

# # 1

## Brain SPECT in Psychiatry

### **Introduction to the illustrations of a brief demo.**

This combined PDF display provides some examples of perfusion Brain SPECT usefulness in the Clinical Psychiatry practice. It also shows the level of details that can be viewed with optimized high quality displays.

The general idea is that before any attempt to quantify results, a comprehensive, clear display of the brain SPECT results is needed. This is not because of lack of interest in quantification but because of a few simple reasons:

1. High quality images can serve as a quality control, before deciding to report numbers.
2. Because just reporting numbers or showing, for example, some variant of “glass brain”, does not tell anything about the quality of the input images.
3. It makes it possible to use reliable visual interpretations in places which may lack the means and staffing needed for selecting and using a solid quantification program.
4. It should make it possible to help promote the use of SPECT in Clinical Psychiatry where the needs are great but its utilization is very low.
5. Indeed, clear, high quality and user friendly images will make it much easier to engage the referring professionals in integrating the use of brain SPECT functional imaging, in their clinical practice.

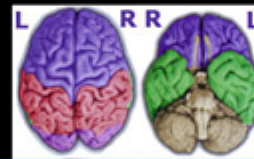
The 6 PDF images starting with #14, as well as the separate MP4 file submitted, are introducing the end product of an algorithm for a comprehensive, automatic, user friendly and low cost sequence of images. This could conceivably be used to attempt a standardization of displays accessible not only to large clinical centers, if they want it, but also to any smaller Nuclear Medicine lab, anywhere in the world.

The last image (#16) is the Legend of Figures

#2

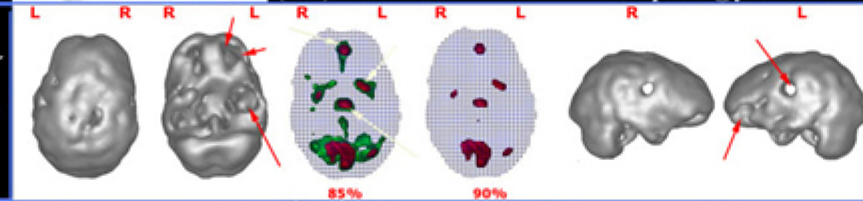


## The "classic" : direct trauma



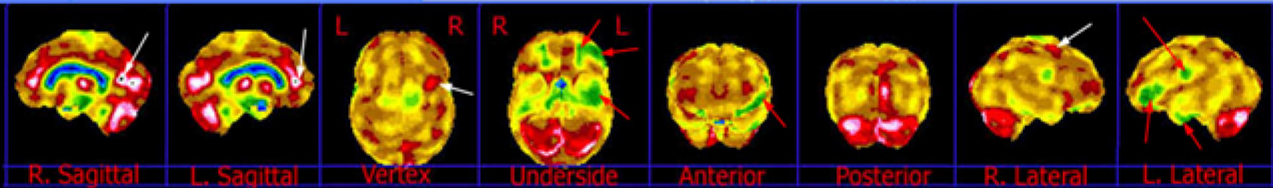
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R. X  
M20621  
19

→ significant decreases  
→ significant increases



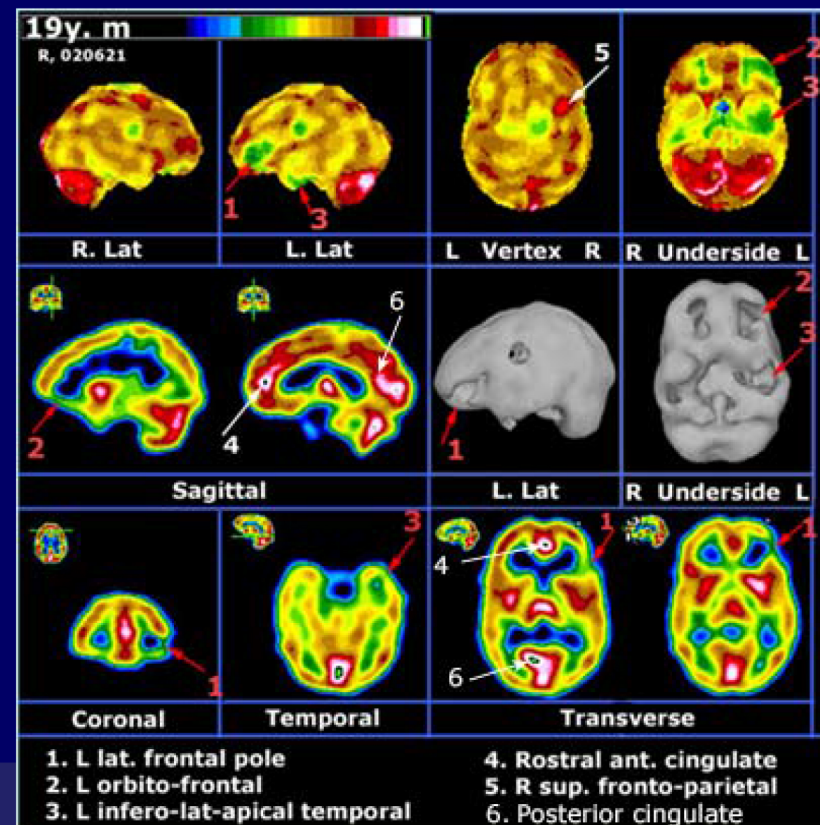
19 y old college student. **3 months earlier**, was hit with full glass bottle of Coca Cola in the L antero-lateral frontal area. **No loss of consciousness** but, subsequently developed **memory** difficulties, **cognitive dysfunction**, **personality** changes and significant **impulse control** problems.

At time of SPECT, was slightly better but **not able to resume college** courses and still having **impulse control** problems and **personality** changes.

CT: only very limited abnormality in left frontal.

**Brain SPECT** : obvious abnormalities.

- **underperfusions** (1, 2, 3) , on the left side
- **hyperperfusions**: striking areas, especially in **rostral** and **posterior cingulate** (4, 6) e.g. in parts of the **limbic system** associated with the Default Mode Network (**DMN**) .

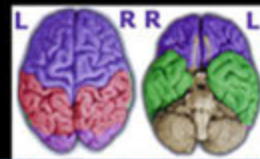




#3



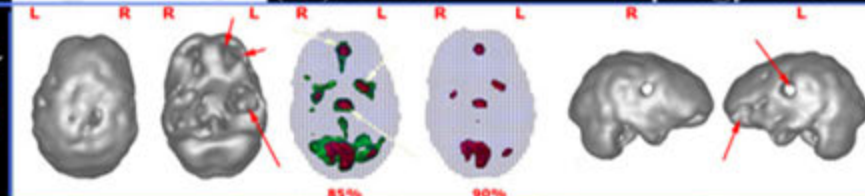
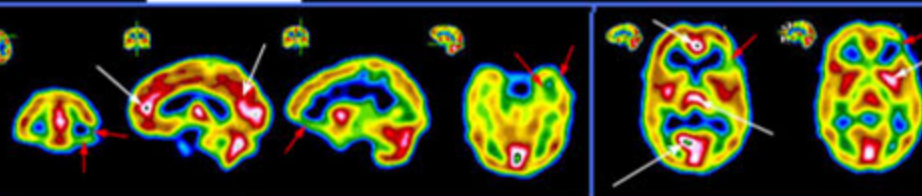
## The "classic" : direct trauma



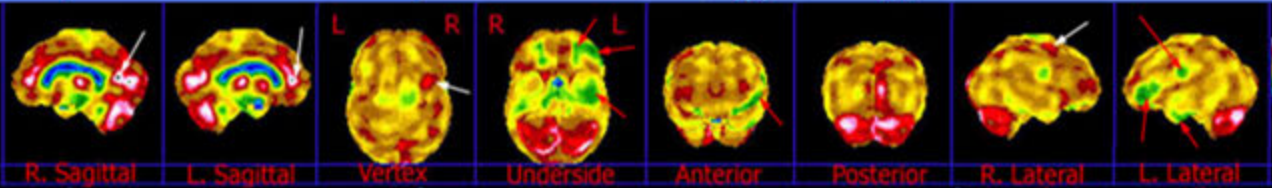
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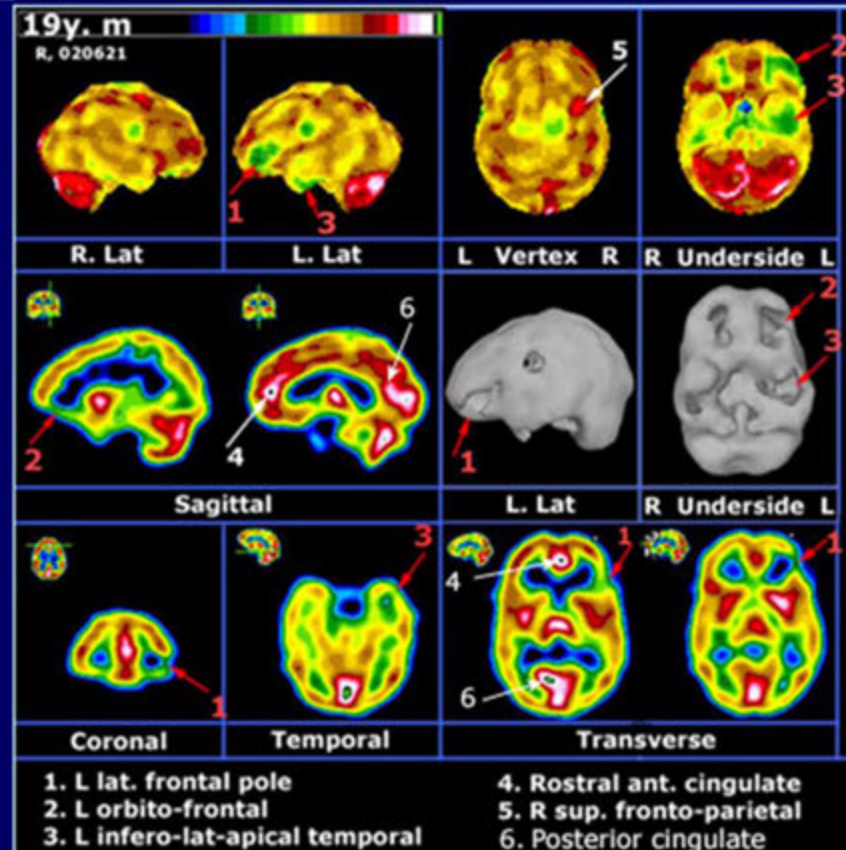
R. X  
M20621  
19



→ significant decreases  
→ significant increases



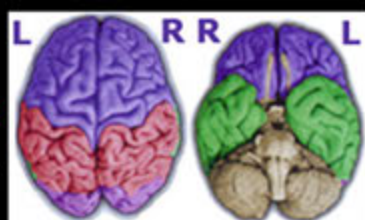
1. A localized hit in the left fronto-temporal area can have **devastating effects**.
2. On Brain SPECT the **local and distributed** consequences of the head injury were clearly seen in the form of **multiple** areas of **underperfusion** but, in addition of **unexpected** areas of marked and **extreme hyperperfusions** including in the **cingulate gyrus**. This is compatible with significant dysfunction in the **DMN** (Default Mode Network).
3. Such findings are extremely important for guiding a **tailored treatment strategy**.



