

# Research Sample – Violence/Suicidal

- **75 Studies, >1500 patients**
- **Amen, 2007, 41 murderers vs. healthy controls**
  - ❖ **SPECT showed significant PFC deficits, more global deficits in older adults**
- **Soderstrom, 2002, 32 patients**
  - ❖ **Aberrant frontotemporal activity most frequently seen in violent behavior.**
- **Hirono, 2000, 20 patients**
  - ❖ **Results indicated an association between aggression and decreased perfusion in the left anterior temporal cortex.**

# Research Sample – Violence/Suicidal

## ➤ **Bufkin, 2005, REVIEW OF 17 STUDIES**

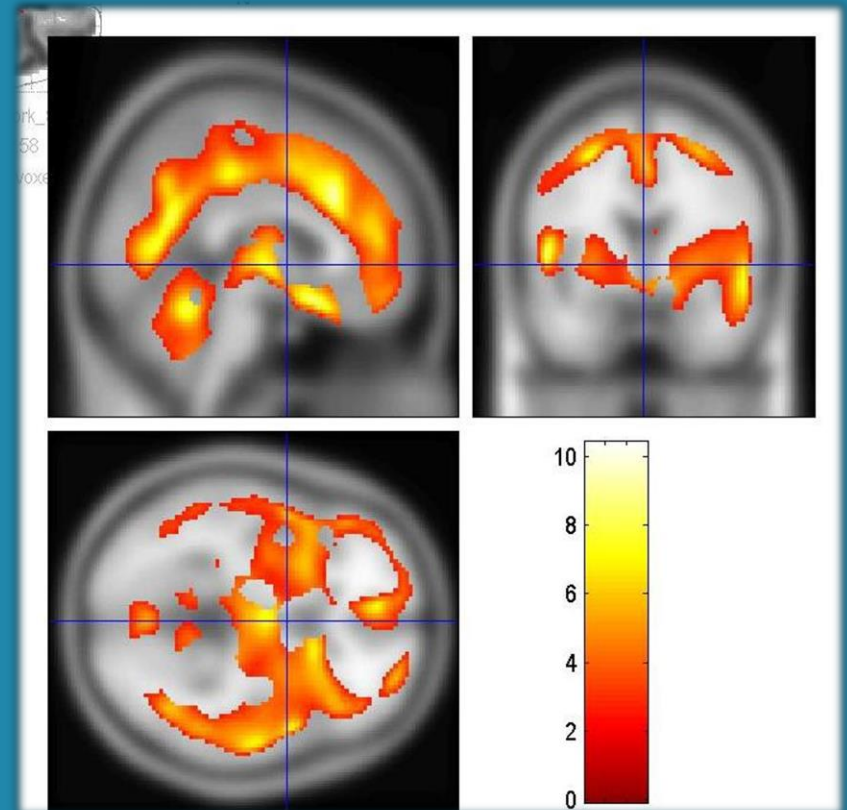
- ❖ **Reveals that the areas associated with aggressive and/or violent behavioral histories, particularly impulsive acts, are located in the prefrontal cortex and the medial temporal regions.**

## ➤ **Woermann, 2000, 83 patients, MRI**

- ❖ **Patients with TLE with aggressive episodes had a decrease of grey matter, most markedly in the left frontal lobe, compared with the control group and with patients with TLE without aggressive episodes.**

# Research Sample – Violence/Suicidal

- **Amen, 2009, 15 completed suicides**
  - ❖ **Marked decreases, especially in the PFC, AC and area 25**



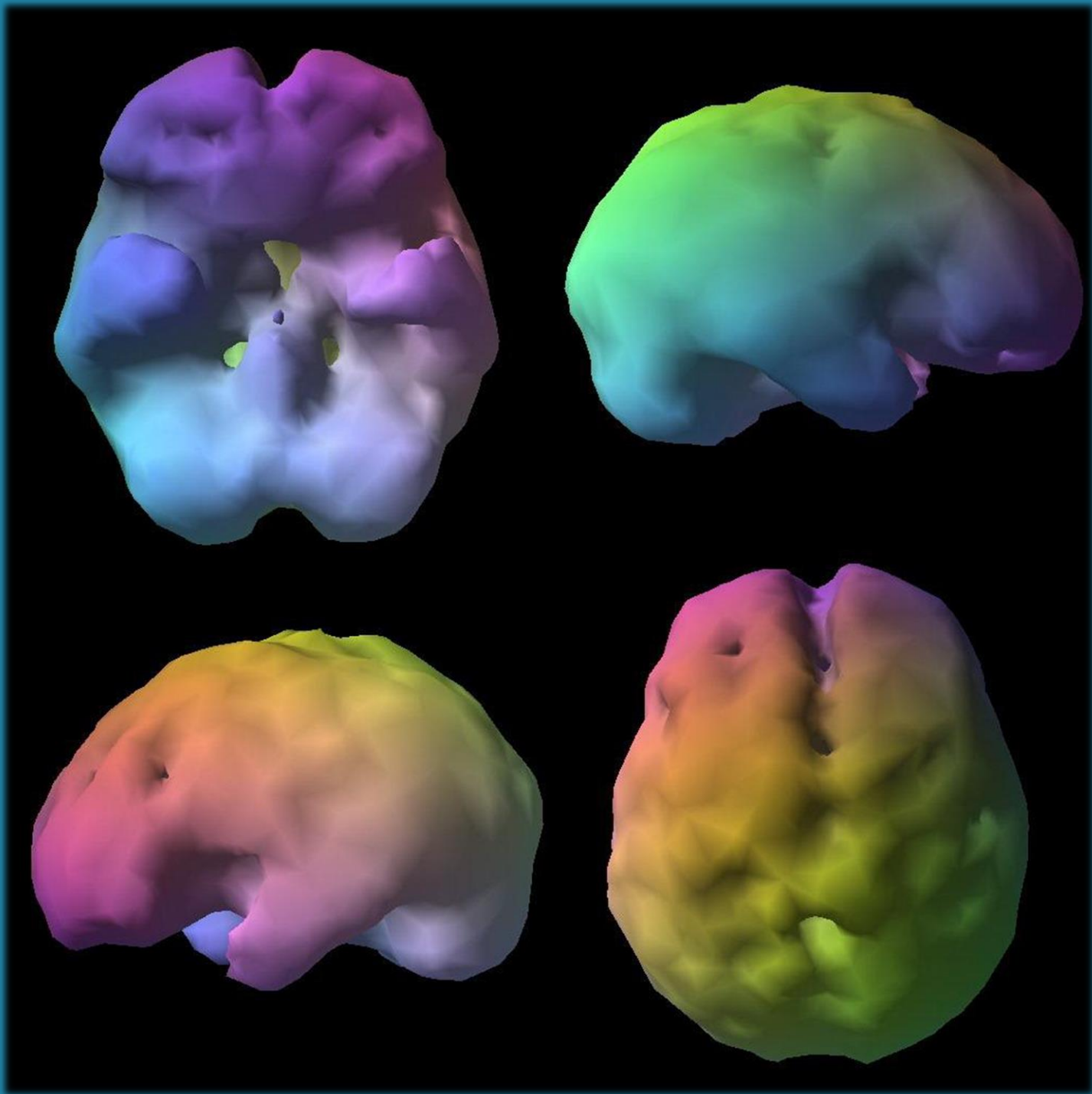
# Imaging Help with Violent Behavior

- **Identify systems involved with violence and direct treatment**
  - ❖ **Prefrontal, Temporal Lobe, Ant. Cingulate**
- **Optimize brain function before rehab**
- **Help motivate treatment**
- **Help understand aberrant behavior**

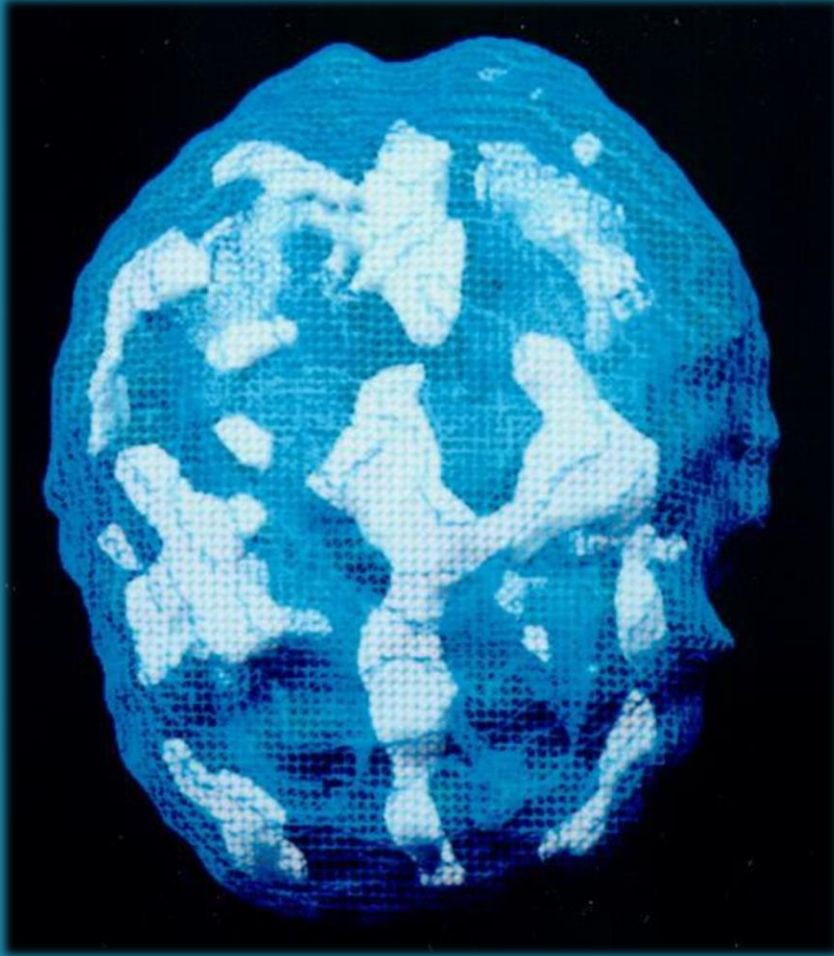
# Head Injury: Leading to Abuse



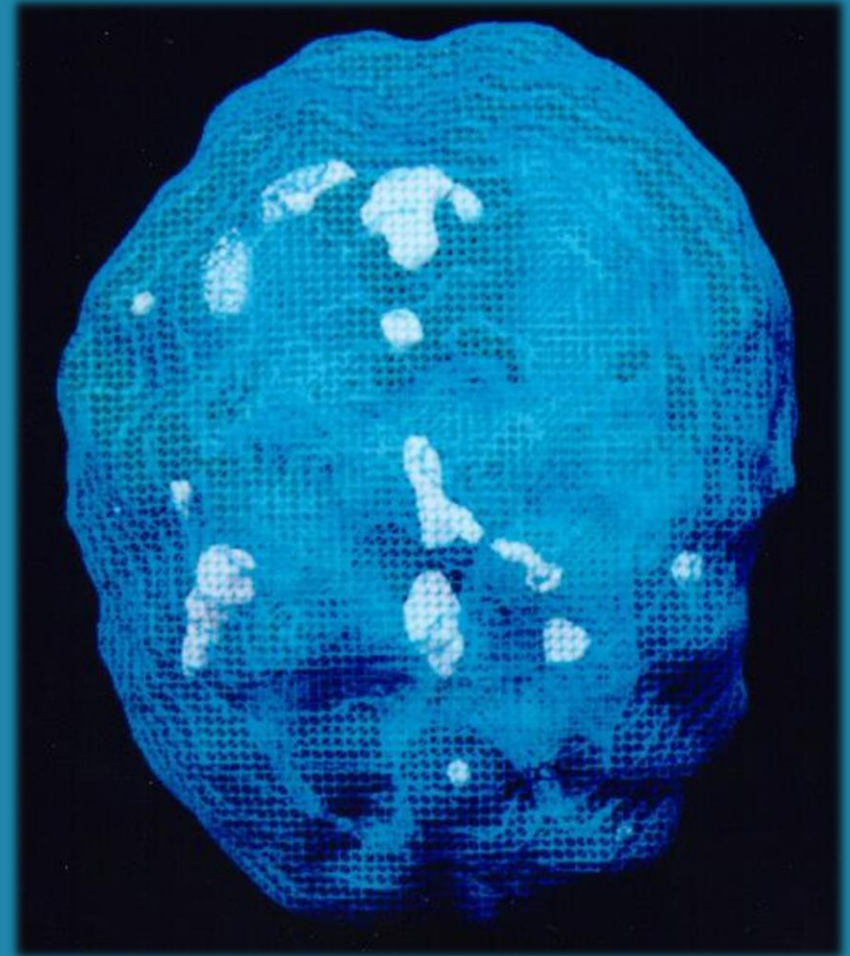
# Chiesa



# WHAT DOES HIS SOUL LIKE?

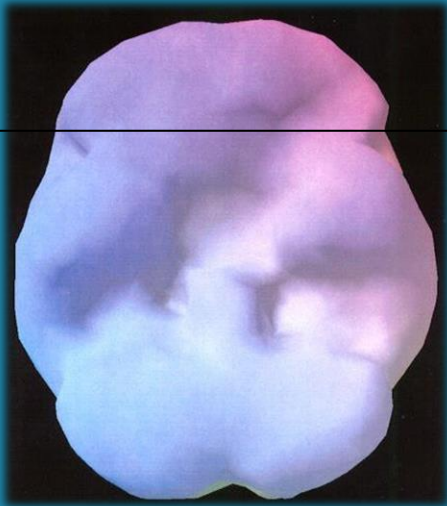


**Before Treatment**

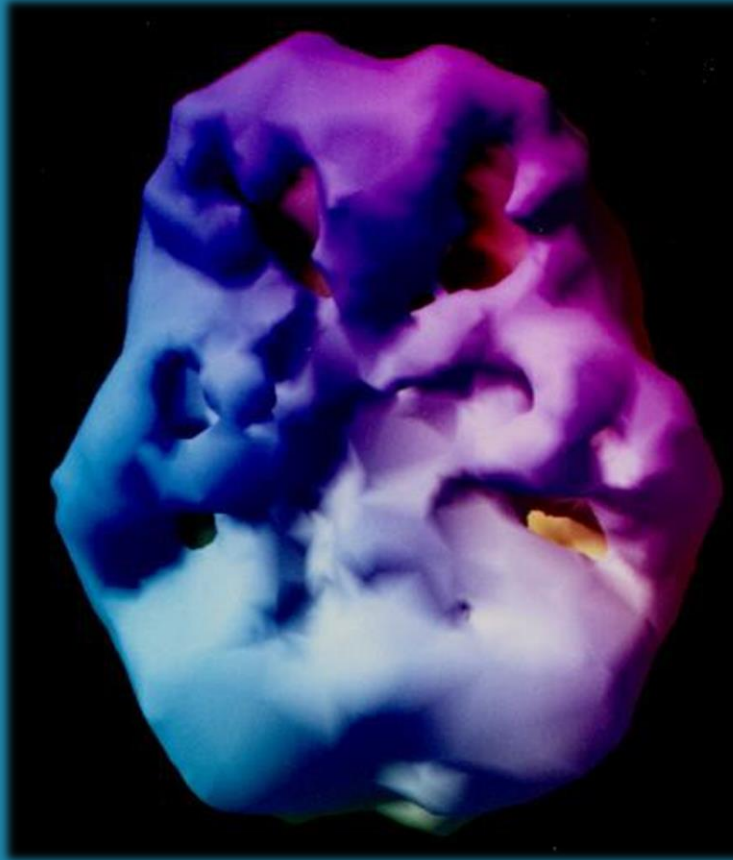


**After Treatment**

# LP - Conc. Without and With Adderall



**Normal**



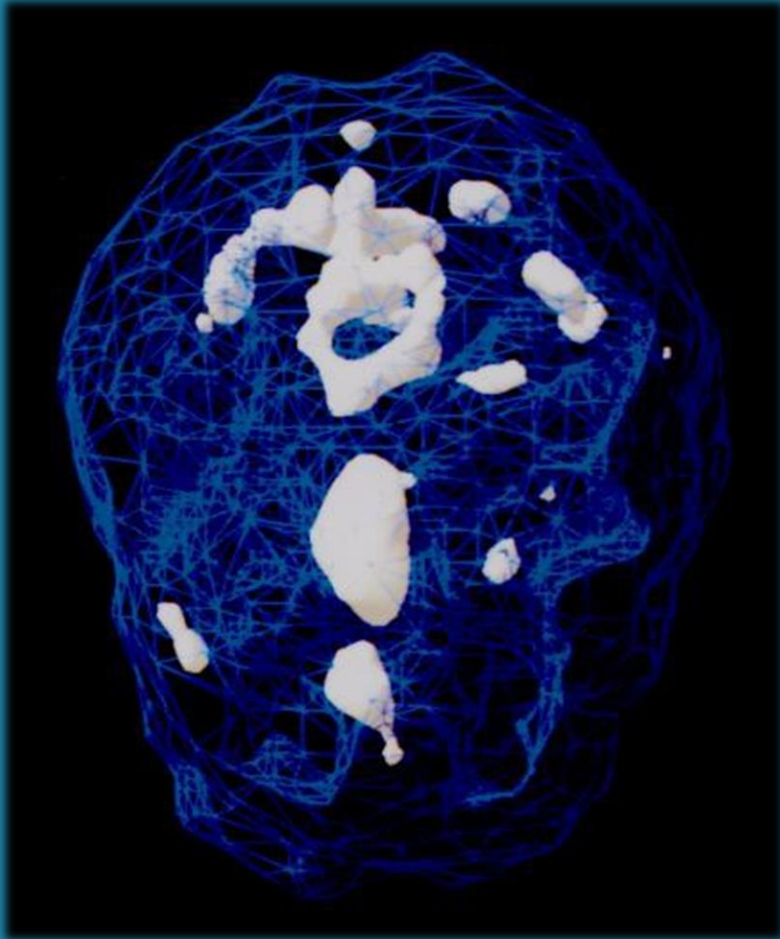
**No Meds**



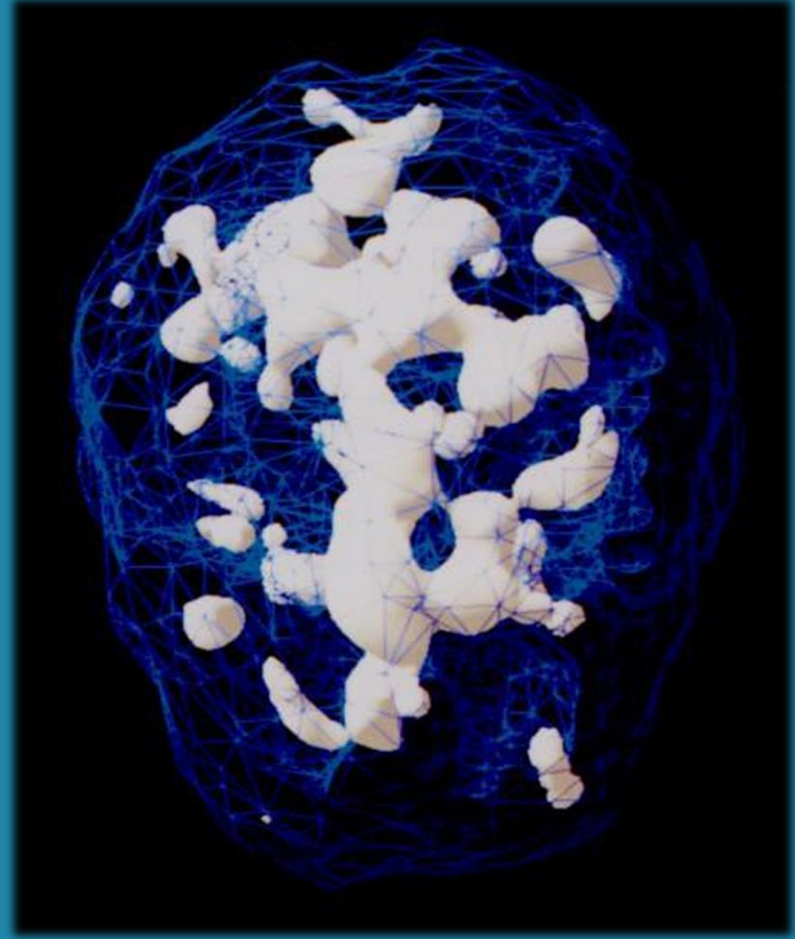
**Adderall 120mg**



# LP - Conc. Without and With Adderall



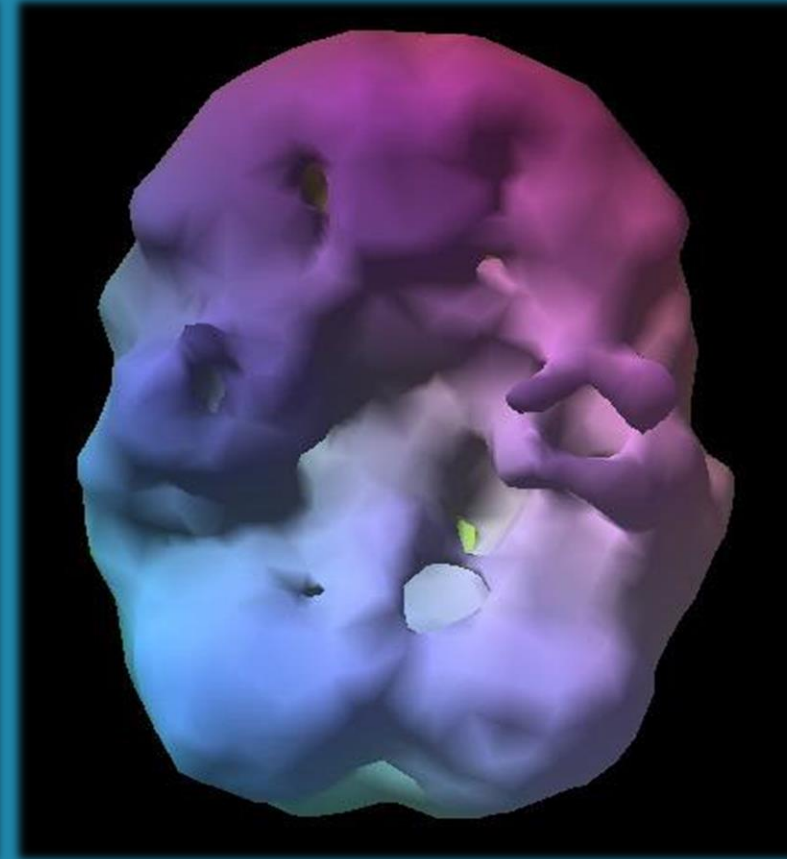
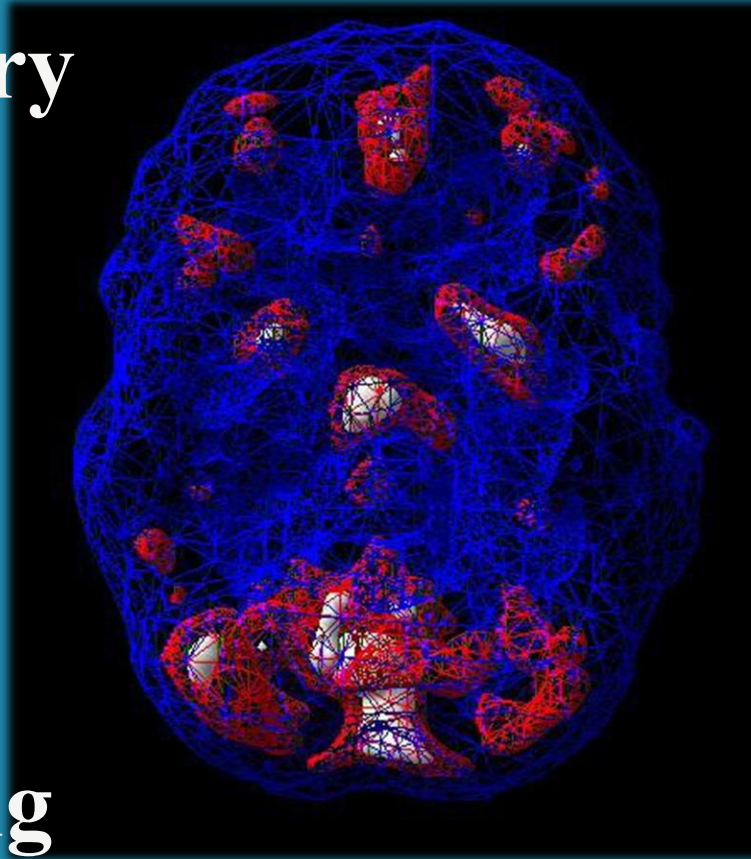
**No Meds**

