

# Demonstrating Brain Injuries with Brain Scanning

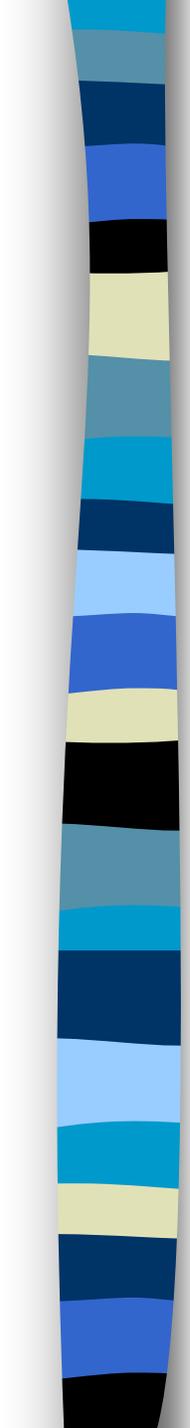
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Sandra Day O'Connor Courthouse

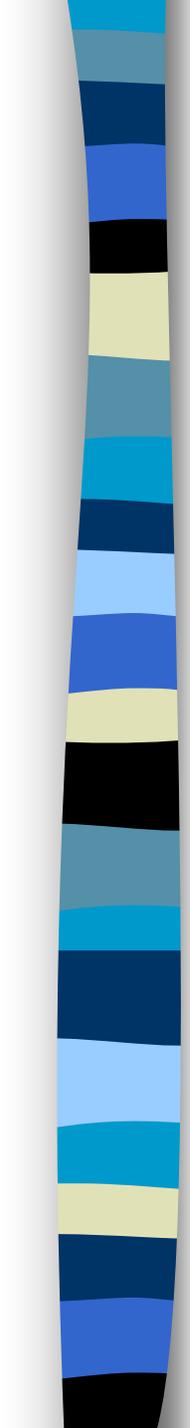
Phoenix, Arizona

April 13, 2007



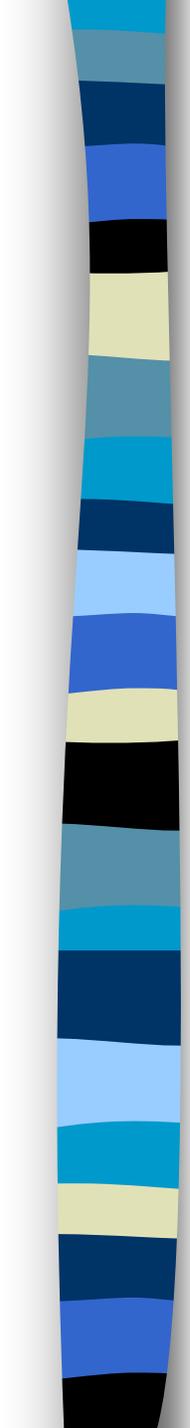
# Plaintiff's Issue in Brain Injury Cases

- How to Demonstrate to the Trier of Fact that the Plaintiff is Suffering Serious Disruptions of Behavior and Function from an Injury that Cannot be Directly Seen
  - More profound the disruptions of behavior and function less challenging the problem
  - Yet may persist even with serious injury



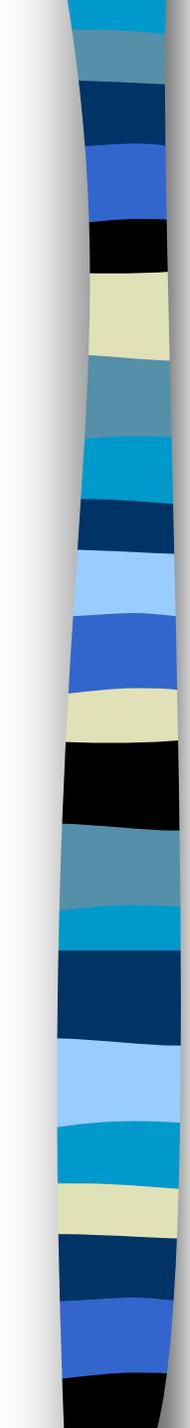
# All Appearances to the Contrary

- Physical Appearance is Normal
- Static Imaging Does Not Depict Signs of Injury
  - Or signs are controversial
- Neuropsychological Testing is WNL
  - Or abnormal findings are controversial
- Performance on “Malingering Testing” is Problematic
- Reported Behavioral is Inconsistent
- Inherent Skepticism



