The Brain on the Stand:

Neuroscience and the law

(The Lobes and the Robes)

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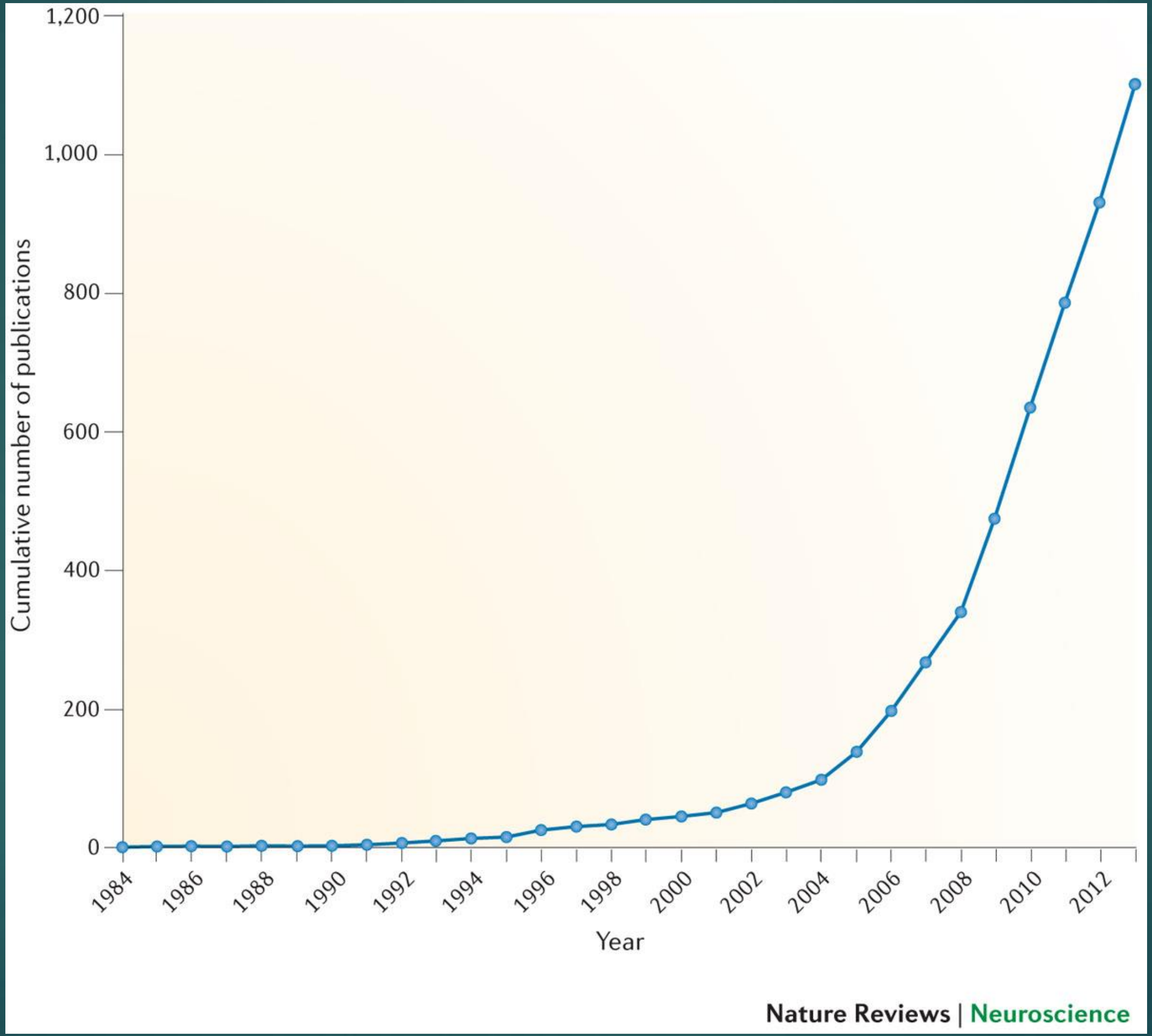
OCTOBER 9, 2017

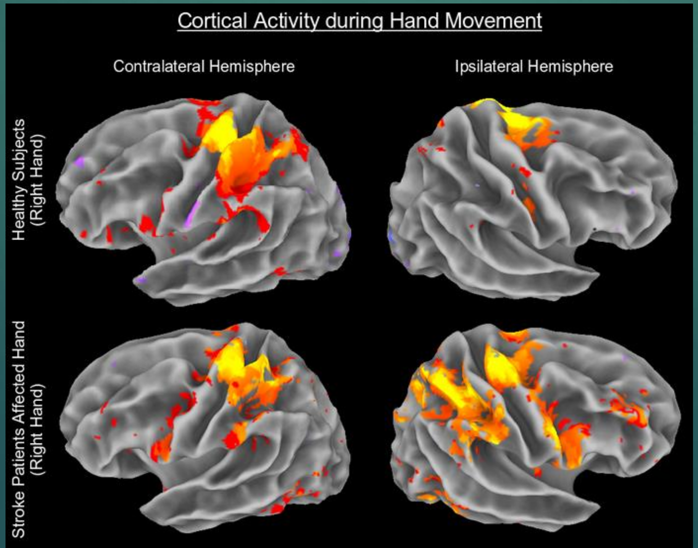
THANKS TO JEFFREY ROSEN, HENRY GREELY, KENT KIEHL

The Human Brain

Steve McAlister / The Image Bank-Getty Images

Neuroscience & the law publications, 1984-2012



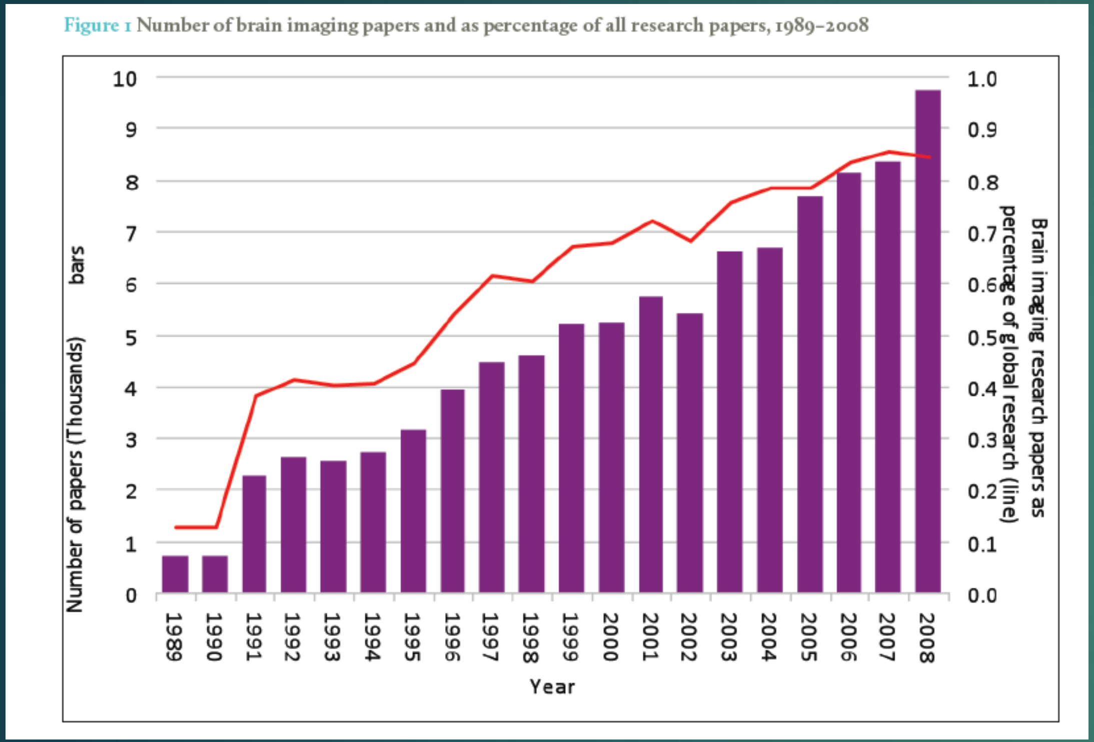

Cortical Activity during Hand Movement
Contralateral Hemisphere
Ipsilateral Hemisphere
Healthy Subjects (Right Hand)
Stroke Patients Affected Hand (Right Hand)

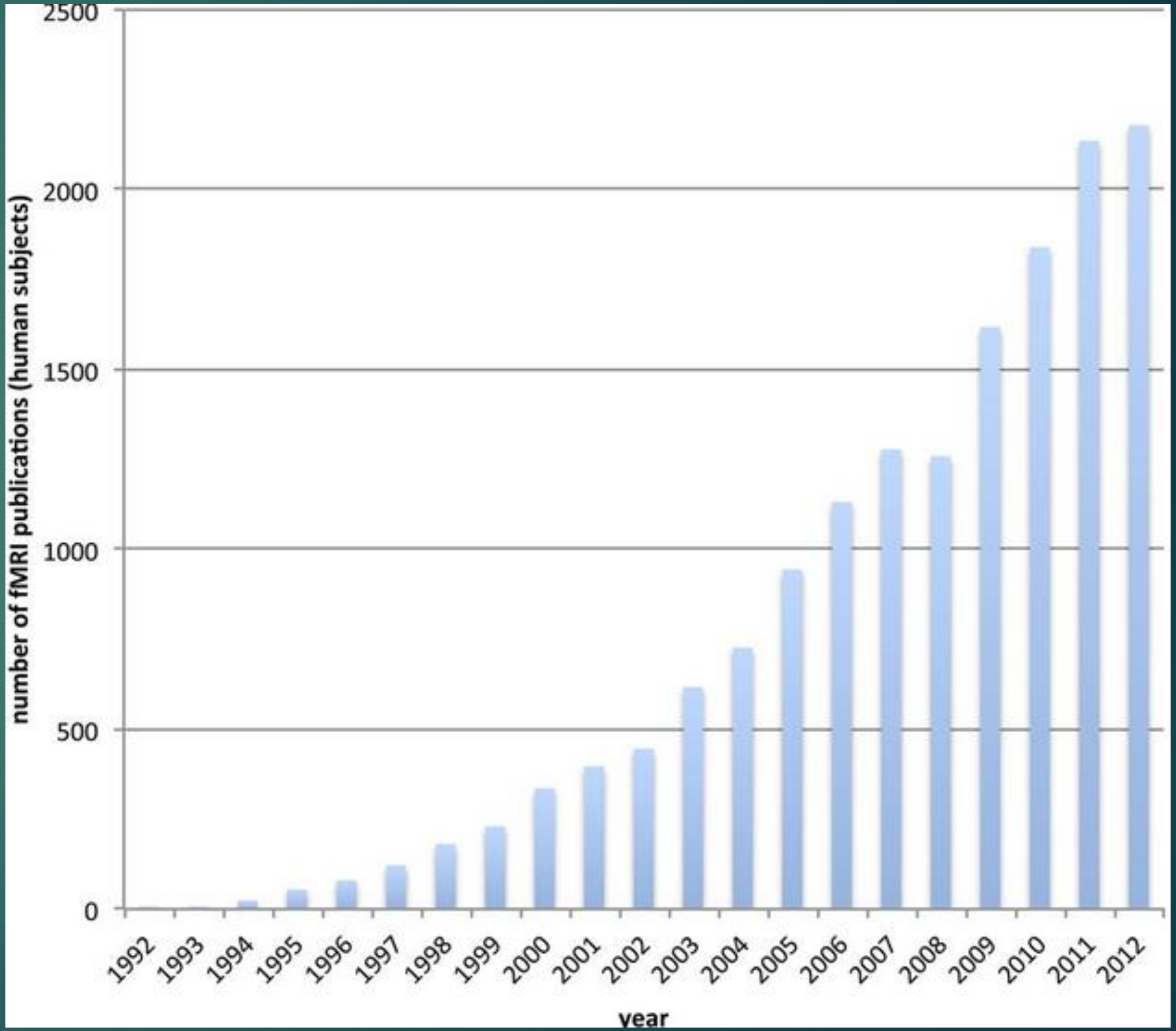
Brain Imaging is a Wonderful New Science

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

- A powerful diagnostic tool

Number of neuroimaging papers: 1989-2012





New terminology to learn about

The New Neurosciences:

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

And, of course, Neurolaw

Caution

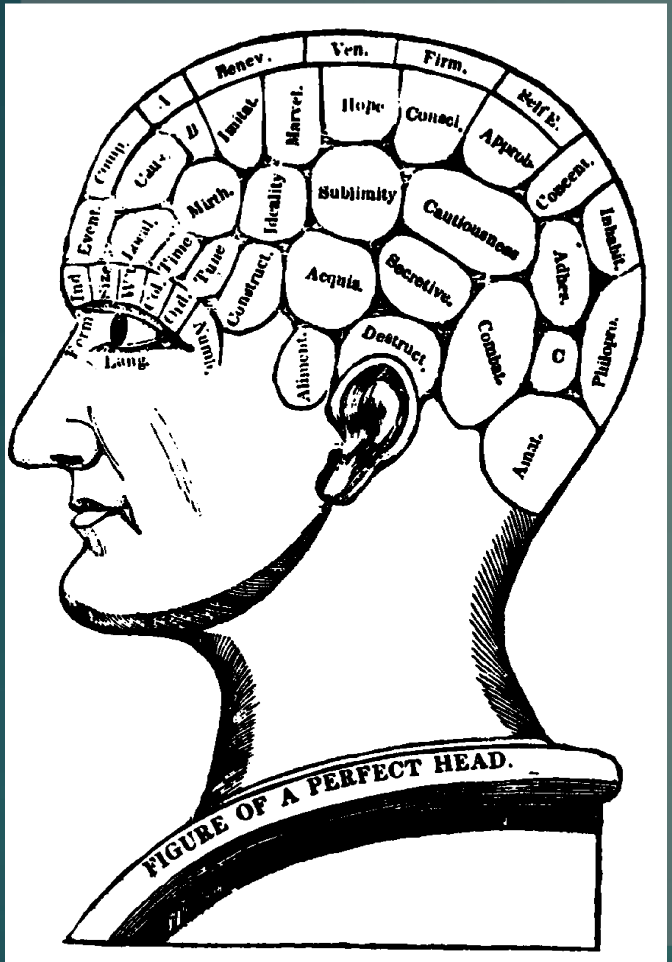
- Neuroscience has been creeping into the nation’s courtrooms with greater frequency. Yet the science, while much of it promising, is not quite ready for use as evidence in most legal cases, U.S. District Judge Jed S. Rakoff told a group of neuroscientists gathered in Chicago.
- Criminal lawyers, for 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.

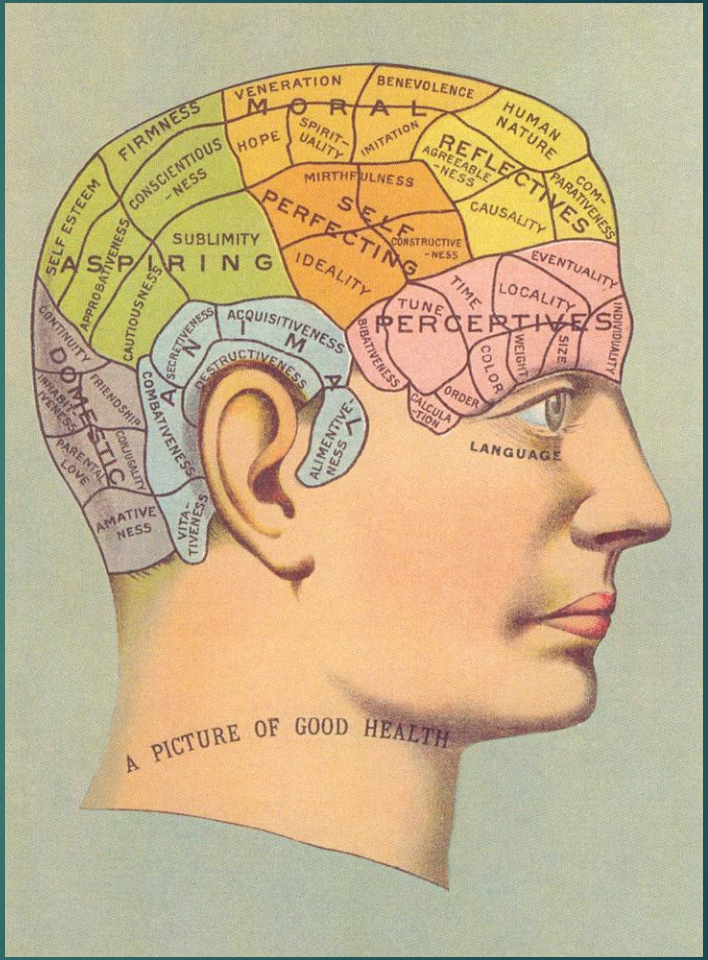
History

- During the last century, the law embraced science in ways that were inhumane and harmful—and eventually 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 in disfavor, Rakoff said.
- In addition, lobotomies were not only accepted by the medical community for psychiatric patients, but courts often ordered the procedure for people whether they wanted it or not, Rakoff pointed out. And in the 1990s, so-called recovered memories led to people being convicted of crimes, often child sexual abuse, on shoddy evidence with no solid scientific basis.

Brief tour of neuroimaging

Phrenology: Bumps make the Man





Dave, Lea, Noelle, Dr. Elizabeth Twamley

Dr. Charles Vella's gift to his daughter Dr. Lea Vella on receiving her Ph.D. In June 2014 from UCSD Neuropsych program.

Go Lea! Proud Papa!

Advanced Neuroimaging circa 1905:

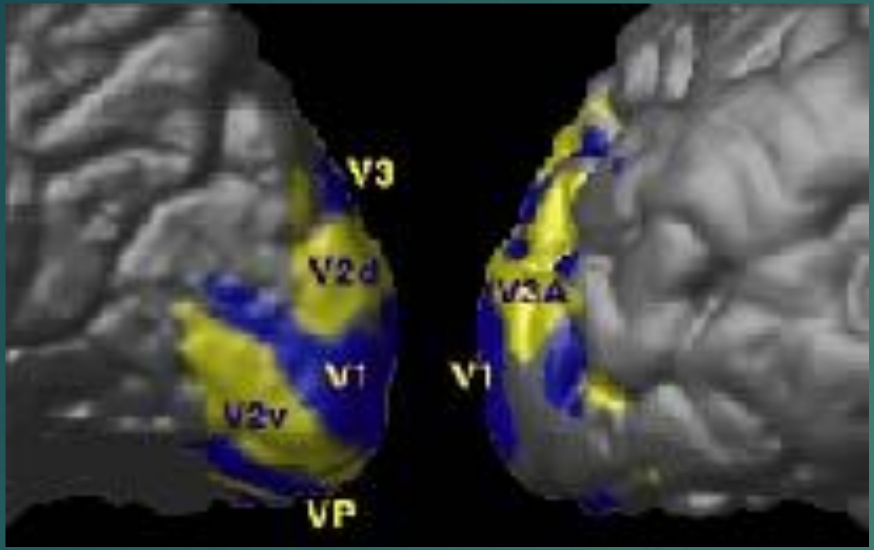
Phrenology “MRI”

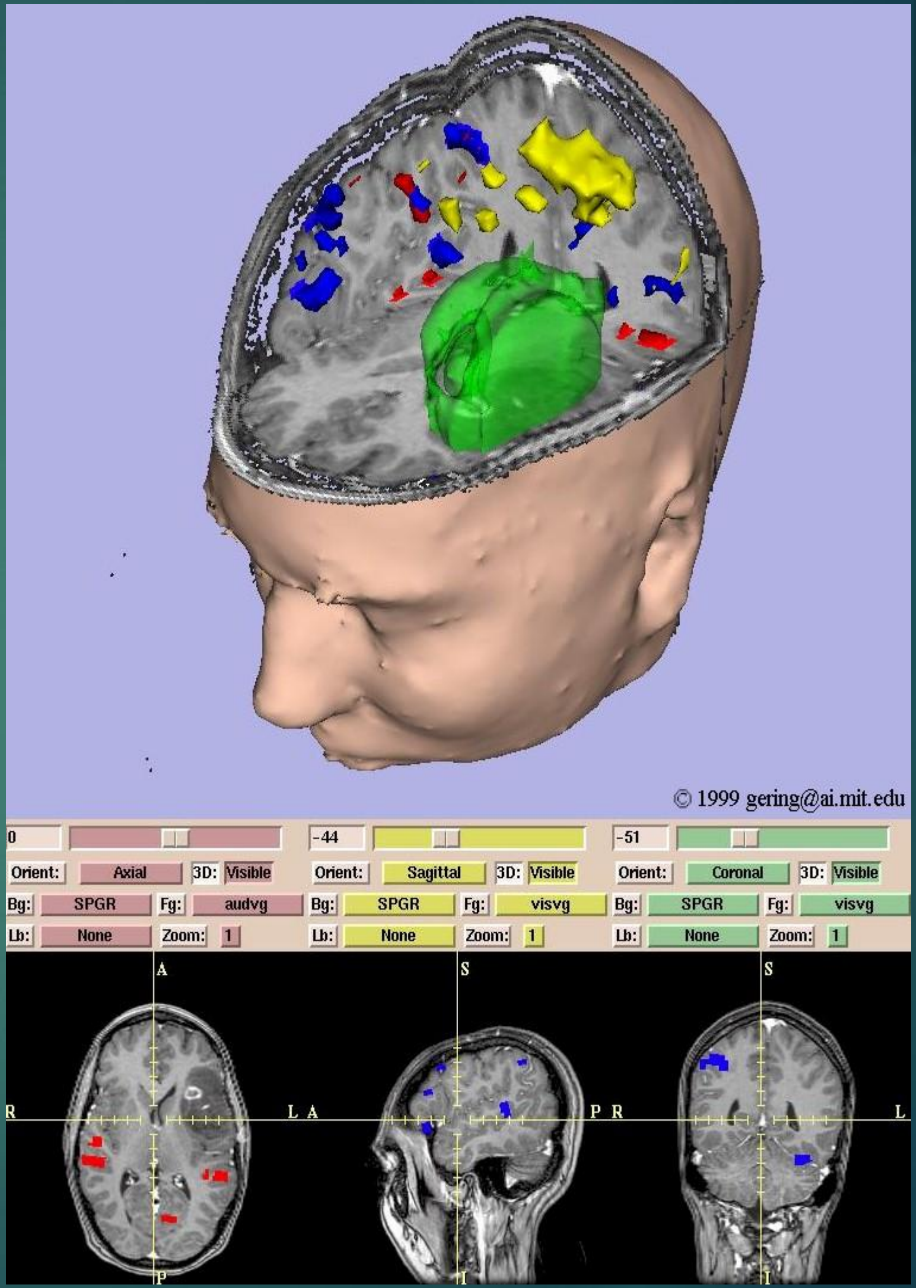
Measured head at 32 points per a five-point scale ranging from “Deficient” to “Very Superior.”

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 ?





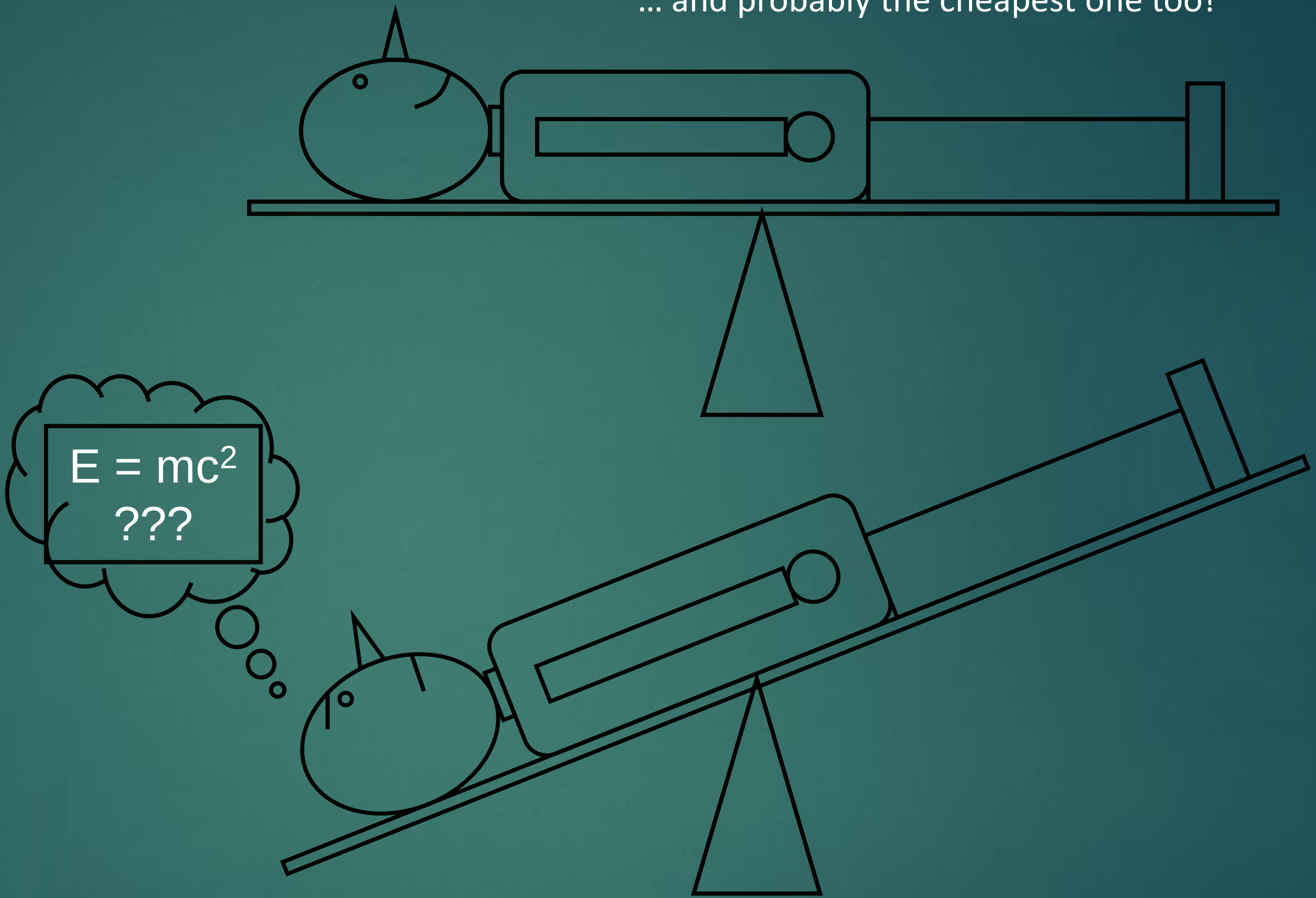
Wilhem Konrad Roentgen, 1845-1923

1895: X-ray

1901: The First "Brain Imaging Experiment"

… and probably the cheapest one too!

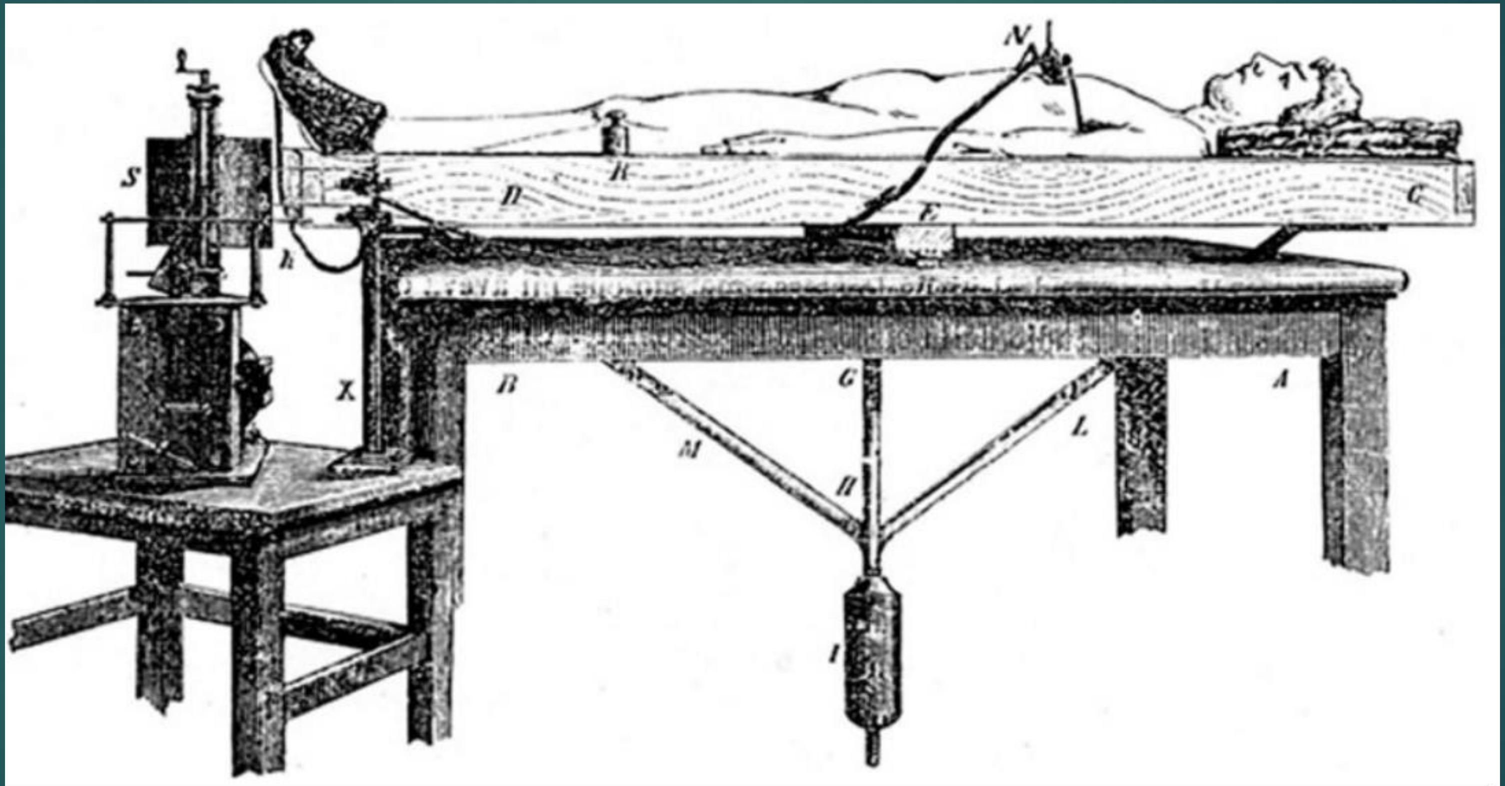
Angelo Mosso
Italian physiologist
(1846-1910)



"[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)

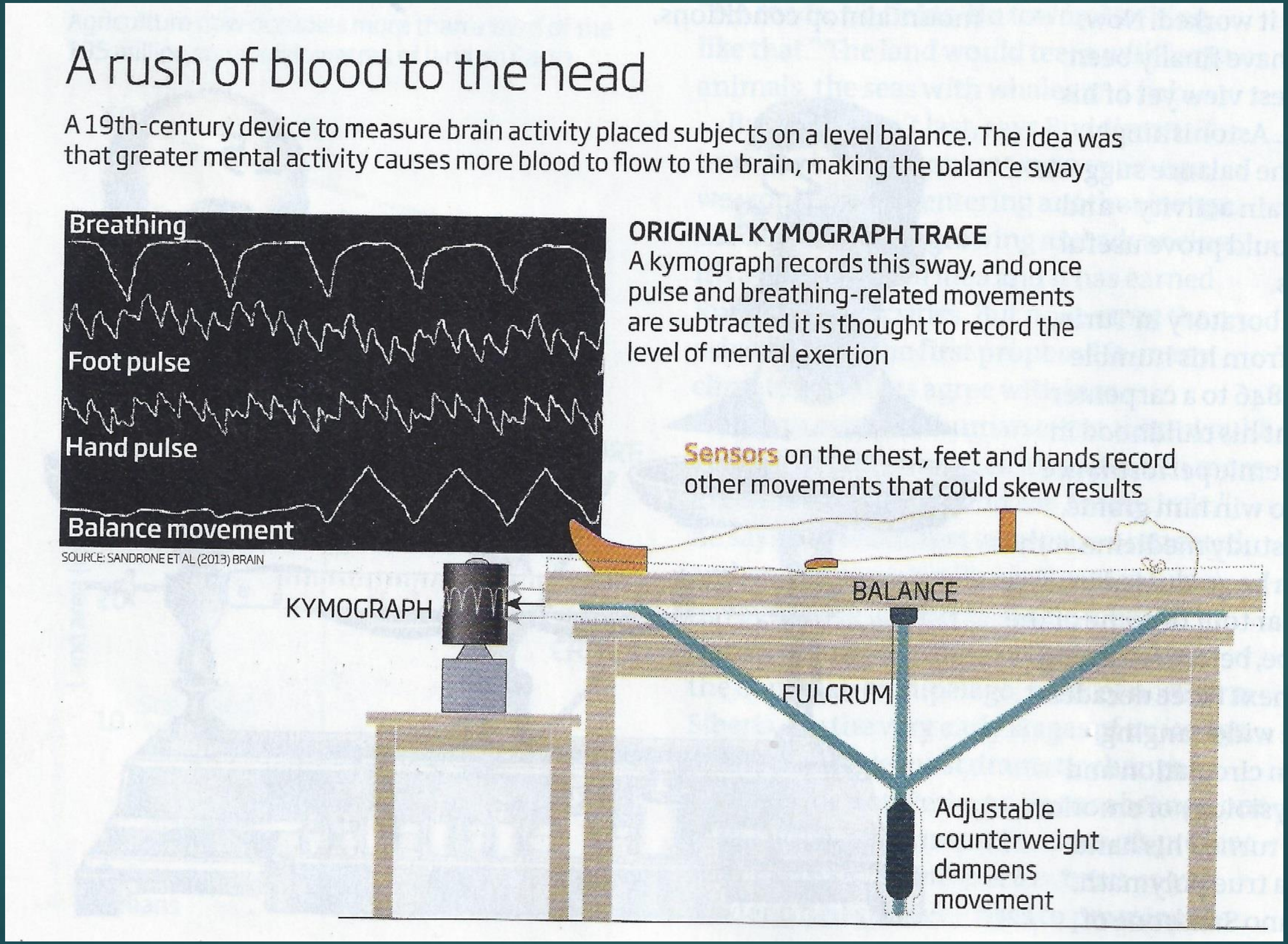
Angelo Mosso in 1901: 1st Brain Activity Device



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

First Hemodynamic Brain Imaging



1907 Fluoroscope (constant xray)

Risks that we do not originally understand

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

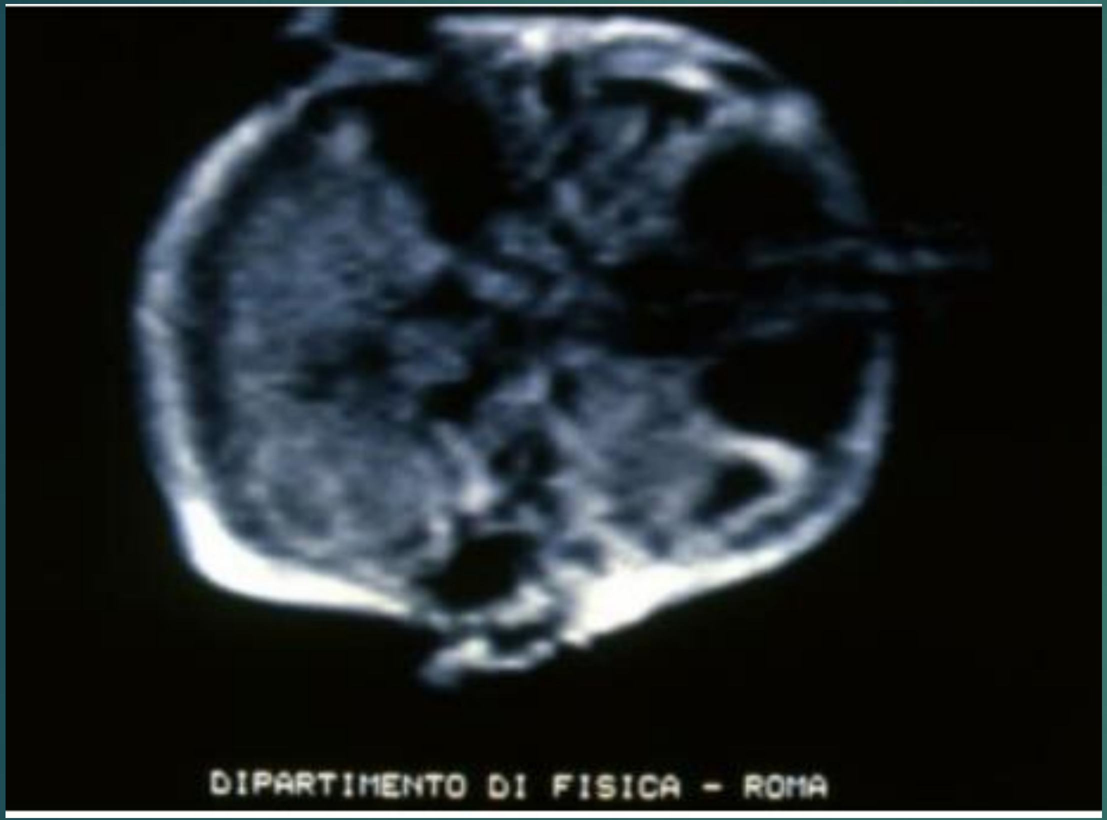
Buster Brown Shoe Stores in 1950s:
Fluoroscope for shoe fitting
Charlie’s first x-ray.

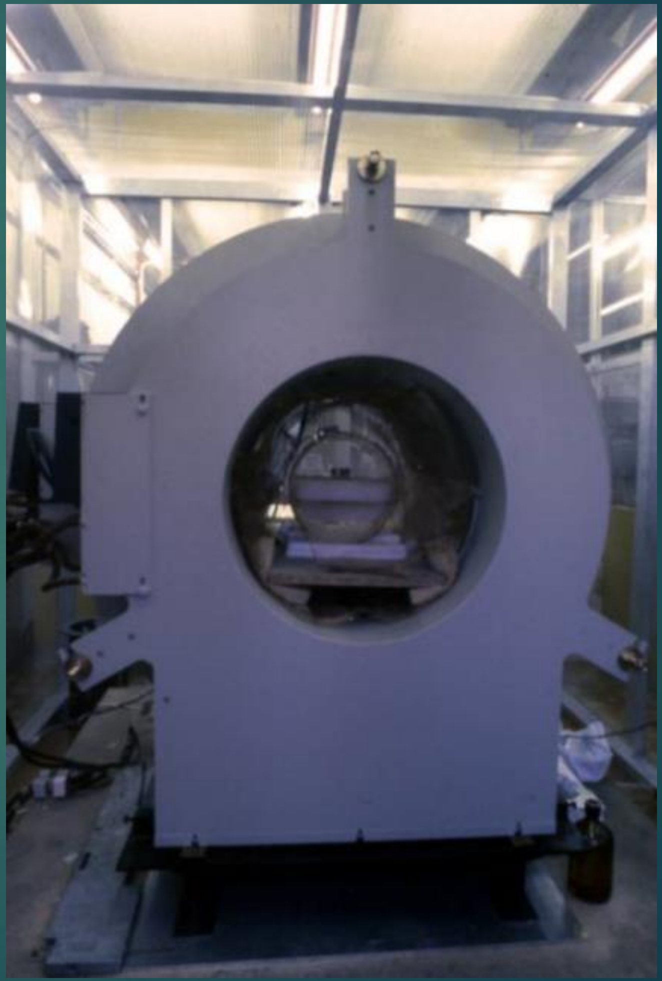
Average of 13 roentgen (r) for 20 seconds
10,000 in USA ; Shoe salesman higher exposures; FDA bans in 1953

“The women doomed to die“: Radium dial painters – 50% died

Radium dial painters working in a factory

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)

MRI

A la Rembrandt's The Anatomy Lesson of Dr. Nicolaes Tulp

New Couples fMRI Machine:
Brain areas sync when we interact

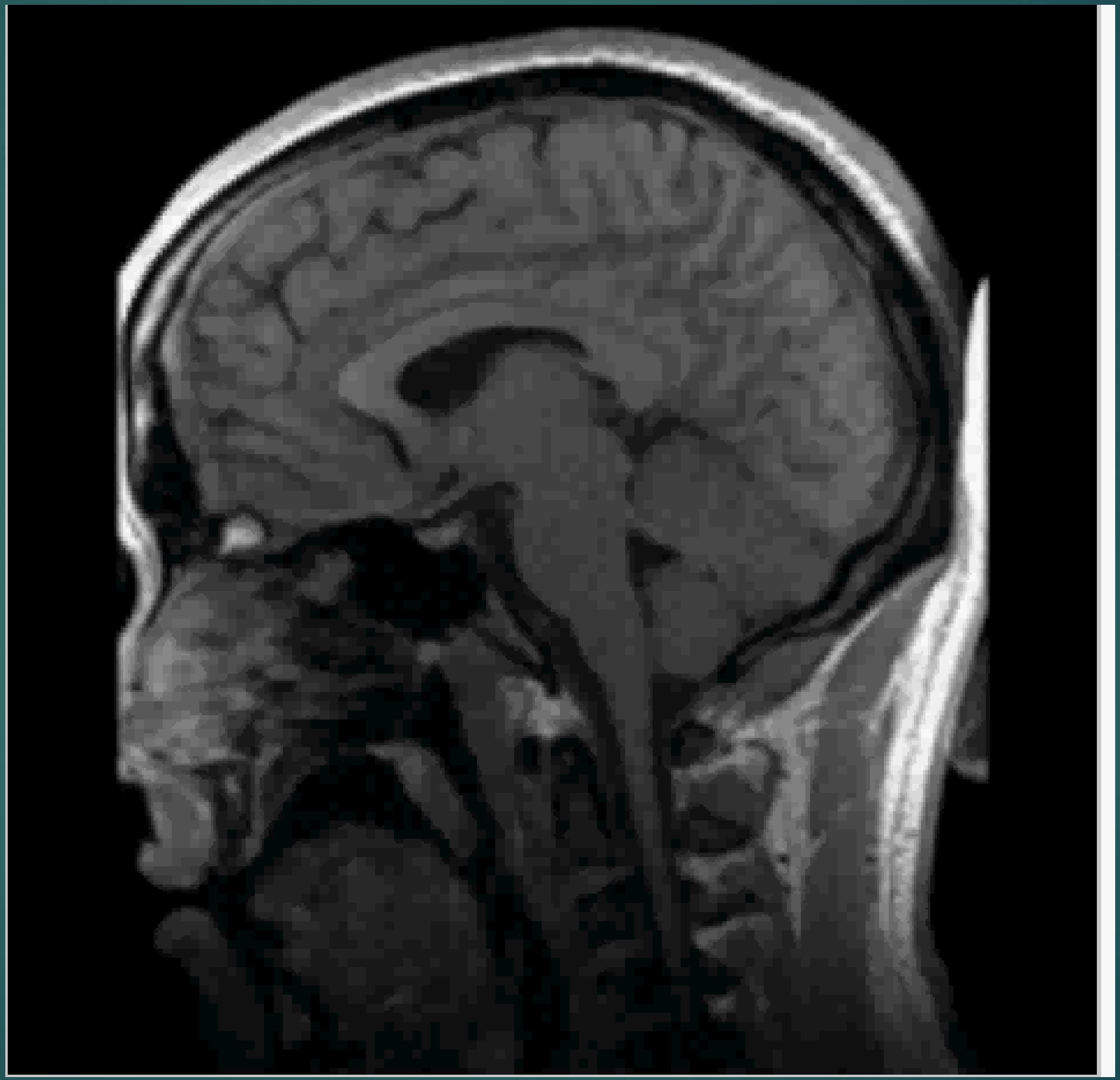
Friends: basal ganglia
Lovers: pCC

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

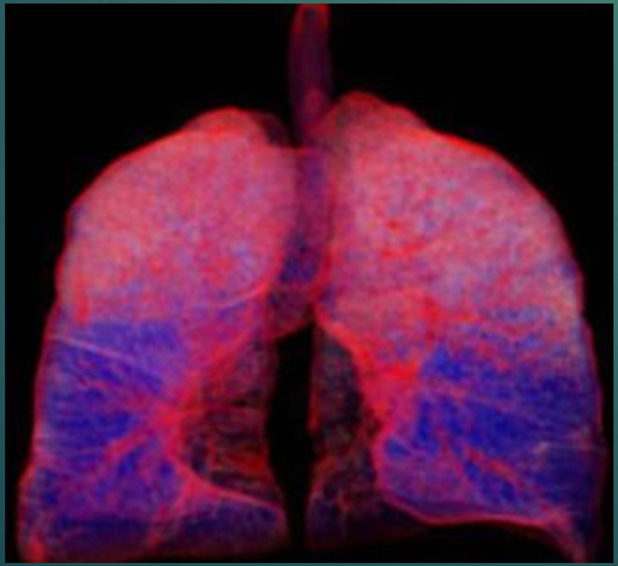
Ray Lee at Princeton University

MRI



Start film

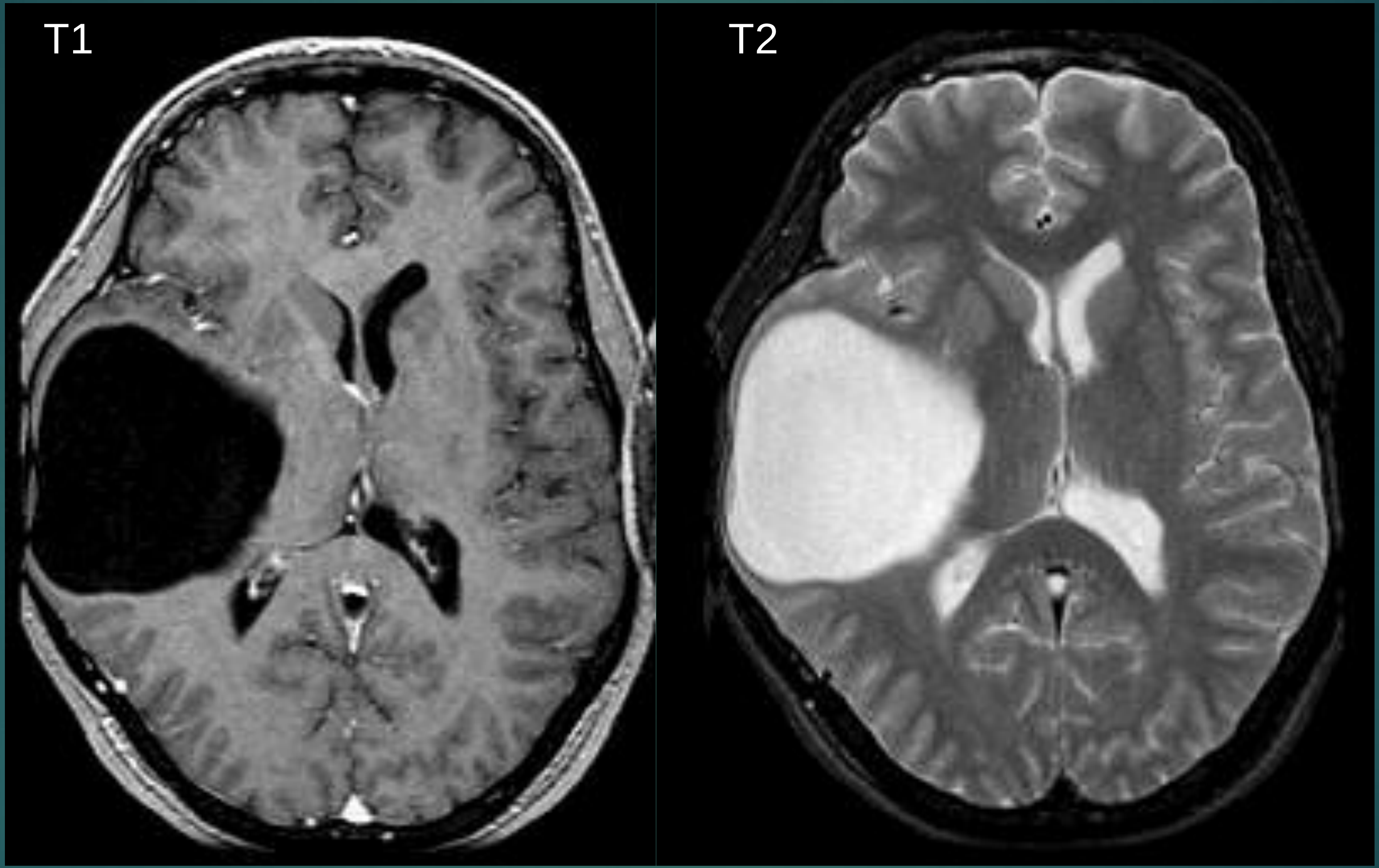
CT - Multidetector Imaging



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.

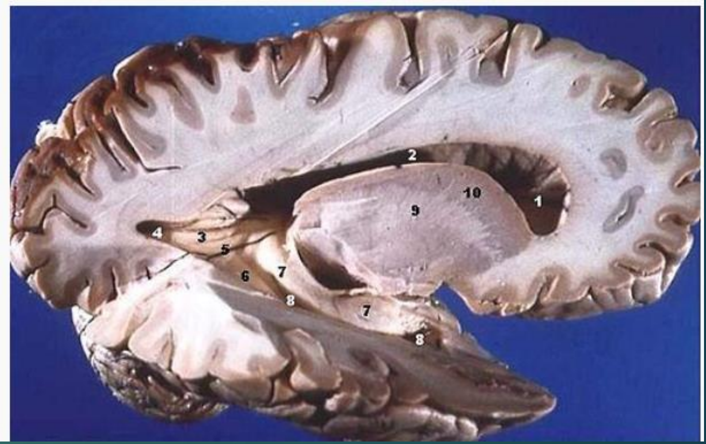
Magnetic Resonance

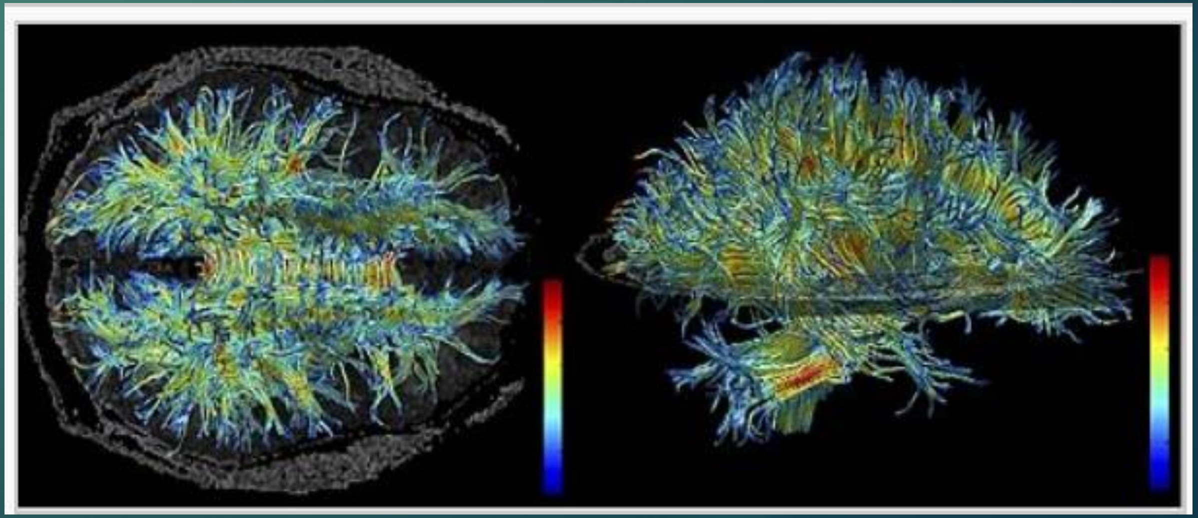


Arachnoid Cyst: water is bright on T2

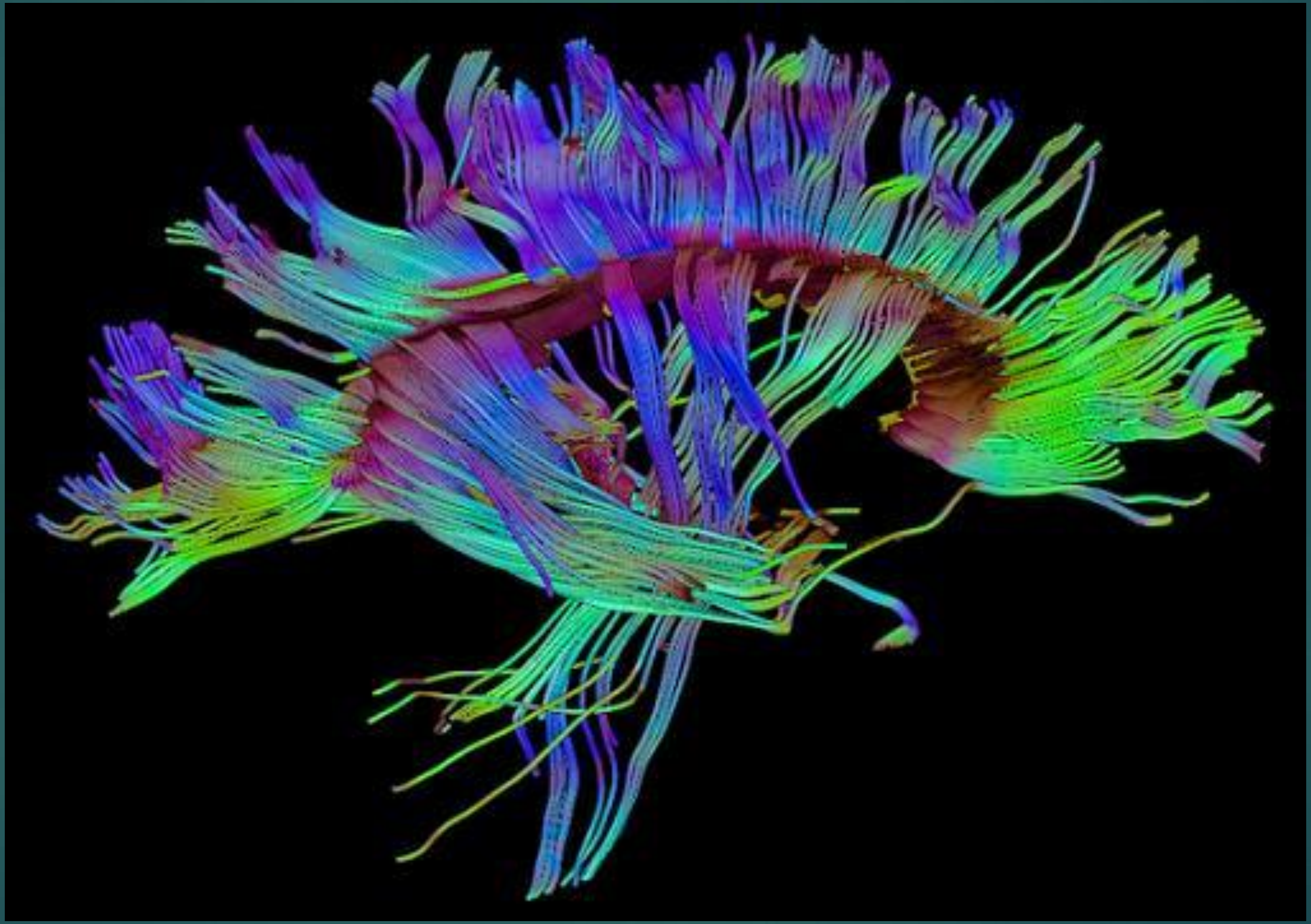
White Matter

- <u>Metaanalysis of non NCD WM disease (8 deficits in order of effect size):</u>
  - thinking speed (greatest deficit)
  - immediate and delayed memory
  - executive functioning,
  - general functioning,
  - language,
  - working memory
  - visuo-spatial construction.