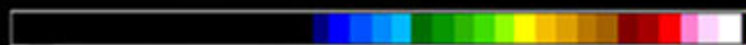




→ significant decreases  
→ significant increases



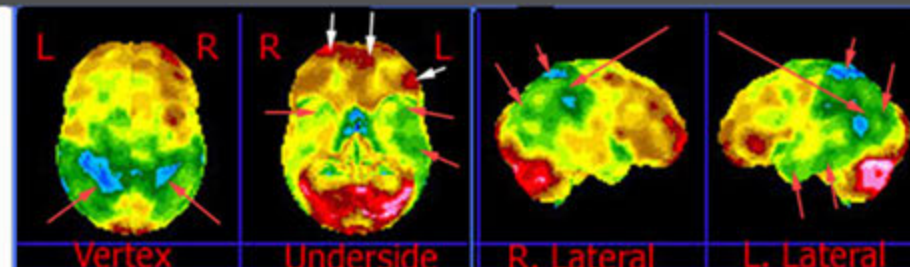
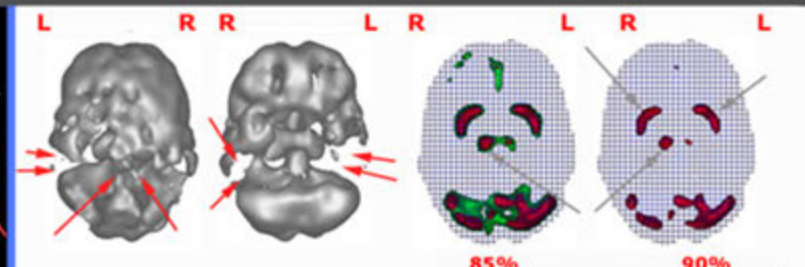
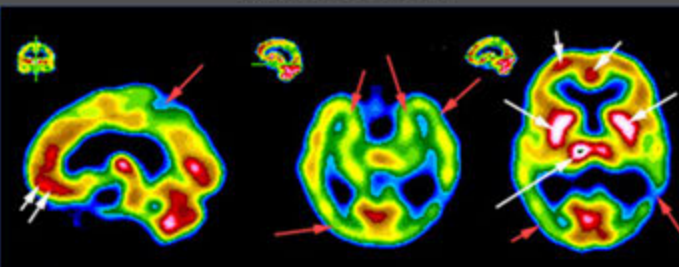
## Brain SPECT: Dementia Differential



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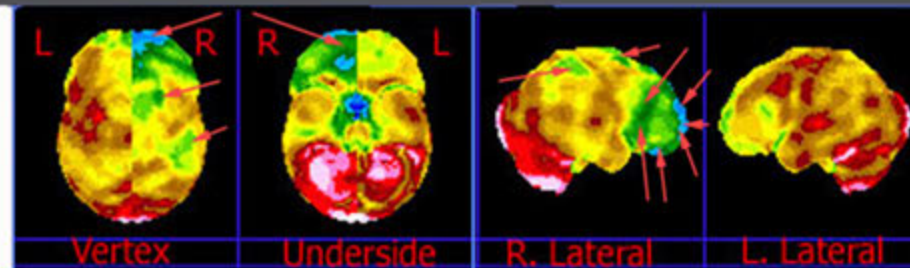
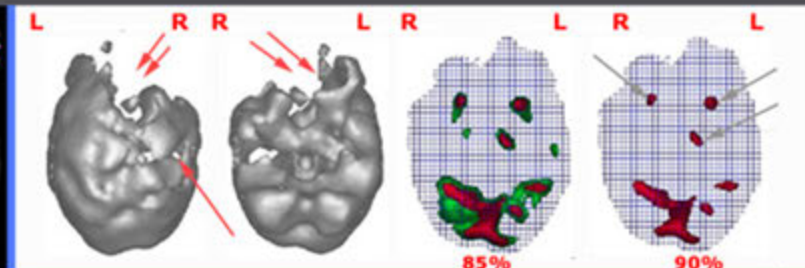
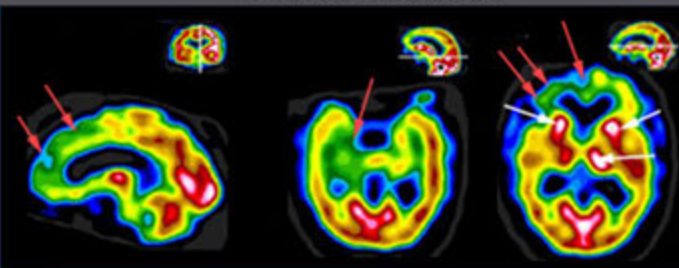
### 1 Alzheimer's

D.  
53y



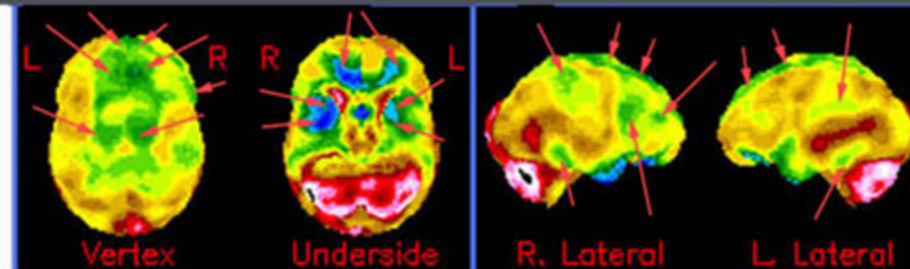
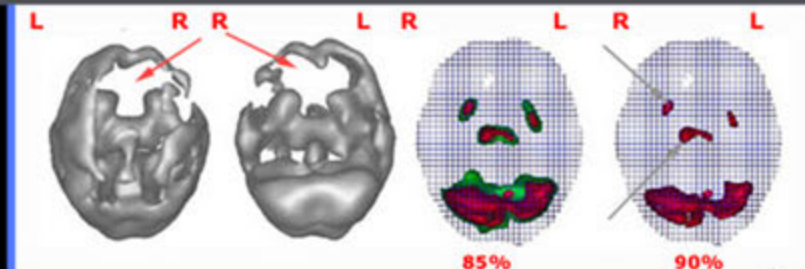
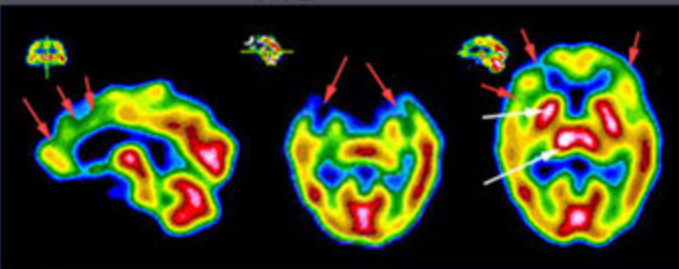
### 2 Pick's disease

B.  
55y



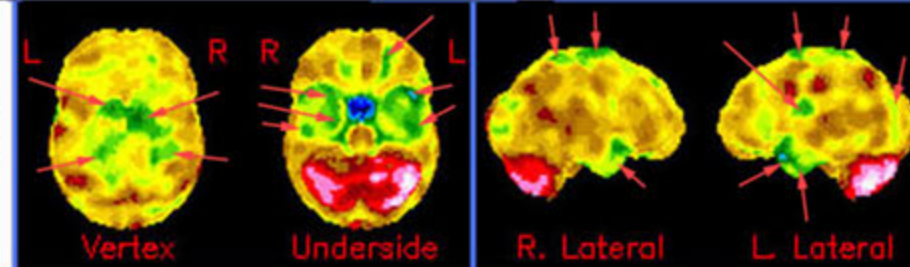
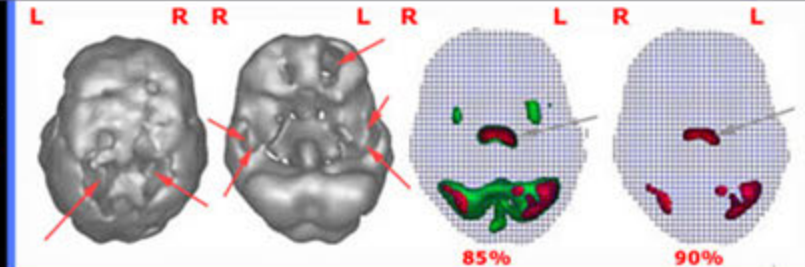
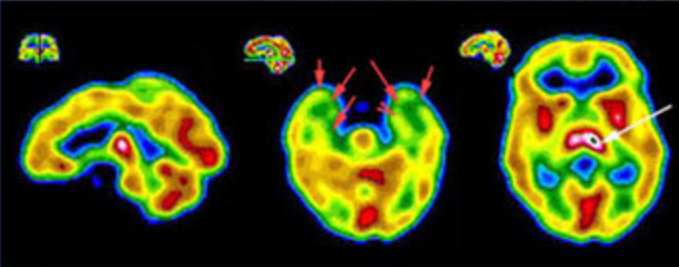
### 3 FTD

S.  
56y



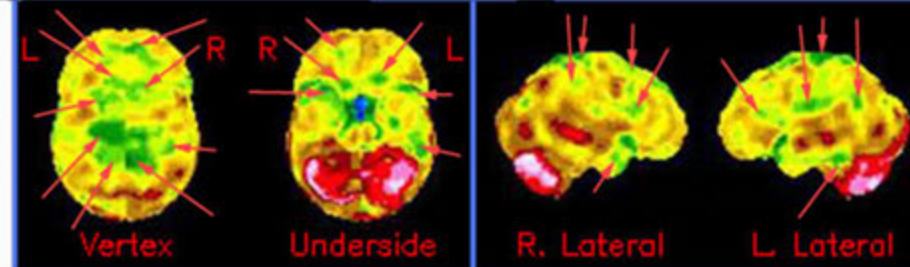
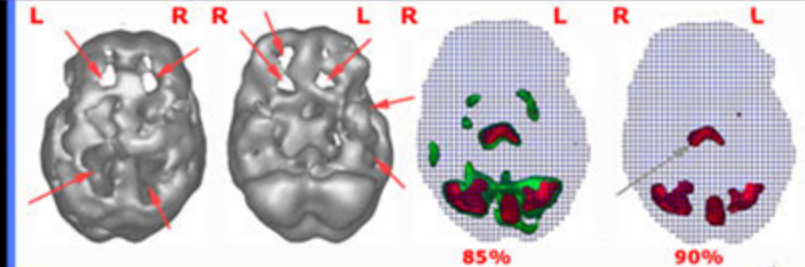
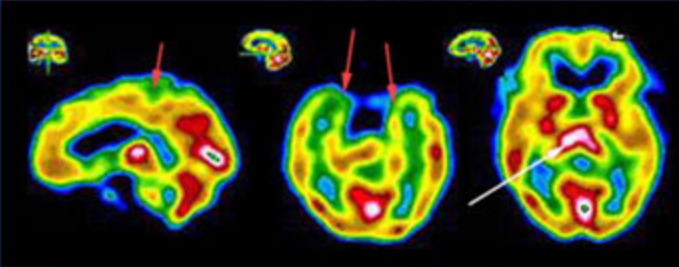
### 4 Semantic Dementia (?)

W.  
54y



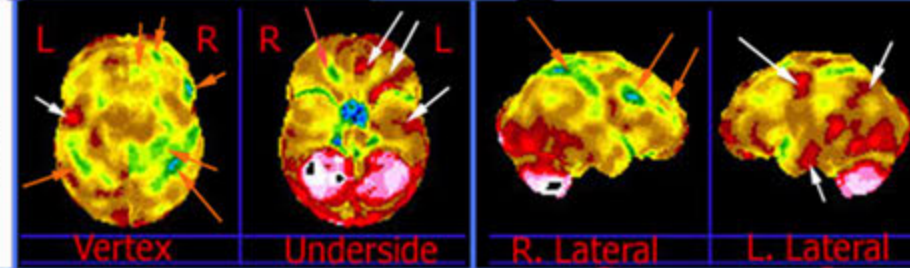
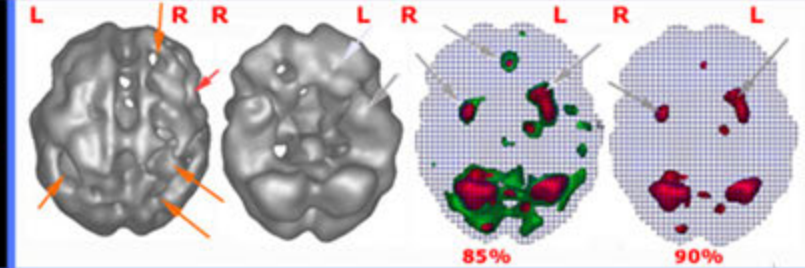
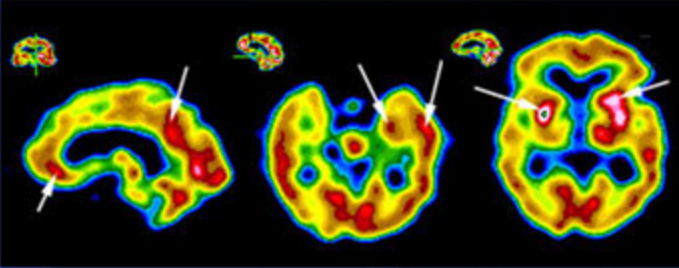
### 5 Vascular Dementia

