introduced as evidence, but not allowing testimony about what they meant.

NS Uses -- Sorting

- Neuroscience might also aid the legal system in sorting individuals into different categories, for different purposes.
- A paradigmatic example, perhaps, would be if neuroscientific measures could reliably identify criminal addicts who were most susceptible to rehabilitative interventions.
- In theory, the legal system could then send some such individuals into drug rehabilitation, instead of into the general prison populations

NS Uses -- Predicting

- Over time, neuroscience may make important contributions to law's efforts to predict various kinds of behaviors.

- 2 studies: initial evidence that certain brain-based variations in incarcerated individuals predict some of the variance in the probability of their rearrests after release. It was a small part of the variance, and the magnitude of the effect is debated due to questions about analytic approach

- Parole boards could revise their actuarial approaches to predicting recidivism (including age, sex, type of crime, etc.), such observations raise the possibility that at some point in the future neuroscientific measures may become relevant.

(Aharoni et al, 2013, 2014); (Poldrack, 2013; Poldrack et al., 2017).

NS Uses -- Intervening

- In theory, neuroscience could aid law through the development and validation of intervention approaches.

- For example, if certain drug treatments prove to substantially decrease the probability of recidivism, psychopharmacological interventions may be recommended for inclusion as a condition of parole.

- Of course this, like many aspects of neurolaw, can raise important ethical considerations about what trade-offs we as a society are willing to make, between perceived benefits, attendant risks and costs, and individual rights

NS uses -- Explaining

- Neuroscientific methods are beginning to uncover regions of the brain, neural responses, and interactions within and between brain regions that subserve the processes by which decisions — key to the functioning of law – – are made

- These could provide new insights into why and how individuals transgress the law, in criminal or civil domains

- They could provide insights into the processes by which jurors and judges make their decisions

(Heekeren et al, 2008; Shadlen & Kiani, 2013); (Scott & Steinberg, 2008; Scott et al, 2016, Steinberg 2016).

Criminal responsibility

- Legally, explanation is not excuse
- It is still a crime, if the reason you stole the bread is because you are starving
- Criminal behavior explanation via genes, poverty, brain tumor, abuse, addiction etc. is not exculpatory under current law; you will be found guilty of a crime
- NS is being used in sentencing, not criminal culpability, side of law

Challenging Assumptions in the Legal System

- Neuroscience may sometimes <u>challenge assumptions in the legal system</u>.
- Legal system currently <u>assumes that solitary confinement is insufficiently damaging to the brain to constitute "cruel and unusual punishment</u>," and thus it is not prohibited as unconstitutional.
- There are 80,000 people, mostly men, in solitary confinement in U.S. prisons for 23 hrs a day
- If the assumption is wrong, that may provide impetus for law reform.
- <u>Solitary confinement can clearly cause 'irreversible' damage to the brain</u>**:** socially isolated people experience memory loss, cognitive decline and depression; chronic stress & depression increase cortisol levels, which kill hippocampal cells

Two Key Caveats

- There are, of course, many cautions and caveats about whether neuroscientific information should directly impact legal decisions and policy and, if so, how to carefully, sensibly, and responsibly incorporate such information
- Here we consider two especially salient, cross-cutting caveats:
- *1 - The Long Chain of Inference:* First, it is not a simple thing to reason from the presence of a brain feature (a large subarachnoid cyst, for example) to the conclusion that that feature contributed meaningfully to generating or enabling a specific behavior (such as murder).
- Such a conclusion requires a long chain of inferences, with many potential weak links. What exactly is the brain feature at issue? How long was it there? What is known to correlate with the presence of the brain feature? What are the known causal pathways of influence? In many instances, answers to one or more of these critical questions are unknown, which greatly tempers confidence in any inferences drawn

Caveats

- 2- *Unknown Frequencies of Predictors and Outcomes*
- One key limitation to drawing logical and informed inferences is that the relative frequency of a feature in the population — Mr. Weinstein's cyst, for instance — is often not known.
- What is the base rate of frontal brain cysts and murder? Without that information, we have no idea how many people are walking around in the population with the same feature, but without engaging in the same behavior as did the accused.
- Knowing the relative frequency of a predictor, as well as of the frequency of a particular outcome (i.e., the base rate), are necessary to determine the increased likelihood, if any, of engagement in an undesirable behavior given the feature in question. Without this information, proper inferences are difficult to draw. With what confidence could one say that Mr. Weinstein's cyst meaningfully, and legally, caused him to commit murder?

Charles Whitman and Texas Tower

- In 1966, he shot his wife and mother, then climbed up a tower at the University of Texas and shot and killed 13 more people before being shot by police officers.
- An autopsy revealed he had a tumor that was putting pressure on his amygdala.
- Was he responsible?

Criminal network in the brain

- 2018 Study of patients who develop criminal behavior following focal brain lesions, referred to as "pseudopsychopathy" or "acquired sociopathy"

- Neurologic symptoms can come from dysfunction in remote brain regions connected to the lesion location rather than from the lesion location itself

Criminal neural network

- Discovered a criminality-associated connectivity pattern: All lesions were functionally connected to the same network of brain regions. Not the same as lesions causing four other neuropsychiatric syndromes.
- This network includes regions involved in
  - morality, value-based decision making, and theory of mind,
  - but not regions involved in cognitive control or empathy
- These heterogeneous lesion locations are part of a single connected brain network that includes the orbitofrontal cortex, vmPFC, and anterior temporal lobes

Criminal networks: caution

- Violence or crime occurs in only:
  - ~9% of patients with traumatic brain injury,
  - 14% of patients with frontal lobe injury,
  - up to 57% of patients with frontal temporal dementia.
  - 37–57% of patients with behavioral variant frontotemporal dementia

- These findings suggest that <u>many patients with lesions lying within the criminal network will not develop criminal behavior</u>.

- Thus, <u>lesions within this identified network may increase the risk of criminal behavior</u>, but <u>should not be interpreted as an inevitable or sole cause of criminal behavior.</u>

Legal Impact of Neuroscience Evidence on jurors

- Impact of neuroscientific evidence on jurors
- For example, in the case of *State of Florida v. Grady Nelson* (2010):
  - Defendant was quickly convicted of a murder
  - Jury: execution or given life in prison without parole.
  - With Mr. Nelson's life hanging in the balance, the defense introduced qEEG evidence (quantified electroencephalography) in support of the inference that Mr. Nelson's brain was too abnormal to warrant his execution.
  - By the narrowest of possible votes, the jury gave Mr. Nelson life in prison.
  - Afterward, two jurors granted interviews indicating that the brain data had turned their prior inclinations, to vote in favor of execution, completely around.

- Two laboratory studies: images themselves appear to have no particular biasing effect on subjects — above and beyond non-pictorial neuroscientific testimony — except in the case of death penalty decisions, wherein images decreased the probability of a vote for execution

(Schweitzer & Saks, 2011; Saks et al, 2014).

Current legal Concepts & NS

- The US Legal system is premised on notions of moral agency, free will and individual responsibility.
- We punish acts that demonstrate willful intent and which violate societal notions of right and wrong.
- Recent developments in neuroscience suggest our mental states are at least partially or fully determined by brain activity, i.e. is there free will?
- Implications for the Law (and life) are enormous.

The Law: Crime & Punishment

- The law sees people essentially as:
  - rational actors,
  - capable of forming intentions,
  - weighing the consequences of their actions
  - and controlling their behavior.
- The law is inherently conservative, and rooted in ancient notions of morality and justice.
- The law is clear: Those who break the rules we have collectively agreed upon make a choice, and those poor choices should be punished.
- Presumption: We have a “self” that can choose & control behavior.

What the Law says vs.
what Neuroscience says….

- The law would have us assume that nearly everyone has the capacity to judge and control his or her behavior.

- Neuroscience is saying that isn't necessarily true.

- Dissociation of knowing rules & control of behavior: remember "Kevin" the pedophile

- A recent court in Florida ruled that failure to consider neuroscientific evidence is grounds for reversal in a death-penalty case.

Assumptions in Current Law

- <u>Ghost in the machine</u> (there is a <u>mind beyond the brain</u>)
- <u>Free will</u> (Religious Salvation & the Law depends on it)
- <u>Human reason can control behavior; knowing right from wrong = ability to not do a behavior</u>
- <u>NS suggests a different paradigm</u>

Caution

- Neuroscience has been creeping into the nation’s courtrooms with greater frequency.
- Yet the science, while much of it promising, is may not be quite ready for use as evidence in most legal cases,
- Criminal lawyers, for example, have introduced brain scans to show a defendant’s brain dysfunction, most often as mitigation in death penalty hearings.
- Lawyers also have tried to introduce brain scans to prove the existence of pain and as evidence for lie detection.

Caution

- The law is about <u>individual responsibility</u>.
- Most scientific studies of people are <u>group studies</u>, using statistics.
- The ability to apply conclusion to individuals is always variable and is potentially questionable. It has not been systematically studied by the scientific or legal communities.
- Application of results may go beyond the scientific conclusion.
- How to read scientific articles or statistics is not taught in law school.

Potential Uses of Neuroscience in Trials

Brain scans could be used in legal trials to detect current mental states:

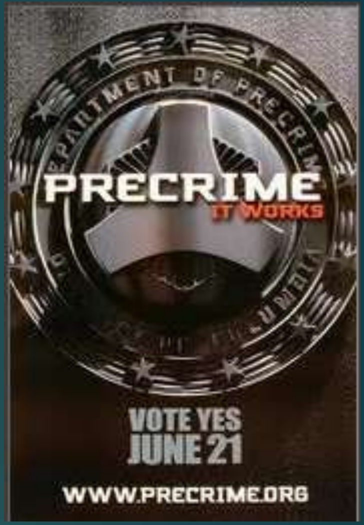
1. Lies by witnesses
2. Memories of witnesses (and jurors?)
3. Bias in jurors (and judges?)
4. Pain in plaintiffs seeking tort damages
5. Consciousness in cases of euthanasia

Neuroscience Areas to Cover

- Other categories of neuroscience effects
  - Behavioral prediction,
  - Mind-reading,
  - Criminal responsibility,
  - Treatment,
  - Cognitive enhancement.

Precrime: Politics of the brain

- Neuroscience research on violence is politically unpopular with both right and left.
- Conservatives worry that biological research will be used to let vicious offenders off the hook.
- Liberals fear that NS may be used preventively to lock up an innocent person with the profile of a violent offender i.e. the movie Minority Report); issue of future danger



For the Defense

- "Defense lawyers," Michael Gazzaniga writes, "are looking for that one pixel in their client's brain scan that shows an abnormality, a predisposition to crime or a malfunction in normal inhibitory networks, thereby allowing for the argument, 'Harry didn't do it. His brain did it. Harry is not responsible for his actions.' "

My brain made me pull the trigger

- Hundreds of legal opinions every year have begun to invoke the science of mind and brain to bolster legal arguments.

- N. Farahany, 2013: 1,500 judicial opinions from 2005 to 2012 in which an appellate judge mentioned neurological or behavioral genetics evidence that had been used as part of a defense in a criminal case.

- The biggest claim people are making is:
  - Please decrease my punishment because I was more impulsive than the next person,
  - I was more likely to be aggressive than the next person,
  - I had less control than the next person.
  - Due to my brain

NS use in courts

- Many cases where neuroscience evidence is introduced resulted in an unfavorable outcome for the defendant, but not all.
- Some defendants got decision overturned that went the wrong way by accusing their counsel of failing to look into whether he had some kind of brain abnormality.
- Jurors and judges are going to be hearing a lot more about amygdalae and orbitofrontal cortices.

Legal Use of Neuroimaging

- Courts: Neuroimages (CT & MRI) have been readily admitted in court as proof of brain disease or trauma.

- Courts have been far more guarded about admitting scans such as PET or fMRI when offered as the basis for inferences about broader issues such as competence, insanity, or criminal responsibility in general.

- Somewhat more liberal standards have been applied to offers of mitigating evidence in death penalty cases, since it is generally acknowledged that death is different.

Supreme Court Rulings: IQ level

- 2002 decision in *Atkins v. Virginia* that executing those with intellectual disability (MR) violated the Constitution's prohibition against cruel and unusual punishment.

- 2014 Supreme Court in *Hall v. Florida*: State laws that draw rigid line on IQ-test results are unconstitutional (rigid score of 70 or below). Judge Kennedy: "Intellectual disability is a condition, not a number."

- He cited a brief from the APA that IQ tests should be read as a range of numbers rather than a specific figure. Need to consider confidence intervals of scores and need for adaptive function assessment

Children: Stress Decreases Frontal Lobe volume

- Effects of childhood poverty and abuse:
- Changes following severe stress:
  - dendritic retraction and debranching,
  - reduced volume in vmPFC and mPFC and ACC.

- Gray matter volume losses in the frontal lobes in adults exposed to child adversities/ACEs:
  - dorsolateral and medial prefrontal
  - orbitofrontal regions
  - anterior cingulate

Adolescent Brains Have a Missing Part

Why do most 16-year-olds drive like they're missing a part of their brain?