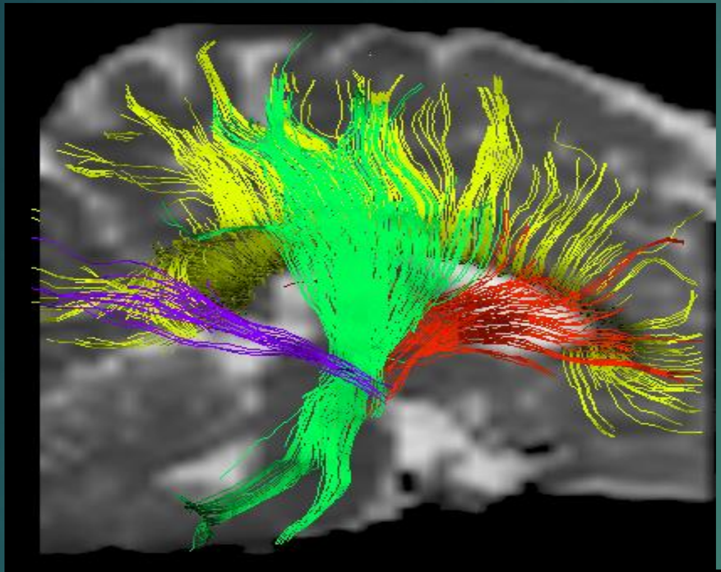




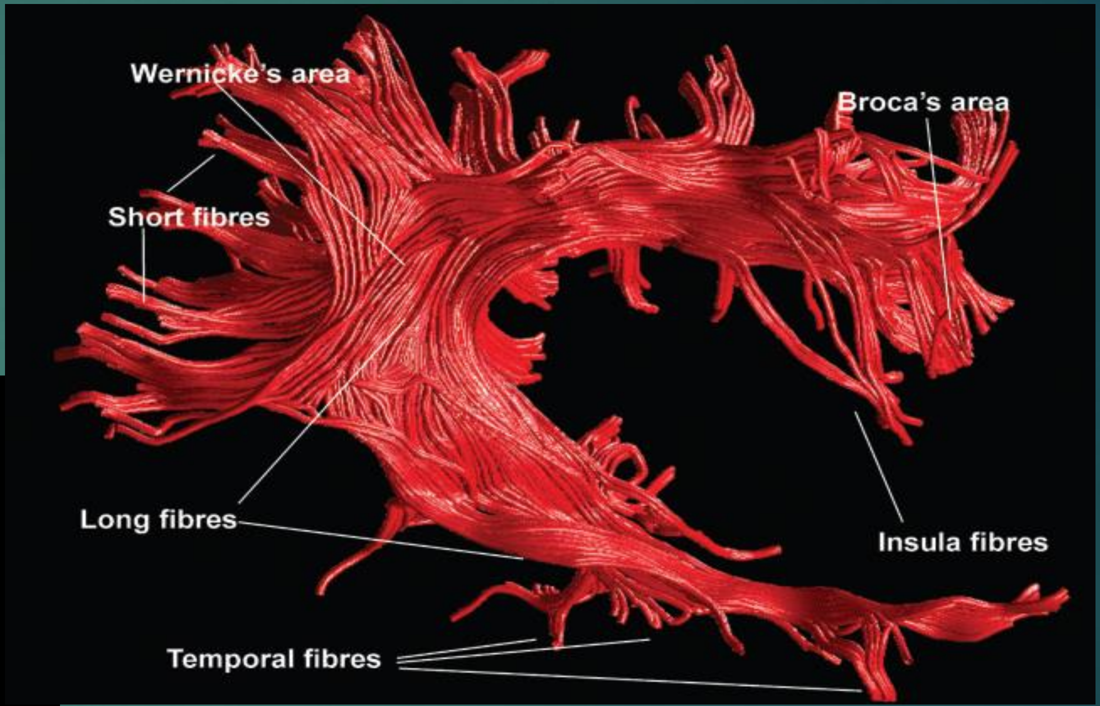
DTI: Diffusion Tensor Imaging – Direction of water molecules



DTI – Tractography

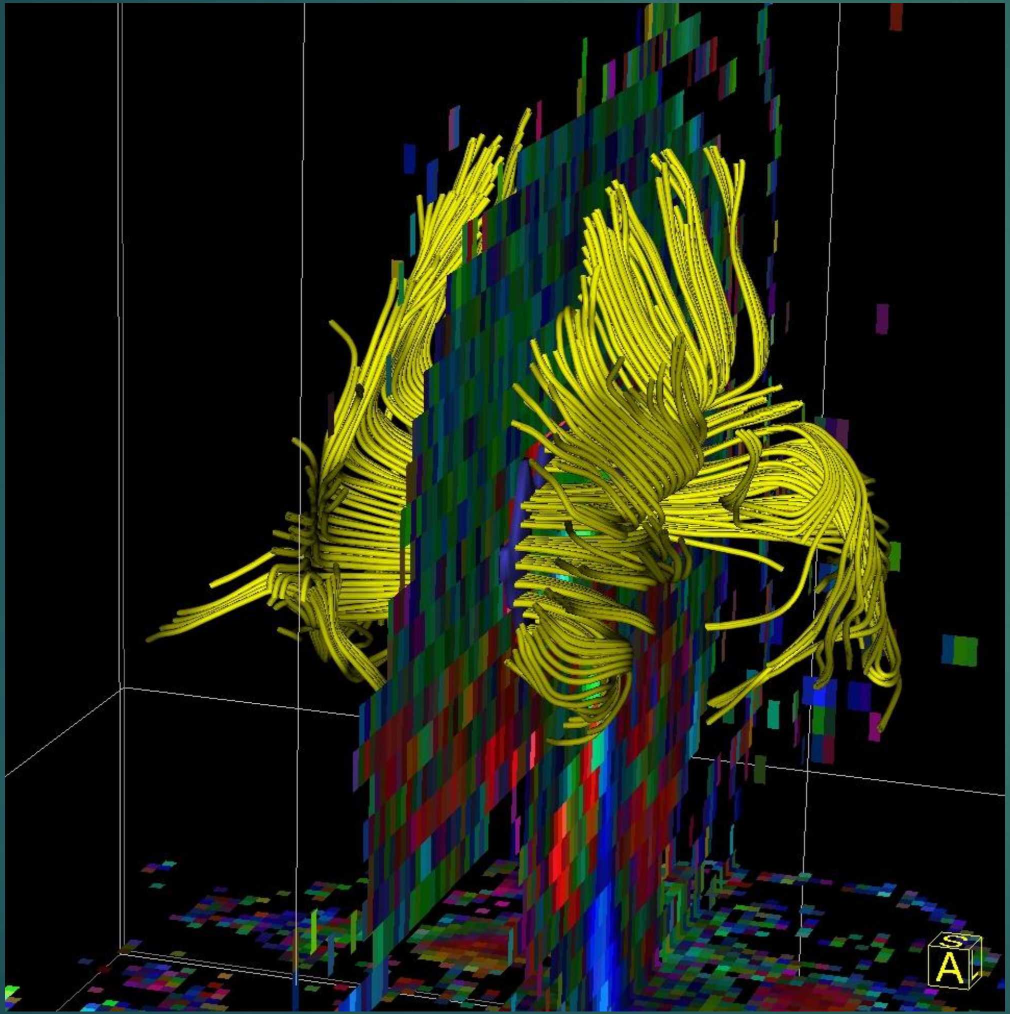


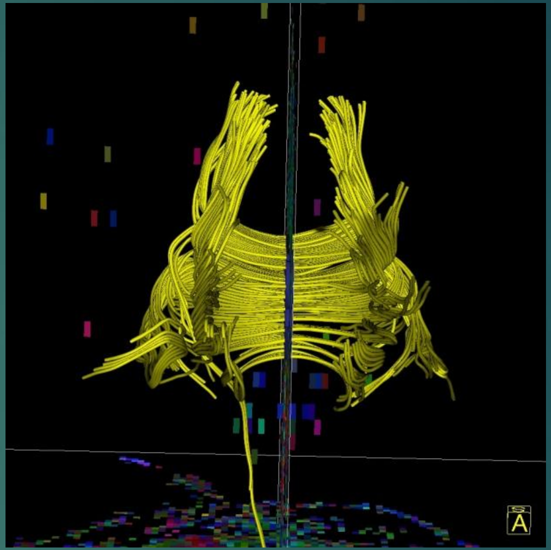
S. Mori - JHU

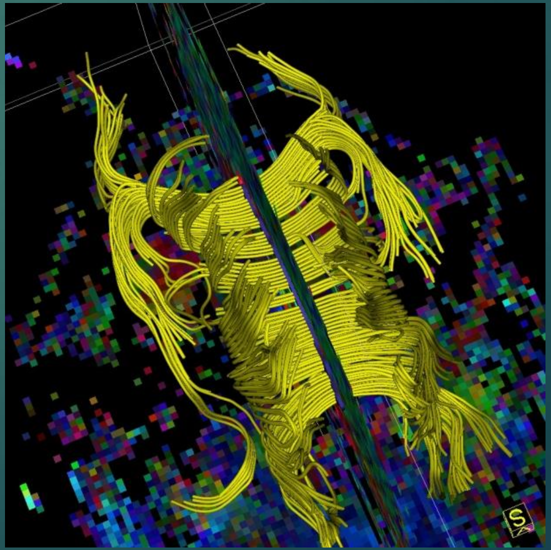


D. Jones – U Nottingham, UK

DTI-Tractography: Corpus Callosum

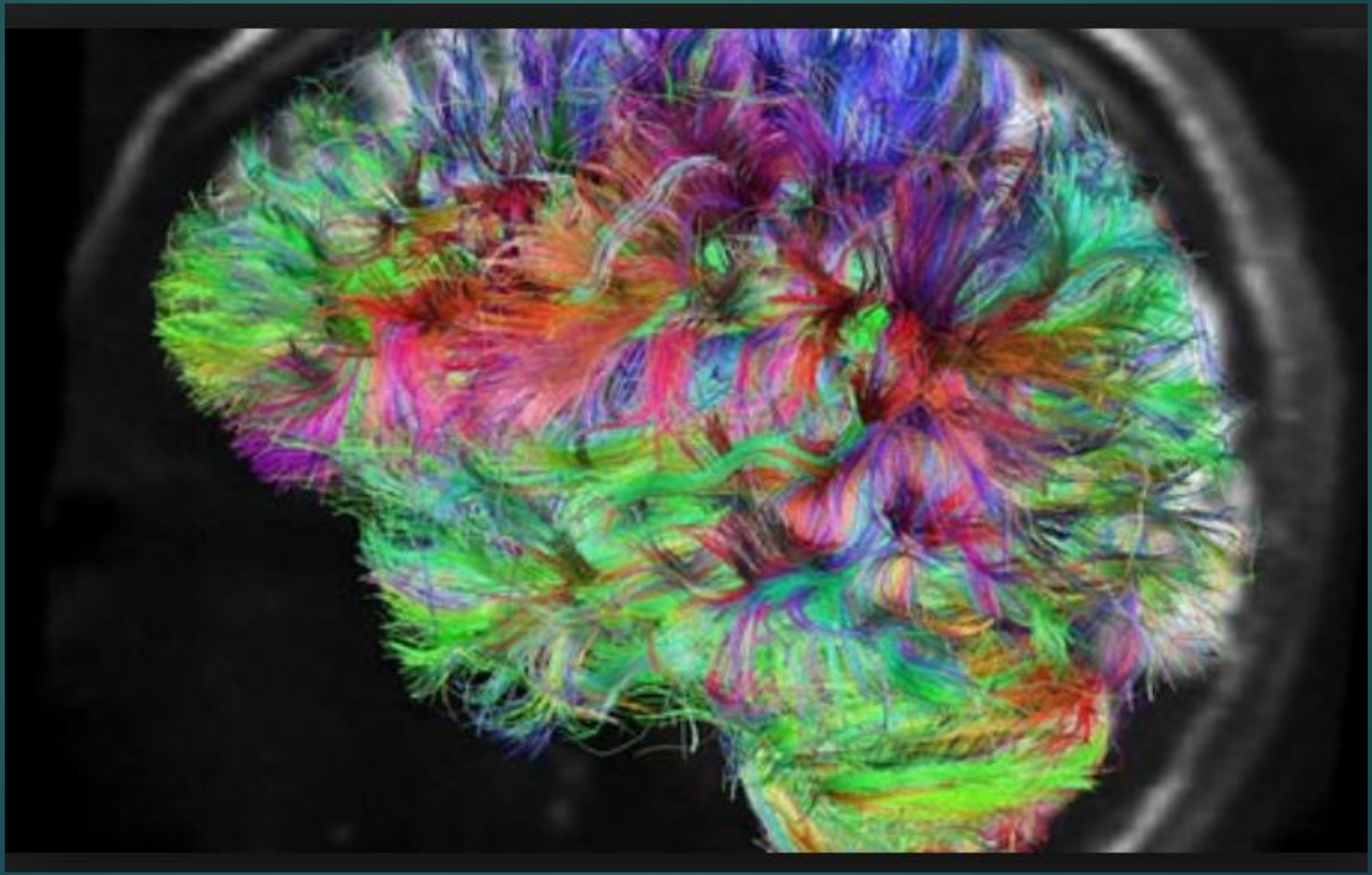




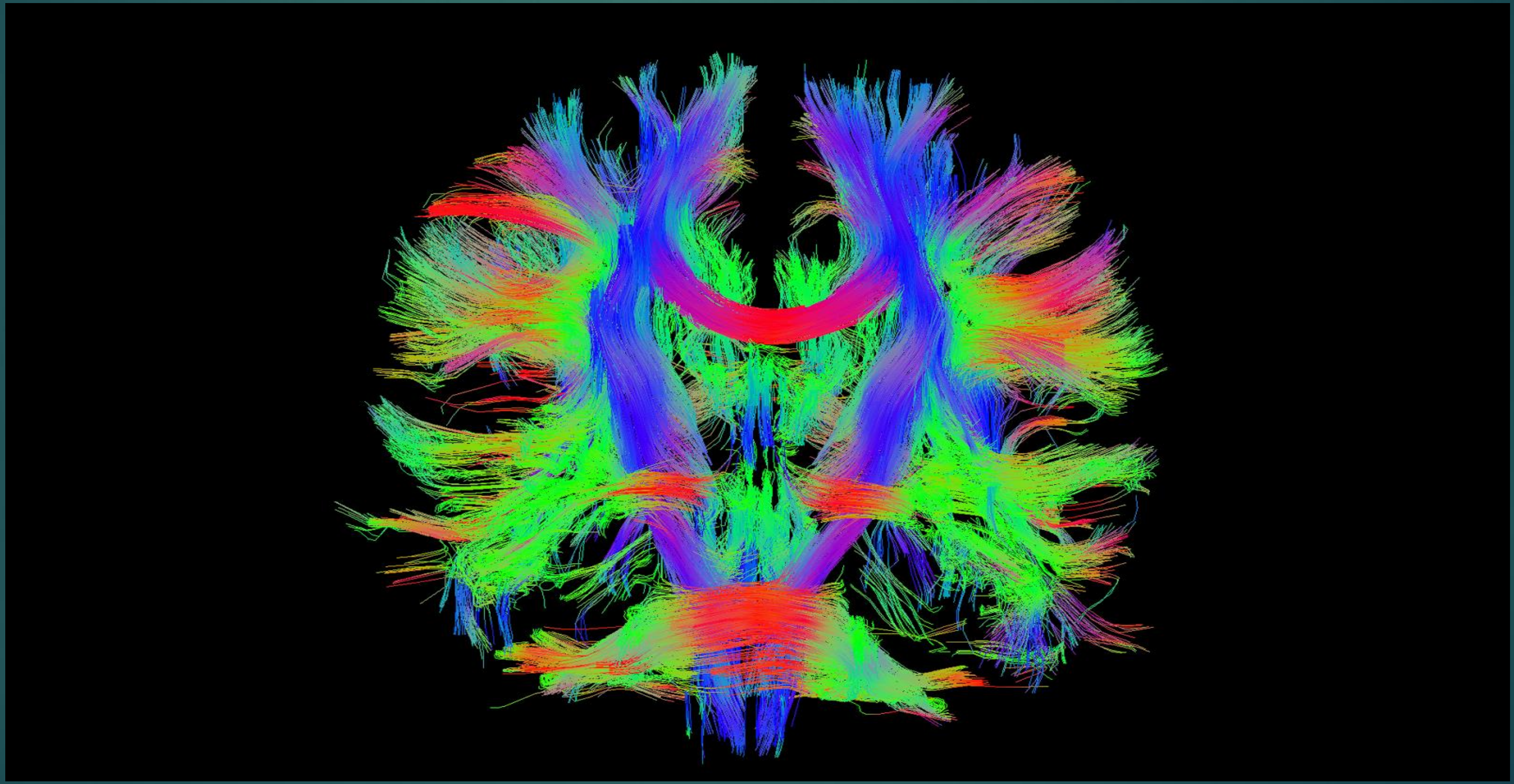


W.Zhan et. al.

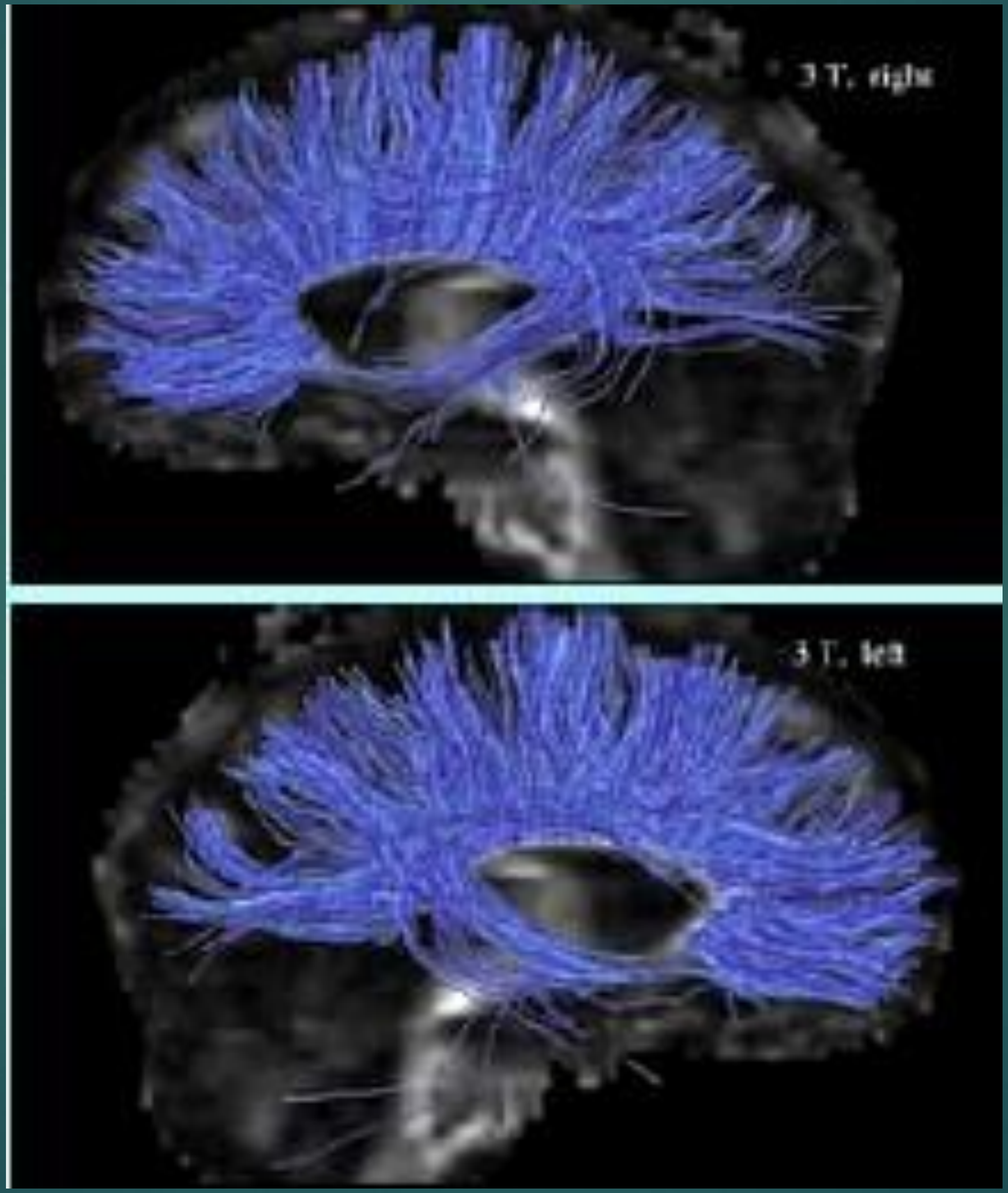
Diffuse Tensor Imaging



Diffusion MRI

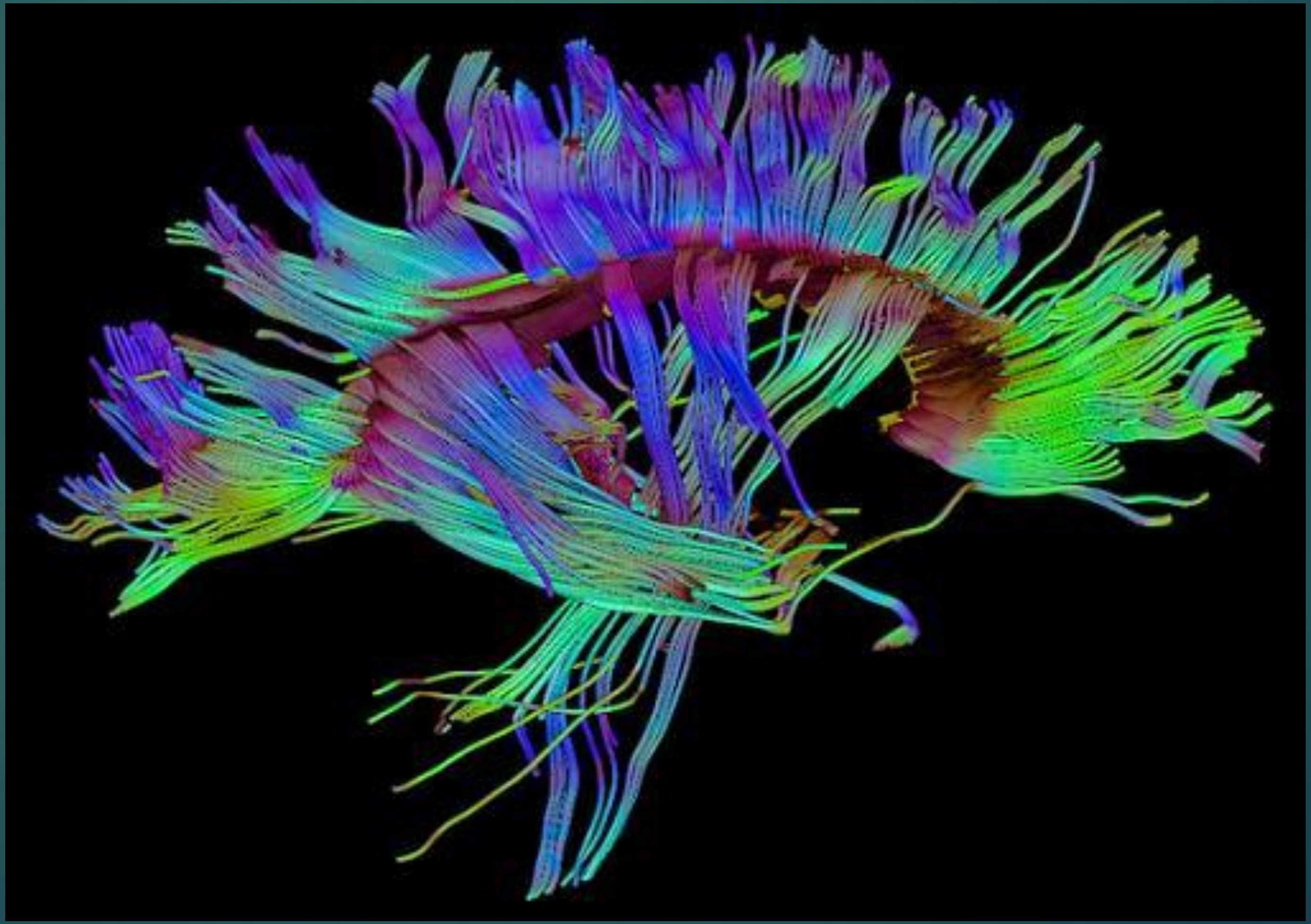


White Matter: Diffusion Tensor MRI

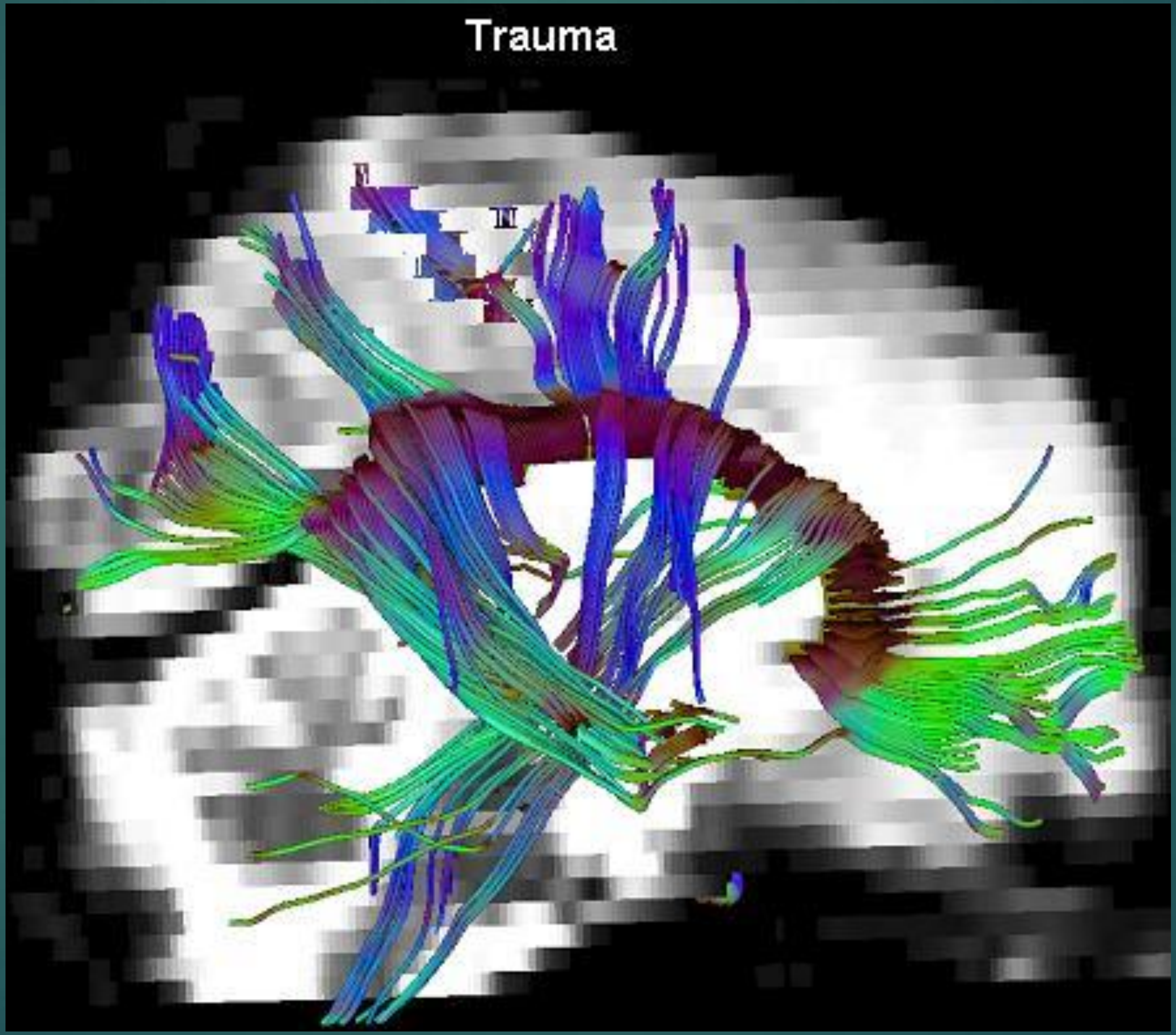


White Matter: Diffusion Tensor MRI in Traumatic Brain Injury

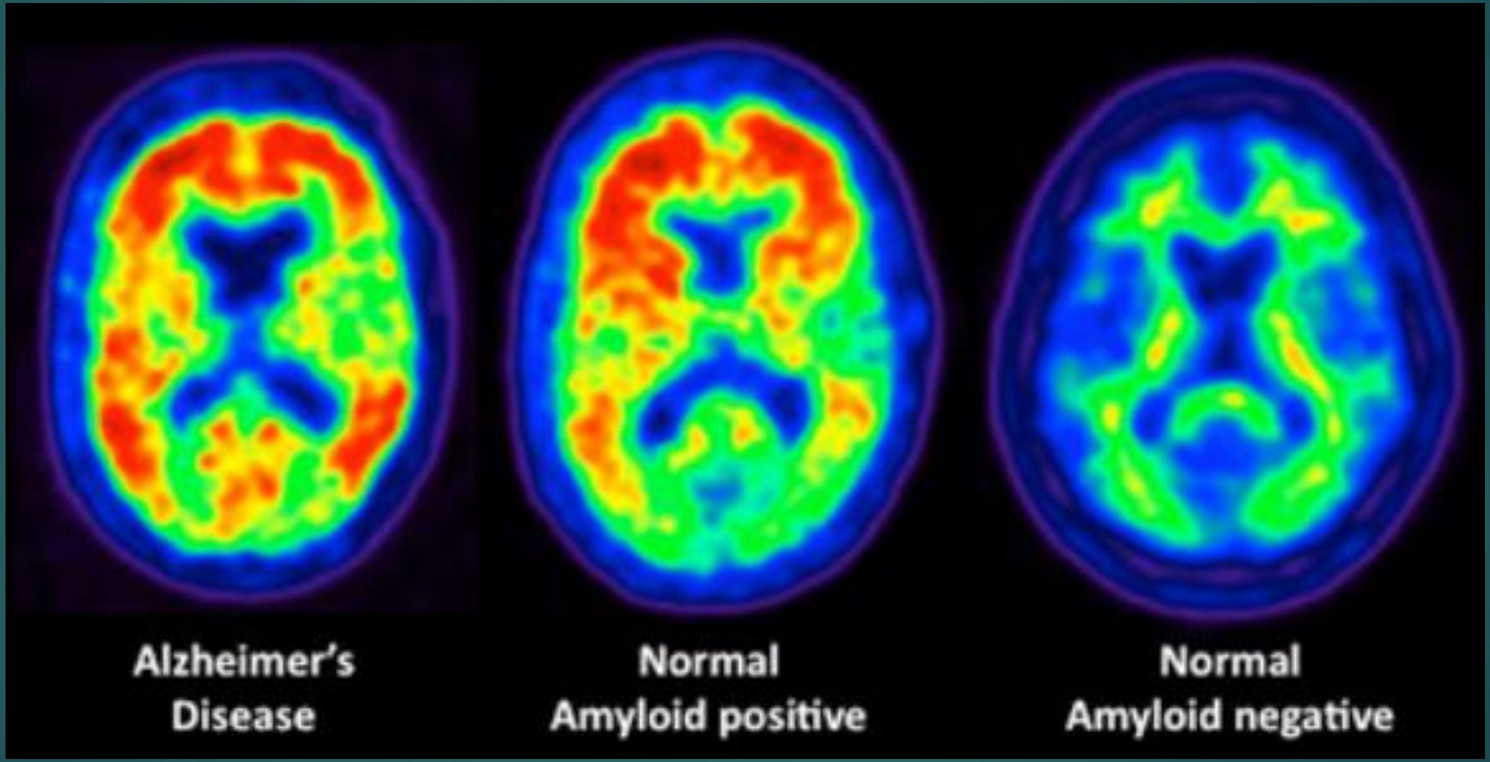
If a man commits a crime after a serious TBI, what would you think of this evidence?



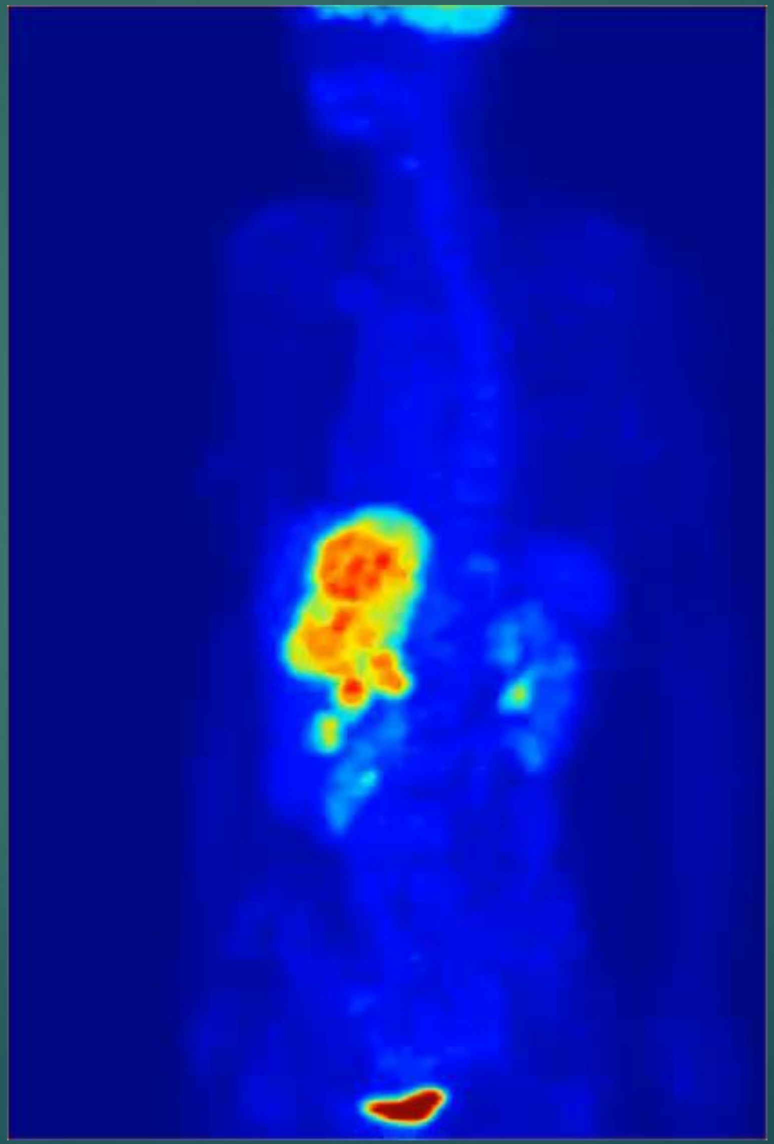
Or for this person with TBI?



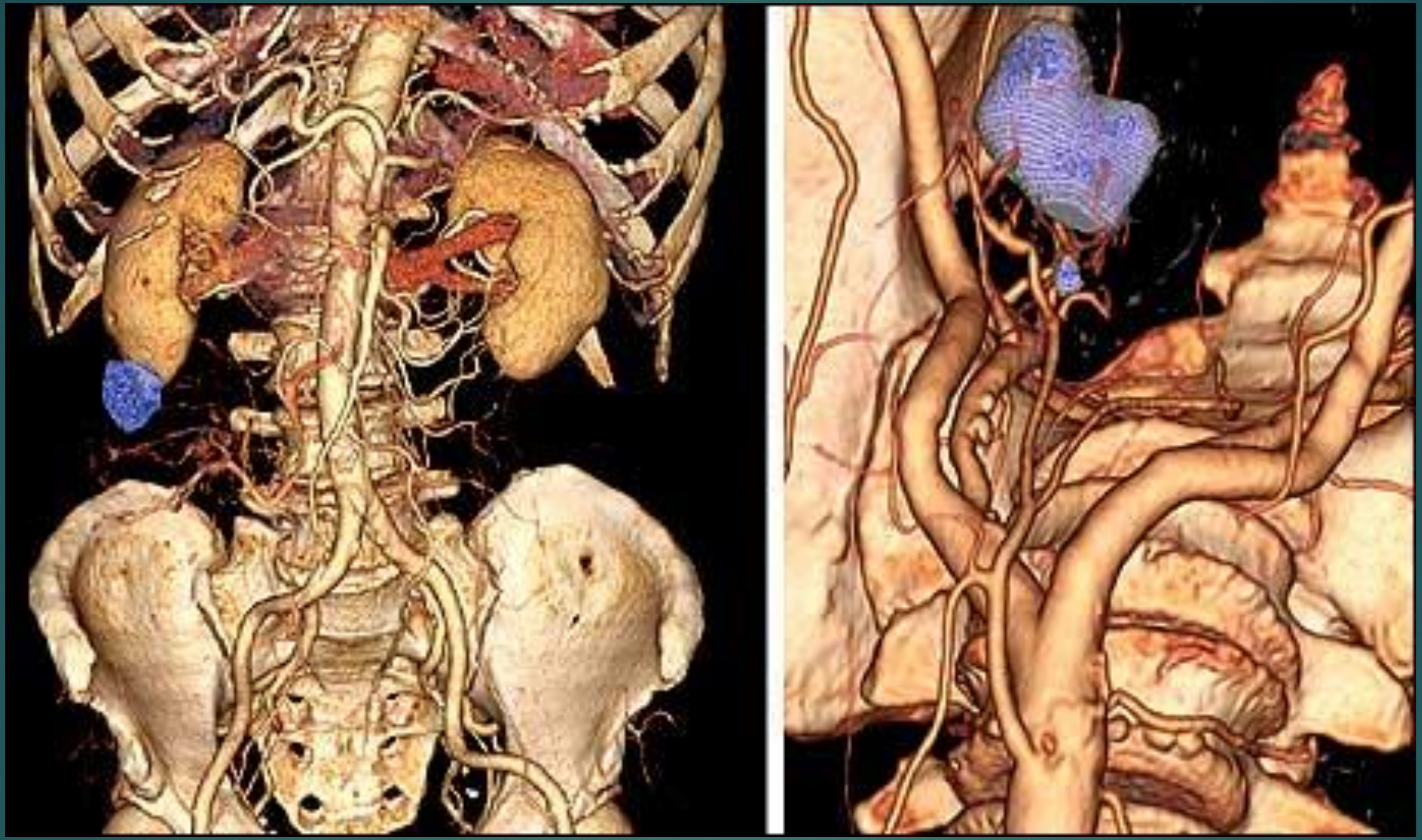
PET: beta amyloid binding



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

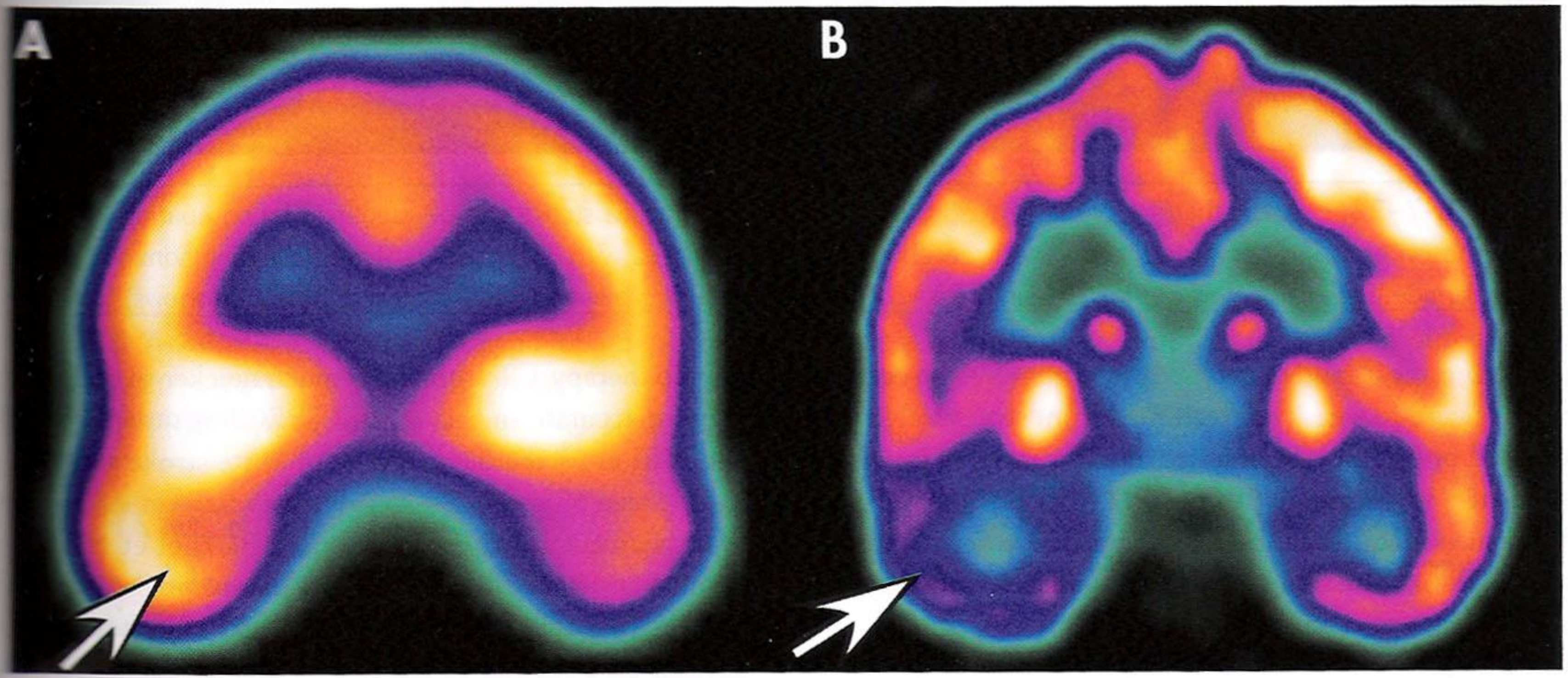
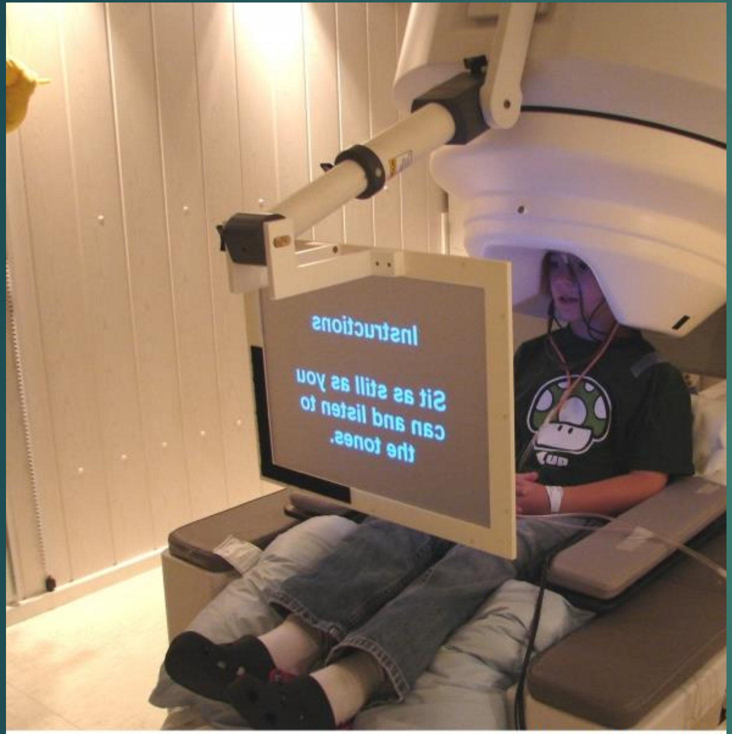


FIGURE 7–27. Nuclear medicine imaging is useful for visualizing the area of an epileptic focus. (A) Scans obtained during a seizure (ictal scan) will show increased perfusion or metabolism, as illustrated here with a coronal single-photon emission computed tomographic image of cerebral blood flow (*arrow*).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

Between seizures

(Cummings and Mega, 2003)

MEG: Magnetoencephalography
“Hairdresser from Mars”

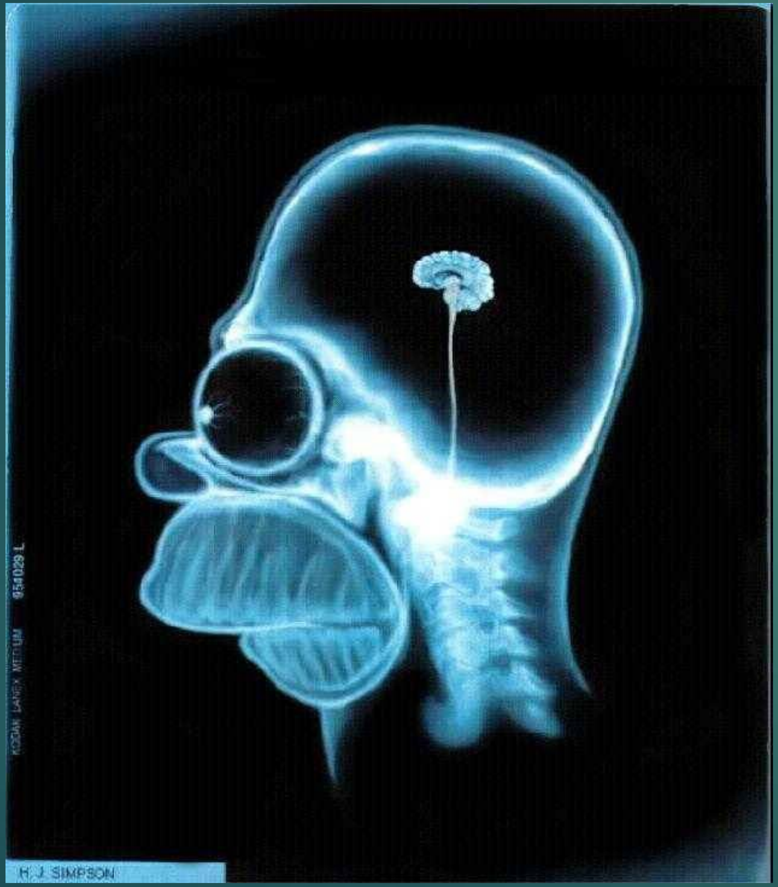


Timothy Roberts, 4-D Neuroimagin

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

MRI vs. fMRI

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

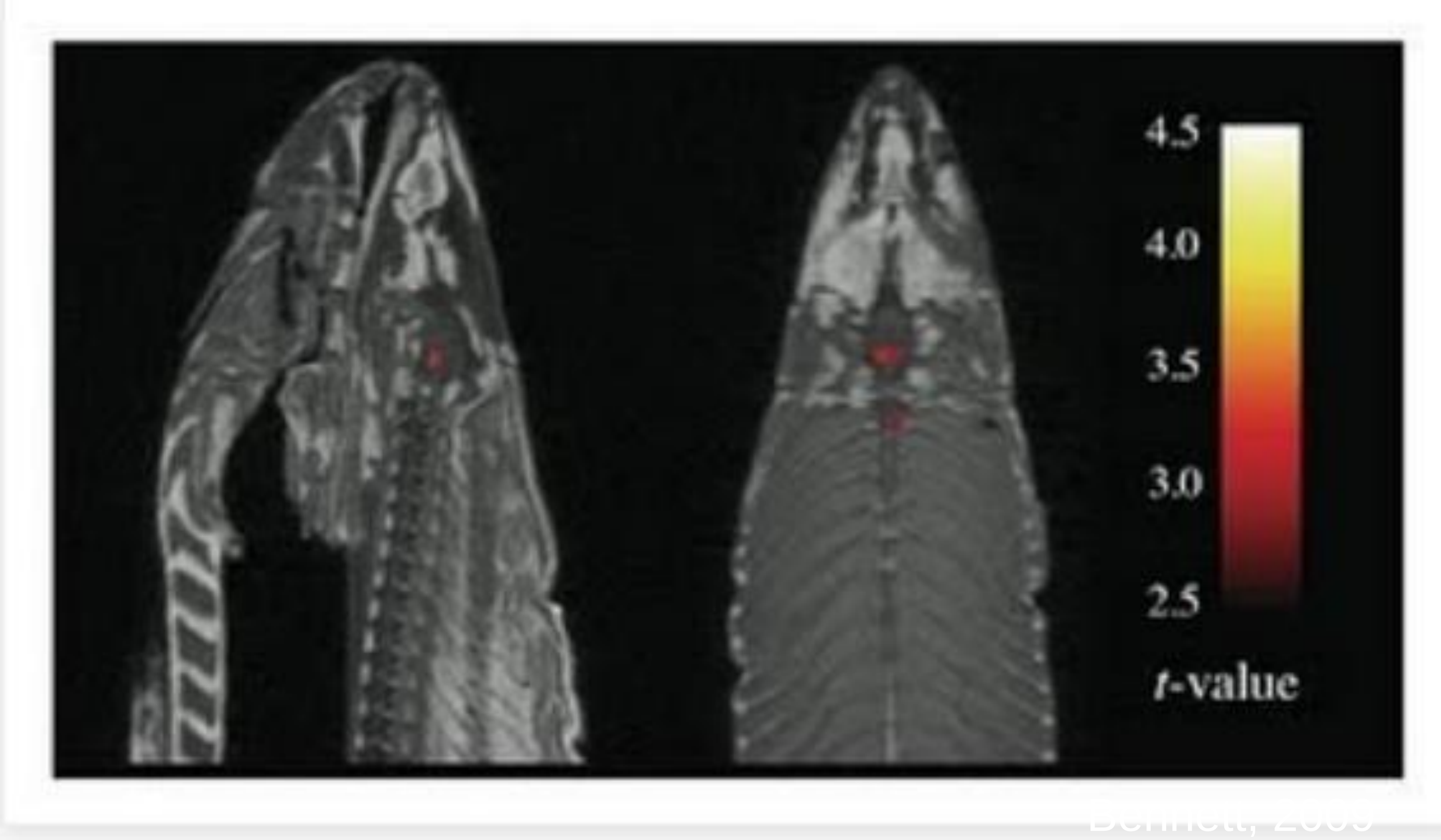


FMRI studies brain <u>function</u>.

Source: Jody Culham's fMRI for Dummies web site

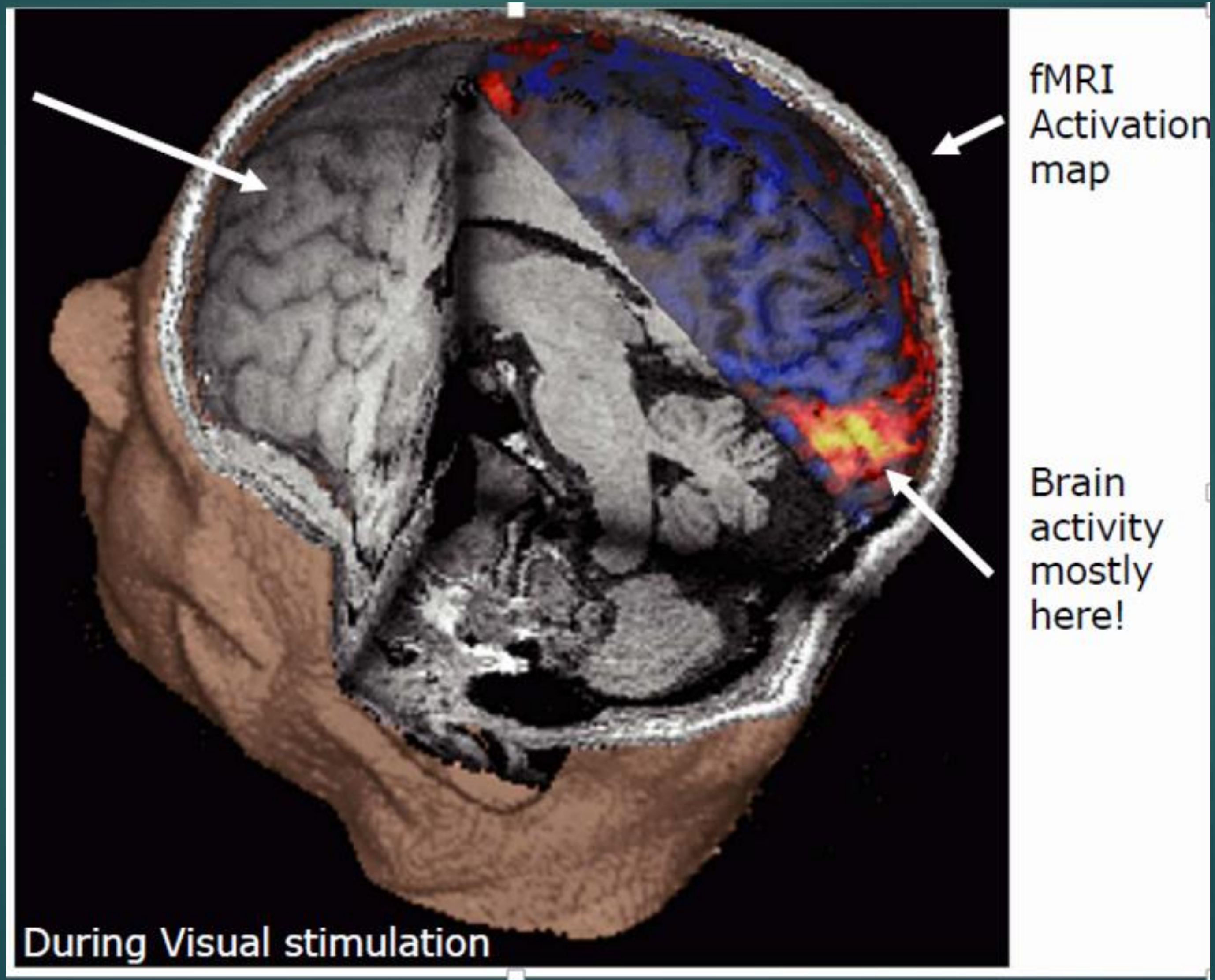
Cautionary Tale: Post-Mortem Atlantic Salmon: false positives in MRI phantom data

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

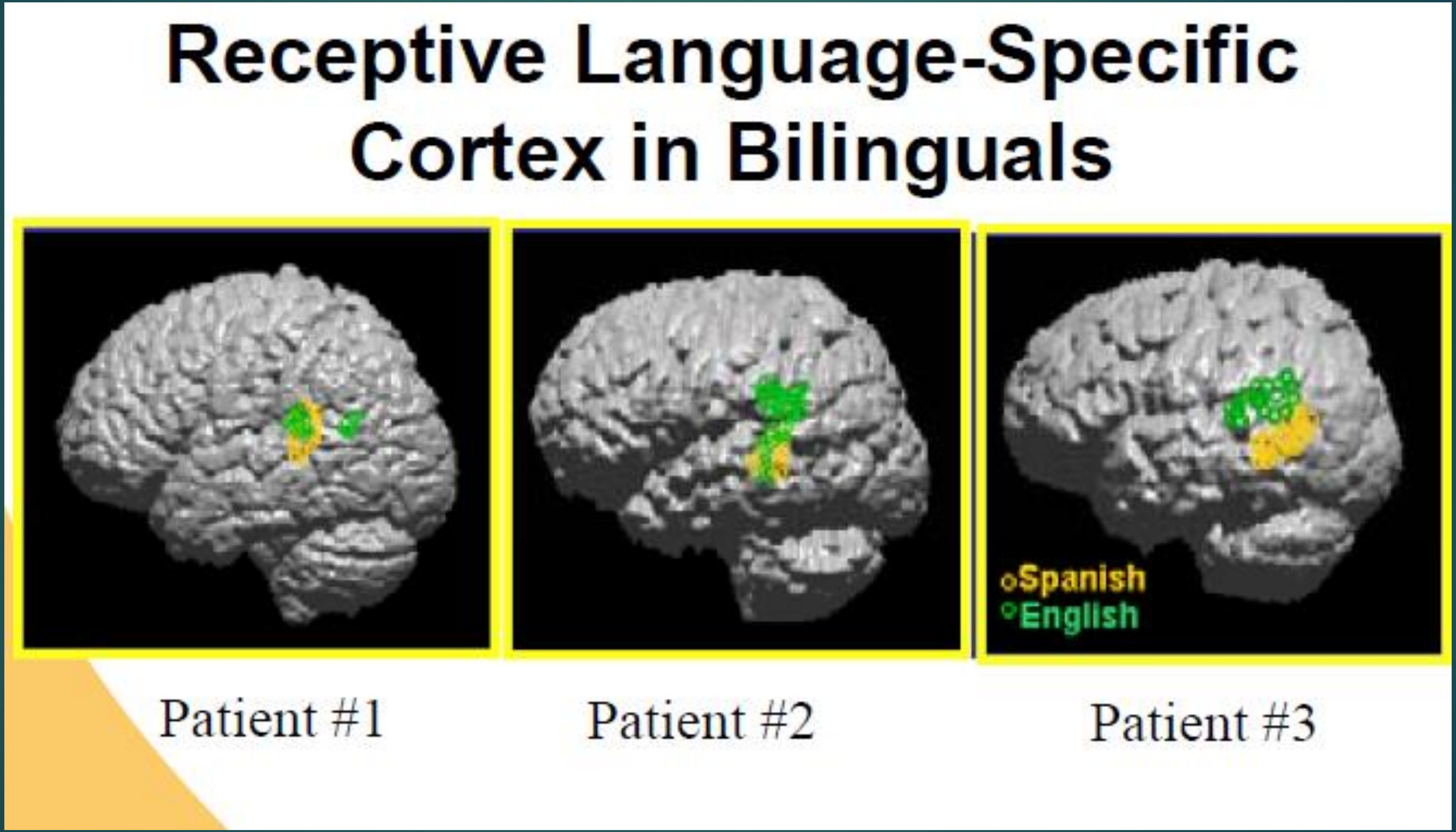


This is a lesson in statistics, not in fMRI. Which is why this was never published in a peer-reviewed journal. It is a lesson about how probability indicates that you certainly can get activation in a dead salmon by chance, and that if you only have one salmon and no corrected threshold in 2 million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

FMRI during visual task

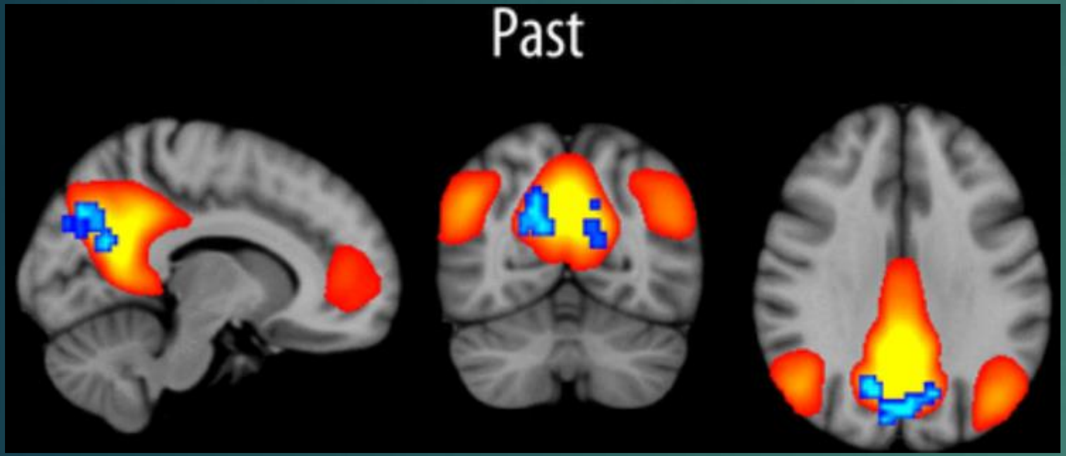


MEG: Bilinguals – Location of each language

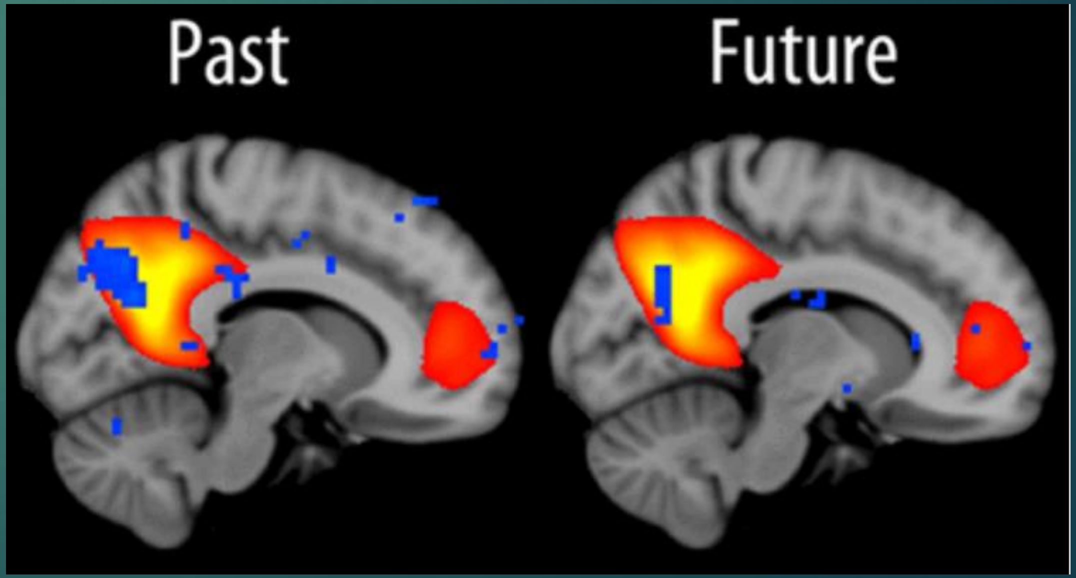


Default Network: Mental Time Travel

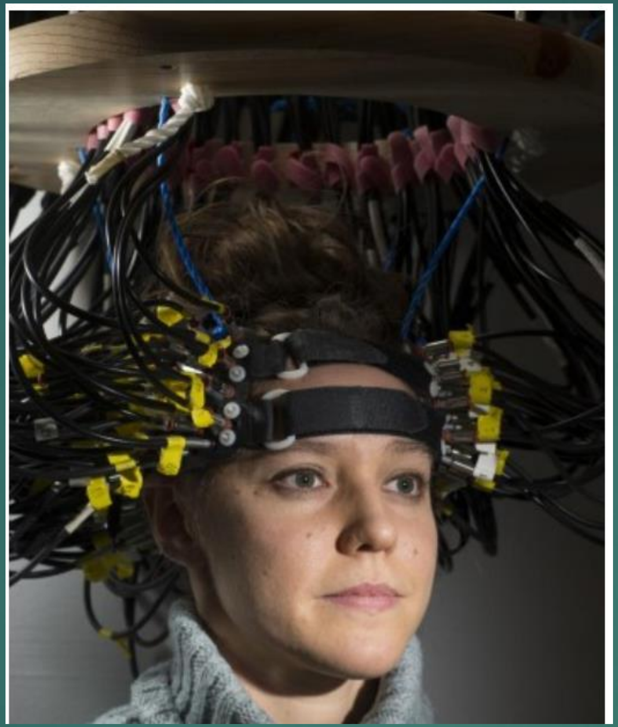
Remembering the past



Imaging the future



Diffuse optical tomography

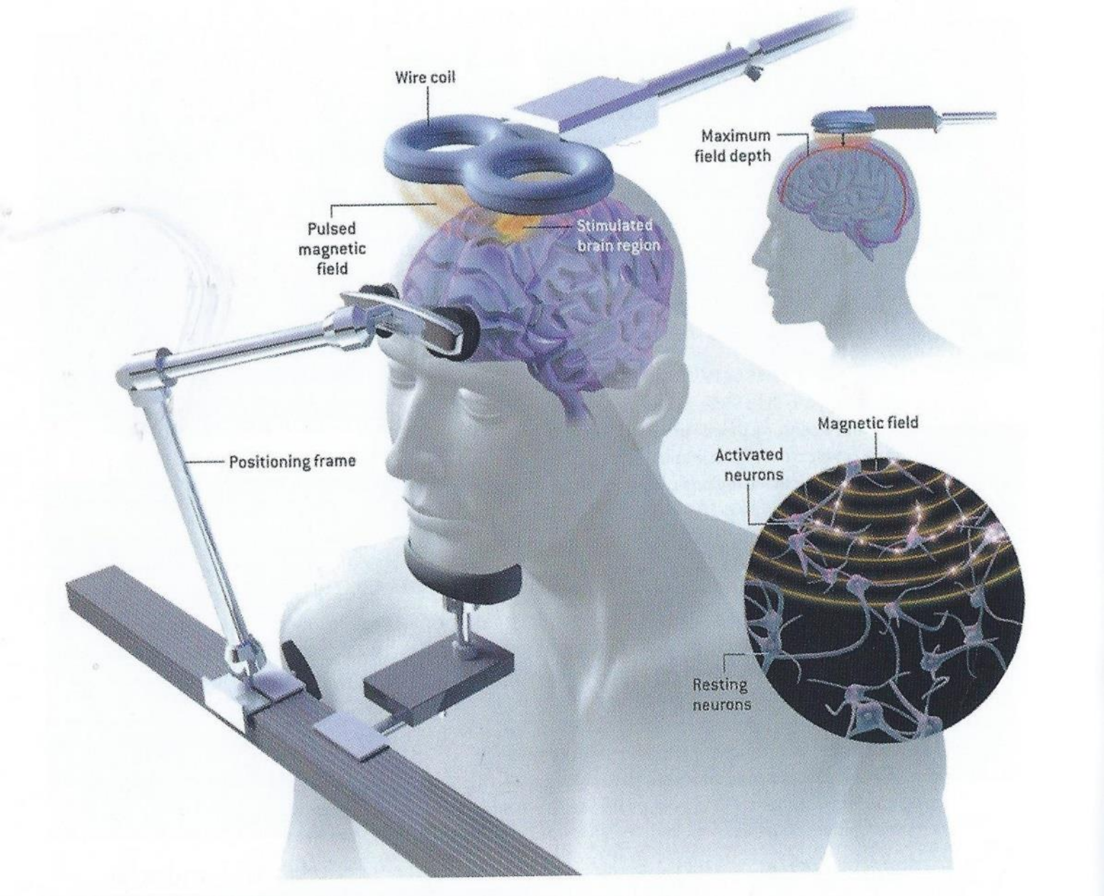


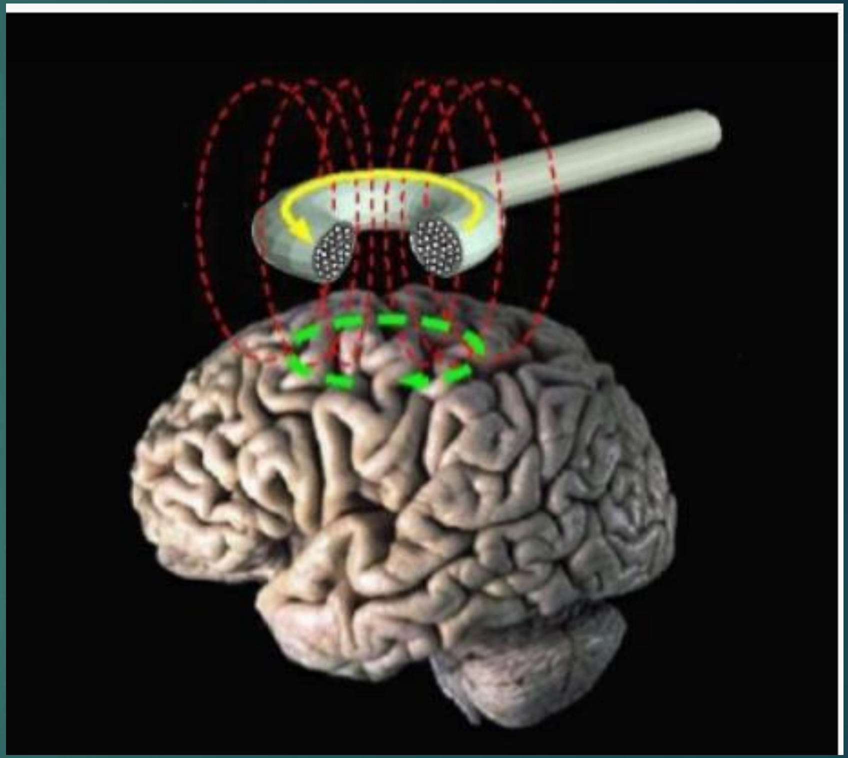
Shining LEDs into the subject's head; latest system able to monitor up to two-thirds of the head at once. Can only reliably image the brain down to a depth of about one centimeter.