O.  
54y



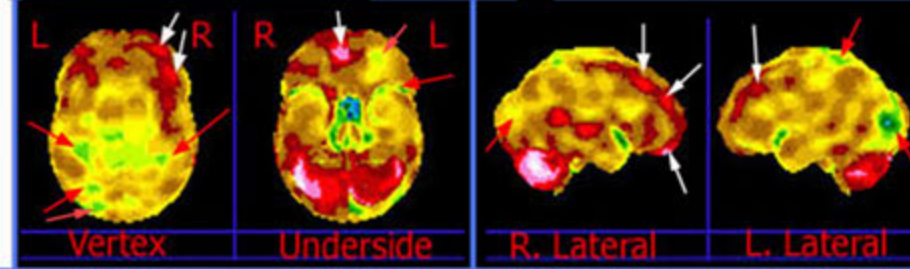
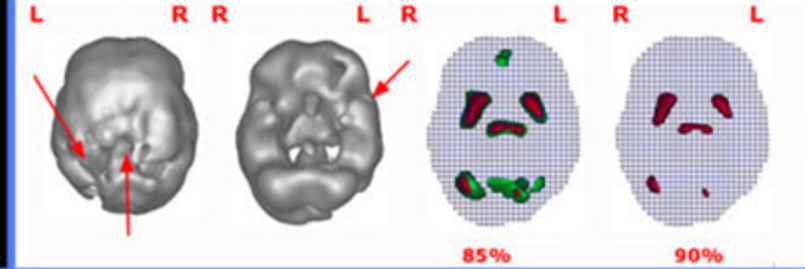
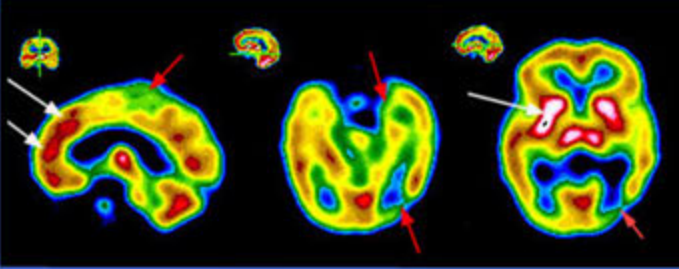
### 6 FTD ruled out

K.  
75y

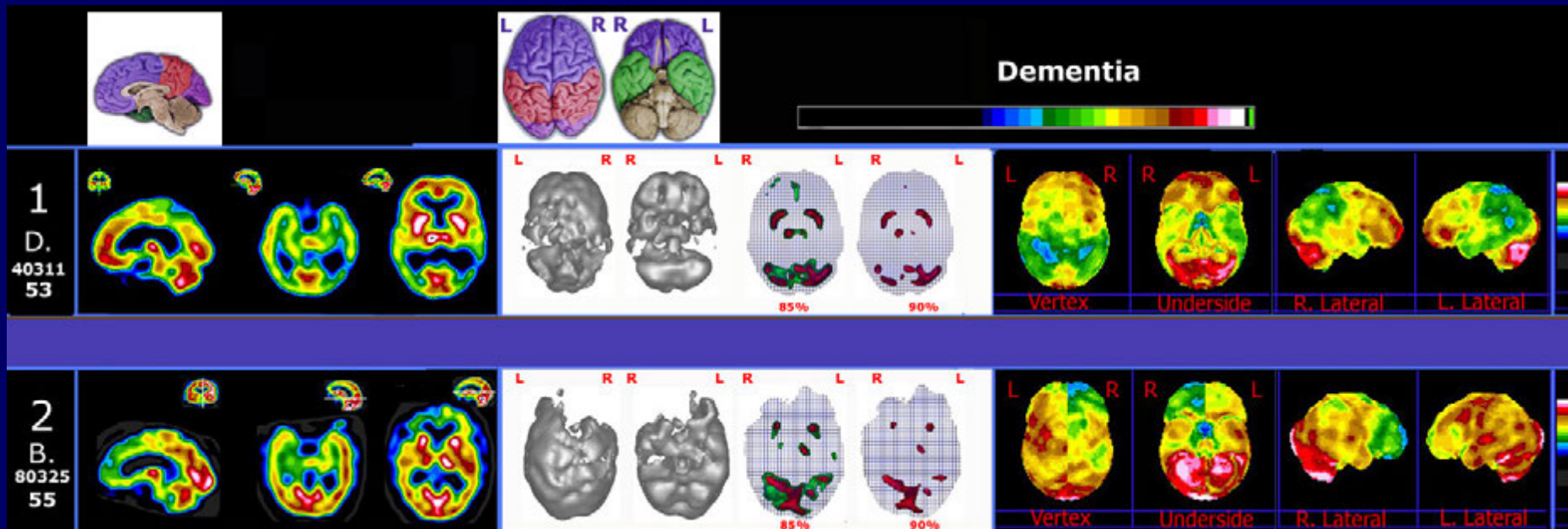


### 7 Down's Syndr. -> A.D.

B.  
45y







## Dementia differential : AD vs FTLD (Pick's disease)

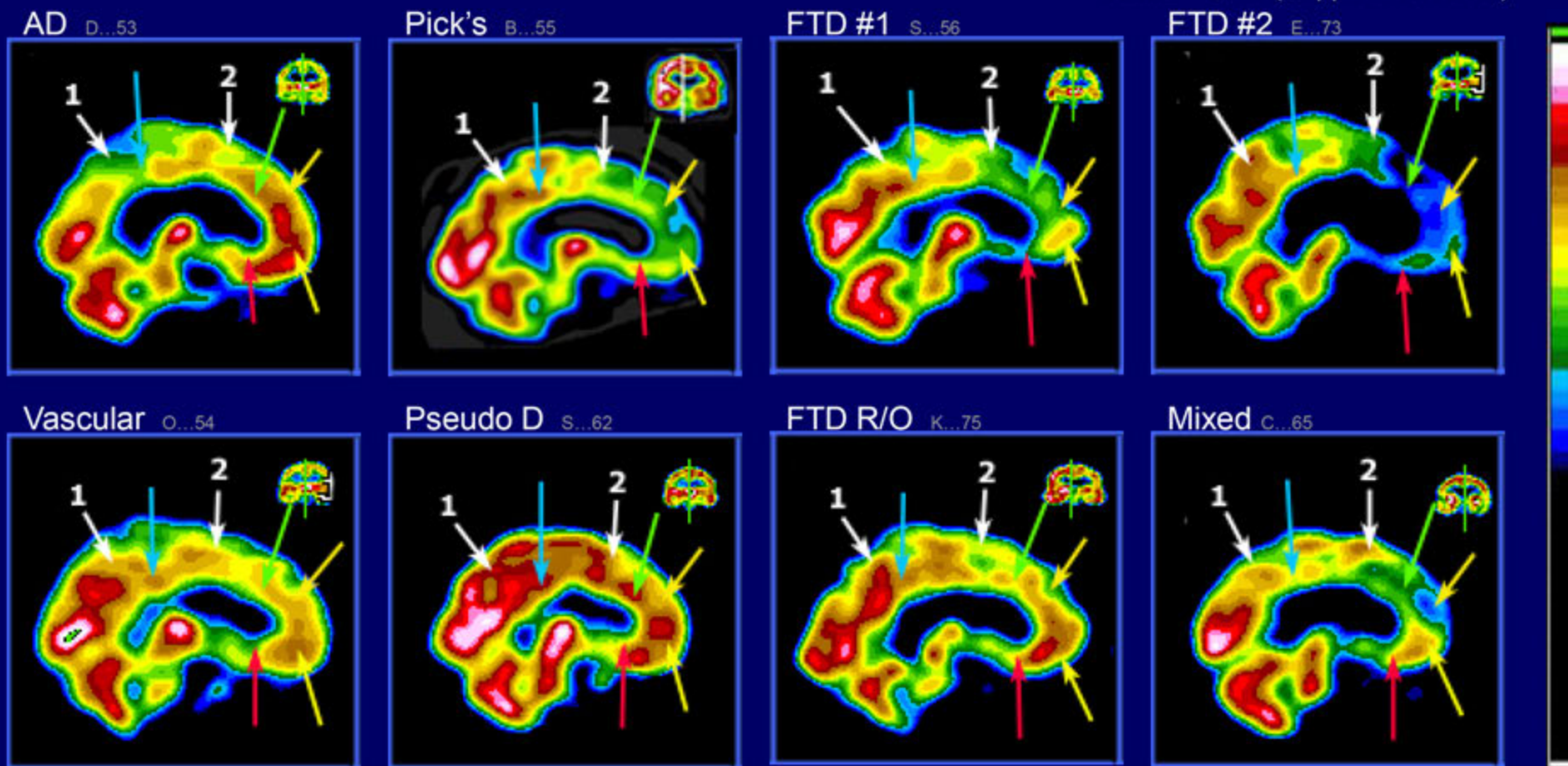


#6



## Cingulate & other sagittal structures

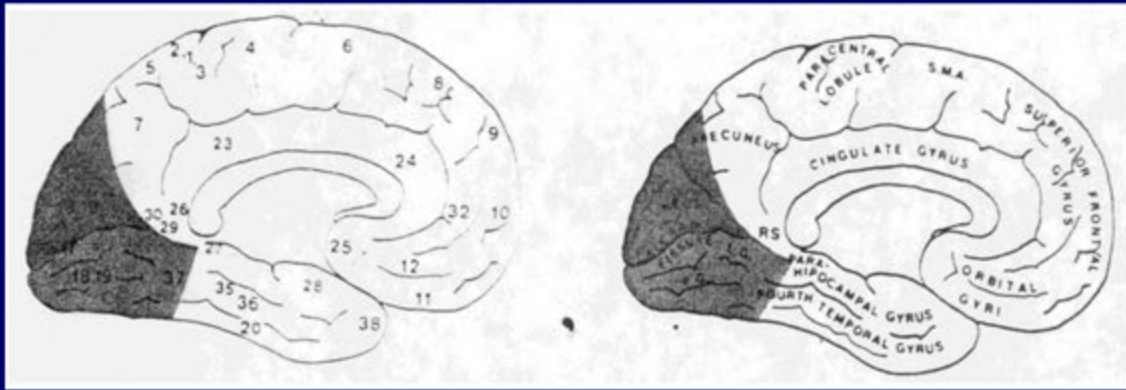
- Red = ant. cingulate / subgenual
- Green = ant. cingulate / dorsal
- Blue = post cingulate/ dorsal
- Yellow = mesial frontal
- White1 = precuneus
- White2 = SMA (Suppl. Motor Area)