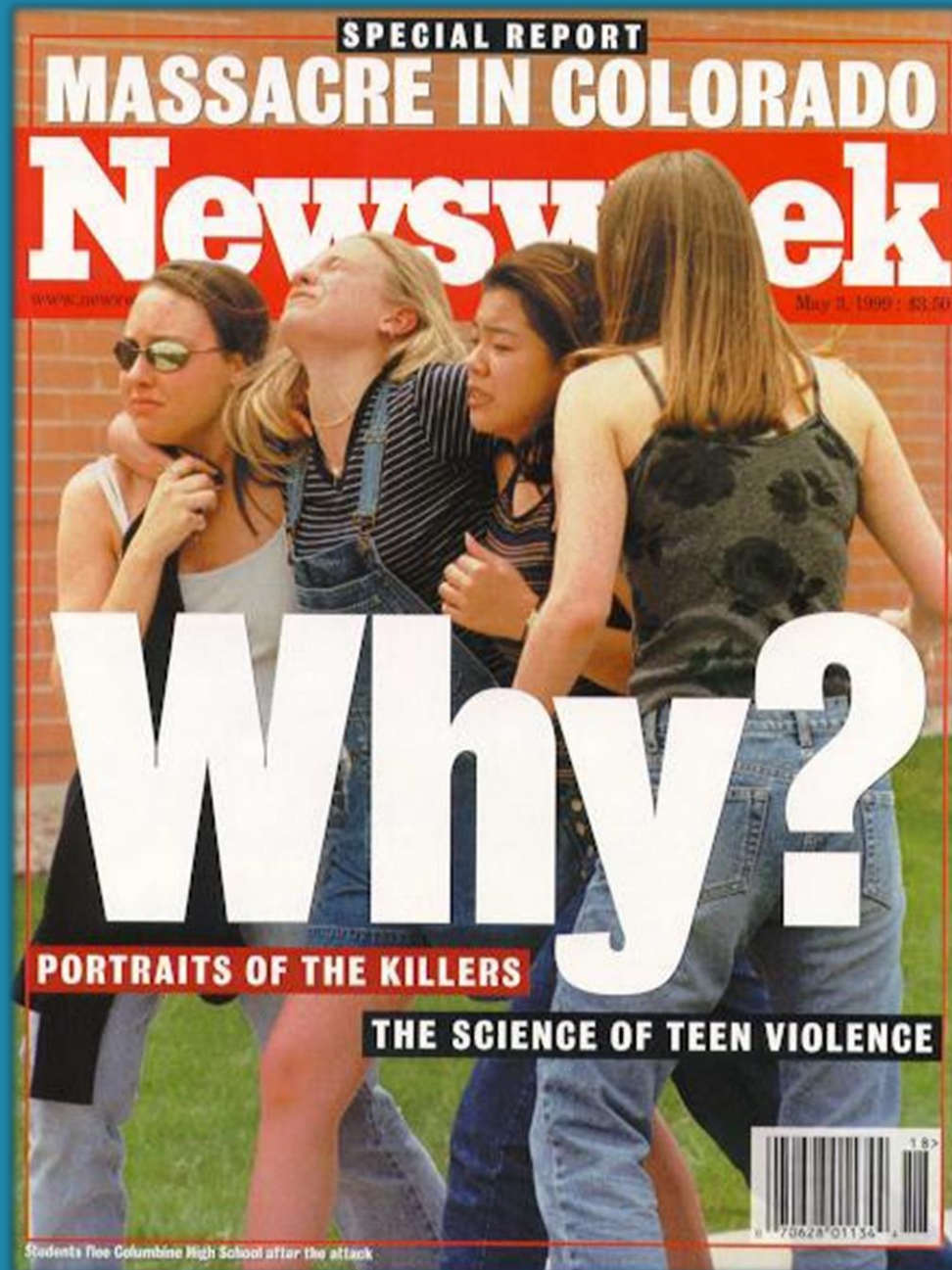


**Adderall 120mg**

# Jason Walker

- **Brain injury**
- **Obsession**
- **Jealousy**
- **Rape**
- **Kidnapping**





**SPECIAL REPORT**

**MASSACRE IN COLORADO**

**Newsweek**

www.newsweek.com

May 11, 1999 \$3.50

**why?**

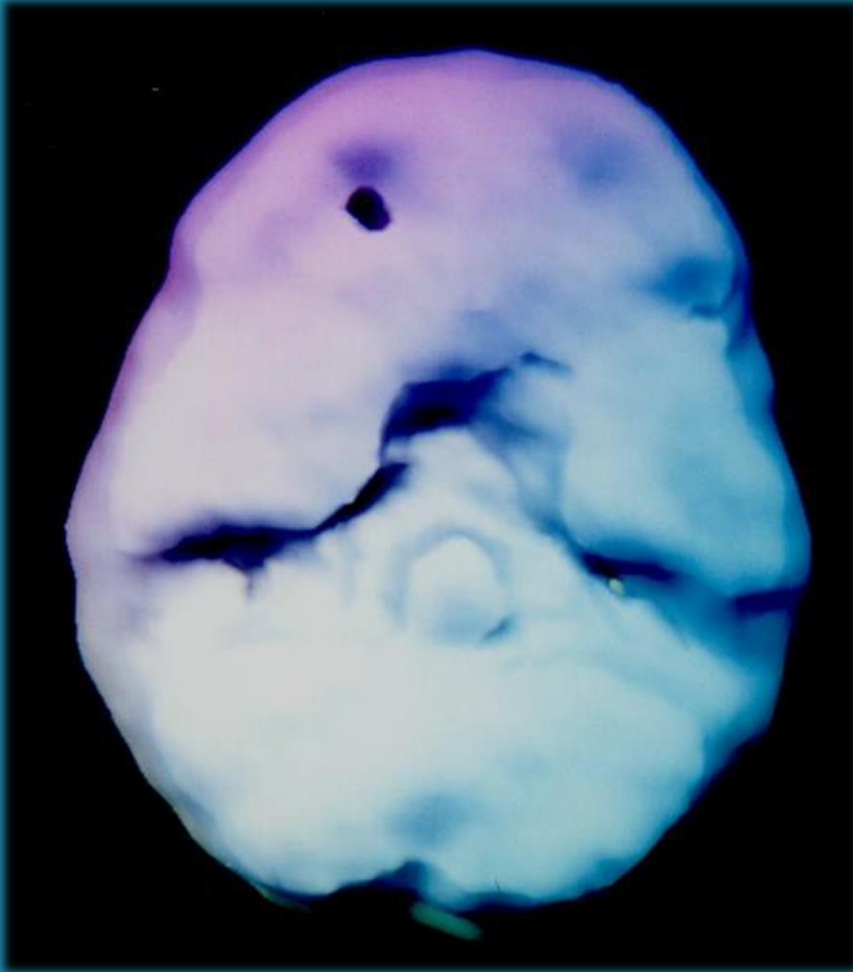
**PORTRAITS OF THE KILLERS**

**THE SCIENCE OF TEEN VIOLENCE**

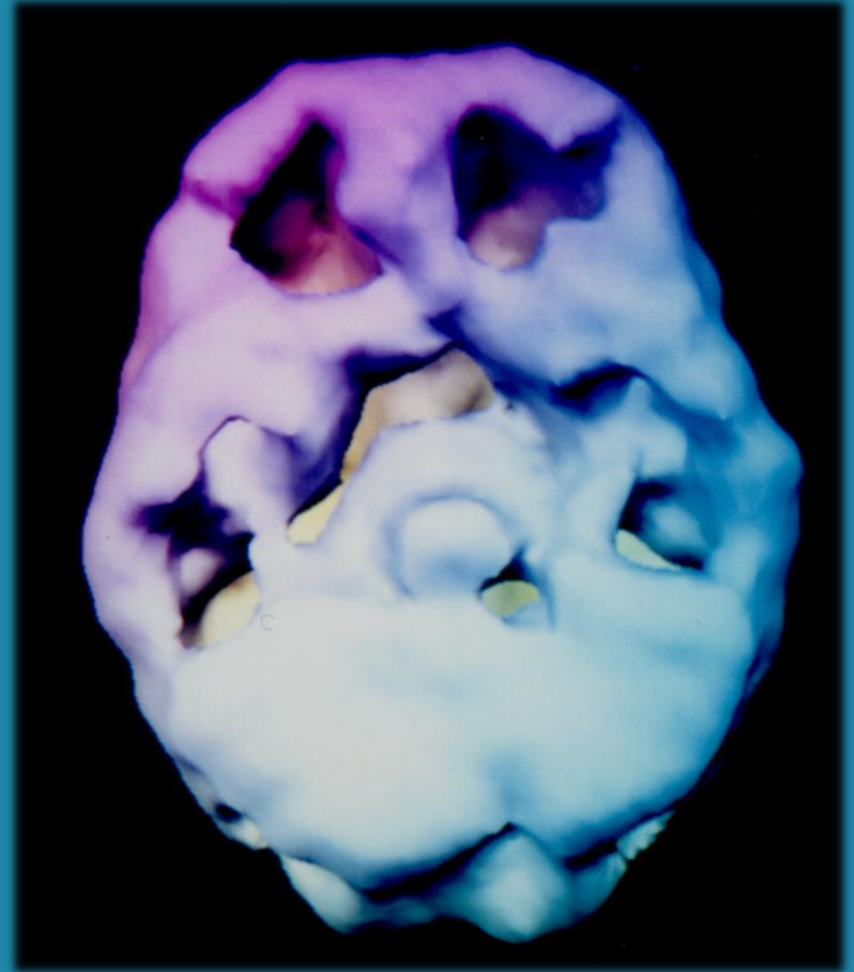


Students flee Columbine High School after the attack

# Normal

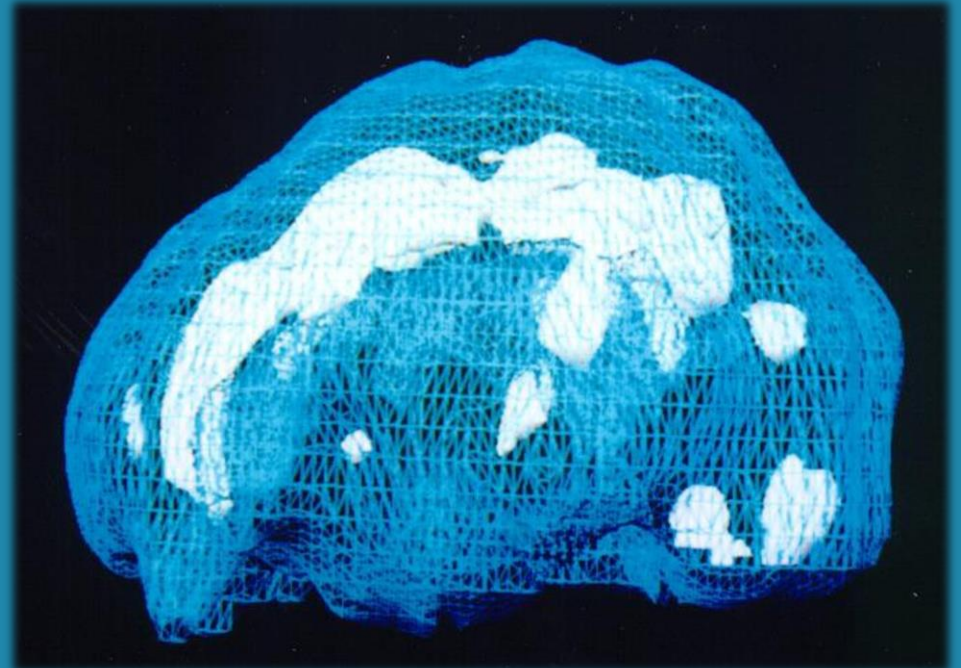
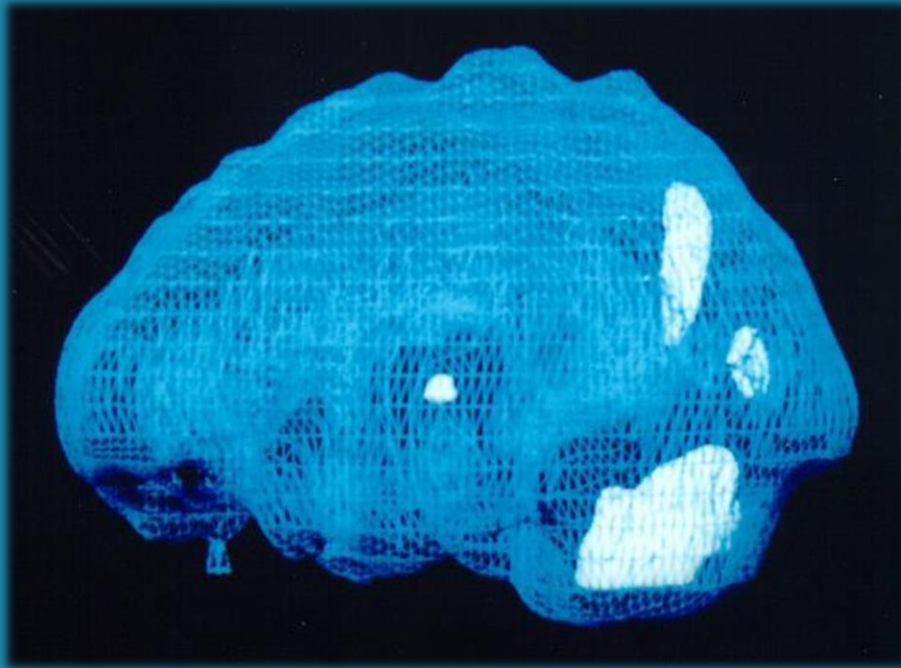