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

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

Transcranial Magnetic Stimulation (TMs)

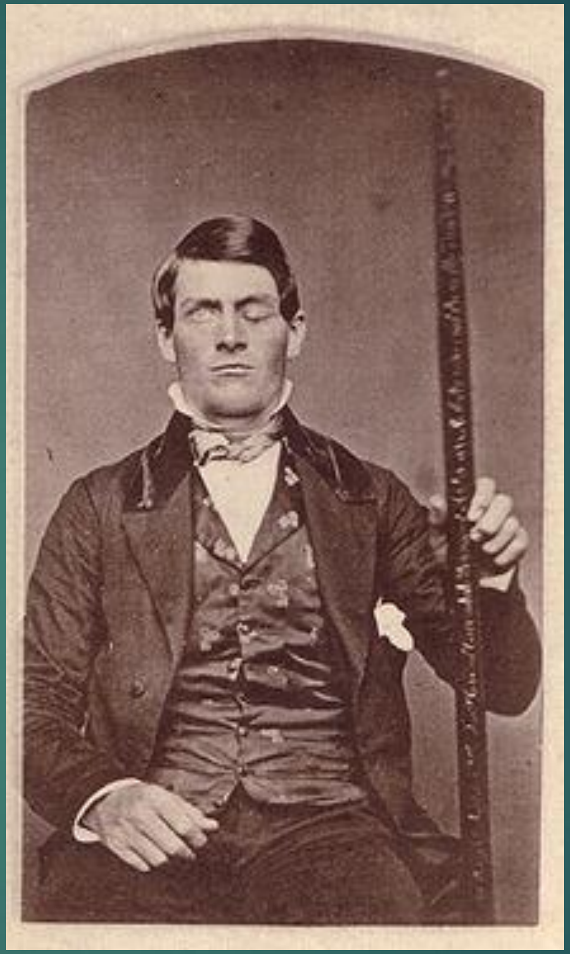




Can momentarily render a brain area dysfunctional

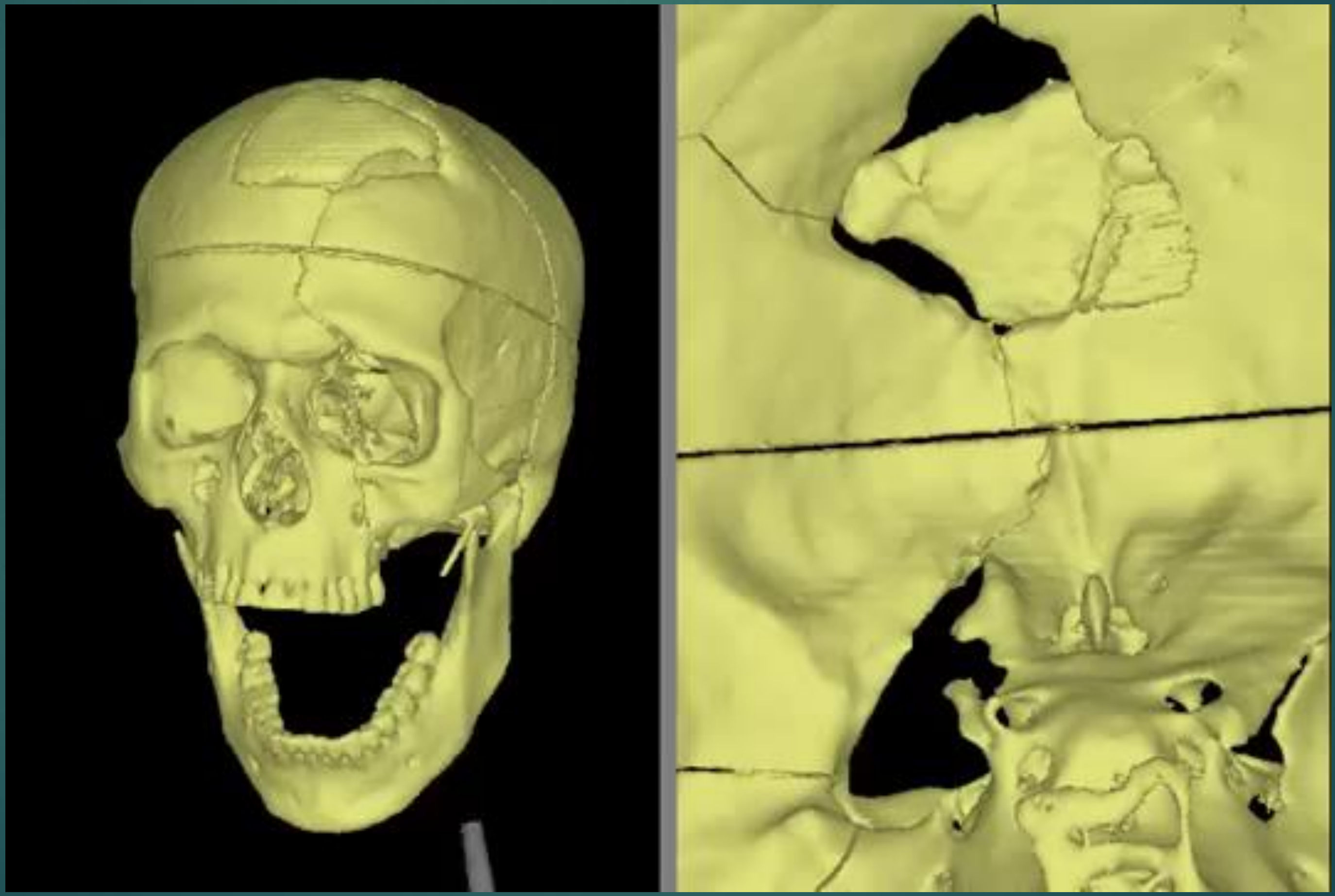
Up to 2.5 tesla
(strength of a magnetic field)

Who is this handsome gentleman?



Phineas Gage, ~ 1848

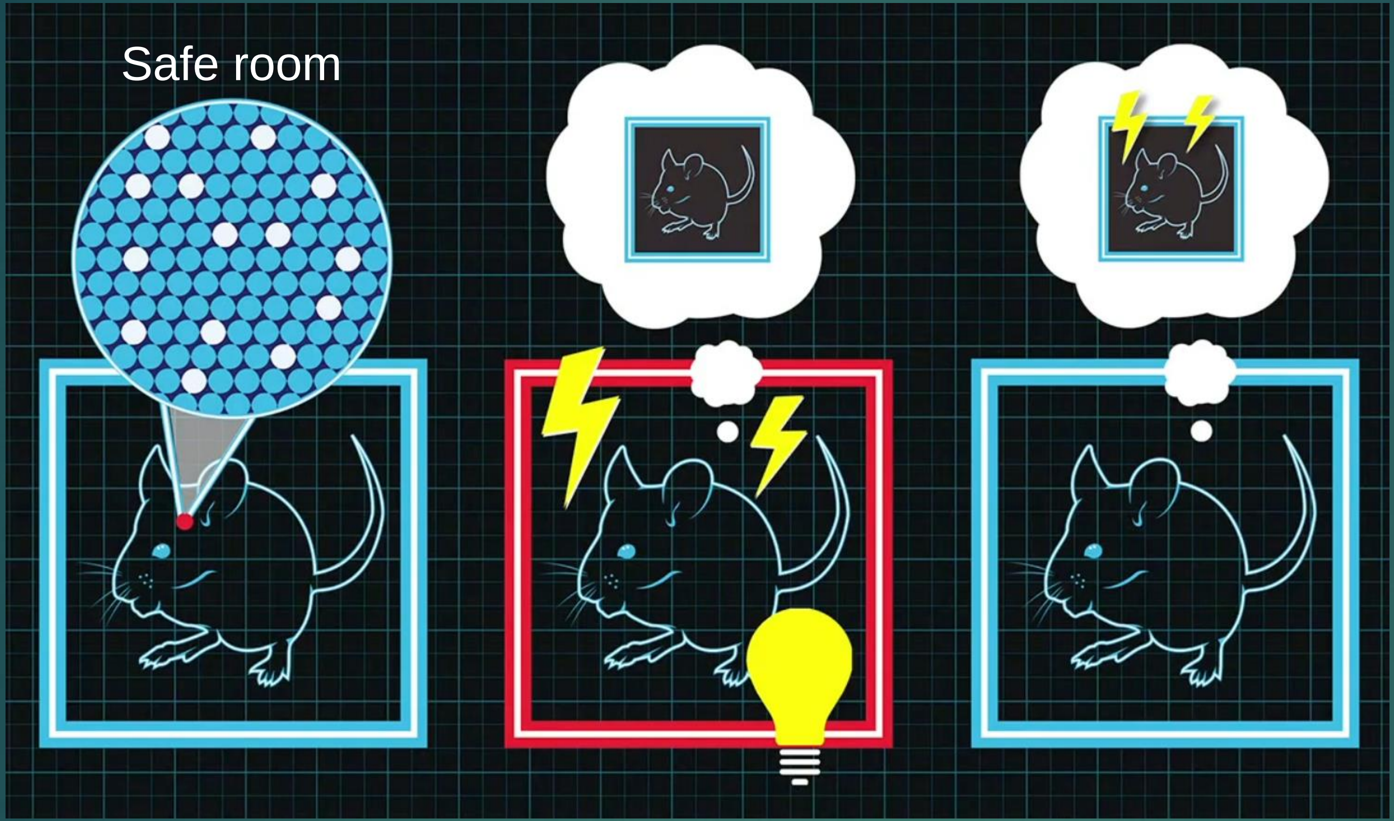
The Phineas Gage Event: Railroad foreman who tapped a metal rod into a hole in a rock filled with black powder



Nature vs. Nurture

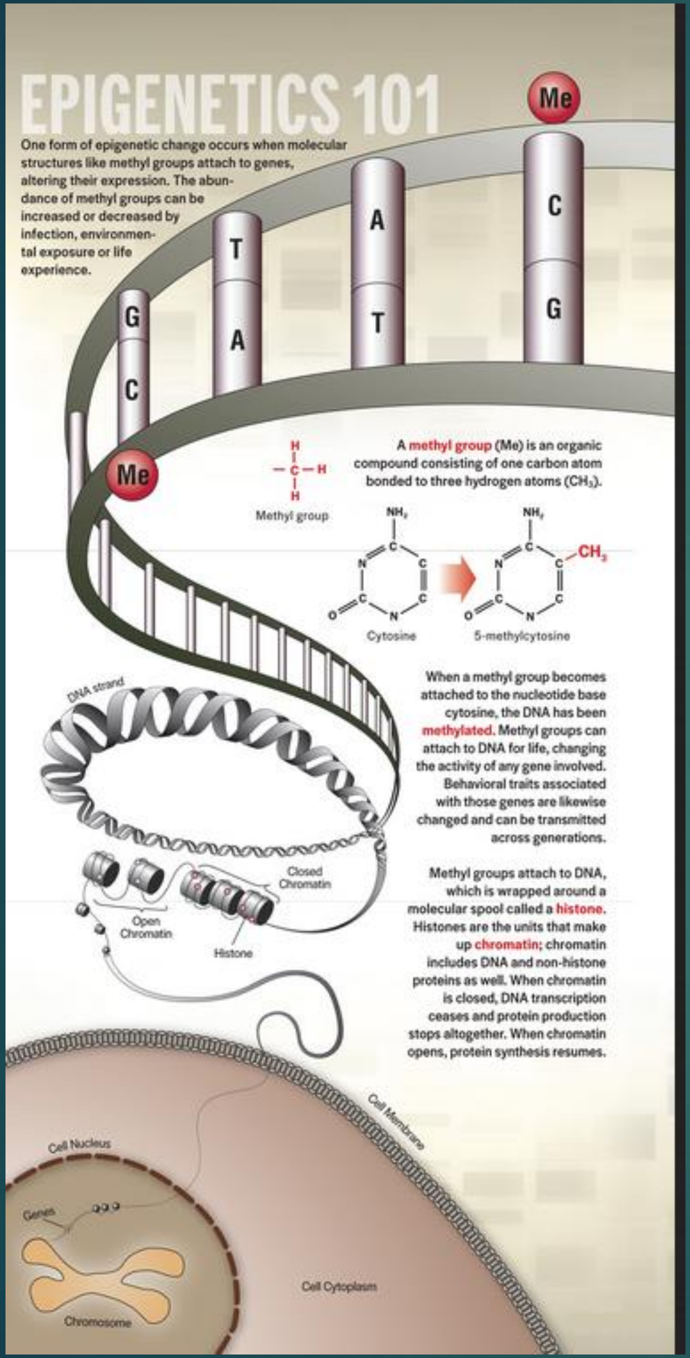
- Darwin and Freud walk into a bar. Two alcoholic mice — a mother and her son — sit on two bar stools, lapping gin from two thimbles.
- The mother mouse looks up and says, “Hey, geniuses, tell me how my son got into this sorry state.”
- “Bad inheritance,” says Darwin.
- “Bad mothering,” says Freud.

Can now create a false memory in a mouse



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 now incorrectly “remembers” as dangerous.



Epigenetics:

- Molecular structures like methyl groups can attach to genes and altering the expression of the gene.
- Early-life environmental conditions can cause epigenetic changes in humans that persist throughout life.
- Audrey Hepburn survived Dutch Hunger Winter: If a mother was well fed around the time of conception and malnourished only for the last few months of the pregnancy, her baby was likely to be born small and stayed small throughout life, no mater how she ate.

Epigenetics: In mice, can pass on your experience

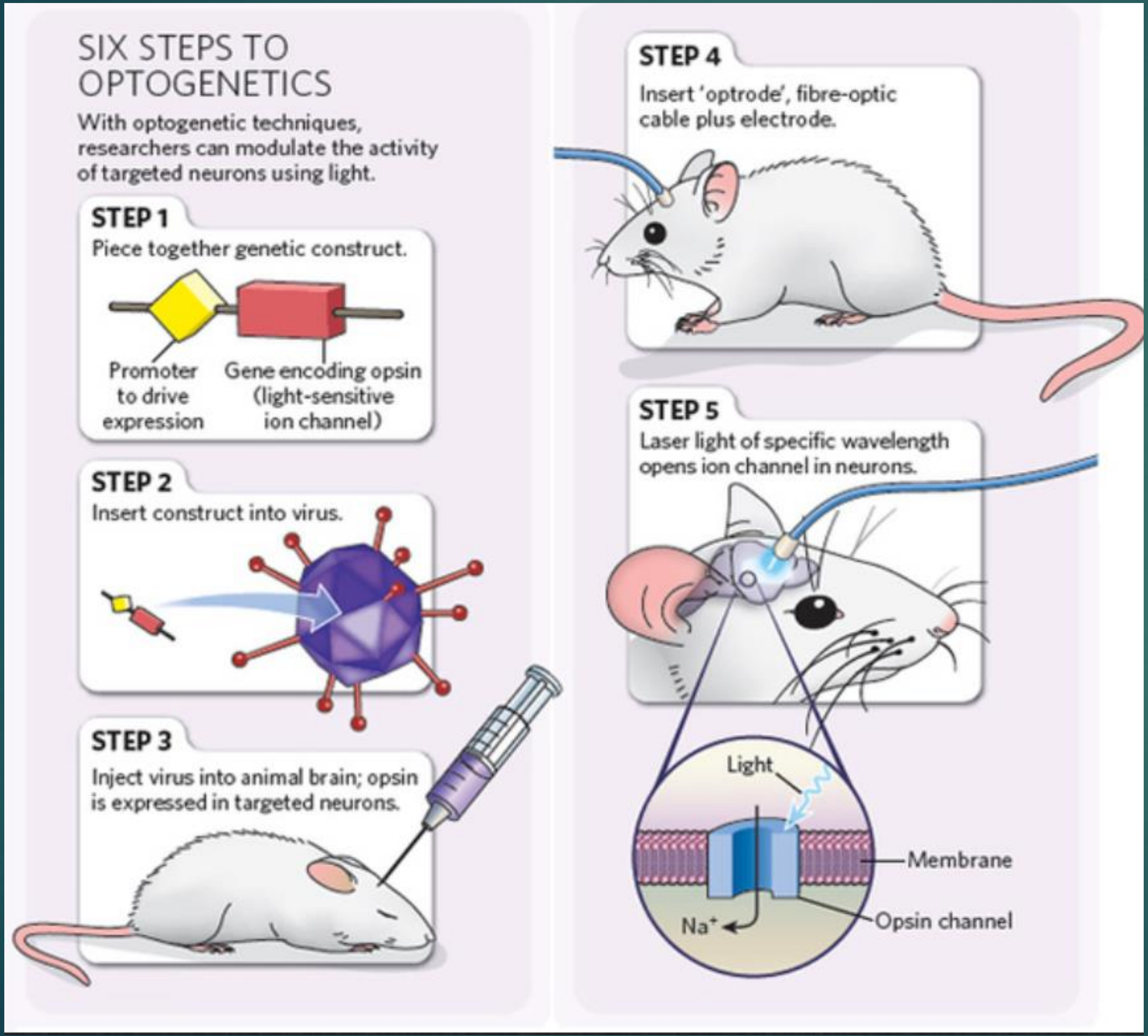
- Showed that a mouse, via epigenetics, could pass on an aversion to a smell to her child

- Male mouse exposed to 10 days of bullying; became socially withdrawn. To test whether such effects could be transmitted to the next generation, another group of bullied mice were bred with females, but the bullied fathers never met their offspring. Despite having no contact with their depressed fathers, the offspring grew up to be hypersensitive to stress and depressed.

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 <u>use flashes of light to trigger firing by specific neurons on command</u>. <u>Use light to determine the precise role of those neurons in freely moving animals.</u>
- 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.

Controlling the Brain with Light



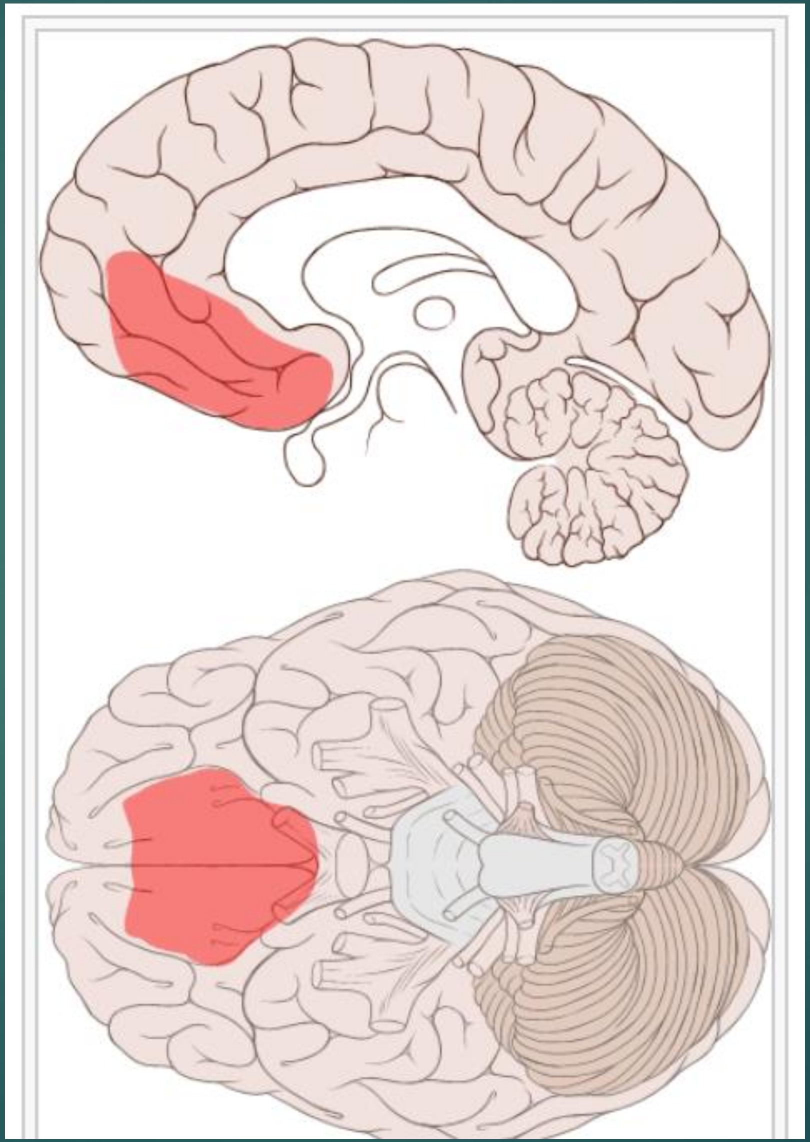
Turn On: ChR2 activates the cells with blue light by depolarization,

Turn Off: NphR inactivates the cells with yellow light by hyperpolarization of the cells

Some Optogenetics Research

- Determine how dopamine-making neurons may give rise to feelings of reward and pleasure
- Deep-brain stimulation may be most effective when it targets not cells but rather the connections between cells
- Hypothalamus cells trigger immediate aggression
- Dentate gyrus neurons can independently trigger the recall of specific fear memories.
- Halting a seizure

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

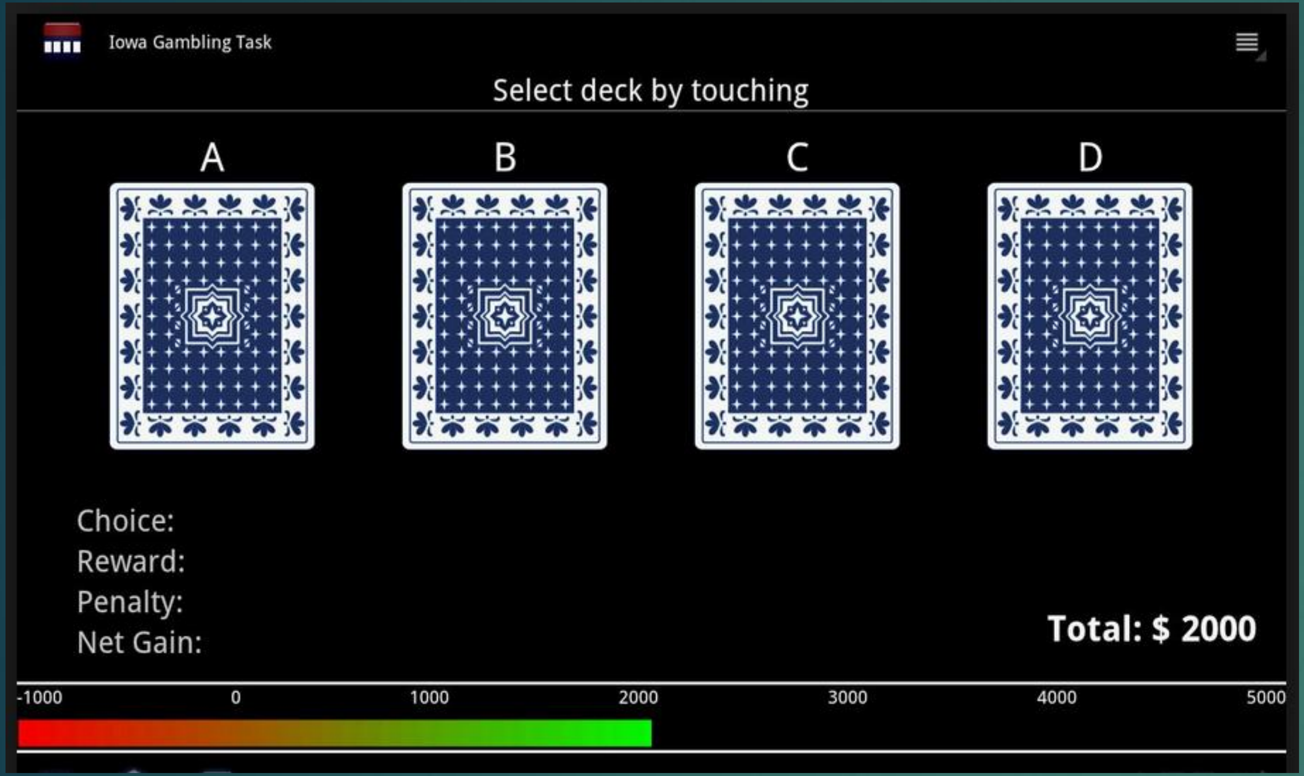


Medial OFC Tumor: Is Mr. Spock’s rationality the ideal

- 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

Iowa Gambling Task



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.

	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

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

“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

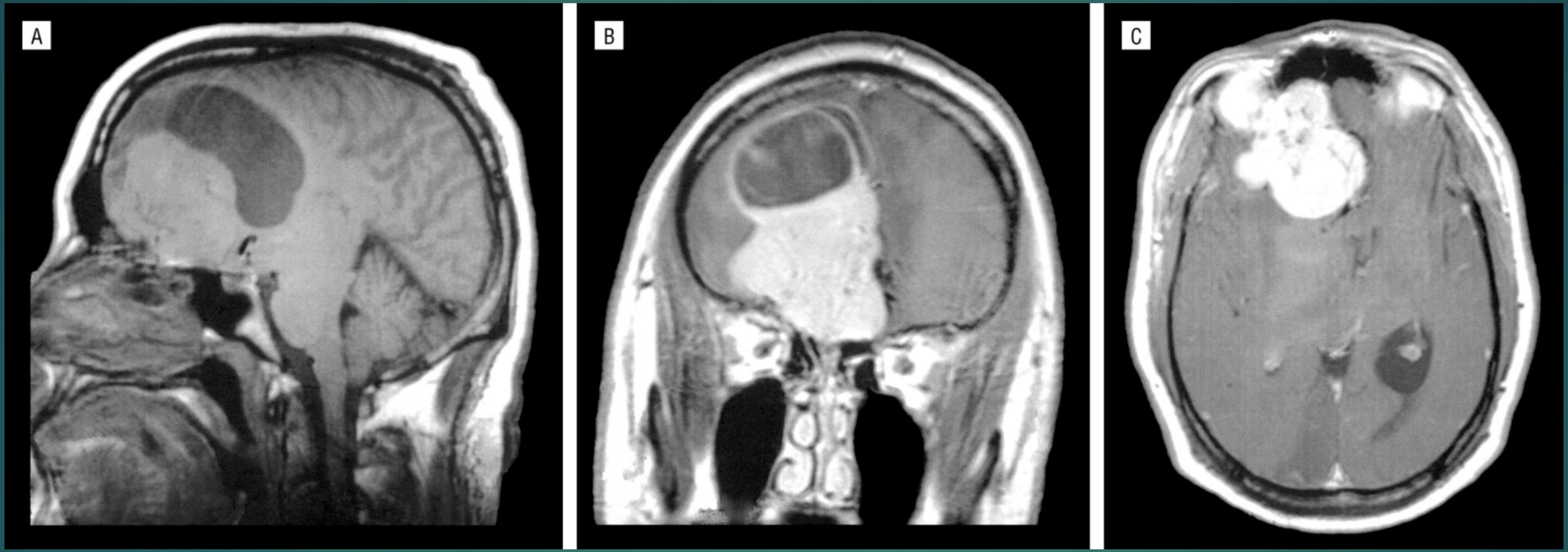


Figure Legend:

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

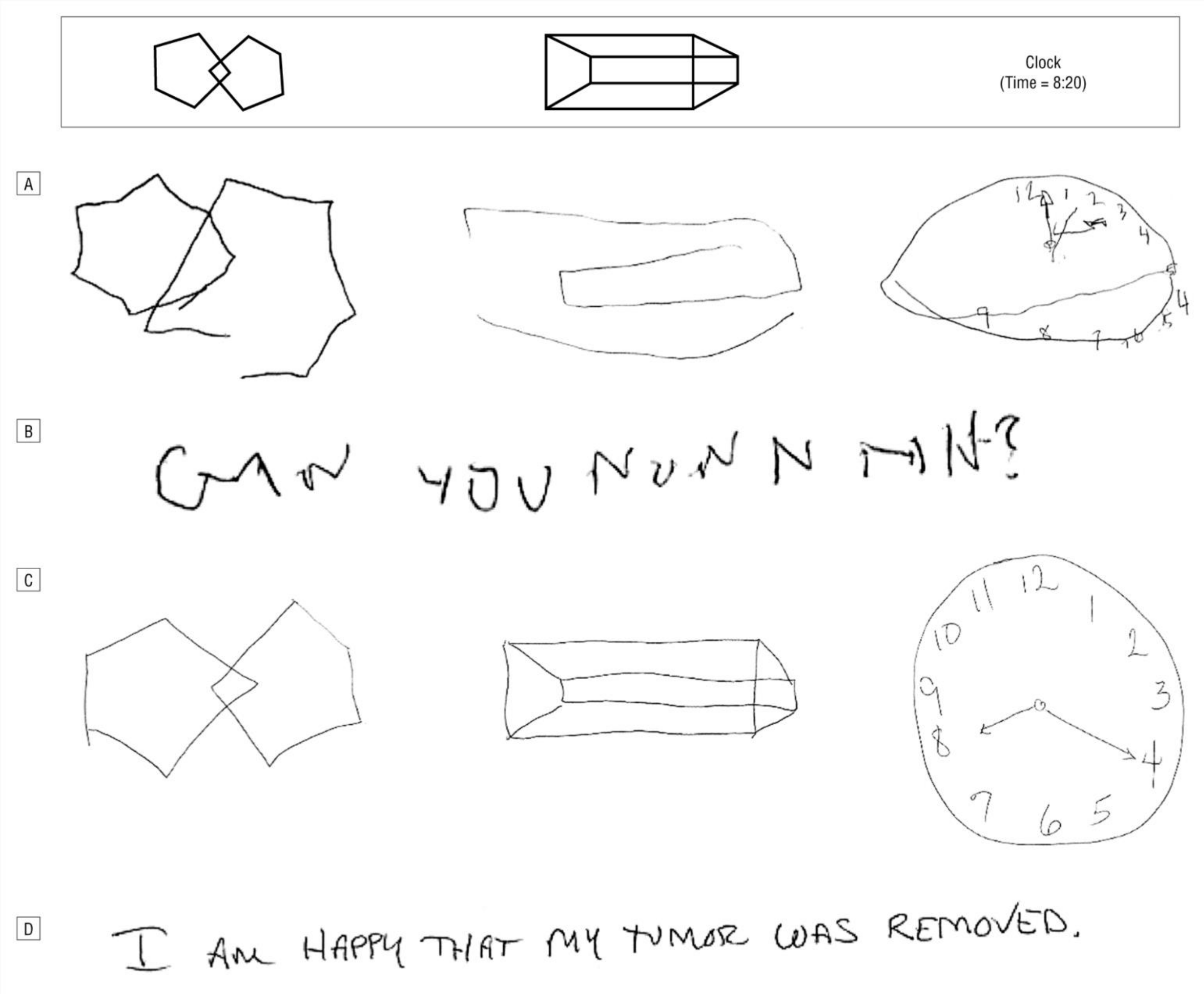


Figure Legend:

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.

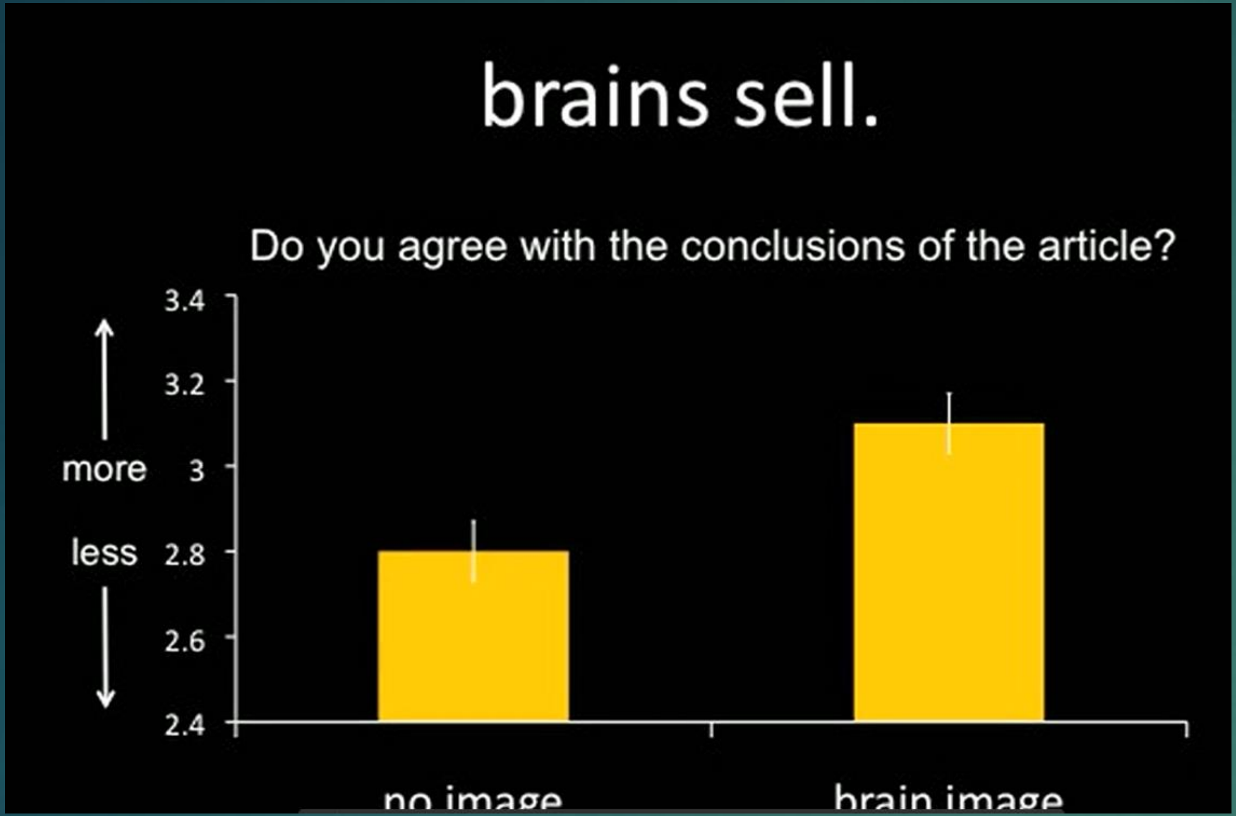
Neuroscience

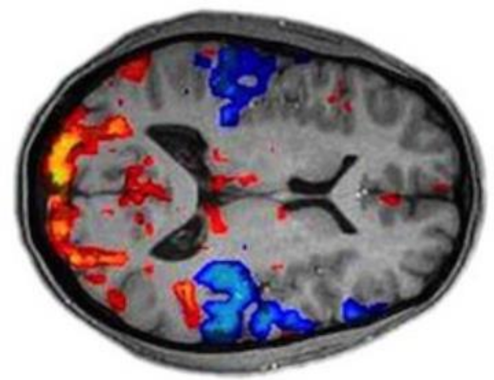
- Cases like this one, reported in the *Archives of Neurology*, raise the issue off how advances in neuroscience are shaping our understanding of moral and legal choices.

- There are many ethical, legal, and social issues raised by our neuroscience knowledge.

- Major concern: brain imaging can be misused by lawyers (intentionally or unintentionally) and 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).

Exposure to Neuroscience

- Increasing exposure to information about the brain, which suggests a more mechanistic account of human behavior, has consequences for how we reason about morality and make moral attributions.

- Exposure to brain-based accounts of behavior, seems to decrease people's support for retributive punishment
- Either by reading a magazine article or through undergraduate coursework, propose less severe punishment for a hypothetical criminal; they saw the criminal as less blameworthy.
- Understanding how much our brain controls our behavior consciously and unconsciously increases moral leniency.

Shariff et al, 2014

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.”

1965: Stopping a bull

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.

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.

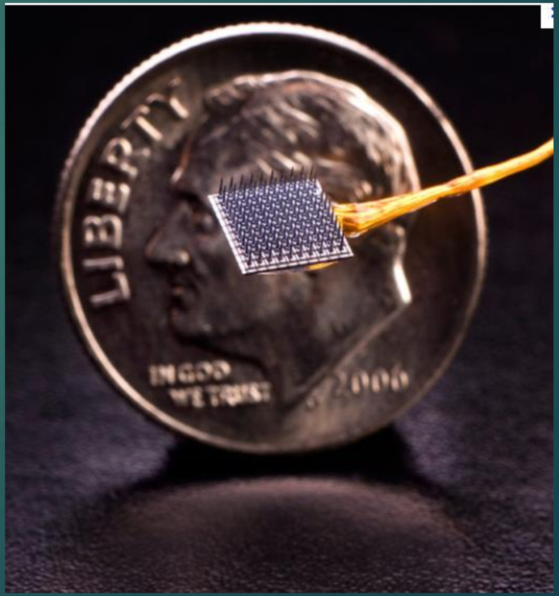
- Ability to move robotic arms or cursors by thought alone via eeg or electrodes (lots of practice req.) (J. Donahue, Cybernetics, BrainGate chip)

- Ability to move paralyzed legs by thinking

- Ability to control a drone by thinking alone.

Robotic Connections

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



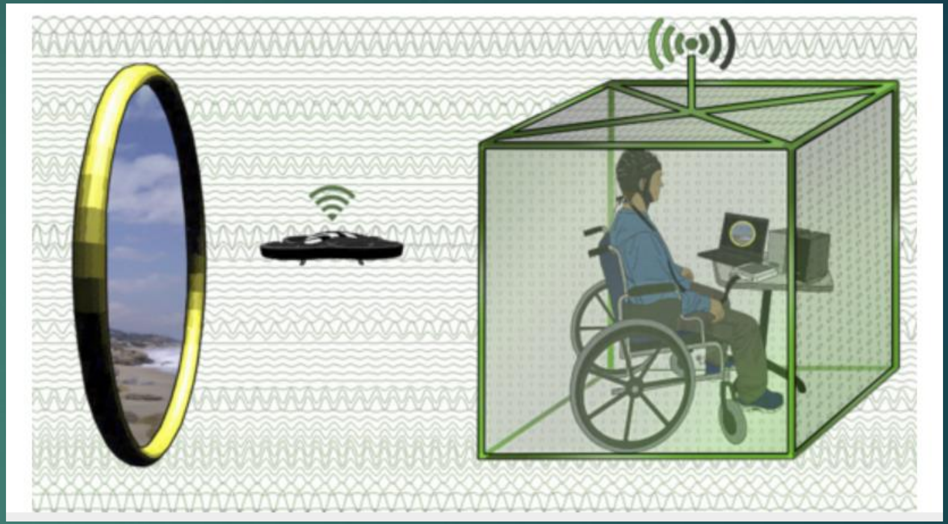
Think and walk

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

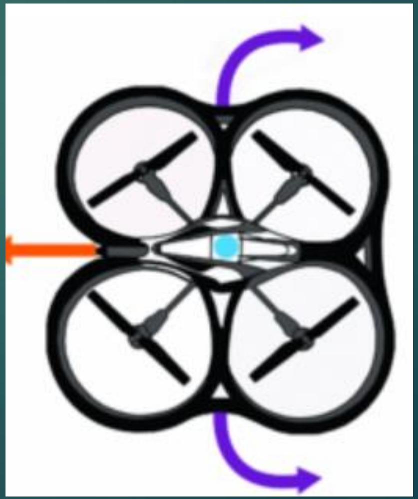
A 26-year-old man who is paralysed in both legs has walked for the first time in five years – just by thinking about it. He is the first person to have his brain activity recorded and used to control a muscle-stimulating device in his legs.

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.

Current Neuroscience Projects: Reading minds

- Enter multivariate pattern analysis: statistical algorithms that link thought with pattern of brain activity (i.e., think tennis, find corresponding motor area activation; computer sees latter and predicts you are thinking of tennis; therefore read your mind)

- Communication with patient with permanent vegetative state, locked in syndrome via fMRI (M. Monti): think "tennis" if yes, visualize your home's layout if no response

Reading emotions: Potential Benefits and Risks for abuse

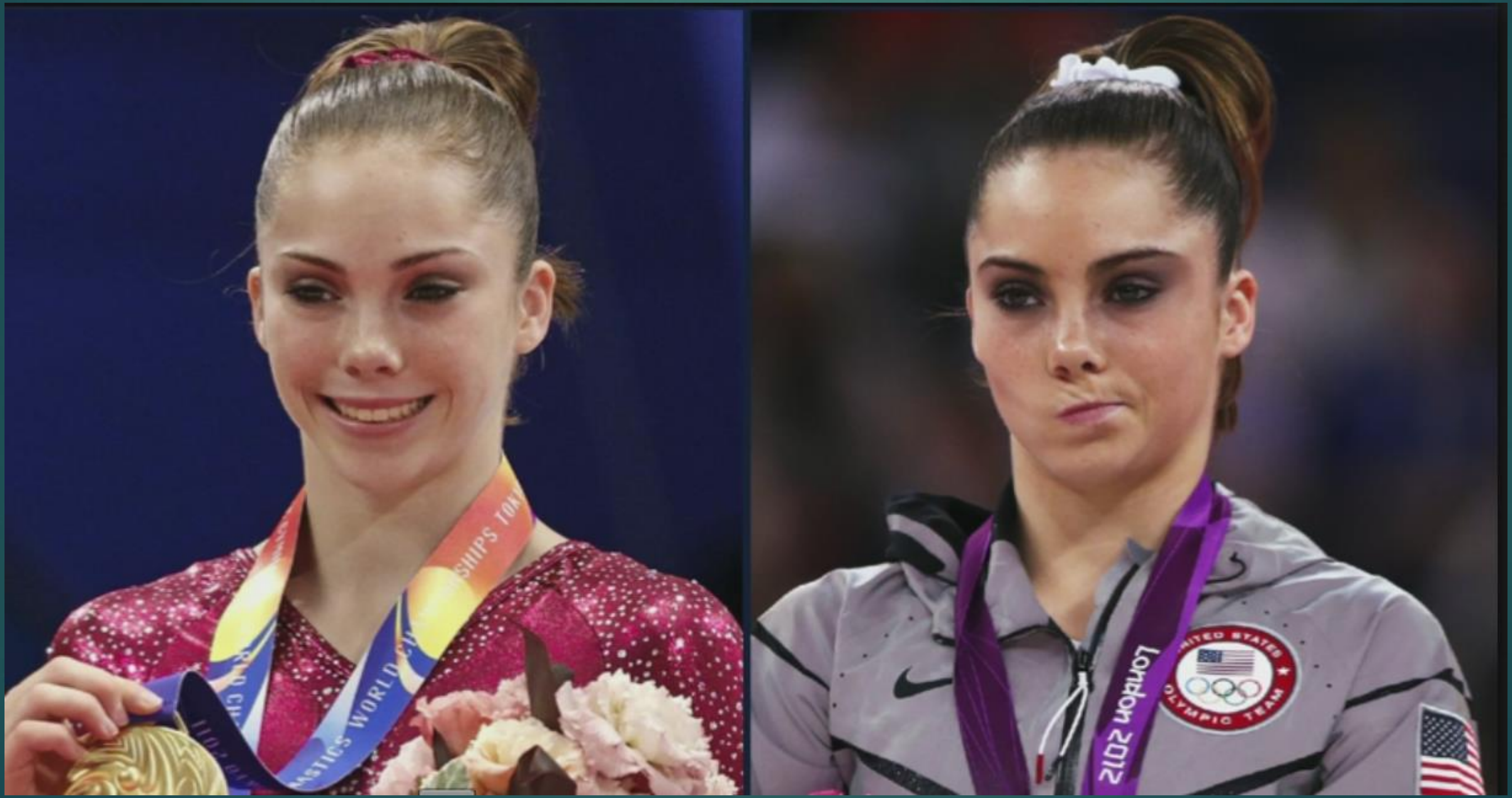
- Emotion reading software, now with 12 Billion facial emotions from 75 countries database; quantifies emotion

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

Surprise

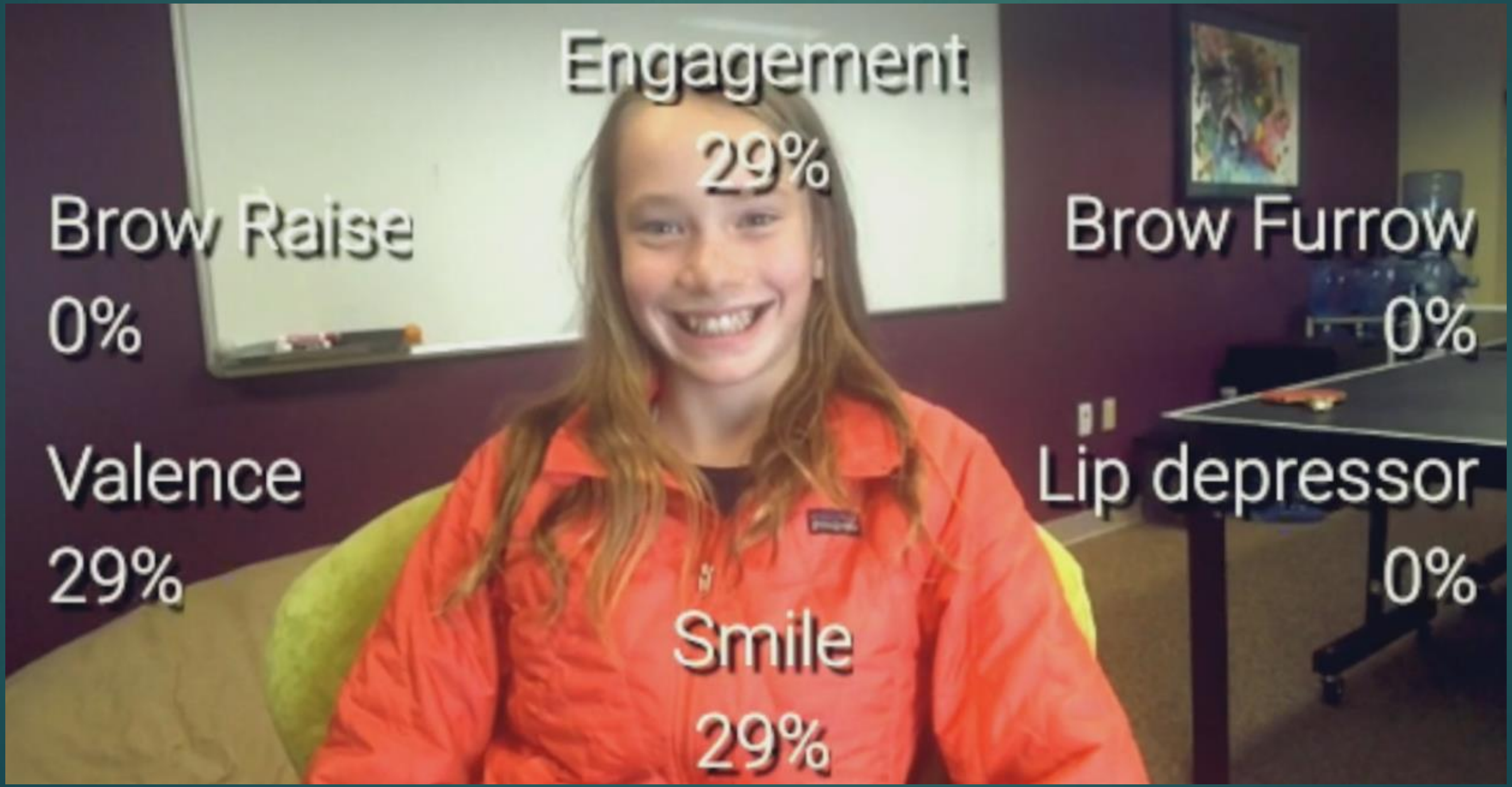
Curiosity

Smile & Frown



Same

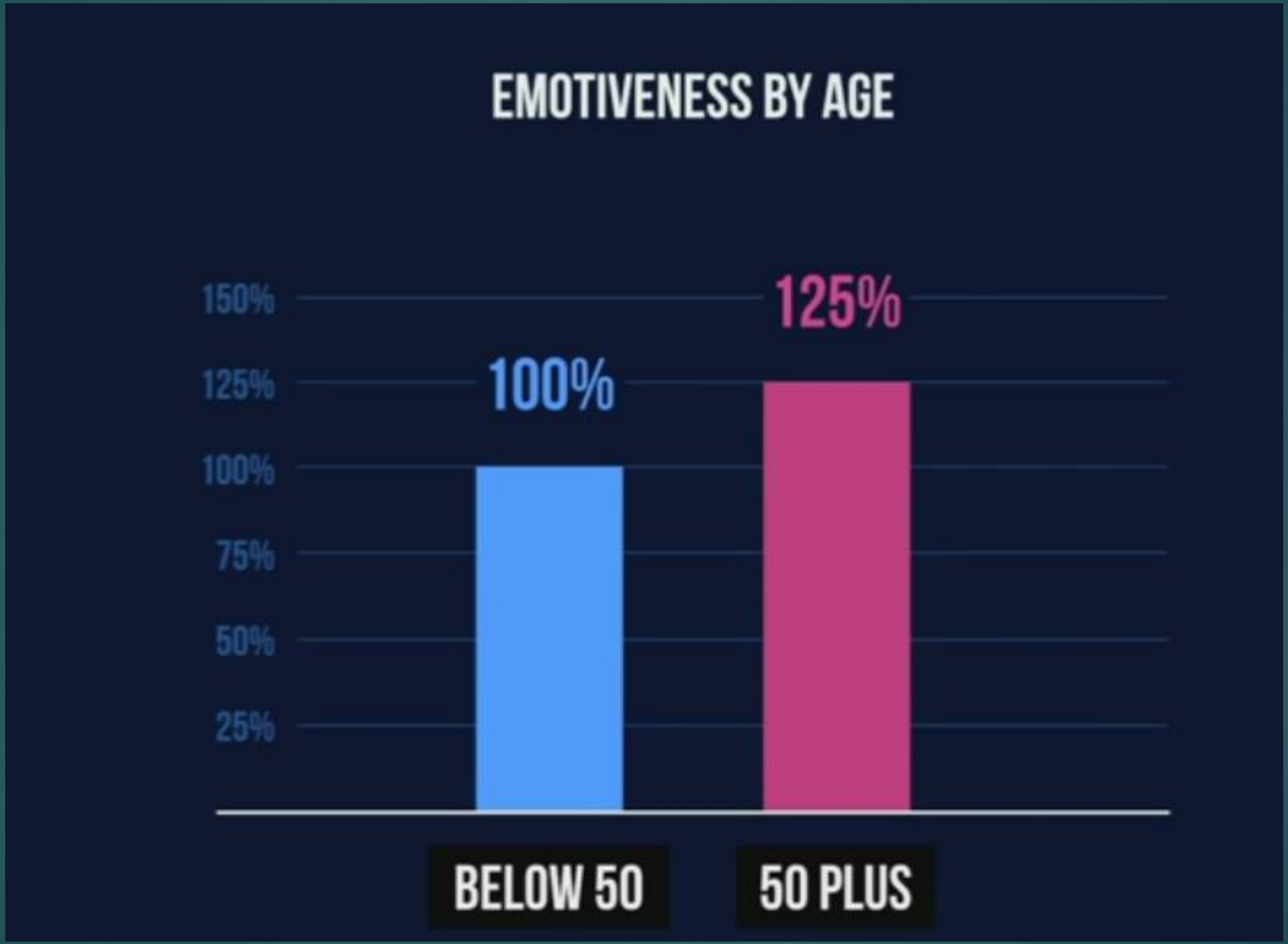
Emotion tracking:
Can analyze your…



Women are more expressive

More Smiles and longer smiles

Older are more emotive



Women in their 20s smile more than men

Smiling even when you are alone

Technology that could help autistics

Or your refrigerator senses you are stressed and autolocks itself!

Marshmallow Test

Marshmallow at 4: Self control

- Walter Meschel, 1968, 4 year olds, get 2 marshmallows if wait 15 minutes; ring bell and get to eat, but no 2nds; 2 minute wait was average; 25% made it to 15 min; n = 653

- At age 4, ability to wait 15 minutes before eating a marshmallow predicts SAT scores 210 points higher at age 18.

- Children who rang the bell within a minute were much more likely to have later behavioral problems, both in school and at home. They struggled in stressful situations, often had trouble paying attention in class and had serious problems with their temper. Had a significantly higher BMI and are more likely to have had drug problems

- Ability to delay gratification is a far better predictor of academic performance than I.Q.