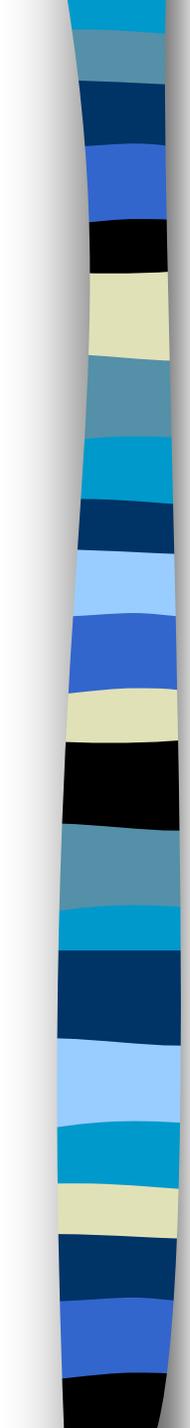
# Visualization Tips the Balance

- Imaging the Locations of Apparent Injury Persuades Trier of Fact that there is a Genuine Organic Basis for Reported Disruptions
  - Converts doubt into confidence
- Clearer the Visualization More Persuaded the Trier of Fact
  - Nothing Quite Like Color



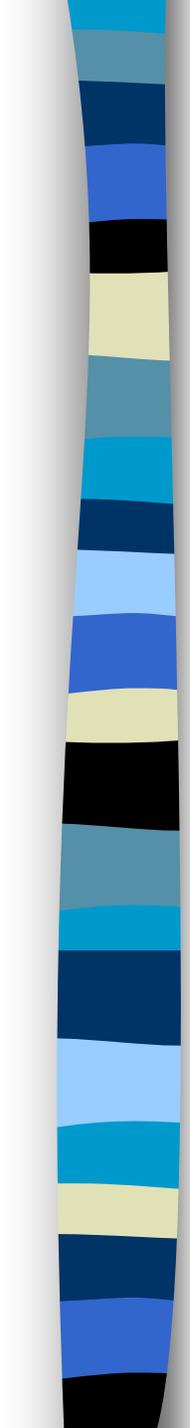
# Imaging Works in Conjunction with Other Assessment Tools

- State of the Art Does Not Stand Alone
  - Methodological issues with imaging methods
  - Rival alternative hypotheses to account for findings
- Plaintiff Seeks Convergence of Indicators
- While Defendant Seeks Divergence



# Imaging Options

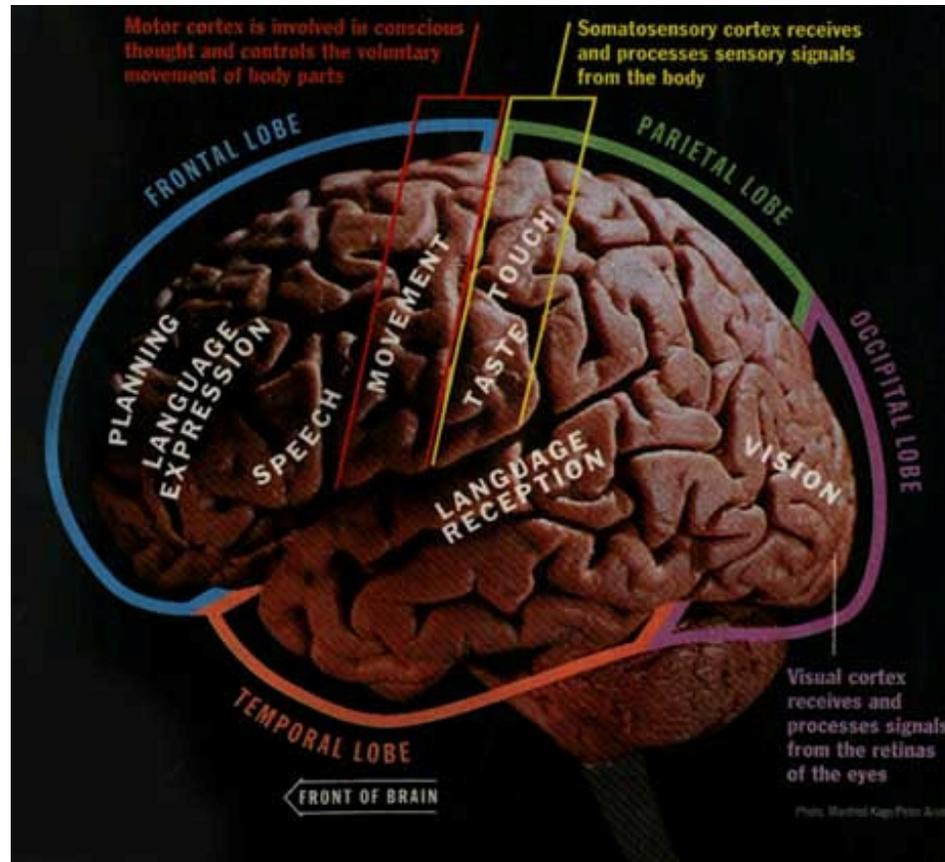
- Structural Neuroimaging
  - CT
  - MRI
- Chemical Neuroimaging
  - MRS (Magnetic Resonance Spectroscopy)
  - PET (focus on chemical aspects of brain)
- Functional Neuroimaging
  - EEG/qEEG
    - ERP (event related potentials)
    - MEG (Magnetoencephalography)
  - PET
  - SPECT
  - fMRI
  - Optical Imaging
- List provided here not exhaustive

