

18<sup>th</sup> European Conference  
Neuro-Developmental  
Delay in Children with  
Specific Learning Difficulties

sponsored by  
The Institute for Neuro-Physiological Psychology

March 2006

“It’s all in the TIMING”

Electrophysiological Variants Related to  
Neurodevelopmental Delay:  
Wiring the Brain

Health and Education  
Implications

Valerie L. Scaramella-Nowinski, Psy.D.  
Drina Madden, M.A., C.A.S.

# Timing

- TIME is a universal process that marks all biological and behavioral processes

# Timing

- Behavioral processes require electrophysiological timing: **SYNCHRONY** of excitation-inhibition between neurons communicating with each other in short bursts of electrical currents – action potential
- **NDD**: Poor synchrony: excitation-inhibition out of sync



# Timing

- Electrophysiological-Behavioral Link:  
“Science fiction” > Reality
- **Traditionally**
  - ◆ Epileptiform discharges-EEG variants:  
often noted, not quantifiable
  - ◆ Clinical events (seizures)/repeated  
seizures (epilepsy), quantifiable

# Timing

- Major problem: Scope
  - ◆ EEG uses a microelectrode to read the firing of a single activated neuron
  - ◆ The neuronal current that the electrode is recording is only one of approximately 100 billion circuits in the brain

# Timing

## ■ Currently

- ◆ Advanced technology and specialized neuropsychological assessment > more quantifiable measures and more specific functional analysis for clinical correlation

# Measures of neuro-activity

- ◆ Sleep deprived EEG and extended ambulatory EEG: electrical activity recorded from scalp (can use video monitor)
- ◆ Evoked Potentials: presents stimulus and measure interval between presentation and reaction
  - ◆ Sensory stimuli: 30-50 milliseconds after onset of stimuli
  - ◆ Complex stimuli: 150-250 milliseconds after onset of stimuli
  - ◆ Cognitive stimuli: 300 milliseconds after onset of stimuli

# Measures of neuro-activity

- MEG: Magnetoencephalography: measures magnetic field of neuronal activity
  - ◆ Magnetic field passes through skull bone
    - more accurate findings

# Measures of neuro-activity

- MRI: Magnetic Resonance Imaging: 3-D picture measuring strength of magnetic field viewing structure of brain
- fMRI: Functional Magnetic Resonance Imaging: measures strength of magnetic field while performing certain tasks

# Measures of neuro-activity

- PET: Positron Emission Tomography: maps blood flow/energy used in brain
- Neuropsychological Assessment used in clinical correlation: functional analysis of cerebral organization of human mental processes

# Measures of neuro-activity

## ■ Seizure Activity

### ◆ Generalized: both sides of the brain

- ◆ Tonic-Clonic - (grand mal) convulsive and altered consciousness
- ◆ Absence - (petite mal) nonconvulsive and momentary altered consciousness



# Measures of neuro-activity

## ■ Seizure Activity

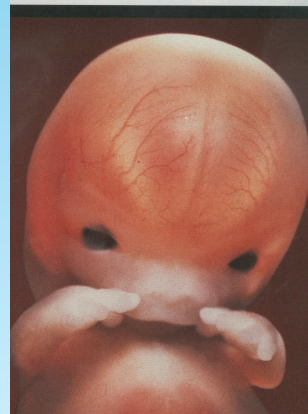
- ◆ Partial-Focal: part of brain
  - ◆ Simple partial: no altered consciousness, usually sensory aura
  - ◆ Complex partial: altered consciousness, aura and automatisms - lip smacking, teeth grating...

# Measures of neuro-activity

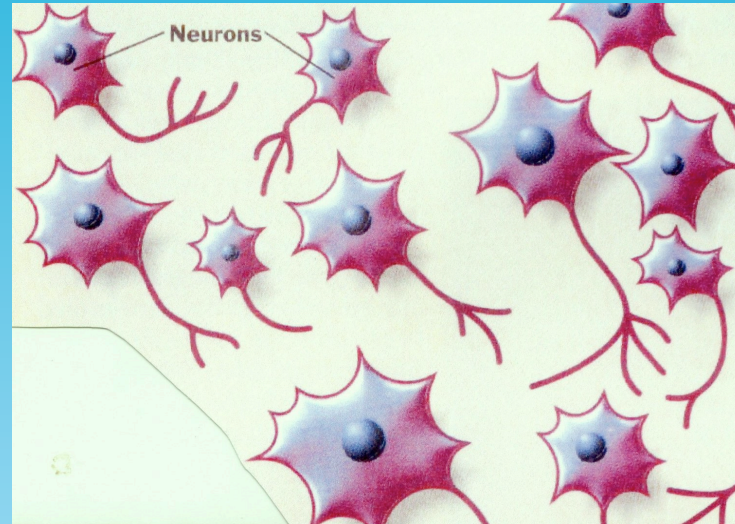
- Seizure Activity
  - ◆ Most seizure activity: combination of generalized and partial profiles