Current Neuroscience Projects: Brain Decoding

- Reconstruct images of faces 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 hitter

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

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

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

- Computer program translates brain waves into individual words with 80-90% Accuracy

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

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

Decoding Brains: Jack Gallant

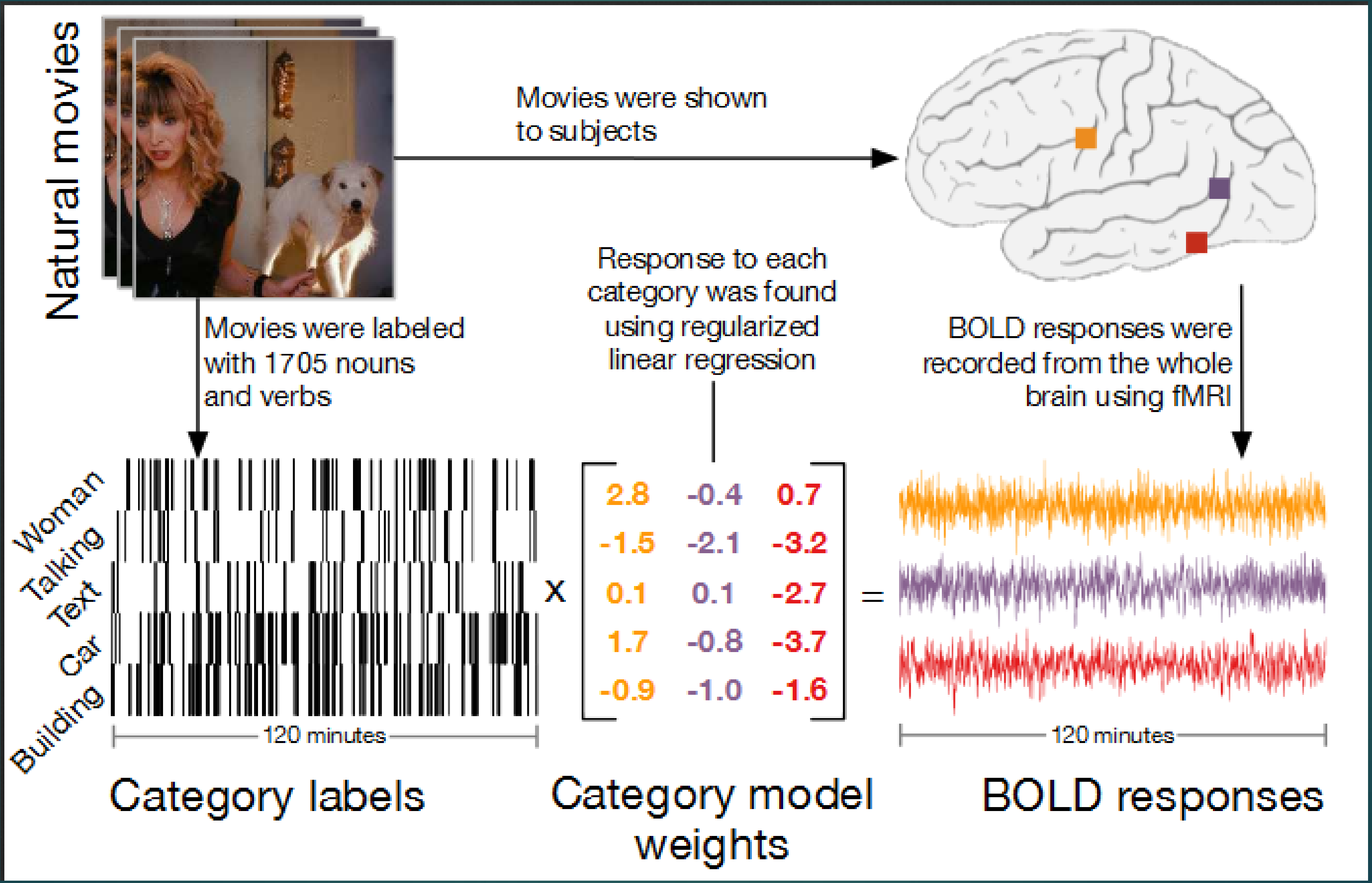
- J. L. Gallant, UCB: Predictive models of brain activity are the gold standard of computational neuroscience

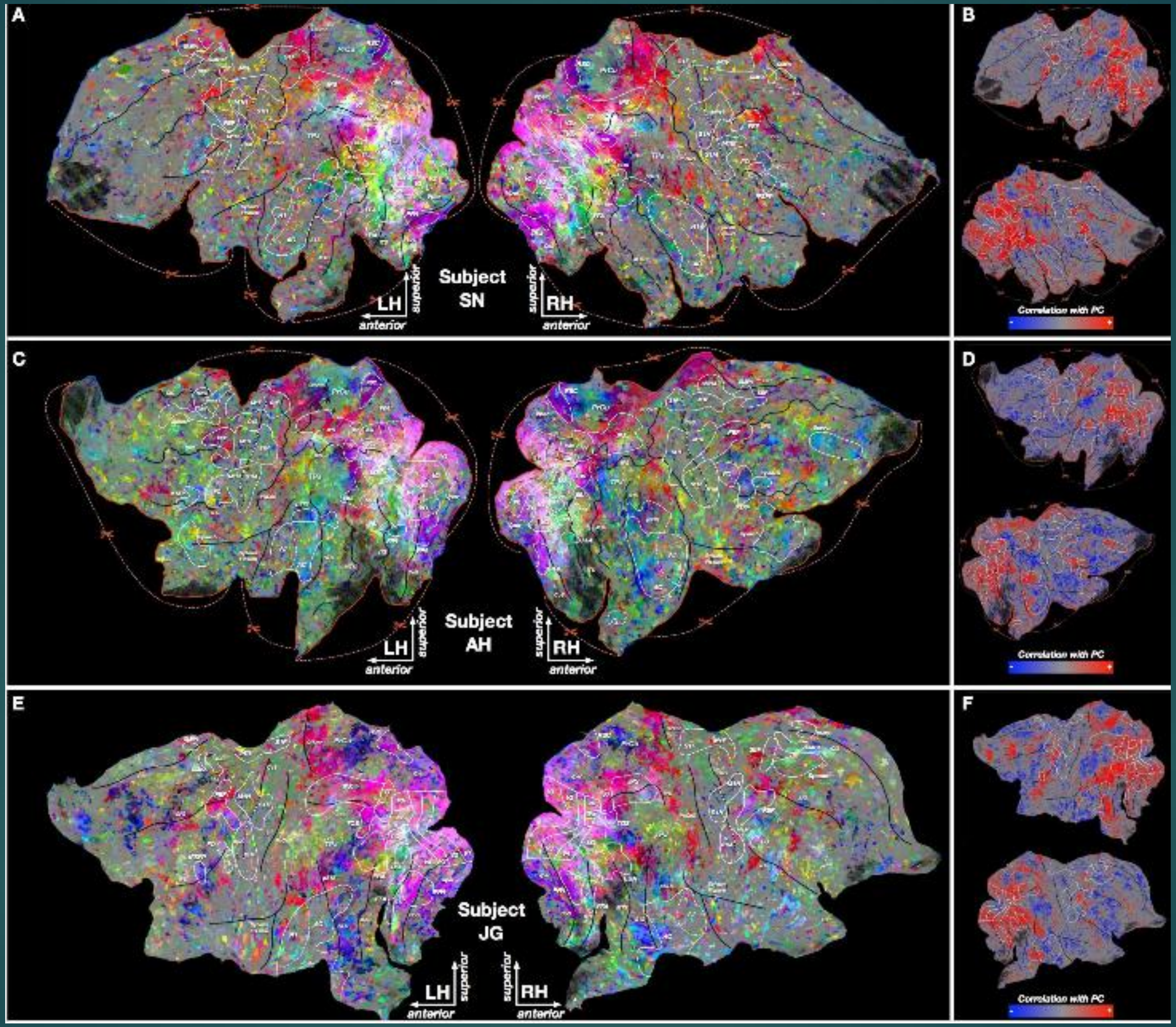
- Using EEG, fMRI for voxel analysis ; statistical analysis, esp. regression; & theoretical modeling: how each element of the visual system encodes information

- 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

Decoding Brains

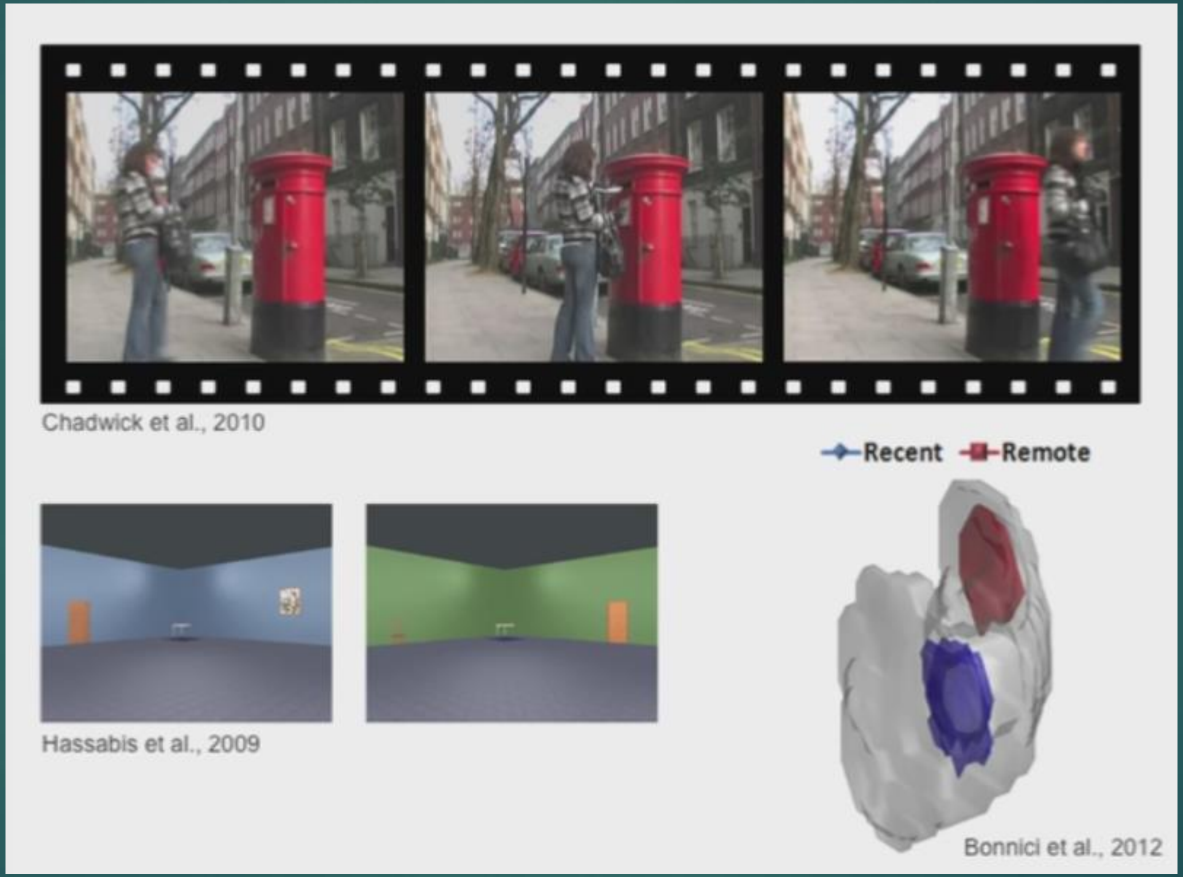




Cortical maps of semantic representation

Brain Decoding Movie

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

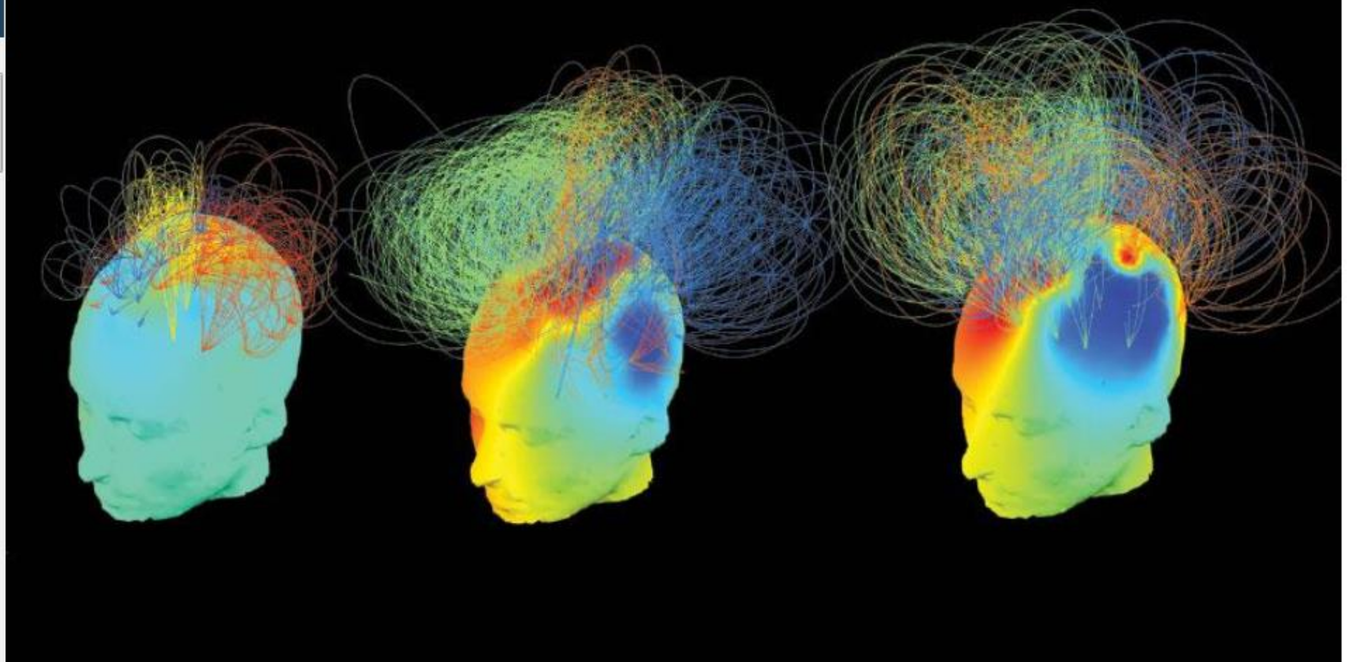
Which tool or building you are thinking about

- In January 2008, a group from Carnegie Mellon came out with a study where they showed people primitive line drawings of objects.
- The objects were five different tools—a drill, a hammer, a screwdriver, pliers, and a saw—and five different buildings—an igloo, a hut, a house, a castle, and an apartment.
- The group was able, with about 80 percent accuracy, to tell not just when each subject was seeing a tool or a building, but which tool and which building the subject was thinking about.

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.

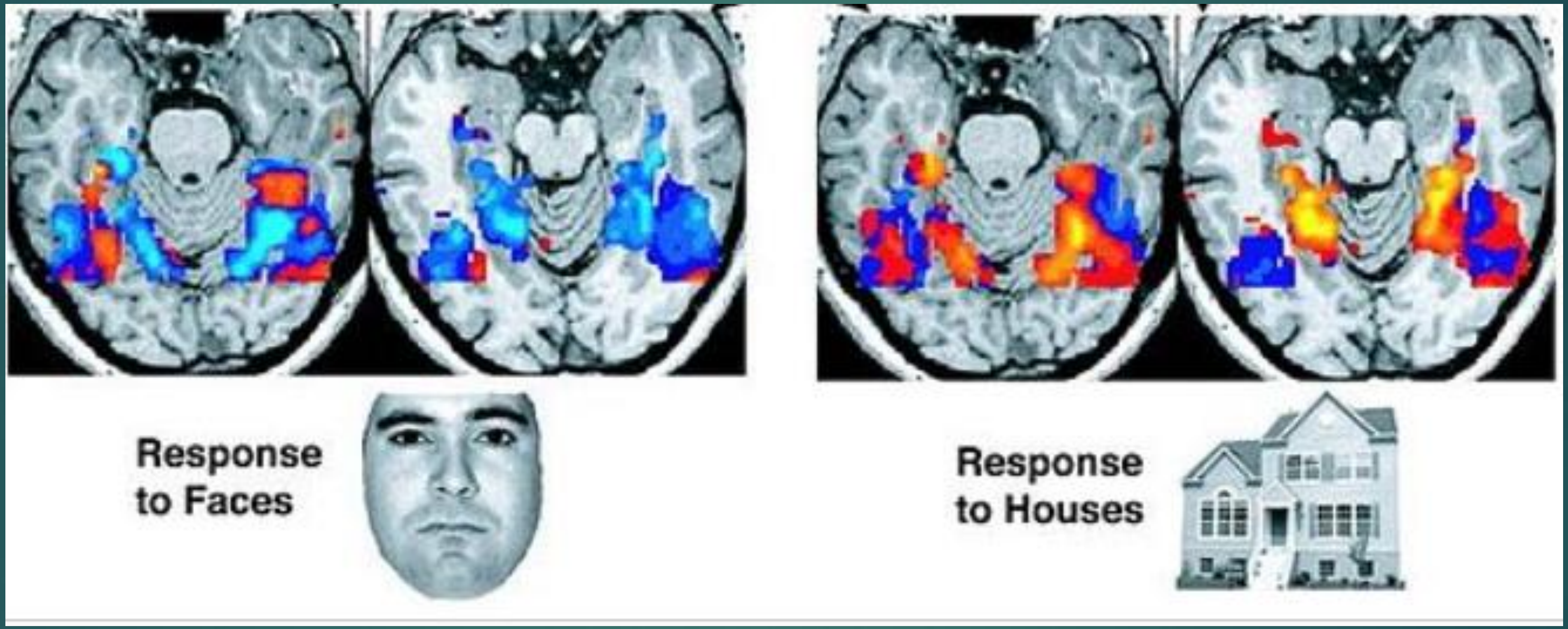
Silently trapped: unconscious but mentally present



LOCKED IN Patients in the left two images are outwardly in a vegetative state. But the neural connections, measured by electrical activity, are much more active in the middle patient, whose brain network more closely resembles a healthy volunteer's (right). All three were asked to imagine themselves playing tennis.

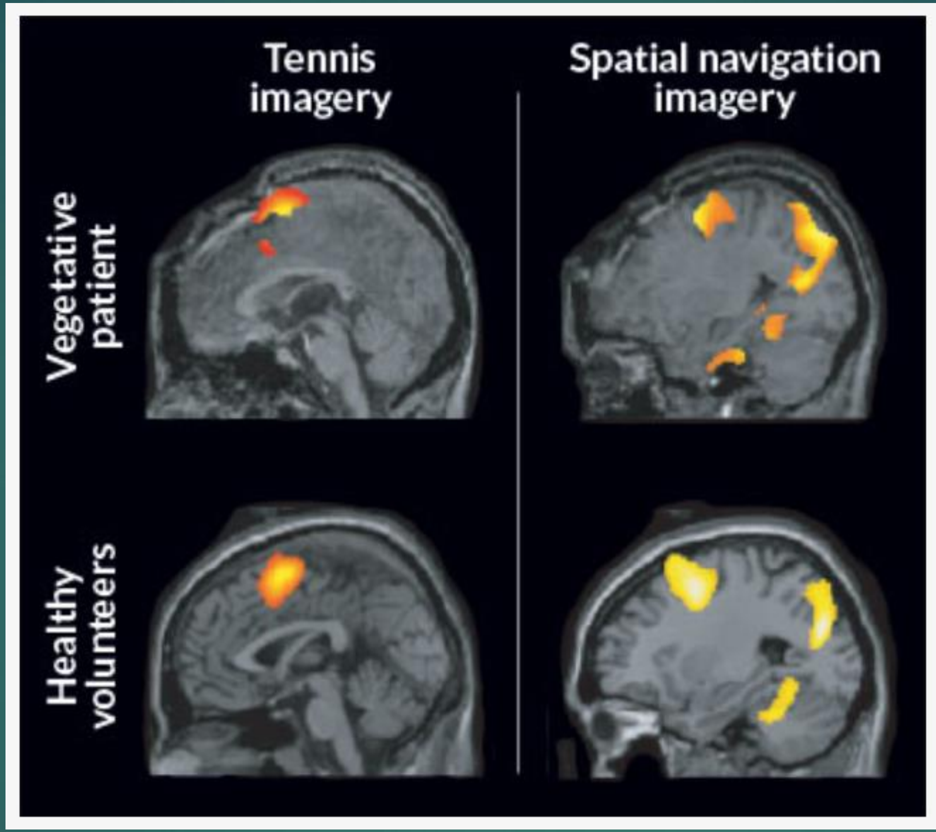
As early as the mid-1990s, doctors were finding hints of hidden consciousness in some vegetative patients. In 1996, in *BMJ,* researchers from the Royal Hospital for Neuro-disability in London suggested that about 40 percent of patients considered vegetative showed some ability to communicate, such as following a simple command to look at an object when their eyes were open.

Method for communication with pts with locked in syndrome



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


TED Ed
Lessons Worth Sharing
0:03 / 4:55
YouTube

Eyewitness testimony

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).
- Studies: Convincing evidence that eyewitness testimony is poor.

You are the eye witness

Eyewitness testimony: Newer data

- Consider the important, and often overlooked, distinction between malleability and reliability. Just because memory is malleable—for example, it can be contaminated with the trace of an innocent person—does not mean that it has to be unreliable. What it means is that the malleability of memory can harm reliability.
- memory can be contaminated with the trace of an innocent person, but under proper testing conditions, eyewitness evidence is highly reliable. Eyewitness evidence needs to be safeguarded against contamination.
- Because the test itself contaminates memory, only the *initial* memory test provides uncontaminated results. Subsequent memory tests, including the dramatic one that occurs in court in front of the jury, constitute contaminated evidence. Second, the police lineup has to be fair (that is, the suspect should not stand out). And third, the confidence expressed by the eyewitness following an identification of someone from the lineup must be recorded. Assessing confidence is critical because it provides direct information about the trustworthiness of the uncontaminated ID. An initial eyewitness identification made with low confidence indicates that even though memory was not contaminated, the ID is untrustworthy. In contrast, a high-confidence ID is highly accurate, across 15 experiments, 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.

Concept of Modular/specialized brain areas

- Historical localizationists (Gall, Broca, etc.) were theoretically correct.
- Above list implies functionally specialized regions.
- Both activation on fMRI for normal function and lesion studies for pathology have proven functional specialties of these areas.
- Correlation with NP functions also confirms these specializations.

Brain as Swiss army knife: Domain Specific Areas

Special purpose, domain specific processors (localized functional areas):

- Classic: Vision, Touch, Motor Control, anger & fear (Amygdala) areas
- Faces
- Color
- Regions of space
- Visual motion
- Body parts (but not faces)
- Hearing sounds with pitch
- Hearing sounds without pitch
- Speech
- Understanding the meaning of a sentence
- Understanding mental states of others
- Voice recognition

141 functions: $1400

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.

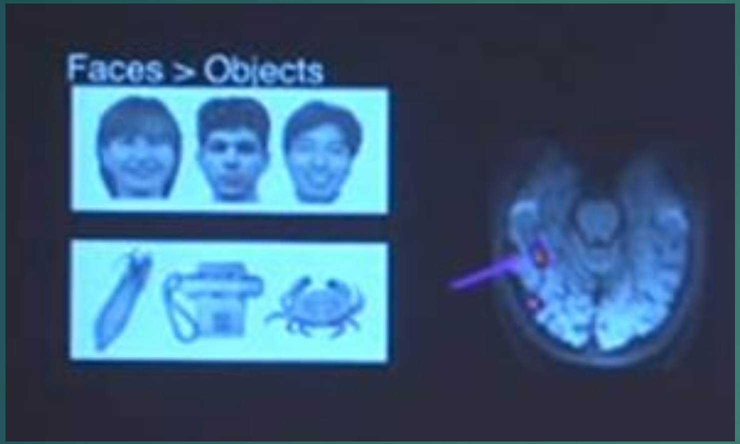
- She also identified what she calls the parahippocampal place area, which is differentially activated when people see places

- 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

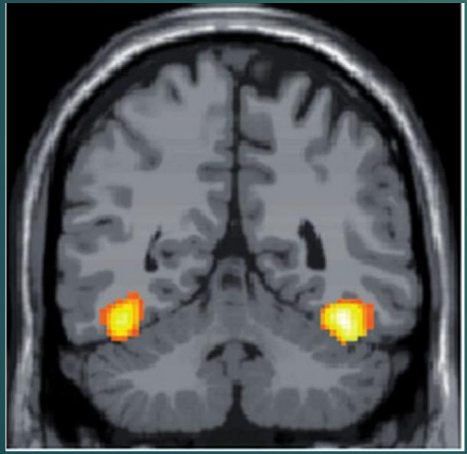
Fusiform Face Area (FFA): Face Recognition

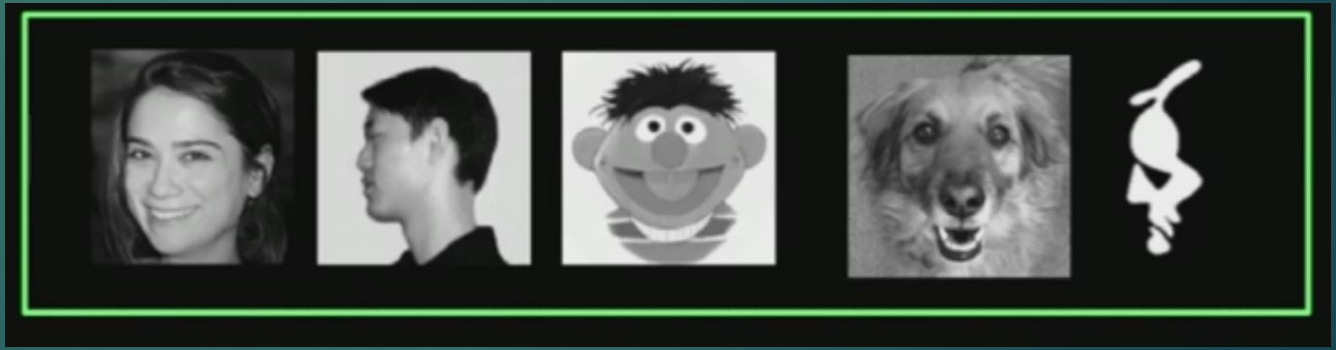
Brain regions for face vs. object recognition



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

No correlation between IQ & face recognition





Confirmed in epileptic pt with 2 electrodes on FFA

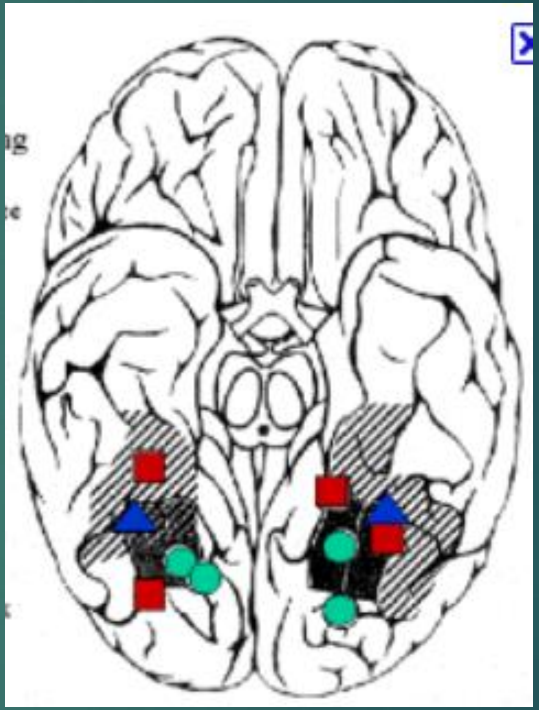
Nancy Kanwisher at MIT

FFA

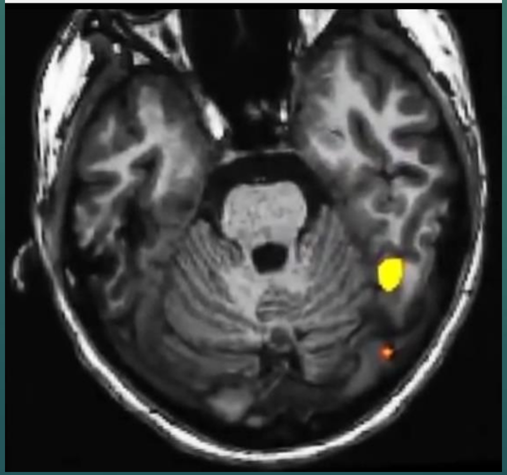
But also visual processing in experts: chess boards in expert chess players

Fusiform Face Area in right Temporal lobe: facial identity

- Fusiform face area (FFA):
  - Perception of unchanging (identity) aspects of human face
  - Only upright faces



Blue & Red



Amygdala beats FFA

- Amygdala has faster face processing than the FFA; faster than blink of an eye (33ms)
- Flashes of faces result in a response from the amygdala, initiating an emotional response, sometimes without even activating the FFA at all.
- You start responding to a face long before you think about it

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

Why you need the Fusiform Facial Area

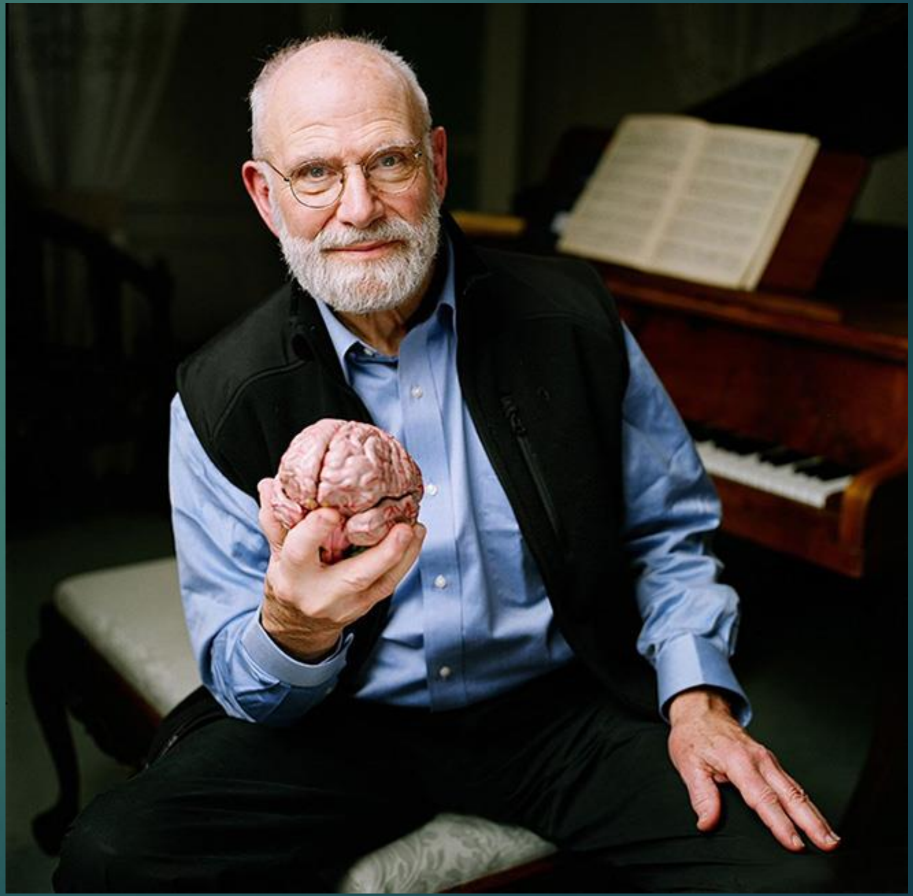
Prosopagnosia: face blindness

Prosopagnosia or Face Blindness

- Patients are <u>unable to recognize faces consciously</u>
- Patient isn't blind (can still read a book); <u>can no longer recognize faces by looking at people.</u>
- <u>Theory = Bilateral damage to the FFA; when face recognition in fMRI, FFA lights up; if damage FFA, prosopagnosia;</u>

Oliver Sacks, MD

- *The Man who Mistook his Wife for A Hat*
- Face Blind (prosopagnosia)
- As is Jane Goodall



http://www.faceblind.org/facetests/index.php

Upside down

Right side up

FFA in Blind People

- Blind individuals given a sound producing device to scan people's faces. Became successful at differentiating different faces.

- On fMRI, this process activated FFA.

- In blind people FFA appears to be wired to circuits that process sounds. So there is substantial reorganization in the brain of the blind. The brain of a blind person retains the module devoted to facial recognition. Genetically hardwired.

Rauschecker, et al., 2014

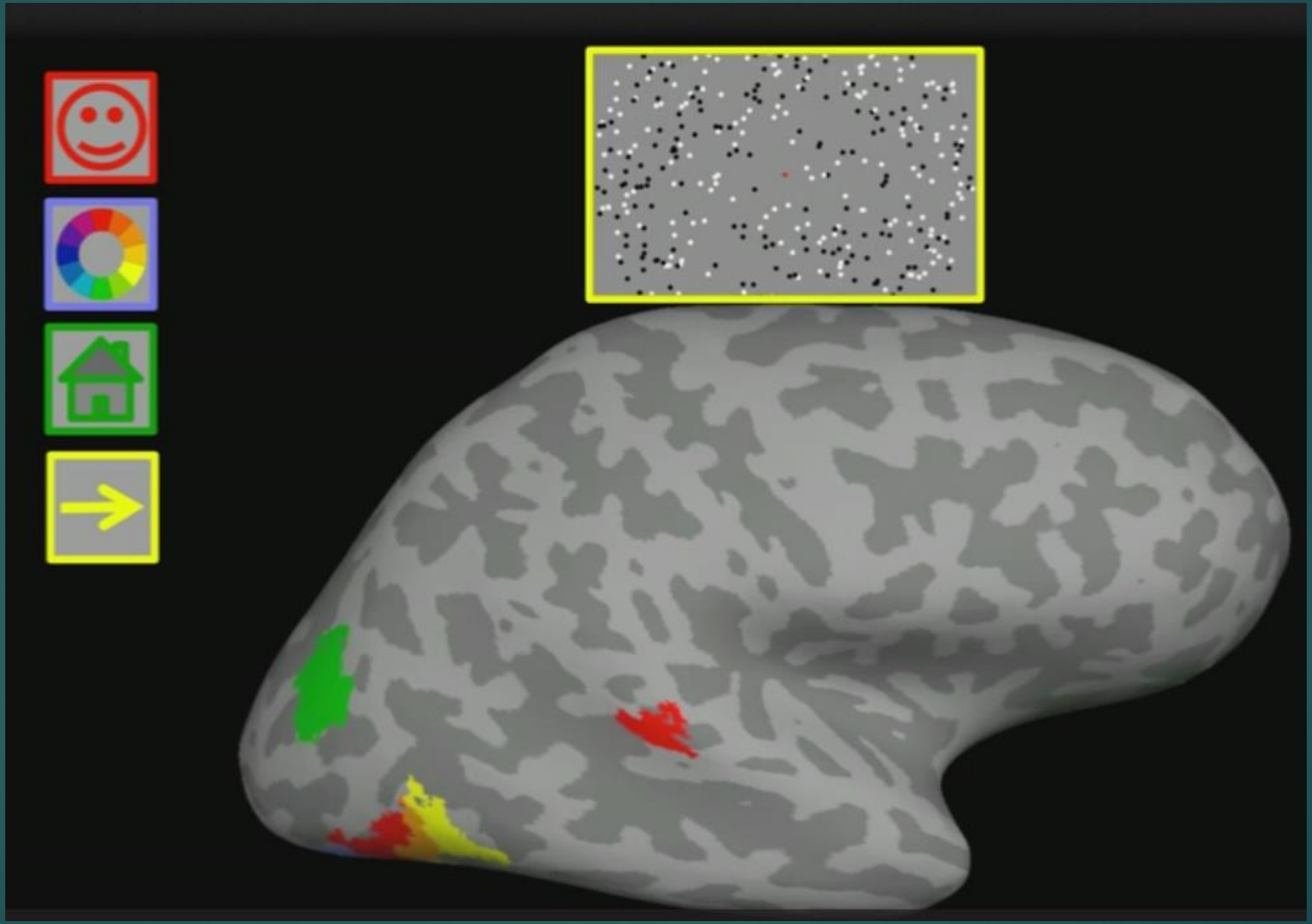
Phonagnosia: Auditory Capgras Syndrome

- Phonagnosia: unable to distinguish a familiar voice from an unfamiliar one.
- 3 voice-sensitive (not speech) areas in anterior, middle, and posterior superior temporal sulcus (STS)
- FFA is more strongly connected to middle and anterior than to posterior areas of the voice-sensitive STS

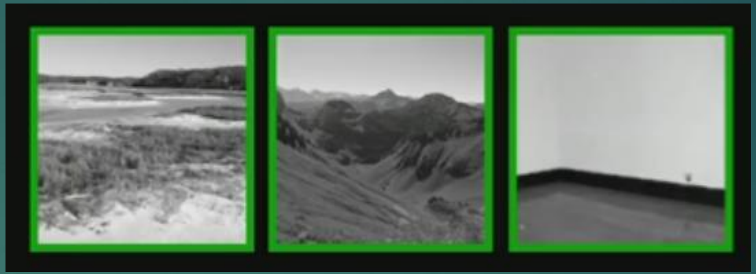
Catherine Perrodin, et a l., 2014

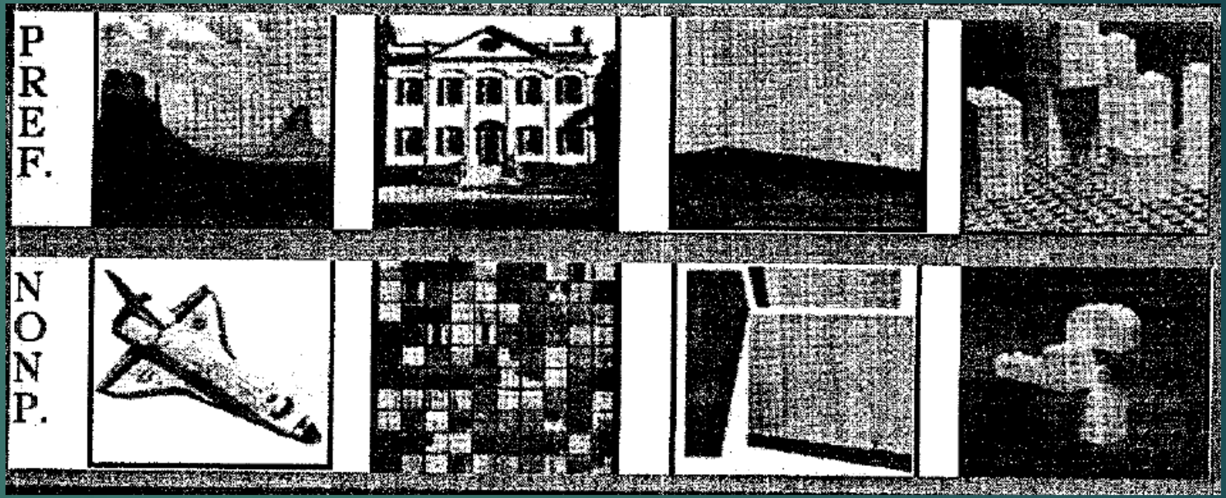
Color Processing Area

Visual Motion area



Parahippocamal gyrus: Recognition of places





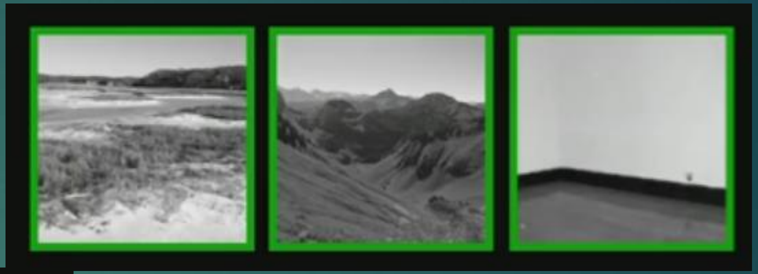
Places

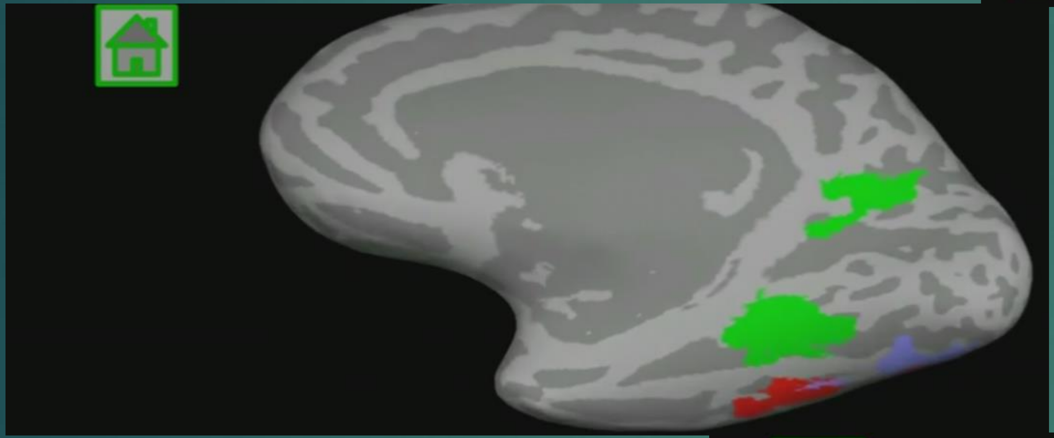
Not

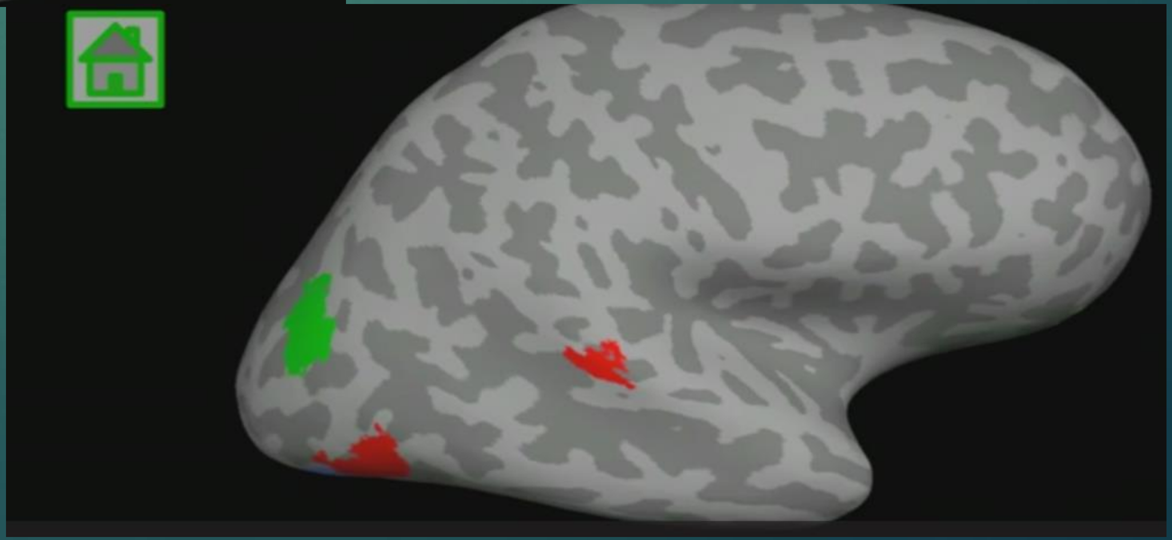
Parahippocampal place area (PPA):

<u>**Place area of brain**</u>: Recognition of spatial layouts

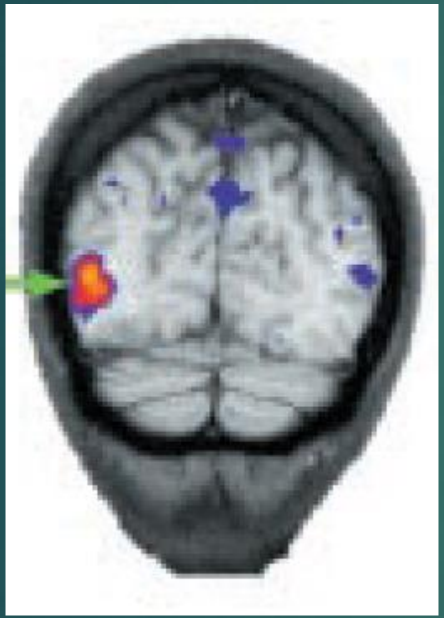
PPA: Place area

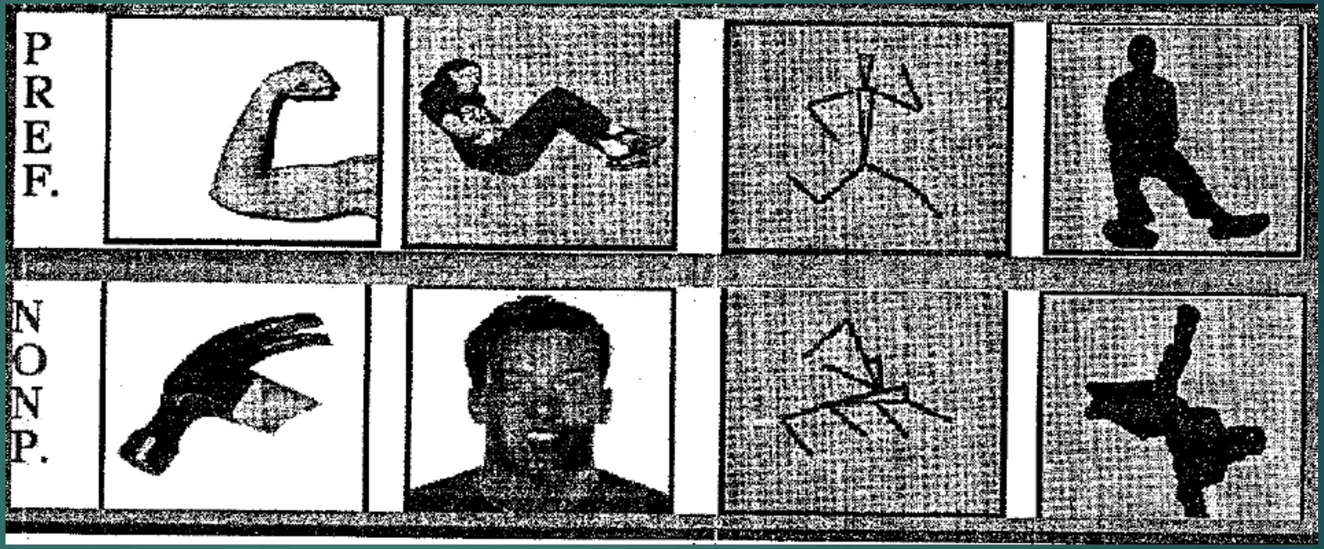






Extrastriatal Body Area



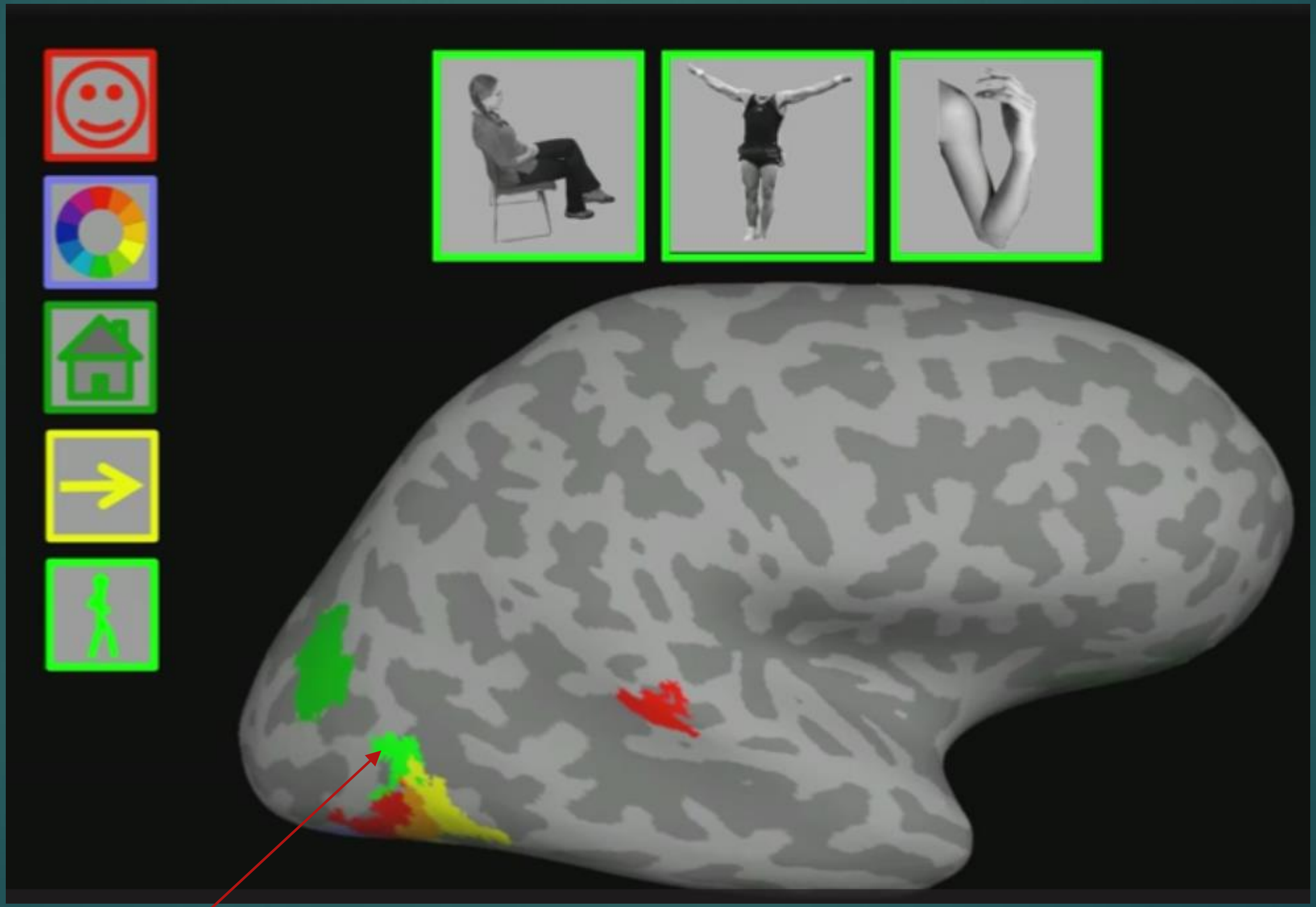


Body

NO

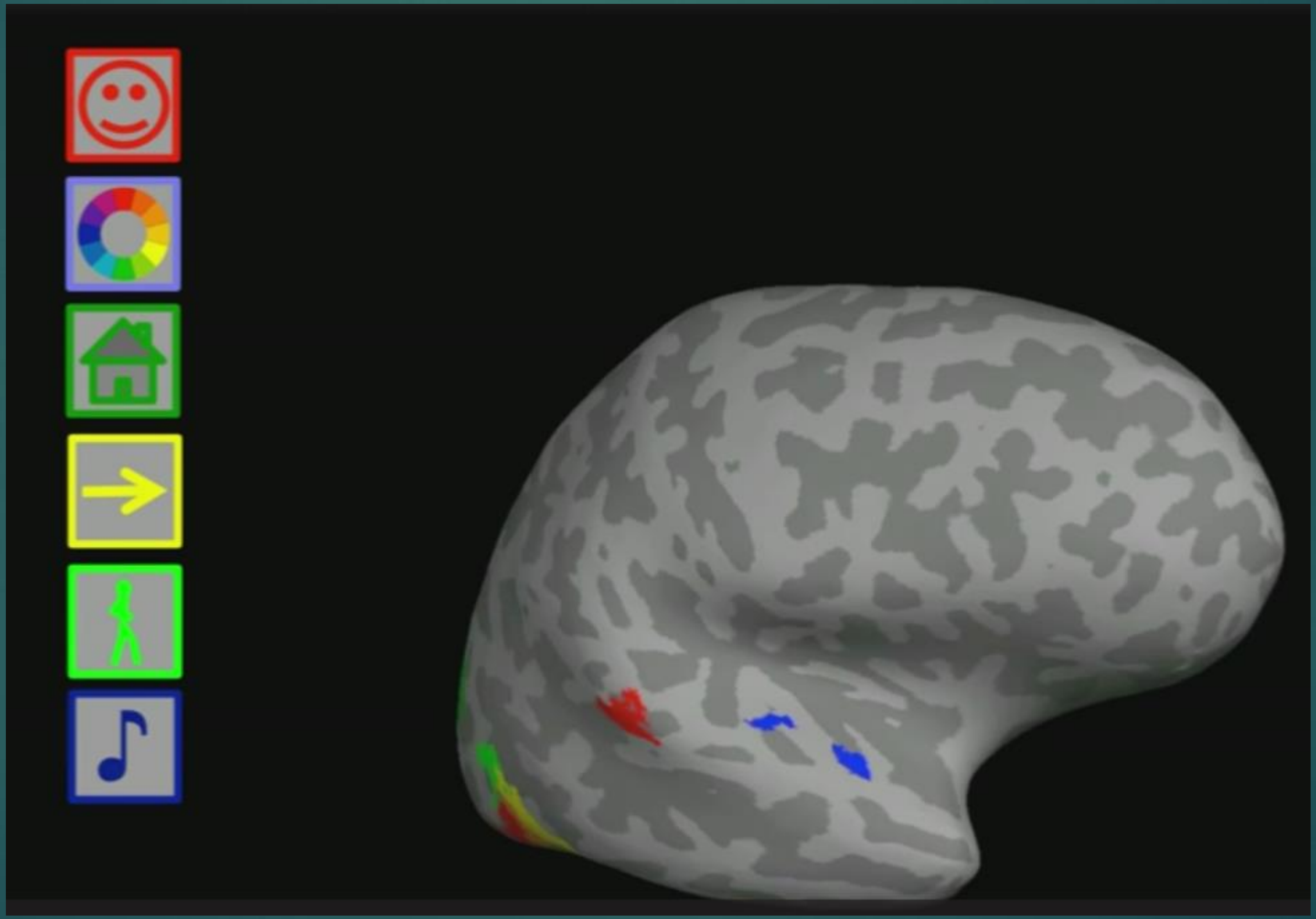
EBA: Only responds to **bodies and body parts**

Body Parts Area



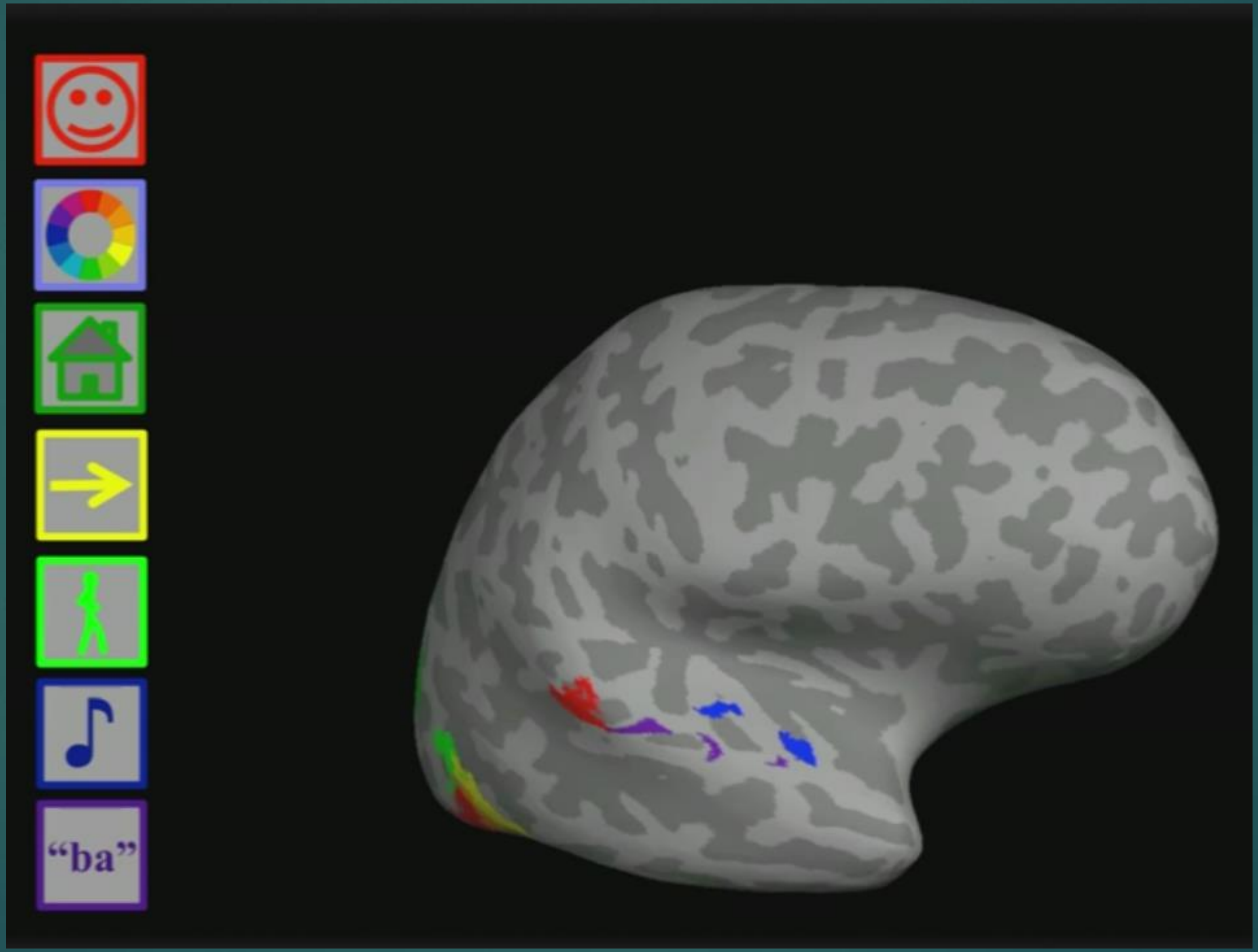
EBA

Hearing pitch area

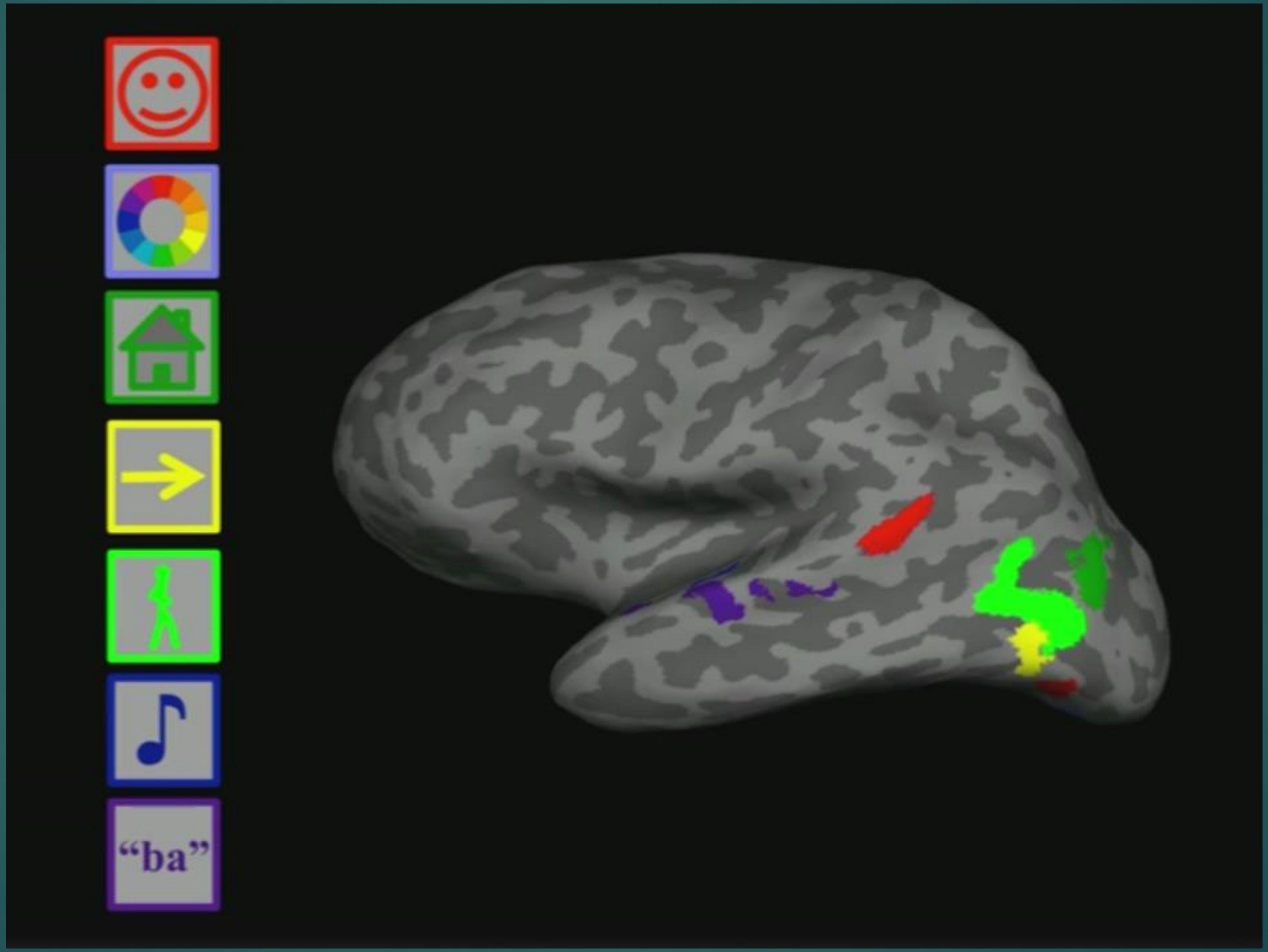


Sounds with pitch i.e. police siren

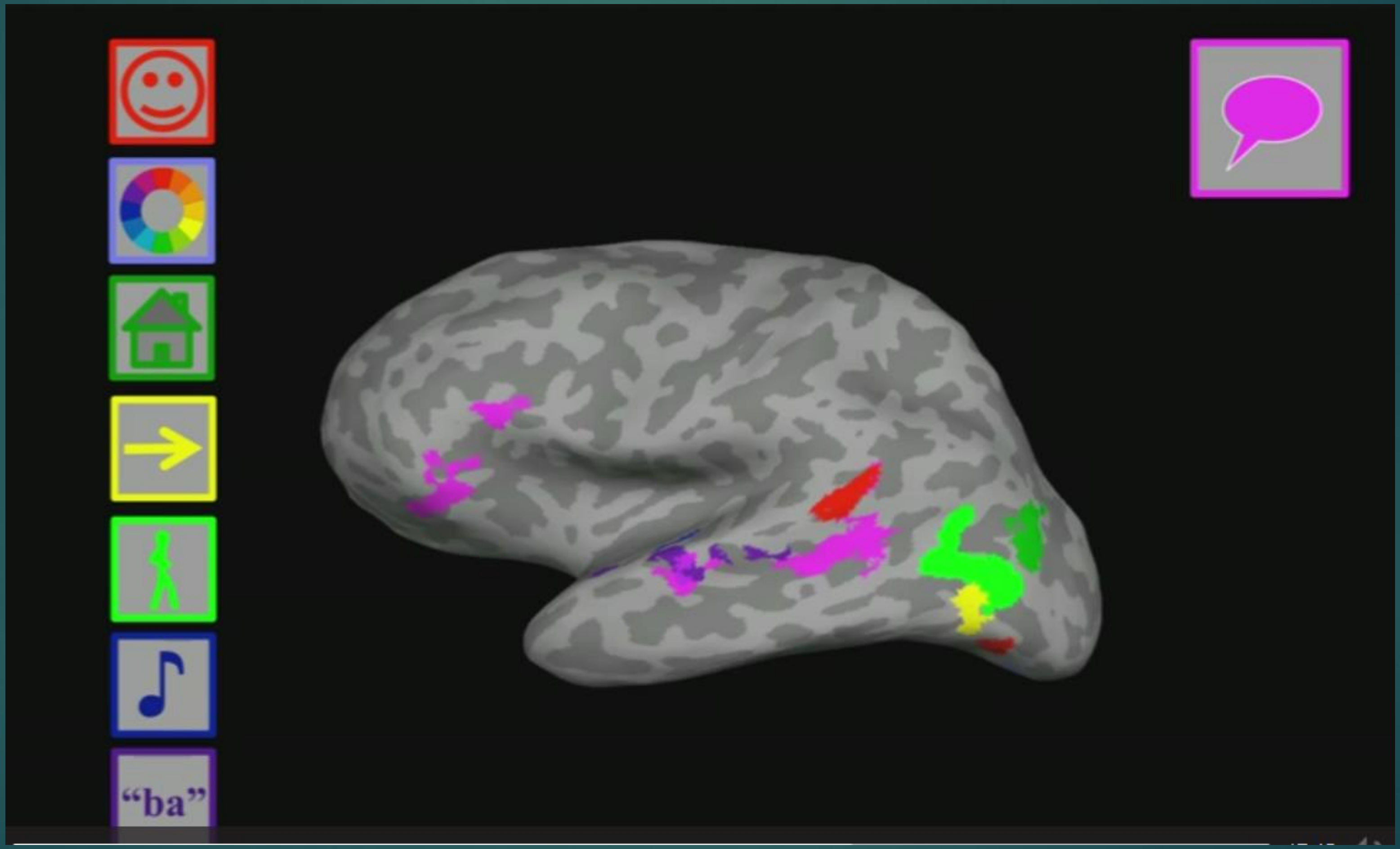
Speech Sound area



Left Hemisphere versions of these areas



Language regions



Visual Word Area: Experience counts

FFA

VWFA
Left ventral
occipitotemporal
cortex

PPA

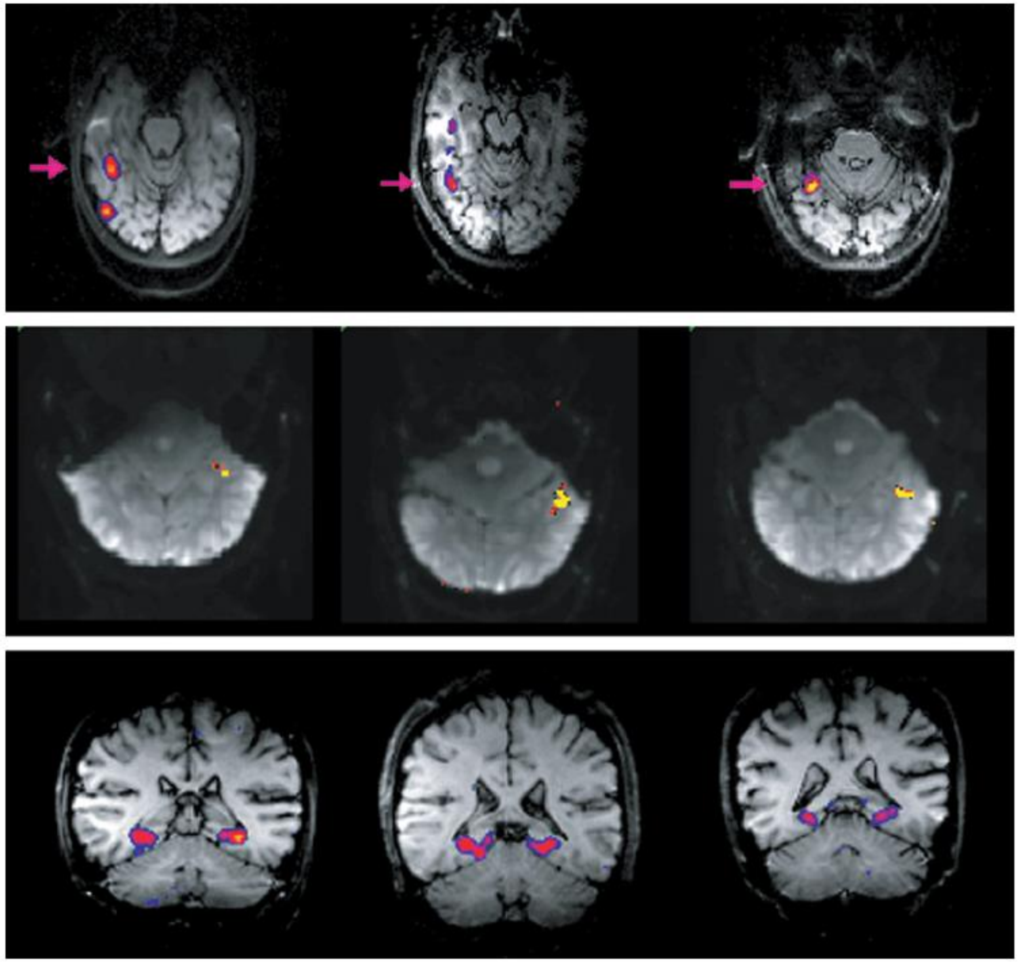


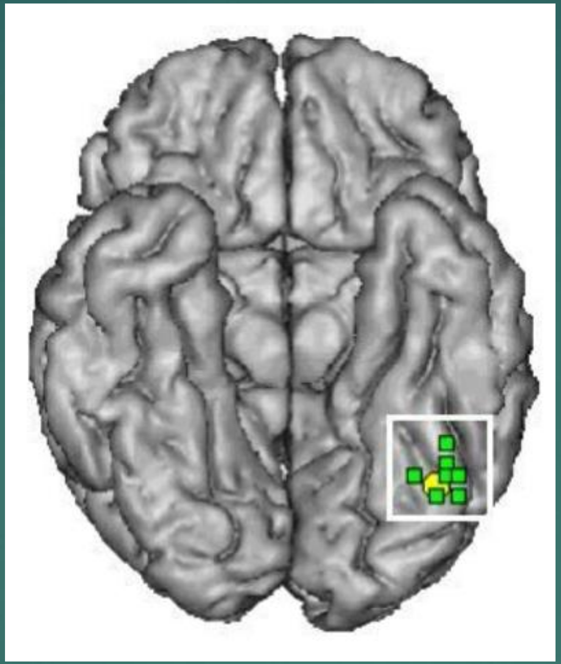
Fig. 6. Three of the functionally specific regions that have been discovered using the individual-subjects functional ROI approach. Top panel: the fusiform face area (FFA), which is defined by a higher response to faces than objects shown in three individual subjects (data from Kanwisher et al. 1997). Middle panel: a word and letter-string selective region, which is defined by its higher response to visually presented words than line drawings of objects shown in three individual subjects (data from Baker et al. 2007). Lower panel: the parahippocampal place area (PPA) which is defined by a higher response to scenes than objects shown in three individual subjects (data from Epstein et al. 1999).