Native display of mid sagittal slices

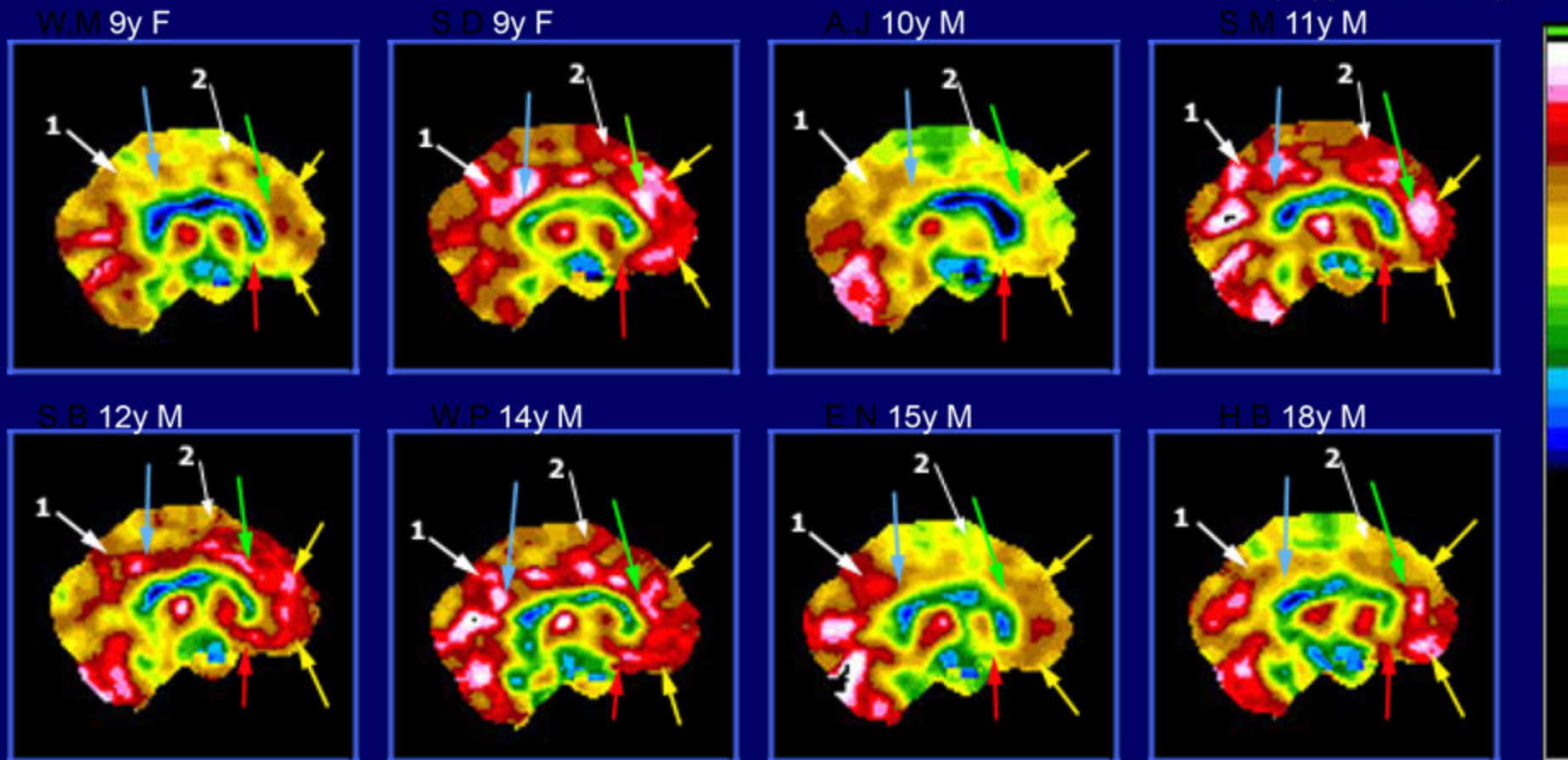


#7



## Cingulate & other sagittal structures : Talairach normalized (Neurostat)

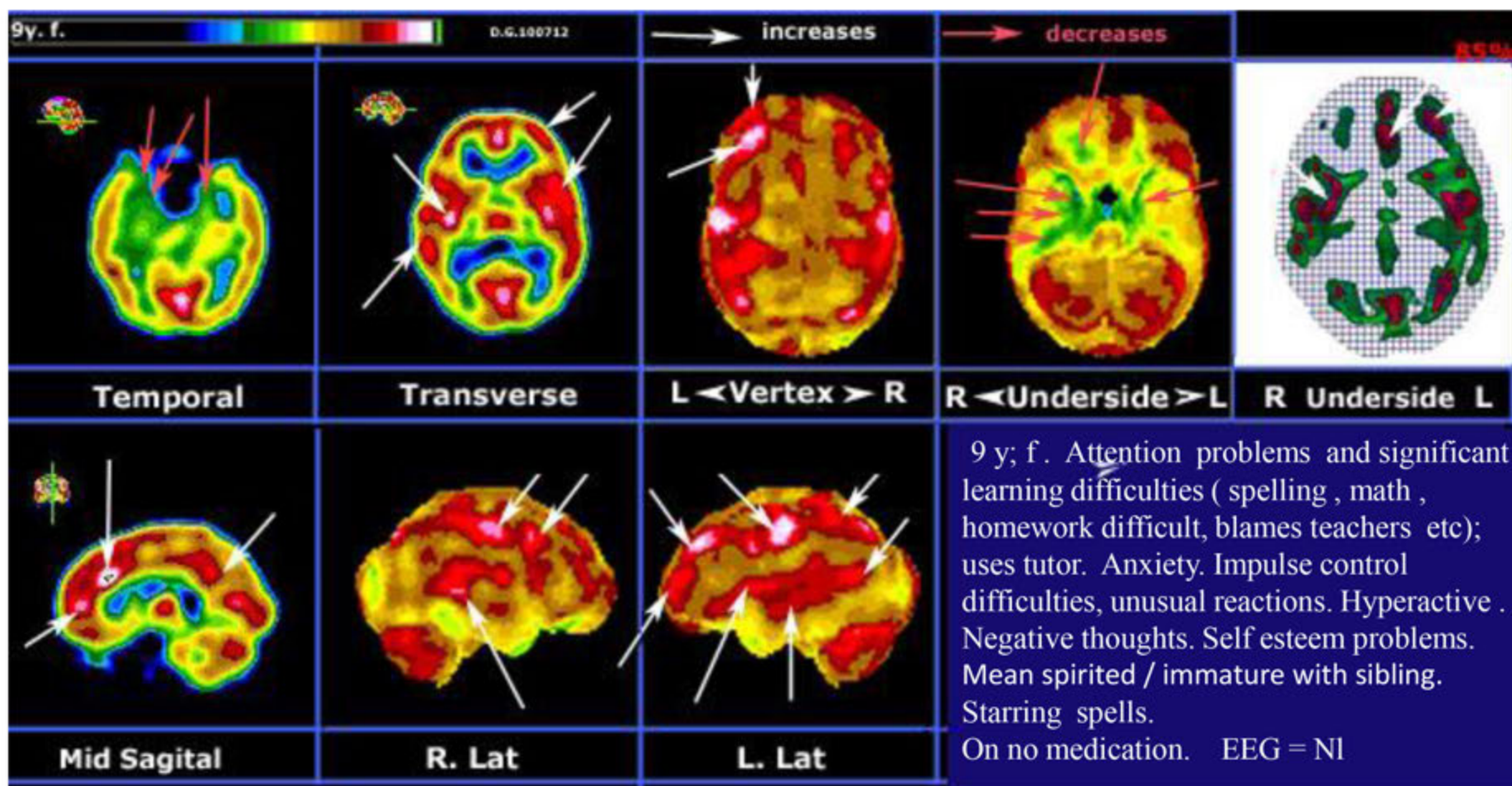
- Red = ant. cingulate / subgenual
- Green = ant. cingulate / dorsal
- Blue = post cingulate / dorsal
- Yellow = mesial frontal
- White1 = precuneus
- White2 = SMA (Suppl. Motor Area)



Display normalized to the Talairach stereotactic Atlas (via Neurostat)



#8a

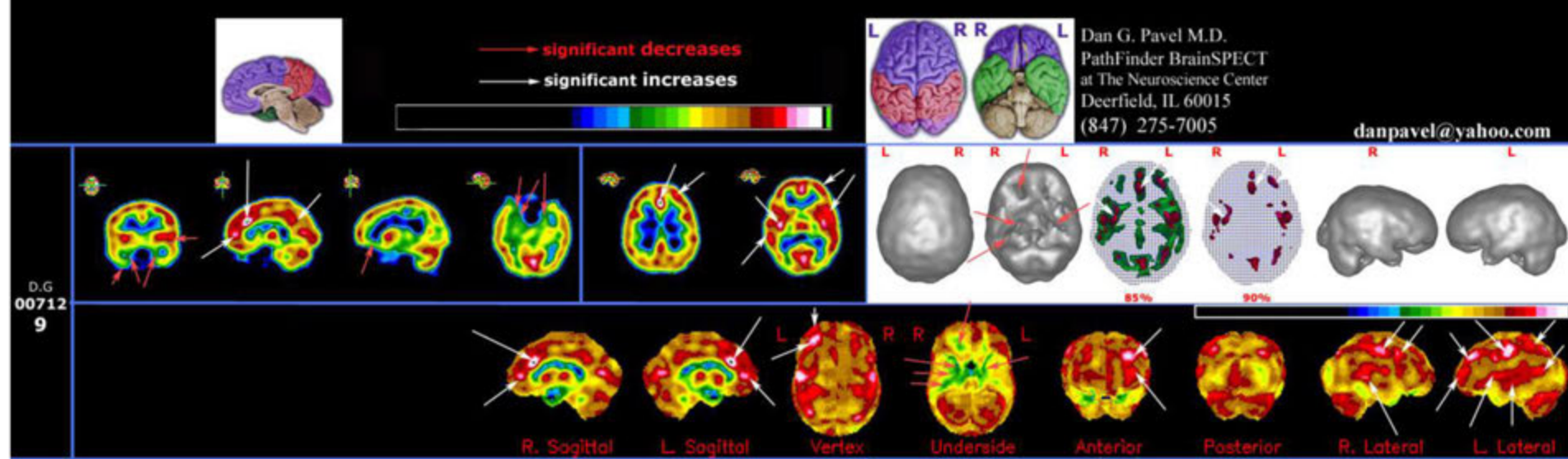


**Brain SPECT.** *Increases* : focal extreme hyperfunction in the anterior cingulate ; localized marked increases in several hemispheric areas (notably L anterior frontal).  
*Decreases*: apico-mesial temporal marked decrease on R and less on the L ; significant R orbitofrontal decrease .

**Neuropsychologic exam** (L.K.): abnormal . **ADHD**, some cognitive deficits (does not think things through); specific Learning Disabil.(reading & mathematic disorder , procedural learning deficits). Disinhibited. Academic skills need to be remediated.



#8b



100712 D.G. 9 y.o. f. (continued)

***Dx. post SPECT & N-psychological testing:*** learning disability ; limbic seizures; ADHD.

***Rx post SPECT:*** anti epileptic drug (AED) , Depakote.

***Follow-up :*** Responded progressively quite well during following few months. Ex : doing better with homework ; good report from tutor-; better grades ;able to sit still. Less staring spells . For first time states that she feels great in school ! Tutor v. pleased c her progress

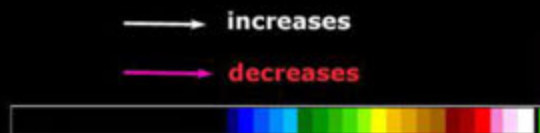
While her learning improved the medication did not address the disinhibition component Ex : several incidents of getting aggressive at school against boys she likes !! At home still mean spirited / immature with sibling.

At this stage added a stimulant (Ritalin) and additional improvement occurred , including in her impulse control capacity.

### ***Brain SPECT's contributions:***

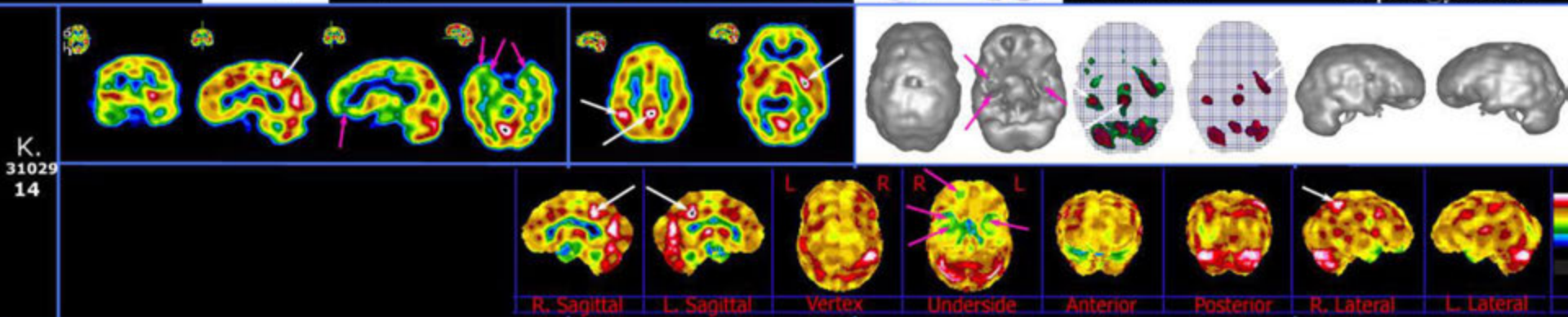
- identified main causes of her **Learning & behavioral** problems : areas of **hyper** and of **hypo**-function
- Helped in the **selection of medications** and of the **sequence** in which medication was given.
- Thus contributed to end result: significant **improvement** of her Learning dysfunction and behavior.