BECAUSE THEY ARE.

Even bright, mature teenagers sometimes do things that are "stupid."

But when that happens, it's not really their fault. It's because their brain hasn't finished developing. The underdeveloped area is called the dorsal lateral prefrontal cortex. It plays a critical role in decision making, problem solving and understanding future consequences of today's actions. Problem is, it won't be fully mature until they're into their 20s.

It's one reason 16-year-old drivers have crash rates three times higher than 17-year-olds and five times higher than 18-year-olds. Is there a way for teens to get their driving experience more safely — giving their brains time to mature as completely as their bodies? **Allstate thinks so.**

STRENGTHEN GRADUATED DRIVER LICENSING (GDL) LAWS.
GDL laws put limitations on teen driving so kids can gain experience safely. Since North Carolina implemented one of the most comprehensive GDL laws in the country, it has seen a 25% decline in crashes involving 16-year-olds.

HAVE THE DRIVING TALK.
75% of teens surveyed said their parents would be the best influence in getting them to drive more safely. The Allstate Parent-Teen Driving Contract can help start the conversation. **Contact an Allstate Agent to get a free copy or visit Allstate.com/teen for the interactive contract.**

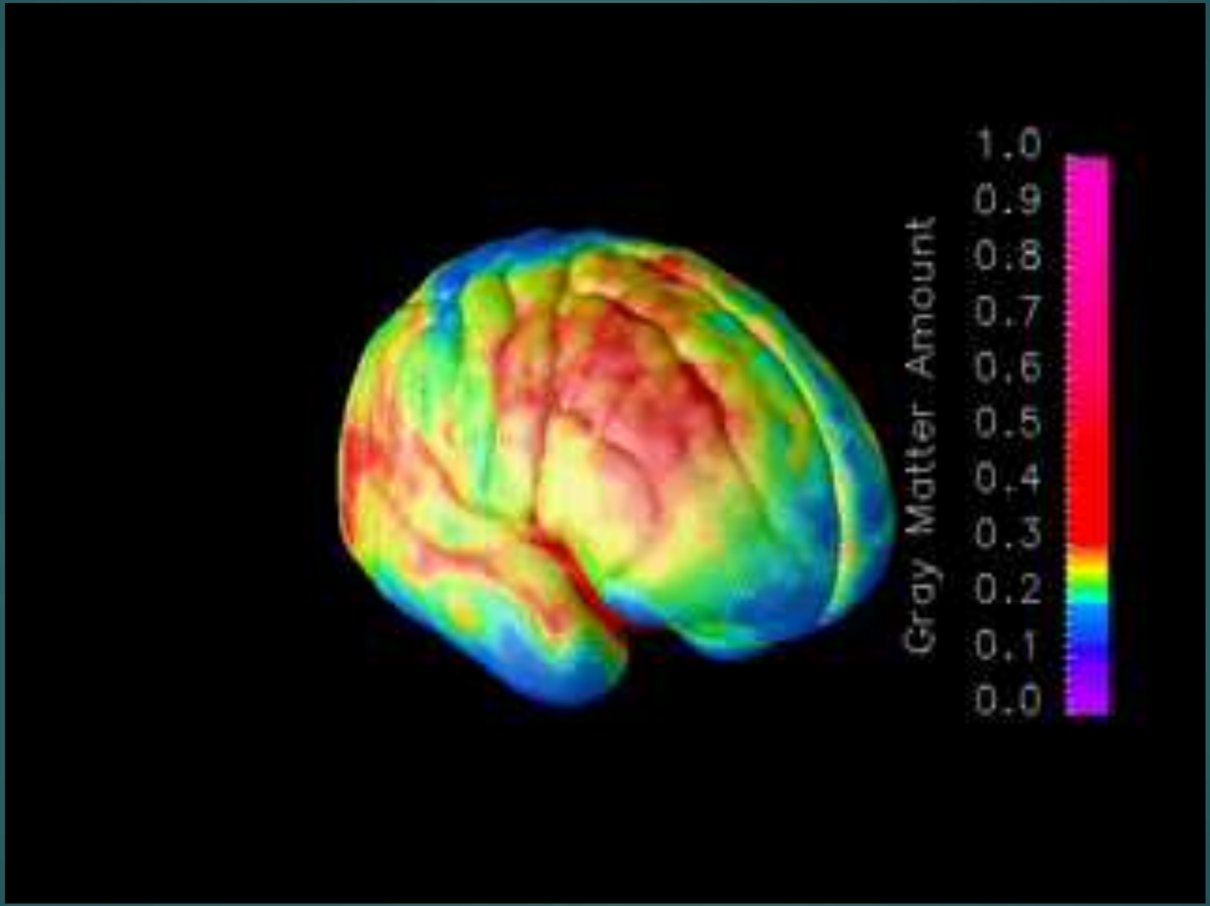
Let's help our teenagers not miss out on tomorrow just because they have something missing today.

It's time to make the world a safer place to drive. That's Allstate's Stand.

Allstate. You're in good hands.

Auto
Home
Life
Retirement

Teen Brain: age 5 to 21



Lose 50% of all synaptic connections.

The Great Pruning: A leaner brain is better

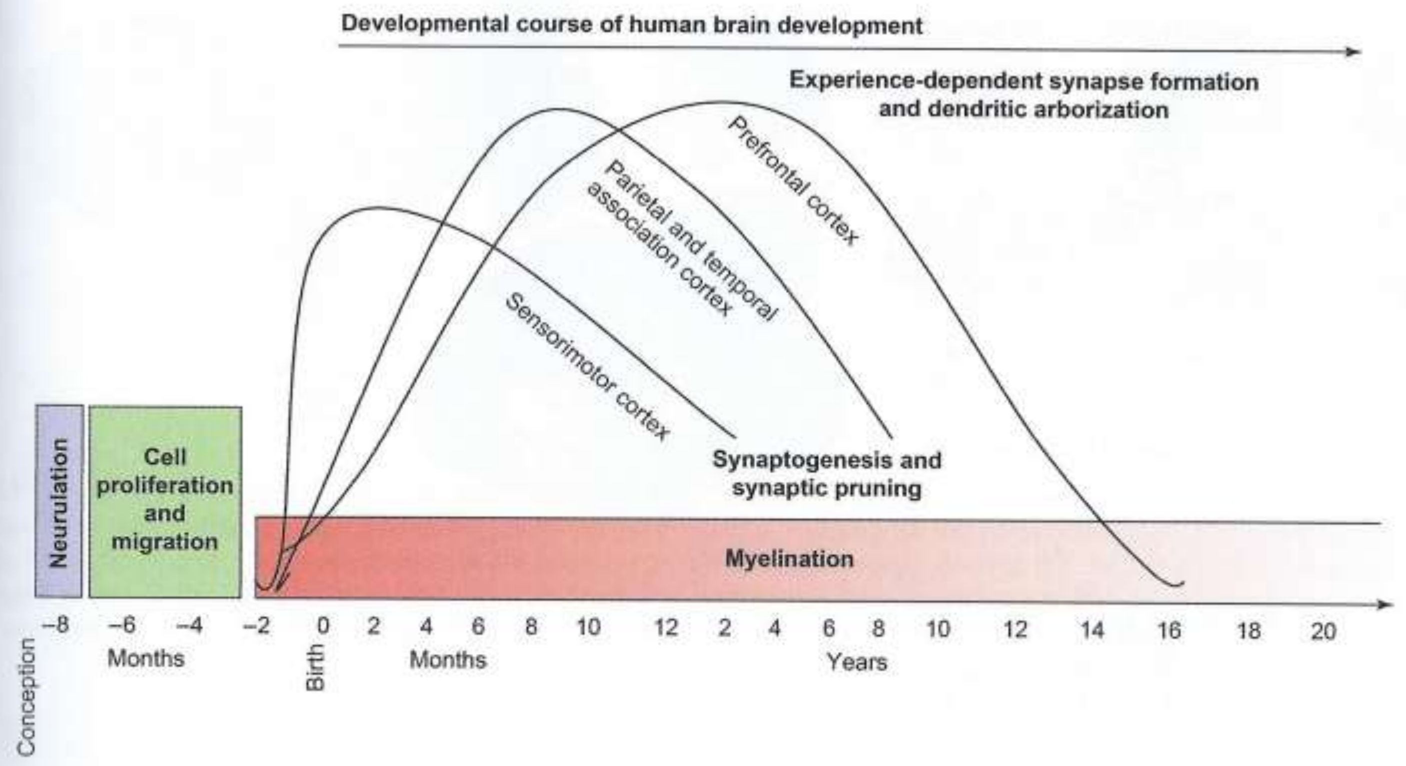


FIGURE 15.15 Developmental course of human brain development. The human brain undergoes dramatic changes in both its structural architecture and functional organization that reflect a dynamic interplay of simultaneously occurring progressive and regressive events. Although the total brain size is about 90 percent of adult size by age 6 years, the brain continues to undergo dynamic changes throughout adolescence and well into adulthood. Figure 15.15 illustrates some of these developmental changes, including proliferation and migration of cells mostly during fetal development, regional changes in synaptic density during postnatal development, and protracted development well into adulthood. Current non-invasive neuroimaging methods do not have the resolution to delineate which of these processes underlies observed developmental changes beyond gray and white matter subcomponents. (Adapted from Thompson and Nelson, 2001.) *Source*: Casey *et al*., 2005.

Adolescent Brain Development

- <u>Intellectual/cognitive maturity</u> at 16.

- <u>Pre-frontal cortex behavioral maturity</u> completed in girls around 22 and males at 25 or 26, if *normal*.

- <u>Psychosocial maturity</u> reaches similar levels of intellectual maturity at 26 and later.

Adolescents are not neurological Adults

- The teenage brain is like a car with a good accelerator but a weak brake. With powerful impulses under poor control, the likely result is a crash.

- Research demonstrates adolescents are different from adults (duh!); but we are talking about up to age 26 or older for some:
  - Impulse control
  - Thrill seeking
  - Future orientation
  - Reward sensitivity
  - Susceptibility to peer influence
  - They know right from wrong but can’t control themselves.

- Crucial decision making frontal lobes are the last to mature

Crime: an adolescent-young adult behavior

- “Today, the peak age (the age group with the highest age-specific arrest rate) is younger than twenty-five for all crimes reported in the F.B.I.'s UCR program except gambling, and rates begin to decline in the teenage years for more than half of the UCR crimes.

- In fact, even the median age (50 percent of all arrests occurring among younger persons) is younger than thirty for most crimes.”

- Adolescents, once frontal lobes are mature, can rehabilitate.

Adolescent Brain

- Psychological studies show that teenagers are reckless and impulsive, less able than adults to recognize risks and think about consequences, more susceptible to peer influence.

- Structural data suggests that full maturation of the human brain may occur as late as into one's 20s.
- Wealth of behavioral and functional neural data highlight the context-dependence of developmental trajectories; the age at which mature behavior may be fully realized is context dependent.

- The adolescent mind is different from that of an adult – in ways that can make youths less blameworthy before the law, and more amenable to rehabilitation.
- The Supreme Court affirmed this in a series of decisions outlawing the death penalty for juveniles and putting tight restrictions on juvenile sentences of life without parole. While the decisions were based primarily on behavioral research, the courts are increasingly looking to neuroscience for guidance in responding to juvenile offenders.

(Gogtay et al, 2004; Mills et al, 2014),

Adolescent and Young Adult Brains: less guilty by reason of adolescence

- A constant challenge for legal systems is figuring how best to handle young offenders. While it has always been obvious that the <u>very young are not as culpable for bad behavior as are the mature</u>, legal systems have often struggled to develop juvenile justice regimes that are stable and fair. Several <u>U.S. Supreme Court cases</u> reflect this struggle.

- In *Roper v. Simmons* (2005) adolescent aged 17 threw a woman off a bridge: the Court held unconstitutional any sentence to death for a crime committed by an adolescent of 16-17 yo. established <u>precedence for fMRI use in trial</u>.

- In *Graham v. Florida* (2010), the Court similarly held it unconstitutional to sentence any juvenile offender, in a non-homicide crime, to a sentence of life imprisonment without possibility of parole (violation of 8th amendment). The ruling requires that states give juveniles a "meaningful opportunity to obtain release based on demonstrated maturity and rehabilitation."

Adolescent brain

- In *Miller v. Alabama* (2012), the Court went further. It held that *mandatory* life imprisonment without possibility of parole, for those under the age of 18 at the time of their crimes, was unconstitutional — even in cases of homicide. (Court left open the possibility of such a sentence, if the judge were to make an individualized assessment of the particular juvenile, crime, and surrounding circumstances.)

- *Montgomery v. Louisiana* (2016) – *Miller* decision must be applied retroactively in US

- Although the role neuroscientific arguments actually played in the disposition of these cases is debatable (Morse, 2013), it is notable in itself that neuroscientific arguments about adolescent brain development were provided to the Court in each case, and cited in some of them (Bonnie & Scott, 2013).