Faces

Visual Words
based on
experience

Scenes

Reading letters area: literacy changes brain



Result of experience

Visual Word Form Area localized to the left occipito-temporal region that is responsible for recognizing visual letters and words (reading written words). VWFA is the highest stage in a hierarchy of visual feature extraction for letter and word recognition.

Both Hebrew & English Words

Kanwisher; Dehaene

Not evolutionary brain change: Literacy changes your brain

- Brain circuits originally evolved for object recognition to become tuned to recognize frequent letters

- Literacy, whether acquired in childhood or through adult classes, enhances brain responses in distinct ways:

- 1 – increases activation of left Visual Word FA

- 2 - allows practically the entire left-hemispheric spoken language network to be activated by written sentences.

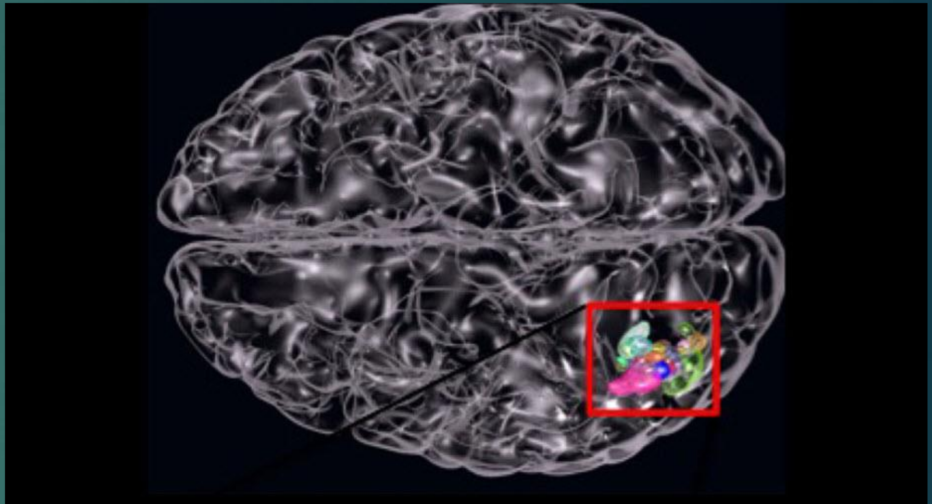
S. Dehaene et al., 2010

Words as Pictures & Sounds:
Deos the bairn not raed ervey lteter by istlef, but the wrod as a wlohe?

VWFA makes pictures out of words.

Left ventral occipitotemporal cortex (specifically the "visual word form area," VWFA) contains a representation based on neurons highly selective for individual real words.

Our neurons must respond to words' orthography—how they look—rather than their meaning.


In the visual word form area, shown in the red box, strings of letters that make words are processed as pictures.

Glezer LS, Jiang X, Riesenhuber M, 2009

When We Read, We Recognize Words as Pictures

- Words are not encoded in the brain by their meaning but rather by simpler attributes such as sound and shape

- As we become more proficient at reading, then, we build up a visual dictionary in the VWFA—much as we accumulate a catalogue of familiar faces on the opposite side of our brain.

- In young children and people who are illiterate, the VWFA region and the fusiform face area both respond to faces. As people learn to read, the VWFA region is co-opted for word recognition. . Brain circuits originally evolved for object recognition converted to become tuned to recognize frequent letters.

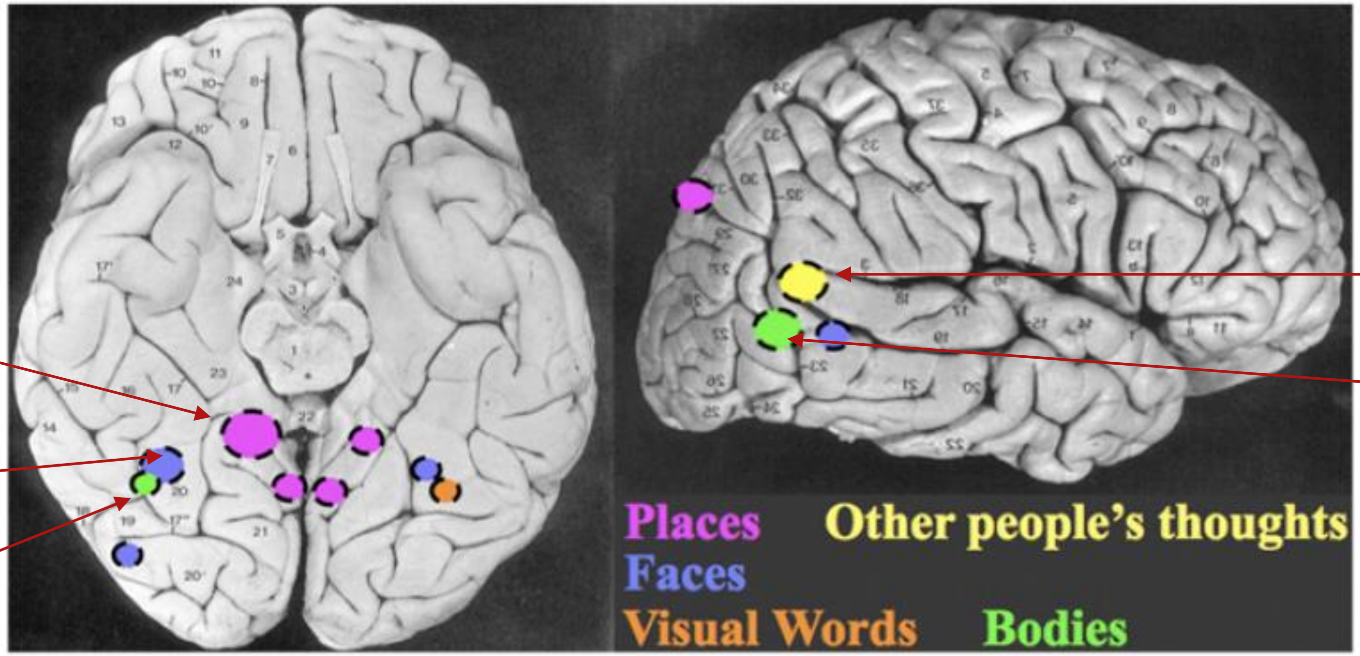
Functionally specific areas:
Faces, Places, Bodies, Visual Words, Thoughts

Ventral
Visual
Pathway:

PPA

FFA

EBA



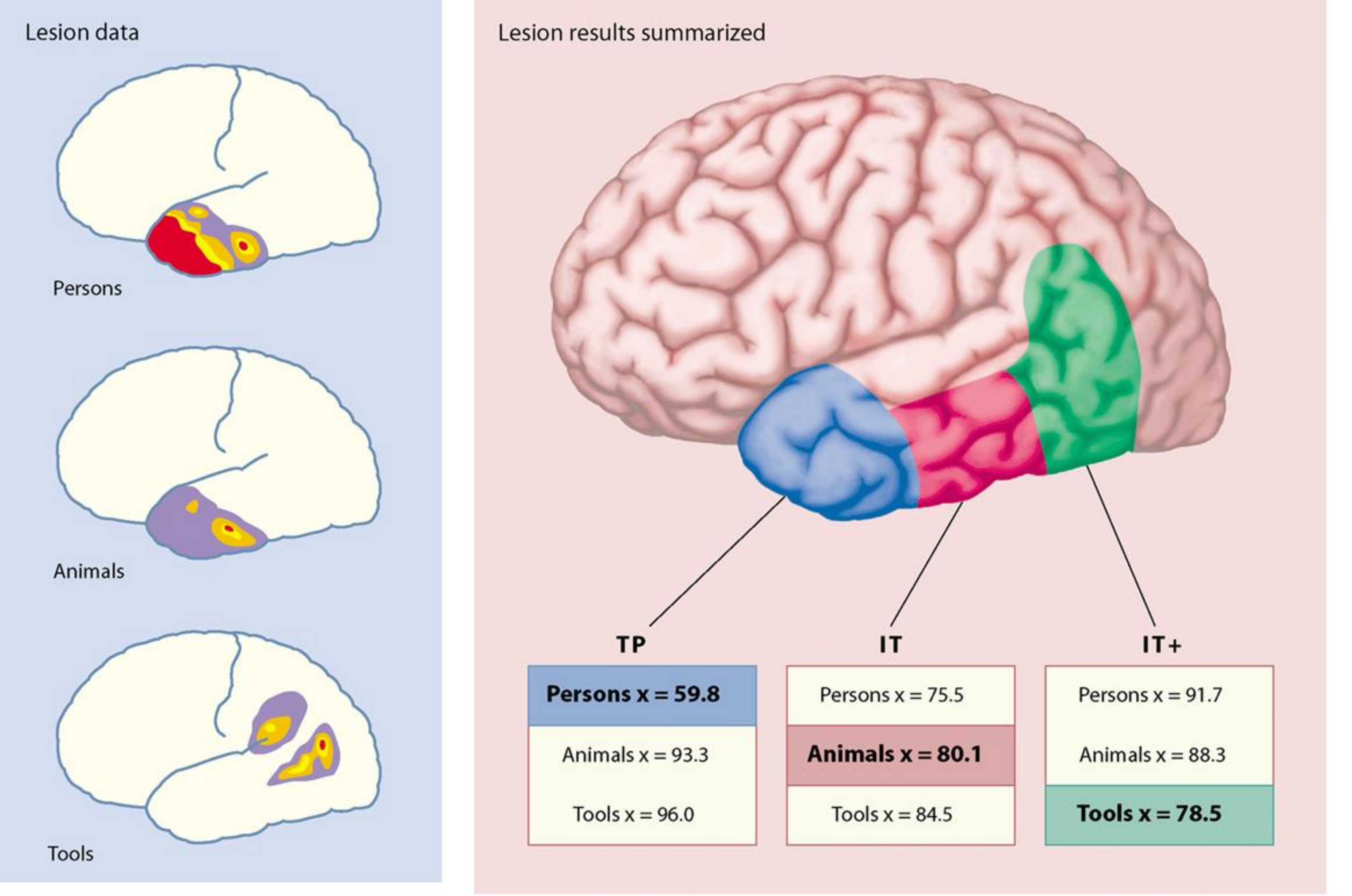
rTPJ

EBA

Fig. 1. This schematic diagram indicates the approximate size and location of regions in the human brain that are engaged specifically during perception of faces (blue), places (pink), bodies (green), and visually presented words (orange), as well as a region that is selectively engaged when thinking about another person's thoughts (yellow). Each of these regions can be found in a short functional scan in essentially all normal subjects.

Nancy Kanwisher1, 2010

Location of people, animals and tools: lesion based



Location of brain lesions that are correlated with selective deficits in anming persons, animals or tools (Damasio et al., 1996).

Visual & Auditory Word Processing

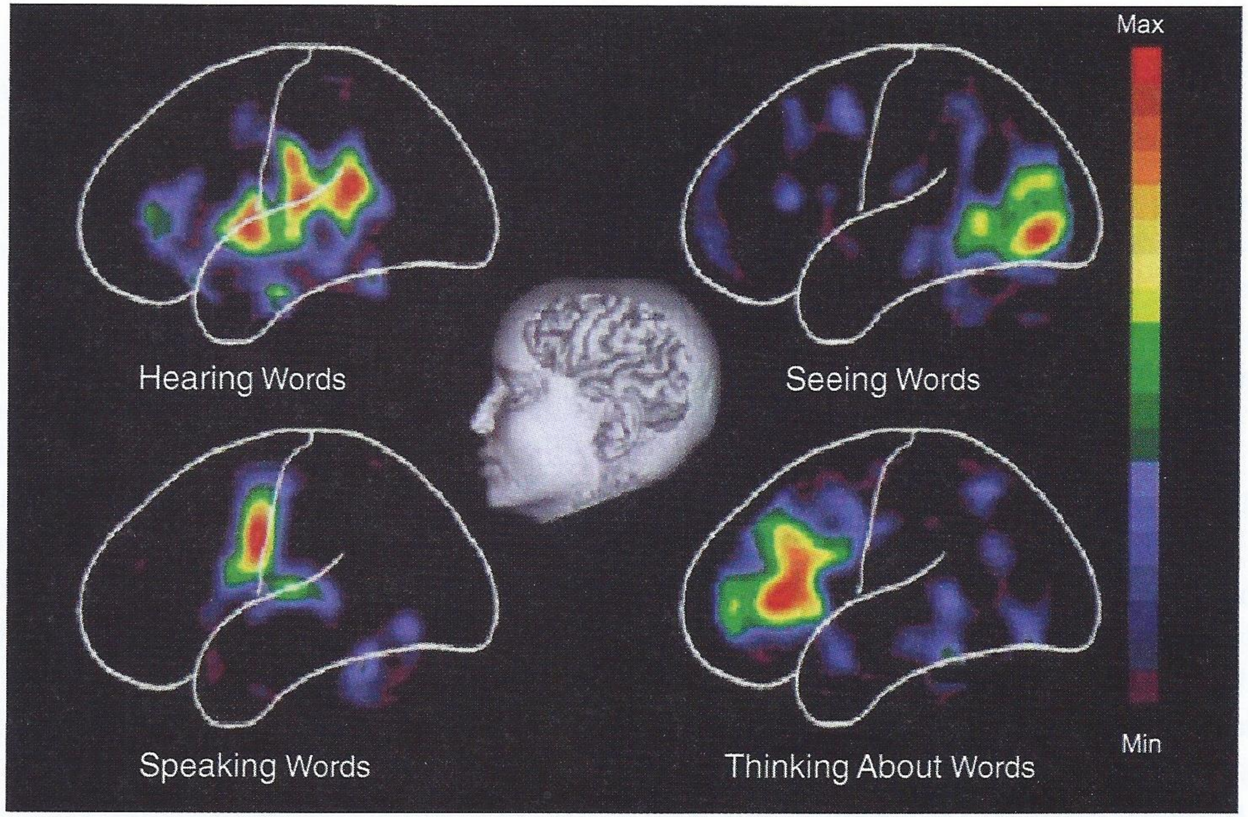
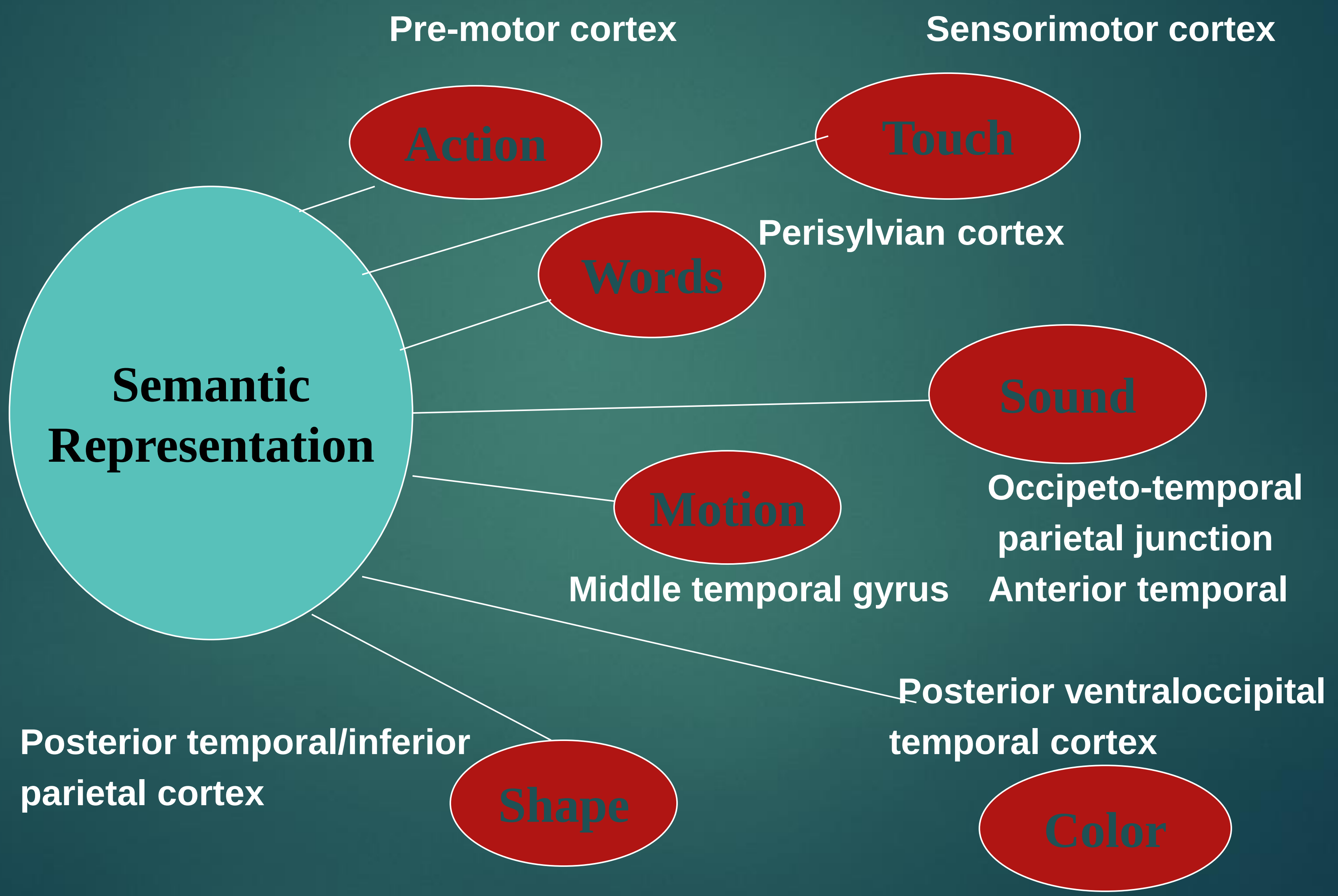


FIGURE 4.30 A classical PET finding: visual versus auditory brain activity. Early PET scans showing different speaking, seeing, hearing, and internally generating words (Posner and Raichle, 1994). Notice that visual, auditory, motoric, and speech production regions appear to be activated. However, the surrounding brain outline (white lines) is only approximate. In more recent brain images, the functional activity would be superimposed upon a structural MRI of the same subject's brain. *Source*: Posner and Raichle, 1994.

Locations of Semantic Memory

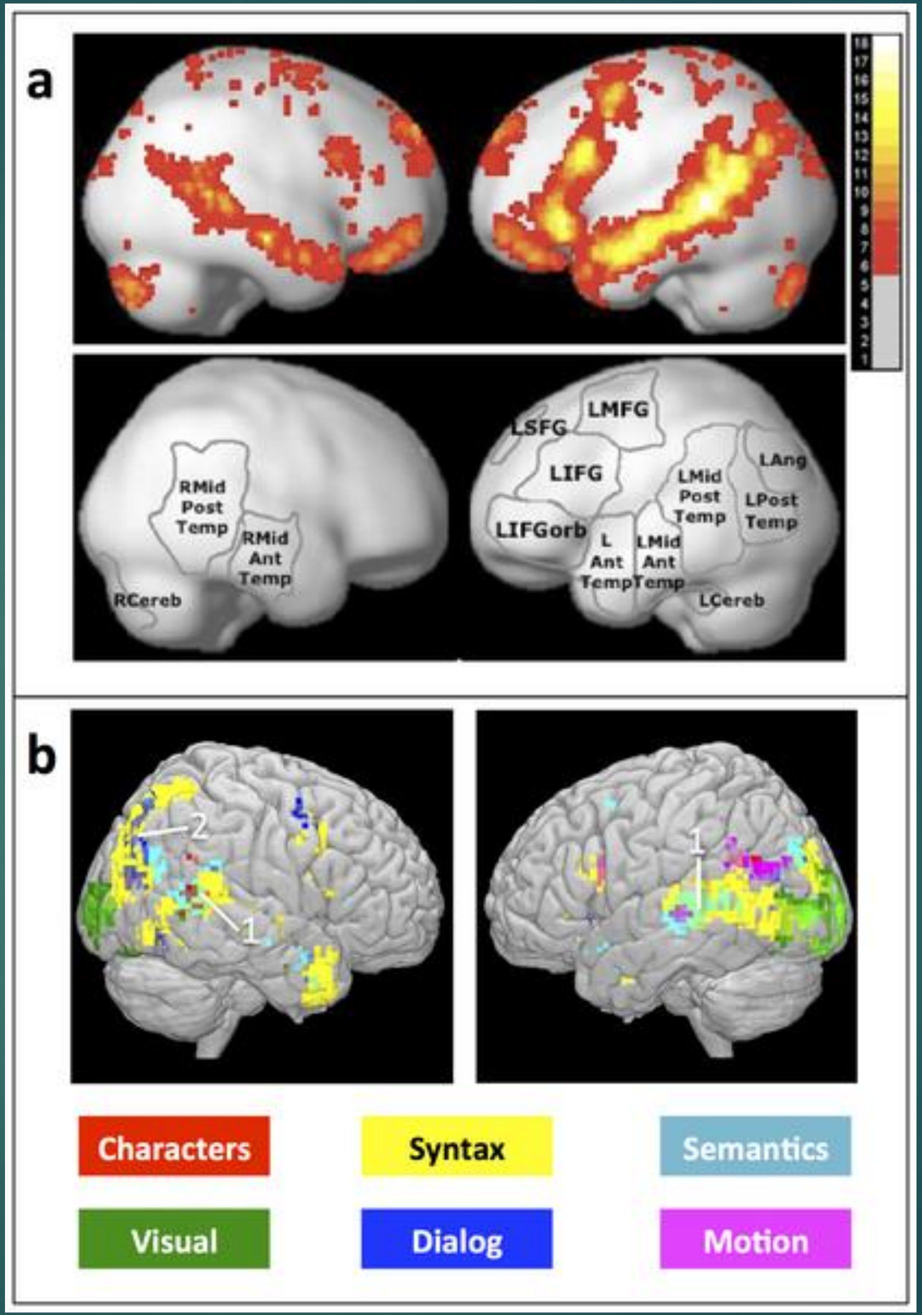


Reading Harry Potter

- 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.



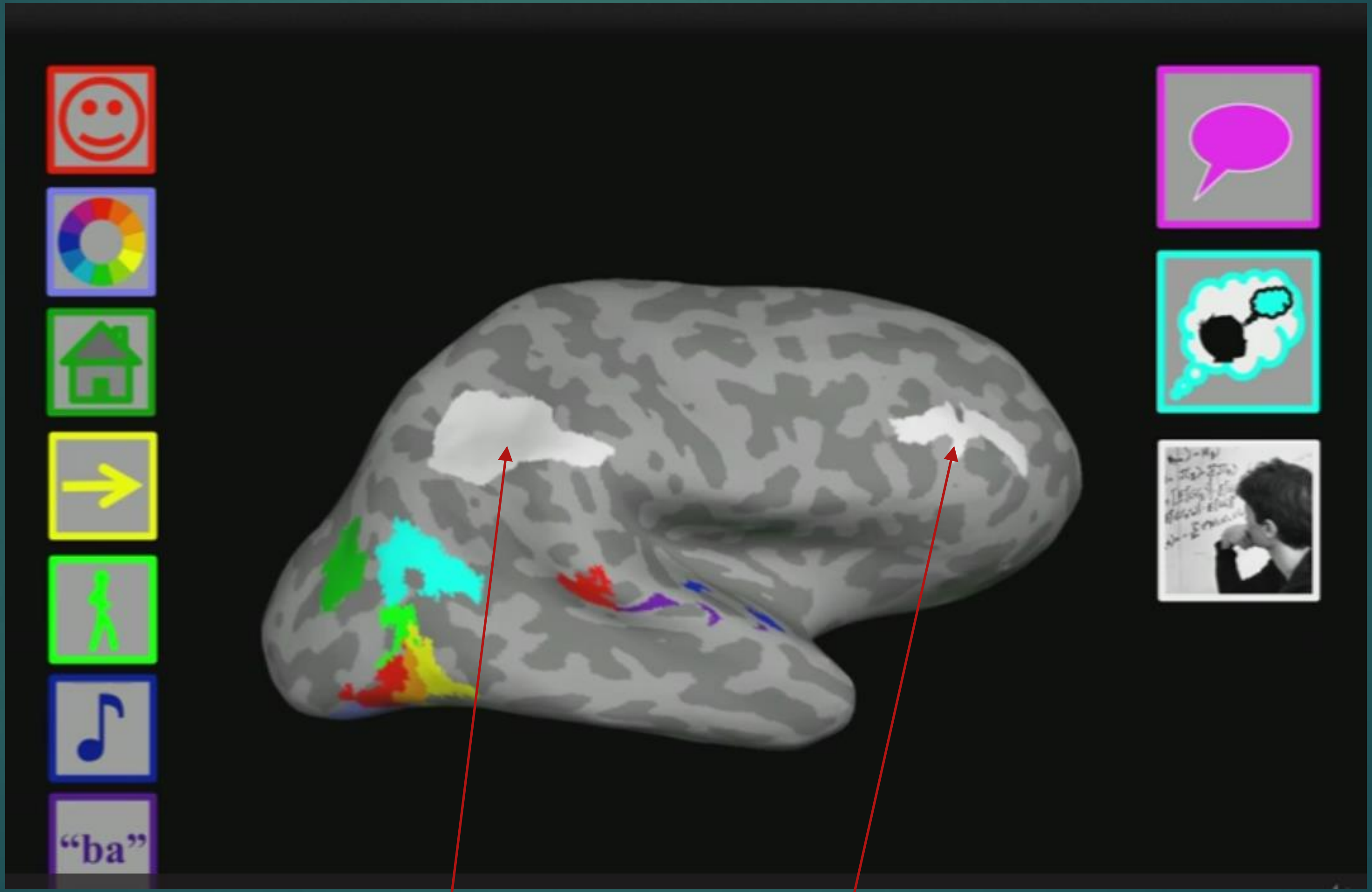
Wehbe L, Murphy B, Talukdar P, Fyshe A, et al. (2014) Simultaneously Uncovering the Patterns of Brain Regions Involved in Different Story Reading Subprocesses. PLoS ONE 9(11): http://www.plosone.org/article/info:doi/10.1371/journal.pone.0112575

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.

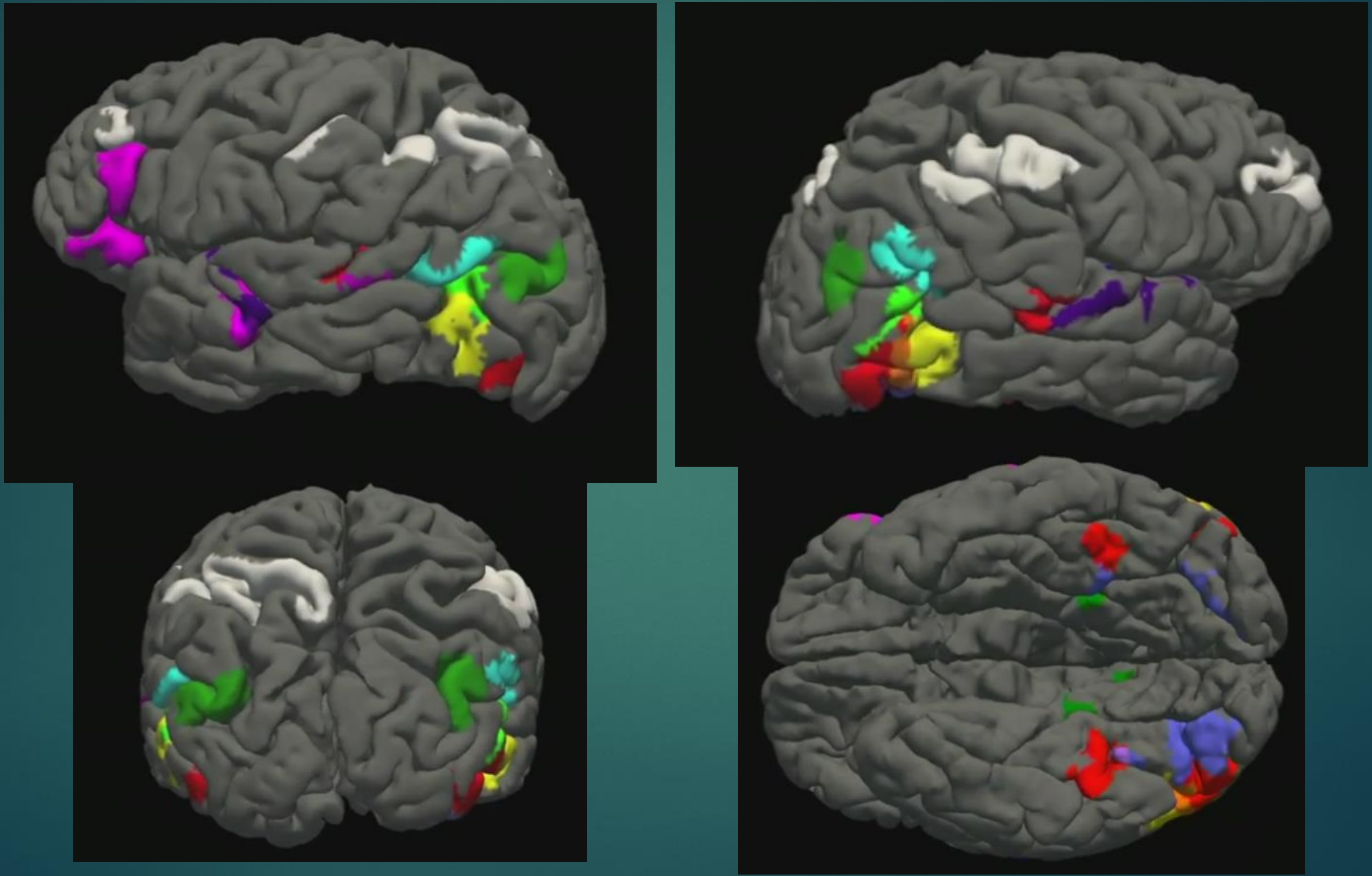
- It’s not just what you are physically seeing, but what you are consciously aware of that is processed by these areas.

General Purpose Processors

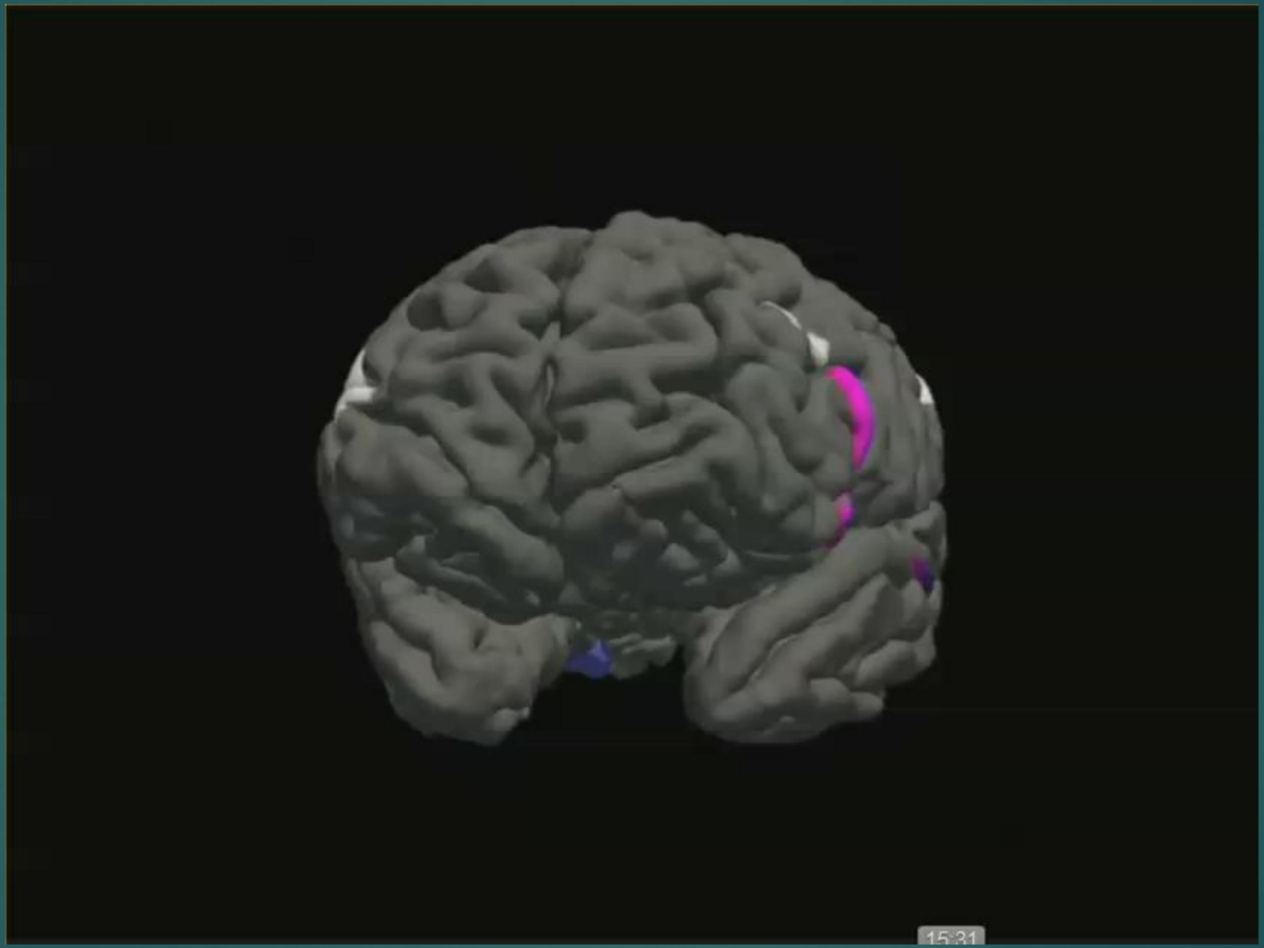


Respond to any difficult mental task

These processors are invariant (genetic) Same places in everyone



Kanwisher’s Brain



Multiple-demand (MD) system:
Functionally general regions: Flexibility

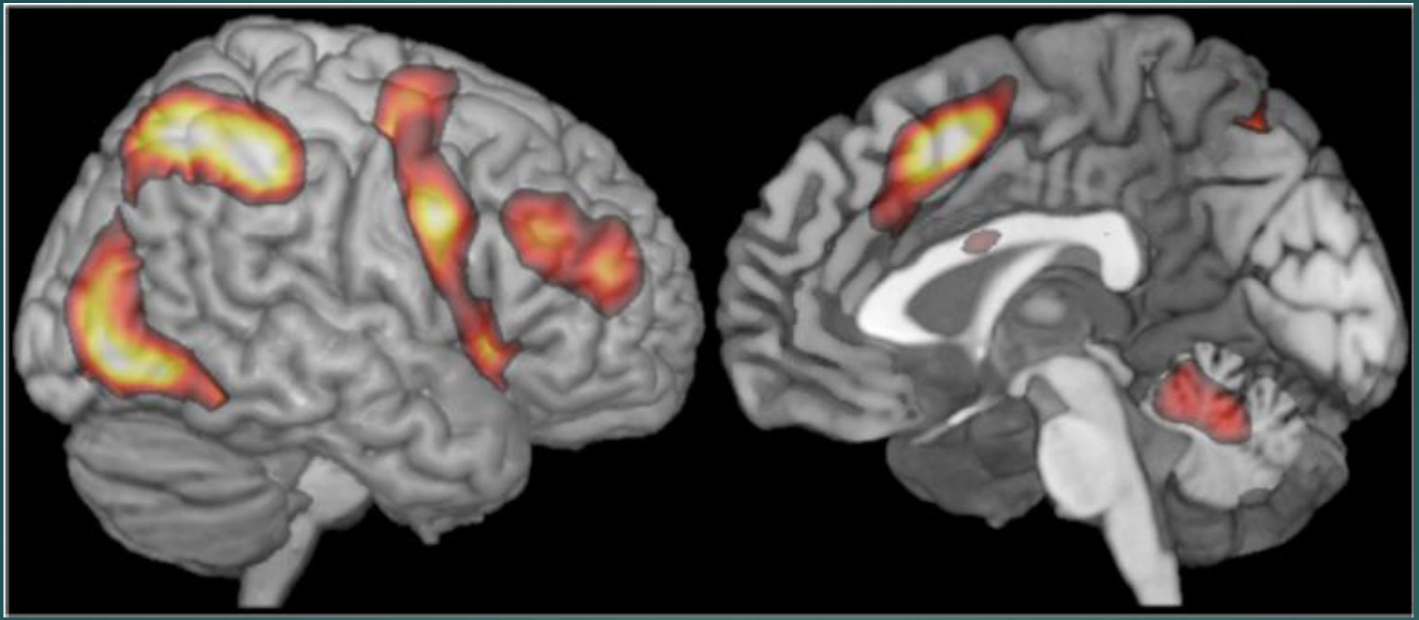
- There are localized domain-specific regions (i.e. Broca for language). Tailored to solve particular problems of longstanding importance to our species,

- There are also a set of functionally general regions that endow us with the cognitive flexibility necessary to solve novel problems.

- Study: Seven diverse demanding cognitive tasks produced overlapping activation at the individual-subject level in a number of frontal and parietal brain regions

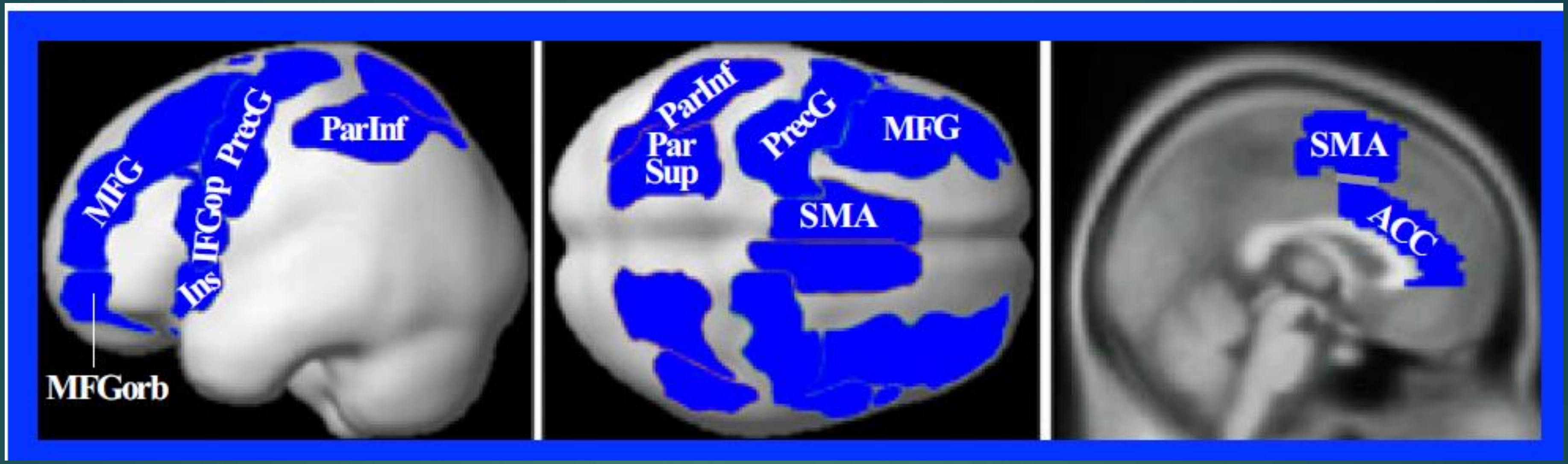
Evelina Fedorenko, et al., 2013

Multiple Demand Processors: 7 areas



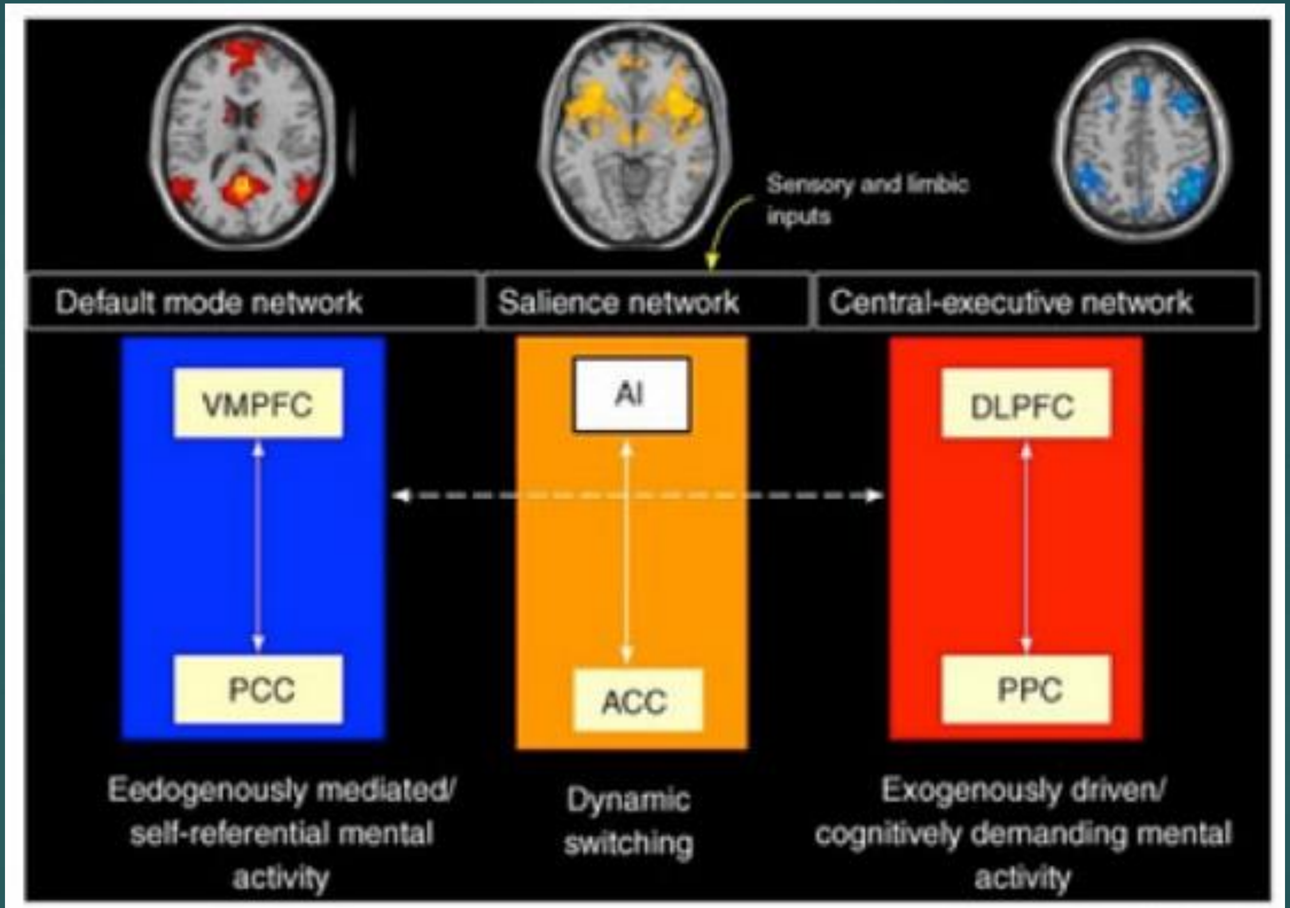
- Problems used: Localization, math, multisource interference tasks, spatial and verbal WM, Stroop
- Opposite of DNM areas: medial temporal lobe, parts of the medial prefrontal cortex, the posterior cingulate cortex, and the precuneus

7 Frontal/Parietal multiple demand regions



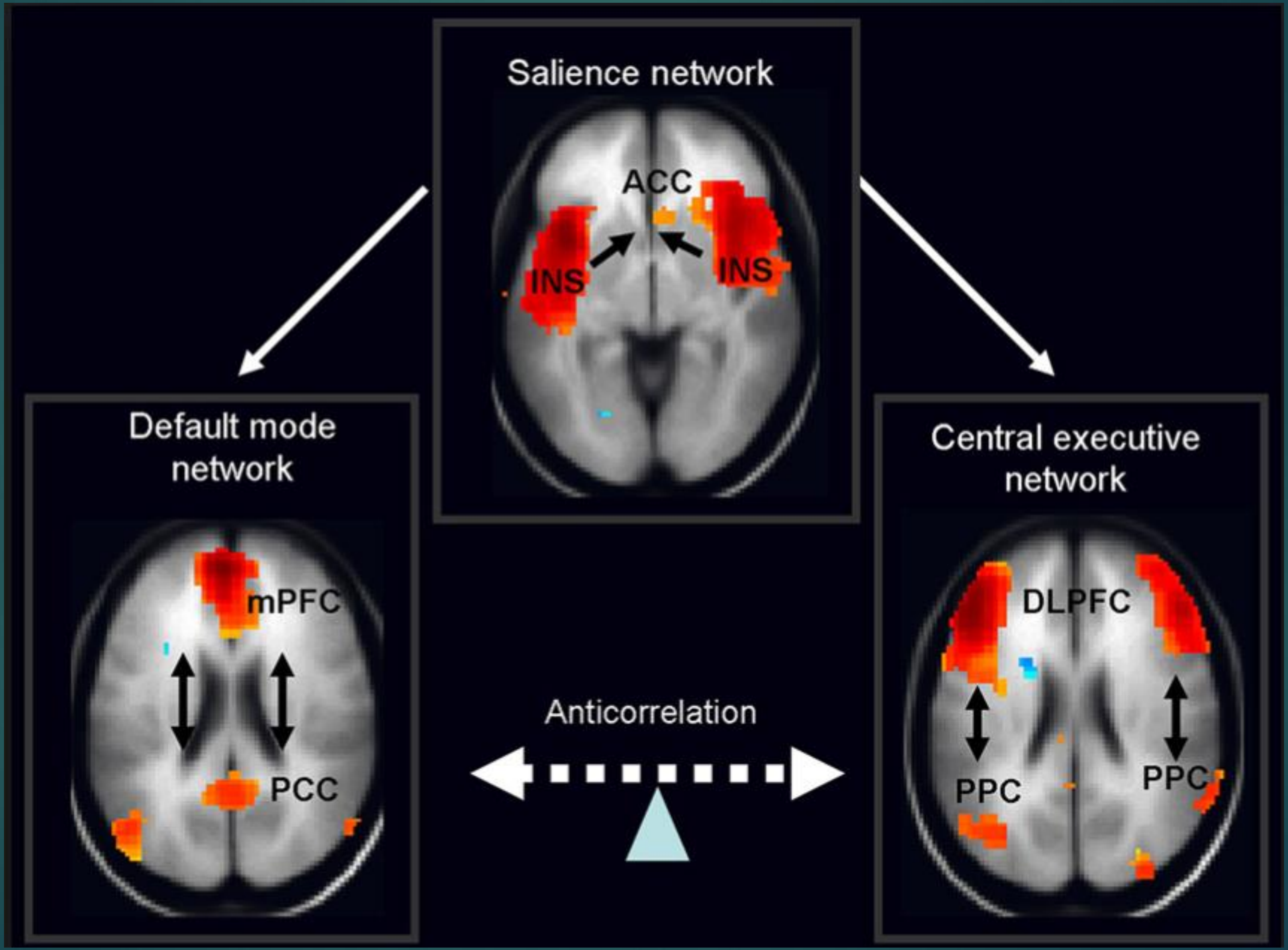
- 7 areas:
  - PrecG: precentral gyrus bilaterally,
  - IFG: opercular part of the inferior\ frontal gyrus (IFG) bilaterally,
  - MFG: right middle frontal gyrus,
  - SMA bilaterally
  - Par Inf & Par Sup: inferior and superior parietal cortex bilaterally,
  - Ins: insula bilaterally
  - Cerebellum

Major Connectivity Networks

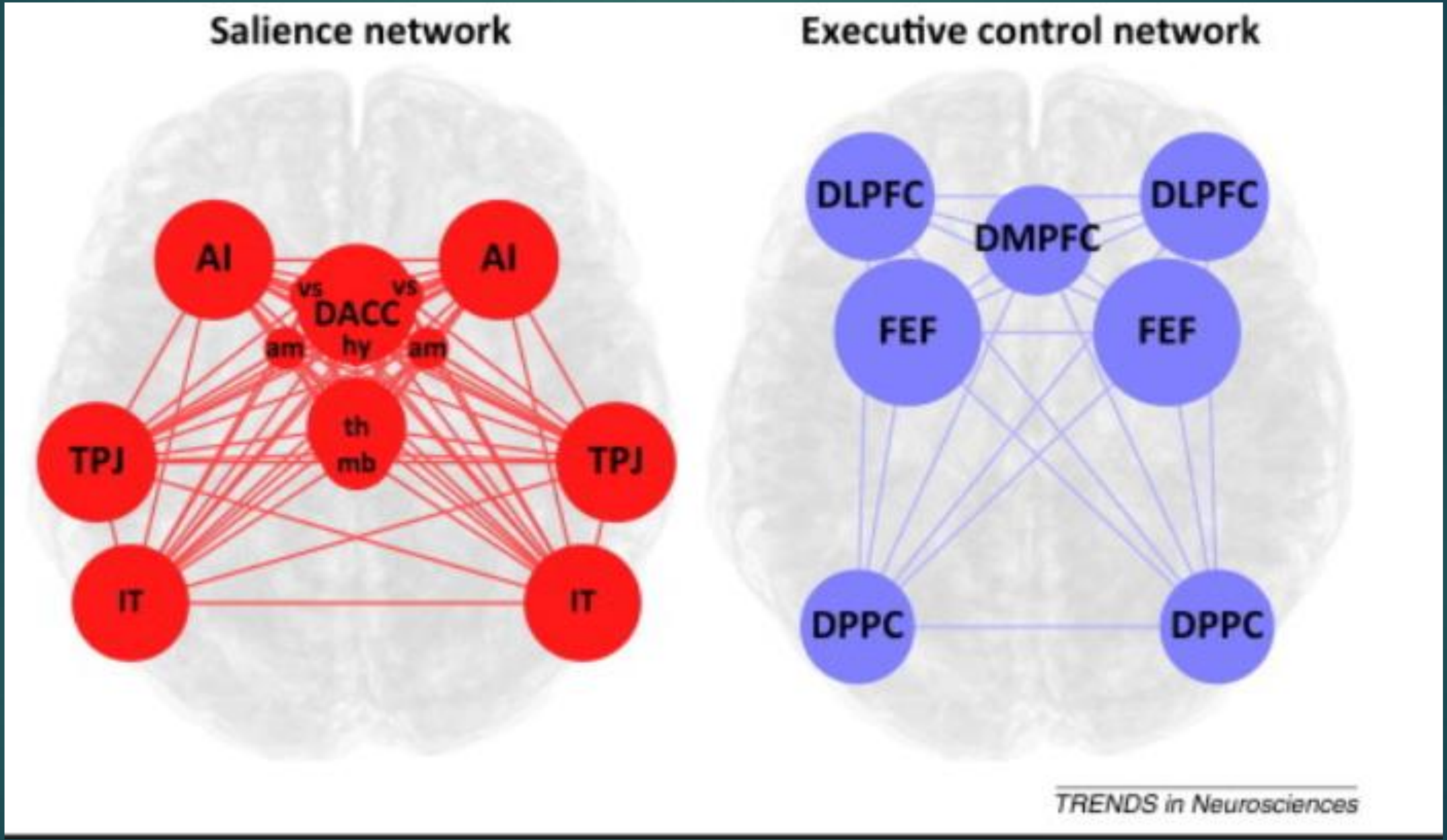


- Three major networks: Default, Salience, Executive; the central executive network "*is engaged in higher-order cognitive and attentional control*."