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K... 14 y.o. 31029

- **History** : 14 y.old. Injury during birth. Hx. of concussions (?) Learning arrested (reads at 8 y.o. level). Attention difficulties; impulse control difficulties. ADHD ; anxious; depressive episodes related to family tensions (divorce); highly immature ; shy; avoidant look; goofy; "giant of a kid" (gets involved in fights for wrong reasons); psychosocial problems: **poor parenting**. School insisted that there is no learning abnormality (!)
- **Rx.** Before SPECT : Adderall (no improvement)
- SPECT results: **Decreases**: marked apical / mesial temporal bilat ; R orbito-frontal. **Increases**: R parietal (marked); post cingulate focal (extreme); L putamen (extreme) ; thalamus.
- **After SPECT** impression: temporal abnormalities combined with focal metabolic abnormalities often indicate a combination of developmental and acquired insults. Findings also compatible with anxiety and depression.
- **Therapeutic** decisions: stopped **Adderall** ; prescribed antiepileptic **Trileptal** (for the "hot spots" - is also indicated in the presence of temporal lobe decreases) and **Lexapro** (anxiety, depression) Subsequently added: **Adderall** (but this time under the protection of Trileptal). Placed into a reading program and switched to a boarding school.
- **Follow up**: Doing much better as far as mood, and temperament /malleability; also marked improvement in learning ability .
- **Messages** : 1) history and family situation could have easily lead to the conclusion of a mostly environmental problem. SPECT indicated clear abnormal features which could be addressed and corrected, with proper **choice** and **sequencing of medications**. 2) given the extreme focal hyperperfusions it is clear why the stimulant Adderall alone **did not** provide relief .



#10

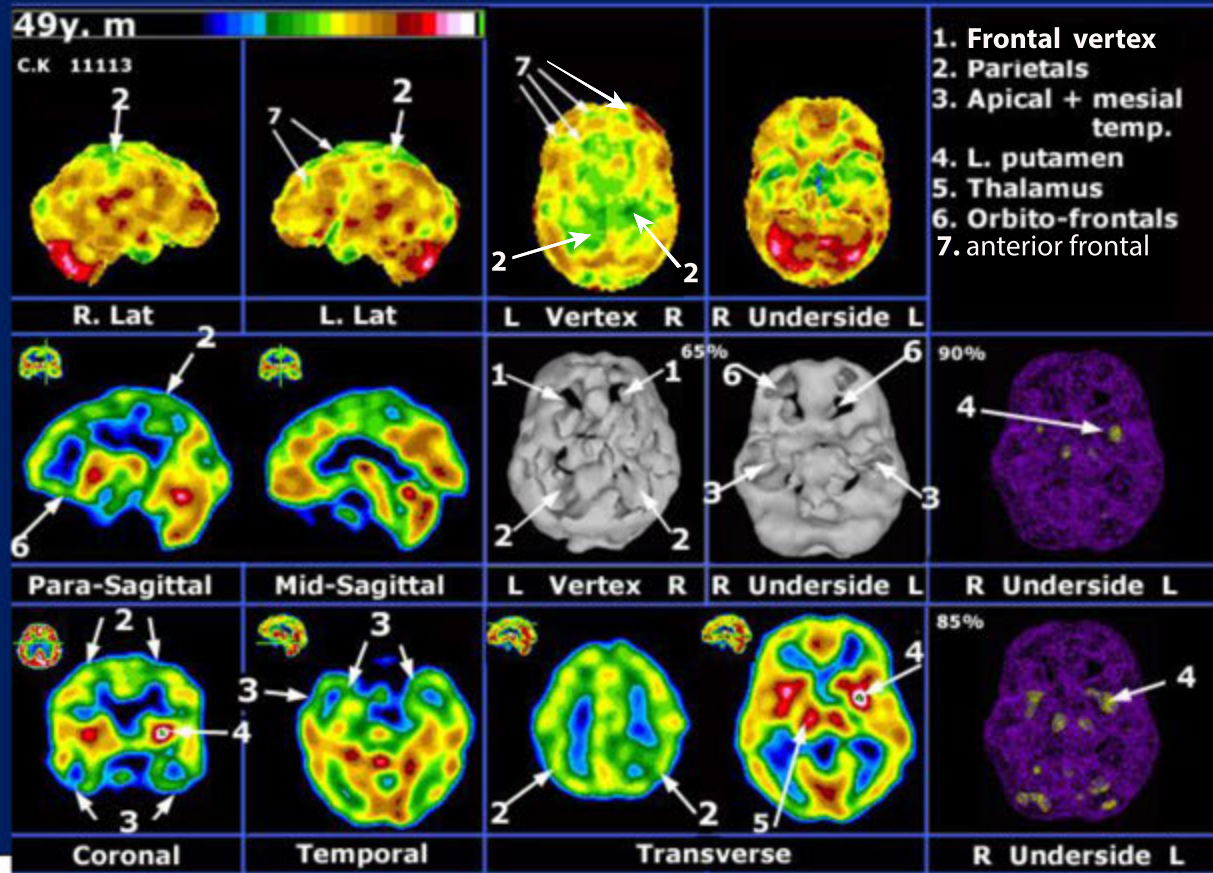


### Follow up after successful treatment of drug addiction with ADD

- **History** : 19 y.o. male with background of poly drug abuse, lately on Ecstasy. Multiple symptoms including ADD.
- **SPECT # 1** : fairly typical for major drug use. Note the mottled cortex, the diffuse underperfusion and the marked bilateral decrease in the orbito-frontal and mesial temporal areas. Asymmetric thalamus increase.
- **Followup** : underwent competent psychiatric treatment and abstained from drugs for 14 months.
- **SPECT #2** (14 months later): Note the significant improvement in hemispheric cortex, temporal apices and orbito-frontal areas. Nevertheless there is now a marked relative increase in the striatum on both sides. The images were then reviewed with the referring physician. It turns out that as soon as a marked clinical improvement set in, including in his executive function, the patient became increasingly anxious upon realizing how much work lies ahead, in order for him to catch up with life and education. Striatum hyperperfusion is indeed a feature found in anxiety.



#11

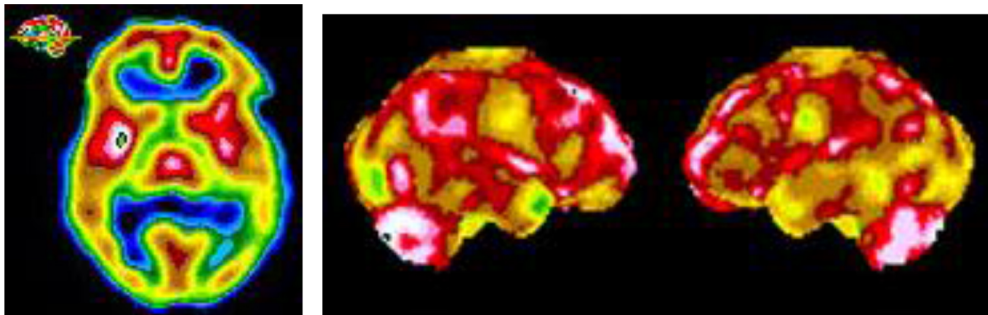


Case 11113 C.

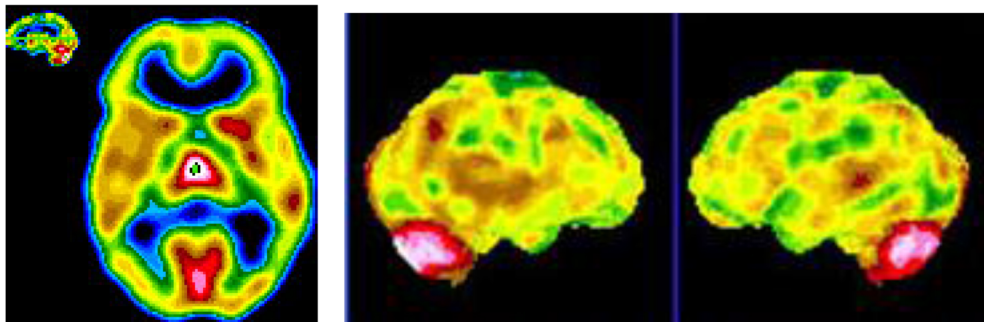
- **History** : 49 y.o. male professional with continuous, longstanding abuse of THC. Low self esteem; anxiety; difficulty with time management and with attention to detail; impulsiveness at work & in social relations, procrastination and under achievement despite high IQ. Increasing short term memory difficulties. Hx. of depression.
- **Brain SPECT** :  
Decreases: marked global hemispheric under-perfusion, most accentuated in vertex and frontal lobes (including orbito-frontal and DLPF areas) and in apical-mesial temporals.  
Increases: Extreme increase in the L putamen.
- **Impression post Brain SPECT**: ADD inattentive, drug abuse .
- **Rx**: Neurontin (for extreme increase in L putamen) and subsequently Adderall for the marked frontal as well as diffuse cortical decrease
- **Follow-up** : new job, more productive, less irritable, better organized, when compliant and when not using THC.
- **Conclusion** : SPECT emphasized the need for the two types of Rx.

# #12

**Patient #1 : too much red, white & black = extensive hyperfunction**

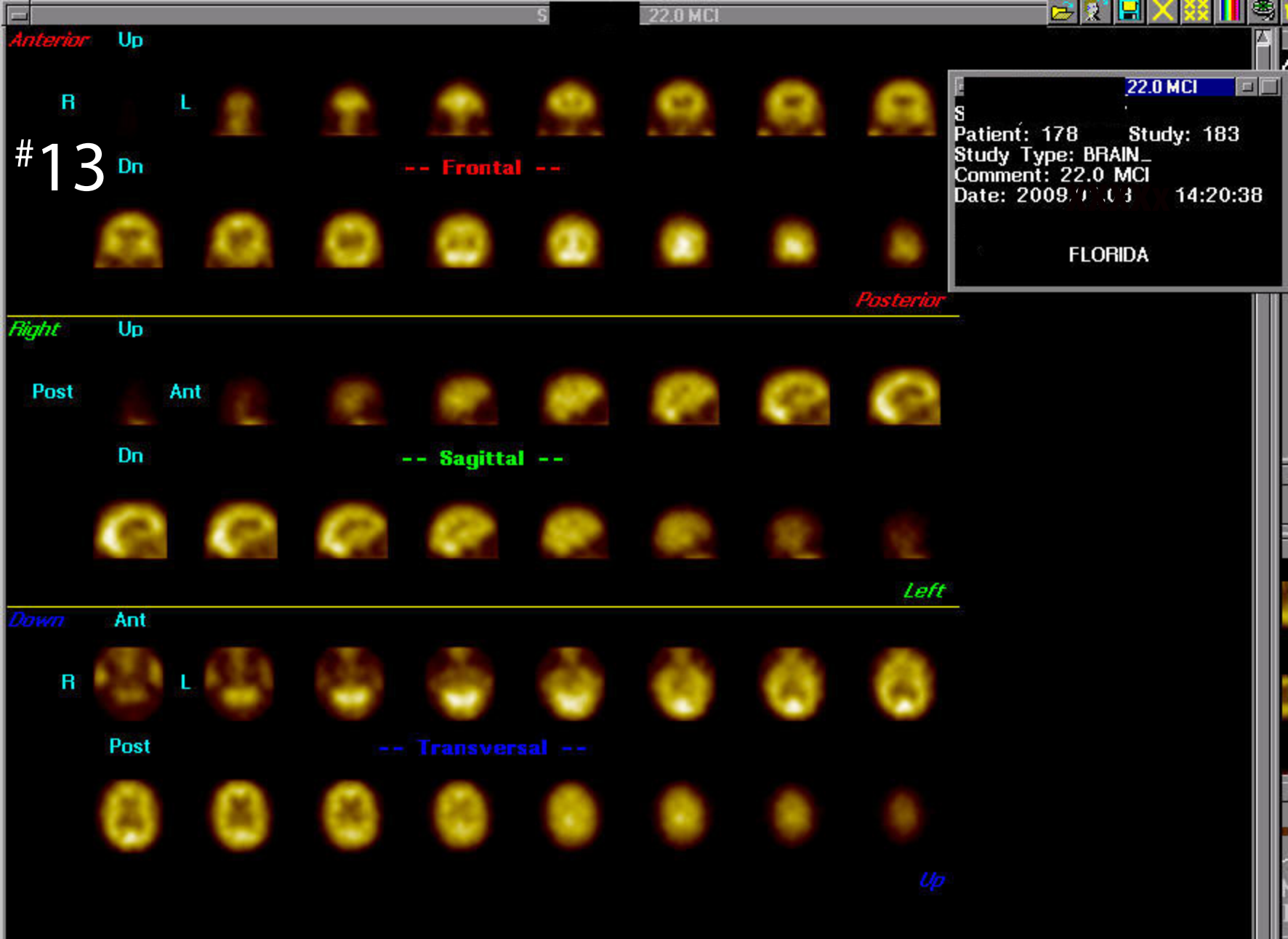


**Patient #2 : One central area of red, white & black indicates localized marked hyperfunction but, multiple areas of green = extensive underfunction**



**Two examples of Brain SPECT images in depression with comorbidity. Based on their obvious differences, there will be a need for different treatment strategies.**





# # 14

## Automatic Rendition of Standardized SPECT Displays

(April 2017)

### Overview

This Brain SPECT Imaging report is a visualization that is created automatically from a reconstructed, attenuation corrected, set of transverse slice data. The software that creates the report is developed by Good Lion Imaging. The overall report consists of two parts:

- a 5-page **static PDF** document
- a **dynamic MP4** file (video file)

### Static PDF document

The static PDF document contains detailed images of the brain SPECT study in various formats, both 2D and 3D. Since PDF is a universal format, it can be distributed freely to any party with a computer or web access. The document contains 5 pages:

- Page 1 shows the distribution of **maximum cortical activity**, rendered on standardized brain anatomy.
- Page 2 shows the same maximum activity distribution in atlas space without the 3D effect caused by the anatomical rendering. The images appear flatter but there are also less distractions. Also, this display includes the **mid-sagittal planes** which enable visualization of inner structures. A set of anatomical reference images are included on this page to guide the reader.
- Page 3 shows the iso-surface plots of the brain SPECT study **at multiple thresholds**. The lower 2 thresholds depict variations of the cortical surface, and the upper 2 thresholds depict the location of the highest perfused areas in the whole brain volume. The 6 standard orientations provide a complete overview of the entire brain in a static format.
- Page 4 & 5 show the lightbox type of displays in the 3 classic **orthogonal** views (transverse, coronal, and sagittal) in addition to a 4-th slicing along the **temporal lobe axis**. The slice data has been transformed into atlas space and resampled to a standard 5-mm thickness. This format provides great consistency and eases interpretation and comparison with follow-up images.