# Wiring the Brain

- ◆ At three weeks: cells in the neural tube grow at approximately 250,000 per minute and brain/spinal cord develop
- ◆ At six weeks: the embryo's brain, rich in blood vessels, is almost as big as the body

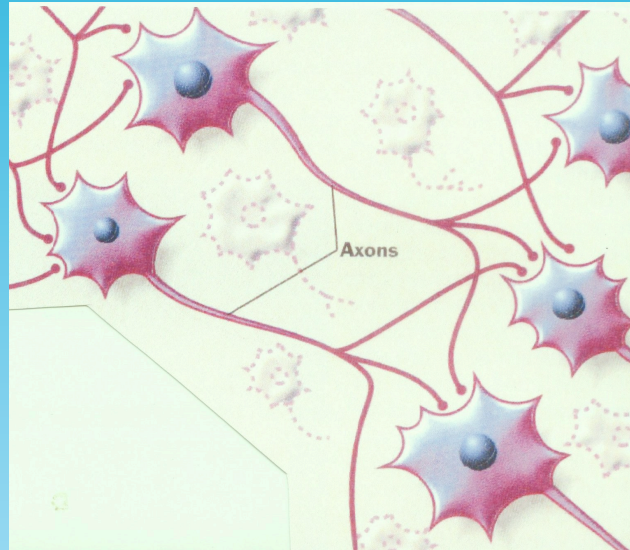


# WIRING THE BRAIN



- ◆ In utero, brain cells proliferate wildly, making connections ready for a lifetime of experiences

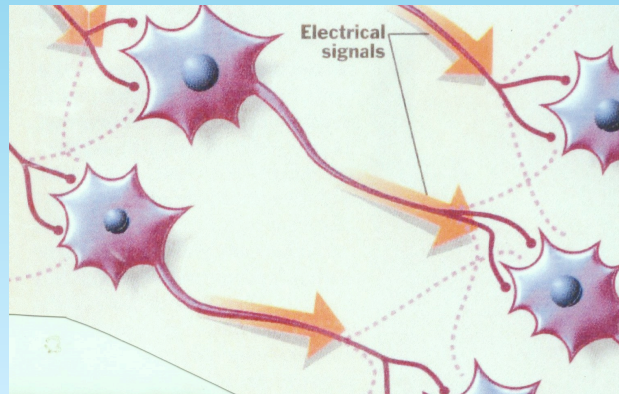
# WIRING THE BRAIN



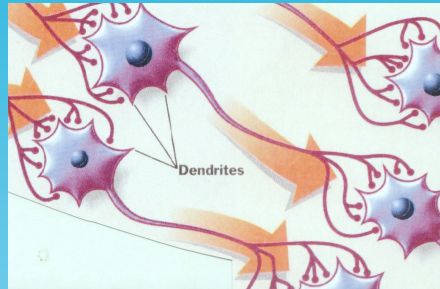
- ◆ Neurons develop axons (send signals) which have multiple branches to other neurons and dendrites (receive signals)

# WIRING THE BRAIN

- ◆ Biochemical sources of neurons have electrical and magnetic fields. These electric/magnetic bursts strengthen connections among neurons. If not strengthened > connections atrophy



# WIRING THE BRAIN



- ◆ **A SHOWER OF SPARKS!:** at birth the brain has another growth spurt as axons and dendrites explode with new connections. Electrical activity triggered by sensory experiences fine-tune the connections: some excited and some inhibited

**A MELODY OF SYNCHRONY DEVELOPS**



# WIRING THE BRAIN

- WIRING ATTENTION
  - ◆ Among first circuits to develop: infant reacts to multisensory stimuli

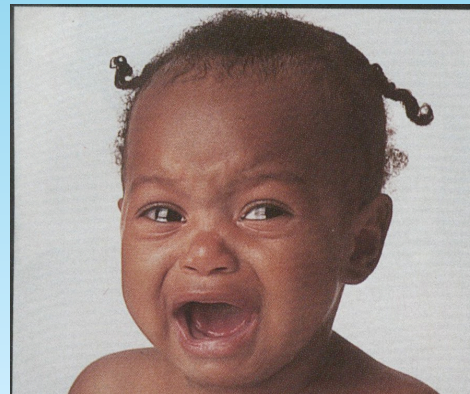




# WIRING THE BRAIN

## ■ WIRING MOOD

- ◆ Among first circuits to develop: relaxed alertness necessary for optimal development
- ◆ By 2 months of age emotional sensation (calm/anxiety) evolves into more complex feelings



# WIRING THE BRAIN

## ■ WIRING MOVEMENT

- ◆ Infants are a bundle of reflexes: refined, more mature reflexes, aid progression of movement/development