3 Major Networks

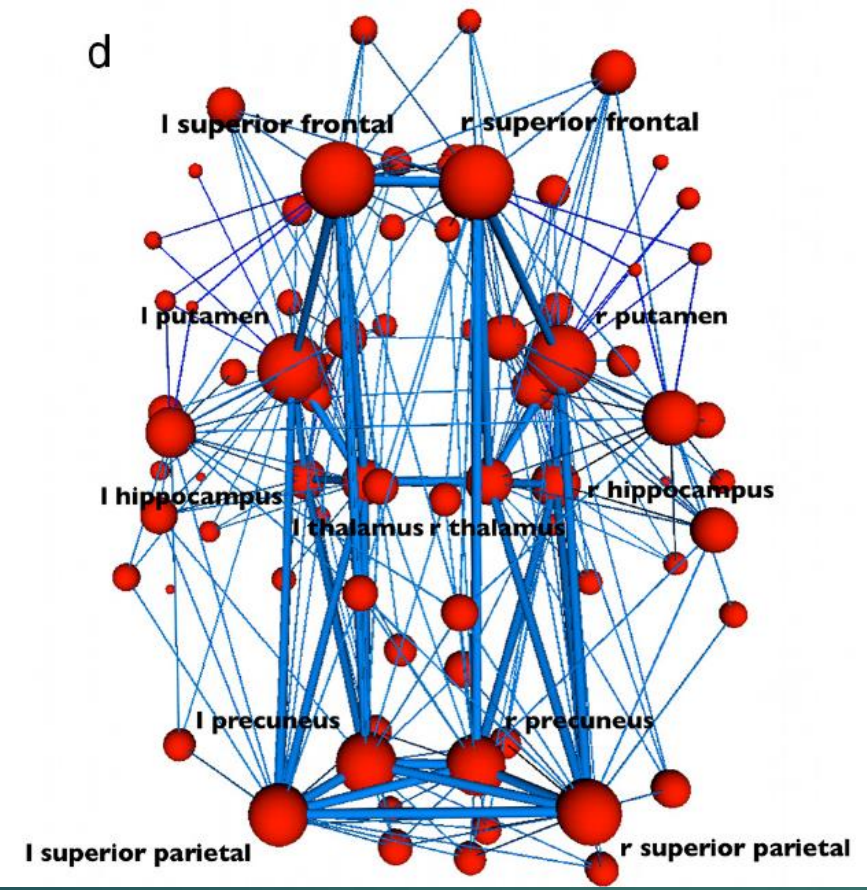


Salience & Executive Network regions

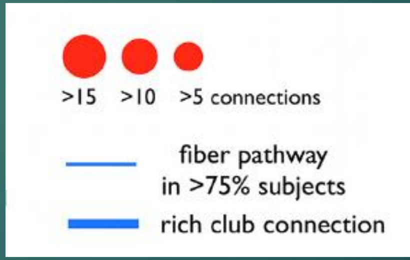


Intrinsic functional connectivity

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.



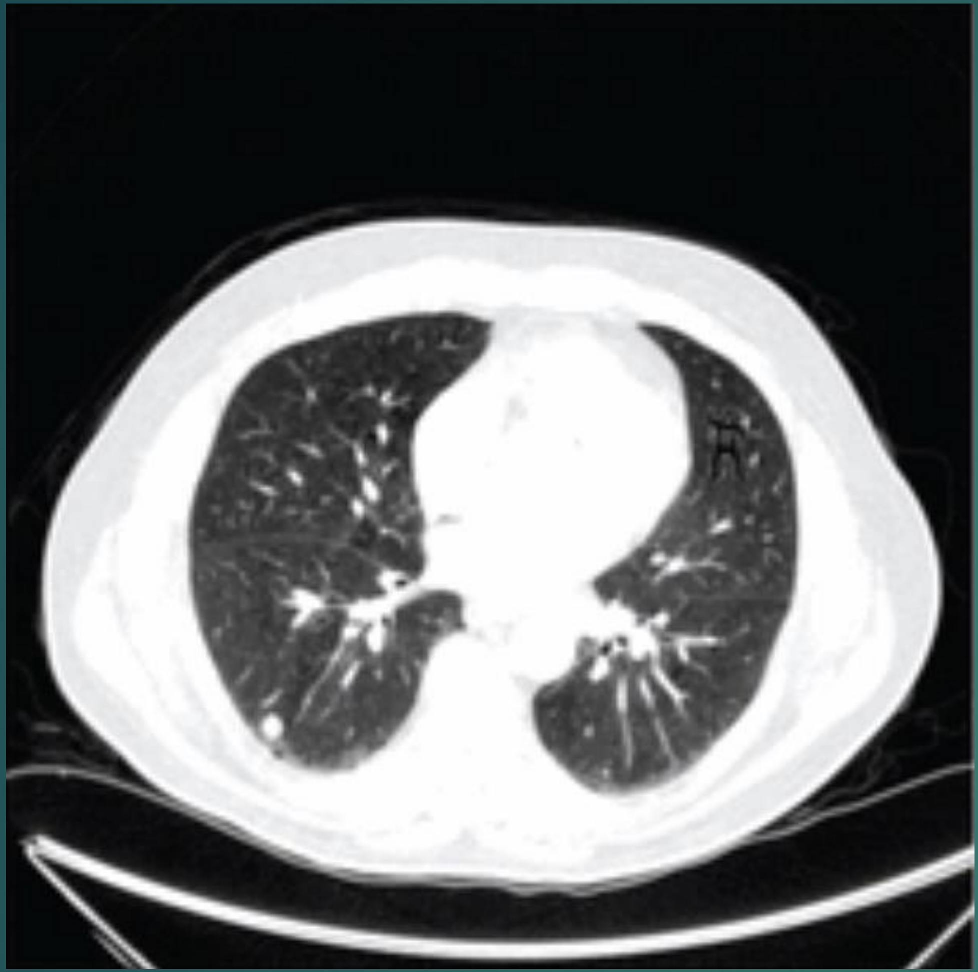
Connections between rich-club regions (dark blue) and connections from rich-club nodes to the other regions of the brain network (light blue). The figure shows that almost all regions of the brain have at least one link directly to the rich club.

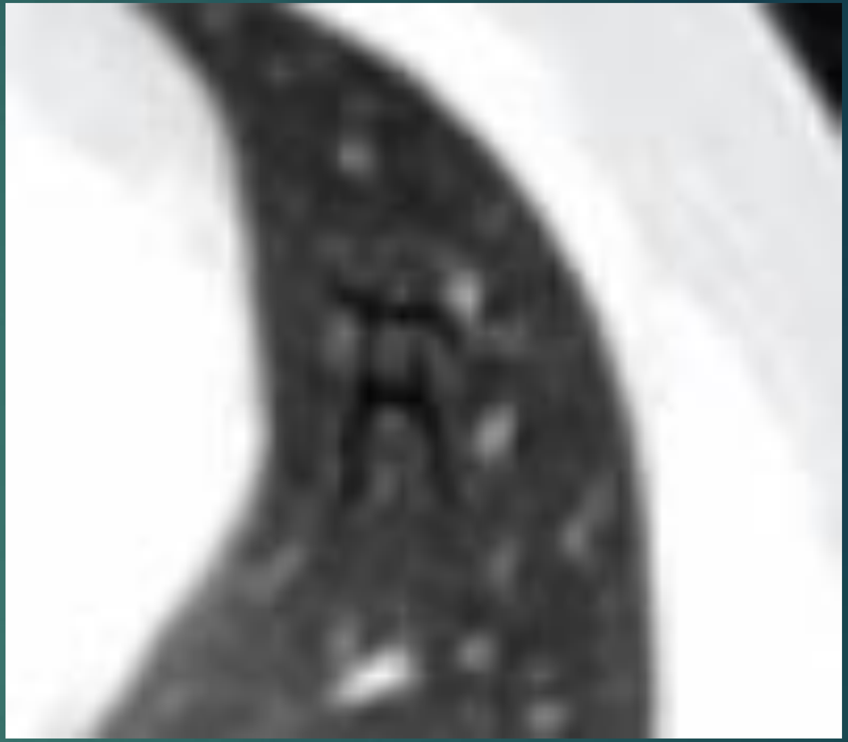
Rich Club Hub Lesions are more damaging

- Important role of functional hubs in optimizing global brain communication efficiency for healthy cognitive brain functioning

- Brain lesions that damage one of the rich club hubs will have more serious behavioral effects (3x more) than damage to non-hub area.

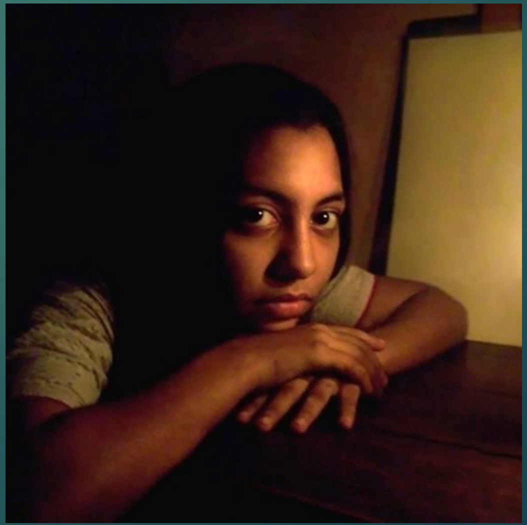
Misperception



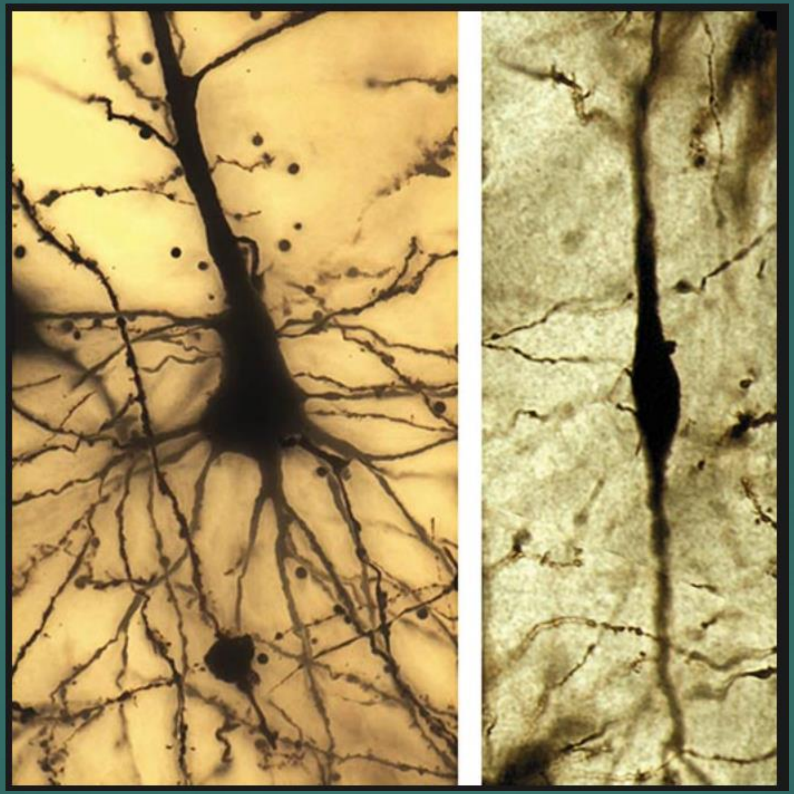


- 83 percent of radiologists missed the gorilla when asked to find node on lungs.

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



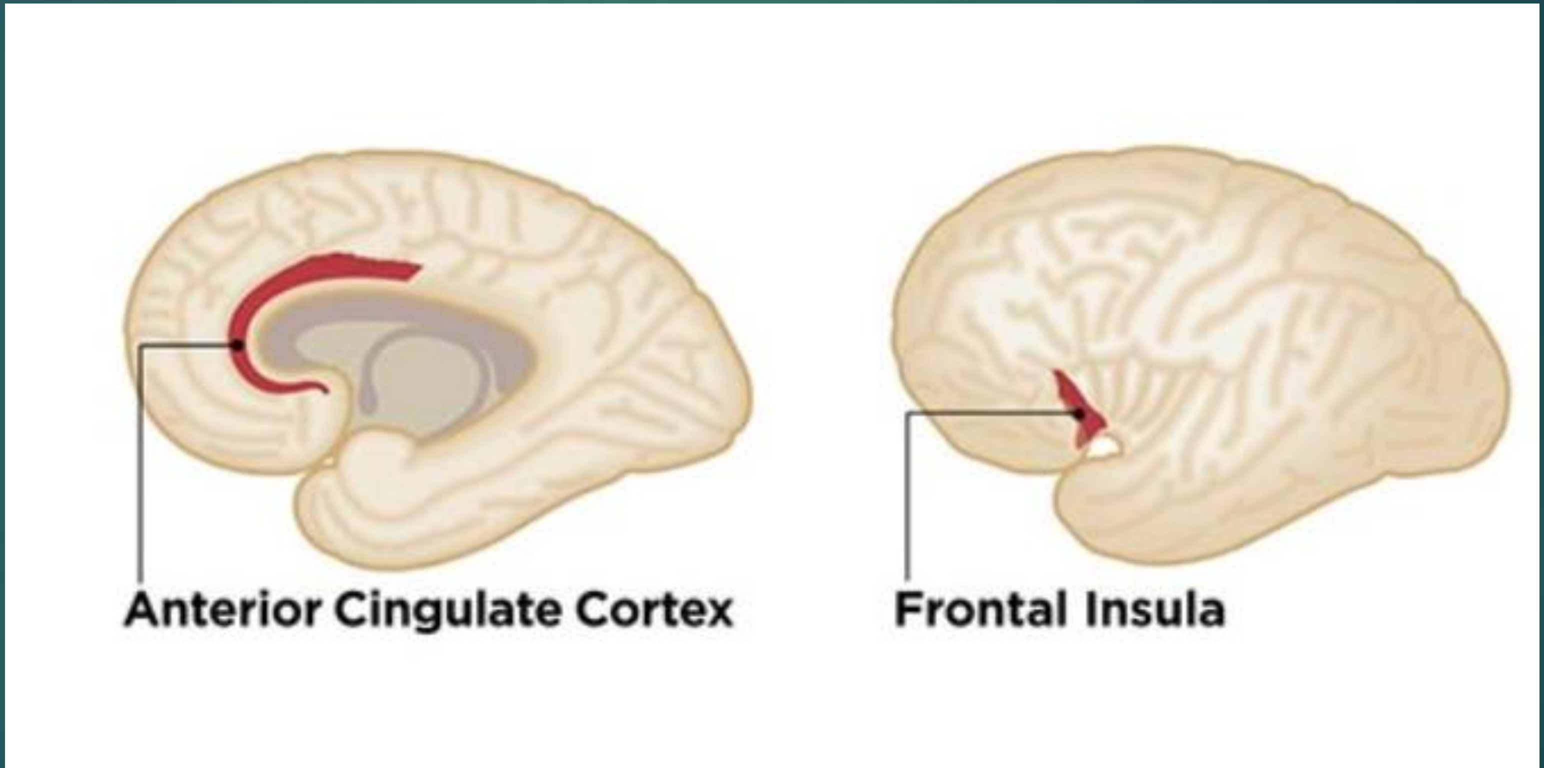
Brain Cells for Socializing? Von Economo neurons



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.

Von Economo Cells

- Fastest, large, bipolar neurons located only in the anterior cingulate and insula (layer Vb), & DLPFC.
- Only 4 species: primates, certain cetacians, elephants and humans. More of them in chimps and human (2x more than chimps).
- The volume of Von Economo neurons is correlated with increased encephalization. Evolved to speed information around a big brain.
- Mirror Test: Ability to recognize oneself in a mirror
- FTD targets ACC and Insula: 70 percent of VENs destroyed
- Abnormally located in autistic brains

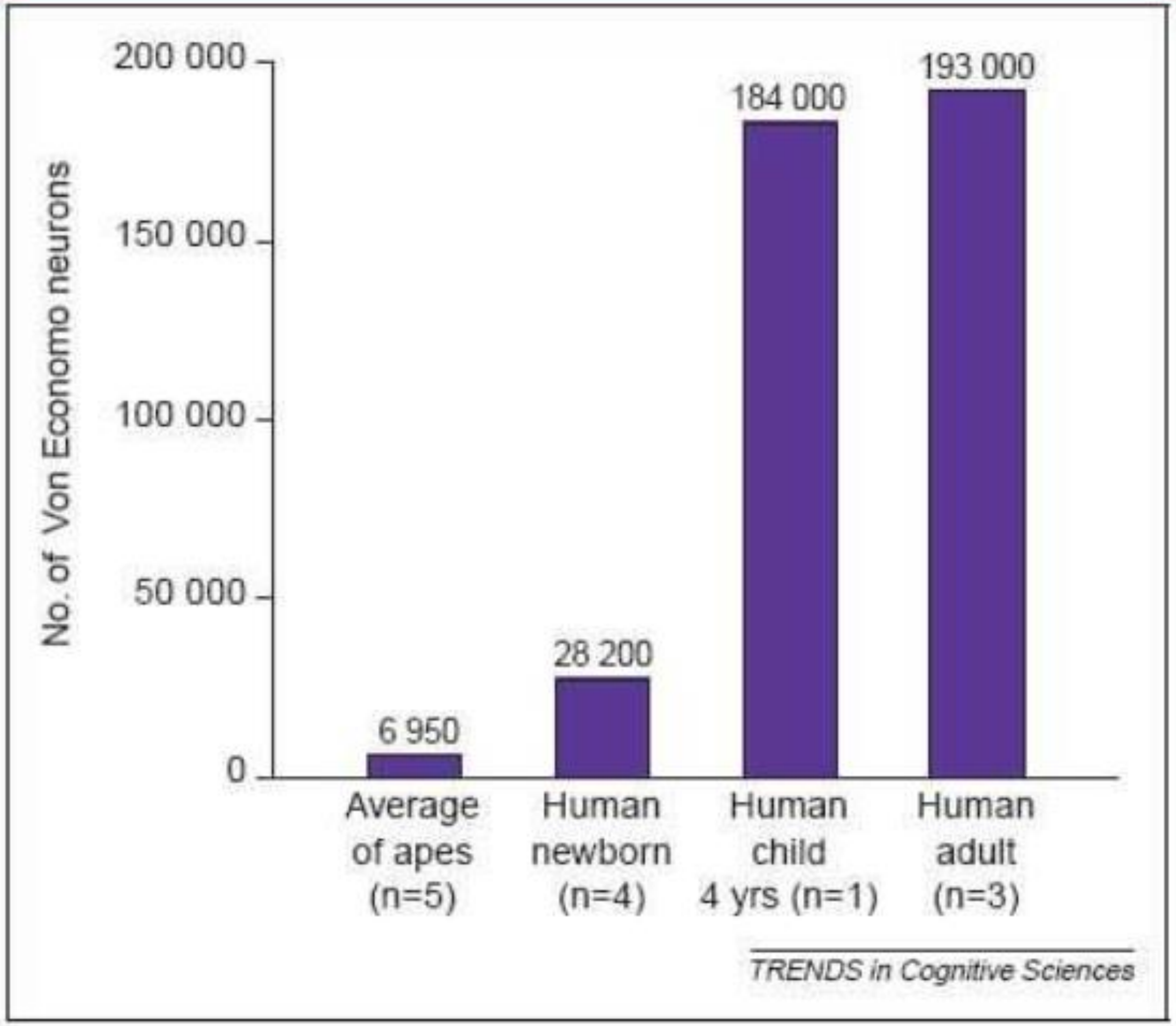


Figure 2. Comparison of Von Economo neuron numbers. Total number of VENs in FI (total of right and left hemispheres) is shown for apes, human neonates, a four-year-old child, and an adult human. The number of subjects is given in parentheses. The data are stereological counts by the authors on brains in the Yakovlev Collection at the National Museum of Health and Science and the Semendeferi Collection at the University of California, San Diego.

Insula

- Frontal insula: generation social emotions such as empathy, trust, guilt, embarrassment, love—even a sense of humor.

- Activation: when a mother hears a crying baby, or when someone scrutinizes a face to determine the other person's intentions.

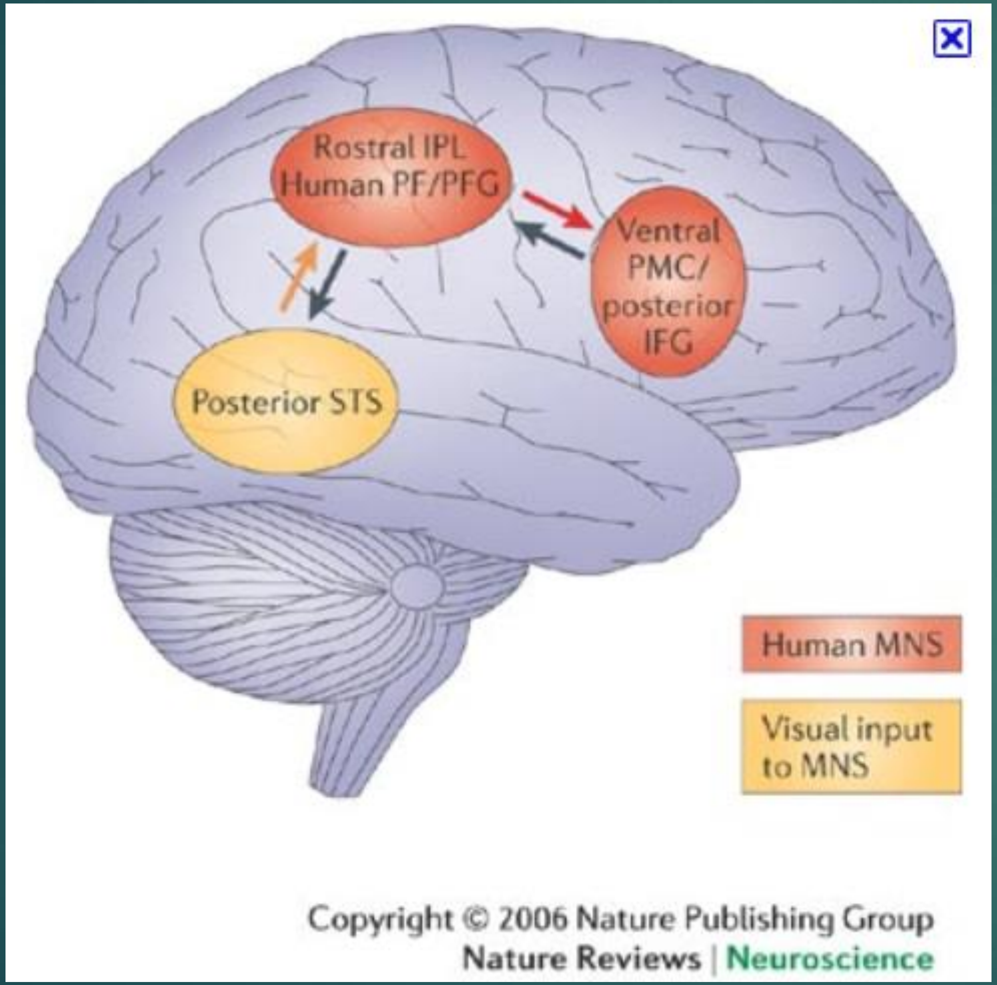
- **Gut feelings**: from bodily sensations

- Monitoring interactions within a social network

- Empathy for pain of others

- Affective component of physical pain

Mirror Neurons: How we read others



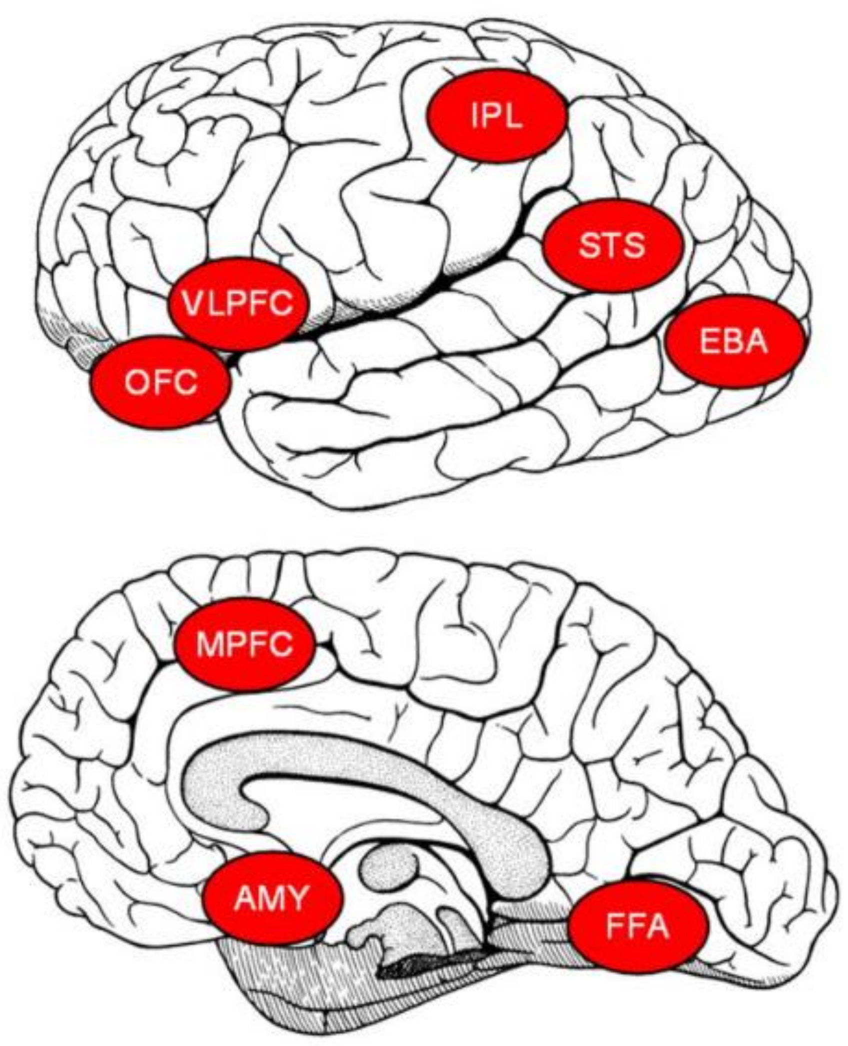
STS: superior temporal sulcus

<u>Monkey who saw researcher lift a banana</u>

<u>Gandhi neurons: dissolve the barrier between you and me</u>

<u>Activation in response to seeing other doing something</u>

Social Cognition: Brain nodes in social brain



Some of the brain regions involved in various aspects of social cognition and social perception.
VLPFC = ventral lateral prefrontal cortex,
IPL = inferior parietal lobule,
STS = superior temporal sulcus,
OFC = orbital frontal cortex,
MPFC = medial prefrontal cortex,
EBA = extrastriate body area,
AMY = amygdala,
FFA = fusiform face area.

K. Pelphrey & E. Carter, 2008

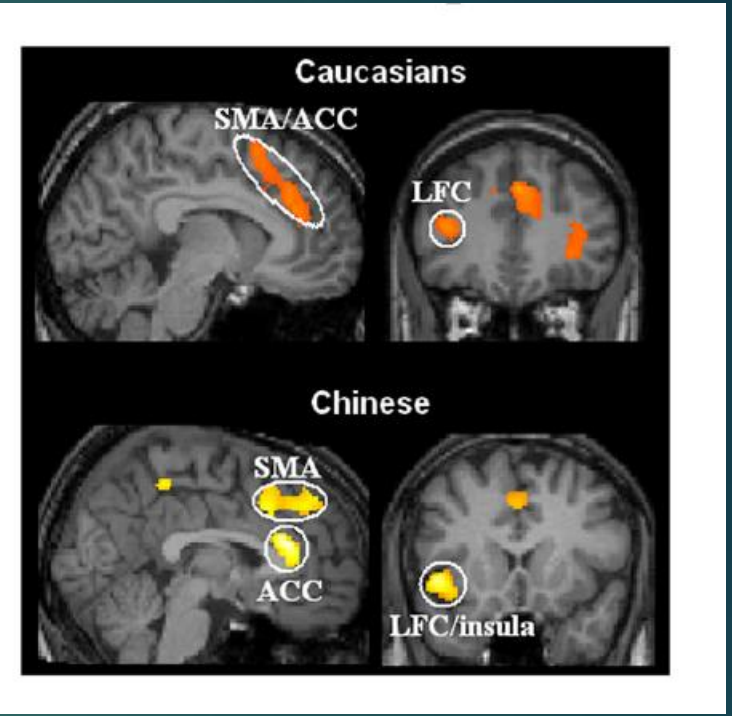
Evidence for Mirror Neuron system for emotions: Disgust

- Insula triggered both for
  - experiencing disgust feelings
  - recognition of disgust in others
- Insula activates
  - if smell rotten odors
  - watch a movie of rotten food (visceral sense of nausea)
  - watch a film of facial disgust in others

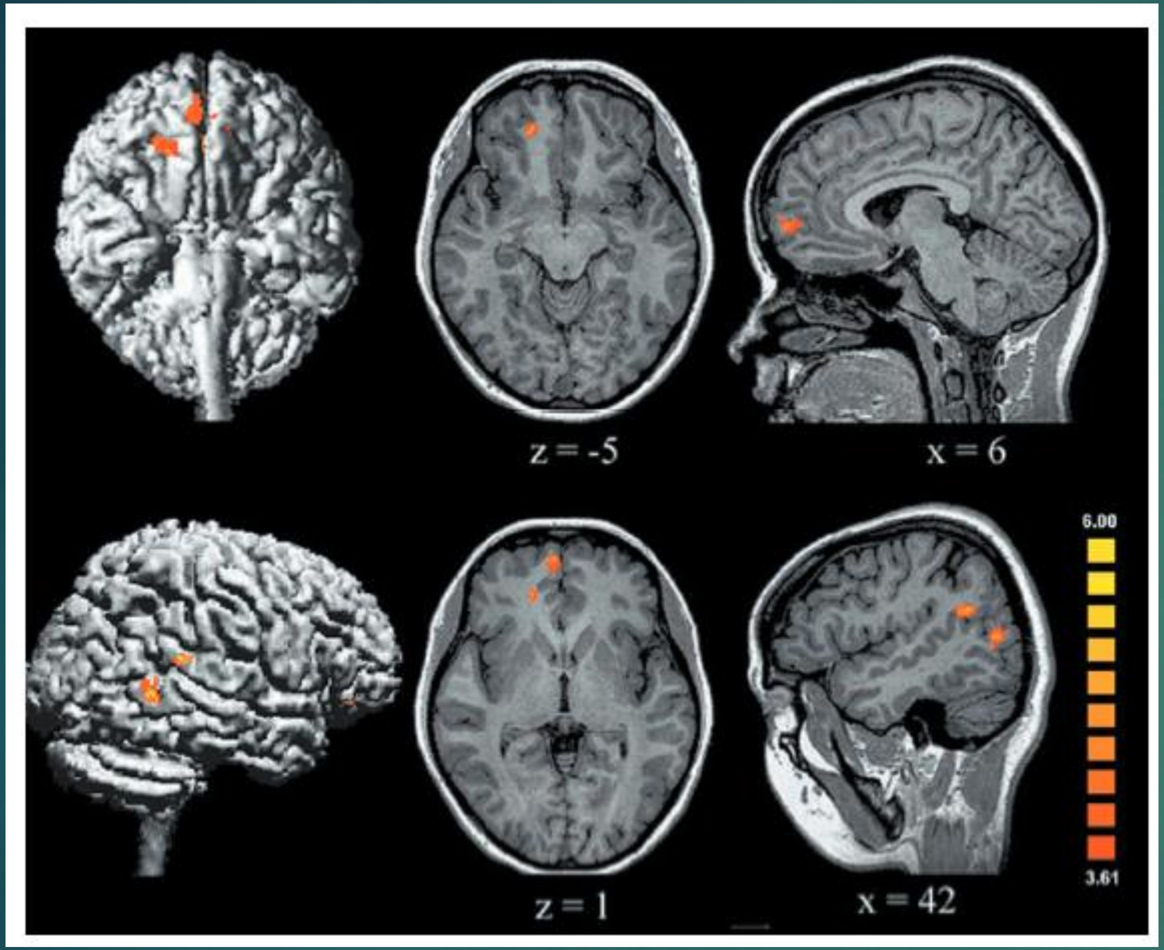
- Insula stroke: inability to see disgust

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

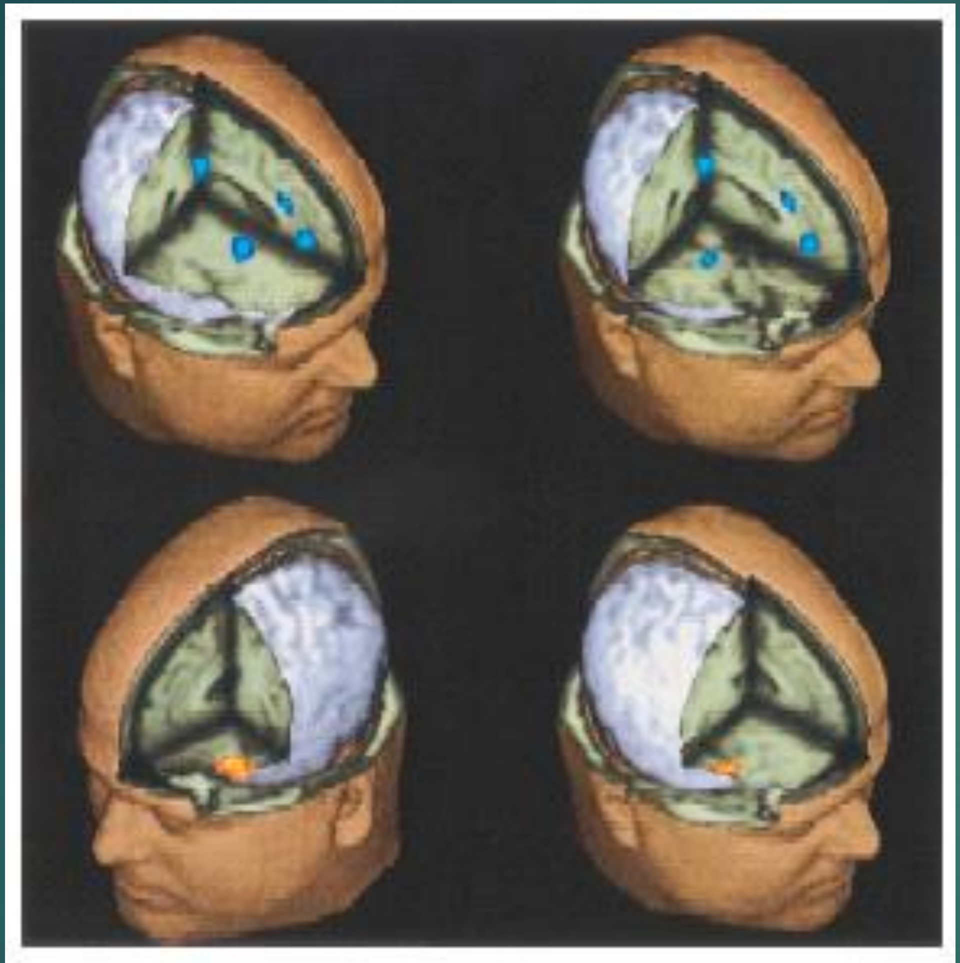


Areas shown are <u>those activated by moral versus non-moral unpleasant visual stimuli.</u> Differential activation was also seen in moral vs. neutral conditions.

(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



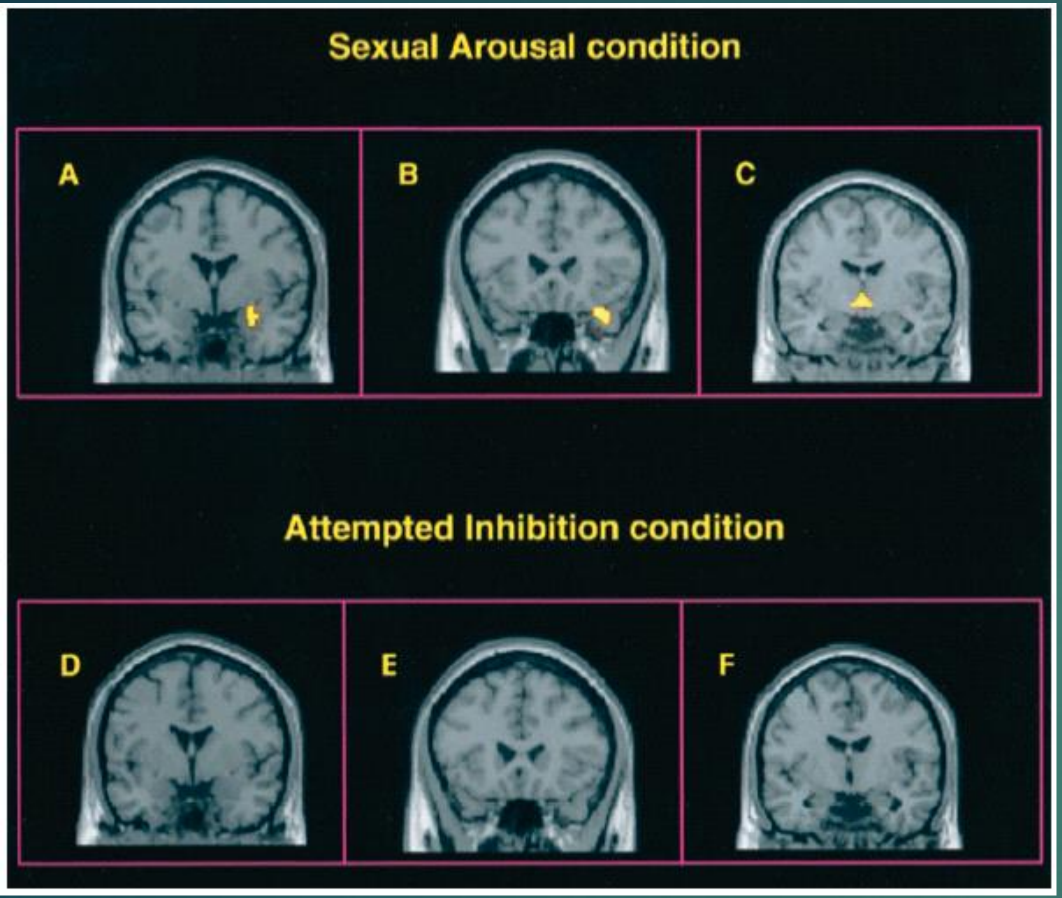
Criminal psychopaths show different patterns of emotional-related activity compared to non-criminal control subjects (Kiehl, Biol Psychiatry 2001)

Areas of less activation

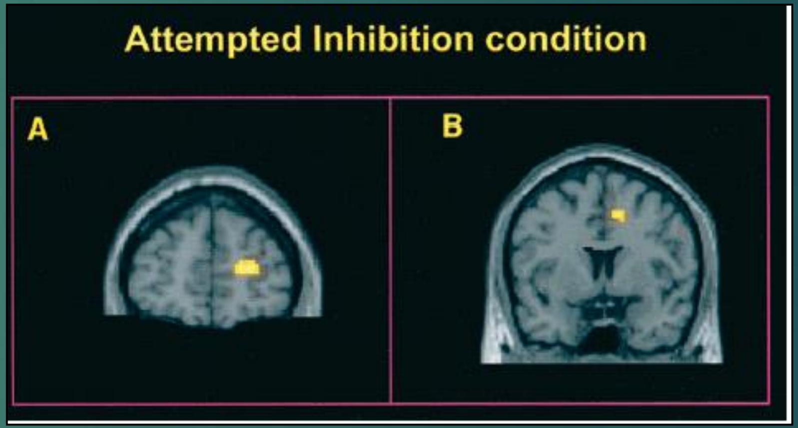
Areas of more activation

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



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.

Beauregard et al, J Neurosci 2001

<u>If scanning shows a *lack* of inhibitory ability, are you likely to commit a sexual crime</u>? If one's brain cannot inhibit arousal<u>, is one responsible for impulsive actions? Should one be required to register with authorities or accept treatment?</u>

Subliminal testing of sexual urges: fraud-proof brain scan test of deviant sexual interests

- When we look at images that we find sexually attractive, our brains show distinct patterns of activation. Method prevents the suspect from knowing what images they were looking at, by using subliminal stimuli that can't be seen at a conscious level.
- Researchers made some of the images subliminal – that is, not visible at a conscious level. To do this, they presented the target images twice extremely briefly – just 16.7 milliseconds at a time – and they used one of two types of "mask". A mask in this context is a second, distracting image shown immediately after the first instance of the target image and designed to interfere with the processing of that target image
- Ethics? Does brain sexual interest = behavioral acting out?

Neuroscience, Behavioral Genetics And Criminal Law

Before analyzing cases….
Some legal basics for non-lawyers

- The techniques
- Criteria for the admissibility of scientific evidence in court
- Insanity defense

The scientific evidence – admissibility

Common Law Systems (UK, US, Australia)

Plaintiff

Defendant

The Judge decides the admissibility of scientific evidence in trial

If evidence admitted:

Expert witness (plaintiff)

Expert witness (defendant)

CROSS EXAMINATION

The Jury renders a verdict (*black box*)

The scientific evidence in civil-law systems

JUDGE

Court-appointed
expert

DEFENDANT
(+ defense Expert)

PLAINTIFF or
PUBIC
PROSECUTOR
(+ Expert)

Written reports

Admissibility of scientific evidence TESTs (common law systems)

a. Frye "general acceptance" rule: Scientific evidence is admissible when the scientific technique, data or method has "gained generally acceptance" by the relevant community.
Frye v. United States, 293 F. 1013, 1014 (D.C. Cir. 1923).

b. Daubert "validity" rule

Trial judges possess "gate-keeping responsibility" in determining validity of scientific evidence and all expert testimony. Factors in assessing validity:

> "Whether the technique can be (and has been) tested;" is it falsifiable?
>
> "Whether the theory or technique has been subjected to peer review and publication."
>
> "In the case of a particular scientific technique, the court ordinarily should consider the known potential rate of error."
>
> "The existence and maintenance of standards controlling the technique's operation"
>
> "'General acceptance' can yet have a bearing on the inquiry."

Daubert v. Merrel Dow Pharms., Inc., 509 U.S. 579 (1993).

Daubert: 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 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.

Imagine…

- Imagine a legal system where, if you are a testifying witness, you must have an fMRI scan of your brain to determine if you are lying or telling the truth.
- Imagine taking a drug that can ease your painful memories, preventing the formation of post-traumatic stress.
- Imagine your employer's routine genetic screening of your traits such, as intelligence, greed, and even criminal behavior.

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.
- We have no theory that even remotely explains our sense of self.
- Recent developments in neuroscience suggest our mental states are fully determined by brain activity, i.e. there is no free will.
- Implications for the Law (and life) are enormous.

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

Uses of Neuroscience in Trials

Brain scans could also be used in legal trials to assess mental *abilities* affecting:

1. Responsibility of adolescents and defendants with brain damage, addiction, mental illness, psychopathy, ...
2. Competence to stand trial or to make life decisions

Uses of Neuroscience in Trials

Neuroscience could be used in legal trials to predict future behavior relevant to:

- Sentencing
- Parole
- Involuntary commitment or detention

Uses of Neuroscience in Trials

Neuroscience could be used in legal trials to enhance memory, attention, and other cognitive abilities in:

Witnesses

Jurors

How neuroscience may affect the legal systems ?

Prediction
.. of future criminal behavior

Assessment & treatment of mental illness:
✓Criminal responsibility
- *mens rea* (assessing guilt)
- sentencing purposes

Mind reading:
✓Deception
✓Pain
✓Bias

Vegetative States:
End of Life Decisions

Neuroscience and free will?

The concept of free will is an illusion and the fallacy of a basic premise of the judicial system will become more apparent – Choices reflect a summation of their genetic and environmental history (Cashmore, 2009)

NEW ATTENTION FOR THE ISSUE

a) Research groups

MacArthur Foundation Law & Neuroscience project - USA – http://www.lawneuro.org/

EANL European Association for Neuroscience and Law (*website under construction…*)

b) Legal and philosophical literature

New journals: Neuroethics

Blog: Law and Neuroscience Blog http://lawneuro.org/blog/

Neuroethics and the Law Blog (Adam Kolber, Brooklyn Law School) http://www.adamkolber.com/

Working papers: e.g. *Brain Imaging for legal thinkers: a guide for the perplexed,* Owen D. Jones, Joshua W. Buckholtz, Jeffrey D. Schall, Rene Marois

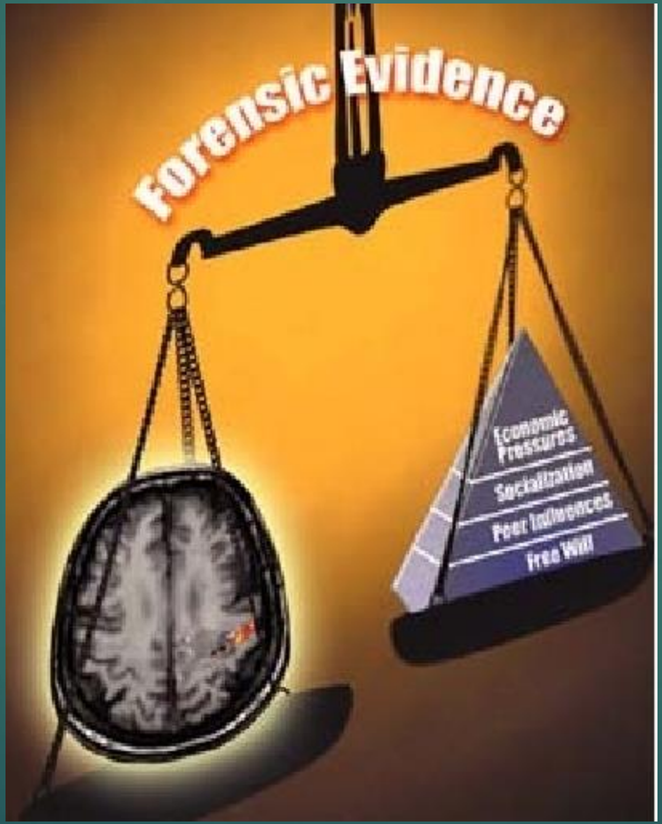
c) Courses for jurists

CSM (Italy)

Brooklyn Law School's Science for Judges

Penn Neuroscience Boot Camp

Brain as Forensic Evidence



What is Neurolaw

- Neurolaw is the area of medical jurisprudence concerned with the medical and legal aspects of the relationship of brain to crime.
- As we learn more about criminals' brains, will we have to redefine our most basic ideas of justice?
- Currently legal responsibility for behavior is a legal conclusion, not a scientific finding.

Neuroscience Areas to Cover

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

Two Major Neurolaws

- Neurolaw of responsibility: how neuroscience will and should affect laws related to responsible action. It was traditionally addressed by punishment theory.

- Neurolaw of technology: concerns the ways the law will and should respond to new brain-related technologies.

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. See 1993 movie *The Advocate*
- In *The Criminal Prosecution and Capital Punishment of Animals*, by E.P. Evans, described more than two hundred such trials from 824 to 1906, spanning Europe and many other parts of the world, including the United States.
- Such a moral concept is now incomprehensible.

A legal prototype of change: Tourette's

- **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 disease and we do not punish, arrest, or convict Tourette's patients for this behavior.

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"

- 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

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

Dark Past

- 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 thirty five to forty thousand Americans, and uncounted others, were lobotomized.

- Walter Freeman lobotomizing Southern women who were not obedient to husbands

Through a Scanner Darkly

- Should we trust Functional Neuroimaging as evidence of a criminal defendant’s past mental states?

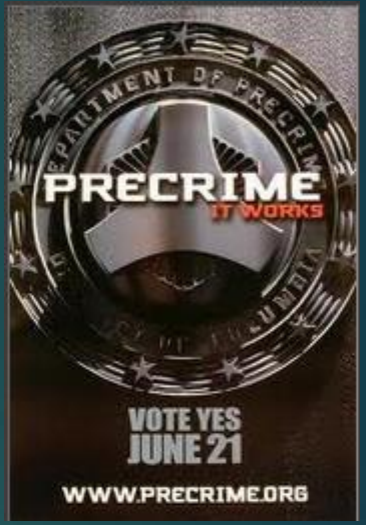
- Or is FMRI data the new phrenology?

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," 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.' "

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

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.

Legal Use of Neuroimaging

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

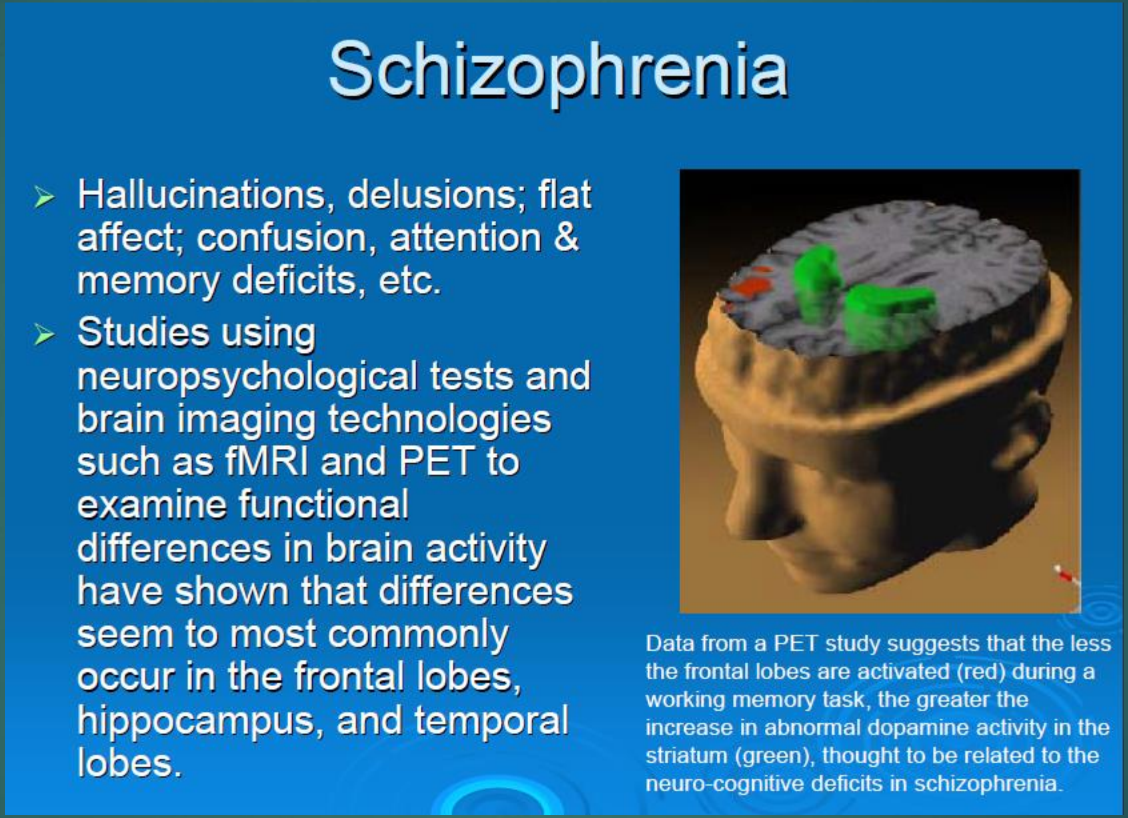
- Courts have been far more guarded about admitting scans such as PET or fMRI when offered as the basis for inferences about broader issues such as competence, insanity, or criminal responsibility in general.

- 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.

Current Legal Mitigation

- Determining extent of responsibility for a crime currently depends on whether crime was:
  - Committed accidentally
  - Committed independently of individual's will when under duress
  - Committed in situations of unavoidable necessity – self-defense or protection of family
  - Committed in conditions of extreme passion or anger when conscious will is obliterated (no planning involved)
  - Committed by individual who are mentally ill with severe delusional thoughts and beliefs

Except in Texas, Mitigation for Schizophrenia Psychosis



Loefler, who shot Gabby Giffords, held incapable of helping in own defense due to schizophrenic psychosis

Case of Kelsey Patterson

- Severely delusional schizophrenic who killed 2 people after previously having been determined to be incompetent in another case.
- So delusional he could not help in his trial; convicted of murder
- Executed in 2004 in Texas

Brain abnormalities not associated with “insanity”

What is dividing line between “normal” and “abnormal” brains?

Daniel Martell, PhD
Forensic Neuroscience Consultants, Inc.

- 15 year "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.

Case of Bobby Joe Long: Predisposed to crime?

- Serial killer (at least nine rape & murders)
- Known as the "classified-ad rapist," because he would respond to classified ads placed by women offering to sell household items, then rape and kill them, Long was sentenced to death after he committed at least nine murders in Tampa.
- Ruben Gur (Prof. of Psychology) called as national expert in PET.
- He testified that a motorcycle accident had left Long in a coma & had severely damaged his amygdala. He committed his first rape not long after coming out of his coma.
- Was Long criminally responsible?
- Has one five-year sentence, four 99-year sentences, 28 life sentences, and one death sentence.

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?

Death Row prisoners are all abnormal

- Research has shown that <u>nearly all Death Row inmates suffer from brain damage due to illness or trauma, while a vast number have also experienced histories of severe physical and/or sexual abuse.</u>

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

Stress Decreases Frontal Lobe volume: less ability to put the brakes on

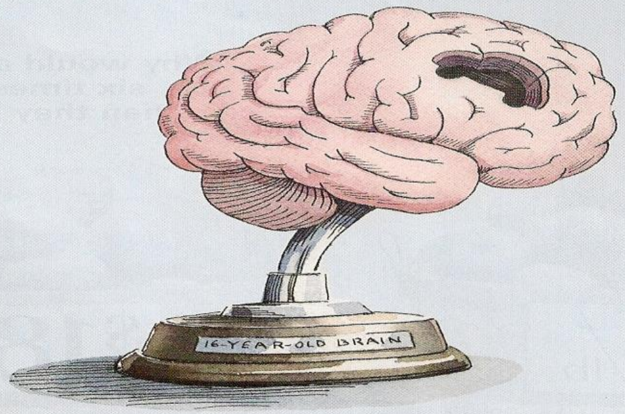
- <u>Childhood poverty and abuse:</u>
- <u>Changes following severe stress:</u>
  - <u>dendritic retraction and debranching,</u>
  - <u>reduced volume in vmPFC and mPFC and ACC.</u>

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

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.

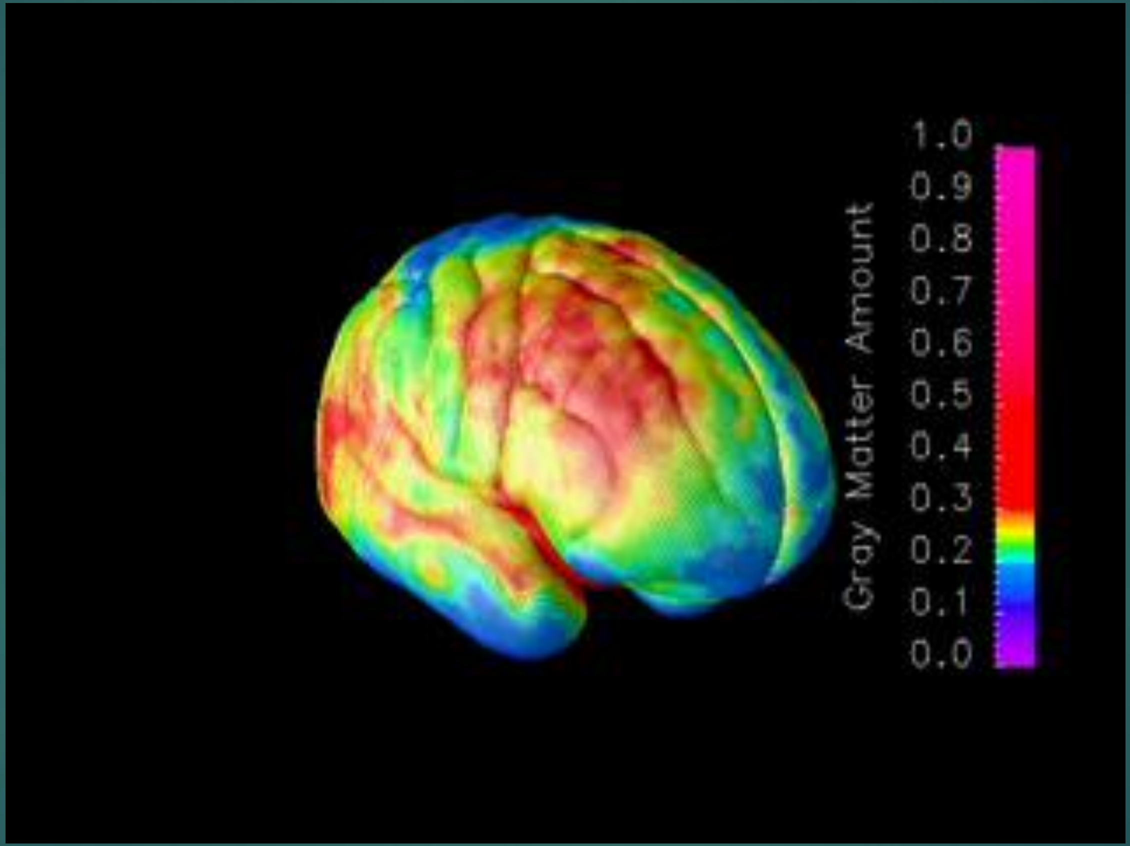
Allstate. You're in good hands. | *Auto Home Life Retirement*

Addiction & Adolescence are legal mitigations

- U.S. District Court Judge Mark W. Bennett recently issued an opinion (*U.S. v. Hendrickson*) 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.

Teen Brain: age 5 to 21



Lose 50% of all synaptic connections.

The Great Pruning: A leaner brain is better

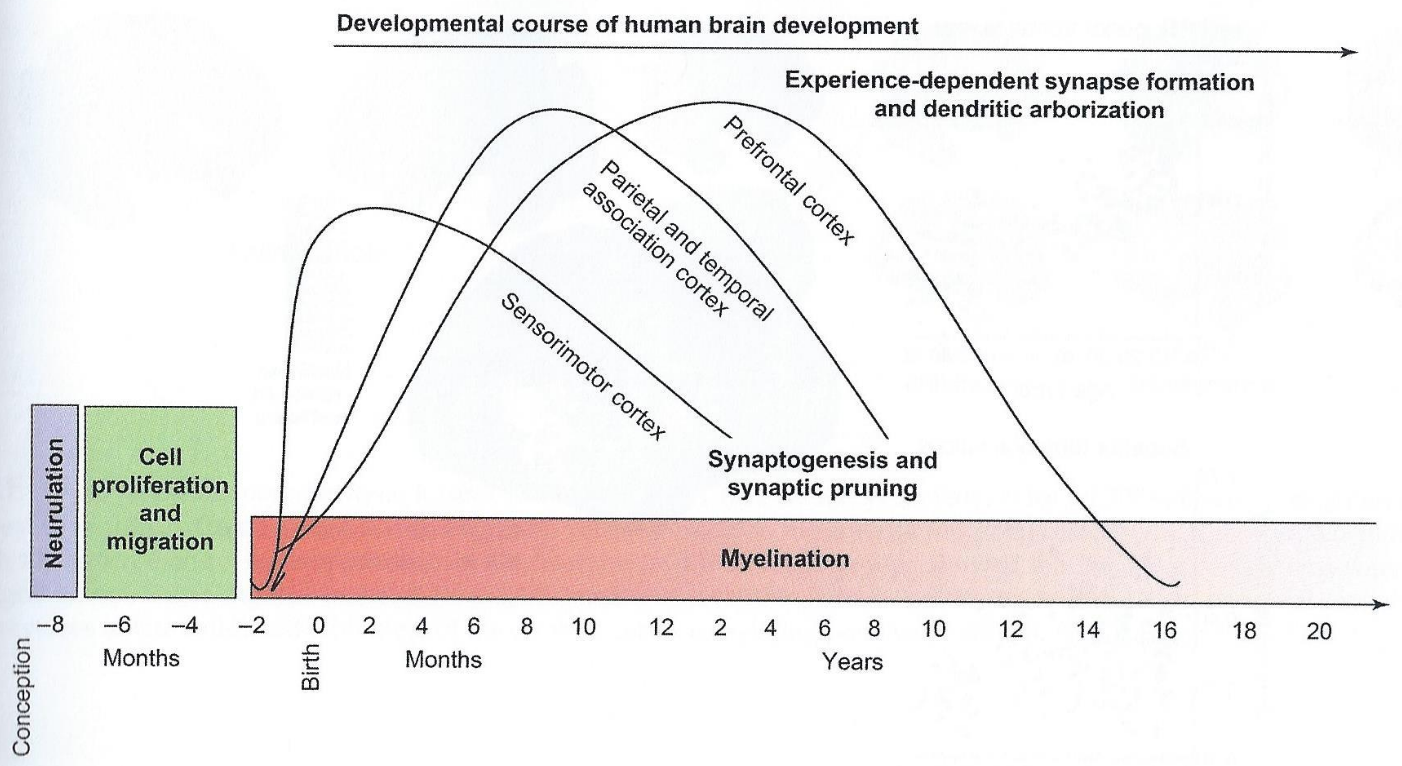


FIGURE 15.15 Developmental course of human brain development. The human brain undergoes dramatic changes in both its structural architecture and functional organization that reflect a dynamic interplay of simultaneously occurring progressive and regressive events. Although the total brain size is about 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

- Intellectual/cognitive maturity at 16.