Addiction & Adolescence are legal mitigations

- U.S. District Court Judge Mark W. Bennett recently issued an opinion (*U.S. v. Hendrickson, 2016*) that cites neuroscience research on addiction and adolescent development and discusses addiction and youth as mitigating factors.

- My Opinion: Adolescents should be viewed as inherently less responsible than adults and should be punished less harshly than adults, even when their crimes are identical. Must be given opportunity for rehabilitation as brain matures

Current dementia case: *Madison vs. Alabama*

- Vernon Madison, an Alabama inmate has been on death row for more than 30 years for the murder of a Mobile police officer, Julius Schulte. In that time, Madison has had several strokes, causing significant brain damage, and suffers from (among other things) dementia and long-term memory loss. As a result, Madison says, he has no memory of shooting Schulte.
- In 1986, in a case called *Ford v. Wainwright*, the justices ruled that the Eighth Amendment bars the execution of inmates who are mentally incompetent;
- 21 years later, in *Panetti v. Quarterman*, the justices held that the lower courts should have considered an inmate's claim that he suffered from "a severe, documented mental illness that is the source of gross delusions preventing him from comprehending the meaning and purpose of" his death sentence.
- Roberts: whether the Constitution bars the execution of an inmate simply because he doesn't remember the details of his crime; and whether dementia can cause someone to be incompetent, so that he cannot be executed.
- Stay was upheld

Biomarkers

Historically: take things we can see (behavioral effects of brain injury) and self report & then guess about brain
Now we are taking brain data and predicting the behavior

What are the *legal* implications of early detection of elevated risk for autism spectrum disorder?

45 year old adult who is fully functional but has increasing amounts of Beta Amyloid: higher risk for developing Alzheimer’s:
Questions: Admissibility of imaging data in court; who should have access to data; Insurability

My Amygdyla Made Me Do It

- <u>Concept of Criminal Responsibility</u>

- <u>Should courts have to decide when to mitigate someone's criminal responsibility</u> just because his <u>brain functions abnormally</u> (whether because of age, trauma, inherited abnormalities, etc)?

Daniel Martell, PhD
Forensic Neuroscience Consultants, Inc.

- "Forensic Neuroscience" consulting business.

- Neuroscience evidence and its impact on death penalty litigation

- Lawyers routinely order neuroimaging: neurological impairment prevents control of behavior

- With MRI evidence, juries choose life imprisonment rather than death penalty.

- Martell believes MRI's have revolutionized law.

Martell

- Neuroscientific evidence has been admitted to show everything from head trauma to the tendency of violent video games to make children behave aggressively.

- It is in death-penalty litigation that neuroscience evidence is having its most revolutionary effect.

- Organic brain defense has become required in any sort of capital defense. Lawyers routinely order scans of convicted defendants' brains and argue that a neurological impairment prevented them from controlling themselves.

Martell 2

- The prosecution counters that the evidence shouldn't be admitted, but under the relaxed standards for mitigating evidence during capital sentencing, it usually is.

- A Florida court has held that the failure to admit neuroscience evidence during capital sentencing is grounds for a reversal.

- Martell remains skeptical about the worth of the brain scans, but he observes that they've "revolutionized the law."

Legal Cases that used NS data

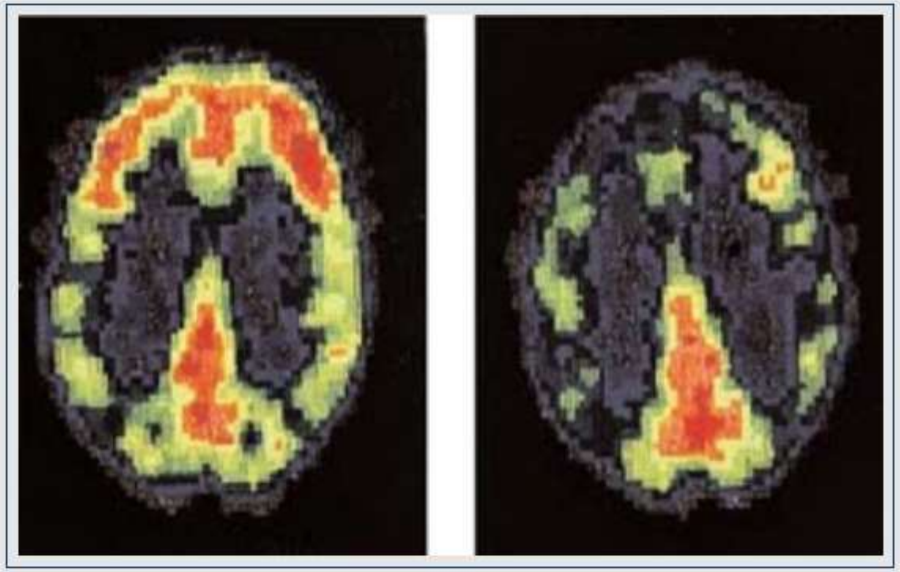
- **United States vs. John W. Hinckley Jr.** (1982) - John Hinckley, who in 1981 attempted to assassinate President Ronald Reagan; CT scan showed enlarged ventricles; found not guilty by reason of insanity.

- **People of New York vs. Weinstein** (1992) – PET scan

- **Harrington vs. State of Iowa** (2003) – after 25 years imprisoned for murder; "brain fingerprinting" (EEG lie detection) technique admitted in court.

- **South Carolina vs. Stanko** (2006) - killed two people and raped a teenage girl; PET revealed brain injury; jury rejected the insanity defense and sentenced Stanko to death.

Average PET of 41 murderers



The pictures here of a normal PET scan, left, and a PET scan from convicted murderer, as reported by the DANA Foundation, show considerably less activity in the prefrontal region at the top of the image, an area of the brain associated with control over aggressive activity.

Prefrontal hypometabolism in murderers

41 Murderers: The First Look

- Raine, 1997: 41 murderers who had pleaded not guilty by reason of insanity, or had been judged incompetent to stand trial vs. controls: PET scanned, while CPT task; 6 schizophrenics
- Prefrontal hypometabolism finding
- Also diminished activation in left angular gyrus, corpus callosum, amygdala, hippocampal functioning
- 15 predatory and 9 “heat of passion” affective group”:
  - affective murderers lacked prefrontal functioning;
  - predatory killers showed relatively good prefrontal functioning but blunted amygdalas

Adrian Raine, 1997

Poor Prefrontal Functioning & Violence

- At a neurophysiological level, reduced prefrontal functioning can result in loss of control over the amygdala—that are thought to give rise to aggressive feelings.

- At a neurobehavioral level, prefrontal damage has been linked with risk taking, irresponsibility, rule-breaking, emotional and aggressive outbursts, and argumentative behavior—all of which predispose to violent criminal acts.

Intent and Punishment

- Humans are notoriously prone to various kinds of psychological biases. At the same time, <u>few things are more crucial to the fair administration of criminal justice than trying to ensure that jurors and judges are minimally biased in their decisions about whether or not a defendant is criminally liable</u> (typically a decision for the jury) and, if he is, <u>how much to punish him</u> (typically a decision for the judge).

- Until recently, nothing was known about how human brains make these important decisions.

- What is the extent to which fMRI might illuminate the neural processes underlying these determinations?

- fMRI study found <u>correlations between guilt and punishment decisions and activity in regions commonly associated with analytic, emotional, and theory-of-mind processes</u> (Buckholtz et al, 2008).

Intent and Punishment 2

- A subsequent study suggested that theory-of-mind circuitry may either gate or suppress affective neural responses, tempering the effect of emotion on punishment levels when, for instance, a perpetrator's culpability was very low, at the same time the harm he caused was very high (Treadway et al, 2014).
- A third study, using repetitive transcranial magnetic stimulation (rTMS) to test the causal role of right dorsolateral prefrontal cortex, found, as predicted, that compared to sham stimulation, rTMS changed the *amount* that subjects punished protagonists in scenarios, without altering how much they *blamed* those protagonists (Buckholtz et al, 2015).
- 4th study: identified distinct neural responses that separately correlate with four key components of liability/punishment decisions: 1) assessing harms; 2) discerning mental states in others; 3) integrating those two pieces of information; and 4) choosing punishment amounts (Ginther et al, 2016).

Juries: Selecting Punishments

- "John, who lives at home with his father, decides to kill him for the insurance money. After convincing his father to help with some electrical work in the attic, John arranges for him to be electrocuted.

- His father survives the electrocution, but he is hospitalized for three days with injuries caused by the electrical shock."

- As a jury member, do you choose guilt based on intention to harm or harm done?

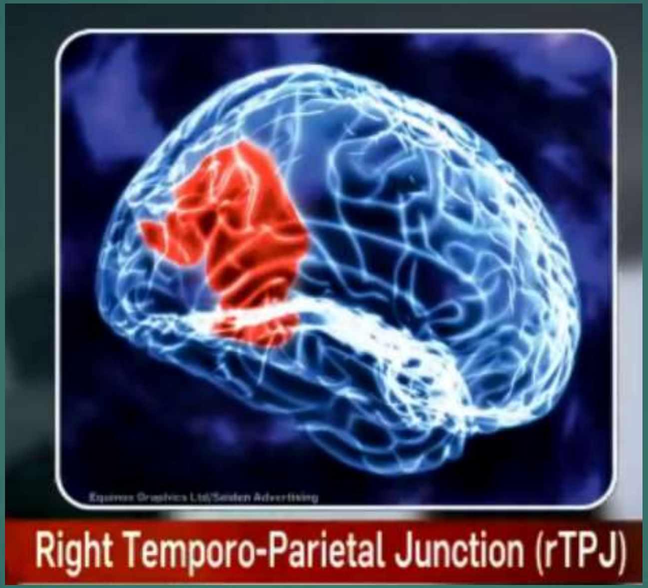
Jury Selection: Whether & How Much to Punish

- Activity in the right dorsolateral prefrontal cortex, tracks the decision:
  - of whether or not a person deserves to be punished
  - but not to deciding how much to punish.

- Amygdala is involved in how much subjects decide to punish.

Marois

Temporal Parietal Junction:
Theory of Mind (think about what others are thinking)



"I know you think you understand what you thought I said, but I don't think you realize that what you heard is not what I meant."

TPJ: Mind reading

- Right Superior temporal sulcus (STS): ability to follow people's gaze and determine where another's attention is directed; judge movement intention from visual context

- TPJ active when people try to understand the minds of other people

- If TPJ Lesion: poor ability to interpret other people's actions and emotions, and ability to judge intention of another

Right Temporal Parietal Junction:
Moral Judgment: Judging intentions

- 1 – Joan asks Susan to get coffee with sugar. Susan sees bowl labeled poison and puts it in coffee. But powder is actually sugar. Joan drinks coffee and is fine. (Bad intention; should be blamed, based on outcome)
- 2 – Or Joan asks Susan to get coffee with sugar. Susan sees bowl labeled sugar and puts it in coffee. Powder is toxic poison. Joan drinks coffee and dies. (Accident: Caused harm but Good intention; can forgive)
- Question: In which condition is Susan to blame?
- People say Susan deserves blame in scenario 1. We judge Susan morally by her intention. Adult capacity to do this by age 12 (kids with older sybs do better)
- Disrupt rTMJ: make decision on basis of outcome, not intention

Rebecca Saxe

How we blame

- Across all cultures:
  - 1 Intentional harm is most blameworthy (i.e. murder)
  - 2 Bad intentions with no harm is next (i.e. attempted murder)
  - 3 No bad intention with harm is next (i.e. civil negligence)
  - 4 No bad intention with no harm is not blameworthy (i.e. no harm)

Temporal Parietal Junction: Intention detector

Used TMs to disrupt RTPJ function

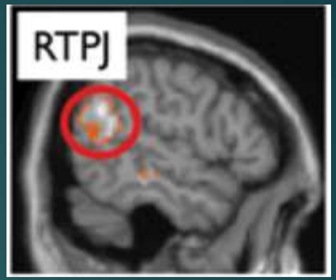
Low RTPJ activation: harsh, outcome-based judgments of accidents
(e.g., she *poisoned* her friend; deliberate intention)

High RTPJ activation: more lenient belief-based judgments
(e.g., she *thought* it was sugar; accident)

Specific patterns in the RTPJ indeed allow a person to *identify* harmful actions as being either deliberate or inadvertent.