Various settings, such as: color scale and thresholds, are user-definable. However, the default settings shown were carefully evaluated and selected and are recommended for most users.

### Dynamic MP4 video

The video visualizes the main features of the brain SPECT study in a single display. It summarizes the essence of the study with a selection of the 3D images from the PDF report, but in a dynamic format. The rotating images can be paused at any part of the cycle and restarted. They not only enhance the 3D experience but also make them easy to understand by lay persons; in other words, a great marketing tool but one that facilitates communication with patients and even with referring professionals. The double row format allows visualization of the entire brain volume without the need for interactivity.

Please note that the performance of the cine display depends on the feature set of the video player application that opens this file on your computer. Some but not all, allow for auto-repeat (a preference setting), and when paused, allow for manual rotation. For example, VLC Player is a free software that can be configured optimally for this purpose.

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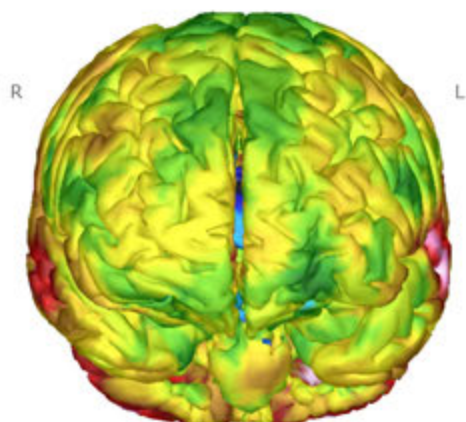
*For any technical questions please contact Simon DeBruin at Good Lion Imaging: [simondebruin@yahoo.com](mailto:simondebruin@yahoo.com).  
For any questions related to clinical applicability contact Dan Pavel MD at PathFinder Brain SPECT Imaging:  
[danpavel@pathfinder.md](mailto:danpavel@pathfinder.md)*



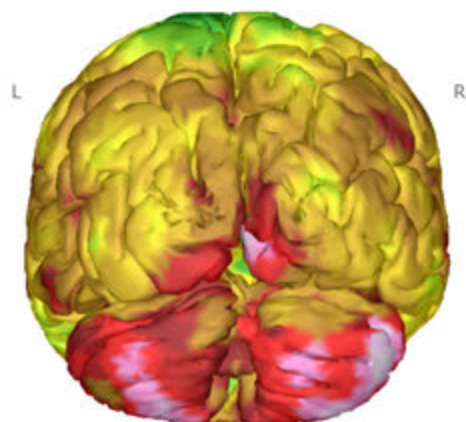
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Sex: M DOB: 1979:03:04  
Series Desc.: path\_026

ID: P1854  
Acq. Date: 2015:09:02  
Acq. Time: 11:45:19

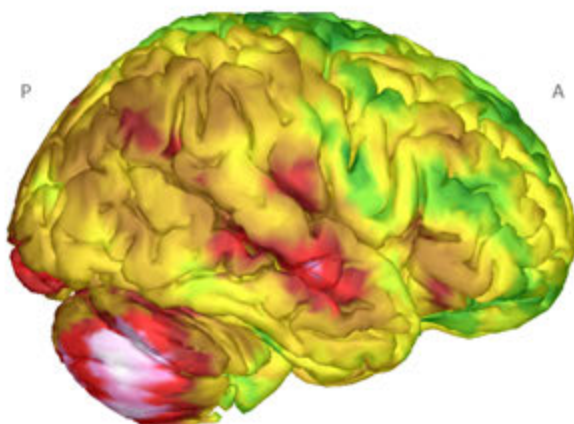
Brain Perfusion SPECT - Maximum Activity Rendered on Standardized Anatomy