# Violent Juvenile



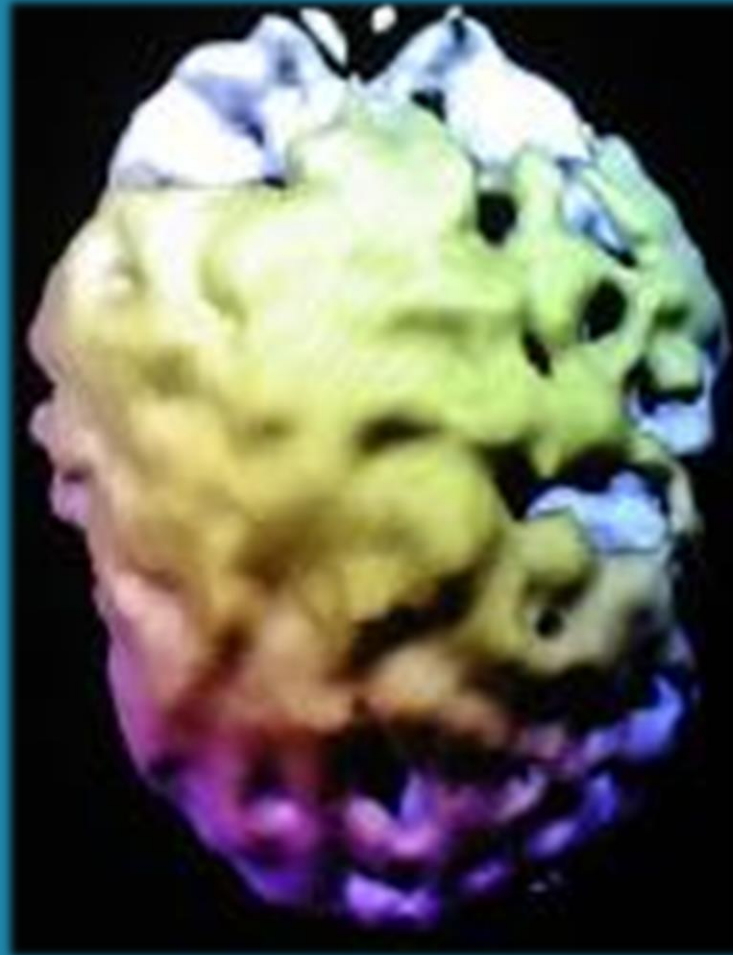
# Normal

# Violent Juvenile

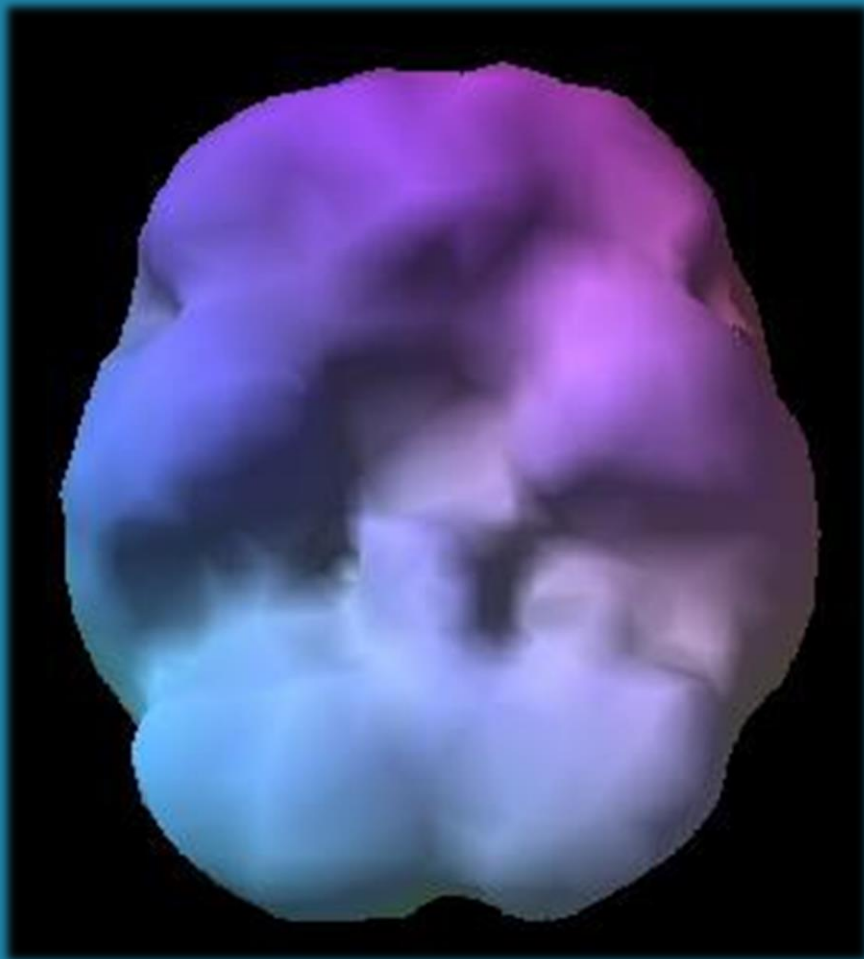


# Rape

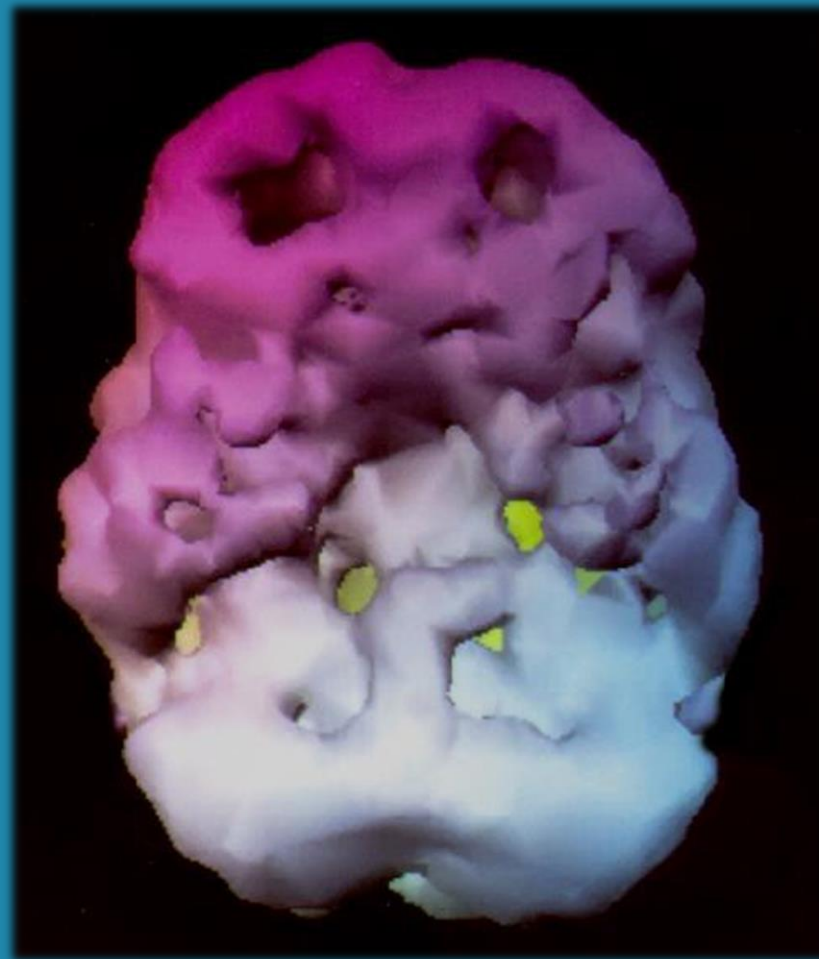
## Left Hemisphere/Brain Injury



# WHAT DOES HIS SOUL LIKE?

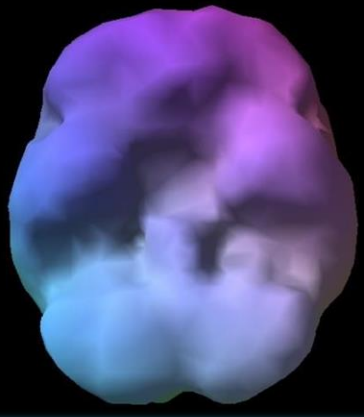


**Healthy Brain**

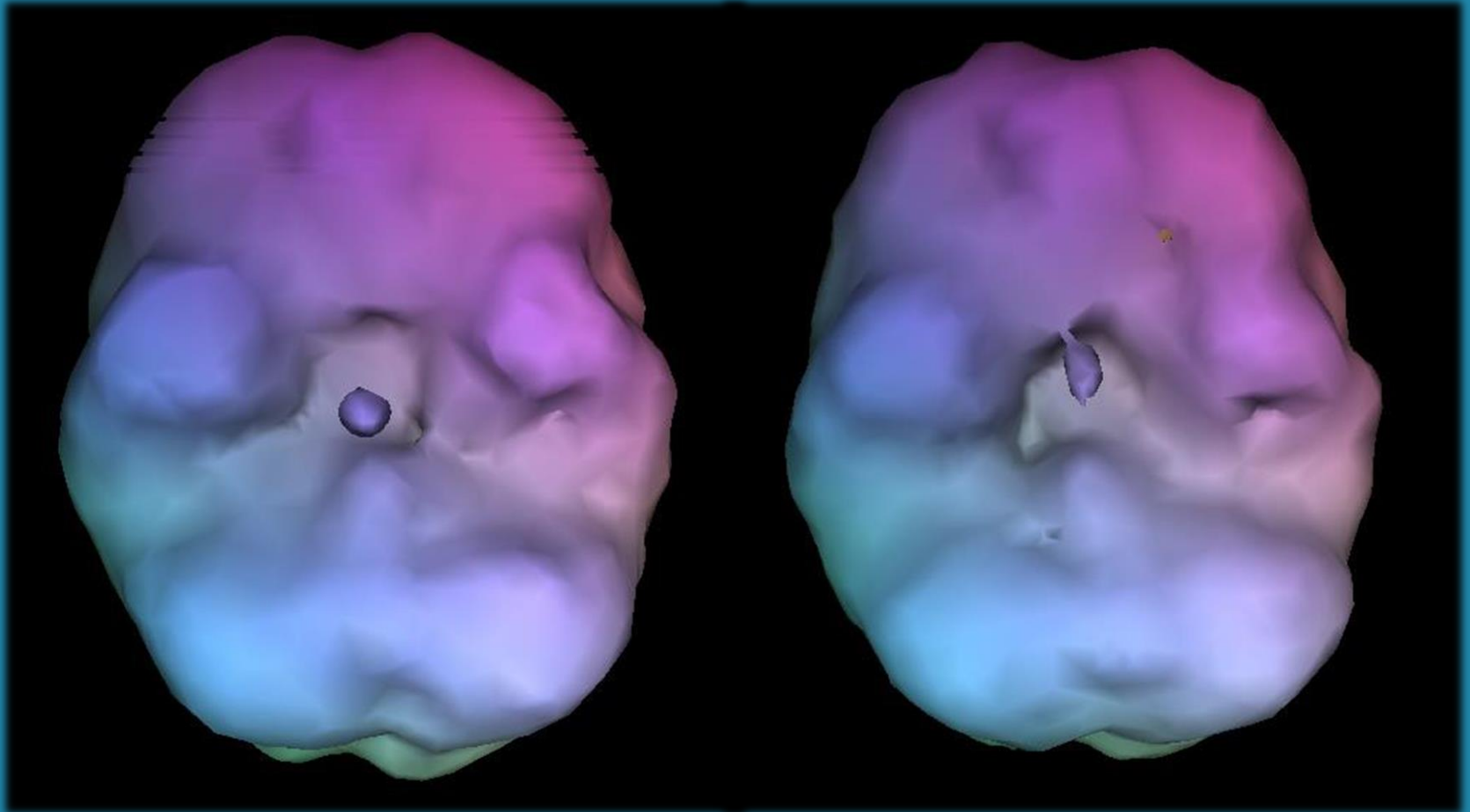


**Kip Kinkel**

# Mild Decreased LTL



**Healthy**

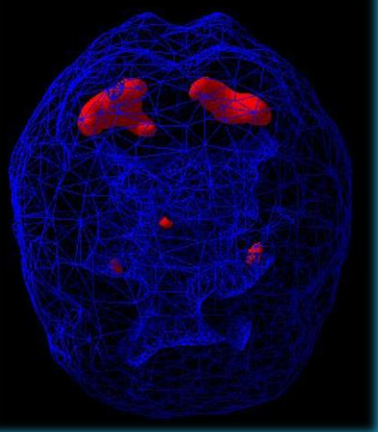


**Baseline**

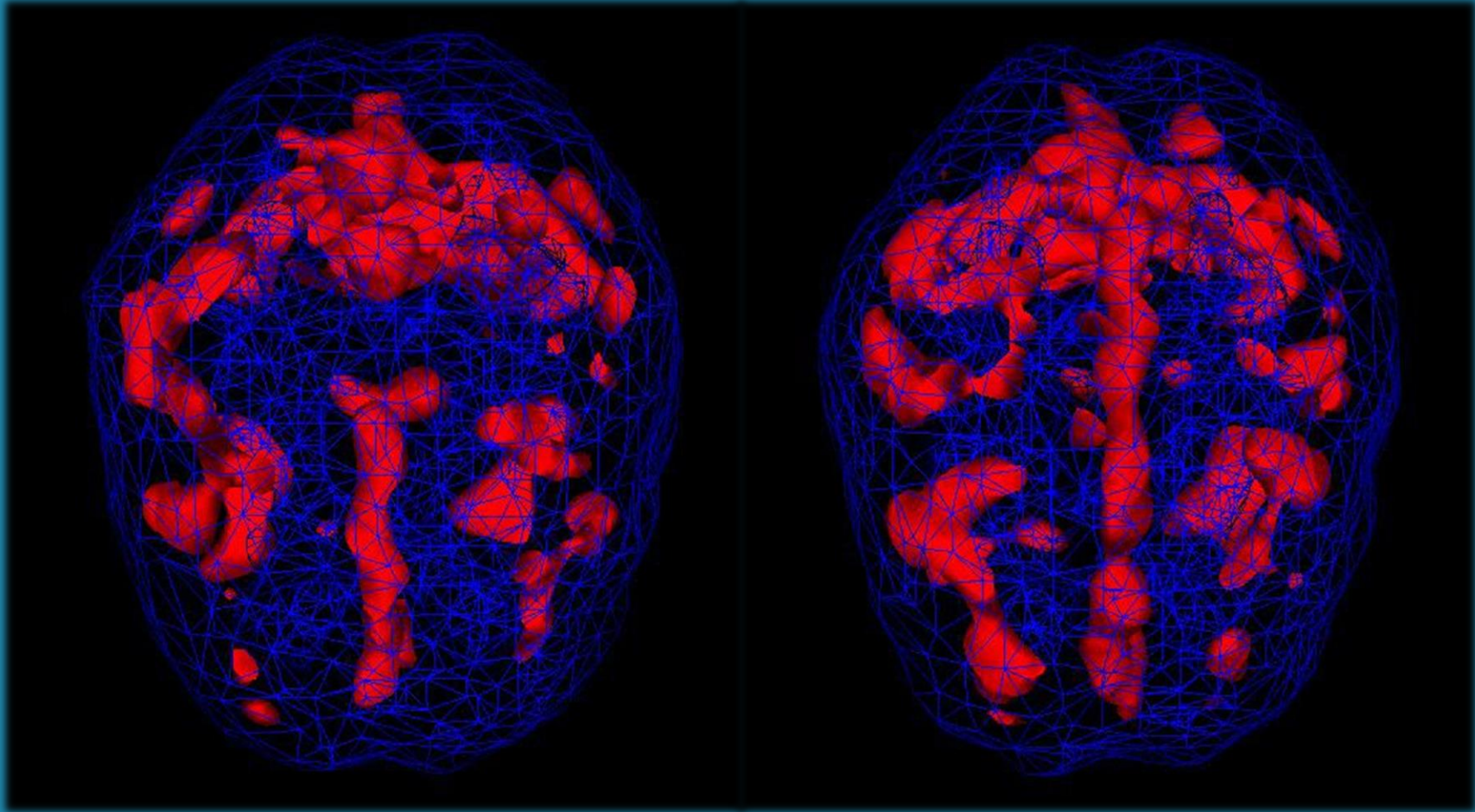
**Concentration**



# Ring of Fire



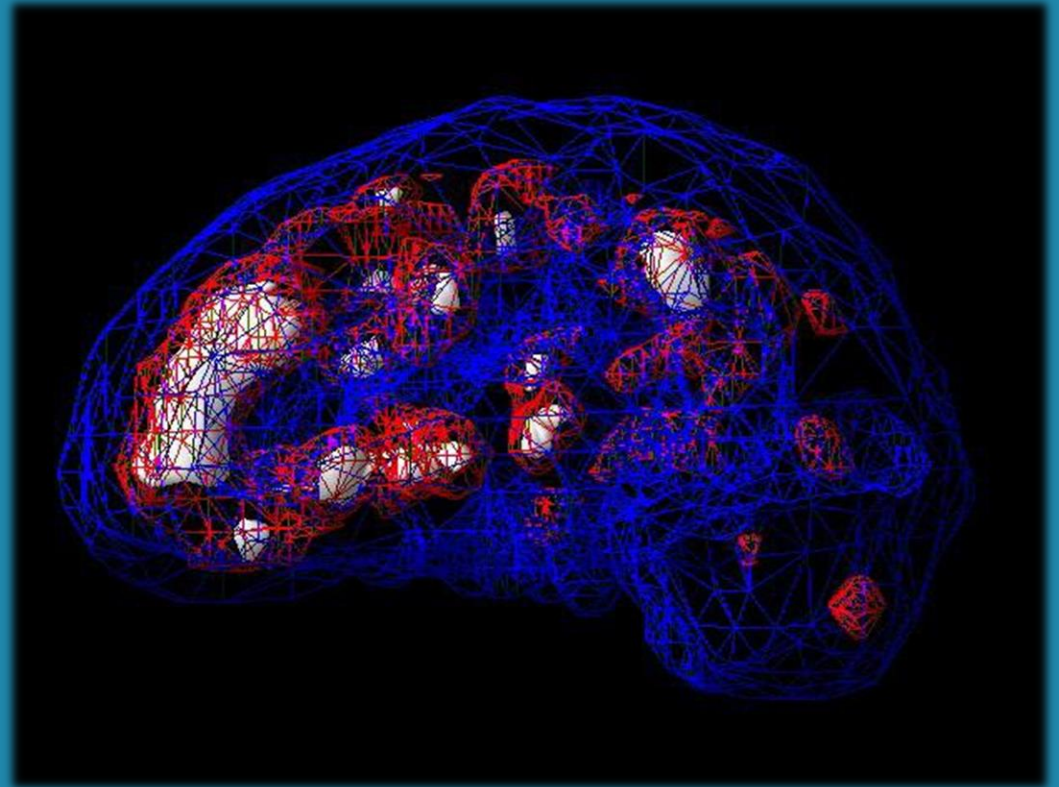
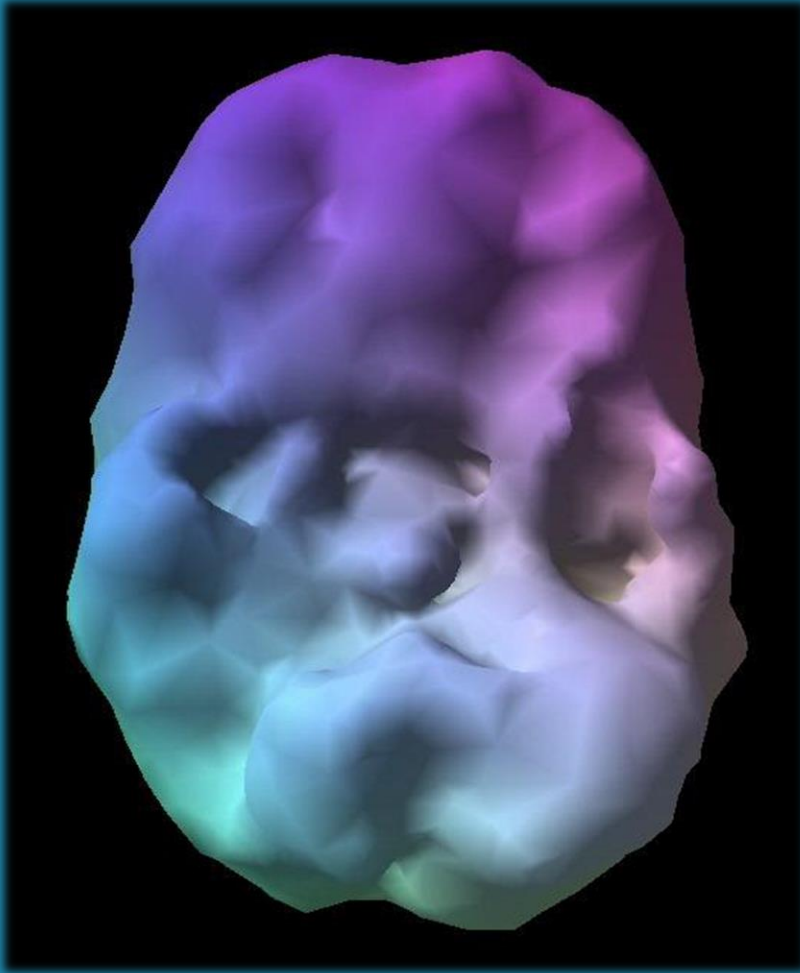
**Healthy**



**Baseline**

**Concentration**

# Trauma Induced Temporal Lobe Epilepsy and OCD



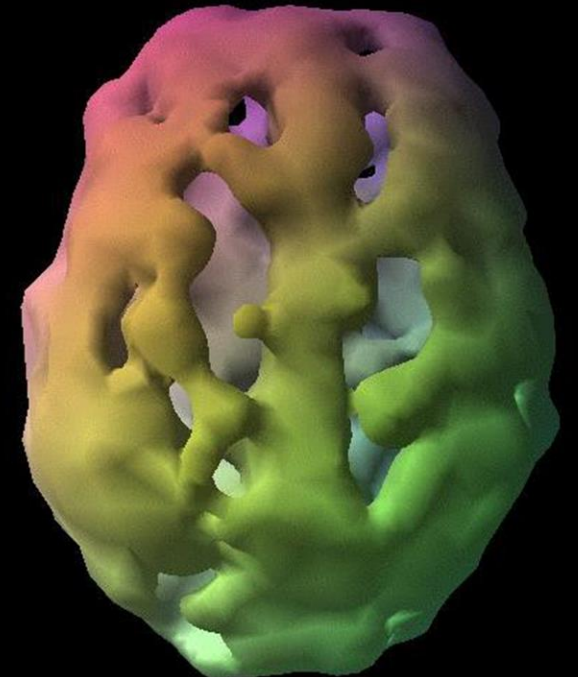
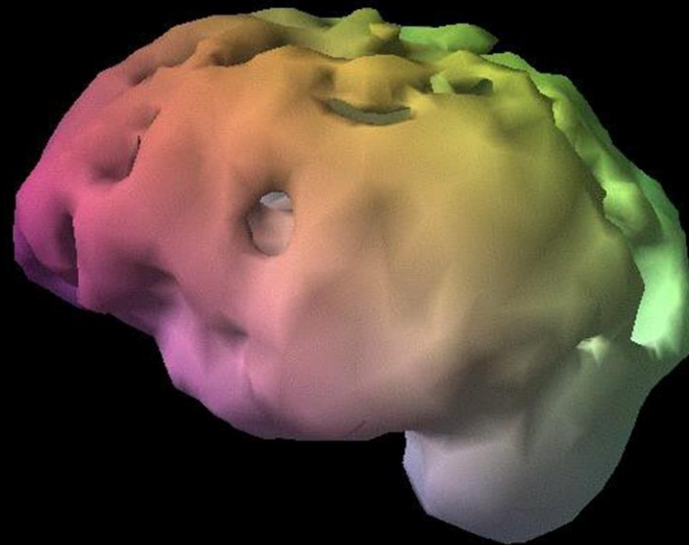
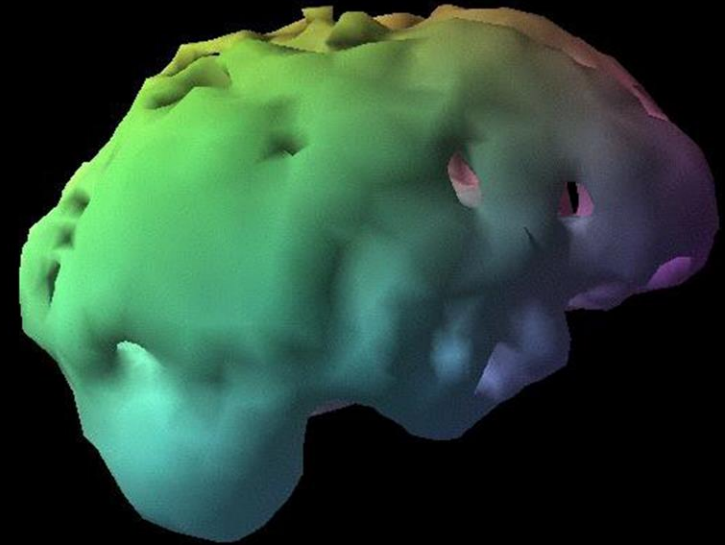
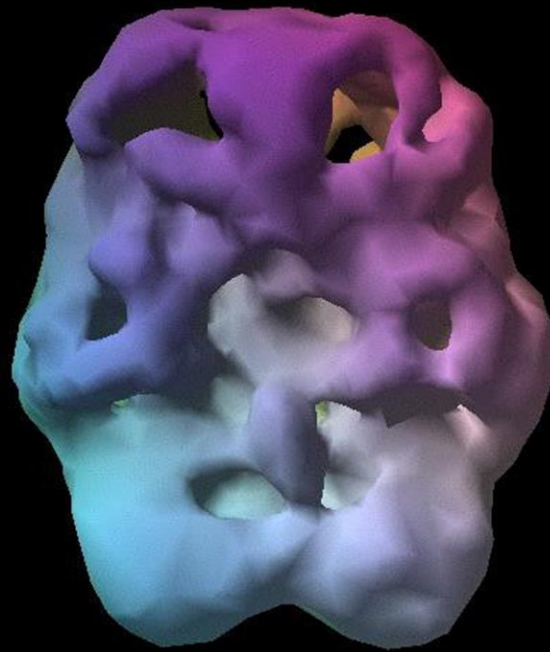
# Research Sample – Toxic Exposure