- Pre-frontal cortex completed in girls around 22 and males at 25 or 26, if *normal*.

- Psychosocial maturity reaches similar levels of intellectual maturity at 26 and later.

Adolescents are not neurological Adults

- Research demonstrates <u>adolescents are different from adults (duh!)</u>; 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.

- <u>Crucial decision making frontal lobes are the last to mature</u>

- <u>Do adolescents have legal right to normal neurodevelopment?</u>

Age and Crime

- “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.”

Roper v. Simmons case

- Gur argued that adolescents are not as capable of controlling their impulses as adults because the development of neurons in the prefrontal cortex isn't complete until their early 20s.
- Roper v. Simmons landmark case
- Supreme Court removed the death penalty for offenders who committed crimes when they were under the age of 18.

Roper v. Simmons, 2005: overturning the juvenile death penalty

- *Roper v. Simmons, 2005* – death penalty for juveniles under 18 violates cruel and unusual punishment prohibition of 8th Amendment.

- *"When a juvenile offender commits a heinous crime, the State can exact forfeiture of some of the most basic liberties, but the State cannot extinguish his life and his potential to attain a mature understanding of his own humanity…. Retribution is not proportional if the law's most severe penalty is imposed on one whose culpability or blameworthiness is diminished ….by reason of youth and immaturity."*

- It is now unconstitutional to impose death penalty for crimes committed while under the age of 18.

Graham v. Florida, 2010

- In 2010, the United States Supreme Court in the case of ***Graham v. Florida*** ruled that juveniles under 18 cannot be sentenced to life imprisonment without parole for non-homicide offenses.

- Both rulings, especially *Graham*, relied on latest neuroscience and notion that juveniles are more malleable and capable of reform than adults.

Criminal brain network

- There are four important findings in the present study.
- First, lesions temporally associated with criminal behavior occur in different brain regions but lie within a single connected brain network that is distinct from lesions not associated with criminal behavior.
- Second, lesions temporally associated with criminal behavior are functionally connected to regions activated by moral decision making, value-based decision making, and theory of mind tasks, but not with regions activated by empathy or cognitive control.
- Third, lesions temporally associated with criminal behavior show opposite connectivity to brain regions activated by competing moral choices, predicting the biases seen in these patients.
- Finally, all results are specifically to regions implicated in moral decision making. These results link lesions resulting in criminal behavior to regions whose activity is correlated with moral decision making, value-based decision making, and theory of mind in normal subjects.

R. Ryan Darby, et al., 2017

Criminal network

- study patients who develop criminal behavior following focal brain lesions, referred to as “pseudopsychopathy” or “acquired sociopathy”
- Charles Whitman, who murdered 16 people following growth of a brain tumor in his right temporal lobe
- Neurologic symptoms can come from dysfunction in remote brain regions connected to the lesion location rather than from the lesion location itself, a phenomenon referred to as diaschisis
- All lesions were functionally connected to the same network of brain regions. This criminality-associated connectivity pattern was unique compared with 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 Network

- Lesions Temporally Associated with Criminal Behavior Are Spatially Heterogeneous. Seventeen patients with a documented temporalrelationship between a brain lesion and criminal behavior were identified through a systematic literature search. Criminal behaviors included “white collar” crimes, such as fraud or theft; however, most of the patients (12 of17) had committed violent crimes, such as assault, rape, and murder.
- The 17 lesions were spatially diverse, including nine in the medial frontal or orbitofrontal structures, three in the medial temporal lobe/amygdala, three in the anterior lateral temporal lobe, one in the dorsomedial prefrontal cortex, and one involving the ventral striatum and parts of the orbitofrontal cortex. Although the most common lesion location was the vmPFC/orbitofrontal cortex, at least seven lesions were documented to not extend into this area.
- Network Localization of Lesions Temporally Associated with Criminal Behavior.
- All 17 lesions temporally associated with criminal behavior were functionally connected (i.e., positively correlated) to the inferior orbitofrontal cortex and anterior temporal lobes, and most (16 of 17) were connected to the vmPFC and nucleus accumbens. all 17 lesions were functionally connected (i.e., negatively correlated) with the intraparietal sulcus, and 15 of 17 were functionally connected with the dorsolateral prefrontal cortex.
- These results suggest that lesions in different locations temporally associated with criminal behavior are characterized by a unique pattern of brain connectivity. Thus, while these lesions are spatially diverse, they are part of a common functional network.

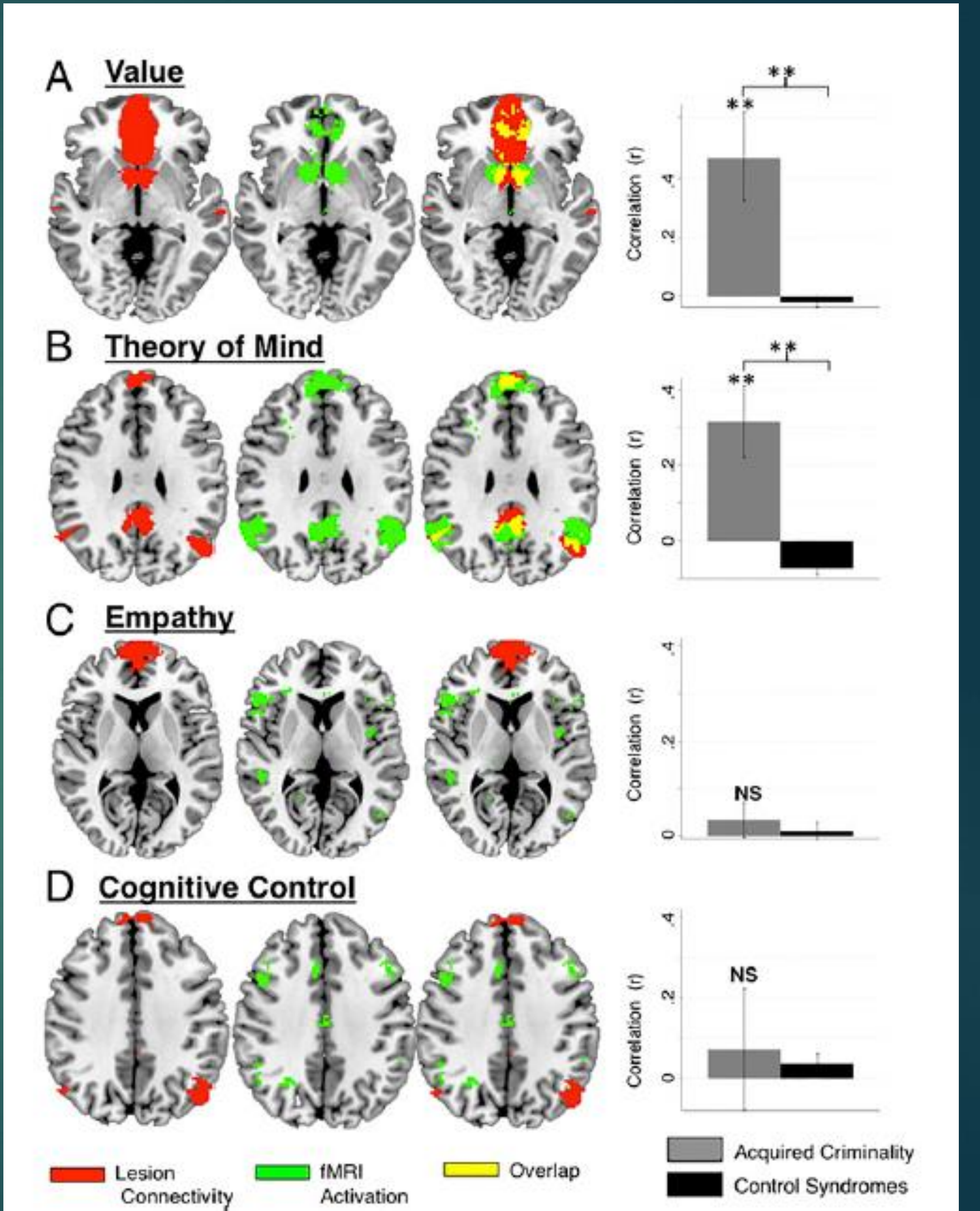
Criminal Network

- Network Localization to Moral Decision-Making Regions
- lesion locations temporally associated with criminal behavior were functionally connected to regions activated by moral tasks
- lesions temporally associated with criminal behavior are uniquely functionally connected to regions involved in moral decision making
- Lesions temporally associated with criminal behavior were functionally connected to regions involved in value-based decision making and theory of mind but not with empathy or cognitive control. Lesions were significantly more connected to value-based decision making and theory of mind regions than empathy or cognitive control regions

Criminal networks

- Network Localization to Competing Brain Networks Matches Abnormal Moral Choices
- We focused on the widely studied conflict between competing networks involved in resolving ambiguous moral dilemmas, such as the “trolley problem”. One network is associated with a strong aversion to directly harming others, while the second network is involved in overcoming this aversion to make more utilitarian decisions (e.g., harm one person to save the lives of five persons). Patient populations with increased risk of criminal behavior [e.g., those with vmPFC lesions, frontotemporal dementia, psychopathy] are more likely than normal subjects to endorse harming others to make more utilitarian decisions
- activity from our lesion locations was positively correlated with brain regions activated when deciding to avoid personal harm and negatively correlated with brain regions activated by utilitarian decisions. Patient populations with increased criminality also tend to reject unfair offers more than normal subjects during the ultimatum game
- Repeat on 23 other lesion cases: Lesion network mapping showed nearly identical results to those for our initial cohort: All 23 lesions were functionally connected to the orbitofrontal cortex, and most were connected to the anterior temporal lobe, vmPFC, mesial temporal lobe/amygdala, and nucleus accumbens.
- This second cohort showed the same pattern of connectivity to regions involved in morality, subcomponents of morality (value and theory of mind), harm aversion vs. utilitarian decisions in moral dilemmas, and fair vs. unfair offers in the ultimatum game

Quantitatively, lesion locations temporally associated
with criminal behavior are functionally connected to regions activated by:
value based decision making (A) and theory of mind tasks (B), but not with empathy (C)
or cognitive control tasks (D).



Criminal Network

- other patient populations prone to criminal behavior. For example, up to 57% of patients with frontotemporal dementia have committed a crime and exhibit pathological changes in regions overlapping those identified in the present study.
- Similarly, psychopaths display atrophy distributed across the vmPFC, orbitofrontal cortex, and anterior temporal lobes, as well as white matter and functional connectivity changes in these regions
- hypothesis that there is “competition” between opponent networks during moral decision making, which is supported by evidence that these networks are normally anticorrelated at rest. We found that lesions temporally associated with criminal behavior were connected to both sets of brain regions, but in opposite directions. Thus, lesions may bias patients toward utilitarian moral decisions (i.e., push someone off the bridge to save others) and rejection of unfair offers in the ultimatum game
- Lesions within a well-defined network increase the relative probability of criminality.

Criminal networks: beware

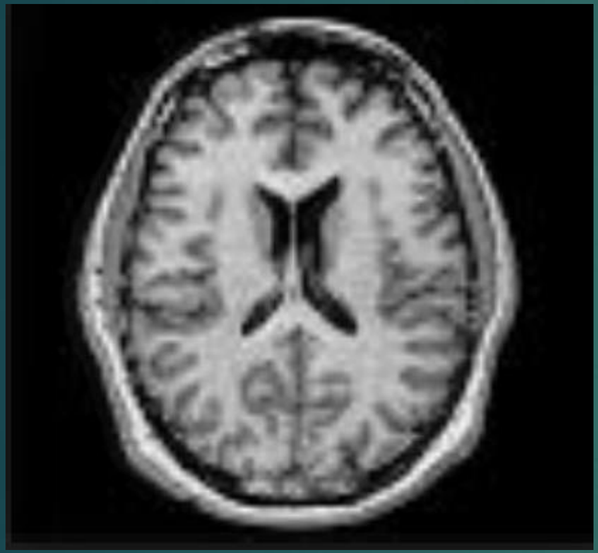
- Violence or crime occurs in only ∼9% of patients with traumatic brain injury (52, 53), 14% of patients with frontal lobe injury (54), and up to 57% of patients with frontal temporal dementia (46–48). Specifically, criminal behavior has been reported in 37–57% of patients with behavioral variant frontotemporal dementia and in 27–56% of those with semantic variant primary progressive aphasia, although these percentages include nonviolent crimes, such as shoplifting and traffic violations
- These findings suggest that many patients with lesions lying within our network will not develop criminal behavior. Thus, lesions within our identified network may increase the risk of criminal behavior, but should not be interpreted as an inevitable or sole cause of criminal behavior.

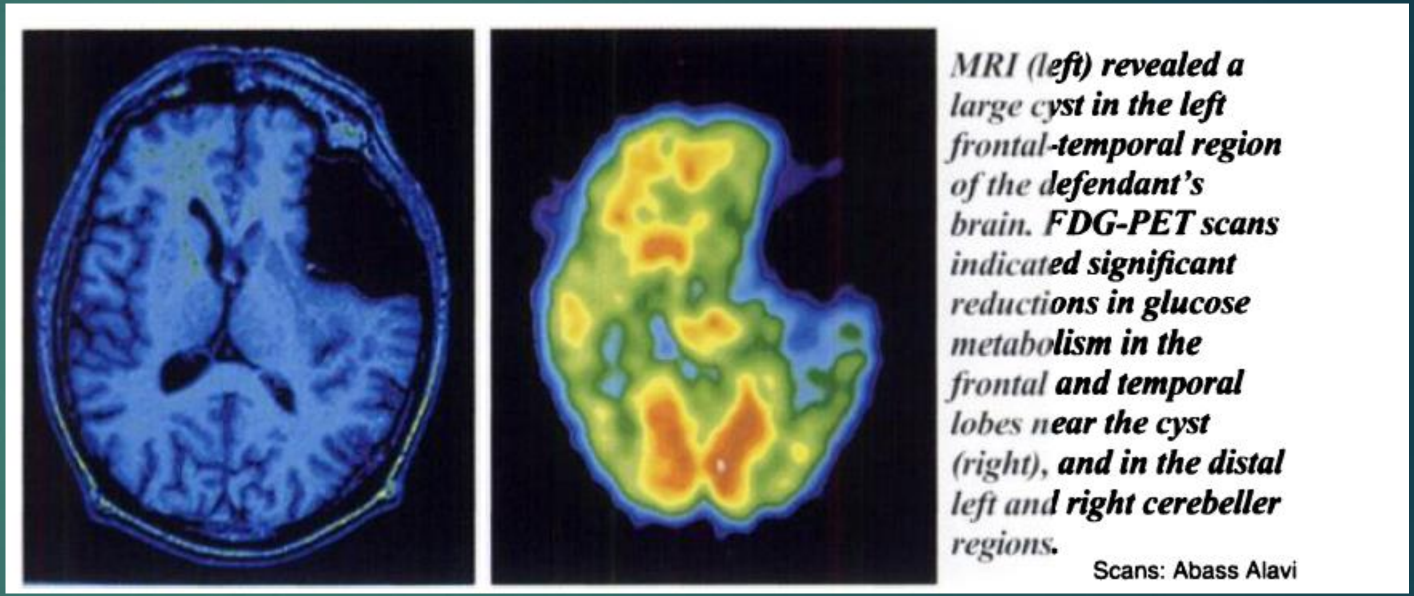
My Amygdyla Made Me Do It

- Concept of Criminal Responsibility

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

Real Case: Would you convict this person with this brain?





Left Frontal-Temporal cyst

Case of Herbert Weinstein's Cyst

- 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 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.

- 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.

- Allowing brain images to be introduced as evidence, but not allowing testimony about what they meant.

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.

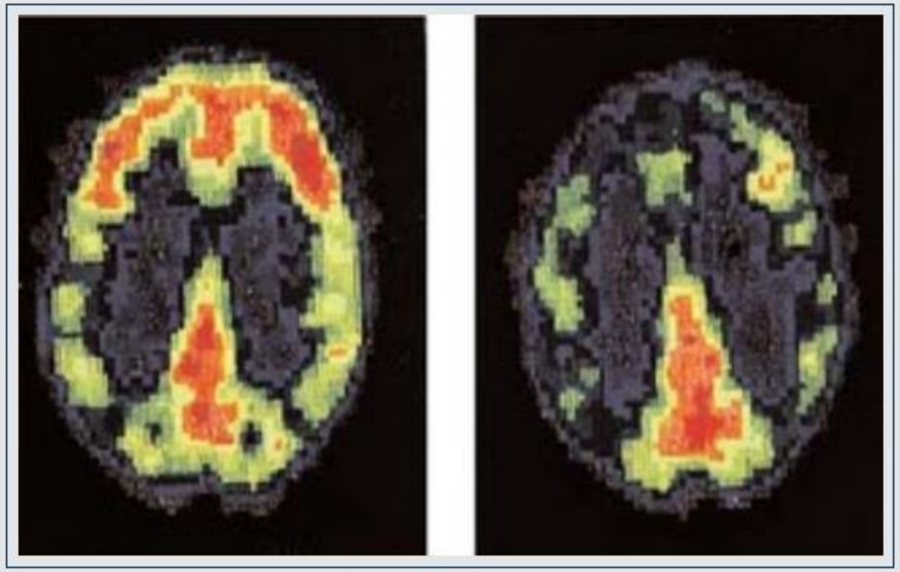
- **People of New York vs. Weinstein** (1992) – PET scan

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

- **Roper vs. Simmons** (2005) – adolescent aged 17 threw a woman off a bridge; Supreme Court ruled no death penalty for teenagers; established precedence for fMRI trial use.

- **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 the prefrontal functioning;
  - predatory killers showed relatively good prefrontal functioning but blunted amygdalas

Adrian Raine, 1997

Neuroscientific evidence

- Influence of neurolaw is clearly growing.
- Neuroscientific evidence has persuaded jurors to sentence defendants to life imprisonment rather than to death penalty
- Courts have also admitted brain-imaging evidence during criminal trials to support claims that defendants like John W. Hinckley Jr., who tried to assassinate President Reagan, are insane.

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.

New Law & NS Programs

- A. John T. and Catherine D. MacArthur Foundation <u>Law and Neuroscience Project</u>

- 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

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."

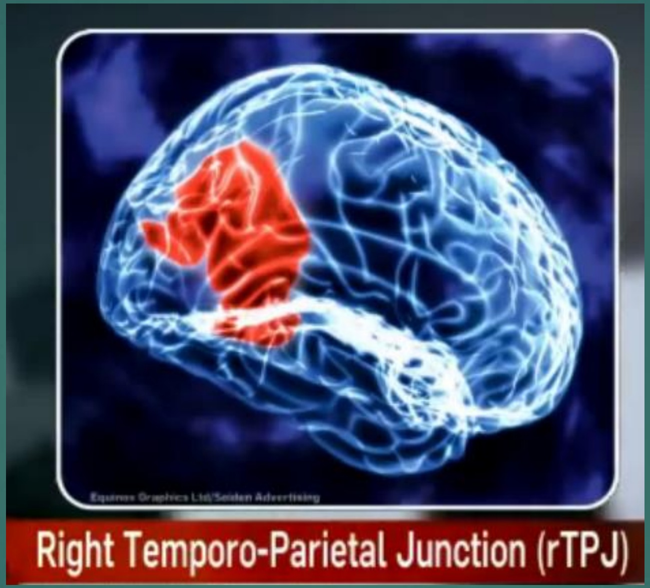
- As a jury member, do you choose guilt based on intention to harm or harm done?

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

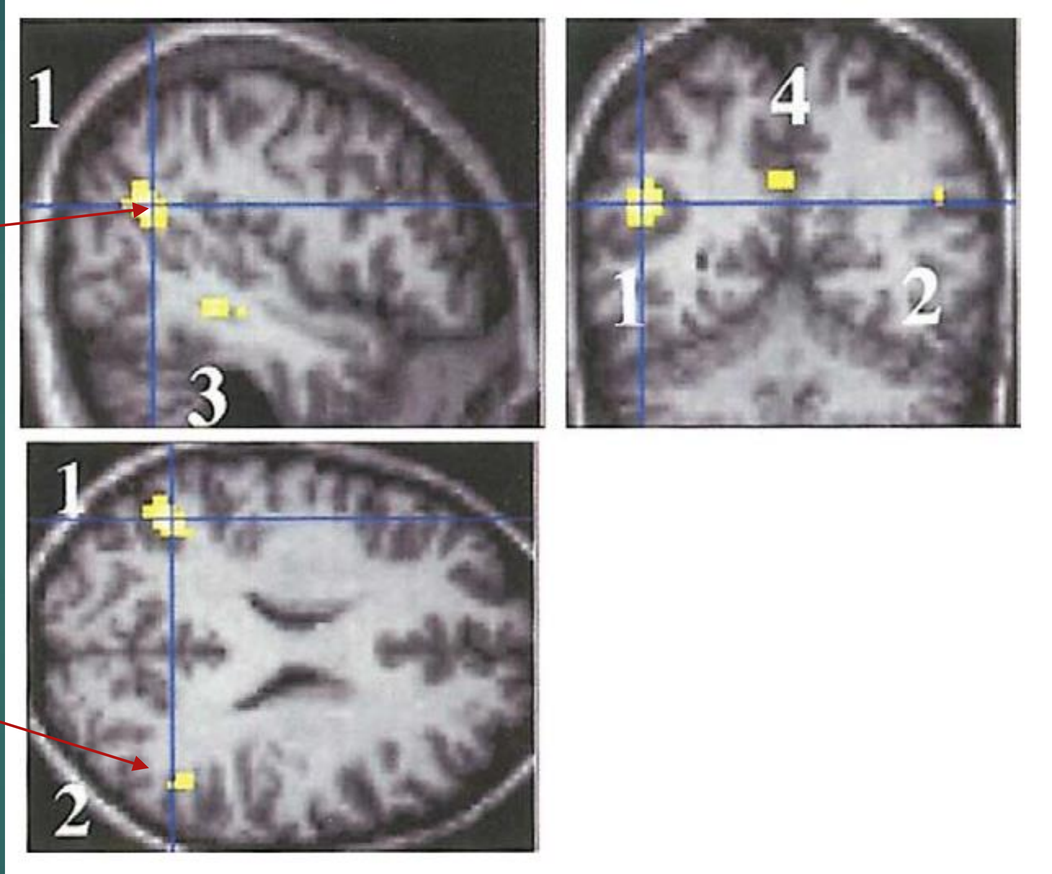
- Right Superior temporal sulcus (STS): ability to follow people's gaze and determine where another's attention is directed; movement intention from visual context
- Thoughts like "The man chased the dog": Two regions in the left superior temporal lobe, one more central, that carries information about the agent, the one doing an action; and an immediately adjacent region, located closer to the ear, carries information about the patient, or who the action was done to.
- TPJ active when people try to understand the minds of other people, as well as when people redirect their attention.

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

rTPJ: Source of Reading Thoughts, Theory of Mind, Intention

left TPJ
verbal

rTPJ
pictures



Reading stories that describe or imply a character's goals and beliefs

Theory of mind vs. mechanical inference stories. Crosshair marks the most significant voxel in the left TPJ (1). Also visible are activations in right TPJ (2), left aSTS (3), and precuneus (4). TPJ, temporo-parietal junction; aSTS, anterior superior temporal sulcus.

Saxe & Kanwisher, 2003

Right Temporal Parietal Junction (vPC):
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. (<u>Bad intention</u>; should be blamed, <u>based on outcome</u>)
- 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. (<u>Accident</u>: Caused harm but <u>Good intention</u>; can forgive)
- Question: In which condition is Susan to blame?
- <u>People say Susan deserves blame in scenario 1. We interpret Susan morally by her intention. Adult capacity to do this by age 12 (kids with older sybs do better)</u>
- <u>Disrupt rTMJ: make decision on basis of outcome, not intention</u>

Rebecca Saxe

How we blame

- Across all cultures:
- 1 Intentional harm is most blameworthy
- 2 Bad intentions with no harm is next
- 3 No bad intention with harm is next
- 4 No bad intention with no harm is not blameworthy
- 1 = murder; 2 = attempted murder; 3 = civil negligence; 4 = no blame

Temporal Parietal Junction: Intention detector

Used TMs to disrupt RTPJ function

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

Higher 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

- Brain circuits devoted to assess intentionality and harm, & to calculation of blame based on these two, using intent as main driver and harm only as tiebreaker.
- rTPJ performs a central role in integrating intent with harm.
- Normals: blame intentional killing most, attempted killing next, accidental killing least
- rTPJ impaired: blame based on harm, using intention to break the ties: intentional killing most, accidental killing next, attempted killing least
- rTPJ is necessary to integrate intent and harm, but not necessary for evaluation of either; impaired can still assess harm accurately & blame based on harm. Can assess intent accurately.
- Brain has 3 circuits: assess intention, assess harm, and 1 to integrate these 2 into level of blame
- Young children blame based primarily on harm, with intention as tiebreaker.

Blaming tree in brain: We blame first on intention, & use harm as tiebreaker

- Was harm significant?

If yes, then was harm intentional?

If not, then DO NOT Blame

If not, then NO OR LOW BLAME, graded to harm

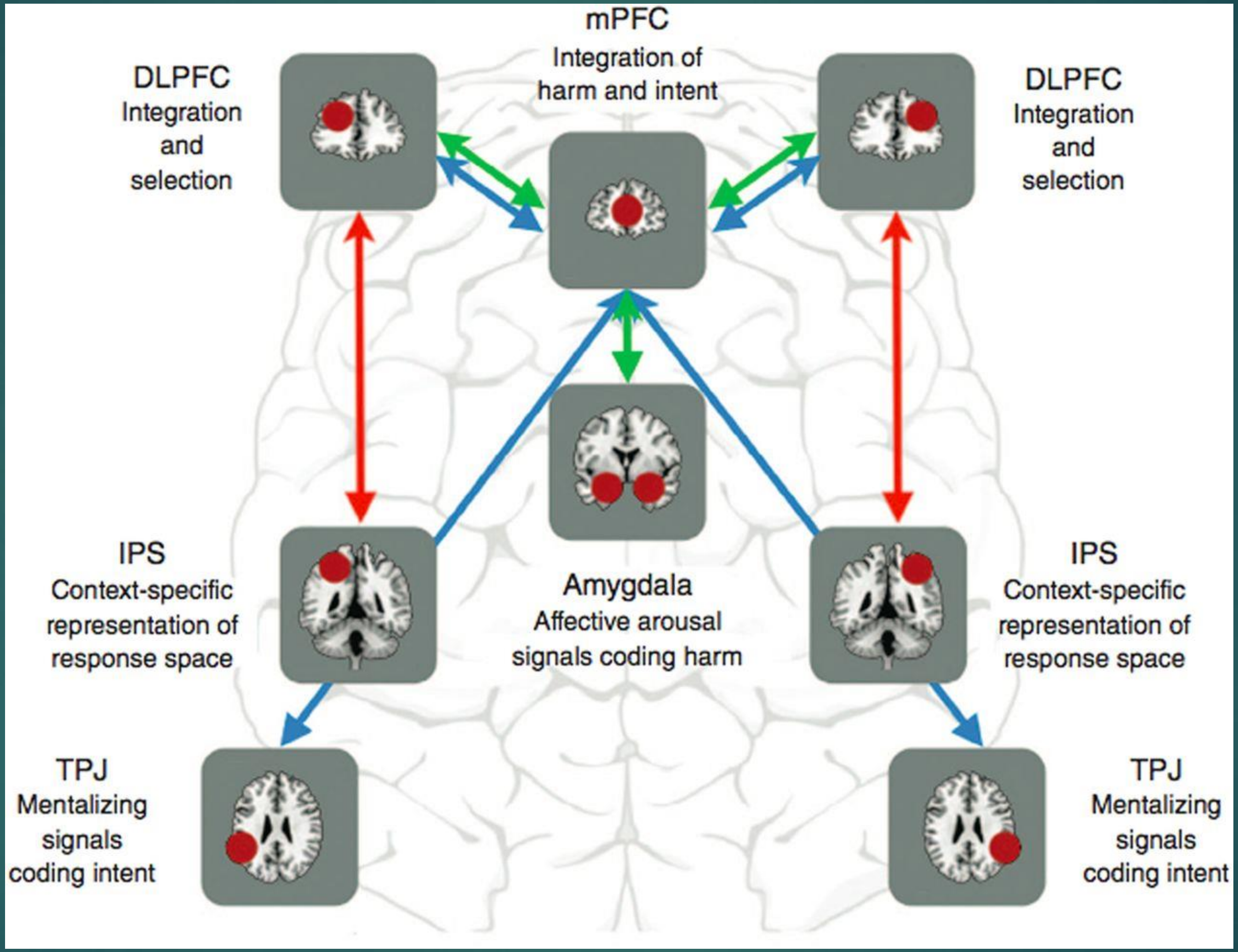
If yes, then HIGH Blame, graded to harm

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.

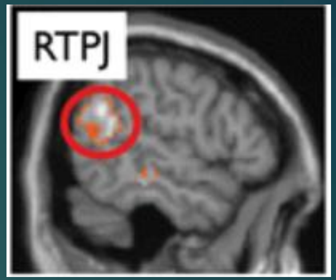
Treadway MT, et al., 2014

A neurocognitive hypothesis for third-party punishment behavior.



Owen D. Jones et al. J. Neurosci. 2013;33:17624-17630

rTPJ: Judge and jury



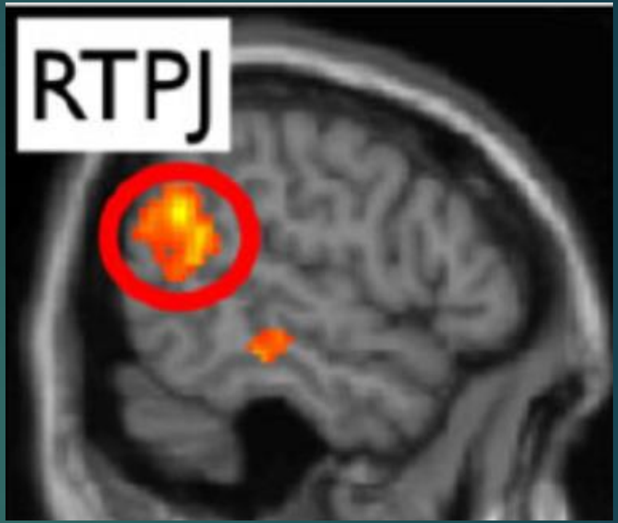
- rTPJ is critical for representing mental state information, irrespective of whether it is about oneself or others.
  - As RTPJ activates, so does the influence of your belief information on moral judgment

- 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

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

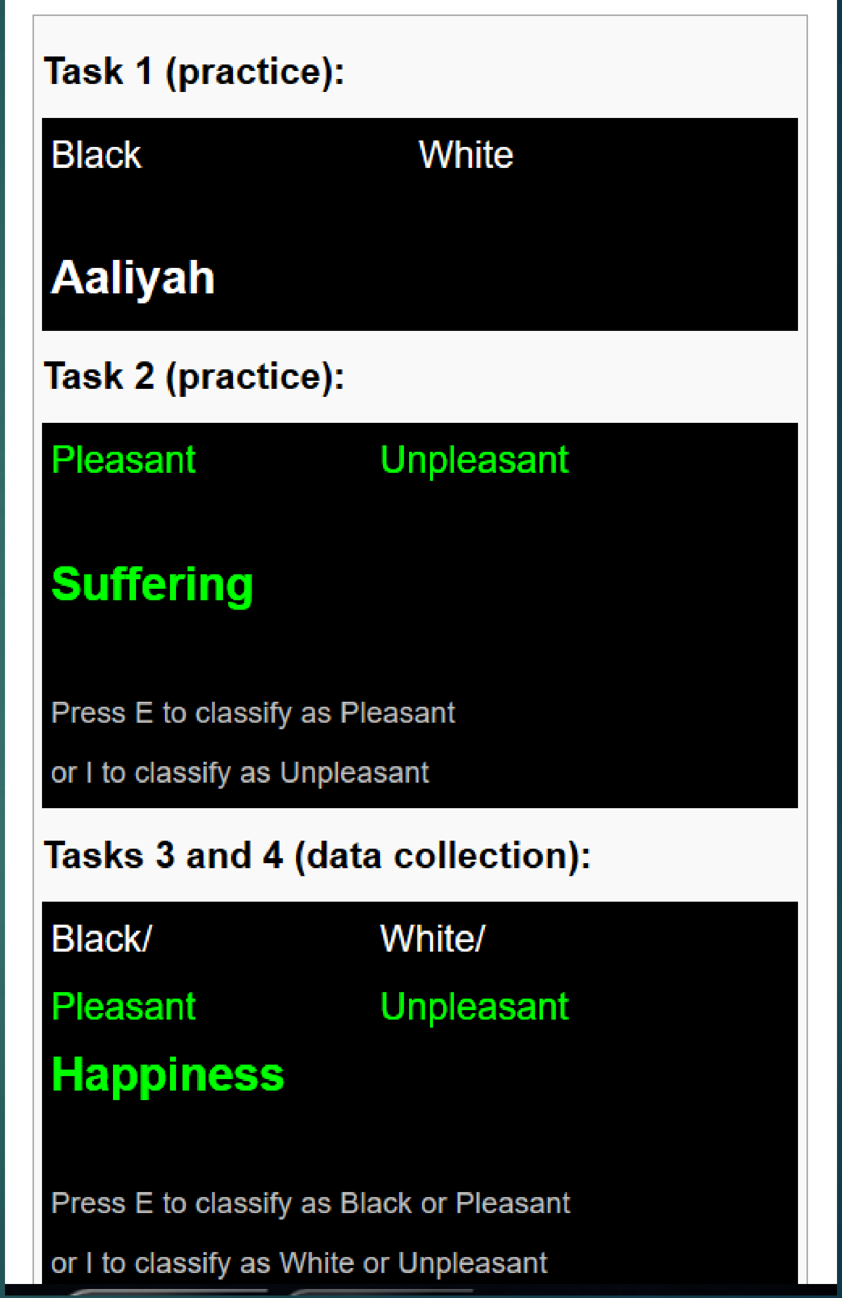
- People infer trustworthiness from faces quickly and with high consensus. Untrustworthy faces incur negative judgments. These biases persist despite information demonstrating that the targets are actually trustworthy
- Facial trustworthiness affects decisions about guilt in court. People whose appearance 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.

Faces: alarming bias in the criminal-justice system.

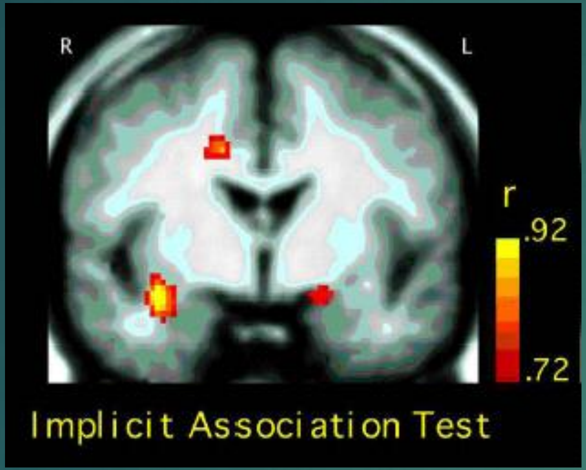
- People overgeneralize trustworthiness in criminal-sentencing decisions when trustworthiness should not be judicially relevant, and they did so even for the most extreme sentencing decision: condemning someone to death.
- Using a comprehensive sample of 371 death-row inmates and matched targets sentenced to life imprisonment, we found that people who look less trustworthy were more often sentenced to death for first-degree murder. Perceptions of untrustworthiness predicted death sentences (vs. life sentences) for convicted murderers in Florida (*N* = 742).
- Link between trustworthiness and the death sentence occurred even when participants viewed innocent people who had been exonerated after originally being sentenced to death.
- These results highlight the <u>power of facial appearance to prejudice perceivers and affect life outcomes even to the point of execution</u>, which suggests an alarming bias in the criminal-justice system.

Implicit Association Test

- A computer-based measure, the IAT requires that users rapidly categorize two target concepts with an attribute (e.g. the concepts "male" and "female" with the attribute "logical"), such that easier pairings (faster responses) are interpreted as more strongly associated in memory than more difficult pairings (slower responses).
- The IAT is thought to measure implicit attitudes about sex, race, stereotypes, etc.

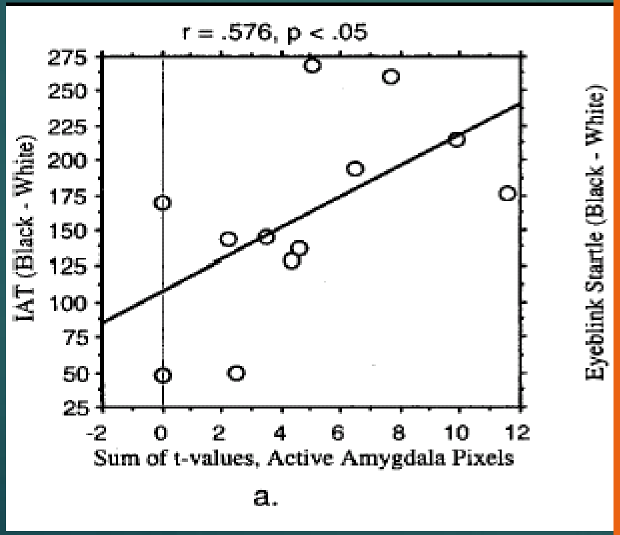


Unconscious racial biases

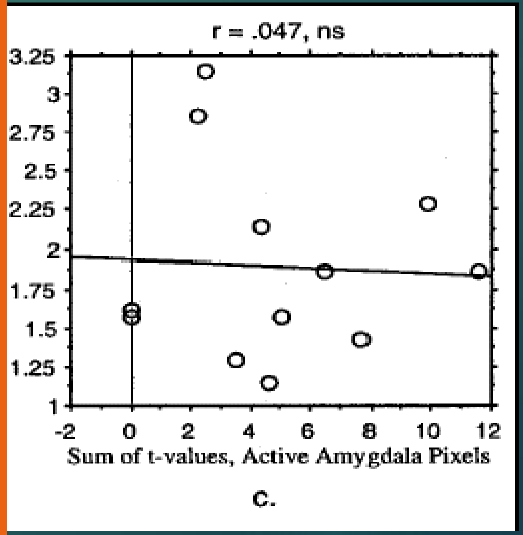


In White subjects, amygdala activation in response to Black faces correlates with unconscious measures of bias (IAT response latencies)

….but not with score on Modern Racism Scale, measuring how "racist" they perceive themselves. (Phelps et al J Cogn Neurosci 2000)



Would it be ethical to screen job applicants, judges, lawyers, teachers, doctors ... for discriminatory biases?



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

- Parahippocampus lights up if you are thinking of familiar place
- Fusiform gyrus = faces
- 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.

Other potential legal uses of Neuroimaging (NI)

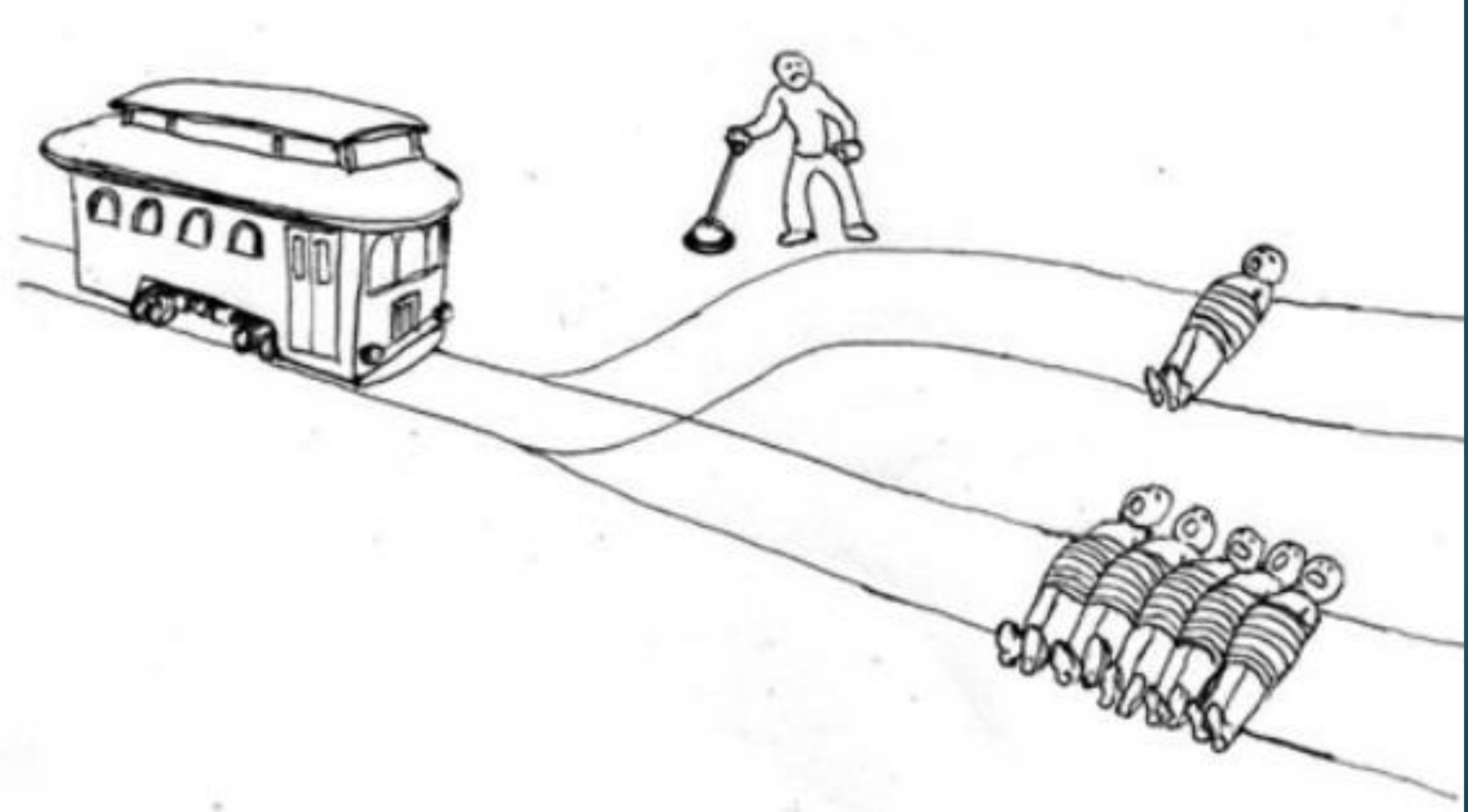
- Deception detection: Neuroimaging of lying
- Pedophilia: Researchers used brain activity to accurately classify the pedophilia status of more than 90% of subjects.
- Sexual Orientation: Researchers could determine sexual orientation with more than 85 percent accuracy
- Pain Imaging: pain is in the brain
  - Detecting those who are malingering
  - Accurately identifying those who really are feeling pain.

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

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

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

Trolley Problem 1: DL PFC active



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

Trolley Problem 2: vmPFC active

Must push person off bridge; 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 is not a single thing: intuitive emotional responses vs. cognitive responses

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.''“

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 harms. 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"

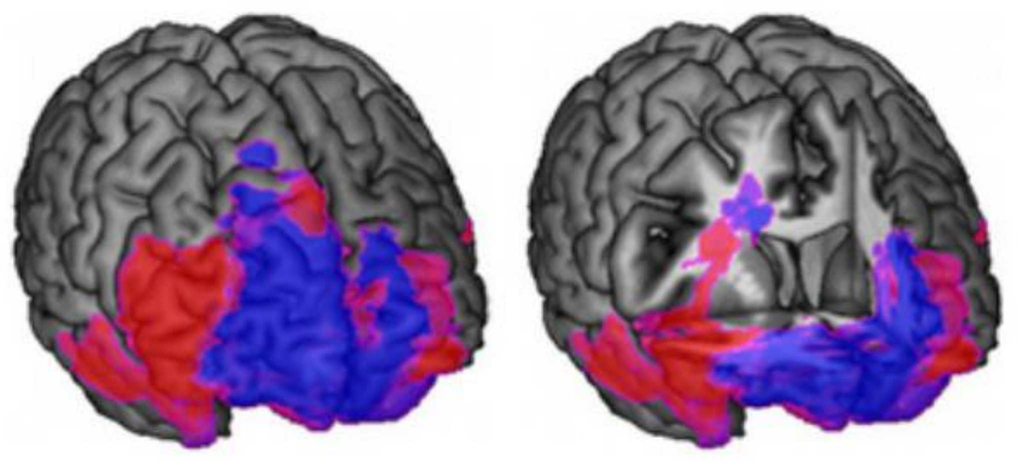
- "At that point, you're dealing with a broken machine, and concepts like punishment and evil and sin become utterly irrelevant.

- 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."

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

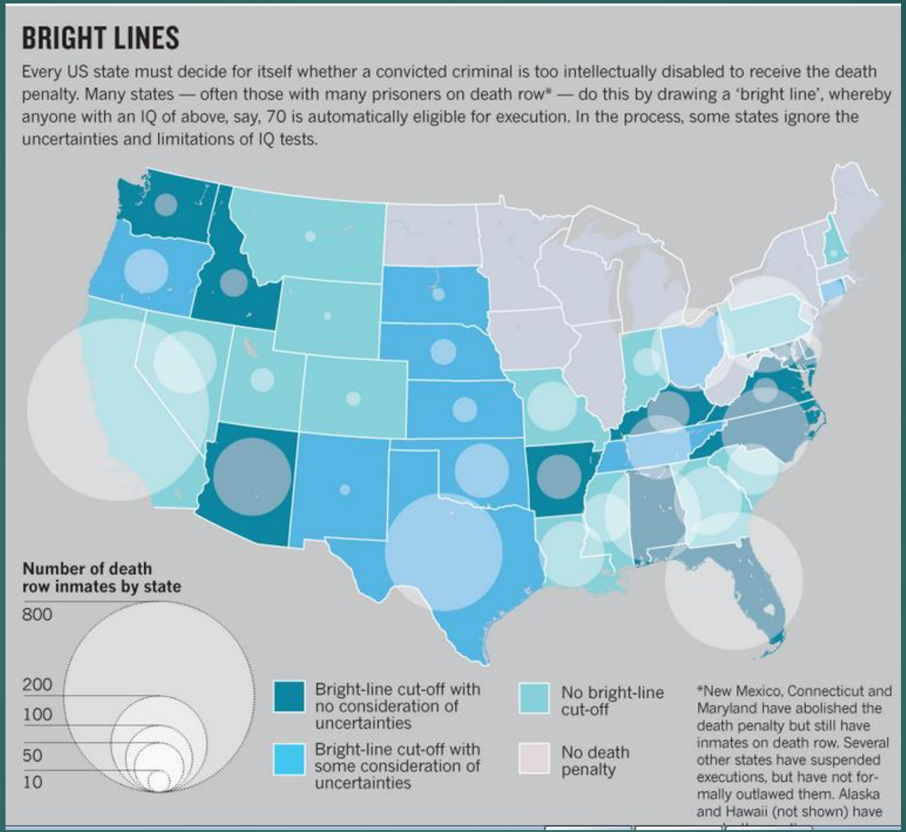
Red = Decision Making
Blue = Behavioral Control

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?

Is “IQ of 70” person competent?



Clinicians generally oppose a bright-line test, not least because IQ tests have an SEM of roughly ten points;
Flynn effect: if score 71 on an IQ test last normalized in 1972, might have scored only 65 on a more recently normed, harder IQ test

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

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: but what about gun access?)

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.

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”

Crazy?

Brain Scans Can Reveal Your Decisions 7 Seconds Before You "Decide"

"In a kind of spooky experiment, scientists at the Max Planck Institute for Human Cognitive and Brain Sciences reveal that our decisions are made seconds before we become aware of them.

In the study, participants could freely decide if they wanted to press a button with their right or left hand.

The only condition was that they had to remember when they made the decision to either use their right hand or left hand.

The Results

By monitoring the micro patterns of activity in the frontopolar cortex, the researchers could predict which hand the participant would choose 7 SECONDS before the participant was aware of the decision."

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.

4 seconds before decision

- John-Dylan Haynes of the Bernstein Center for Computational Neuroscience Berlin and his colleagues had volunteers decide whether to add or subtract two numbers while in the fMRI scanner.
- They found patterns of neural activity that were predictive of whether subjects would choose to add or subtract that occurred four seconds before those subjects were aware of making the choice—a rather long lag time.
- The brain is making the decision before the person

Haynes repeats Libet

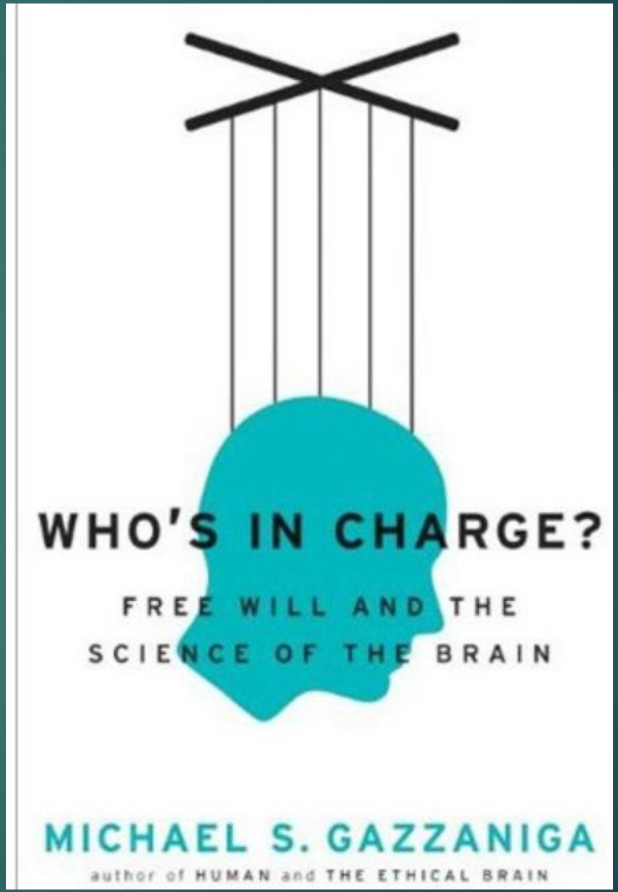
- In 2008, Dylan Haynes asked subjects to choose to press right or left button under FMRI

- Strong prefrontal and parietal signals up to 10 seconds before subject consciously decided to act.

Who's in Charge?, by Gazzaniga

- "The issue isn't whether we are 'free,'" he writes. "The issue is that there is <u>no scientific reason not to hold people accountable and responsible</u>."

- The mind constrains the brain.



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).
- Limbic system is not engaged during moral or emotional trigger

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?

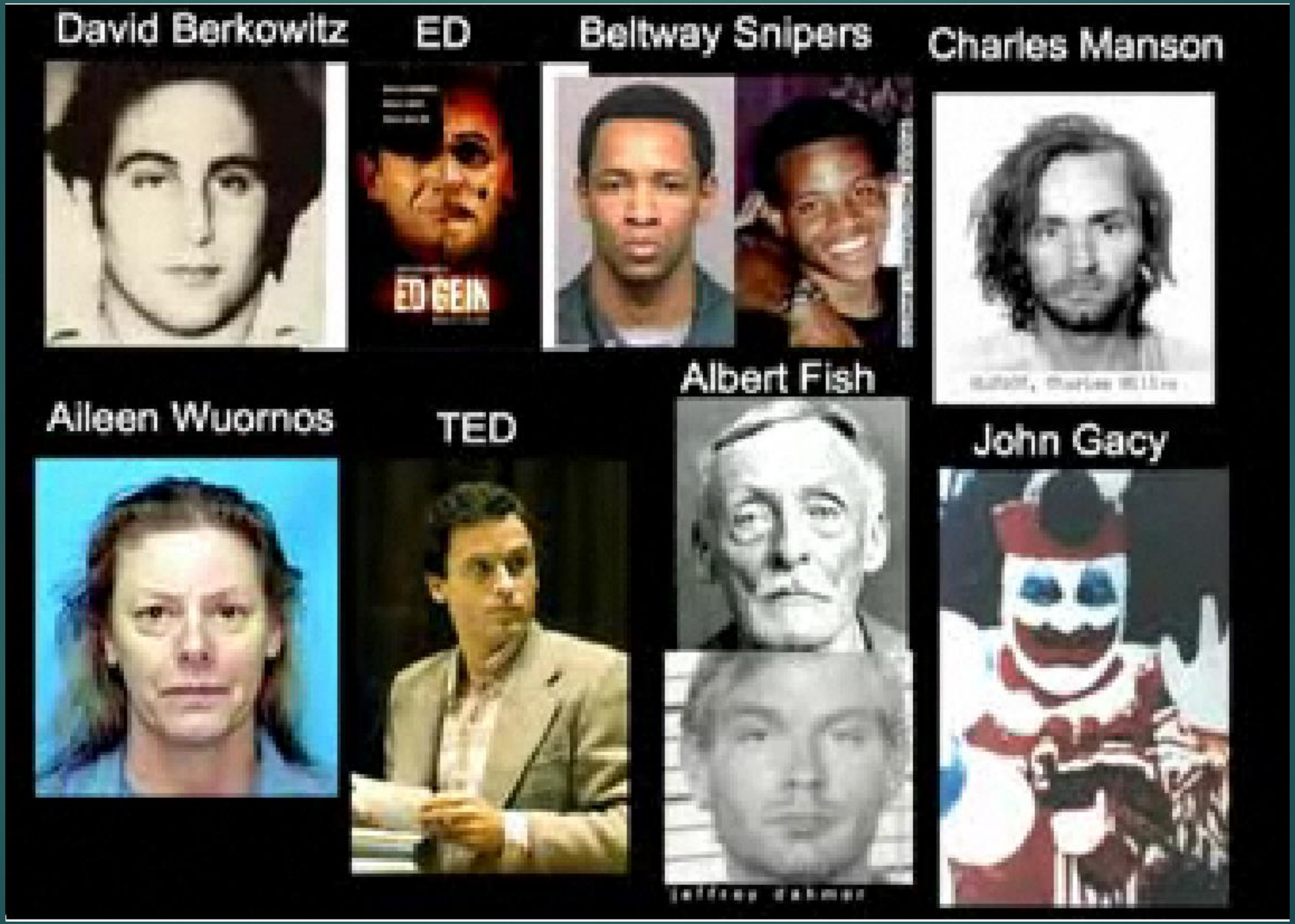
- How would we want to use that information? What if you can say that these particular 12-year-olds will be psychopaths?

- What do you do with the children you are confident will be psychopaths?

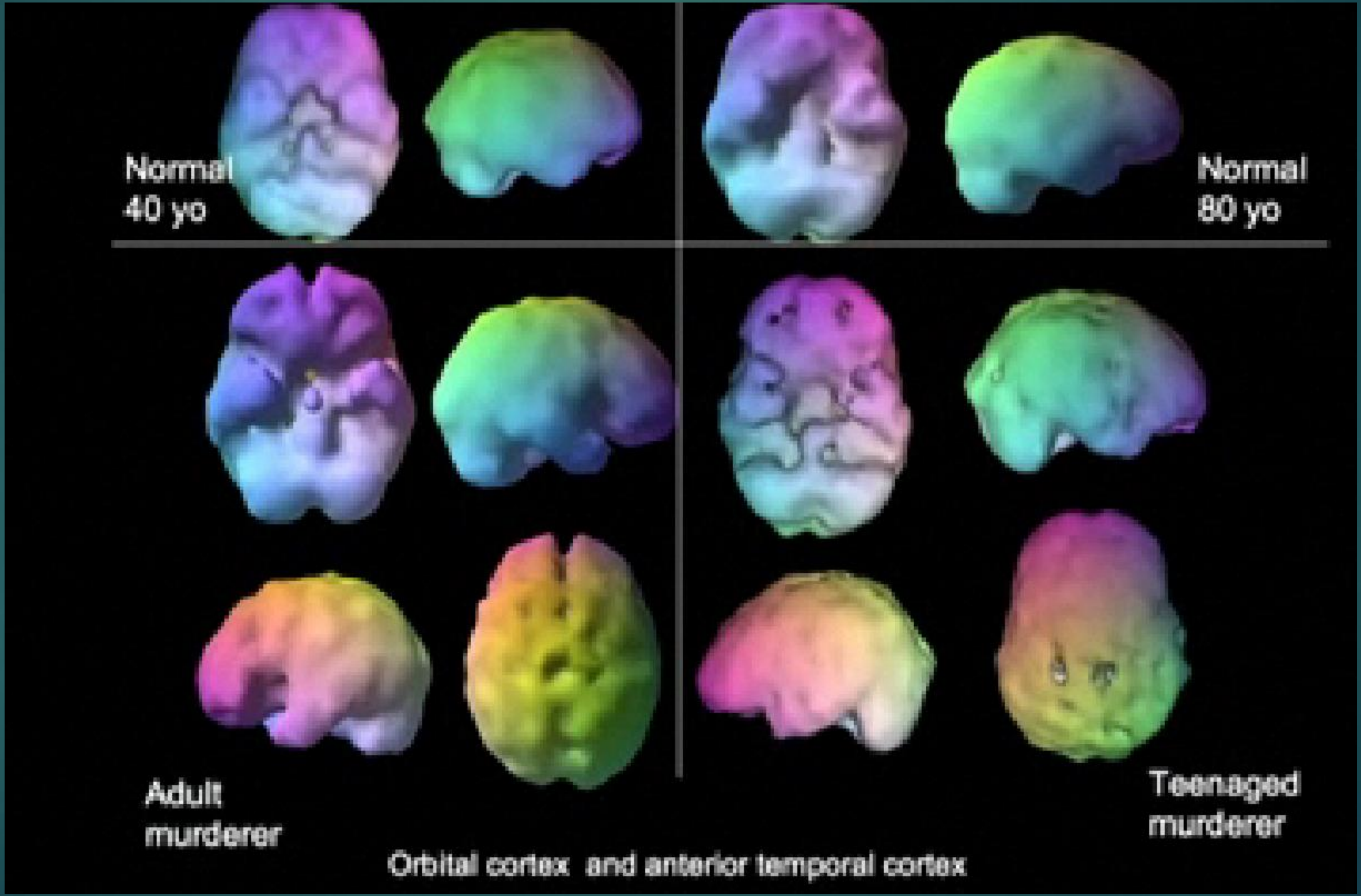
Psychopathic Personality Disorder: Reduced Prefrontal Gray

- 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.