ASD: atypical, only outcome-based moral judgments, blame even for accidental outcome
Psychopaths: more likely to "forgive" accidental harms; blunted response to harmful outcome

rTPJ: Judge and jury of intention



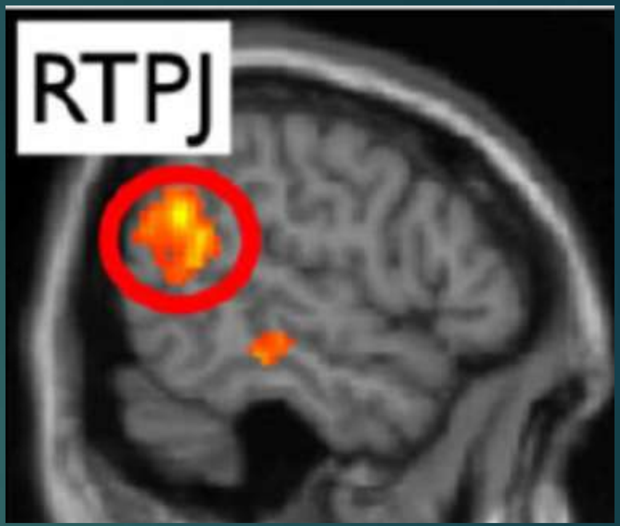
- rTPJ is critical for representing mental state information, irrespective of whether it is about oneself or others.
  - As RTPJ activates, so does the influence of your belief information on moral judgment

- Higher the activation: take intention into account; less blame/more forgiveness if believe harm was accidental (see it from their perspective)

- Lower the activation: less able to take intent into account; reduces the influence of belief information on moral judgments

L.Young and R. Saxe, 2007, L. Young, et al., 2009

RTPJ: It's the thought/intention that counts



- Evil twin tries to poison twin brother but fails
- In judging people, usually bad intention more important than the outcome: Call Foul if intentional
- **Premeditation.** When rTPJ was turned off, rely less on the actor's intentions and, judge attempted harms as less morally forbidden and more morally permissible;

L. Young, et al., 2009

Tell jury a gruesome murder: spike jury’s amygdala

- Emotionally graphic descriptions of harmful acts amplify punishment severity, boost amygdala activity and strengthen amygdala connectivity with lateral prefrontal regions involved in punishment decision-making.

- However, this was only observed when the actor's harm was intentional; when harm was unintended, a temporoparietal-medial-prefrontal circuit suppressed amygdala activity and the effect of graphic descriptions on punishment was abolished.

- These results reveal the brain mechanisms by which evaluation of a transgressor's mental state gates our emotional urges to punish.

Treadway MT, et al., 2014

Wired for Bias: Innate Prejudice

- African Savannah, 2 Mya: fast identification of stranger/the other fosters survival and is an evolutionary advantage
- Despite this overwhelming evidence that our brains are evolutionarily wired for bias, our society continues to think about prejudice as premeditated behavior.
- Our current laws against discrimination, as well as the majority of diversity training programs, assume that prejudice is overt and intentional.
- Rarely do we teach people about how automatic prejudices might taint their behavior towards others.
- The fact that prejudice often occurs automatically doesn't mean we can't find ways of overcoming its negative effects.
- Monkeys show ingroup and outgroup prejudice.

One's face may determine one's fate: People who look less trustworthy receive harsher criminal sentences

- People infer trustworthiness from faces quickly and with high consensus. Untrustworthy faces incur negative judgments. These biases persist despite information demonstrating that the targets are actually trustworthy
- Facial trustworthiness affects decisions about guilt in court. People whose appearance seems congruent with an alleged crime are more often thought guilty than those whose appearance evokes incongruent stereotypes. Similarly, people whose faces look less trustworthy are judged guilty on the basis of less evidence in hypothetical crime vignettes.
- Black defendants who looked more stereotypically Black were more likely to be sentenced to death than Black defendants who looked less stereotypical.
- Afrocentric appearance predicted longer sentences for both White and Black defendants.

Greene: 2 approaches to criminals

- Retribution: dominates the current criminal justice system: idea of giving people what they deserve.

- Concept of free will forms the foundation for the retributivist model.

- Deterrence: The consequentialist argument is that punishment = "promoting future social welfare,"; prevent future harm

- The law should focus on deterring future harm. Permit punishment for crimes but rest on a sound scientific underpinning.

Sapolsky: Social Safety not Retribution

- Joyce Carol Oates: “Do you still actually believe in in the concept of “evil”? Isn’t that rather medieval?”

- Robert Sapolsky: "You can have a horrendously damaged brain where someone knows the difference between right and wrong but nonetheless can't control their behavior"

- "At that point, you're dealing with a broken machine, and concepts like punishment and evil and sin become utterly irrelevant.

- Does that mean the person should be dumped back on the street? Absolutely not. You have a car with the brakes not working, and it shouldn't be allowed to be near anyone it can hurt."

Sapolsky: Frontal Cortex and Criminal Justice System

- Need to remove morality from justice system; Criminal justice system needs to be utilitarian and consequentialist and give up idea that someone chooses to be “bad”.
- Sapolsky: “Whereas it is true that, at a logical extreme, a neurobiological framework may indeed eliminate blame, it does not eliminate the need for forceful intervention in the face of violence or antisocial behavior. To understand is not to forgive or to do nothing;
- You do not ponder whether to forgive a car that, because of problems with its brakes, has injured someone, you nevertheless need to protect society from it.”

R. Sapolsky, 2004

Sapolsky

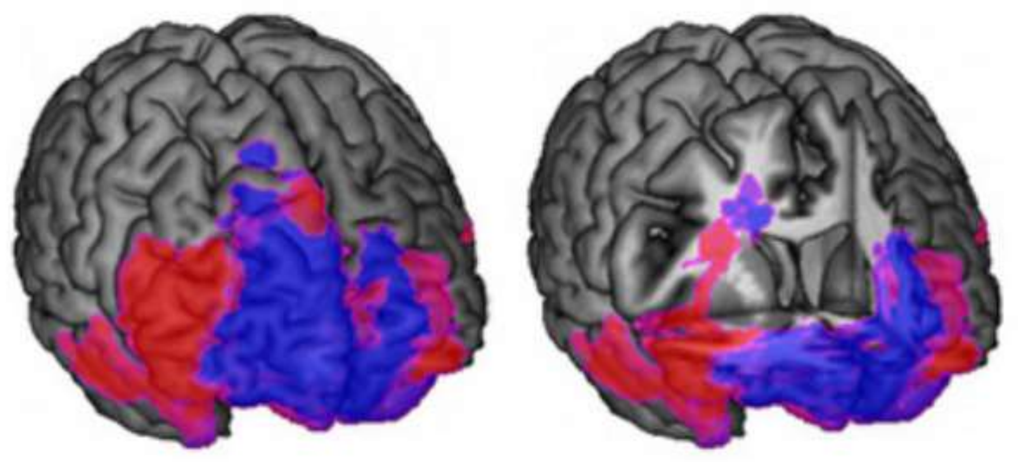
- “Legal scholars have objected to this type of thinking for a related reason, as well. In this view, it is desirable for a criminal justice system to operate with a presumption of responsibility because, ‘to treat persons otherwise is to treat them as less than human’ (Morse 1976).
- There is a certain appealing purity to this. But although it may seem dehumanizing to medicalize people into being broken cars, it can still be vastly more humane than moralizing them into being sinners.”

Prefrontal doesn’t get a vote with hyperactive Amygdala

- There is a dissociation between knowing right from wrong and the ability to base behavior on that knowledge

- Rationality may not affect ability to control behavior

Prefrontal: Decision making & inhibition are independent areas



MRI scans of a human brain show the regions significantly associated with decision-making in blue, and the regions significantly associated with behavioral control in red. On the left is an intact brain seen from the front — the colored regions are both in the frontal lobes. The image on the right is that same brain with a portion of the frontal lobes cut away to show how the lesion map looks in the interior.

[Credit: California Institute of Technology]

Based on University of Iowa's dept. of neurology—the world's largest lesion patient registry.

N = 350

Decision making:
Reward system

Red = Decision Making
Blue = Behavioral Control

Ian Glascher, et al., 2012

Legal consequences should be consistent with actual brain capacity

- There should be no punishment for what is not under a person's control
- Don't punish more than someone deserves
- No death penalty for low IQ or child or adolescent crime because they have less capacity
- What to do with psychopaths who have vmPFC damage?

The Conservative View

- How is this neuroscientific attempt at ‘causal explanation’ different from e.g. explaining human behavior by
  - The environment / social institutions?
  - Genetic or psychological factors?

Westside Story & Officer Krupke: Chicago School of not guilty

- RIFF
  Who me, Officer Krupke?

  RIFF
  Dear kindly Sergeant Krupke
  You gotta understand
  It's just our bringin' upke
  That gets us out of hand
  Our mothers all are junkies
  Our fathers all are drunks
  Golly Moses, naturally we're punks

  JETS
  Gee, Officer Krupke
  We're very upset
  We never had the love
  That every child oughta get
  We ain't no delinquents
  We're misunderstood
  Deep down inside us there is good
- RIFF
  Dear kindly Judge, your Honor
  My parents treat me rough
  With all their marijuana
  They won't give me a puff
  They didn't wanna have me
  But somehow I was had
  Leapin' lizards, that's why I'm so bad

RIFF
Dear kindly Judge, your Honor
My parents treat me rough
With all their marijuana
They won't give me a puff
They didn't wanna have me
But somehow I was had
Leapin' lizards, that's why I'm so bad

SNOWBOY IMITATING JUDGE
Right! Officer Krupke
You're really a square
This boy don't need a judge
He needs an analyst's care
It's just his neurosis
That oughta be curbed
He's psychologically disturbed

RIFF
I'm disturbed

JETS
We're disturbed, we're disturbed
We're the most disturbed
Like we're psychologically disturbed

Greene & Cohen (no free will) vs. Morse (free will)

- Joshua Greene and Jonathan Cohen argue that we do not have free will and that advances in neuroscience will eventually lead us to stop blaming people for their actions.

- Stephen Morse, by contrast, argues that we have free will and that the kind of advances Greene and Cohen envision will not and should not affect the law

You are nothing but your Brain

- 'To a neuroscientist, you are your brain; nothing causes your behavior other than the operations of your brain,'' Greene says.

- ''If that's right, it radically changes the way we think about the law. “

- The official line in the law is all that matters is whether you're rational, but you can have someone who is totally rational but whose strings are being pulled by something beyond his control.''“

Stephen Morse for the Conservatives

- "There's nothing new about the neuroscience ideas of responsibility; it's just another material, causal explanation of human behavior," says Stephen J. Morse, professor of law and psychiatry at the University of Pennsylvania.
- "How is this different than the Chicago school of sociology," which tried to explain human behavior in terms of environment and social structures?
- "How is it different from genetic explanations or psychological explanations? The only thing different about neuroscience is that we have prettier pictures and it appears more scientific."
- Morse insists that "brains do not commit crimes; people commit crimes"

Brain Overclaim Syndrome

- Morse calls this "brain overclaim syndrome" and cites as an example the neuroscience briefs filed in the Supreme Court case Roper v. Simmons to question the juvenile death penalty.

- "What did the neuroscience add?" he asks. If adolescent brains caused all adolescent behavior, "we would expect the rates of homicide to be the same for 16- and 17-year-olds everywhere in the world -- their brains are alike -- but in fact, the homicide rates of Danish and Finnish youths are very different than American youths.'' CJV: he does not account for gun access

- Francis Shen: Even if we do not have free will, the legal system will have to maintain something equivalent

90+% of behavior is Nonconscious: Is Libet Right?

- "Suppose neuroscience could reveal that reason actually plays no role in determining human behavior," he suggests tantalizingly.

- "Suppose I could show you that your intentions and your reasons for your actions are after the fact rationalizations that your brain generates to explain to you what your brain has already done" without your conscious participation.

- If neuroscience could reveal us to be automatons in this respect, Morse is prepared to agree with Greene and Cohen that criminal law would have to abandon its current ideas about responsibility and seek other ways of protecting society.

Which Happens First?

- Thought or willful action?

1. Readiness potential (spike in brain electrical activity) occurs 800 milliseconds prior to movement.

2. Benjamin Libet showed conscious decision to move comes 350 milliseconds AFTER readiness potential occurs. Recent studies: 10 s

3. Conscious will does not cause our movements!

4. Whose mind is it? The Mind of God? Determinism?

Libet: Free Will ?

- In 1977, Benjamin Libet devised cleverly designed experiments at the University of California, San Francisco, that detected activity in the motor cortex of subjects nearly half a second before they became conscious of their decision to press a button.

- This suggested to many that free will was an illusion.

- Libet also showed that there is a brief window of time in which the conscious mind can still veto an action before it is taken.

- These and other experiments reinforced the notion that much of what goes on in our brain takes place outside of & before our conscious awareness

The Evidence

- http://youtu.be/IQ4nwTTmcgs

- Or Google “Libet’s experiment”

Not Free Will but Free Won’t

- Libet told subjects to move their fingers whenever they felt like it. Libet detected brain activity suggesting a readiness to move the finger half a second before the actual movement and about 400 milliseconds before people became aware of their conscious intention to move their finger.

- Libet argued that this leaves 100 milliseconds for the conscious self to veto the brain's unconscious decision, or to give way to it -- suggesting, in the words of the neuroscientist Vilayanur S. Ramachandran, that we have not free will but "free won't."

- We have less free will than many people tend to believe. But there is a big difference between having less and none at all.