- **Rea, 2003, 30 patients with toxic mold exposure**
  - ❖ **86% had abnormal low activity**
- **Kao, 1994, 18 children with viral encephalitis**
  - (a) SPECT abnormal more often than CT/MR in acute phase and provided better location.**
  - (b) Acute encephalitis locally increased rCBF**
  - (c) After acute episodes, SPECT returns to normal in most**
  - (d) Normal SPECT in subacute phase usually indicates a good outcome after a year.**

# Research Sample – Toxic Exposure

- **Kao, 1998, 10 patients with CO poisoning**
  - ❖ Overall decreased perfusion
- **Vera, 1999, 26 children with cancer chemotherapy**
  - ❖ Pattern of decreased perfusion noted
- **Callender, 1993, 33 patients - environmental toxins**
  - ❖ 94% had abnormal SPECT scans with most frequent areas of abnormality being temporal lobes (67.7%), frontal lobes (61.3%), basal ganglia (45.2%), thalamus (29.0%), and parietal lobes (12.9%)

# Toxic Exposure



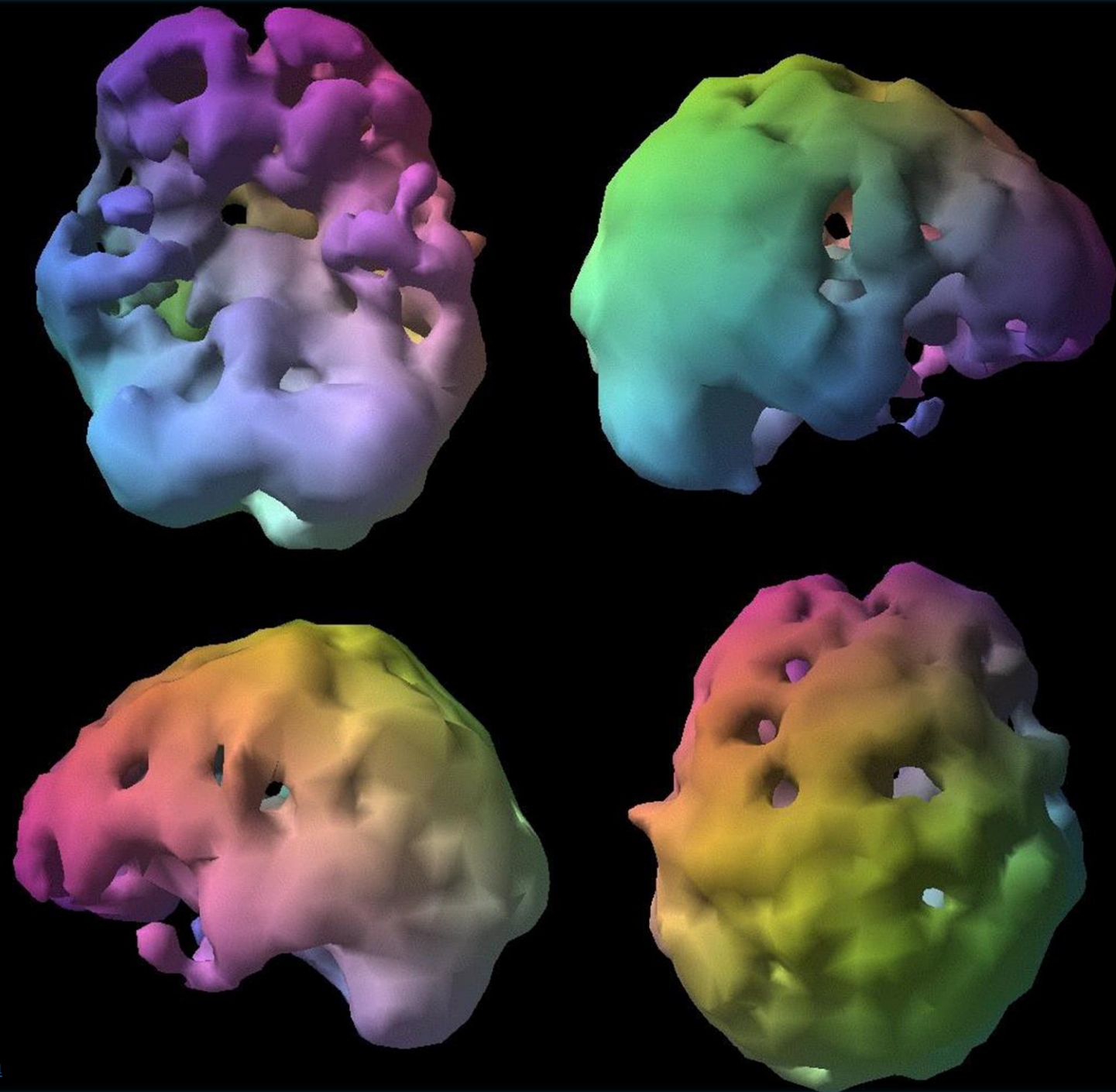
# Research Sample – Substance Abuse

- **Andinoff, 2006, 35 cocaine vs. 37 normals**
  - ❖ **Decreased bilateral orbital frontal PFC**
- **Kucuk, 2000, 10 teenagers with inhalant abuse**
  - ❖ **Serious decreased overall activity**
- **Okada, 1999, 16 solvent abusers**
  - ❖ **Overall decreased activity**
- **Botelho, 2006, 17 heroin addicts**
  - ❖ **Overall decreases especially in PFC**

# Research Sample – Substance Abuse

- **Tungving, 1986, 9 THC smokers**
  - ❖ **Decreased overall perfusion**
- **Noel, 2002, 20 alcoholics**
  - ❖ **Decreased medial PFC predicts increased relapse**
- **Pezawas, 2002, 21 opioid dependent**
  - ❖ **Overall decreased activity compared to normals**
- **Pallavicini, 2002, 60 drug abusers, abstinent 28 days**
  - ❖ **Abnormally decreased in 60% of patients**
- **Harris, 1999, 22 abstinent alcoholics and controls**
  - ❖ **Decreased cerebellum in abstinent alcoholics, increased aging**

# Substance Abuse





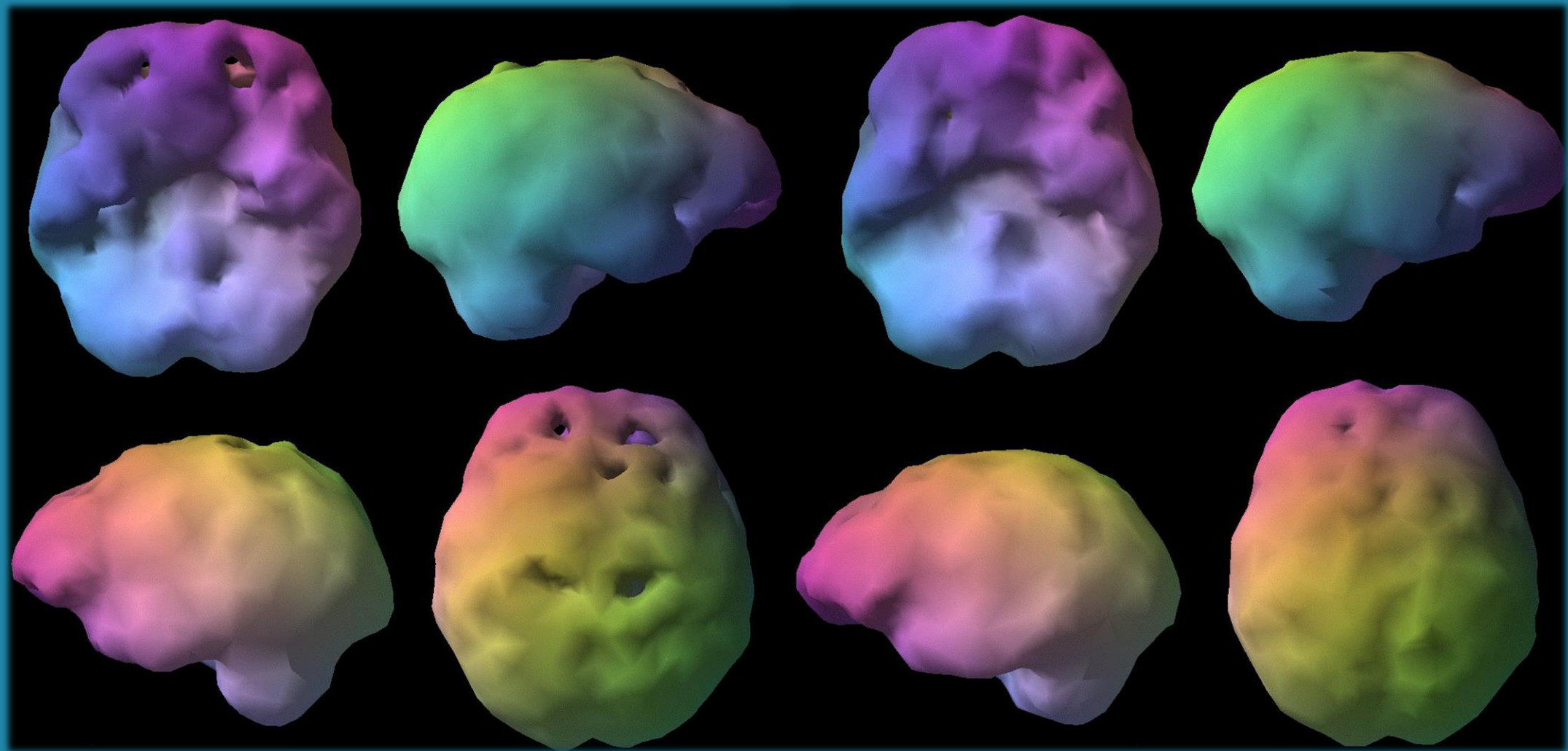
# Research Sample – Treatment Response

- 107 studies, 2695 patients
- Shi, 2003, 320 patients with brain injury and HBOT
  - ❖ HBOT increased SPECT and treatment response
- Cho, 2007, 34 children with ADHD, Ritalin + vs. –
  - ❖ SPECT correctly classified 88%, responders lower AC
- Lee, 2005, 23 ADHD, Ritalin improved i/o PFC
- Matthew, 1996, 10 SAD patients and light therapy
  - ❖ Increases in responders in PFC and AC

# Research Sample – Treatment Response

- **Amen, 2006, 6 police officers and EMDR**
  - ❖ **Decreased right lateral temporal lobe and increased L DLPFC**
- **Shimizu, 2006, 51 Alzheimer's with donezepil**
  - ❖ **Increased frontal lobes**
- **Vangu, 2003, 15 patients before and after ECT**
  - ❖ **Increases in PFC/temporal lobes in treatment responders**
- **Hoehn-Saric, 1991, 6 patients with OCD**
  - ❖ **Prozac decreases hyperfrontality in OCD**

# Treatment Response



# SPECT Treatment Prediction Biomarkers

- Cho 2007 (n34) - *ADHD children non-responders to stimulants had higher rCBF in AC and right BG. 88% classified correctly*
- Amen 2008 (n157) – *ADHD deactivation PFC pole + with concentration stimulant, activation associated with – stimulant response*
- Navarro 2004 (n47) – *Late onset severe depression, left frontal - cerebellar perfusion ratio positive predictive value of treatment 94%*
- Brockmann 2009 (n93) – *Depression hyperfrontality + SSRI response, low – SSR*
- Langguth 2007 (n24) – *Depression rTMS responders ↑ AC rCBF*
- Richieri 2011 (n18) – *Depression rTMS non-responders with lower PFC rCBF*
- Hanada 2013 (n45) – *Depression, older, non-responders lower middle frontal cortex and insular rCBF*

# SPECT Treatment Prediction Biomarkers

- Hoehn-Saric 2001 (n16) – *OCD treatment responders to SSRIs higher pre-treatment PFC rCBF*
- Noel 2002 (n20) – *Alcoholics PFC rCBF predicts relapse*
- Warwick 2006 (n31) – *Social Anxiety Disorder treatment response lower insular cortex citalopram (also AC) and moclobemide*
- Tanaka 2004 (n70) – *Alzheimer's temporal-parietal predicts positive response to donepezil*
- Kanetaka 2008 (n91) – *Alzheimer's PFC perfusion predicts positive response to donepezil*
- Jobst 1997 (n391) – *Predict Alzheimer's 89% sensitivity, 80% specific, 83% accurate, with CT 80% sensitive, 93% specific, and 89% accurate*

# SPECT Treatment Prediction Biomarkers

- Bonte 2006 (n49) – *Autopsy confirmed Alzheimer's, sensitivity 87%, specificity 89%, ppv 93%, npv 83%, accuracy 88%*
- Bonte 2004(n20) – *95% separates Alzheimer's & FTLD PC sign*
- Guedj 2007 (n17) – *Fibromyalgia ↓ bilateral medial PFC rCBF predicts negative response to ketamine (100%ppv, 91% npv)*
- Eturgul 2009 (n22) – *Schizophrenia, treatment responders showed higher frontal basal ganglia perfusion with treatment*
- Rodriquez 1997 (n39) – *Schizophrenia ↑ thalamus, left basal ganglia, right prefrontal predicts positive response to clozapine*
- Kao 1994 (n18) – *Childhood viral encephalitis – early healthy SPECT predicts positive outcome at 1 year*
- Jacobs 1996 (n136) – *mTBI predicts outcome at 1 year, sensitivity 100%, specificity 85%, 83/89% positive/negative predictive value*

# Answering Important Questions

## ➤ **SCIENTIFIC EVIDENCE?**

>2800 articles housed on website about SPECT in clinical psychiatric practice

## ➤ **HAS DR. AMEN'S TEAM PUBLISHED RESEARCH**

>50 peer reviewed articles

## ➤ **CAN'T DOCTORS TELL CLINICALLY?**

How can you tell without looking? Large outcome studies say most psychiatric treatments are not better than placebo

## ➤ **EXPENSE?**

Consider cost of having an ineffectively treated psychiatric disorder

## ➤ **RADIATION DOSE WITH SCANS?**

Exposure is less than most CT scans, which are routinely ordered when needed

## ➤ **WILL IT IMPROVE OUTCOMES?**

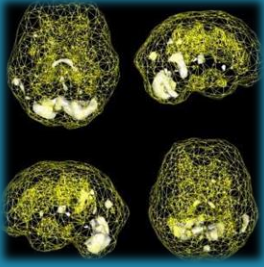
ACI sees complex patients who failed 3 providers and 6 medicines, after 6 months >75% show improvement across all measures, 85% improved QOL

## ➤ **DOES ACI MAKES DIAGNOSES ONLY FROM SCANS?**

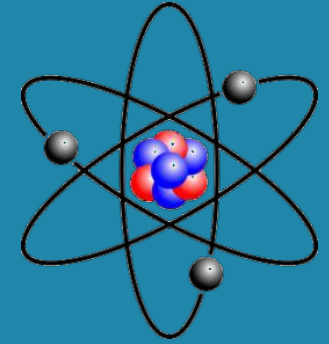
No, we use scans in the context of full bio / psycho / social / spiritual evaluations

## ➤ **WILL SCANS GIVE A FINAL DIAGNOSIS**

They don't. You have to talk to people. Scans give the underlying physiology of what you are treating to better guide treatment plan

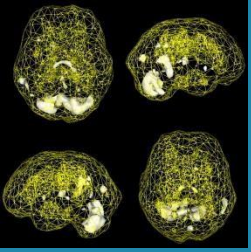


# Brain SPECT Imaging Made Ridiculously Simple



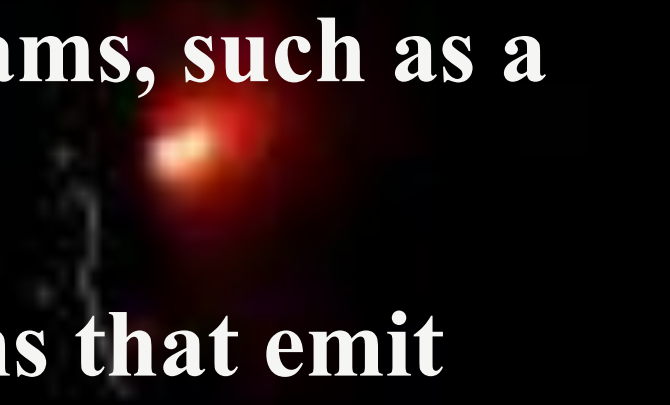
- **How SPECT works**
- **Nuclear physics made simple**
- **SPECT performed, processed and rendered**
- **Review of SPECT cameras and imaging agents**
- **Reading SPECT**
- **How scans can fool you if you are not careful**

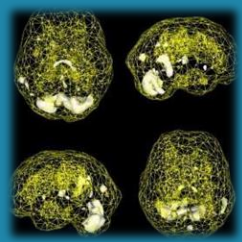




# How SPECT Works

- In nuclear imaging, radioisotopes are used
- They act like tracers or light beams, such as a flare at sea to track a lost boat
- Radioisotopes are unstable atoms that emit gamma rays or photons that can be measured by gamma cameras





# How SPECT Works

- These radioisotopes are attached to medications (radiopharmaceuticals RP) that are easily taken up by certain organs, such as the brain or heart
- The RP can be injected, swallowed or inhaled
- A camera detector takes a picture of where RP has gone, giving images of living tissue activity

# Periodic Table of the Elements

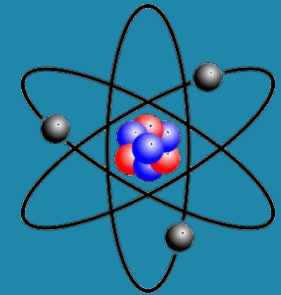
IA											VIIIA																				
1 H 1.0079											2 He 4.0026																				
3 Li 6.941	4 Be 9.0122											5 B 10.81	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.179														
11 Na 22.990	12 Mg 24.305	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.06	17 Cl 35.453	18 Ar 39.948																								
19 K 39.098	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.941	24 Cr 51.996	25 Mn 54.938	26 Fe 55.847	27 Co 58.933	28 Ni 58.71	29 Cu 63.546	30 Zn 65.38	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.904	36 Kr 83.80														
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30														
55 Cs 132.91	56 Ba 137.33	57 La 174.97	58 Ce 178.49	59 Pr 180.95	60 Nd 183.85	61 Pm 186.21	62 Sm 190.2	63 Eu 192.22	64 Gd 195.09	65 Tb 196.97	66 Dy 200.59	67 Ho 204.37	68 Er 207.2	69 Tm 208.98	70 Yb (209)	71 Lu (210)	72 Hf (211)	73 Ta (212)	74 W (213)	75 Re (214)	76 Os (215)	77 Ir (216)	78 Pt (217)	79 Au (218)	80 Hg (219)	81 Tl (220)	82 Pb (221)	83 Bi (222)	84 Po (223)	85 At (224)	86 Rn (225)
87 Fr (223)	88 Ra (226.03)	89 Ac (260)	90 Th (261)	91 Pa (262)	92 U (263)	*Name Not Officially Assigned																									

- Alkali Metals
- Alkaline Earth Metals
- Transition Metals
- Other Metals
- Nonmetals
- Noble Gases
- Inner Transition Metals
- Gaseous State
- Liquid State
- Solid State
- Synthetically Prepared

Lanthanide Series	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.4	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04
Actinide Series	89 Ac (227)	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)

# Technetium

- Technetium has 22 reported isotopes, mass number ranging from 90-111
- Tc 99 (43 protons, 56 neutrons)
- **Half-life = 6.01 hours**
- Need a full 24 hours between scans



# Units of Radioactivity

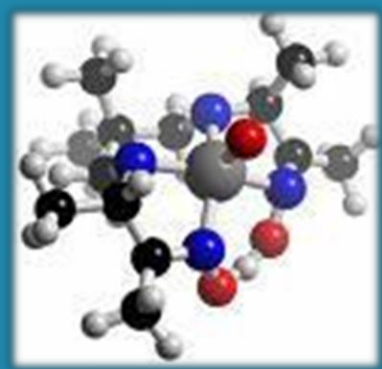


## Becquerel (Bq)

- **1 Bq = one radioactive decay per second**

## Curie (Ci)

- **1 Ci =  $3.7 \times 10^{10}$  radioactive decays per second**
- **Typical patient dose is 20-25 millicuries of Tc**



# SPECT Radiopharmaceuticals

- **Currently, two clinically available tracers**
- **Ceretec (HMPAO, Exametazime)**
- **Neurolite (ECD, Bicycysate)**
- **Both have advantages and disadvantages.**

# HMPAO Ceretec

- **80% taken up in a first pass extraction**
- **Peak uptake within several minutes of injection**
- **Taken up through blood-brain barrier (BBB), converted to another shape that cannot cross back over BBB**
- **Remains fixed in brain for several hours**
- **Measures regional cerebral blood flow**

# HMPAO Ceretec

## Advantages

- Seems to provide more stable imaging over time
- Main tracer uptake is in the cerebellum, which contains half of the brain's neurons
- Amen Clinics database is made up almost exclusively of HMPAO scans

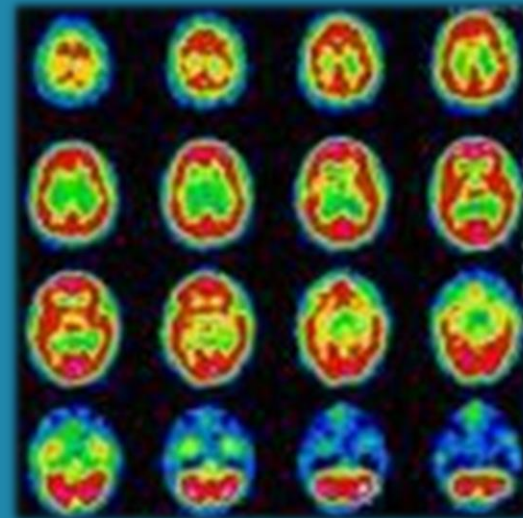
## Disadvantages

- It can be taken up outside of the brain and cause artifacts that need to be understood and dealt with



# ECD Neurolite

- **Enters brain tissue through BBB**
- **Also converted to a form which cannot pass back through the BBB**



# ECD Neurolite

## Advantages

- Major advantage is that there is no extra-axial uptake, such as in the tear ducts or parotid glands, and artifact is less of a problem.