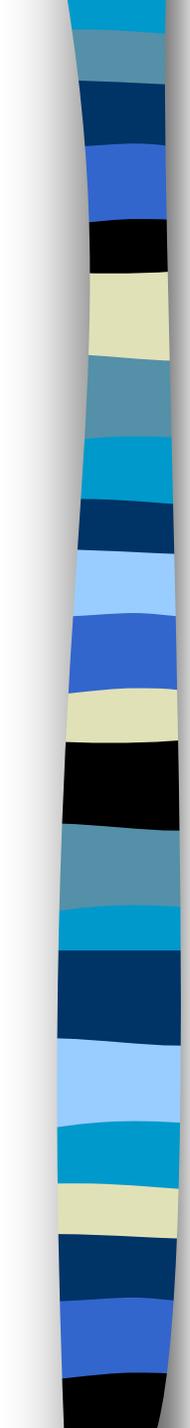


# Promise of Imaging in Brain

- Coordinate Reported Symptoms with Observable Areas of Damage
- Assumes a Viable Theory Linking Location with Function
  - Lay expectation is that injury to a specific location will result in corresponding specific dysfunction

# Localization of Function

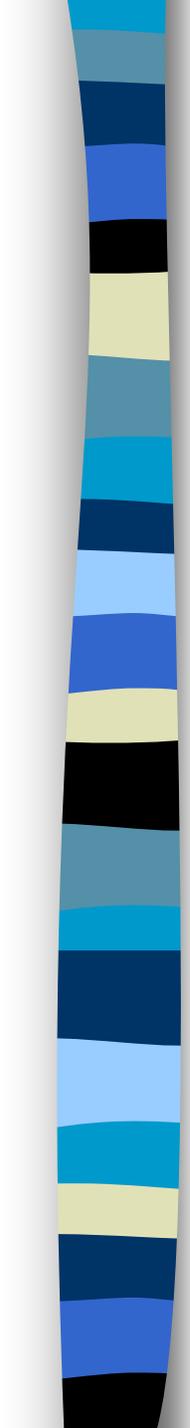




# Alternative Theory of Sources of Function

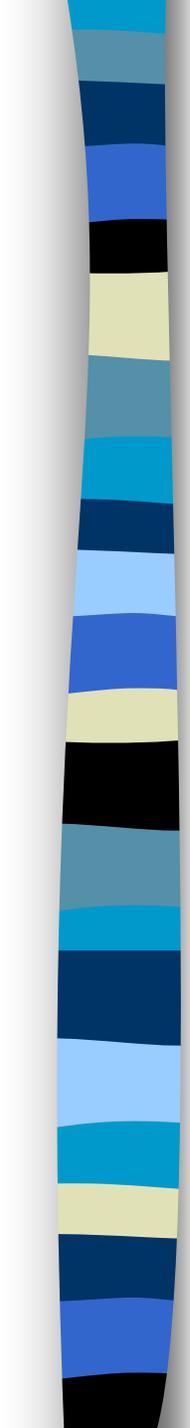
## ■ Neural Networks

- Pathways drawing on multiple contributions to achieve a functional outcome



# Illustration: Attention

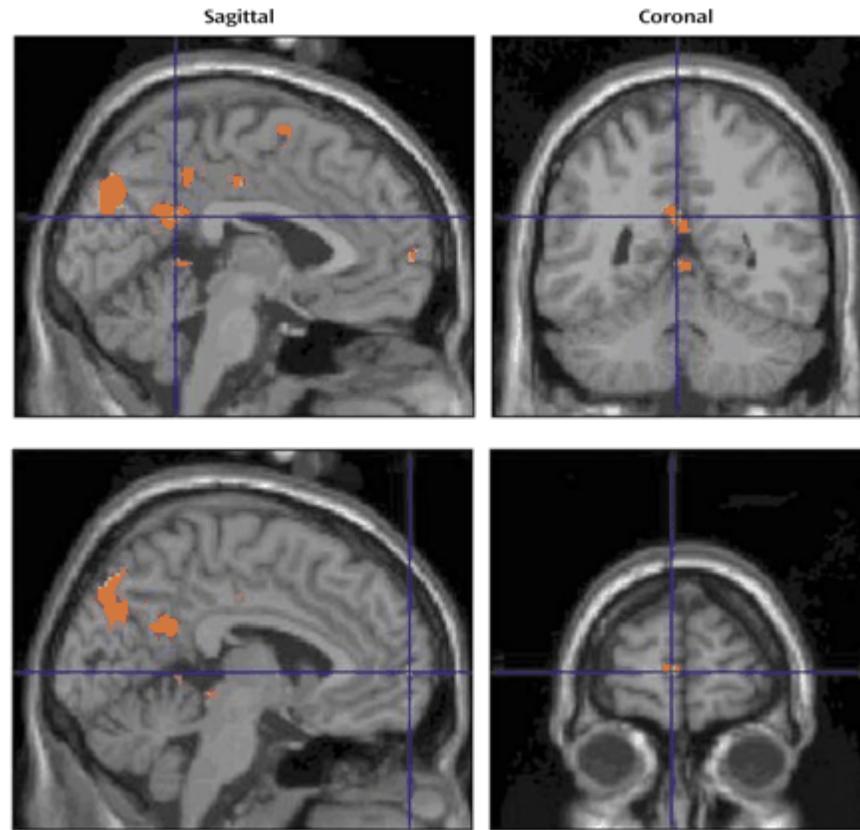
- Filtering of sensory information so as to rapidly isolate important input from the sensory environment in support of cognitive analysis