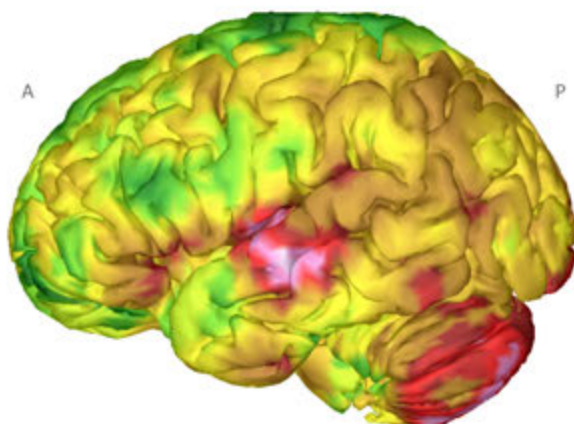
Anterior



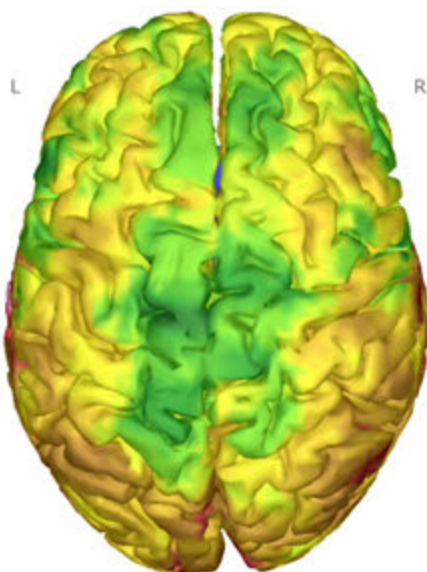
Posterior



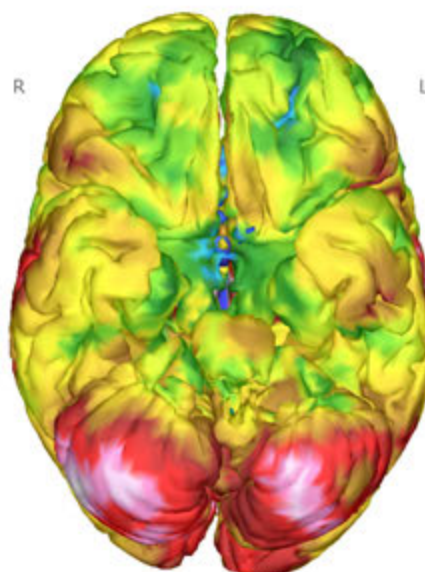
R. Lateral



L. Lateral



Vertex

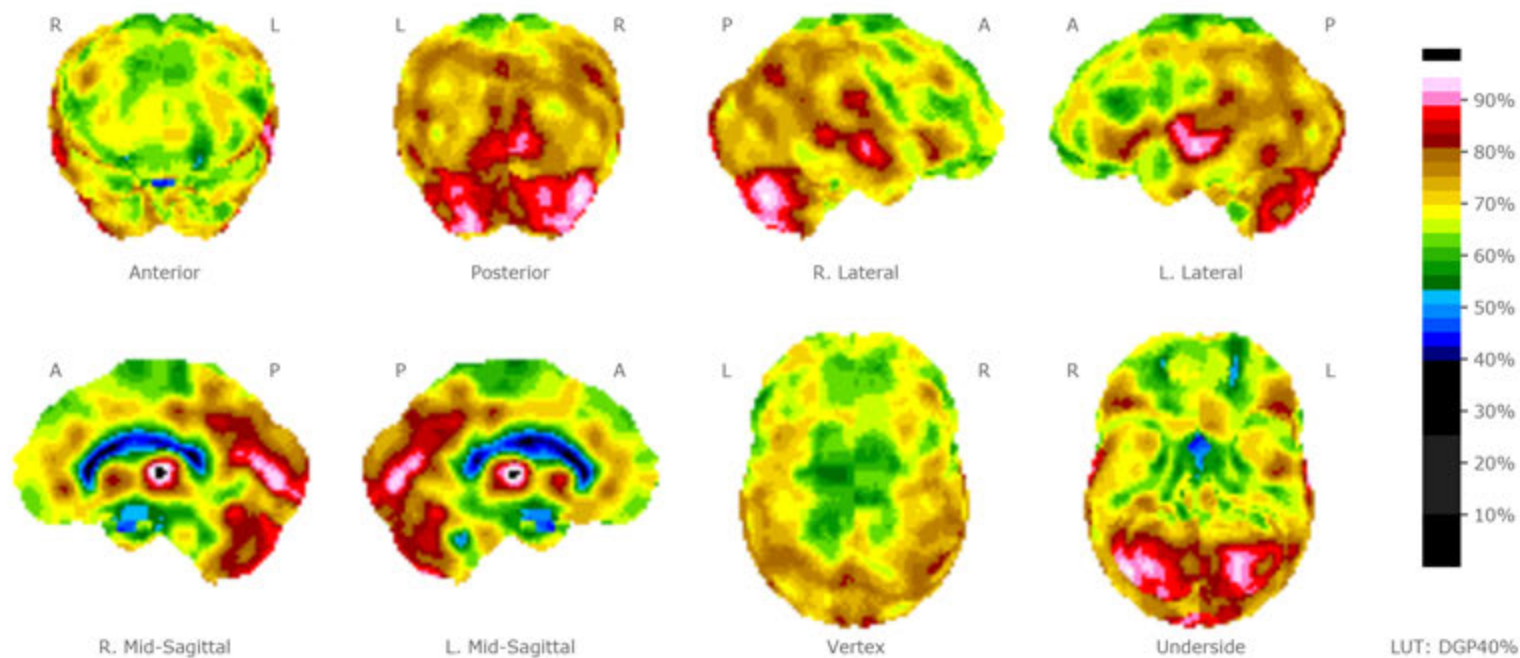


Underside

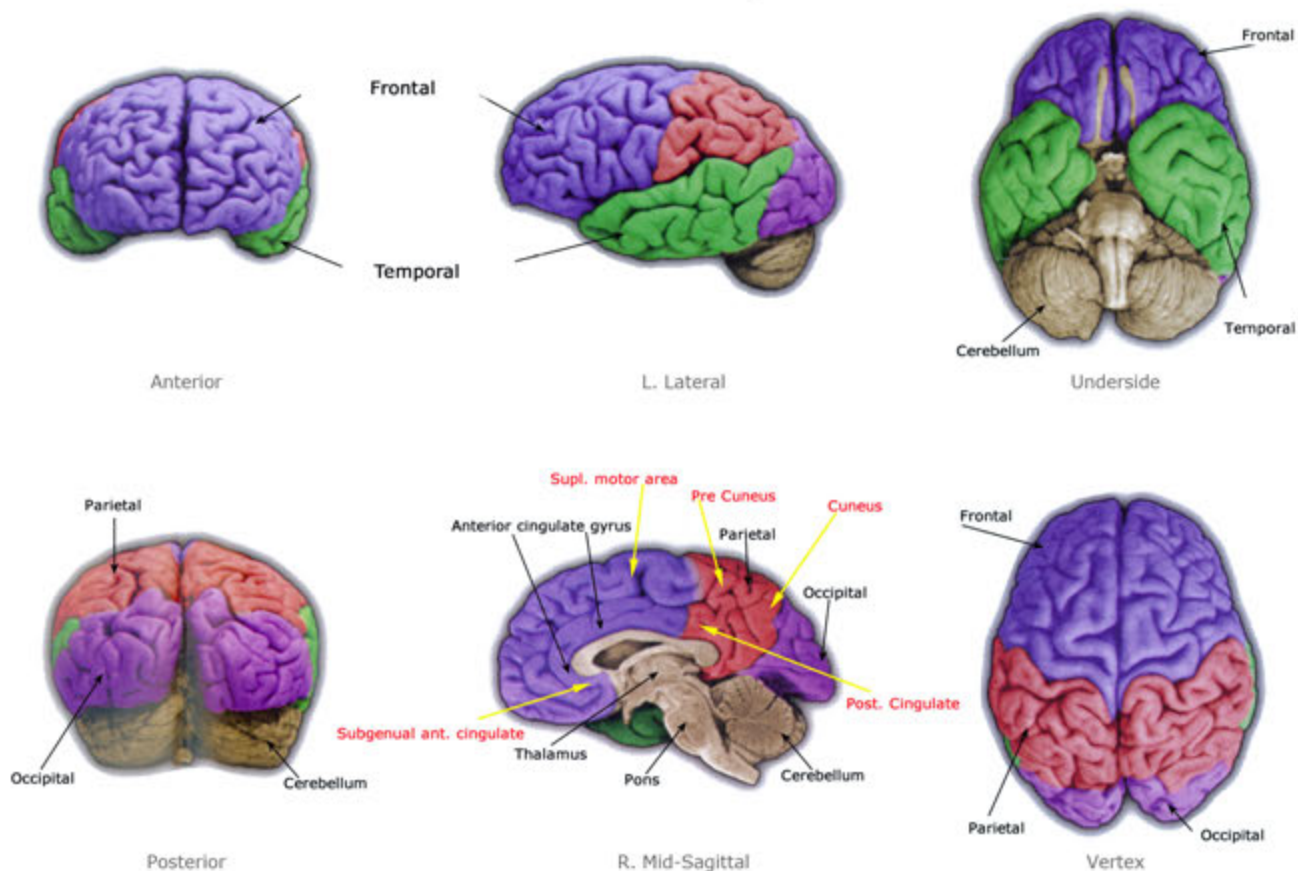
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Sex: M DOB: 1979:03:04  
Series Desc.: path\_026

ID: P1854  
Acq. Date: 2015:09:02  
Acq. Time: 11:45:19

Brain Perfusion SPECT - Maximum Activity Rendered on Atlas Normalized Space



Anatomical Reference Images

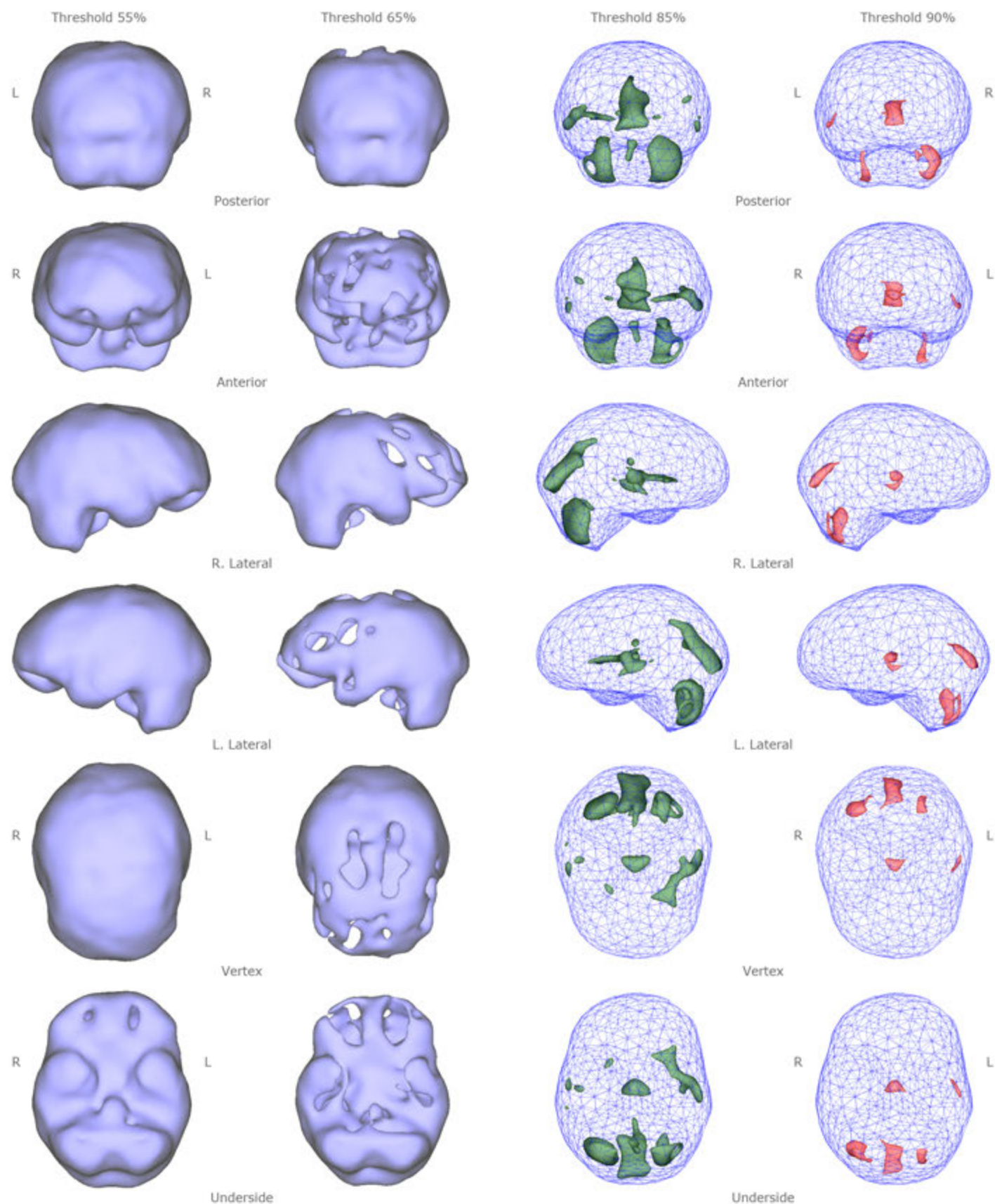




Patient Name: NJ  
Sex: M DOB: 1979:03:04  
Series Desc.: path\_026

ID: P1854  
Acq. Date: 2015:09:02  
Acq. Time: 11:45:19

## Brain Perfusion SPECT - Multi-Threshold Volume (MTV) Display



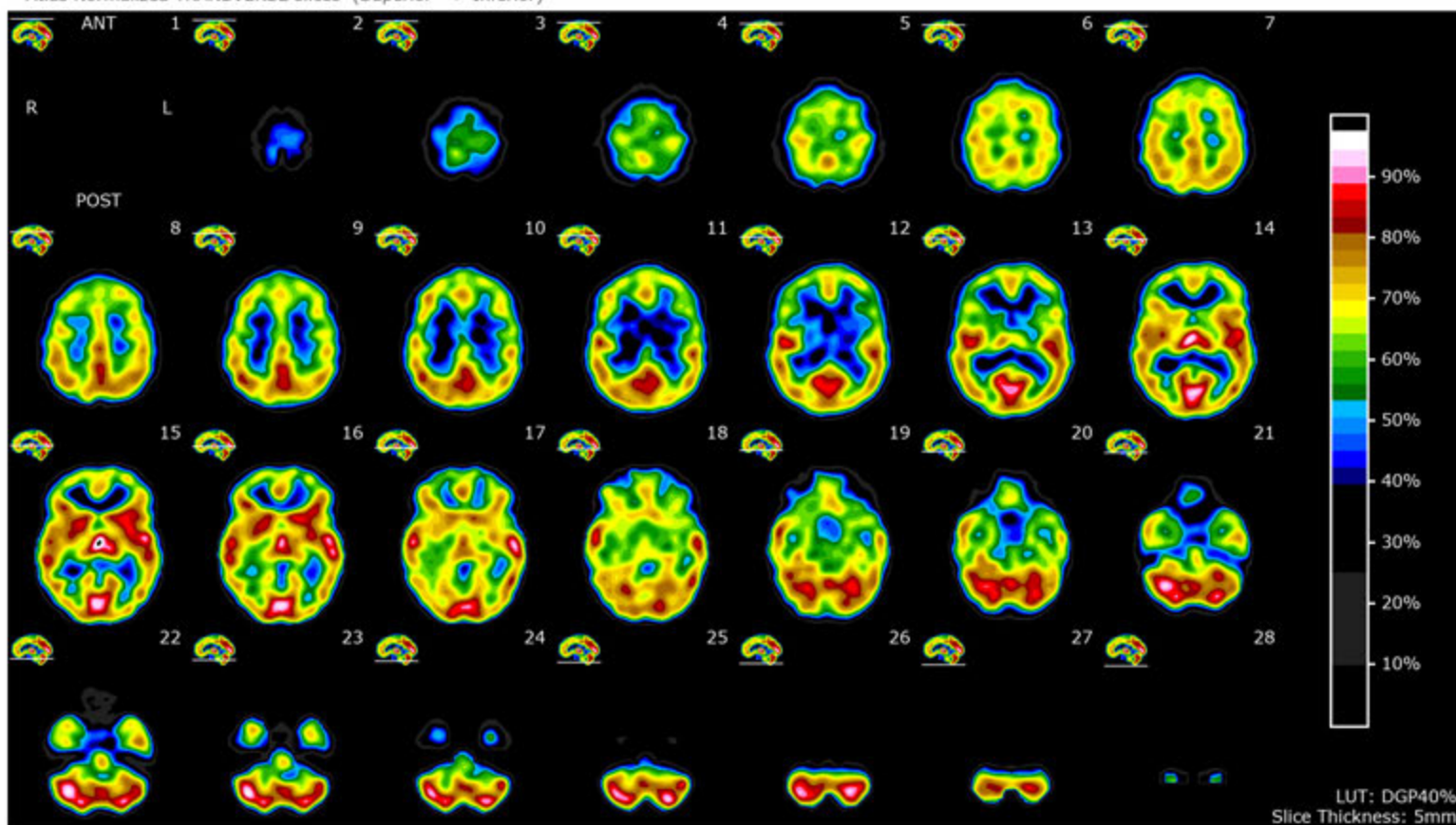
#14-4

PathFinder Brain SPECT Imaging  
at The Neuroscience Center  
Dan G. Pavel, M.D.