## Disadvantage

- In our experience, ECD underperfuses the temporal lobes, which needs adjustment in comparing it to HMPAO scans
- ECD does not seem as stable over time, and its most intense uptake is in the occipital lobes, as opposed to the cerebellum

# Other Tracers and Agents

- **Xenon 133 gas, blood flow tracer**
- **DaTscan for DA receptors**
- **Iodine 123 amphetamine (IMP)**
  - ❖ **Iodine-123-QNB, an acetylcholine muscarinic antagonist, for Alzheimer's disease**
  - ❖ **Iodine-123-Iodine labeled ligands IBZM and IBZP for imaging dopamine system in Parkinson's disease**
  - ❖ **Iodine-123 labeled ligands for imaging the benzodiazapine and the serotonin receptors**

# Safety of SPECT

- **Brain SPECT imaging is a safe procedure**
- **Radiation from Tc-99m HMPAO is 0.7 rem (Roentgen equivalent man) per 20 mCi dose**
- **Similar to bone scan or head CT**
- **43% of the average annual background radiation in the U.S.**
- **OSHA gives 5 rem a year as a safe exposure**

# Safety of SPECT

Devous, past president of SNM, writes:

*SPECT and PET have no more risk than MRI-based procedures...*

*Indeed, there are no data that have ever demonstrated any harm to humans by radiation exposure at diagnostic imaging levels. In fact, current data support the presence of radiation hormesis: that low levels of radiation exposure induce beneficial effects of cellular repair and immune system enhancement... Therefore it should be concluded that neither SPECT nor PET brain imaging procedures are associated with any particular risk over activities of daily living and certainly should not be considered to be any more “risky” than MRI or any of its associated functional imaging derivatives*

# The Gamma Camera

**Gamma camera collects photons emitted from patient, enabling scientists to reconstruct a picture of where the gamma rays originated and determine how a particular organ or system is functioning.**



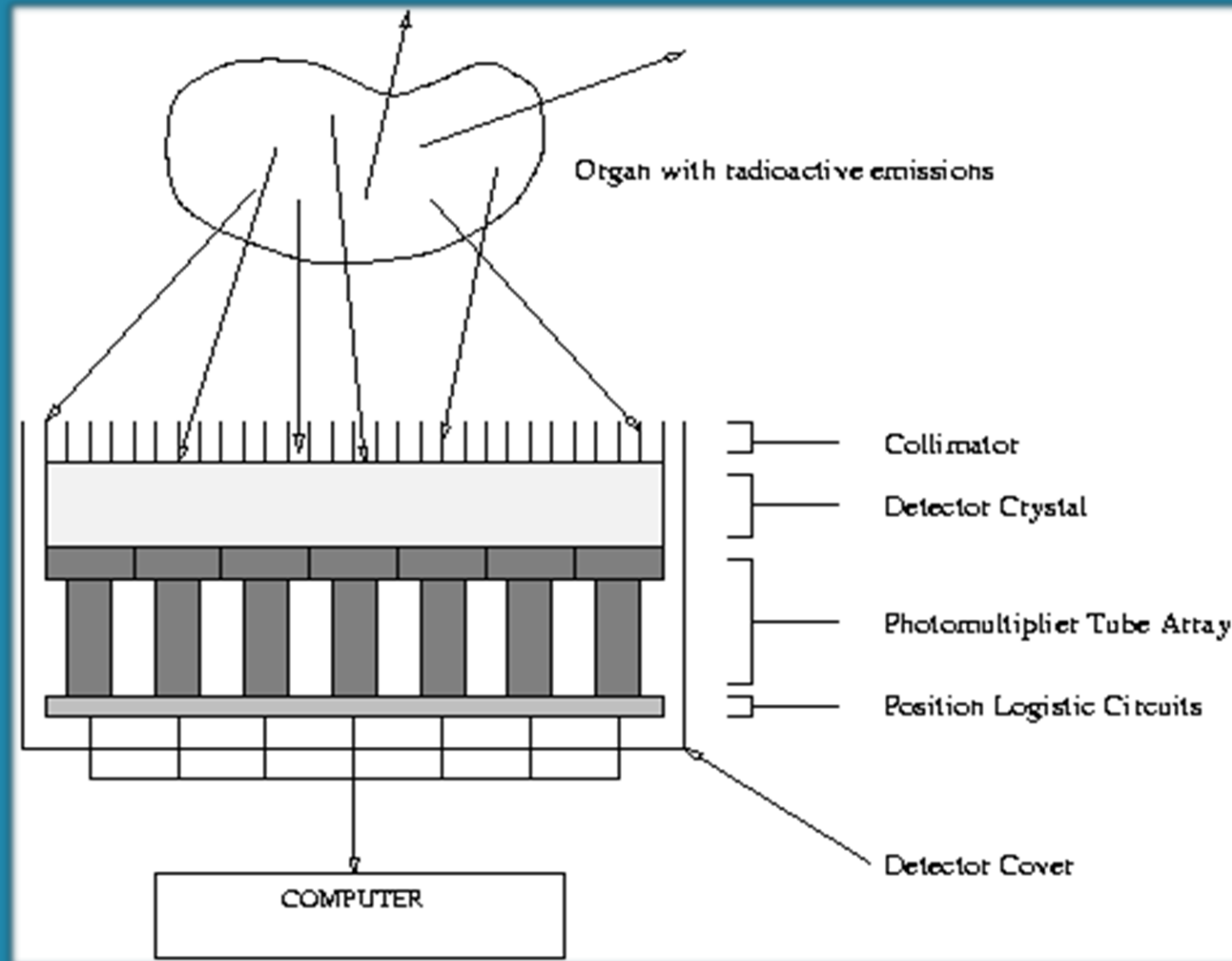
# The Gamma Camera

➤ **Components making up the gamma camera are:**

- ❖ **Collimator**
- ❖ **Detector crystal**
- ❖ **Photomultiplier tube array**
- ❖ **Position logic circuits**
- ❖ **Data analysis computer**



# The Gamma Camera

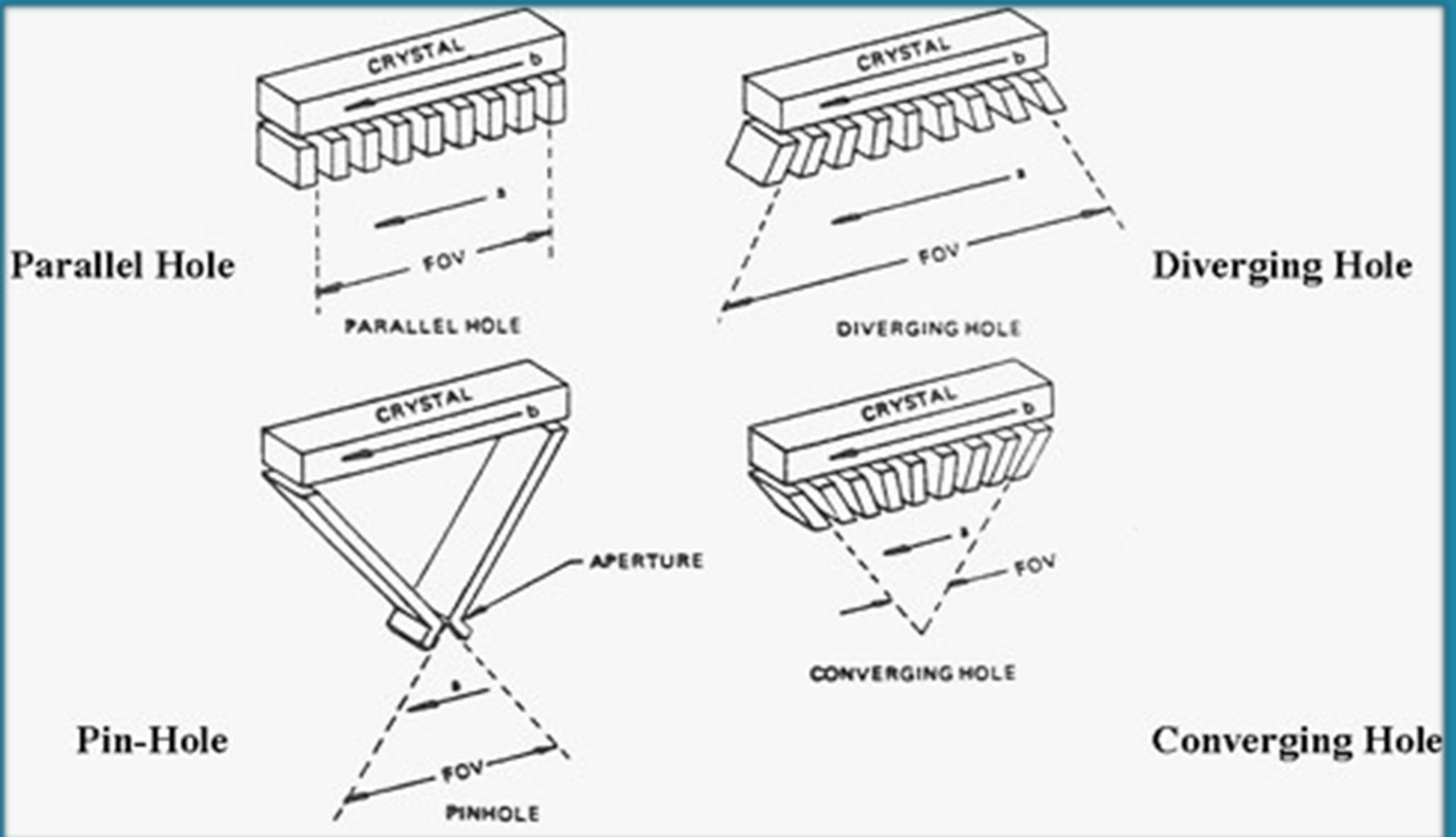




# Collimator

- **The first object emitted gamma photon encounters after exiting the body is the collimator**
- **Pattern of holes through gamma ray absorbing material, usually lead or tungsten, that allows the projection of the gamma ray image onto the detector crystal**

# Collimator – Parallel vs. Fan Beam

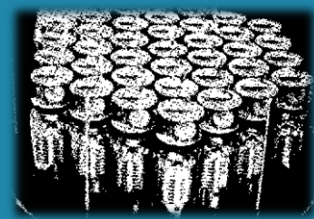


# Detector Crystal



- **Detect photons**
- **Sodium iodide [NaI] detector crystal optimal**
- **Typically 3/8" thick**
- **Photon interacts with crystal causing the release of electrons which in turn interact with the crystal lattice to produce light**
- **Process known as scintillation.**

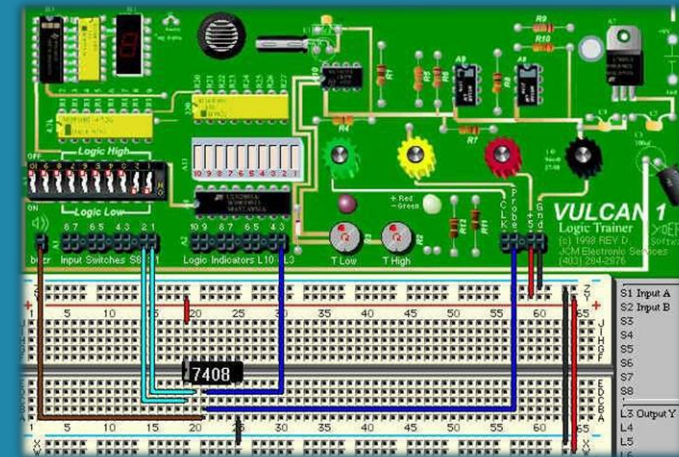
# Photomultiplier Tubes PMT



- Only very small amount of light given off from scintillation detector, so PMT tubes attached to the back of crystal.
- PMT tubes detect and amplify the electrons and converts them into an electrical pulse.
- Each gamma camera has several photomultiplier tubes arranged in a geometrical array. The typical camera has 37 to 91 PMT's.

# Position Logic Circuit

- Immediately follow the PMT tube array
- Receive the electrical impulses from the tubes
- Allows the position circuits to determine where each scintillation event occurred in the detector crystal.



# Data Analysis Computer

- **Finally, to deal with incoming data and process it into a readable image a processing computer is used**
- **Computer may use various different methods to reconstruct an image**



# Images

- **Images acquired are digital consisting of picture elements called pixels**
- **Typical SPECT acquisition consists of 60 to 120 projections**
- **Each projection will have approximately 100,000 counts, and take about 20 seconds**
- **Each scan is made up of about 10 million counts or times the photons hit the crystals**

# Time in Camera

- **Data acquisition times for a complete SPECT scan:**
  - ❖ **Single headed camera 46-60 minutes**
  - ❖ **Dual headed camera 30 min**
  - ❖ **Triple headed camera 15 min**





# Dual Head SPECT System

- **Most commonly used in a hospital setting and enjoys the largest installed base**
- **Performs all types of nuclear medicine studies; excellent general purpose system.**



# Triple Head SPECT System

- Specialized system, optimized for brain and cardiac imaging
- Small detectors allow for “close in” positioning of detectors
- 3 heads means short acquisition/scanning times
- Largest installed base of any brain SPECT system



# Performing Brain SPECT



# Pre-Arrival

- **Patients instructed on day of exam to avoid:**
  - ❖ **caffeine and alcohol**
- **Stop stimulants 4 days prior to the scan**
- **Check with their doctor about other prescription medications**
- **A number of psychiatric medications have long biological half-lives**



# Scanning On or Off Medication

- **I prefer brains off medication, but...**
- **Depends on the question being asked**
- **If someone stable on meds wants additional help, then scan them on their medications**
- **If meds not helpful, then take them off until washed out of body, then scan**

# Informed Consent

- **Enclosed in handout material**
- **Send ahead of time**
- **Ensure patients know about injection and radiation exposure**
- **Insurance reimbursement varies by plans. Have patients check with their company to see if it is a covered benefit.**

# Informed Consent



## Risks?

- **Study does not involve a dye**
- **People do not have allergic reactions to the study**
- **Possibility exists, although very small, of a mild rash, facial redness and edema, fever and a transient increase in blood pressure**
- **Amount of radiation exposure from one brain SPECT study is approximately same as head CT scan**
- **Rarely, patients have green urine for a day or two**

# Pre-Injection

- **Steps to achieve consistent scan environments:**
  - ❖ **Seat patient in a quiet, dimly-lit room, eyes and ears open**
  - ❖ **No gum or candy to minimize extra-axial tracer uptake**
  - ❖ **Place intravenous access at least 5-10 minutes prior to injection to permit accommodation**
  - ❖ **Instruct the patient not to speak**
  - ❖ **Minimize interaction with the patient during and up to 15 min post-injection**
  - ❖ **Closely monitor demented patients and those with neurologic or movement disorders**



# Why Two Scans?

- **Best information obtained with two scans**
- **Various disorders affect the same regions of the brain in different ways depending on rest or concentration**
- **To minimize residual activity interfering with the second study, the intervening time between two studies should be no less than 24 hours**
- **ACI usually does concentration scan first**

# Baseline Study

- **Patient sits quietly for about 10 minutes before injection of the radiopharmaceutical**
- **Patient instructed not to talk and to just allow his or her mind to wander**
- **After the injection patient should remain quiet for a minimum of 10 minutes**

# Concentration Study

- **Protocol consists of a standardized concentration challenge task administered by a computer (Conner's CPT)**
- **Protocol lasts 15 minutes**
- **Tracer administered at 3 minutes into the test, allowing at least 10 minutes of concentration following injection**

# Scan

- **Image acquisition may begin 20-30 minutes after the resting or concentration phase**
- **Patient needs to hold very still**
- **If desired, give patient a blanket, as room is often cold for health of cameras**
- **Goal is 10,000,000 counts per stud**
- **With HMPAO, imaging should be completed within 4 hr post injection if possible**

# Sedation



- **After injection**
- **IV Versed (midazolam), needs to be monitored**
- **Short acting**
- **Amnestic**
- **Consult with an anesthesiologist or nurse anesthetist**

# Information Pertinent Reading the Scan

- **The following data is essential for proper interpretation of scan:**
  - ❖ **Patient history (including any past drug use or trauma)**
  - ❖ **Age, gender**
  - ❖ **Reason for the study**
  - ❖ **Current medication and when last taken**
  - ❖ **Time of start of last menstrual cycle**
  - ❖ **Any recent morphologic imaging studies (e.g. CT, MRI)**

# Brain SPECT Processing



# Processing Raw Data

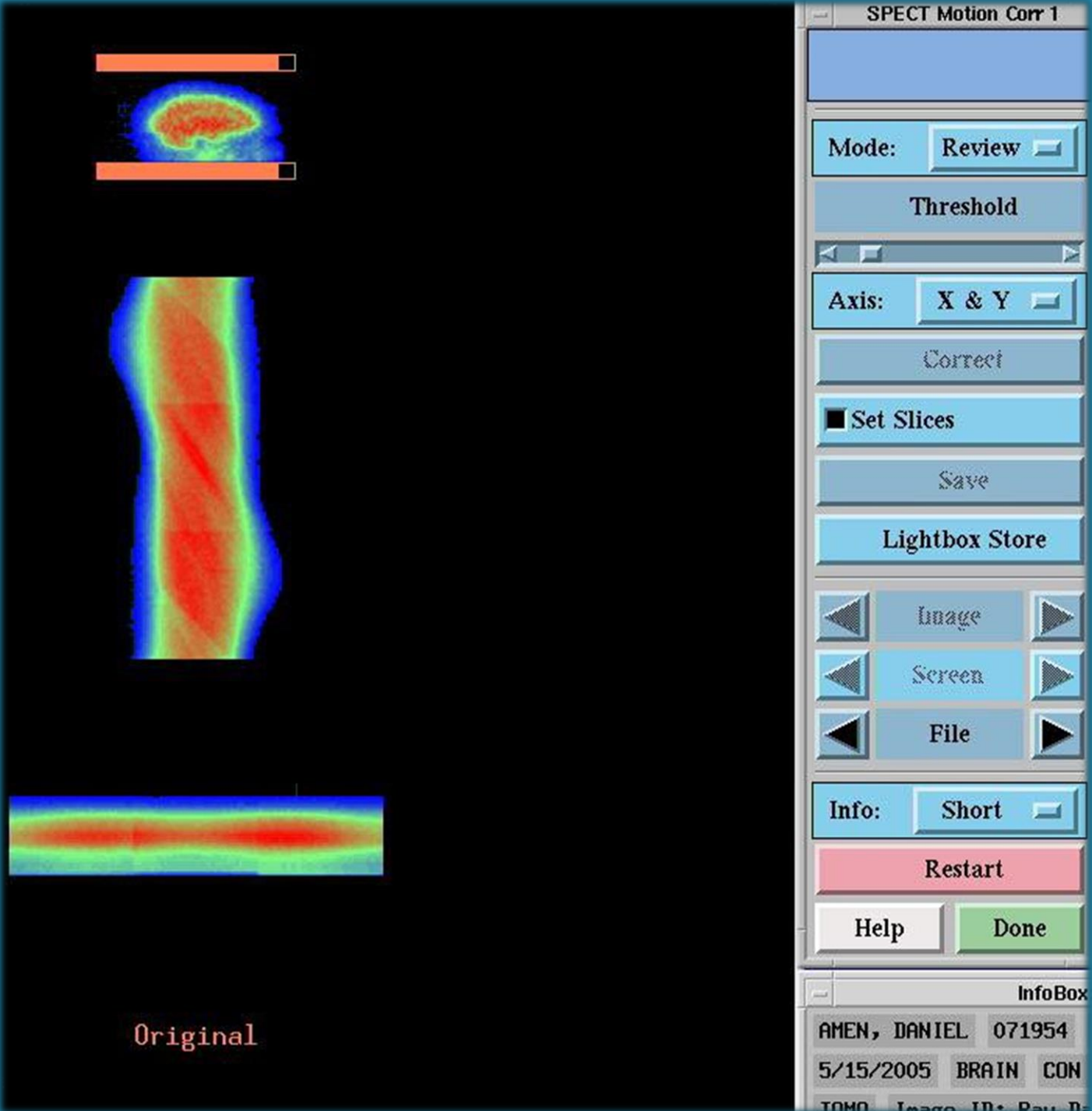
- **Once the camera captures the raw data it needs to be processed so it can be easily read**
- **ACI processes all of the scans in the same way to give us good consistency and reliability**
- **Here are the steps...**



# Check for Motion

- **No motion....**
- **This can be a challenge**
- **Do not trust motion correction software**
- **Beauty of SPECT, you can scan patients for up to 6 hours if needed**
- **You can even sedate them, after the injection, if needed, and not affect the scan**

# Check for Motion



The image displays a software interface for SPECT motion correction. On the left, three vertical SPECT slices are shown: a brain slice at the top, a torso slice in the middle, and a horizontal slice at the bottom. The word "Original" is printed below the bottom slice. On the right, a control panel titled "SPECT Motion Corr 1" contains several settings and buttons. The "Mode" is set to "Review", the "Axis" is set to "X & Y", and the "Info" is set to "Short". A "Threshold" slider is visible. Buttons include "Correct", "Set Slices", "Save", "Lightbox Store", "Image", "Screen", "File", "Restart", "Help", and "Done". An "InfoBox" at the bottom right displays patient information: "AMEN, DANIEL 071954", "5/15/2005 BRAIN CON", and "TOMO Image ID: Ray D".