  - Decide on which objects and locations in the visual field are currently important
  - Direct sensory receptors to that visual field
  - Retrieve information
  - Hold information for subsequent processing
    - *Giesbrecht, et al, Functional Neuroimaging of Attention in Cabez and Kingstone, Handbook of Functional Neuroimaging of Cognition, 85-111*

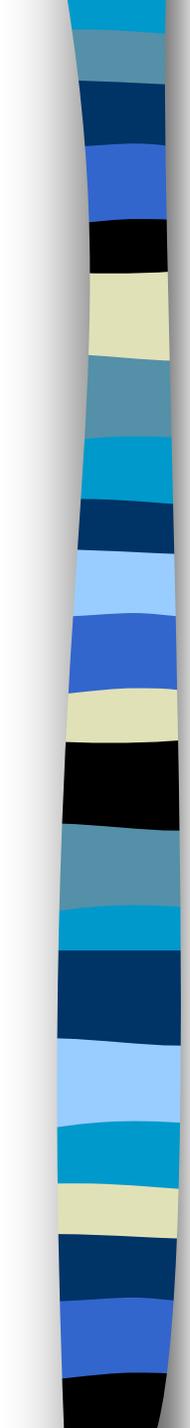


# Illustration: Grief

- Intense sadness associated with loss
  - Common response to serious injury
  - Consequences for various aspects of functioning, including cognition
- Neural Network
  - Affect processing, mentalizing, episodic memory retrieval, processing of familiar images, and autonomic regulation
    - *Guendel, et al, Functional Neuroanatomy of Grief: An fMRI Study, 160 American Journal of Psychiatry 1946 (2003)*