Sam Harris: No Free Will

- 66 page essay book elucidating his thesis that human beings don't have contra-causal free will (free will is not caused by anything)
- "...most of what is distinctly human about our lives seems to depend upon our viewing one another as autonomous persons, capable of free choice."
- He couches the issue in the context of a nauseatingly horrific crime - the home invasion in Connecticut by two men in 2007 (murder/rape)
- When we make a choice, the decision has already been made somewhere in our brain; when we become conscious of it, we believe we are making it. We then take ownership of it and call it free will. We don't know what we intend to do until the intention itself arises in our mind.
- What made you decide to …(infinite regressive causation)

- See also ***The Illusion of Conscious Will*** by Daniel Wegner

Kent Kiehl, PhD & his 1100 Psychopaths

Kent Kiehl in front of the semi-trailer that houses a portable MRI scanner at the Western New Mexico Correctional Facility.

Kiehl on Psychopaths: reduced paralimbic activity

- Psychopathy: Score of 30 of 40 on Hare's Psychopathy Checklist-Revised (PCL-R) (normals score 4)

- Psychopaths typically exhibit impulsivity, poor planning, little insight and an utter absence of guilt or empathy. Most had engaged in sexual activity by the age of 12 and showed early signs of violence, including a predilection for arson and animal torture, he said

- One to two percent of the general population, but 15 to 20 percent of prisoners in minimum to medium security prisons qualify as psychopaths, and as high as 30 percent for those in maximum security.

- Psychopaths have impairment in the paralimbic system (ACC, OFC, Amygdala don’t activate). Paralimbic function subserves the relationship between cognitive control and antisocial behavior

- Limbic system is not engaged during moral or emotional trigger

- Neuroprediction of future rearrest: An offender with relatively low anterior cingulate activity would be rearrested

What if…

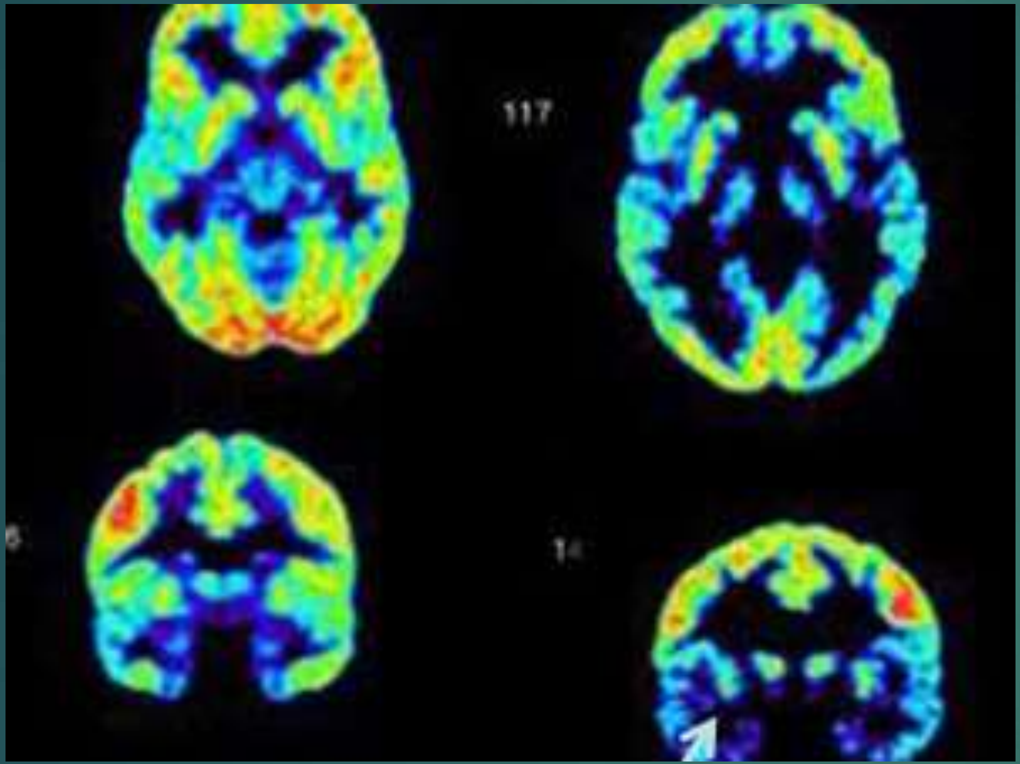
- What if you could do a brain scan and determine to a high probability whether a criminal defendant was a psychopath, with, for example, a 60-70 percent chance of recidivism within five years instead of only 20-30 percent?
- Would that make a difference to a judge or a jury? What if you were a juror in a capital case in the sentencing phase? Would you want to know if someone is a psychopath or not if it affects his odds of committing another murder?
- How would we want to use that information? What if you can say that these particular 12-year-olds will be psychopaths?
- What do you do with the children you are confident will be psychopaths?

Psychopathic Personality Disorder: Reduced Prefrontal Gray

- Raine, 2000: 11% reduction in prefrontal gray matter volume
- May underlie the low arousal, poor fear conditioning, lack of conscience, and decision-making deficits that have been found to characterize antisocial, psychopathic behavior.

James Fallon Family: Who is psychopath?

Brains of James Fallon PhD and son (cousins of Lizzy Borden): Thwarted Sociopathy



Low Orbital Frontal Activation in Fallon

Fallon's brain (on the right) has dark patches in the orbital cortex, the area just behind the eyes. This is the area that Fallon says is involved with ethical behavior, moral decision-making and impulse control.
The normal scan on the left is his son's. His is on left.

Fallen on Psychopathy: Combination of Factors

1 – Low Orbital Frontal activation pattern

2 - MAO-A gene (monoamine oxidase A):
high-aggression variant (low Serotonin), Warrior gene
3 – Mother transmission to son
(X chromosome), too little Serotonin:
higher rates among males
4 – History of childhood abuse or seeing lots of traumatic violence

Kiehl on Psychopaths: Brakes don’t work

- KKK burning a cross: Kiehl says most psychopaths do not differ from normal subjects in the way they rate the photos: Both psychopaths and the average person rank the KKK with a burning cross as a moral violation.
- When a normal person sees a morally objectionable photo, his limbic system lights up
- When psychopaths see the KKK picture, their emotional circuit does not engage in the same way.
- Kiehl says the emotional circuit may be what stops a person from breaking into that house or killing that girl.
- But in psychopaths, the emotional brakes don't work

Inherited proclivity: When should neurogenetics mitigate moral culpability for purposes of sentencing?

- Certain genes and neurobiology (‘neurogenetics’) may predispose some people to violent behavior.
- Increasingly, defendants introduce neurogenetic evidence as a mitigating factor during criminal sentencing.
- Identifying the cause of a criminal act, biological or otherwise, does not necessarily preclude moral or legal liability.
- However, valid scientific evidence of an inherited proclivity sometimes should be considered when evaluating whether a defendant is less morally culpable for a crime and perhaps less deserving of punishment.

‘Can Your Gene Make You Murder?’ and ‘Are Some People Just Born Evil?’

- In 2012, Alex Duran was a Private First Class in the Marine Corps when he awoke hearing voices in his head. This was not the first time he heard these voices. Duran grew up being physically abused. He slept with a knife under his pillow and was known to sporadically punch walls without reason. That night in 2012, Duran ran outside shoeless and attacked a guard using a homemade machete, striking him multiple times in the neck. In a general court martial, Duran was found guilty of attempted murder, maiming, and assault upon a sentry, for which he was sentenced to 15 years of confinement.
- In 2014, Duran appealed, claiming the failure by his defense counsel to investigate for the presence of genes associated with criminality prior to sentencing constituted ineffective assistance of counsel.
- The appeal argued that Duran's ‘violent’ upbringing exposed him to environmental risk factors scientifically known to bring out certain genetic proclivities for violence, and if a genetic cause for his behavior was known prior to sentencing, it would have constituted mitigating evidence and Duran's punishment would perhaps be less severe. ‘We are in the second decade of the 21st century: behavioral genetics is and should be in the mainstream of the criminal justice system’, opined the defense counsel.

Born evil?

- The marine attacked by Private First Class Duran was fortunate to survive after suffering the deep lacerations to his neck. In 2014, Duran's appeal based on the failure of the defense counsel to pursue genetic testing for potential mitigating evidence was denied.

- 85% of individuals with the GxE combination of the ‘low activity’ MAO-A allele and a history of severe childhood maltreatment developed antisocial behaviors.

- Commentators generally agree that an inherited vulnerability to violent conduct should not influence the outcome of the guilt-determination phase of criminal proceedings

- Increasingly there are efforts to introduce genetic evidence during sentencing to convey that a defendant's inherited proclivities to criminal behavior constitute a mitigating condition. Evidence of a mitigating condition is intended to diminish the defendant's moral culpability and therefore lessen the punishment imposed

Survey of what people want to be kept secret

Brain Search Warrants

- Can the police get a search warrant for someone's brain?
- Should the Fourth Amendment protect our minds in the same way that it protects our houses?
- Can courts order tests of suspects' memories to determine whether they are gang members or police informers, or would this violate the Fifth Amendment's ban on compulsory self-incrimination?
- Would punishing people for their thoughts rather than for their actions violate the Eighth Amendment's ban on cruel and unusual punishment?

Brain-based Memory Detection

- Behavioral expressions of memory serve as critical evidence for the law, including eyewitness identifications and memory-based statements about an individual's intent or frame-of-mind during a past act
- Legal interest in whether neural measures can detect the presence or absence of a memory, or distinguish true from false memories; probing the probability of deception
- Study: person with camera on their shirt for weeks; accuracy of recall of what he saw vs camera of others.
- Under controlled experimental conditions, memory states can be detected from fMRI-measured brain patterns

Law and Neuroscience: Progress, Promise, and Pitfalls
Owen D. Jones & Anthony D. Wagner, 2018

We can detect whether you recognize a real vs false memory; whether you recognize a scene you experienced

Memories as our enemy

- fMRI interrogation possibility:

- Did you have an affair?
- Did you kill this person?

- Our memories may become the evidence that embarrasses or incriminates us in the future.

Scanned Memories

- Michael Gazzaniga, a professor of psychology at the University of California, Santa Barbara, and author of "The Ethical Brain," notes that within 10 years, neuroscientists may be able to show that there are neurological differences when people testify about their own previous acts and when they testify to something they saw.

- "If you kill someone, you have a procedural memory of that, whereas if I'm standing and watch you kill somebody, that's an episodic memory that uses a different part of the brain."

FMRI: Revelation of What You are Thinking or Memory for a Crime

- Parahippocampus lights up if you are thinking of familiar place

- What people are thinking about even if they deny it.

- Implications: Because subconscious memories of faces and places may be more reliable than conscious memories, witness lineups could be transformed.

- A child who claimed to have been victimized by a stranger could be shown pictures of the faces of suspects to see which one lighted up the face-recognition area in ways suggesting familiarity.

Multi-voxel pattern classification differentiates personally experienced event memories from secondhand event knowledge

- 2018: fMRI technique that can differentiate whether you were at the scene of a crime
- Can differentiate if a photo of a scene is autobiographical or not

Tiffany E.Chow, et al., 2018

Other potential legal uses of Neuroimaging (NI)

- Deception detection: Neuroimaging of lying

- Pedophilia: Researchers used brain activity to accurately classify the pedophilia status of more than 90% of subjects.

- Sexual Orientation: Researchers could determine sexual orientation with more than 85 percent accuracy

- Pain Imaging: pain is in the brain
  - Detecting those who are malingering
  - Accurately identifying those who really are feeling pain.

Mental States: Detecting Lies and Memories

- Can neuroscience identify brain processes associated with lying and remembering?
- Several companies in the U.S. apparently believe so, and offer "lie detection" based on functional magnetic resonance imaging (fMRI).
- Attorneys in a few cases have attempted to introduce the outcomes of these tests as courtroom evidence; to date, the courts have not allowed them
- Can brain activity tell us whether an individual accurately recognizes a person whose face she has seen or an event she has witnessed?

Brain-based Memory Detection

- Problems: classification accuracy (recognized vs novel) was only slightly above chance when attempting to discriminate true versus false recognition of faces (Rissman et al, 2010).
- Similarity of brain responses during true and false memory (Schacter & Slotnick, 2004), and suggests that brain-based measures may not solve the law's frequent quandary of knowing when a witness's memory is accurate or mistaken.
- <u>Accuracy is at chance when person uses cognitive countermeasures</u> (shifting attention);
- As with the polygraph (National Research Council, 2003) and fMRI-based lie detection, potential real-world application of brain-based memory detection can be 'beat' by motivated non-compliant individuals
- Thus, while extant data highlight that brain-based memory detection is possible, significant hurdles to real-world application remain.