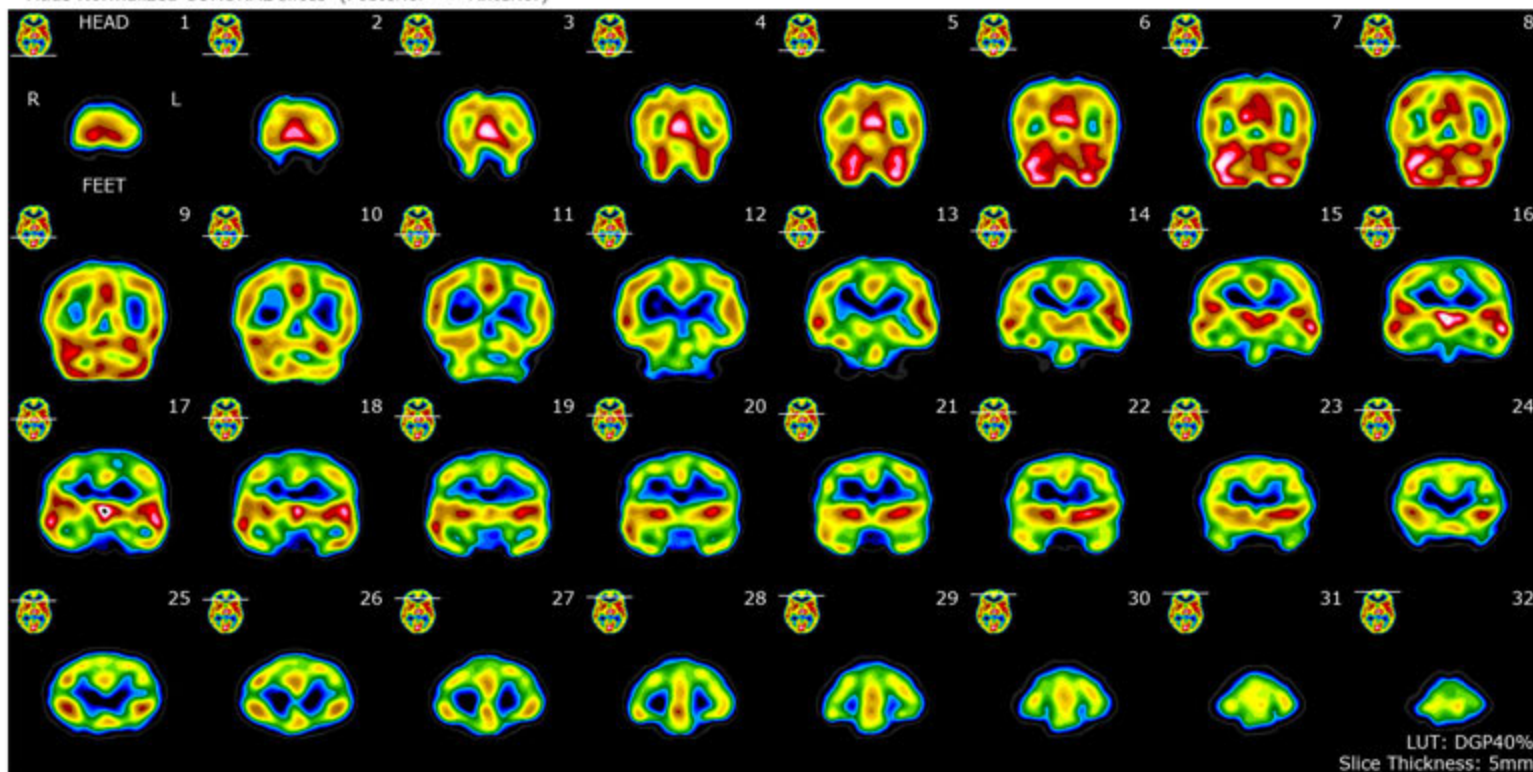
4

Patient Name: NJ  
Sex: M DOB: 1979:03:04  
Series Desc.: path\_026ID: P1854  
Acq. Date: 2015:09:02  
Acq. Time: 11:45:19

Atlas Normalized TRANSVERSE slices (Superior --&gt; Inferior)



Atlas Normalized CORONAL slices (Posterior --&gt; Anterior)

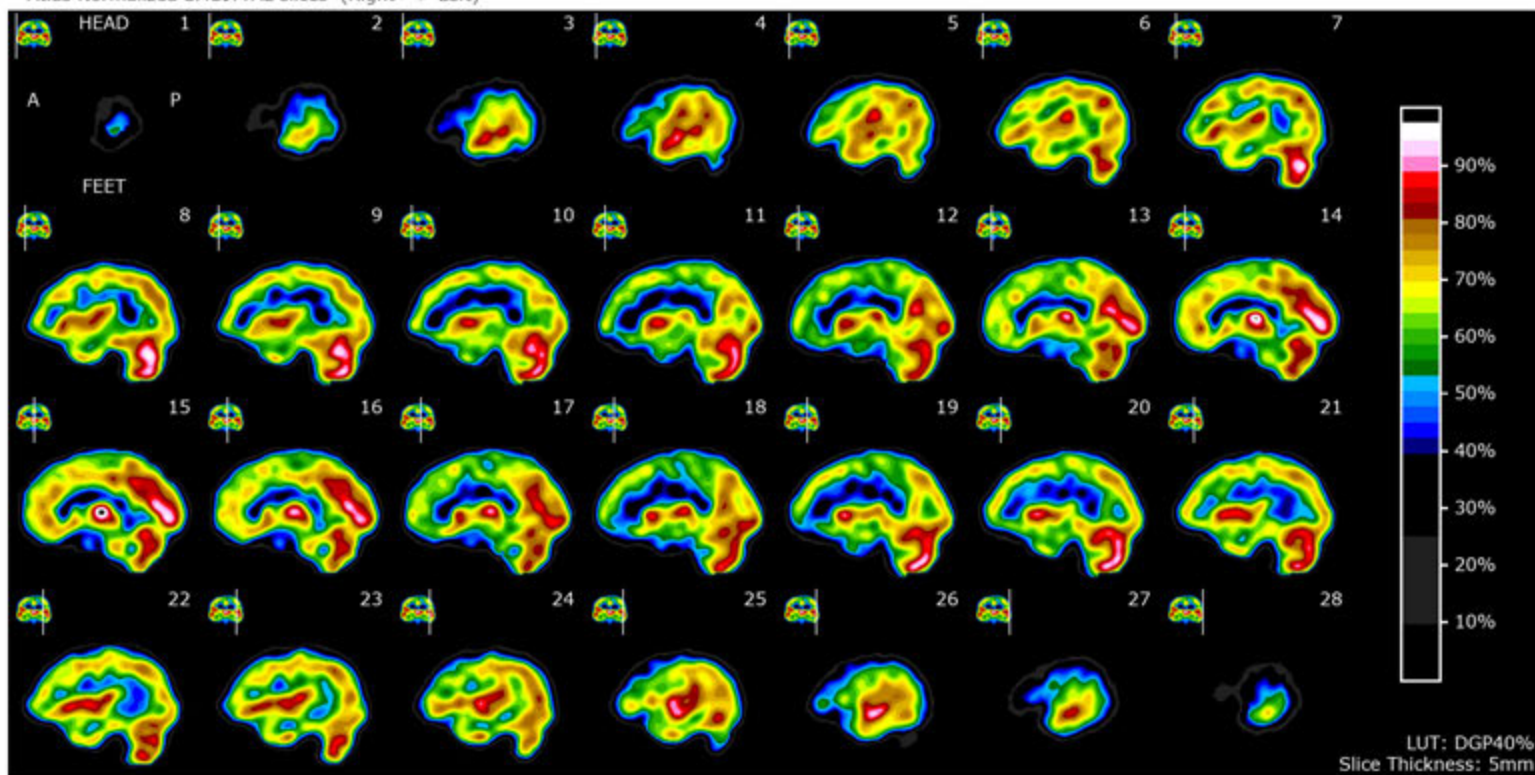




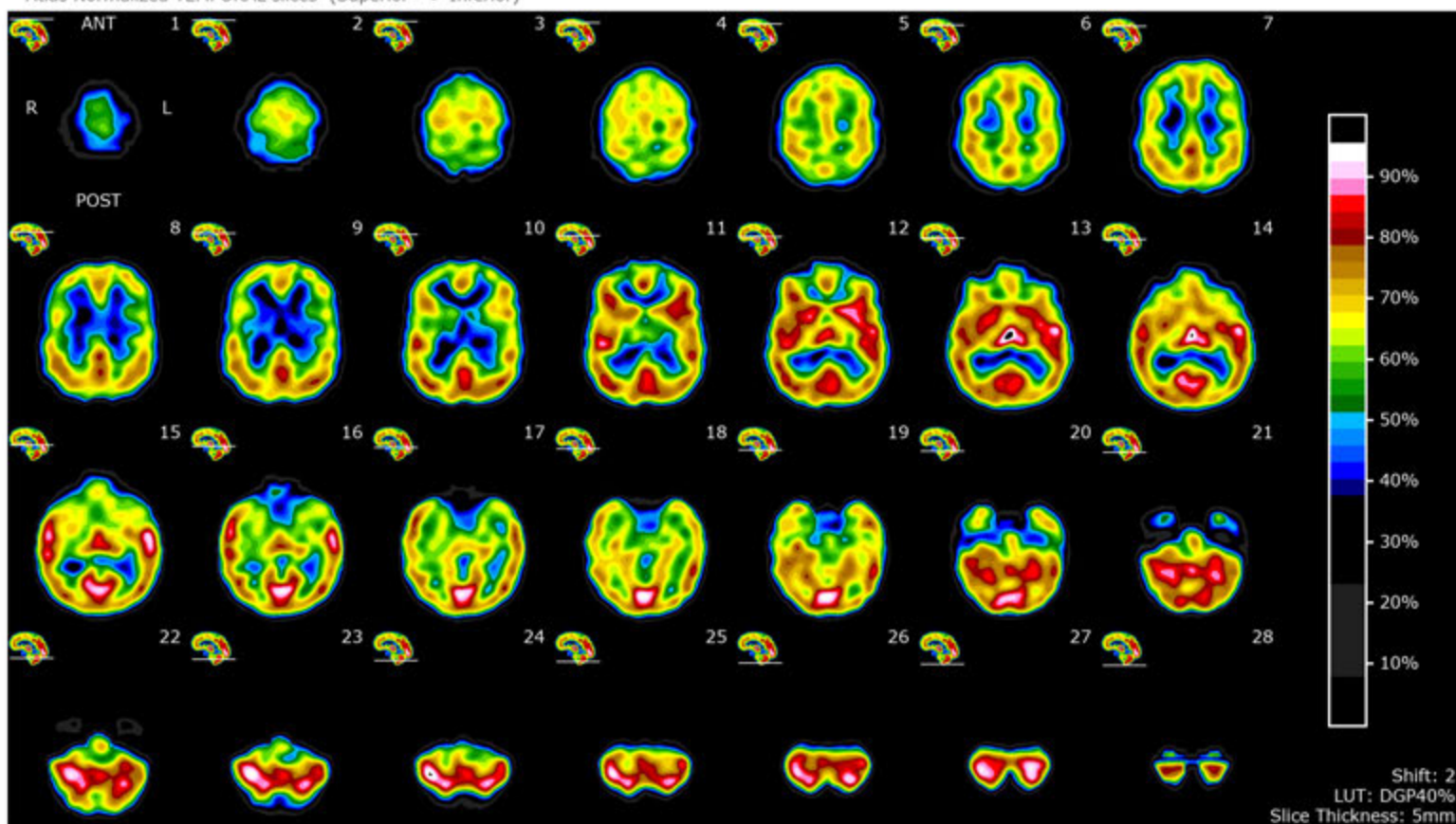
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Atlas Normalized SAGITTAL slices (Right --&gt; Left)



Atlas Normalized TEMPORAL slices (Superior --&gt; Inferior)



# **15**

Please see the attached MP4 file:

**NJ\_2015\_0\_026.mp4**



# #16

## Legend for illustrations 1-15 (above)

(They are included in one PDF Acrobat document and a separate MP4 file)

The 14+ illustrations are included in one large PDF Acrobat document and in one separate MP4 file

# 1 : text: Introduction to the Brain SPECT demo illustrations

The first 12 illustrations are based on cases from our teaching materials. They are generated with our present display software which has stood the test of time but, still requires significant operator time. For this reason we are in the process of switching to a similar but more automatic display as illustrated in #14.

#2 & 3 are addressing one type of TBI and the variety of informations that can be obtained from SPECT

# 4 & 5: Are self explanatory and are a tribute to the long track record of SPECT contributions to the evaluation of Neurodegenerative disorders, contributions which seem to be increasingly forgotten

# 6 & 7 : are examples of the details that can be gathered from evaluating the mid sagittal views. It emphasizes the details and wide array of variations in the cingulate gyrus and adjacent structures (precuneus, etc). This is true in the dementia differential (#6) as well as in youngsters ages 9 - 18 (#7). In the latter, it has enabled us lately to also tie some of these changes to the status of DMN (default mode network) and search for practical applications related to prognosis and treatment.

# 8a & b : pediatric Psychiatry case with its own legend (2 pages)

# 9 : another pediatric Psychiatry case with its own legend

# 10 : young adult before and after Rx for addiction.

# 11 : adult professional with prolonged marihuana use and comorbidity.

# 12 : simplest teaching slide for the usefulness of SPECT in adult depression with comorbidity.

# 13 : a sad example of what we are still getting, even today, from patients who had had brain SPECT done elsewhere. Sometimes one has to wonder ..... !

# 14 : 36 y.old male with multiple comorbidities (anxiety ; OCD; depression; chronic pain; Lyme disease; ETOH & THC exposure).

The text introduces and explains the 5 page display that follows. These are the components of an automated algorithm that only requires as input the single slice sequence obtained after reconstruction and attenuation correction. It does not even require software purchase because the data can be uploaded to a secure server and processed off site for a minimal cost.

# 15 : a reminder to look at the attached MP4 file of the same 36 y. old case as in # 14.