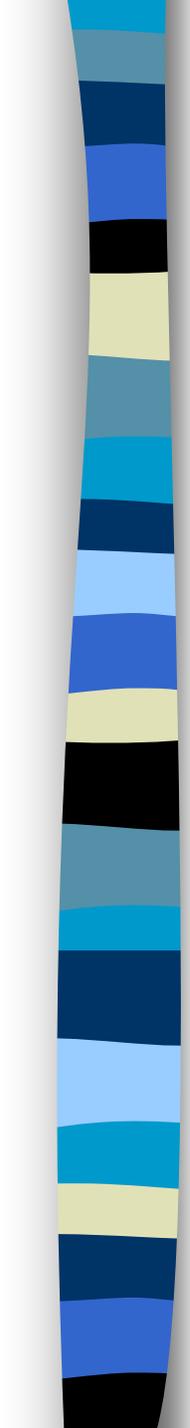
# Brain Areas Activated During Verbal Evocation of Grief





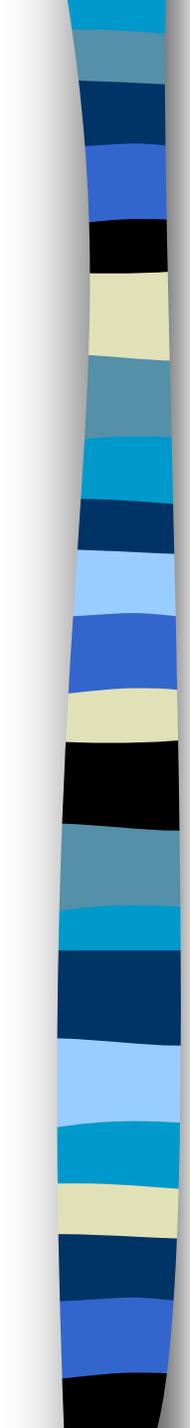
# Promise of Neuroimaging from a Litigator's Standpoint

- Exhibit Presence of Real Damage to Brain tissue
- Correlate Damage to Brain Tissue with Disruption of Function
  - But note that not every brain injury results in persistent disruption of function
- Demonstrate how Less Serious Injury Can Nonetheless Have Significant Consequences



# Promise Not Met - Yet

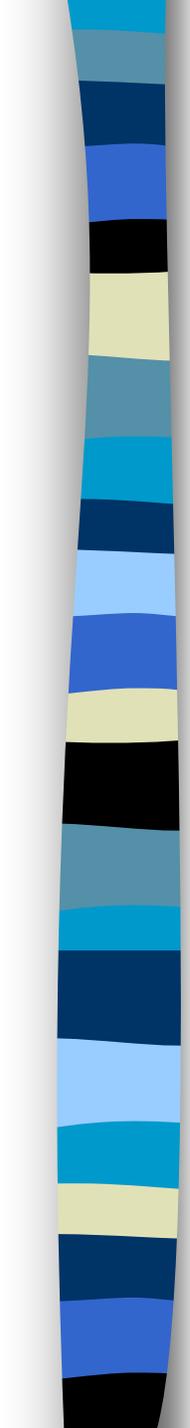
- Insofar as foundation of brain injury is at the axonal level and diffusely distributed in the brain, static imaging inadequate to visualize genuine injury when present
  - *Azouvi, Neuroimaging Correlates of Functional Outcome after Traumatic Brain Injury*  
*13 Current Opinion in Neurology 885 (2000)*
- Methodological Problems with Dynamic (Functional) Imaging
  - Challenges to admissibility
  - Attack as to integrity of findings



# Methodological Foundation Issues for the Neuroimaging Problem

## ■ Validity

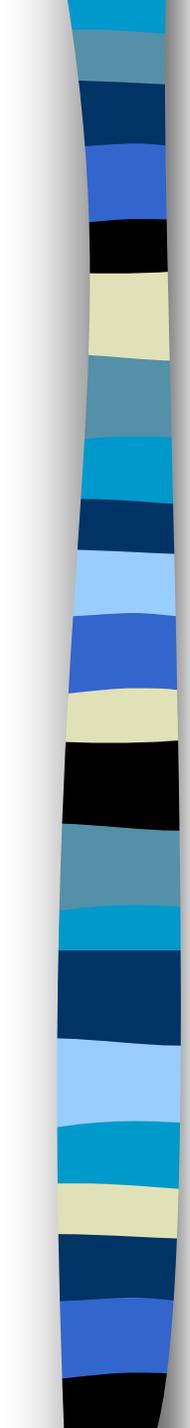
- Does this instrument measure what it purports to measure?
  - Recall the functional imaging instruments do not directly measure the functions in issue
    - PET Scans: Cerebral metabolism is used as an indicator of functional activity
    - SPECT Scans: Blood perfusion as an indicator
  - Require a theoretical model linking what is measured (e.g. in PET scans, glucose metabolic abnormalities) with the function (some aspect of attention) in issue
    - Lack independent measures to support presumed one-to-one correlation between abnormal imaging data and underlying neuronal pathology