Lie Detection Throughout History

- Dry mouth (Rice)
- Flushing
- Sweating
- Torture
- Gross behavior (E.g. downcast eyes)
- Pulse and blood pressure (Marston, 1917)
- Respiration
- Galvanic skin response (GSR)
- Polygraph
- Electroencephalograph EEG) and Evoked Brain Potentials (EBP)
- Voice stress analysis (FSA)
- Facial heat distribution
- Facial micro-expressions
- Positron Emission Tomography (PET)
- Functional Magnetic Resonance Imaging (fMRI)

Brain-based Lie Detection

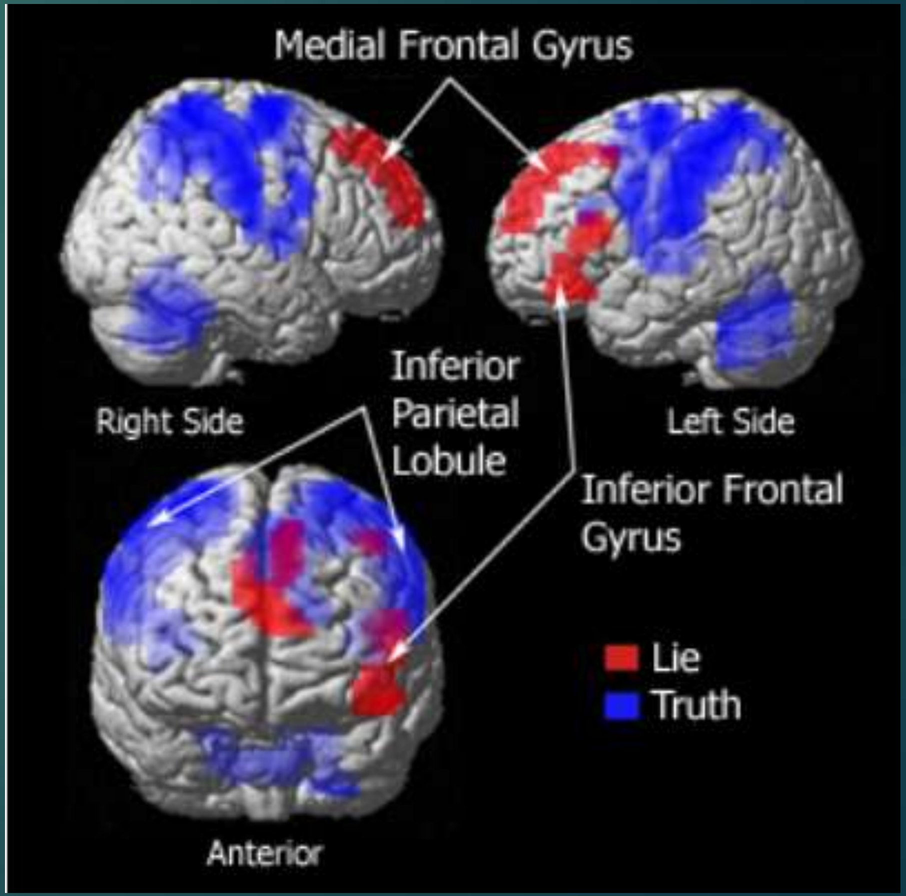
- Lawyers are increasingly proffering (i.e., “offering into evidence”) neuroscientific evidence, both structural and functional. In many cases, such evidence is the subject of admissibility hearings, in which a judge determines whether the jury will be allowed to hear and see the evidence
- With the advent of fMRI, cognitive neuroscientists are examining whether brain-based lie detection is possible. Despite some very promising studies (Greene & Paxton, 2009), the prospects for legal use remain almost entirely speculative
- (a) laboratory-based studies predominantly use instructed or permitted lie paradigms, and have negligible stakes for failure to successfully deceive (in contrast to the stakes in real world settings);

Lie detection

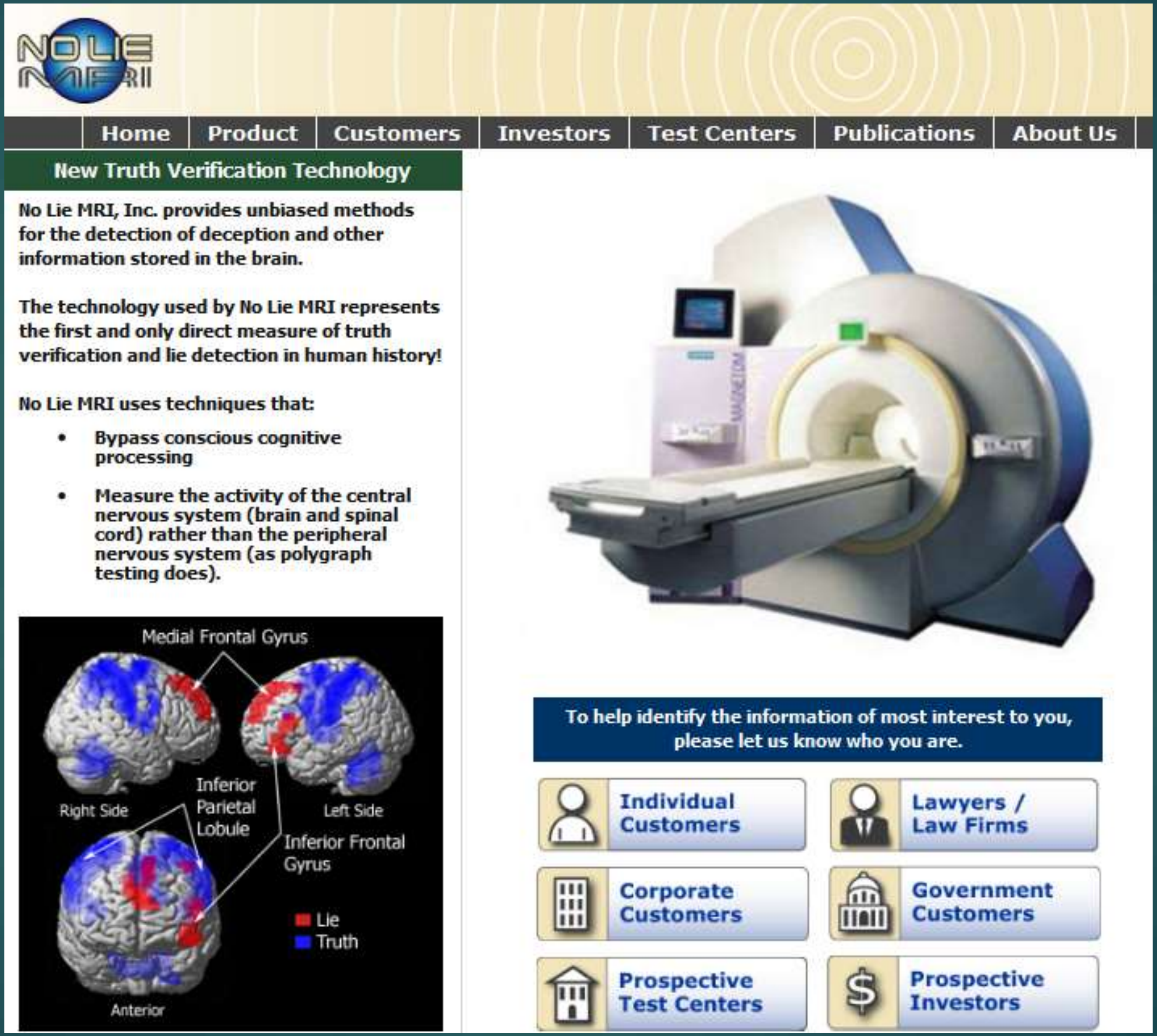
- (b) a set of frontal and parietal lobe regions are often more active during the putative “lie” versus “truth” conditions, and most evidence comes from group-based analyses that average over trials and subjects (c.f., the law requires an assessment of truthfulness about individual facts in individual brains);
- (c) experimental design limitations raise uncertainty as to whether these neural effects reflect responses associated with deception or whether they reflect attention and memory confounds that are unrelated to deception; and (d) countermeasures appear to alter these neural responses, suggesting that, even if associated with deception, it may be possible to mask such responses.
- These limitations will frequently prevent brain-based techniques from satisfying the legal standards for admissibility of scientific findings

Neural Lie Detection

- EEG (Brain Fingerprinting and BEOS)
- fMRI (Cephos and No Lie MRI)



No Lie MRI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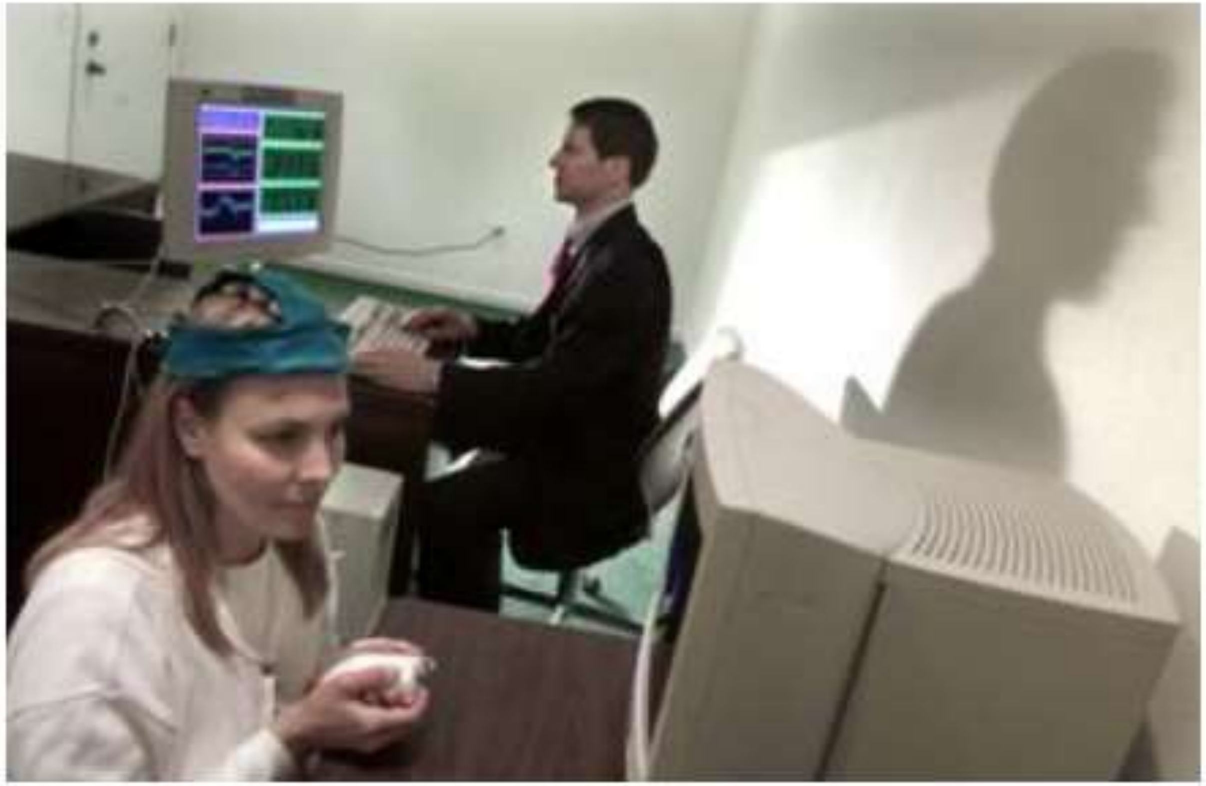
New Truth Verification Technology
No Lie MRI, Inc. provides unbiased methods for the detection of deception and other information stored in the brain.
The technology used by No Lie MRI represents the first and only direct measure of truth verification and lie detection in human history!
No Lie MRI uses techniques that:
• Bypass conscious cognitive processing
• Measure the activity of the central nervous system (brain and spinal cord) rather than the peripheral nervous system (as polygraph testing does).
Medial Frontal Gyrus
Inferior Parietal Lobule
Right Side
Left Side
Inferior Frontal Gyrus
Lie
Truth
Anterior
To help identify the information of most interest to you, please let us know who you are.
Individual Customers
Lawyers / Law Firms
Corporate Customers
Government Customers
Prospective Test Centers
Prospective Investors

Computer Lie Detection



Farwell measures brain-wave responses of a person looking at words or pictures displayed on a computer screen using a headband with built-in electrodes

It's harder to lie:
More active Inferior parietal & frontal

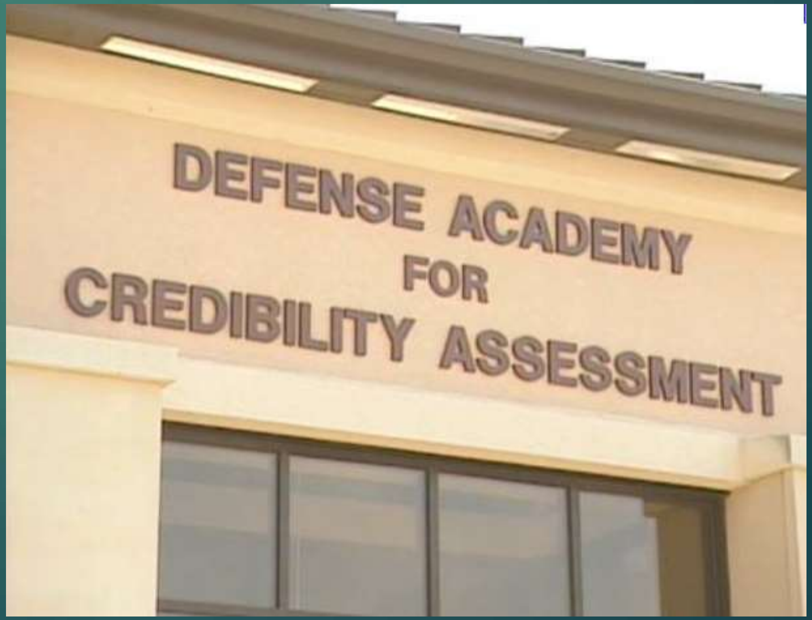
- PFC and parietal activation reflect GREATER brain activity in the deception condition (lying) relative to brain activity in the normal condition

- Malingered response times were associated with activity in the dorsomedial frontal, temporal and inferior parietal regions

Conclusions on Lie Detection

- No method of neural lie detection so far is reliable enough for courtroom use.
- In the future, burden of proof will become crucial:
  - Criminal prosecution needs to establish defendant’s guilt beyond a reasonable doubt.
  - Defense only needs to show reasonable doubt.
  - Businesses, government agencies, and private people do not need to prove claims beyond reasonable doubt.