Original

SPECT Motion Corr 1

Mode: Review

Threshold

Axis: X & Y

Correct

Set Slices

Save

Lightbox Store

Image

Screen

File

Info: Short

Restart

Help Done

InfoBox

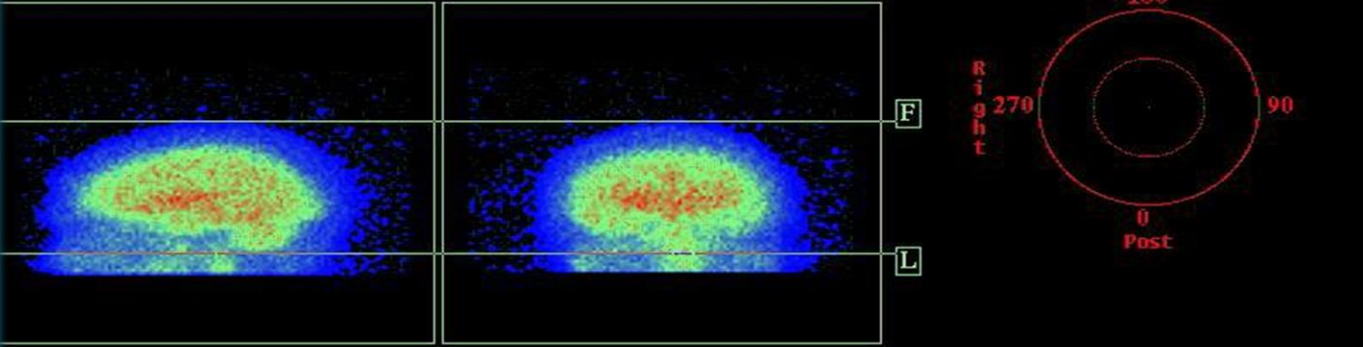
AMEN, DANIEL 071954

5/15/2005 BRAIN CON

TOMO Image ID: Ray D

# Transverse Reconstruction

Slice: 47, 90 Orbit: 180



Right

Post

Transverse Reconstruction 1

AMEN, DANIEL CON POST

Best Postfilter  Batch Recon

Recon Slices Next File

Help Done

44 slices 3.6mm Cine

Ref. Frames:

Use 'Ref Frames' buttons to change reference projection pair. Click 'Help' button for further information.

Image ID: Trans

Filter: Ramp

Diameter (cm): 45.5

Offset 1 (cm): 0

Offset 2 (cm): 0

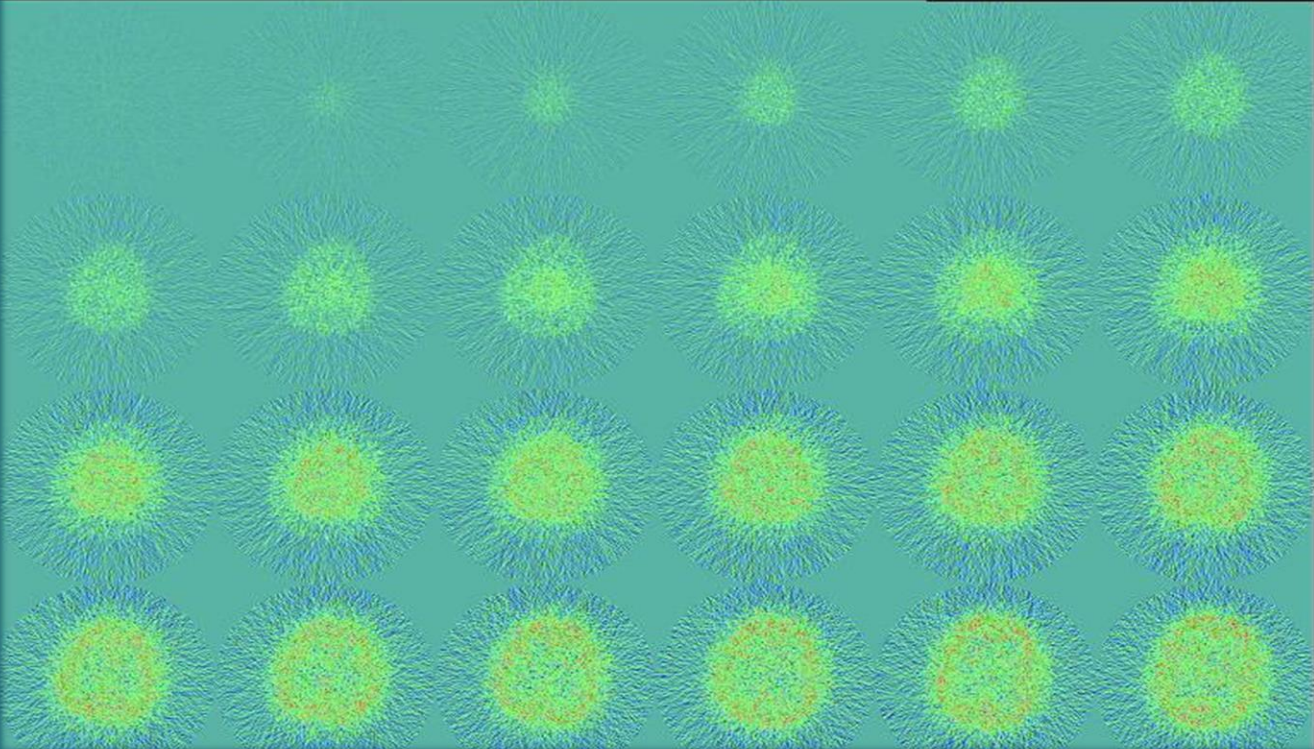
First Slice: 47

Last Slice: 90

Slice Thickness: 1

Recon Matrix: default

Algorithm: 360 Filtered BP



# Filter Data

- Low pass filter
- Order 5.0
- Cut off 0.25
- Smooths images making them easier to read

The screenshot displays a medical software interface for PET scan processing. It is divided into several sections:

- UnFiltered Images:** A grid of eight PET scan slices (labeled 18-25) showing noisy, high-frequency data.
- Filtered Images:** A corresponding grid of eight PET scan slices (labeled 18-25) showing the same data after low-pass filtering, appearing much smoother.
- Image Power Spectrum Filter:** A graph with 'Amplitude' on the y-axis and 'Spatial Frequency (cycles/pixel)' on the x-axis. It shows two curves: a red curve for the 'Image Power Spectrum' and a green curve for the 'Filter'. A horizontal line indicates a '10% Noise Component'. The filter curve starts at 1.0 and drops to 0.1 at a spatial frequency of 0.25.
- 3D Postfilter Control Panel:** A window titled '3D Postfilter' for patient 'AMEN, DANIEL Trans CON POST BRAIN'. It shows 'Low Pass Mag=1.00' and 'Distance: 15 cm'. The 'Filter' is set to 'Low Pass' and the 'Isotope' is 'Tc-99m'. A text box explains that sliders can vary filter parameters and that 'Filter File' and 'Write File' buttons are used to save the current settings. The 'Order' is set to 5.0 and the 'Cutoff' is 0.25. Other controls include 'Image ID: LP 5.0, .25', 'Slice Thickness: 1', and buttons for 'Previous Screen', 'Next Screen', 'Batch Filtering', 'Next File', 'Filter File', 'Write File', 'Restart', 'Help', and 'Done'.
- Image Workbench Table:** A table at the bottom of the interface showing acquisition and processing details.

File	User-Macros	Acquisition	SPECT-Processing	Planar-Proce
AMEN, DANIEL		T16	CON POST	Trans TOMO
AMEN, DANIEL		T17	CON POST	Trans TOMO

# Attenuation Correction

- Helps deeper tissue have similar look to surface
- Change Method, 0.110 setting

att\_spect

AMEN, DANIEL 071954  
Image ID: ACACLP 5.0 Att. Coef. : 0.110

If necessary, rotate slices with 'Rotation Adjustment'  
Choose fitting method with 'Ellipse Fitting'  
Initiate fitting using 'Fit Ellipse(s)'  
Check fit using the Slice Slider and/or 'Cine On/Off'  
Do correction and create output file with 'Apply'

Edge Det. Threshold: 5

Ellipse Fitting 1 per group(3)

Fit Ellipse(s)

Rotation: -10 degrees

Rotation Adjustment

Cine On/Off  Zero Mask

Slice Group 9 of 15

Apply Restart

Help Done

# Mask Data

- To eliminate artifact
- 0.000 setting



The image shows a software interface for processing medical data. On the left is a circular brain scan with a color scale from blue (low) to red (high). The scan is labeled 'Right' on the left and 'Post' at the bottom. A small box with the number '8' is in the top right corner of the scan area. On the right is a control panel titled 'att\_spect'. It contains the following information and controls:

- AMEN, DANIEL 071954
- Image ID: ACACLP 5.0 Att. Coef. : 0.000
- Instructions: "If necessary, rotate slices with 'Rotation Adjustment'. Choose fitting method with 'Ellipse Fitting'. Initiate fitting using 'Fit Ellipse(s)'. Check fit using the Slice Slider and/or 'Cine On/Off'. Do correction and create output file with 'Apply'."
- Edge Det. Threshold: 0
- Ellipse Fitting: 1 per group(3)
- Fit Ellipse(s) button
- Rotation: 0 degrees
- Rotation Adjustment
- Cine On/Off
- Zero Mask
- Slice Group: 8 of 15
- Buttons: Apply, Restart, Help, Done

# Oblique Reformat

## ➤ Spatial orientation for slices

The interface displays a grid of brain slices in Transverse, Coronal, and Sagittal views. The Transverse view shows slices 20-25, Coronal shows 17-22, and Sagittal shows 19-24. A 'Post' view is also visible. Below the grid are three interactive diagrams: 'Select Coronal' (Transverse view), 'Select Sagittal' (Coronal view), and 'Select Trans Oblique' (Sagittal view). Each diagram shows a selection box and a diamond for centering. The control panel on the right includes a 'How To' section, a 'Mode' dropdown set to 'Sag/Cor/Trans Obl', an 'Info' dropdown set to 'None', a 'Batch' checkbox, a 'File' field showing 'T2D AMEN, DANI CON POST ACACLP 5.0', a 'Select' dropdown set to 'Coronal', an 'Image' field set to '23', a 'Cine' button, and a 'Slice Thickness' field set to '3 pixels' and '6.5 mm'. Below these are three columns for 'Select Coronal', 'Select Sagittal', and 'Select Trans Oblique', each with an 'ID' field, 'Angle' field, 'Z (cm)' field, 'Slices' field, and a 'Reformat' button. At the bottom are buttons for 'Zero all angles', 'Reformat all views', 'Zero mask', 'Store', 'Restart', 'Help', and 'Done'.

**Oblique Reformat 1**

**How To**

Click on a displayed image to select it as a work image, or use the Image scrollbar.  
Adjust the slice center by dragging the selection box center line.  
Set the angle using the circle. Select slices with the diamond.  
For asymmetric studies, use the square to center the OTHER views.  
Store slices by pressing the "R" or the view's Reformat button.  
Select a view by clicking on its work area.  
Reselect this view to get specific instructions.

Mode: Sag/Cor/Trans Obl

Info: None  Batch

File: T2D AMEN, DANI CON POST ACACLP 5.0

Select: Coronal

Image 23 Cine

Slice Thickness: 3 pixels  
6.5 mm

Select Coronal	Select Sagittal	Select Trans Oblique
ID: Cor	ID: Sag	ID: Trans Obl
Angle: 0	Angle: 0.8	Angle: 0
Z (cm): 0.5	Y (cm): -1.3	X (cm): 0.2
Slices: 33	Slices: 27	Slices: 29
Reformat	Reformat	Reformat

Zero all angles Reformat all views  Zero mask

Store Restart Help Done

# An Introduction to Reading Brain SPECT





# rCBF – Regional Cerebral Blood Flow

- **SPECT measures relative blood flow**
- **Most intense pixels in brain = 100%**
- **Least intense pixels = 0%**
- **All else is scaled between these 2 poles**
- **Most intense pixels usually in cerebellum**
- **Be careful with interpretation when the cerebellum is not active with HMPAO**

# What Is Normal? How Do We Know?

- Full, even, symmetrical activity
- With HMPAO cerebellum most active
- Often some basal ganglia or thalamic activity
- Children most active
- Females more active than males
- 59 normal SPECT studies for children & adults

# Research Sample – Normal

- **Chiron, 1992, 42 children**
  - ❖ **By age of 2 children have same relative perfusion pattern as adults, although their brains more active**
- **Catafu, 1996, 68 normal adults**
  - ❖ **Symmetrical rCBF distribution can be assumed between homologous regions, independent of age**
- **Yang, 1996, 52 adults**
  - ❖ **Significant negative correlation found between rCBF and advancing age, particularly in males**

# Research Sample – Normal

## ➤ Barthel, 1997, 23 children

- ❖ Systematic differences between 4 to 15-year-old children and adults regarding normal rCBF
- ❖ Normal ranges should be determined separately for the age groups 4-10 and 11-15 years.

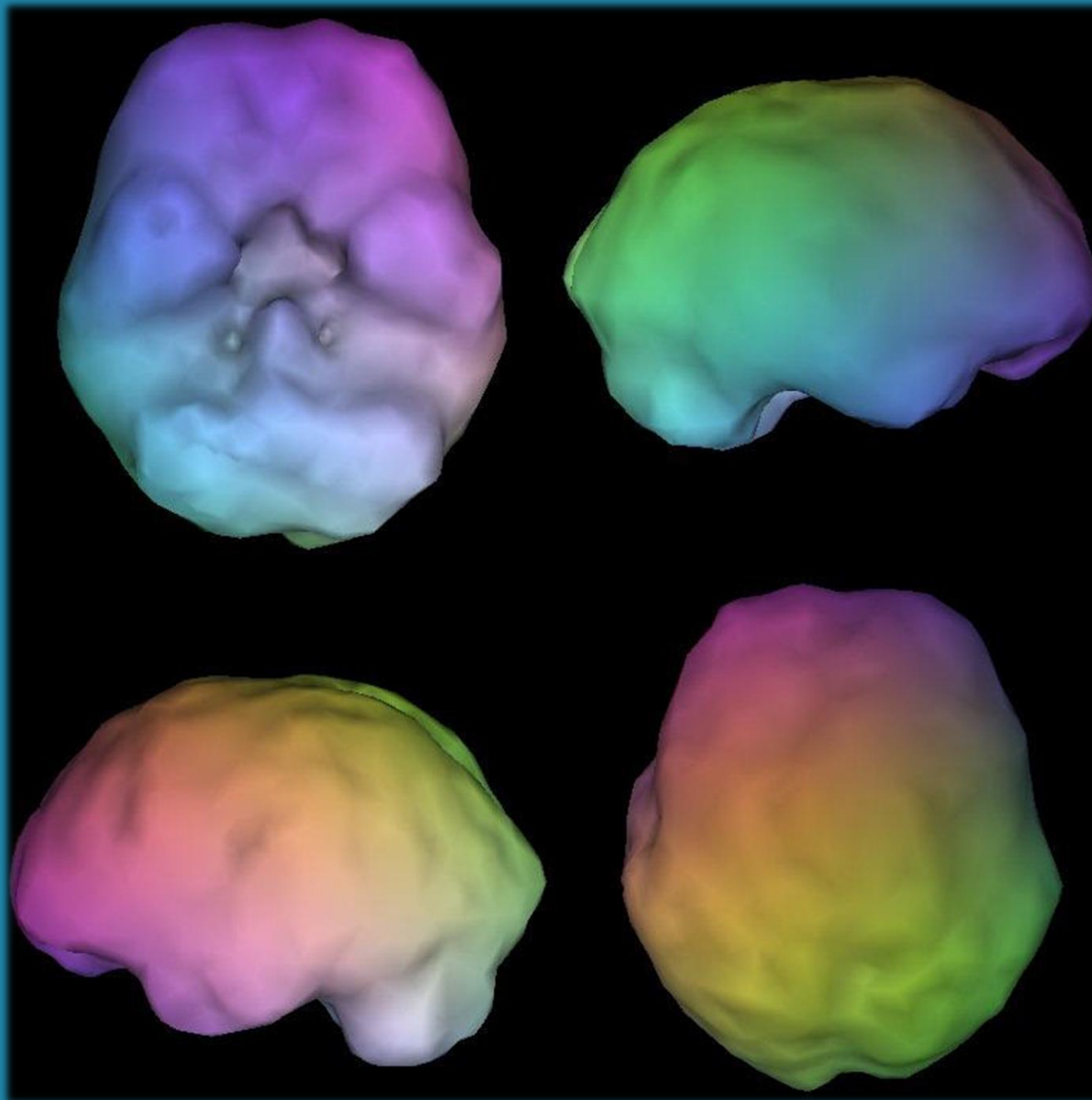
## ➤ Slosman, 2001, 187 adults

- ❖ Significant differences between the sexes and a significant decline as a function of age

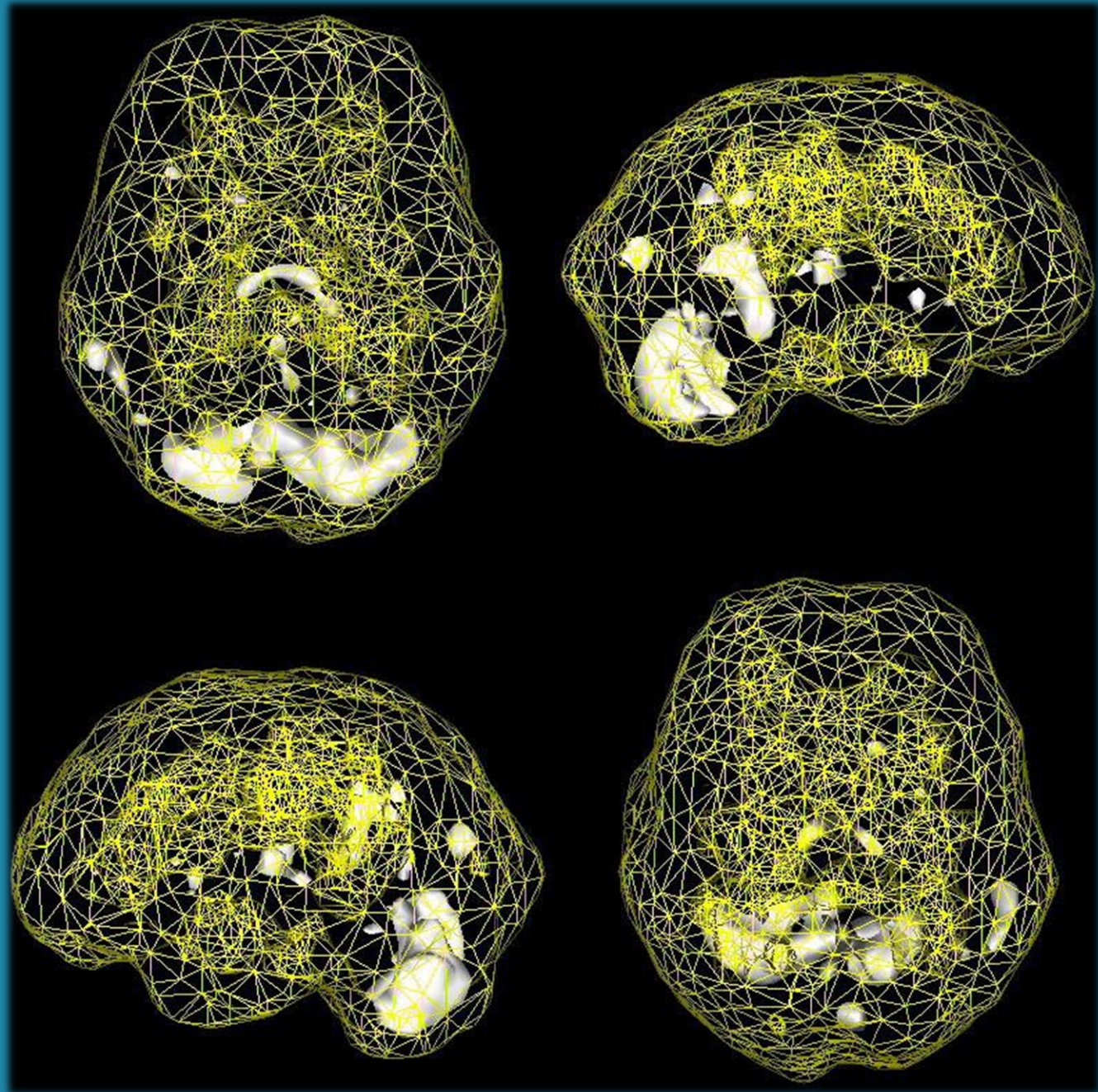
# ACI Healthy Brain Study

- **No psychiatric illness**
- **No first degree relative with psychiatric illness**
- **No head injury**
- **No or very limited substance abuse**
- **Not on any medication**
- **Scanned 99 healthy adults**