# Methodological Foundation Issues in Neuroimaging (Cont.)

## ■ Reliability

- Whatever the instrument measures does it measure it consistently?
  - Requires consideration of other factors relevant to the indicator being used (e.g. metabolism, perfusion, electrical activity) that may be resulting in observed variation with respect to that indicator



# Methodological Foundation Issues in Neuroimaging (Cont.)

## ■ Sensitivity

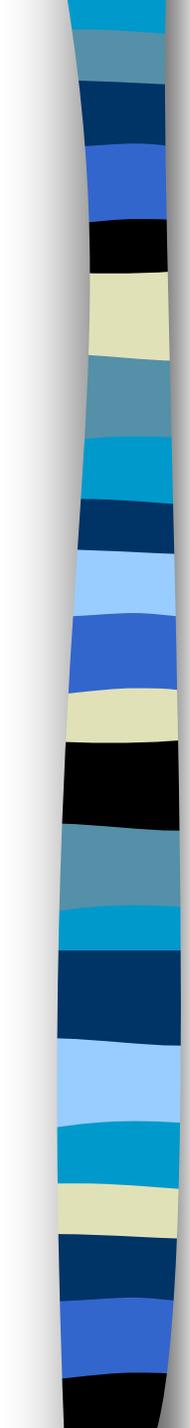
- To What extent is the instrument sensitive to the presence of the functional activity in which are interested

## ■ Specificity

- To what extent is the instrument is able to distinguish the functional activity in issue from other functional activities
  - False positive problem-should have estimate available
  - No abnormality pattern unique to TBI

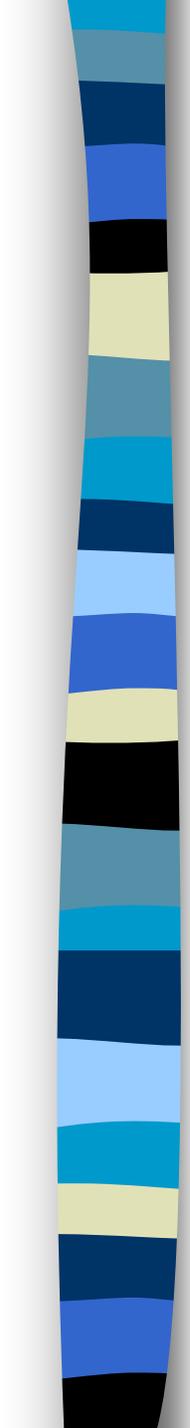
## ■ Note Conceptually the Inverse Relationship between Sensitivity and Specificity

- *Mark, Decision Making in Clinical Medicine in Kasper, et al (eds), Harrison's Principles of Internal Medicine at 9*



# Considerable Controversy within Neuroscience

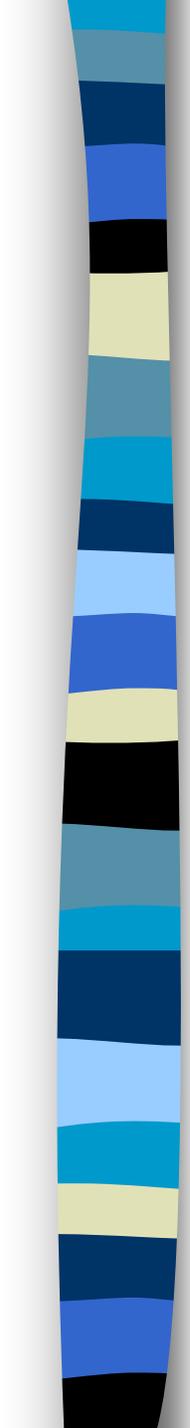
- Series of American Academy of Neurology Position papers
  - qEEG 1989, 1997
    - *Newer, et al, 49 Neurology 277 (1997)*
    - But see *Hoffman, et al, 11 Journal of Neuropsychiatry and Clinical Neurosciences 401 (1999)*.
    - See also APA, 1991 and AEEG, 1994
  - PET, 1996
  - SPECT, 1996 *46 Neurology 278 (1996)*
    - Follow up notes progress, but expresses similar concerns
      - *Davalos and Bennett, 9 Applied Neuropsychology 92 (2002)*
  - fMRI
- Insurance Companies Maintain Experimental
  - Cigna Health Care
    - *November 15, 2006 (experimental, investigational or unproven)*
      - *qEEG, Neuroimaging*
    - *December 15, 2006 (MEG)*



