Frontal Lobes: Injury, Assessment and Relevance to Addiction Disorders

OASAS Conference · May 25, 2011

Victor Zelek, Ph.D.
Director of Neuropsychology Service
Northeast Center for Special Care, Lake Katrine, NY
www.northeastcenter.com
The Prefrontal Cortex is to the brain what a...

- CEO is to a corporation
- General is to an army
- Conductor is to an orchestra
Prefrontal Cortex

The prefrontal cortex is the front portion of the frontal lobes and it covers areas forward of the premotor cortex.

The prefrontal cortex contains a map of the whole cortex.

The prefrontal cortex is 29% of the human brain, 7% of the dog’s and 3% of the cat’s.
Making Room for the Frontal Lobes

1. Homo Sapiens
2. Neanderthal
3. Gorilla
4. Dog
5. Horse
6. Dolphin
Neuronal and synaptic pruning

Newborns have almost 50% more neurons than mature adults. The process of pruning is especially active in the frontal lobes.
Frontal Lobes

The frontal lobes are involved in “higher” cognitive functions

- Executive functions
- Spontaneity
- Mental effort & goal pursuit
- Working memory
- Foresight & planning
- Sequencing
- Motivation & will
- Judgment
- Impulse control
- Sustained attention
- Supervisory attentional system
- Metacognition
- Complex social behavior
- Emotional regulation
- Understanding humor & metaphors
- Awareness of others
Uneasy Relationship

PREFRONTAL CORTEX
(Inhibitory function)

LIMBIC SYSTEM
(Excitatory function)
When addicts think about a drug, take a drug, or crave a drug their *nucleus accumbens* shows abnormal activation in functional brain imaging studies. The activity of *nucleus accumbens* is moderated by the prefrontal cortex.
Brain connections visualized using diffusion tensor tractography. Red fiber tracts show ipsilateral connections. Teal color fibers show connections between the two hemispheres traveling across the corpus callosum.
The base of the skull is rough, with many sharp edges and protuberances. These ridges can cause injury to the **frontal** and **temporal lobes** of the brain during rapid acceleration.
Phineas Gage

This 19th century railroad worker lost a large chunk of his forebrain when a steel rod was blown through his skull.

He underwent a dramatic personality change – from “purposeful and industrious worker” into a “drunken drifter.”

This classic case of Frontal Lobe injury spurred interest in what was used to be called the Silent Lobes.
Frontal Lobes

Injury to the frontal cortex leads to

- Impulsivity
- Disinhibition
- Apathy, lack of motivation
- Attention problems
- Difficulty planning
- Disorder of sequencing
- Perseverative behavior
- Difficulty shifting mental sets
- Poor judgment
- Emotional deregulation
- Problems with short-term memory
- Decreased will, drive & energy
- Diminished creativity
- Diminished understanding of humor
- Lack of social sensitivity
- Lack of foresight, but not necessarily insight
Diffuse Axonal Injury

- Regular CT or MRI scans are not sensitive enough to pick up this pathology.
- High Resolution (2-3 Tesla) MRI, Diffusion-Tensor Imaging, Gradient Echo MRI, Tractography or MEG are more sensitive, BUT more expensive and less available.
Causes of brain injury

- Traumatic
- Vascular
- Anoxic
- Toxic/metabolic
- Tumors
- Infection
- Iatrogenic

The frontal lobes have an exceptionally low functional breakdown threshold.

“Frontal lobe dysfunction is to the brain disease what fever is to infection – both highly predictable and nonspecific.” – E.G.
Effects of Extensive Alcohol Abuse on Brain Morphology, Brain Perfusion and Brain Metabolism
Brain changes in chronic alcoholics

- PET studies show significantly reduced glucose metabolism in the frontal lobes.
- SPECT studies show significant hypoperfusion in the frontal lobes (by 65%).
- MRI studies show volume reduction and cortical atrophy in the frontal lobes, ventricular enlargement and widening of cerebral sulci.
- QEEG studies show reduced brainwave amplitudes in the frontal lobes, increased activity in the limbic structures and in the anterior cingulate, problems with brainwave coherence, symmetry and phase.
- Post-mortem studies show reduced overall brain weight, marked cortical atrophy, and reduction of number of cortical neurons in the frontal lobes.
59-year-old man with a history of extensive alcohol abuse and an early onset of Alzheimer’s disease. Blue color indicates brainwave activity diminished more than 2 Std Dev below the mean.
20-year-old college student with ADD – before and after smoking marijuana.

D.H., 20 y.o., no medication
Dgn: ADD

ADD, 2 hours after smoking marijuana
40-year-old man with cocaine addiction and severe depression.
Neuropsychological Tests for Frontal Lobe Dysfunction

- Wisconsin Card Sorting Test
- Stroop Test
- Category Test
- Hayling Sentence Completion Test
- Brixton Spatial Anticipation Test
- Tower of London, Tower of Hanoi Tests
- Trailmaking Test A & B
- Verbal Fluency Test
- Design Fluency Test
- The Proverb Test
- Similarities Test
- Iowa Gambling Test
Frontal Lobe Deregulation Syndromes

- Dorsolateral Syndrome, a.k.a. “Pseudodepression”
  (apathy, abulia, lack of drive and initiation, perseveration, rigid thinking)

- Orbitofrontal Syndrome, a.k.a. “Pseudopsychopathic syndrome”
  (disinhibition, impulsivity, recklessness, aggression, jocularity, “tipsy adolescents”)

- Reticulofrontal Disconnection Syndrome
  (ADD-like disorders)
Traumatic Brain Injury

Cognitive/Emotional Problems

Alcohol & Substance Abuse
**Vicious Circle**

**TBI**
- ↓ Processing speed
- ↓ Mental energy
- ↓ Organization skills
- ↓ Impulse control
- ↓ Judgment
- ↓ Memory
- ↓ Inhibition

**Lead to**
- Frustration
- Disinhibition
- Depression/Anxiety
- Lack of foresight
- ↑ Risk of drug/alcohol abuse

**Alcoholism**
- Compulsive use
  - ↑ Tolerance & use
  - ↓ Impulse control
  - ↓ Judgment
  - Withdrawal
- Failed efforts to control
- Increased time using

**Lead to**
- Emotional deregulation
- Social isolation
- Psychiatric comorbidity
- Cognitive impairment
- ↑ Risk of TBI

Risk of TBI
Treatment Directions

• **TBI & Alcoholism**
  - Recognition and acceptance
  - Maintaining abstinence
  - Awareness of cognitive deficits
  - Cognitropic drugs
  - Cognitive remediation
  - Emotional self-regulation
  - Psychotherapy, psychoeducation
  - Neurofeedback, Hemoencephalography, LENS

• Accepting the need for simultaneous treatment
• Focusing on the most limiting problem first
• Aggressive Case Management
• Awareness and interaction of all providers
The End

Thank you!

(take good care of your frontal lobes!)

Victor Zelek, Ph.D.
Director, Neuropsychology Service
Northeast Center for Special Care, Lake Katrine, NY
www.northeastcenter.com