Defense Department: Homeland Security using Lie Technology



Pathological Liars: Prefrontal Tissue (WM) of Lies

- Those who lie, cheat and manipulate others
- Temp Agency recruitment; half of liars were malingerers
- Normals: significant increase in WM from 2-10 & increase in ability to lie
- Relatively widespread increase in white matter particularly orbitofrontal cortex (22–26% increase), inferior frontal cortex (32–36% increase) and middle frontal cortex (28– 32% increase) compared with both non-lying antisocials and normals; 36-42% reduction in prefrontal grey/white ratios
- Liars had significantly higher verbal relative to performance IQ scores than both control groups,
- Ability to make fast, on the fly connections

Y. Yang, et al. 2005, 2007

Lie Detection

- The biggest lie detection study has looked at only 30 people. And results were averaged.
- As of February 2007, 12 peer-reviewed articles had been published on fMRI-based lie detection.
- You can't really coerce someone into submitting to a brain scan. All they have to do is move their head.
- NI: Moving from the group average to the individual will be very hard; they are based on correlation (not cause); i.e. Mozart vs Stones vs. loudness

Problems with lie detection

- Not reliable:
  - High false positives (claim innocents are lying): 33%
  - Low false negatives (does catch liars)
- Published counter measures for computer techniques; able to defeat the techniques
- Unknown real life application (i.e. lawyer rehearsal of real facts, or reading about crime)
- Real criminals may use countermeasure strategies to avoid detection.
- Psychopaths lie best: VL PF does not activate, nor does Amygdala activate

5th Amendment

- How will the Fifth Amendment's guarantee against self-incrimination apply to evidence culled from a defendant's own brain?

- The Supreme Court will have to decide whether brain images are testimony and, if so, what protections an individual is afforded under the Fifth Amendment.

You be the judge

- Jonathan Donahue convicted of beating a restaurant manager senseless with the butt of a gun.
- Mr. Donahue had been identified as a psychopath based on a standard interview — that is, he had a history of aggressive acts without showing empathy.
- Testimony from a neurobiologist and renowned expert on the causes of psychopathy: the defendant had inherited a gene linked to violent, aggressive behavior, that altered the development of brain areas that generate and manage emotion.
- Study: Neurobiological evidence reduced judges' sentences by an average of about 7 percent for a fictional defendant convicted of battery and identified as a psychopath.

Behavioral biology sways judicial decisions.

- 181 state judges from 19 states who agreed to read a fictional case file and assign a sentence to an offender
- The judges who read above testimony gave Mr. Donahue sentences that ranged from one to 41 years in prison, a number that varied with state guidelines. But the average was 13 years — a full year less than the average sentence issued by the judges who had not seen the testimony about genetics and the brain.
- Aggravated battery normally carries a sentence of nine years, on average, and 15 years if the defendant is identified as a psychopath

James Tabery, et al., Science, 2012

Making Judgments

- Judges make <u>judgments based more on defendant intention</u> in the crime <u>than harm done to victim</u>

- <u>If you disable R prefrontal cortex by TMS, punishment decisions are based on emotions not reason; punish crime less</u>

Minority Report: Precrime

Chief Justice Roberts Nomination

- In the 2005 nomination hearing of John Roberts as Chief Justice of the United States, Sen. Joseph Biden (D-Del.) posed a rhetorical question about an issue the Supreme Court might face: “Can brain scans be used to determine whether a person is inclined toward criminality or violent behavior?”

- His question illustrates the degree to which neuroscience, especially neuroimaging, has entered into the legal system.

Are You Responsible for What You Might Do?

- Efforts to use science to predict criminal behavior have a disreputable history.
- In the 19th century, the Italian criminologist Cesare Lombroso championed a theory of "biological criminality," which held that criminals could be identified by physical characteristics, like large jaws or bushy eyebrows (being a dark Southern Italian).
- PET scans of convicted murderers were first studied in the late 1980s by Adrian Raine; he found that their prefrontal cortexes, areas associated with inhibition, had reduced glucose.
- Subjects who received a diagnosis of antisocial personality disorder, which correlates with violent behavior, had 11 percent less gray matter in their prefrontal cortexes.

Future prediction

- Neuroscience, it seems, points two ways:
  - it can absolve individuals of responsibility for acts they've committed,
  - it can also place individuals in jeopardy for acts they haven't committed -- but might someday.

Throw away the key?

- It's not necessarily the case that if predictions work, you would say take that guy off the street and throw away the key

- You could require counseling, surveillance, G.P.S. transmitters or warning the neighbors.

- None of these are necessarily benign, but they beat the heck out of preventative detention.

War on Terror Use

- We can tell whether someone has a strong emotional reaction to seeing things, and you can certainly imagine an anti-terrorist friend-versus-foe scanner.
- If you put everyone who reacts badly to an American flag in a concentration camp or Guantánamo, that would be bad.
- But is it appropriate to mark someone down for further surveillance?

Precrime: Predispositions

- The idea of <u>holding people accountable for their predispositions rather than their actions</u> poses <u>a challenge to one of the central principles of Anglo-American jurisprudence</u>: namely, that <u>people are responsible for what they do, not what they think.</u>

- Russia just passed such a law.

‘Brain reading’: Ethics of neuroimaging

- Growing public perception of neuroimaging as “hard” science, complementary to the “soft” science of psychological evaluation

- However this new technology should be applied cautiously – Neuroimaging is not evidence for causation.

News Feature, Nature 2001 vol 410: 296-298

Brain based TXs

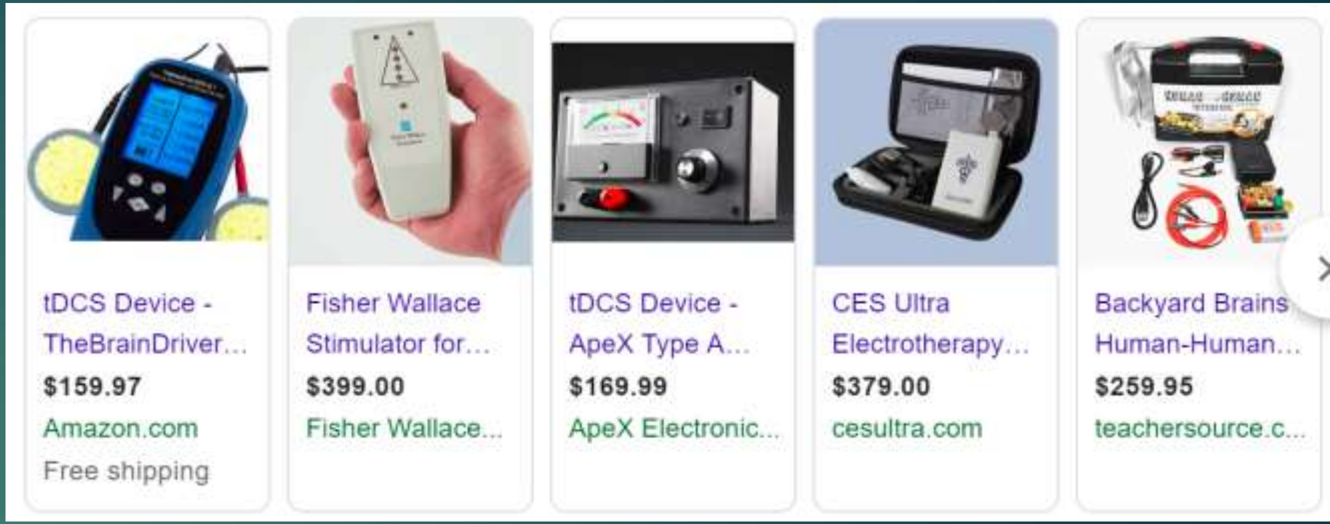
- Brain-based treatments for criminal behavior:

- Seven states in the United States currently require use of a technology that directly alters the brain as part of sentencing for some crimes: “chemical castration,” involves the administration to male convicts of a drug called Depo-Provera (black box warning for women for bone density)

- Remember Alan Turing & estrogen Tx for his homosexuality?

Brain Enhancement

- Coffee
- Adderal, Ritalin
- Performance enhancing drugs
- Psychotropics
- tDCS home brain stimulators



DTC neurotechnologies: Unclear Efficacy, Potential Harms

- Direct to consumer neurotechnologies: Marketed for the purpose of modulating cognition or a variety of affective and mental states, a growing ecosystem of neurotechnology products is being sold direct to consumers (DTC)
- Offering individuals the prospect of monitoring and manipulating a range of brain functions from memory to mental health, the major product categories are neuromonitoring devices, cognitive training applications, neurostimulation devices, and mental health apps.
- Questions have been raised about whether
  - devices that deliver transcranial direct current stimulation (tDCS) can improve cognitive performance
  - whether cognitive gains from brain-training games are generalizable
  - whether the behavioral effects of EEG neurofeedback and mental health apps are due to placebo.

- See psyberguide.org/apps/

Weaponizing Neuroscience

- There is no question that in the future, neuroscience will be able to be weaponized.

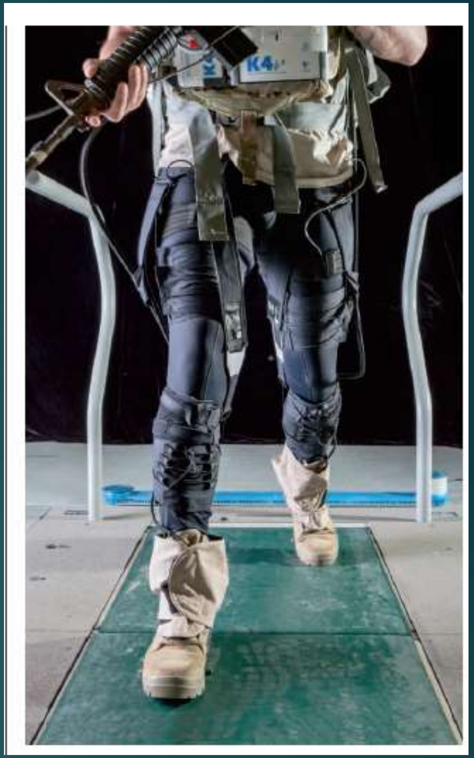
- DARPA, or Defense Advanced Research Projects Agency, has already begun to blur the line between human and machine.

- One of their projects allows Department of Defense analysts to process images with blindingly fast speeds. Other projects in nano-neuroscience, pharmaceuticals, neuro-imaging, and cyber-neurosystems could be used for "offensive capabilities".

- The future of neuroscience in military must be progress with careful oversight.

Exo-skeletons in the military: who is in control

- Ability to enhance normal individuals with military grade exo-skeletons – slippery slope of human enhancement.
- Implant brain machine interfaces in parietal lobe, resulting in preconscious control over the exo-skeleton.
- In most courts, cannot have a criminal act without a guilty mind resulting in a guilty action.
- BMIs enhanced with AI could result in Involuntary actions that confound criminal culpability and raise questions about free will.



The Myth of the Double-Edged Sword

- An Empirical Study of Neuroscience Evidence in Criminal Cases – Deborah W. Denno

- Neuroscience Study: reviewed 800 criminal cases addressing neuroscience evidence over the past two decades (1992-2012); majority murder cases

- Neuroscience is often viewed as a "double-edged sword," capable both of lessening and enhancing a defendant's blameworthiness;

- That view fuels myths that neuroscience will either justify the freeing of violent criminals or bolster unjust predictions regarding defendants' future dangerousness

Double edged sword?

- Investigated how courts assess the mitigating and aggravating strength of such evidence.

- Analysis revealed that neuroscience evidence is usually offered to mitigate punishments in the way that traditional criminal law has always allowed, especially in the penalty phase of death penalty trials.