# Sources of Artifacts and Error in Assessment

## ■ Generally

- Abnormalities may be produced by conditions present other than brain injury
- Interactions with other physical and emotional conditions
- Medication effects
- Interaction with environment
  - Including examiner
- fMRI, PET and SPECT measure slow physiological processes
  - Limitations on ability to detect fast processes associated with cognition and emotion
- Normative data limitations
- Result driven rather than theoretically driven



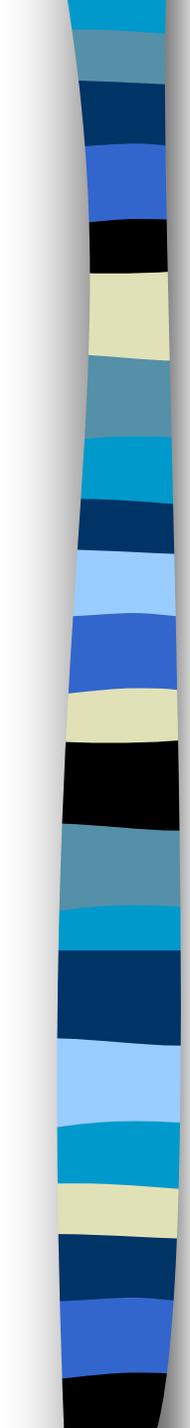
# Artifacts and Error (cont.)

## ■ EEG

- Severe limitations in detecting intracerebral electrical sources

## ■ qEEG

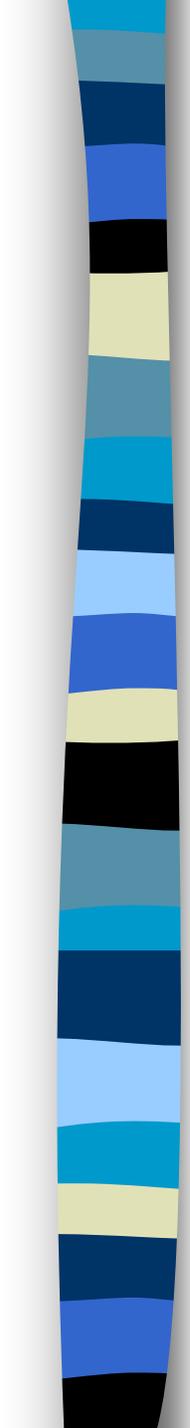
- Controversy over validity of algorithm projections
- Very sensitive to other conditions and hence high risk of false positives



# Artifacts and Error (cont.)

## ■ MRI

- Environment yields emotional reactions
  - Fixation
  - Claustrophobia
- Levels of wakefulness during procedure
- Truncate procedures due to time limits
- Physiological constraints on resolution (e.g. imprecision in control of blood flow)
- Sensitivity to variations in magnetic flow



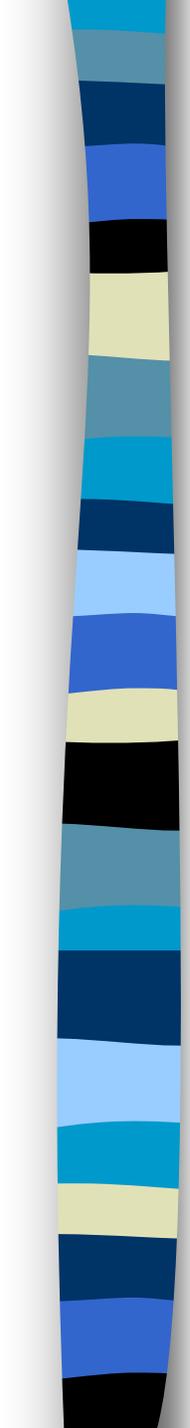
# Artifacts and Error (cont.)