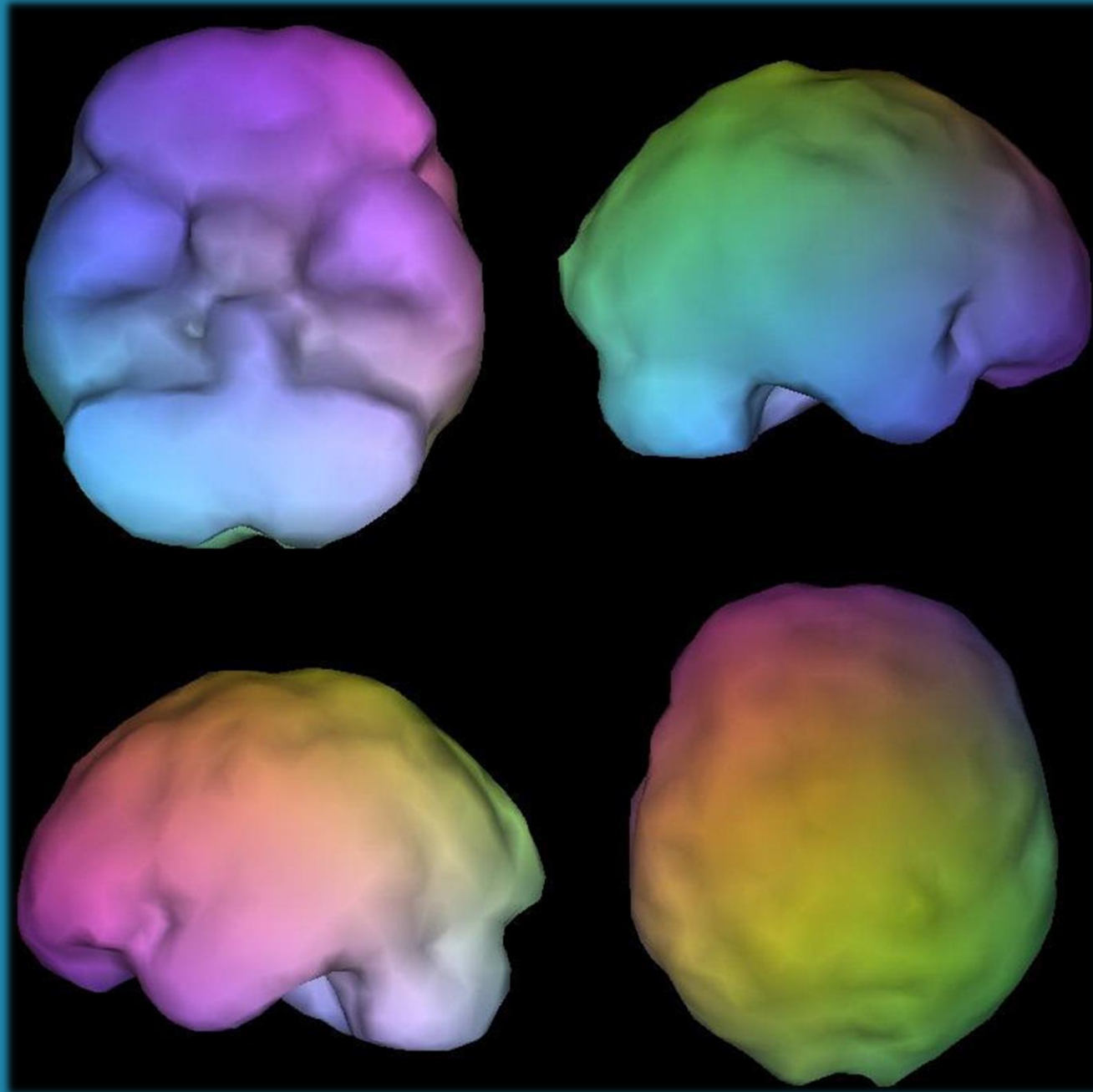
# Case 1: Normal



# Case 1: Normal

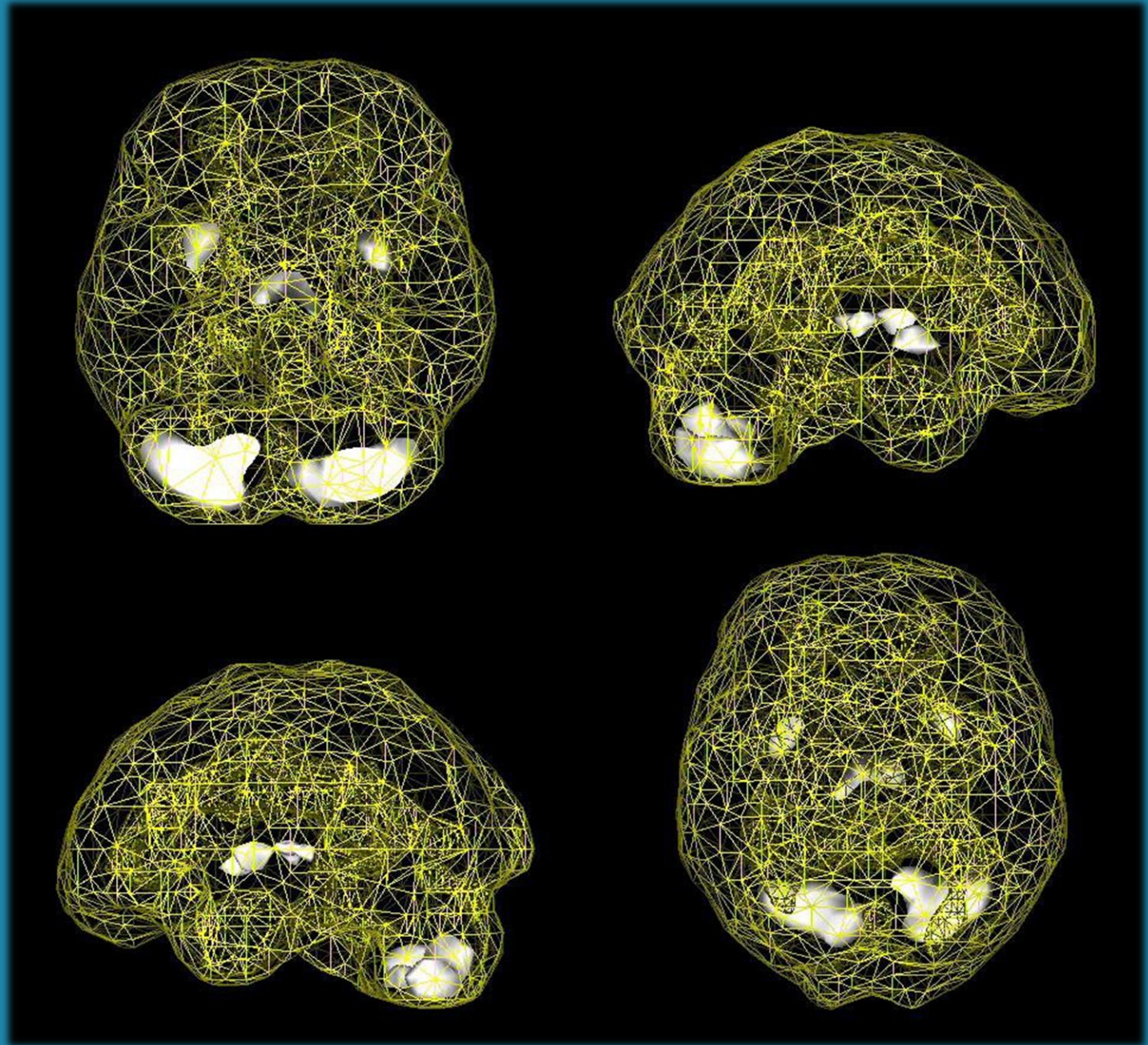


# Case 2: Normal

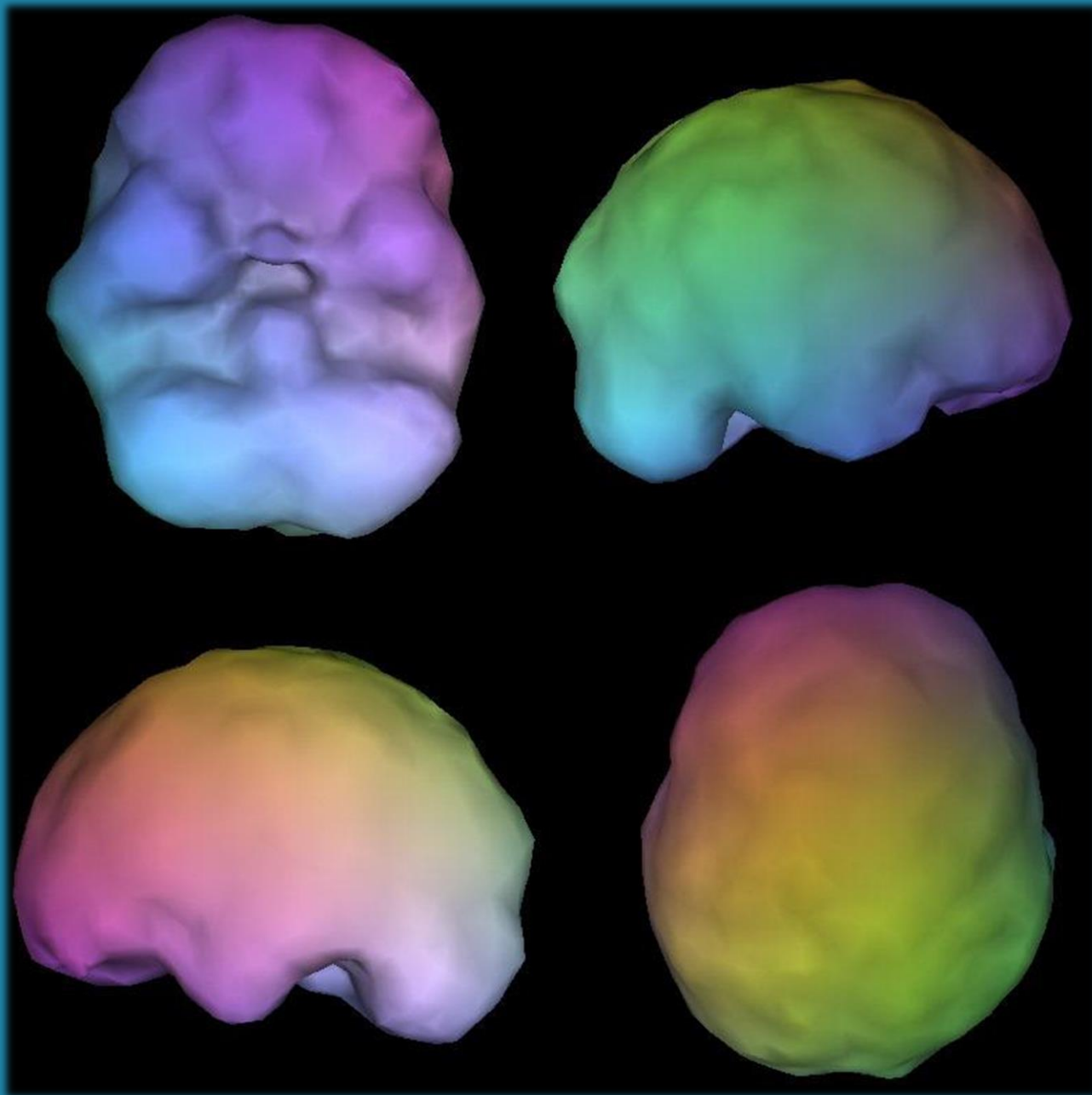




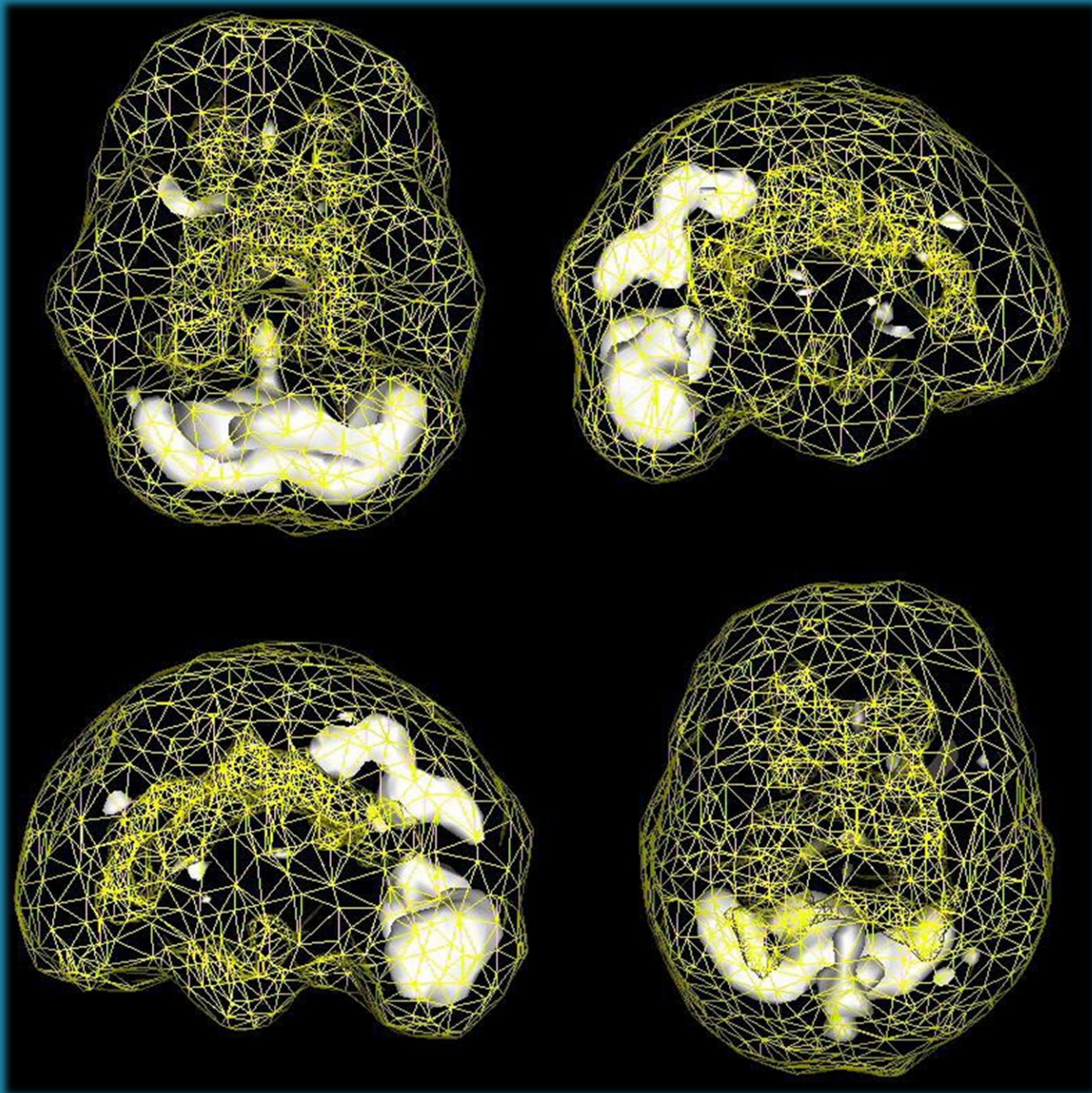
# Case 2: Normal



# Case 3: Normal



# Case 3: Normal



# Normal Clinical Pearls

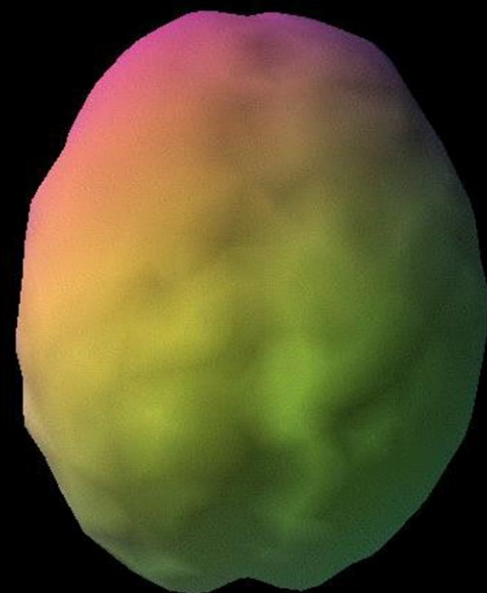
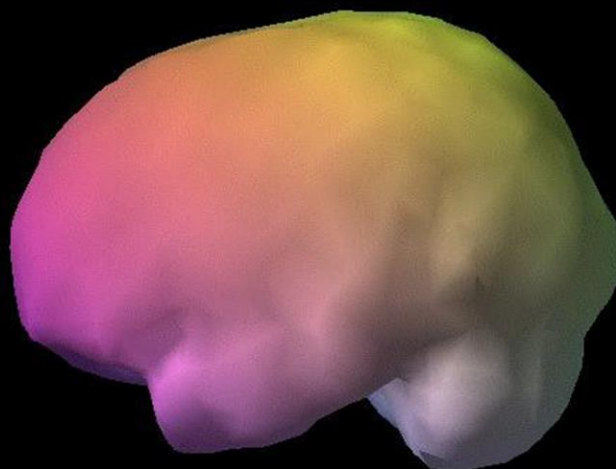
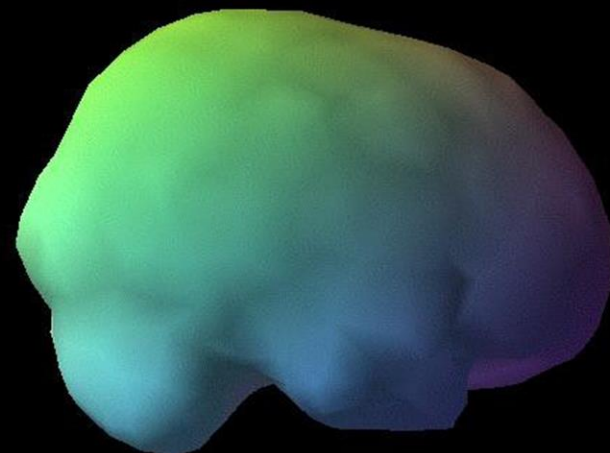
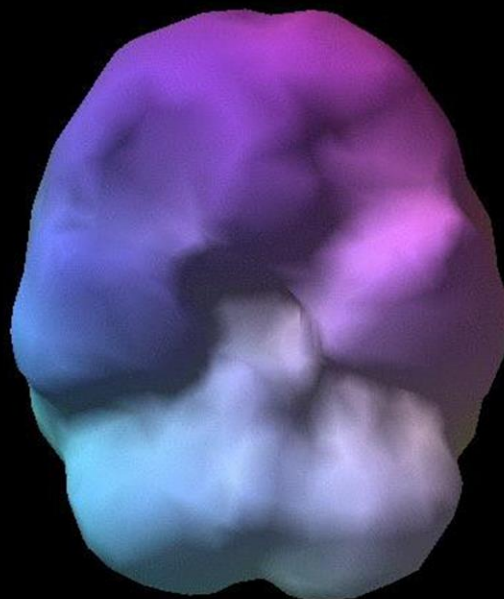
- **Brain are like faces**
- **Age and sex matters**
- **See problems on SPECT years before they develop, such as Alzheimer's**
- **Someone might report being normal, but their scan may show they are headed for trouble**

# Normal Scans

## Age and Gender Matched

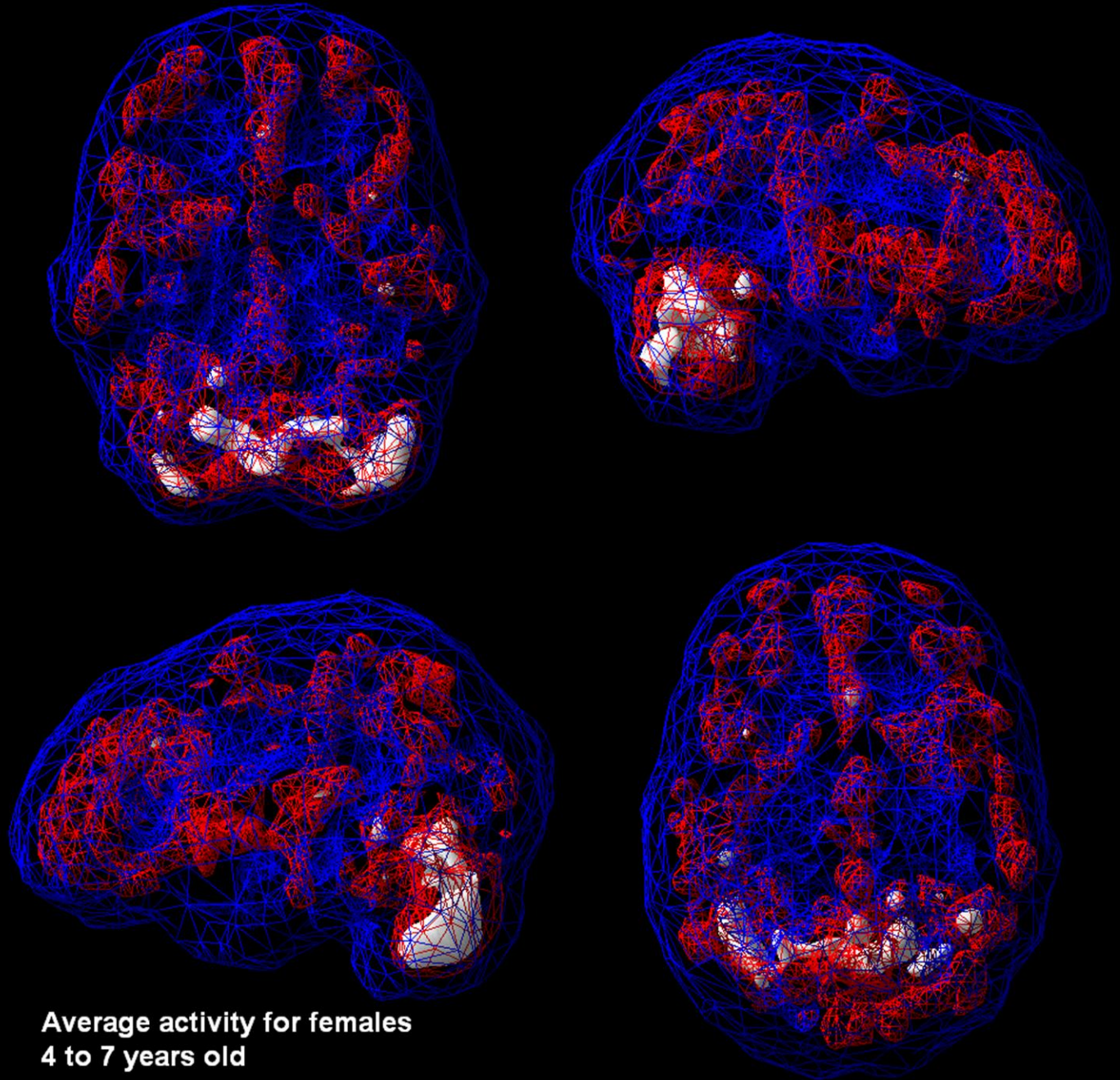
- **Surface scans show full, even, symmetrical perfusion**
- **Active scans vary over age and gender**
- **Examples that follow are from ACI's normal database for adults**
- **From healthiest 179 children and teens from a clinical sample**