- This finding controverts the popular image of neuroscience evidence as a double-edged sword — one that will either get defendants off the hook altogether or unfairly brand them as posing a future danger to society.

The Myth of the Double-Edged Sword 2

- Study shows that courts accept neuroscience evidence for the purpose of increasing reliable evidence, and in fact expect attorneys to raise this evidence when possible on behalf of their clients.

- This expectation is so entrenched that courts are willing to grant defendants their "ineffective assistance of counsel" claims when attorneys fail to pursue this mitigating evidence.

- It also reveals that the potential future danger posed by defendants is rarely a facet of cases involving neuroscience evidence

Case

In 2010, shortly after escaping from prison, John McCluskey killed a retired couple in order to steal their camping trailer.[2] The crime was horrific: McCluskey and two accomplices shot the defenseless couple inside their trailer and then set their truck ablaze with their bodies inside.[3] Yet a jury rejected the death penalty, instead sentencing McCluskey to life in prison without the possibility of parole.[4] The jury's life-over-death choice was seemingly influenced by the defense's introduction of brain scans indicating substantial damage to McCluskey's frontal lobe.[5] According to legal analysts, the jury viewed McCluskey's brain abnormalities as a mitigating factor that decreased his level of culpability and ability to plan or intend such a crime, rather than as an aggravating factor that heightened his future danger to society.[6]

Denno review

- Neuroscience evidence is typically used in cases where defendants face the death penalty, a life sentence, or a substantial prison sentence

- Mitigating evidence: 50% of cases present expert testimony about evidence of brain damage (childhood trauma, MVA, alcoholism)

- Confirmed dxs: (top 7 of 10 dxs) 87% polysubtance abuse, 47% TPF lobe dysfunction, 43% depression, 42% organic brain damage, 30% MR, 18% BPD, 14% psychosis/psychopathy

NS stats for mitigation cases

- Purpose of presenting NS: Of 553 cases, 189, to prove brain damage; 127, brain injury; 99, low IQ; 55, malingering; 55, ID

- Type of Imaging used (63% of cases): 82 cases, CT; 94, MRI; 105, EEG; 60, PET; 14, SPECT; 11, QEEG

- Nonimaging Neuropsych testing results: 48 -- WAIS-r; 43, MMPI; 20, Bender Gestalt; 12, Rorschach; 12, Halstead Reitan; 11, WRAT; 10, WCST; 10, TMT; 6, TOMM

NS and Mitigation evidence

- <u>Mitigation (penalty reduction) inquiry</u> requires attorneys to investigate defendant's cognitive and intellectual deficiencies because such evidence has a particularly pronounced impact on mitigation, especially in death penalty cases

- U.S. Supreme Court's emphasis on the mitigating value of neuroscience evidence in criminal cases

- <u>Nearly all of the successful appeals claims were based on an attorney's failure to appropriately investigate, gather, or understand neuroscience evidence; Of these 74 cases, each of the 66 death penalty cases resulted in the petitioner's death sentence being annulled. 50% were cases where lawyer knew of mitigating NS evidence & did not use it</u>

NS and future dangerousness

- Attorneys are required to investigate and present mitigating circumstances, esp. in death penalty cases; NS evidence must be investigated.
- In death penalty states, need to consider a defendant's potential for future dangerousness; an aggravating factor worthy of consideration during the penalty phase of a capital trial.
- A major concern is that prosecutors will seek the death penalty based on neuroscience evidence indicating that a defendant is likely to commit future crimes
- Neuroscience Study found minimal support for this concern; only 14% (80) cases feature any discussion of future dangerousness related to the defendant

Ultimately a moral & legal problem

- <u>Neuroscience itself can never identify the mysterious point at which people should be excused from responsibility for their actions</u> because they are not able, in some sense, to control themselves.

- <u>That question is "moral and ultimately legal," and it must be answered not in laboratories but in courtrooms and legislatures</u>

Current status

- Ours is an age in which brain research is flourishing – a time of truly great expectations. Yet it is also a time of mindless neuroscience that leads us to overestimate how much neuroscience can improve legal, clinical and marketing practices, let alone inform social policy.

- The naive media, the slick neuroentrepreneur, and even the occasional overzealous neuroscientist exaggerate the capacity of scans to reveal the contents of our minds, exalt brain physiology as inherently the most valuable level of explanation for understanding behavior, and rush to apply underdeveloped, if dazzling, science for commercial and forensic use.

Current Status

- The neurobiological domain is one of brains and physical causes; the psychological domain is one of people and their motives. Both are essential to a full understanding of why we act as we do.

- But the brain and the mind are different frameworks for explaining human experience. And the distinction between them is hardly an academic matter: it bears crucial implications for how we think about human nature, as well as how to best alleviate human suffering.

Conclusions

- We still need significantly better understanding of behavioral consequences of brain anomalies.
- We do know some of the neurology of violence and murder; the amygdala and the frontal lobe are clearly implicated.
- But scans cannot perfectly predict behavior. Yet.
- Anyone who, today, intuits behavior from a scan is speculating.
- But it is clear that we are our brains. And that science will eventually explain who we are.

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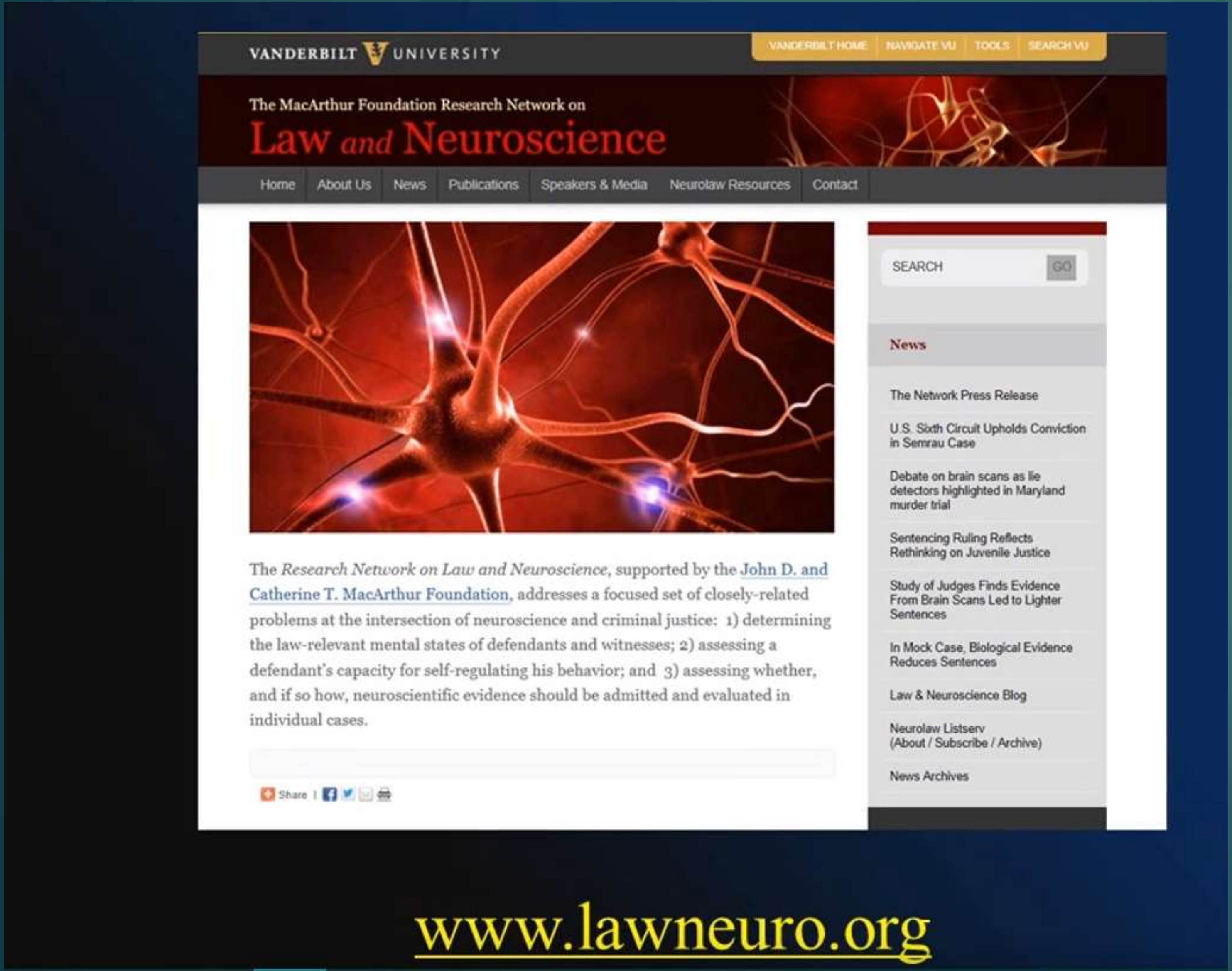
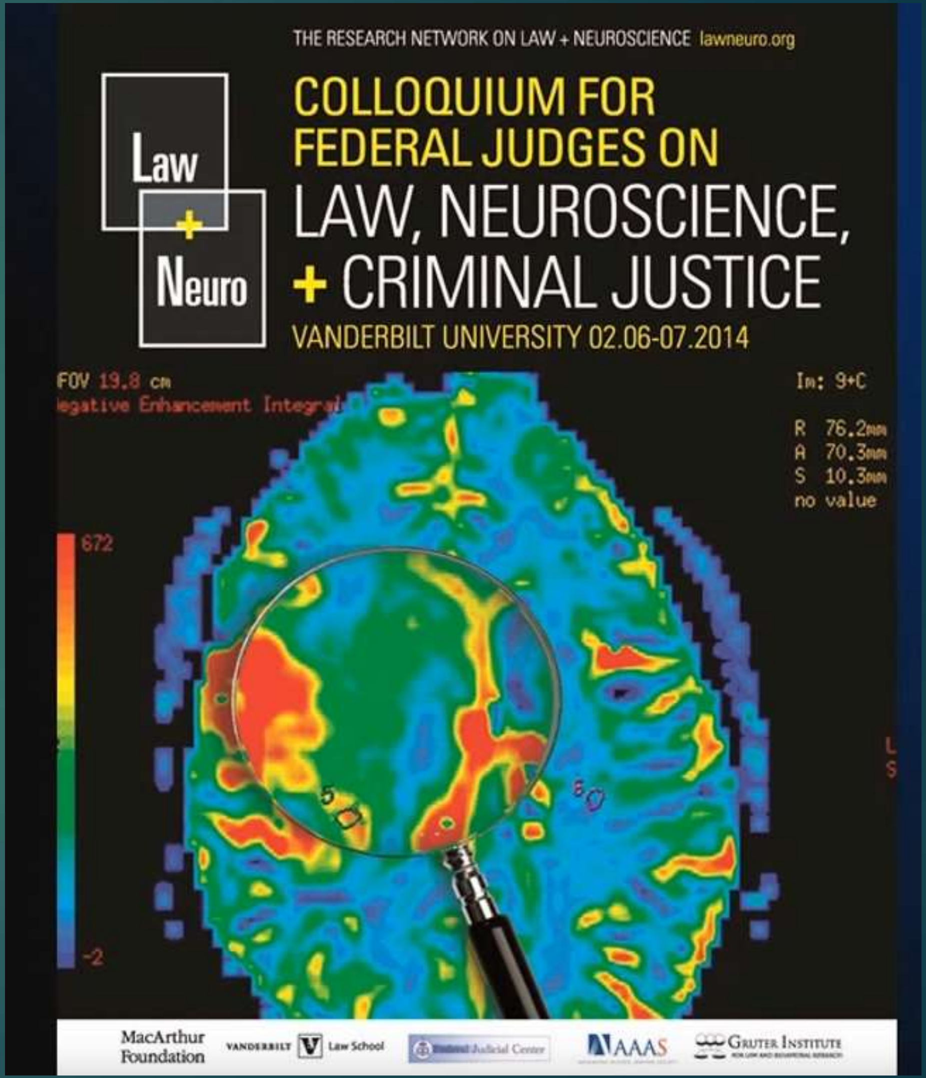
- *Oxford Handbook of Neuroethics* - Judy Illes & Barbara J. Sahakian eds., 2011

Critical Blogs

- Neuroskeptic
- Neurocritic
- Neurobollocks

MacArthur Foundation:
Research Network on the Law & Neuroscience





New Law & NS Programs

- A. John T. and Catherine D. MacArthur Foundation Law and Neuroscience Project
- Interdisciplinary effort to unite scientists, law professors, judges and philosophers in studying how to integrate new neuroscientific findings into the legal system.
- $10,000,000 grant
- Database: 1200 legal cases involving neuroimaging

New Law & NS Programs

- B. Vanderbilt University into a kind of Los Alamos for neurolaw. The university has just opened a $27 million neuroimaging center

- C. Baylor College of Medicine Initiative on Law, Brains, and Behavior: new ways of making and enforcing the law, by helping to understand why people act illegally, and predicting, or even changing, the probability they will do it again