## ■ PET

- Anxiety and fear over insertion of isotopes
- Temporal resolution problems due to variance in distribution of isotopes in brain
- Normative data limitations unique to TBI

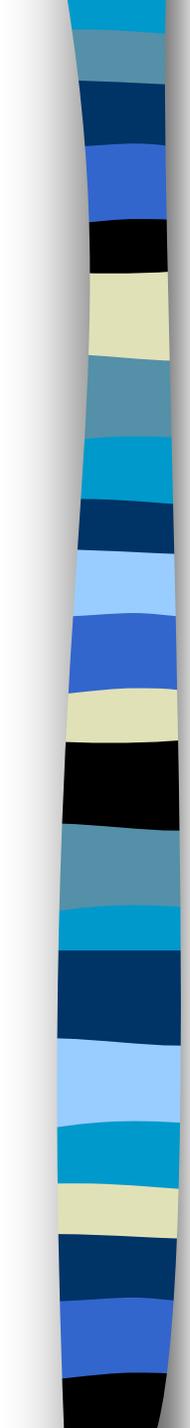
## ■ SPECT

- Anxiety and fear over insertion of isotopes
- Image distortion
- Normative data limitations



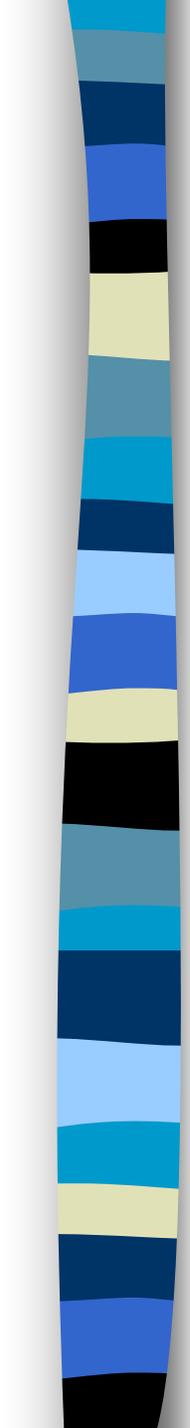
# Legal Environment

- Case law on Admissibility is not Well Established at this Point
  - Bran Mapping and qEEG have not fared well
    - Zimmerman; Breast Implant Litigation; Craig v. Orkin; Head v. Lithonia;
  - Other imaging methodologies have had mixed reactions
    - PET
      - Jackson v. Calderon; Penny v. Praxair; but see Hose v. Chicago Northwestern
    - SPECT
      - Summers v. Missouri
- Concern about Commitment to Procedure in Face of Uncertainty about Admissibility



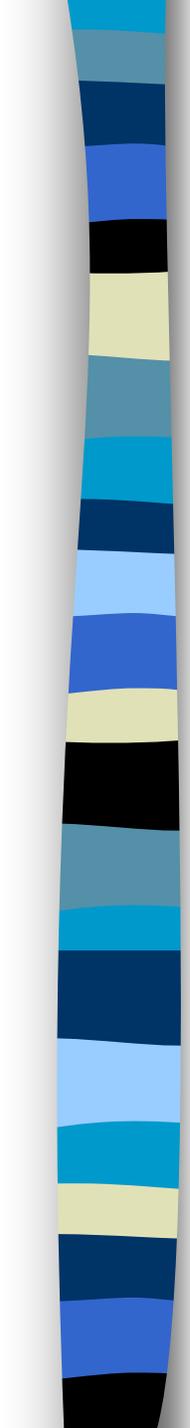
# Practical Issues in the Application of Neuroimaging in Litigation

- Invasive Techniques not Favored by Clients
  - Particularly where nuclear medicine involved
    - *Ruth v. Smith* (2007 unreported District Court: no inquiry into refusal to have PET)
- Physically and Emotionally involved Clients Increase Risk of Patient Motion Artifacts
- Physical limitations on access
- Discoverability Concerns in the Face of Unpredictability of Outcome
  - Absence of findings can be compelling evidence of absence of dysfunction
- Cost



# The Future

- Will Litigants Risk Consequences if Do Not Submit to Neuroimaging?
  - Harris v. U.S. – unreported 2005 District Court decision of action filed under the Federal Tort Claims Act
    - MVA: Law school student's vehicle struck by a postal service tractor trailer while on his way to take a final law school examination

- 
- Findings: “A mild traumatic brain injury cannot be seen on an MRI or CAT scan. However, such an injury may be seen on a sophisticated scan such as a photon emission computer tomography , known as a PET scan, or a single photon emission tomography, known as a SPECT scan, because these scans show activity within the brain.”
  - Findings: “Mr. Harris did not have either a PET scan or a SPECT scan to confirm Dr. Morris’ diagnosis of a mild traumatic brain injury.”
  - Conclusions: “Mr. Harris has not proven that he suffers from continued emotional/cognitive injuries”