# Surface Scans Males and Females



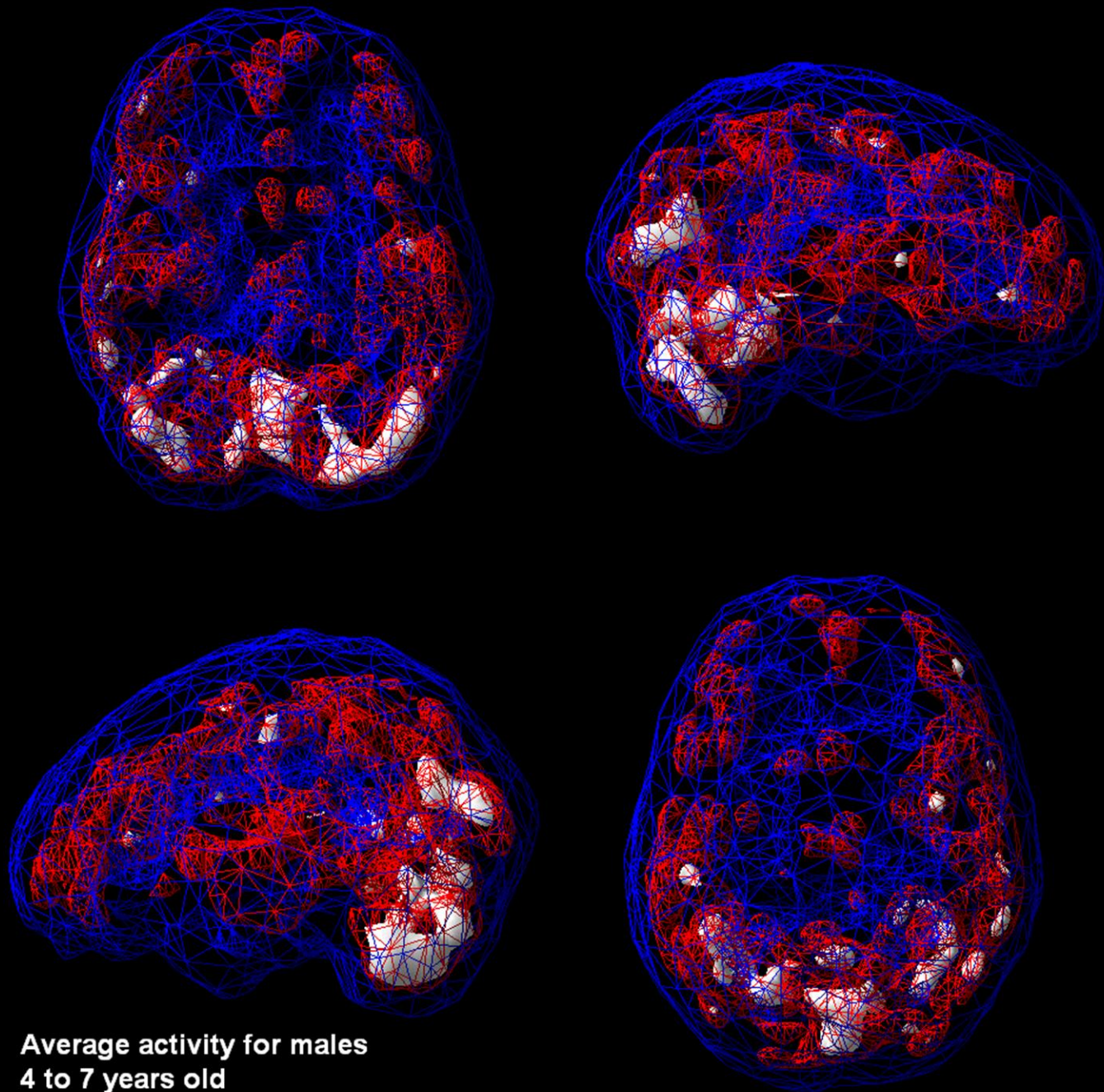
Healthy Surface Activity  
for Males, ages 5 to 21

# Active Scans Age 4 - 7 Females



Average activity for females  
4 to 7 years old

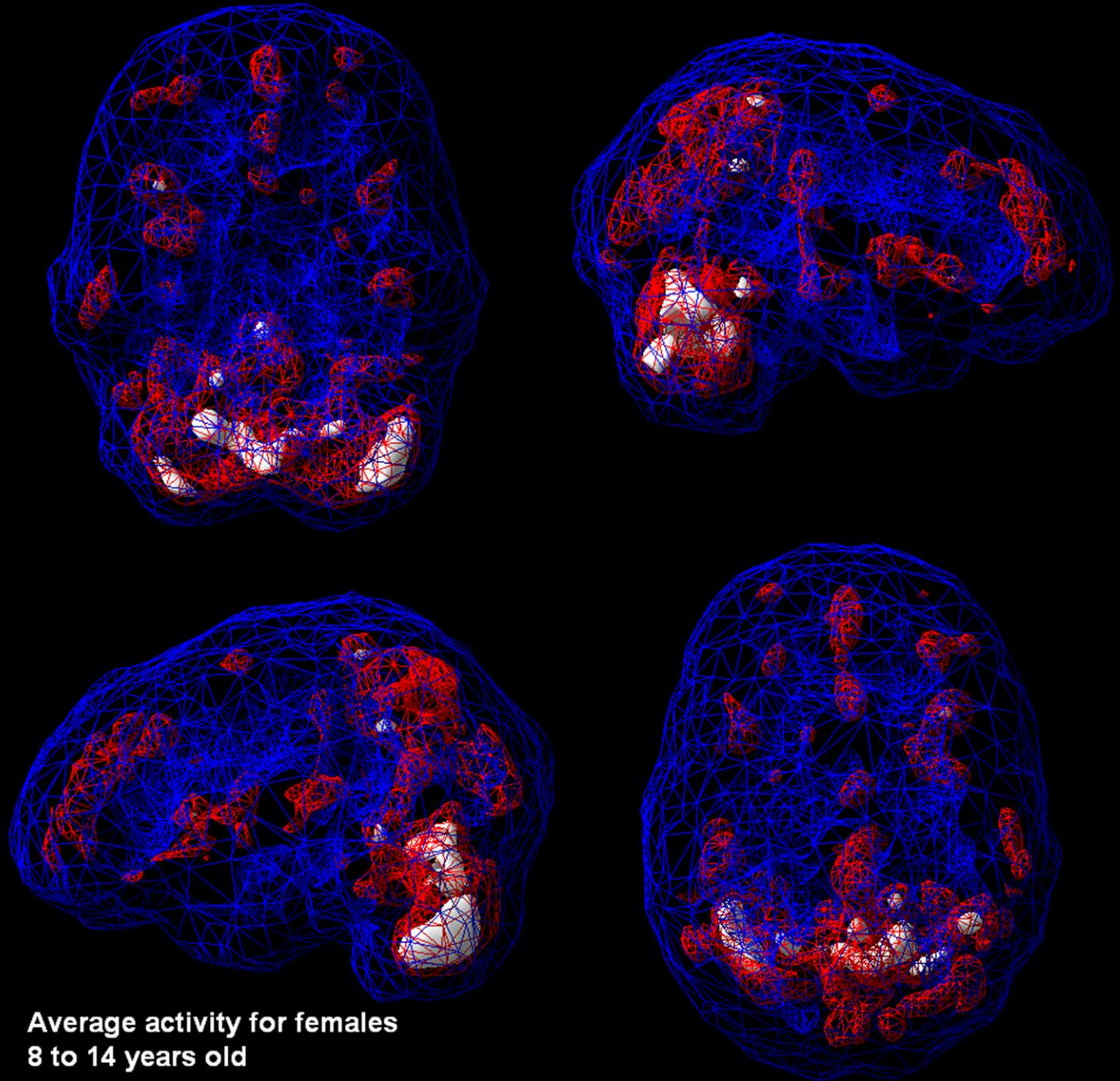
# Active Scans Age 4 - 7 Males



Average activity for males  
4 to 7 years old

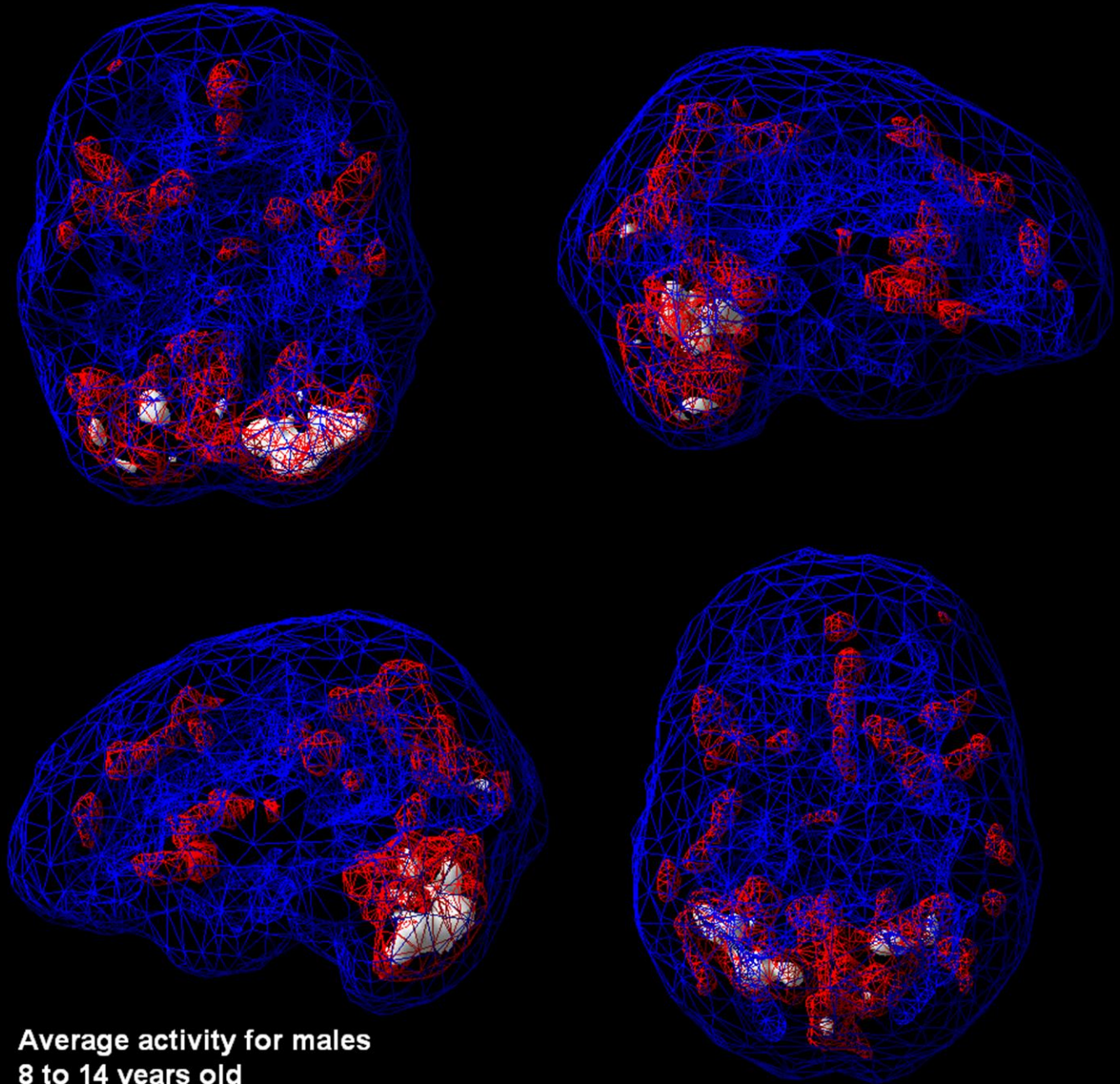


# Active Scans Age 8 - 14 Females



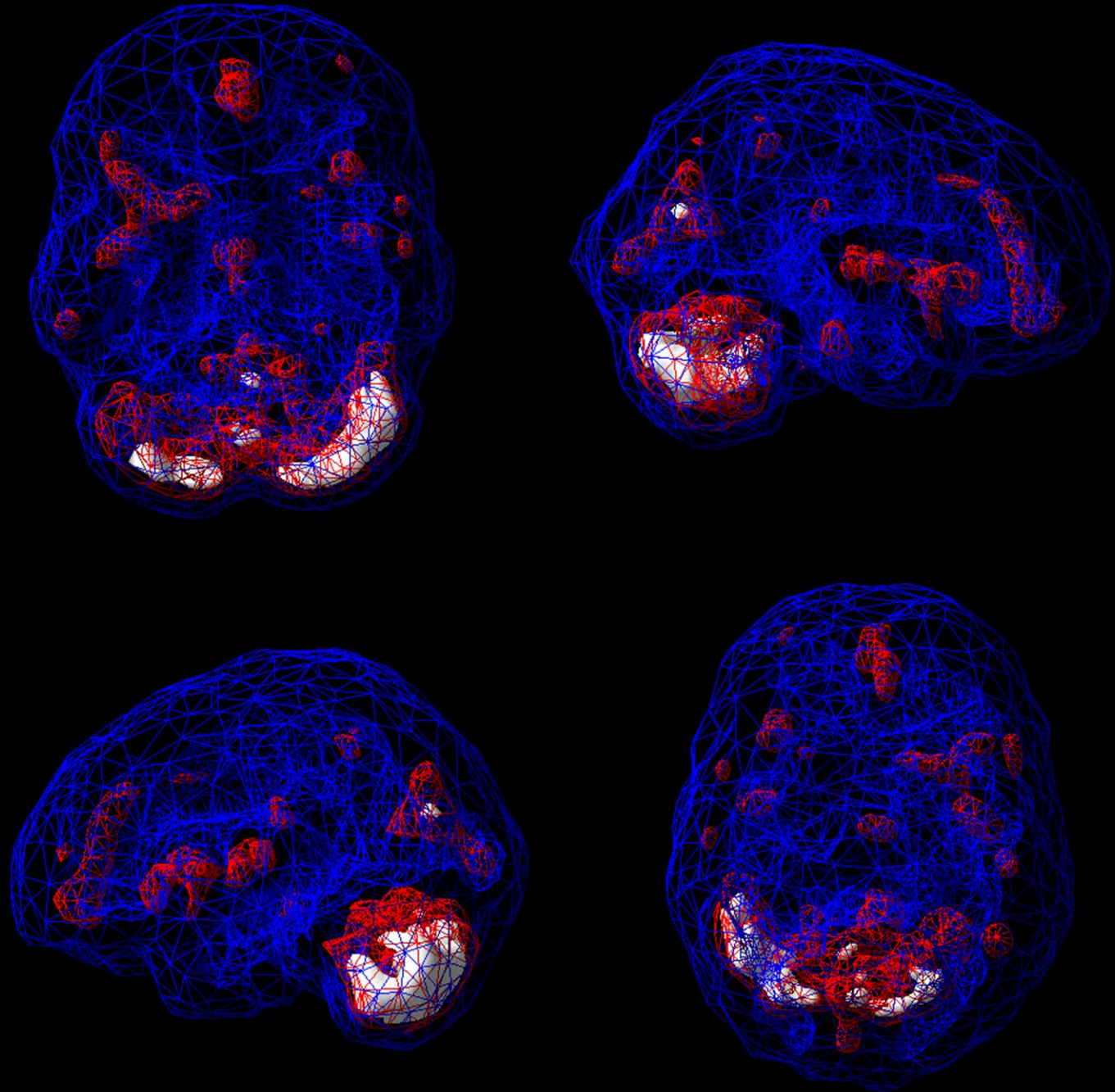
**Average activity for females  
8 to 14 years old**

# Active Scans Age 8 - 14 Males

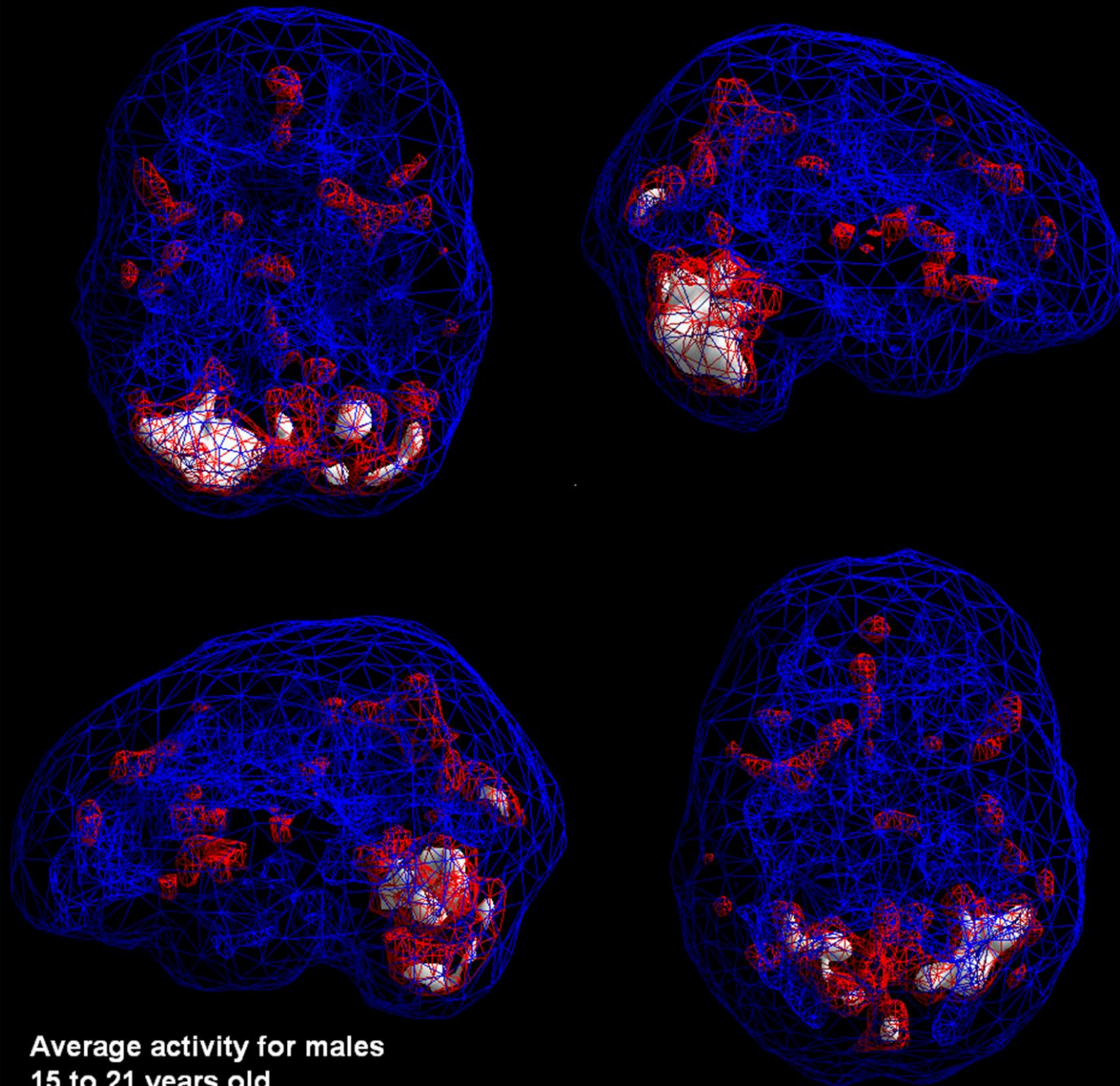


Average activity for males  
8 to 14 years old

**Active Scans  
Age 15 - 21  
Females**



# Active Scans Age 15 - 21 Males



**Average activity for males  
15 to 21 years old**