Psychopaths

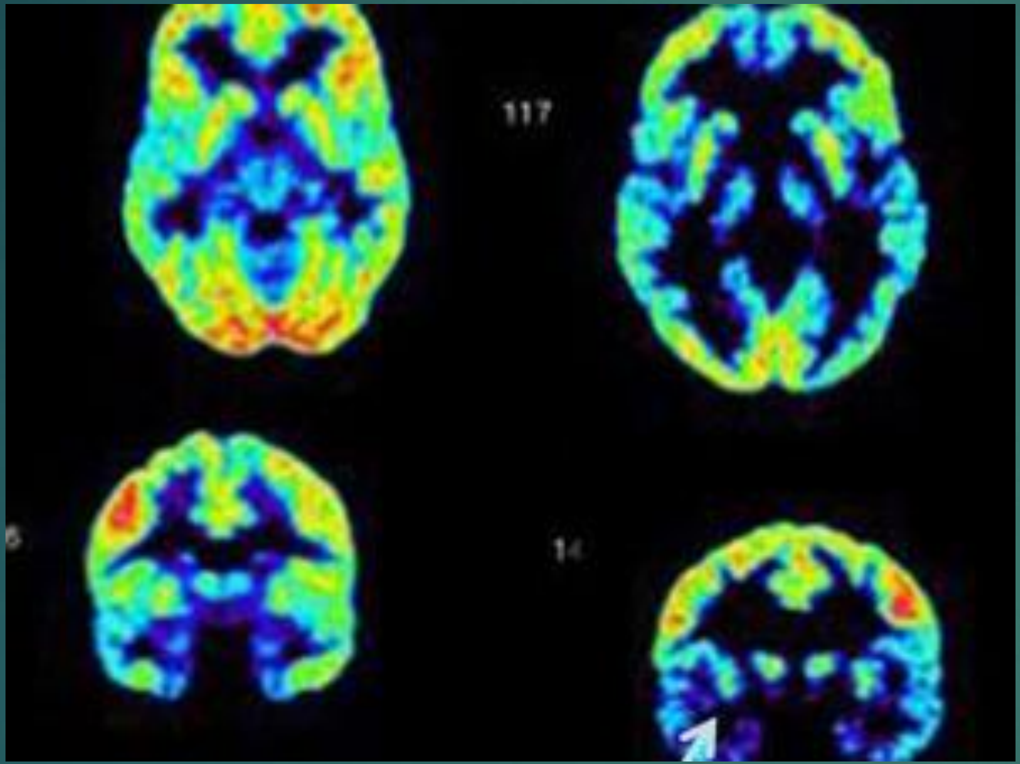


Psychopathy:
Low Activation in Orbital cortex and Anterior Temporal cortex



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

3 – History of childhood abuse or
seeing lots of traumatic violence

Brian Dugan

Mug shot of Brian Dugan from 1970.

For the first time fMRI was brought up in the court as a 'mitigating circumstance', in a case in which death penalty was at stake.

fMRI was admitted as scientific evidence (Frye Test) aimed to demonstrate that Dugan suffered from psychopathy, but scans were rejected on the grounds that bright colors could confound and bias the jury.

The Court allowed jurors to only see power point slides representing graphics and bars of the scans.

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 like Dugan 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 like Dugan, the emotional brakes don't work

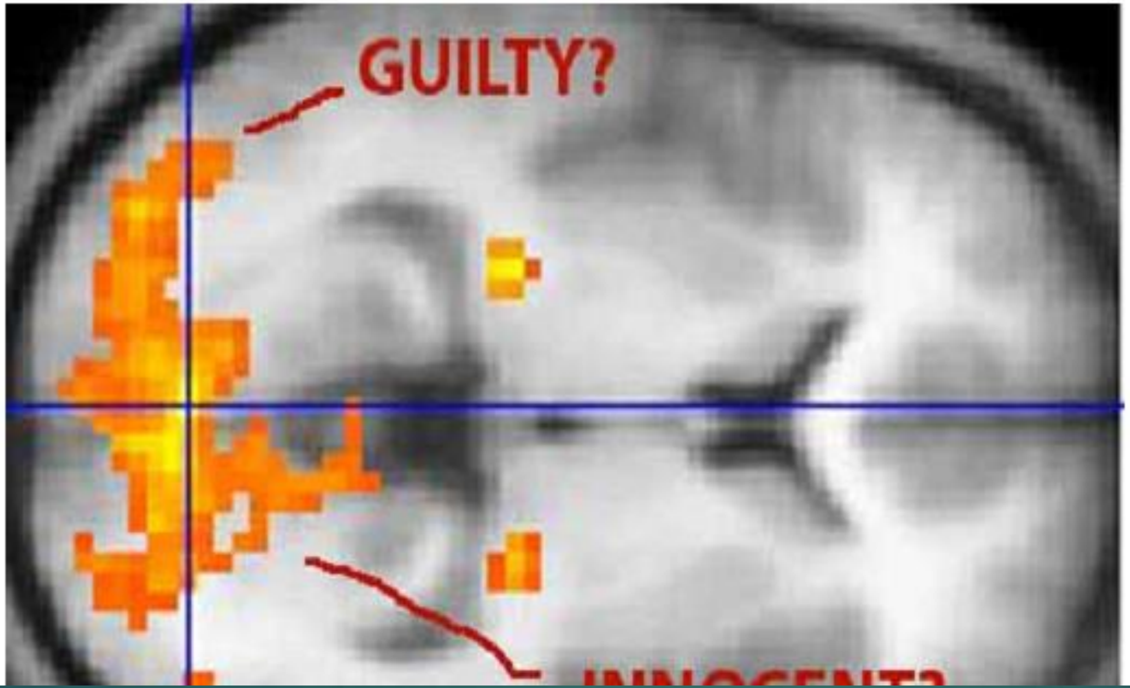
Brian Dugan

- Dugan was only 18 when he started his serial killing and raping of girls and young women.

- Hare Psychopathy Checklist: scored 37 out of 40. “Brian is very unique,” Kiehl said. “That puts him in the 99.5 percentile.”
- Judge’s decision to suppress Kiehl’s best graphic evidence — the actual pictures of Dugan’s brain.
- Less than a week after Kiehl testified, the jury voted unanimously to impose the death penalty on Brian Dugan.

Is the MRI lie detector test reliable?

Asks Leo in Arizona



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)

Pre-scientific Lie Detection

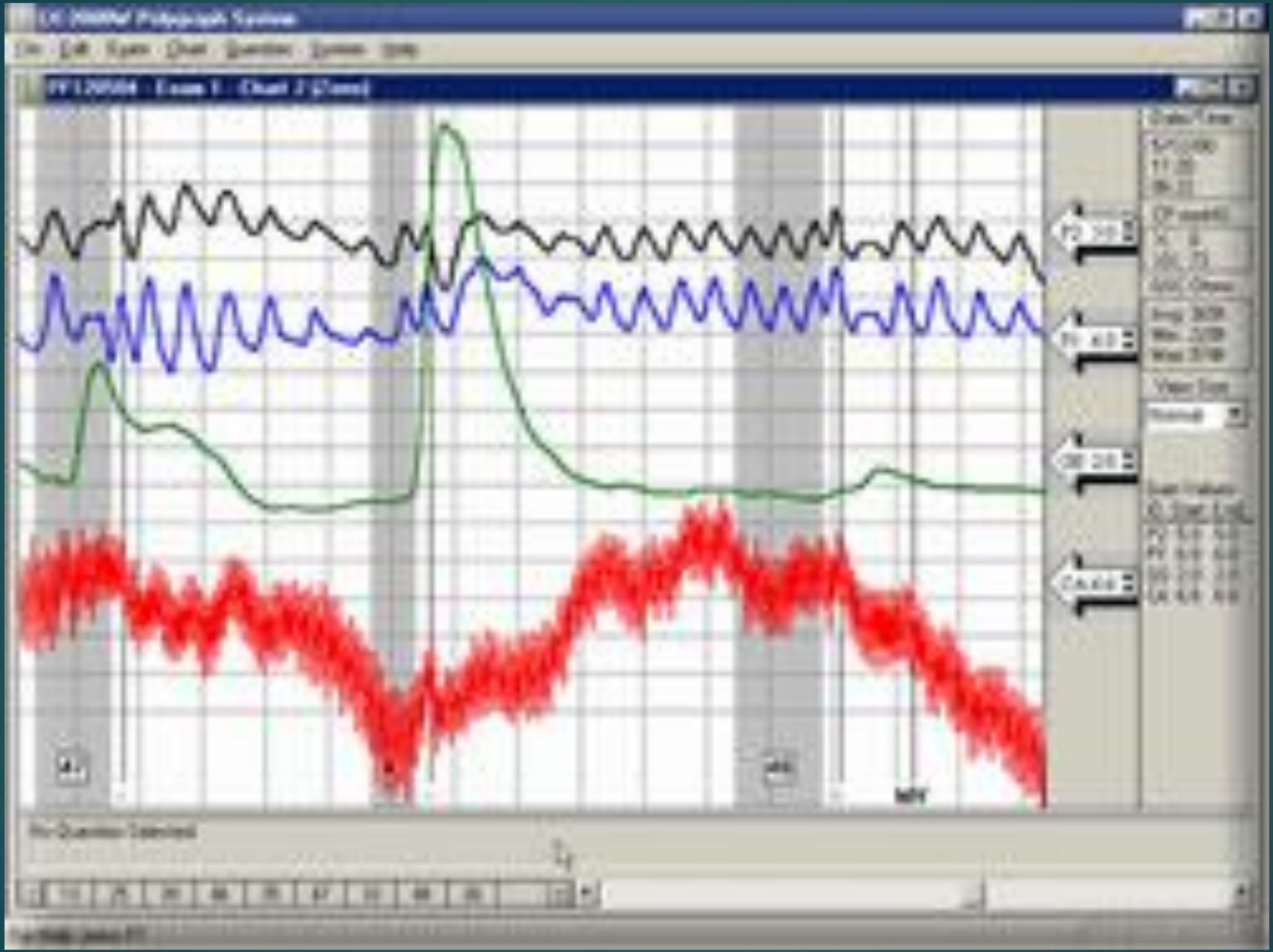
- Torture, drowning, and meatballs
- Cross-examination

Polygraphs

- Skin conductance response (SCR)
- Systolic blood pressure

(possibly in conjunction with drugs, such as amobarbitol)

Polygraph

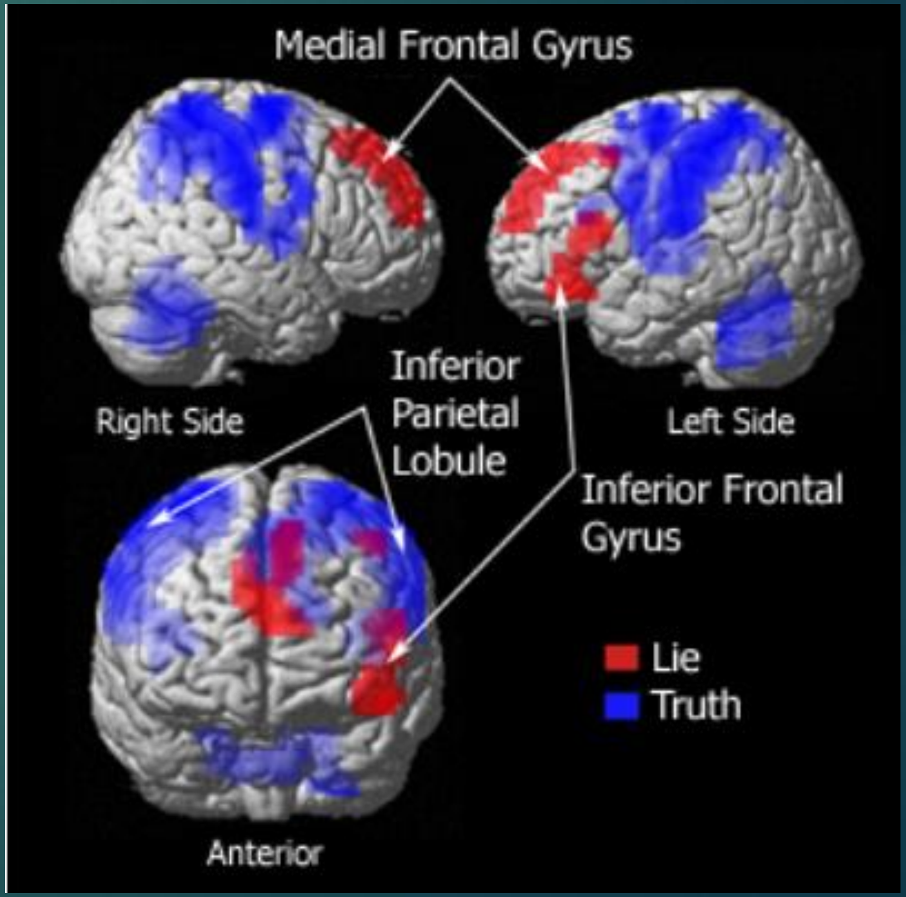


More Scientific Lie Detection

- 1 – periorbital thermography
- 2 – micro-facial expressions
- 3 – near-infrared laser spectroscopy
- 4 – electroencephalography (EEG)
- 5 – fMRI

Neural Lie Detection

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

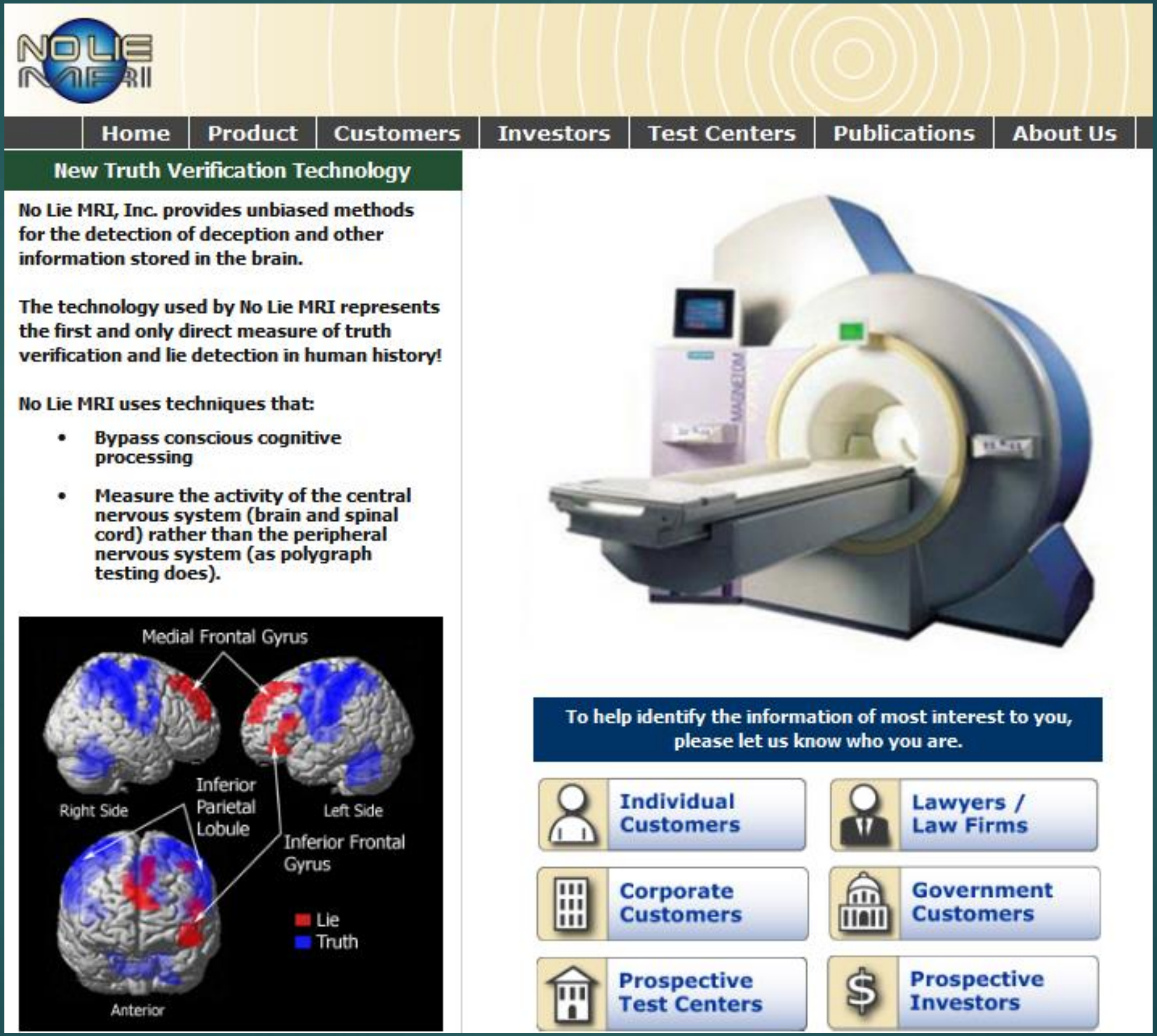


Brain Fingerprinting

- Uses EEG (electroencephalography); Developed by Lawrence Farwell; Sold by Brain Fingerprinting Labs; (www.brainwavescience.com)

- The Technique aims to determine whether specific information is stored in a subject's brain. It measure electrical brainwave responses to words, phrases, or pictures that are presented on a computer screen (invented by Lawrence Farwell).
- The theory is that **the brain processes known, relevant information differently from the way it processes unknown or irrelevant information. The brain's processing of known information, such as the details of a crime stored in the brain, is revealed by a specific pattern in the EEG (electroencephalograph)** . Farwell's brain fingerprinting originally used the well known P300 brain response to detect the brain's recognition of the known information. Later Farwell discovered the MERMER ("Memory and Encoding Related Multifaceted Electroencephalographic Response"), which includes the P300 and additional features and is reported to provide a higher level of accuracy.

No Lie MRI



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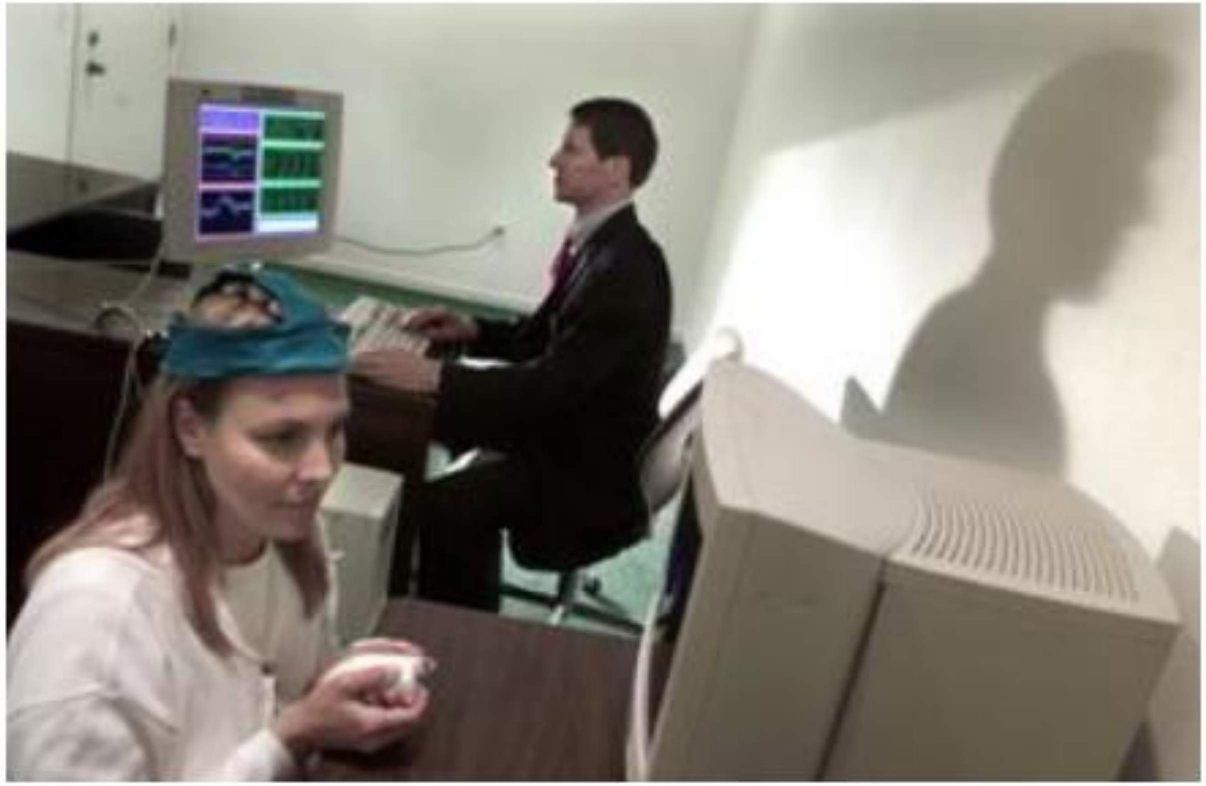
New Truth Verification Technology
No Lie MRI, Inc. provides unbiased methods for the detection of deception and other information stored in the brain.
The technology used by No Lie MRI represents the first and only direct measure of truth verification and lie detection in human history!
No Lie MRI uses 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

No Lie MRI & Cephos

- The second lie-detection technology uses fMRI. machines to compare the brain activity of liars and truth tellers.
- It is based on a test called Guilty Knowledge, certain areas of the brain lighted up when people lied.

- Two companies, No Lie MRI and Cephos.

- The 90-percent- to 95-percent-accuracy range -- which should be high enough to satisfy the Supreme Court's standards for the admission of scientific evidence.

- fMRI lie detection technology has been subjected to both *Daubert* and *Frye* challenges and thrown out.

- fMRI lie detection evidence led to more guilty verdicts than lie detection evidence based on polygraph

fMRI of Lying

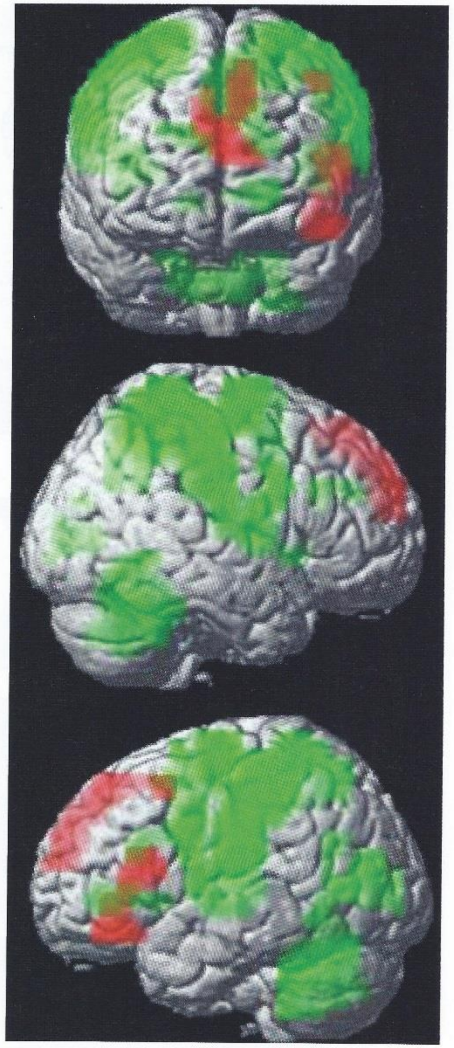


FIGURE 4.40 Are these the truthful and the deceptive areas of the cortex? fMRI differences between brain regions that had greater BOLD activity when people were telling the truth (green) and cortical areas when they were made to tell a lie (red). Is this the truth-telling cortex (green) and the lying cortex (red)? Why or why not? *Source*: Davatzikos *et al.*, 2005.

Green: telling the truth

Red: forced to tell a lie

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

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

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

Questions

- 1 – Is this really lie detection?
- 2 – How reliable is it? Labs are not realistic circumstances

Brain Fingerprinting in Court

- On March 5, 2001, Iowa District Court Judge Tim O'Grady ruled that Brain Fingerprinting® testing is admissible in court.
- Dr. Farwell conducted a Brain Fingerprinting test on Terry Harrington, who was serving a life sentence in Iowa for a 1977 murder.
- The test showed that the record stored in Harrington's brain did not match the crime scene and did match the alibi.
- On February 26, 2003, the Iowa Supreme Court reversed Harrington's murder conviction and ordered a new trial.

India 2008

- Uditi and Pravin meet in McDonald Hotel
- Pravin later dies from cyanide.
- There was evidence (cyanide on Uditi’s purse), but there was not enough evidence to convict, until she volunteered to take neural lie detection.
- BEOS technique based on Farwell’s research
- The test came out positive for lying.
- Uditi was convicted and sentenced to life in prison.
- She was recently given a new trial.
- Is this evidence good enough? Finding guilt *vs*. innocence

fMRI Lie Detection

- No Lie MRI was started by Joel Huizenga and is located in La Jolla, CA. Its methods are based on work by Daniel Langleben at University of Pennsylvania. See http://www.noliemri.com/

- Cephos is run by Steven Laken and is located in Boston, MA. Its methods are based on research by Andrew Kozel and Mark George at the Medical University of South Carolina. See http://www.cephoscorp.com/

The Main Problem

Do circumstances in labs where neural lie detection works resemble circumstances of real trials in relevant ways?

That depends on what exactly the neural method is detecting.

Since this is not clear, we need to guess

Nervousness

1. People get nervous when they lie, so maybe neural methods test when people are nervous, but witnesses get nervous even when they tell the truth in trials.

Inhibition

2. People have a natural impulse to tell the truth that they must inhibit when they lie, so neural methods might test when people inhibit such impulses. However, lawyers advise witnesses to suppress their impulse to blurt out answers even when they are telling the truth.

Kinds of Memory

3. People who were at the crime have episodic memories of being there rather than just semantic memories that it happened, so maybe neural methods test for episodic memories, but episodic memories can be triggered by pictures, imagined experiences, similar memories, and so on.

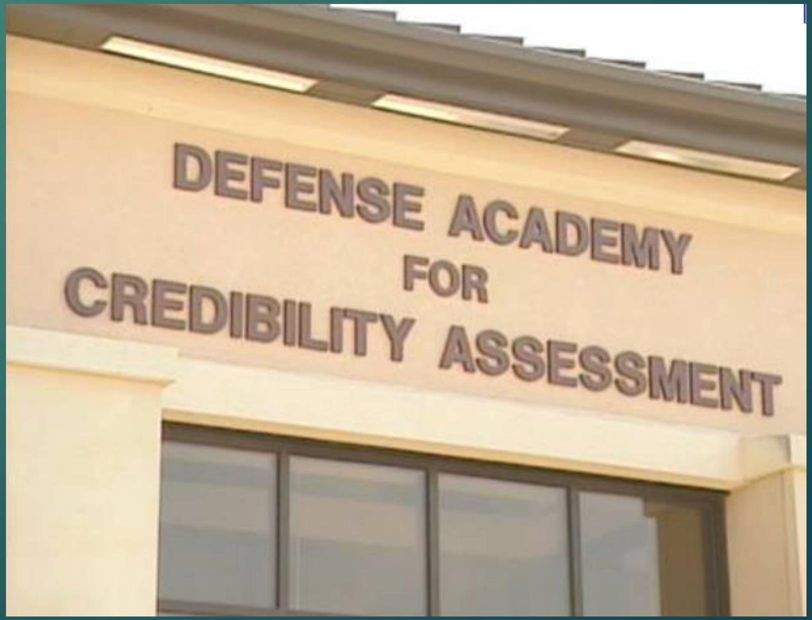
Conclusions on Lie Detection

- 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

Department *of* Defense

Defense Academy *for*
Credibility Assessment



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

Transcranial magnetic stimulation: Force the Truth

- Transcranial magnetic stimulation has been used to stimulate or inhibit specific regions of the brain. It can temporarily alter how we think and feel.

- Mark George, an adviser to the Cephos company and also director of the Medical University of South Carolina Center for Advanced Imaging Research, has submitted a patent application for a T.M.S. procedure that supposedly suppresses the area of the brain involved in lying and makes a person less capable of not telling the truth.

Self Incrimination and Privacy

- <u>If and when lie-detection fMRI's are admitted in court</u>, they will raise vexing <u>questions of self-incrimination and privacy.</u>

- Unless courts found the tests to be shocking invasions of privacy, <u>witnesses could even be compelled to have their brains scanned.</u>

Memories as our enemy

- <u>fMRI interrogation possibility</u>:

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

- <u>Our memories may become the evidence that embarrasses or incriminates us in the future</u>.

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."

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

Lying Imaging: Poses Many ?s

- Society will first have to decide whether this works and then, if it does work, how we want it used.
- Do we want its use regulated?
- Do we want employers to be able to use it?
- What about schools or parents?
- Do we want the police, FBI, or intelligence community to be able to use it?
- Does it matter if it is voluntary or involuntary?
- Should we allow its involuntary use with a court order—a search warrant for the brain?
- Could it be used in court, and, if so, when and how
- Are brain scans “testimonial” in nature or, like blood tests or x-rays, “physical” measures?

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.

Scans vs. real life:
Question of ecological validity

- We have no evidence whatsoever that activity in the brain is more predictive of things we care about in the courtroom than the behaviors themselves that we correlate with brain function.

- In other words, just because you have a biased reaction to a photograph doesn't mean you'll act on those biases in the workplace.

Pretty Pictures influence us

- Jurors might be unduly influenced by attention-grabbing pictures of brain scans.
- Frank Keil's research: when you have a picture of a mechanism, you have a tendency to overestimate how much you understand the mechanism.
- Functional MRI (fMRI) and expert testimony can persuade juries to be more lenient.

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.

Behavioral biology sways judicial decisions.

- Neurobiological evidence reduced judges’ sentences by an average of about 7 percent for a fictional defendant convicted of battery and identified as a psychopath.
- 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 this 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.
- 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.

Future of Criminal Control?

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

- Remember the Optogenetics research on 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

‘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
- Psychotrophics

Brain-machine interfaces

- Real:
- Cochlear implant
- Computer controlled movement

- Possible:
- Vision-producing visor used by the Startrek character Geordi La Forge.
- In its scary form, it is the thorough integration used by the alien species, the Borg.

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.

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?

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
- 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

- Neuroscience evidence is typically introduced to provide fact-finders with more complete, reliable, and precise information when determining a defendant’s fate.
- Study shows that courts accept neuroscience evidence for this purpose, 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

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, MR

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

- Nonimaging: 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

- Mitigation inquiry 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

- 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

- Attorneys are required to investigate and present mitigating circumstances, esp. in death penalty cases; NS evidence must be investigated.

NS and future dangerousness

- The majority of death penalty states consider a defendant's potential for future dangerousness to be 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

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

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

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.

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Neuroscience and Pain Assessment

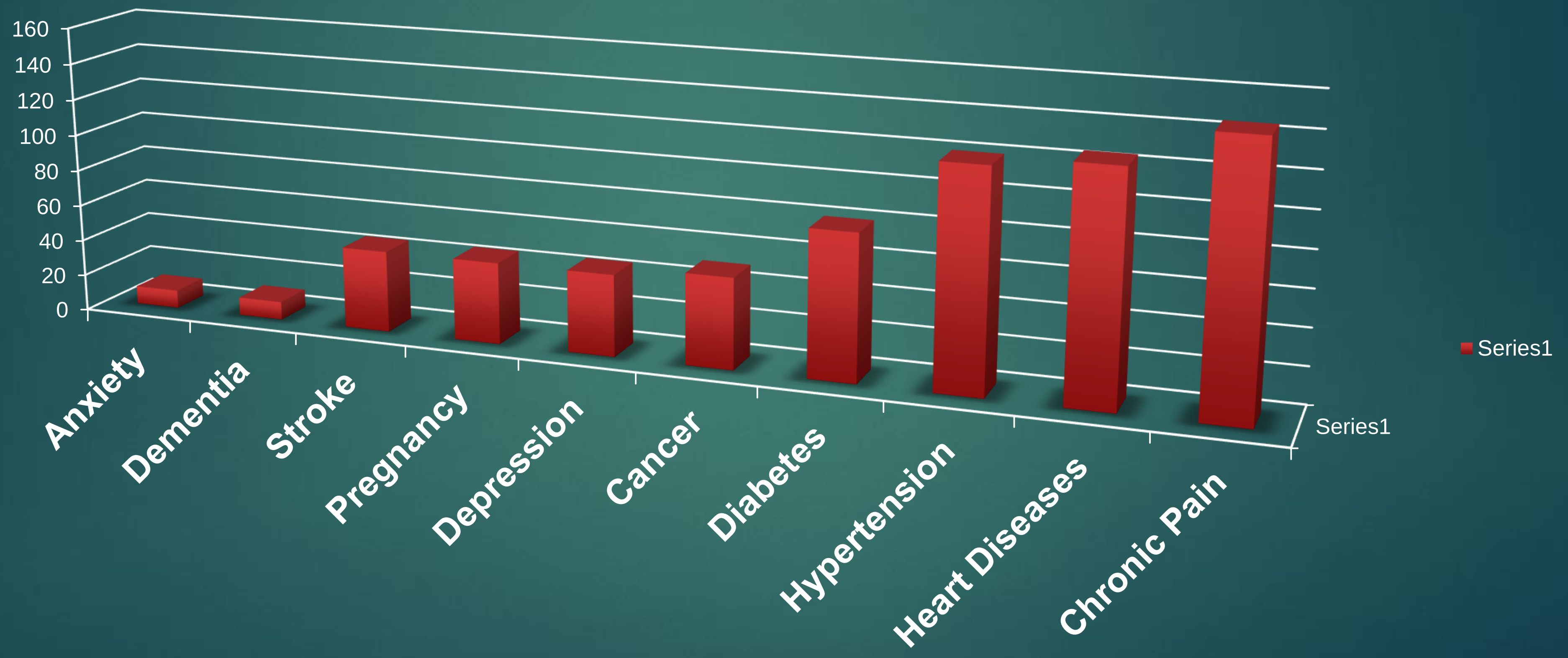
Back pain is the most common reason for filling worker compensation claim and accounts for 40% of absences from work, second only to the common cold as a cause for sick leave (Guo et al., 1999).

- Pain is perceived by the brain
- No feasible tests or procedures which can objectively determine if chronic pain is present and it magnitude

WE HAVE TO RELY ON A SUBJECTIVE EVALUATION OF THE CHRONIC PAIN BY THE PATIENT!

Health Care Costs of Chronic Pain in the US

Source: National Research Council – Washington DC –



Malingering

Because of its subjective qualities, pain is a favorite symptom of malingerers (persons who consciously feign illness or disability).

3 forms:

1) Invention
2) Exaggeration
3) Perpetuation

The root of the problem

- Pain is perceived by the brain
- No feasible tests or procedures which can objectively determine if chronic pain is present and it magnitude

WE HAVE TO RELY ON A SUBJECTIVE EVALUATION OF THE CHRONIC PAIN BY THE PATIENT!

Neuroscientific attempts to measure pain

1) U.S. Pat. N. 6018675 (Apkarian)

1, 2, 3, 4, 5, 6, 7, 8, 9, 10……

Variable pain

Brain responses are recorded (fMRI)

Subjective indications of the level of discomfort are recorded

CORRELATION

In order to characterize the brain’s representation of the pain in relation to the patient’s perception
and
Irrespective of the details of the stimulus

Limitations of the Apkarian’s patent

- The patient may be externally manipulated (e.g. movement of a leg in patients with chronic back pain)
- The method does not distinguish between chronic pain and transitory pain
- The method cannot establish the presence and/or magnitude of chronic pain on an objective basis

Future demonstrative techniques Pain and Suffering Cases?

Brain Scans?

Among the reasons to be cautious…

- The variability in terms of baselines for pain of different individuals
- The heterogeneity of “chronic pain”: which subset of patients are we talking about?
- How beliefs (expectancy) can influence pain perception
- The unknown rate of false positive and false negatives
- ……

Raises questions of privacy and self-incrimination

- Should we be compelled to have our brain's scanned by the legal system?
- How about in getting a job? How is this different from a personality test?
- Should 'freedom of thought' be protected?
- Should we punish people for their their thoughts and not simply their behavior?
- As new technologies develop, could the police get a search warrant for someone's brain?

Behavioral genetics

- ❑ the field of study that examines the role of genetics in human behavior
- ❑ "nature versus nurture" debate
- ❑ highly interdisciplinary (biology, genetics, psychology, and statistics.)

" Behavioral Genetics applications in the criminal justice system are quickly outpacing the advances in the science "

(N. Farahany & W. Bernet)

THE FIRST TIME BEHAVIOURAL GENETICS ENTERED THE COURT

Stephen Mobley - USA – 1994
(murder of a 24-year man)

- He filed a motion seeking funds to hire experts witnesses to assess his potential deficiency in MAOA enzymatic activity, based on the then-recent studies suggesting a possible genetic basis for violent and impulsive behavior .

- The court denied Mobley’s motion: lack of scientific verifiability

-- Mobley was executed by lethal injection in 2005 in Georgia

THE STARTING POINT

- In 1978 a Dutch woman walked into University Hospital in Nijmegen with a problem
- Genetic investigation on her family
- 15 years later - first outcomes: a genetic defect on the X chromosome
- The Gene coding for an enzyme (MAOA) that may help regulate aggressive behavior

Caspi, Moffit (Science, 2002): Monoamine oxidase A (MAOA).

Low activity of this gene → neurotransmitters in the brain (serotonin, dopamine, norepinephrine) are not properly metabolized low activity of MAOA in males + maltreated as children = a much greater likelihood to manifest violent antisocial behavior in the future.

Caspi, Moffit et al. (2003): SLC6A4 gene

Individuals with one or two copies of the short allele = more depressive symptoms, suicidability in relation to stressful events

Cases – since 2002

USA

- Expert witnesses mostly based on gene SLC6A4

- State v. Jon Hall
- Hines v. State
- State v. Payne
- State v. Godsey
- People v. Uncapher
- State v. Sanders
- State v. Newton

(Source:
Bernet W. Et al. , *Bad Nature, Bad Nurture, and Testimony regarding MAOA and SLC6A4 Genotyping at Murder Trials*, J.Forensic Sci., Nov. 2007, Vol. 52, n.6)

COMMENTS:

- More attempts to mitigate the sentence than attempts to obtain a declaration of insanity

- Use by the prosecutors: social dangerousness

2004 - annual anthropologists' meeting in Florida – scientific jounalist Ann Gibbons coins the phase "Warrior Gene", describing MAOA gene

Media & Behavioral Genetics

http://www.youtube.com/watch?v=sMfWSGi3Y2k

http://topdocumentaryfilms.com/born-rage-inside-warrior-gene/

http://www.familytreedna.com/landing/warrior-gene.aspx

ITALY – BAYOUT CASE
Court of Appeal of Trieste
September 2009

The convicted man [Abdelmalek Bayout] was an adult male affected by schizophrenia who was found guilty at the first level of judgement and was given a reduced sentence (9 years) owing to his mental illness.

At the appeal court, a new expert assessment took place, and behavioral genetic testing was requested by the defense.

The judge reduced the sentence from 9 to 8 years, based on the fact that the accused had tested positive for genetic
variants that made him **particularly prone to be aggressive under stressful circumstances** and therefore he was even more vulnerable because of that

“ A person should be judged on the basis of his actual condition and mental capacity at the moment of the act, independent of any theoretical predisposition to develop some disease or inappropriate behavior even assuming that there is really a link between abnormal behavior and specific genetic variants”

Issue: reliability of the method!

(Forzano et al. , in: European Journal of Human Genetics)

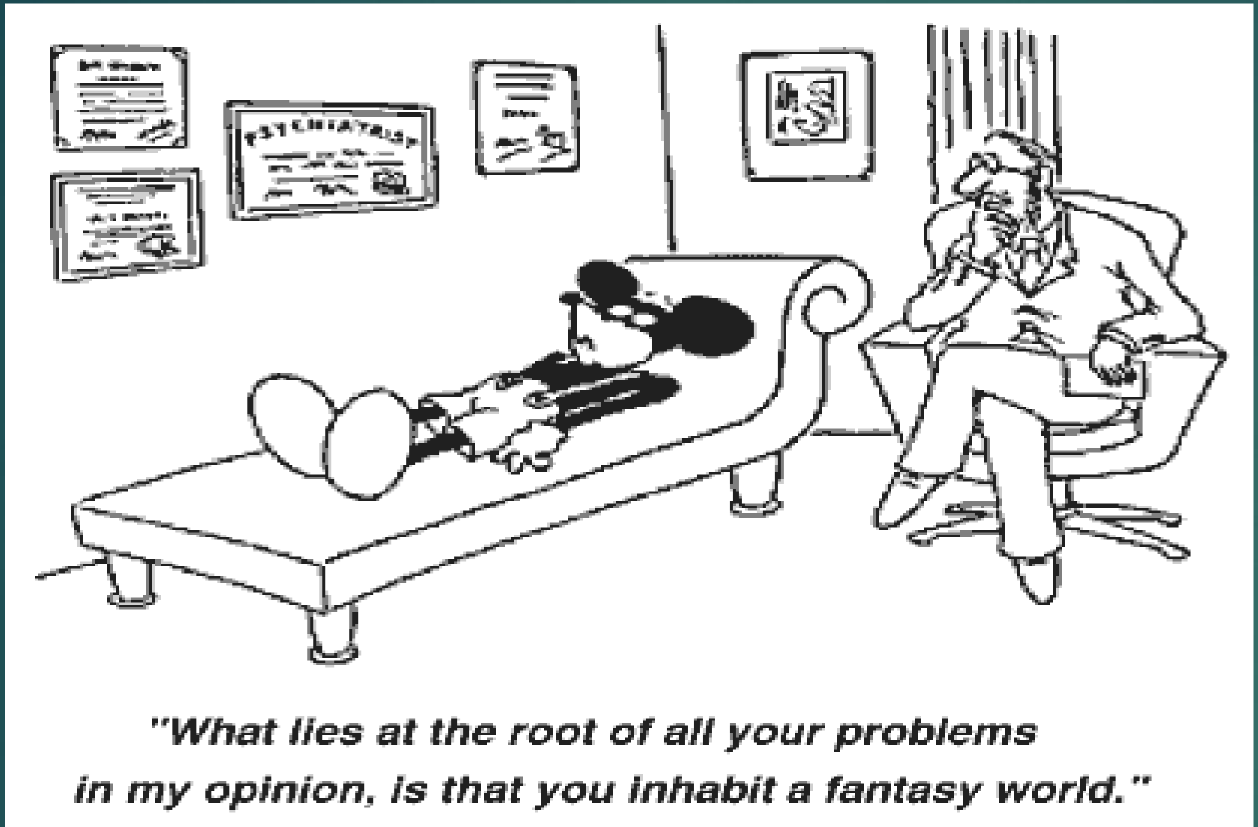
Albertani case:
the factual background

STEFANIA
ALBERTANI

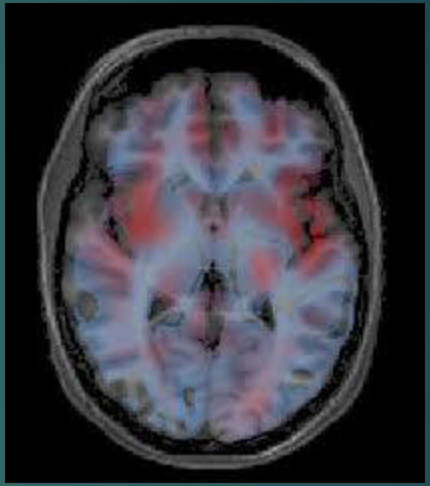
MARIAROSA
(STEFANIA'S
SISTER)

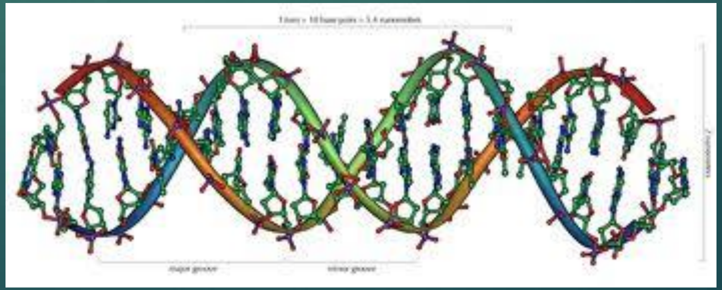
STEFANIA'S
PARENTS

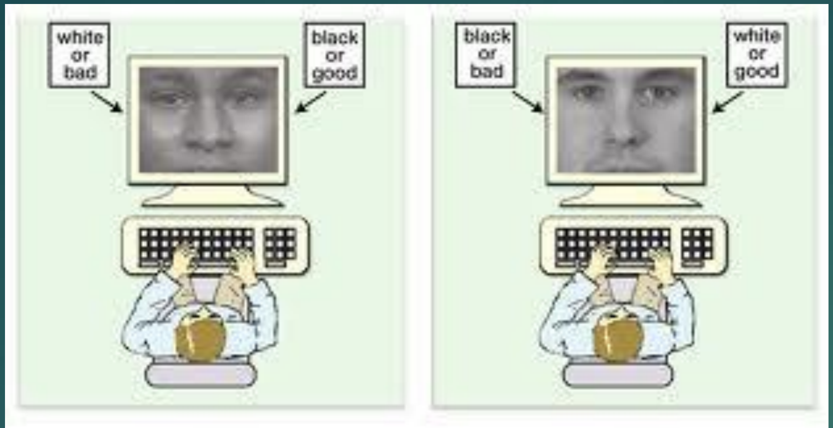
The experts' opinion



"What lies at the root of all your problems in my opinion, is that you inhabit a fantasy world."







aIAT TEST

“the test aims to establish whether an autobiographical memory trace is encoded in the respondent's mind, allowing one to evaluate which of two contrasting autobiographical events is true for a given individual “

Since pairing of a truly autobiographical event with the true-bottom should facilitate responses, the specific pattern of response times in the two blocks indicates which autobiographical event is true and which is false.

92% accuracy

BUT

..many doubts surround this method

The **retrievable literature** about aIAT method is mainly ascribable:

- to the experts themselves or
- to researchers who critically conducted experiments that showed how easily the test is subjected to **countermeasures**:

it is sufficient for the subject to be instructed to slowly answer the questions, or to answer using particular accuracy.

VBM (Voxel-Based Morphometry)

- VBM based on structural MRI yielded significant results. According to the experts' report, the defendant's cerebral grey matter was compared with that of an **appropriate** control group consisting of **10 female subjects**, without **relevant disorders** and with **analogous personal data**

- there were **statistically significant differences** between Albertani's cerebral grey matter volumetry and controls' one. This would cause an impairment in those functions regulated by the anterior cingulated gyrus, namely: 1) inhibiting automatic behavior and replacing it with another one 2) regulate lying phenomena, causing high levels of suggestibility 3) regulating decision making processes

MAOA Genetic Test

- The experts wrote that, according to many published studies, the analyses revealed that the defendant is carrier of susceptibility alleles associated to a major risk of developing aggressive and impulsive behavior (MAOA)

"With reference to Albertani's genotype at MAOA-uVNTR locus, she is heterozygous 3/4 and the allele 3 is associated with a low efficiency form of the enzyme, ***notoriously related to aggressive and antisocial behavior in men****. In women these findings* ***cannot be clearly interpreted****: Due do the epigenetic mechanism of X inactivation, heterozygous women show a intermediate phenotype. However****, it's not possible to exclude the association****. In addition,* ***allele 4 is associated with criminal behavior, especially associated with psychosocial adverse events****. Miss Albertani carries both the adverse alleles at MAOA-uVNTR locus."*

Judicial Decision and Sentence

- Diminished cognitive and volitional capacity

art. 89 Italian Penal Code (Vizio Parziale di mente)

- Sentence reduced from 30 to 20 years imprisonment

- ‘At least’ 3 years in a mental health hospital

Decision and Sentence

Prevalence of the defense experts' opinion on the court-appointed one:

"the neuroscientific investigations <u>carefully</u> arranged by the defense's experts integrating the traditional psychiatric and neuropsychological investigations are welcome."

A Copernican revolution is not being introduced in terms of assessment, evaluation and diagnosis of mental pathologies

NO Introduction of deterministic criteria to infer some behavior from morphological alterations.

Rather, the knowledge about cerebral morphology and genetic structure should be considered valuable in order to find possible correlations

1) *between brain anomalies and lack of capacity to control impulsivity*
2) *between genes' alleles and the risk of a greater vulnerability to the development of socially unacceptable behaviors when more exposed to the effect of environmental stress factors.*

CONCLUSIONS

- Neuro-techniques, as such, follow a method based on statistical analysis: they can be a useful tool to assess brain damages and infer considerations on mental illness, but they cannot replace the comprehensive analysis of a person, from her experience to her behavior.
- Behavioral genetics: there is a serious risk of reductionism. The most common mistake surrounds the difference between behaviors and traits. A trait can be described as a sort of broad inclination. Behaviors are *actions* rising from those inclinations. Traits are selected for over long stretches of time, while behaviors rise as their current, context-sensitive expressions.

Dr. Semrau,

Tennessee District Court (USA), 2010

Semrau's defense asks the Judge to admit FMRI as a Lie Detector (In order to demonstrate the veridicity of Semray's declarations)

- The method **doesn't** pass the Daubert Standard

The error rate of real life fMRI- based lie detection is unknown!

- Error Rates ?
- General Accepted?

The method has not yet been accepted by the scientific community

- the probative value of Dr. Laken's testimony is substantially outweighed by the danger of unfair prejudice to the jury(F.R.E. 403)

"courts in this circuit have consistently found that the high risk of unfair prejudice associated with the admission of testimony regarding unilaterally obtained polygraph results will preclude such testimony from being admissible".

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When Truth Matters

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About Contact Lie Detection Investigations Expert Services Publications

Our Business Is the Truth

We believe truth is among the most valuable of commodities, but getting to the truth can be difficult. Oftentimes determining the truth requires interpreting and assembling distinctly different types of information from vastly different sources. That's why we offer services ranging from traditional private investigation to state-of-the-art forensic DNA services to brain-based lie detection.

Cephos has over 20 years of investigative experience, over 15 years of DNA expertise and is the only company licensed to perform brain-based lie detection. If you are looking for professional, responsible and dedicated personnel to help with your investigation needs we can help.

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DNA Expert Services

Cephos provides expert DNA forensic consulting services. All matters from sample collection, extraction, amplification to results reporting are areas our experts help you and your clients.

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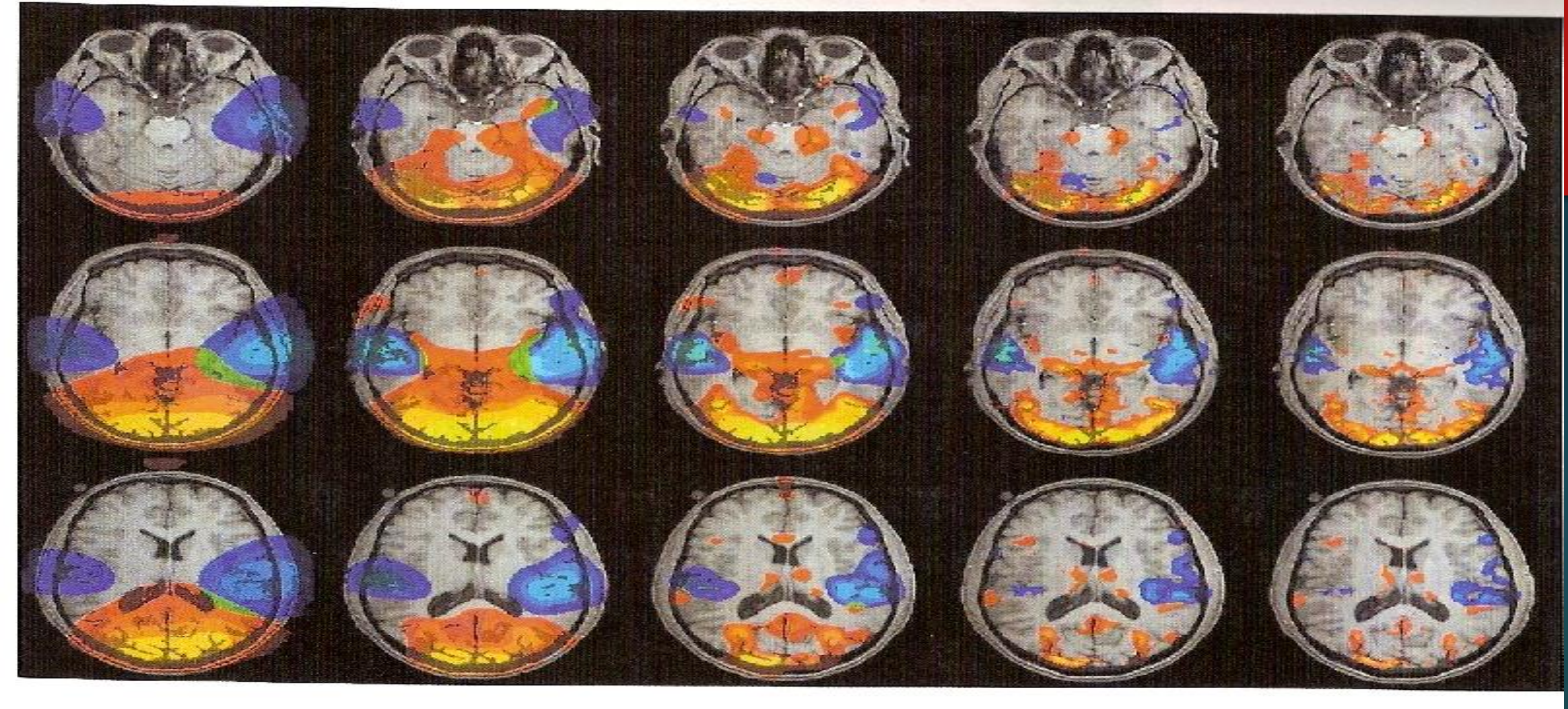
Lie Detection

Cephos truth verification brain imaging service provides independent validation of your truthfulness. If your word or your reputation is in dispute, contact Cephos today for scientifically validated testing.



Source: S.M. Smith, Preparing fMRI data for statistical analysis, in P. Jezzard *et al., eds. Functional MRI: An introduction to methods, Oxford University Press, 2001.*

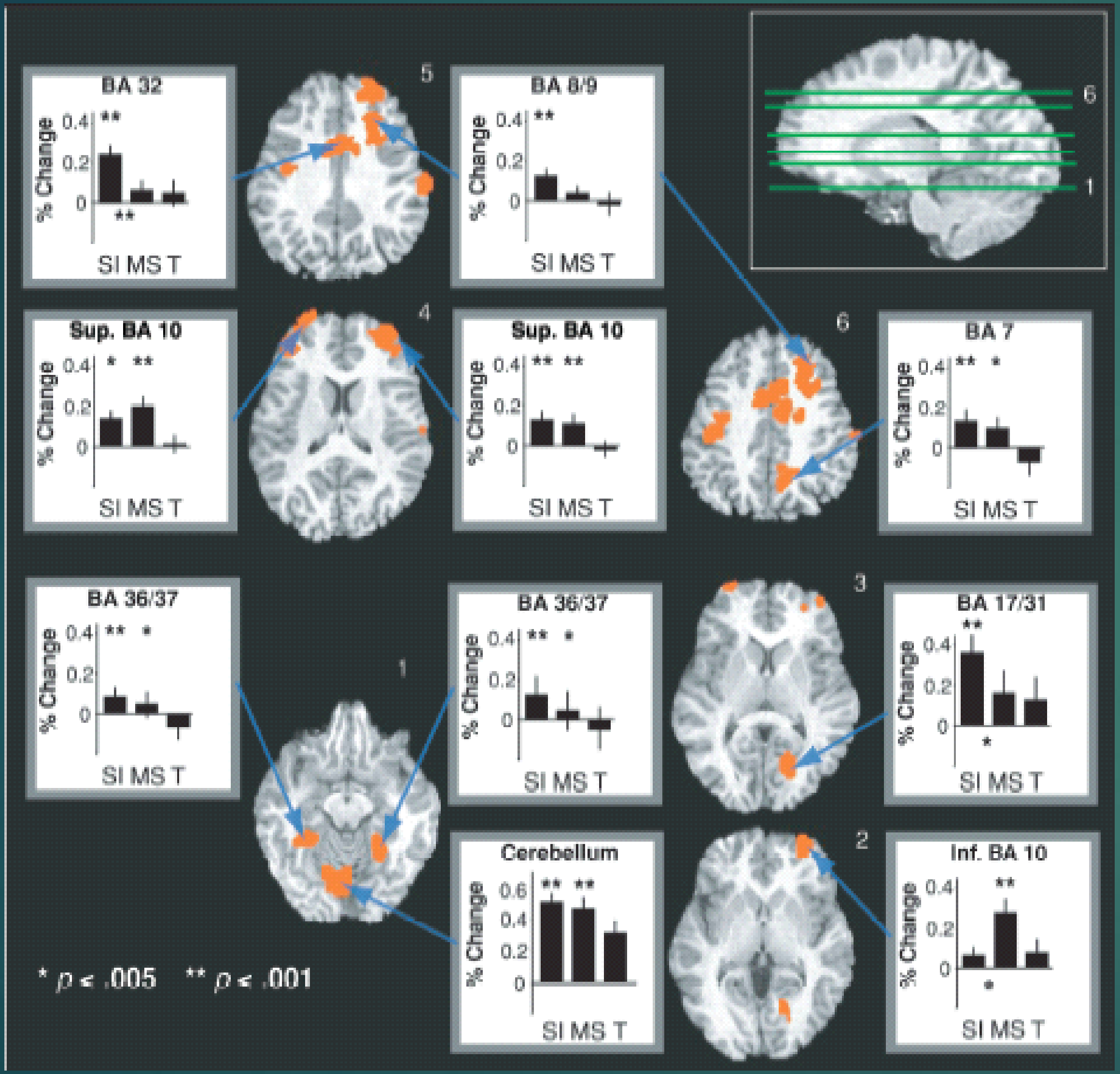
Five different ways to reproduce same data originate different fMRI visual images.
Each sequence applies a different statistical filtering to the same data set.

Differences between visual images results are noticeably

NAS on Brain Image Lie Detectors

- There is no solid base of repeated scientific findings that associates brain images with deception.
- The new imaging techniques have not been shown to exceed the low accuracy levels of the classic polygraph. (NAS 2003, Paraphrased)

Deception and lie detection



<u>Differential patterns of activation observed for Truth (T), spontaneous-isolated lies (SI) and memorized scenarios (MS).</u> **This may be evidence for neural correlates of different types of lying.**

Ganis et al, Cerebral Cortex 2003

Can we tell when someone is lying? Can we tell if someone has a false memory?

- If you think the ethical problems arising should we have a workable and validated brain imaging lie detector are substantial, consider how even more severe the ethical problems would be if the method did not work and we erroneously assumed that it did.
- We should make every effort now to avoid repeating the current situation with polygraphs—a persistent and continued presence despite little scientific validity.

Case #1

- Imagine being accused of robbery.
- You know that you are innocent.
- A witness says that he saw you do it.
- You have no alibi or other counterevidence.
- Your lawyer tells you that a new method of lie detection is accurate 95% of the time.
- Your defense attorney asks the judge to let him test the witness and you.

Case #2

- Imagine being robbed.
- You identify the defendant.
- His friend testifies that they were elsewhere during the robbery.
- The prosecutor knows about accurate neural lie detection.
- The prosecutor asks the judge to allow him to test the friend and you.

What is a Lie?

- People lie when they say something they know is false with the intention to deceive and usually to induce reliance.
- To show someone is lying, a method needs to detect knowledge and intent.
- There's no way to do show this directly. All tools use indirect accompaniments.