# WIRING THE BRAIN

## ■ WIRING VISION

- ◆ Infant can see at birth, but not yet develop focus, depth perception, eye-hand, eye-body perception



# WIRING THE BRAIN

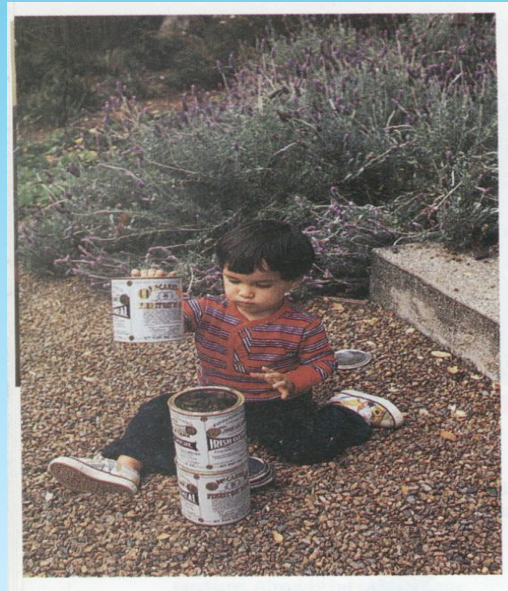
- **WIRING SPEECH/LANGUAGE**
  - ◆ Melody of voice is sensed in utero
  - ◆ At six months, infants are functionally deaf to sounds outside of native tongue



# WIRING THE BRAIN

## ■ WIRING MEMORY

- ◆ Cessation of attention reflex (habituation) results in memory consolidation



# WIRING THE BRAIN

- As brain is being wired, multisensory reflex connections are being synchronized
- Efficient synchrony also strengthens electrical connections

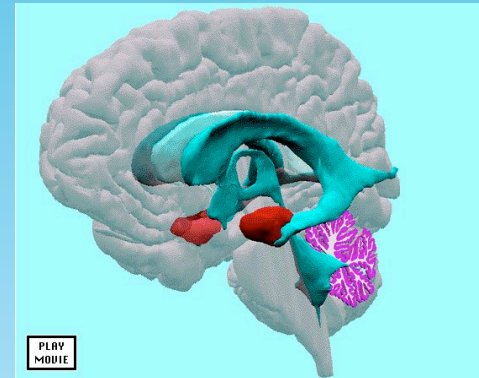


# The Working Brain

- Behavioral/Anatomical Interactive Model of Development: The Working Brain
- Three Systems
  - I. Activation – Inhibition
  - II. Reception – Analysis – Storage
  - III. Expression – Plan - Verification

# The Working Brain

- I. Activation – Inhibition: Regulates cortical tone (Subcortical Diencephalic/Limbic formations)



**Thalamus – sensory station**

**Hypothalamus – vital functions**

**Basal Ganglia – voluntary movement/sensations**

(hippocampus, amygdala, septum, cingular gyrus)



# The Working Brain

## III. Expression

Plan

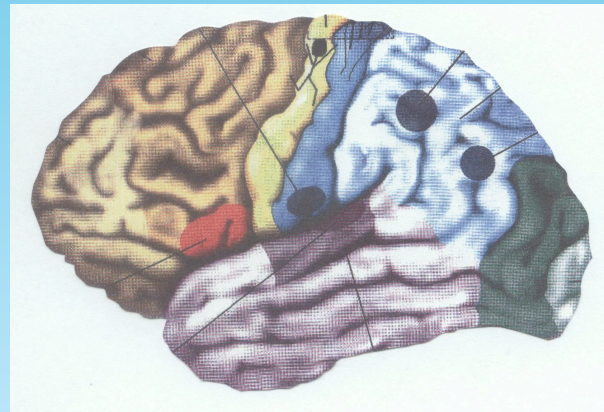
Verification:

## II. Reception

Analysis

Storage:

Anterior Brain



Posterior Brain

# The Working Brain

- Systems governed by: structure-electrical-chemical activity
- Dependent upon Nature and Nurture (genes and environment)

***THE BRAIN  
IS THE ONLY ORGAN IN THE HUMAN SYSTEM  
THAT LEARNS!***

# The Working Brain

- At young ages, lower systems influence higher systems.
- As we develop, higher systems influence lower systems

*We learn by*

*REPETITION > RECOLLECTION > REFLECTION*

# Electrophysiological-Behavioral Link

(Seminars in Pediatric Neurology)

- **Infantile Spasms (R. Caplan): Social/Nonverbal Communication Study**
  - ◆ Reviewed medical and surgical history of 23 children (2.8 months mean age) with intractable seizures/infantile spasms
  - ◆ Surgery resulted in 50% of children improving preverbal gestures/social communication

# Electrophysiological-Behavioral Link

(Seminars in Pediatric Neurology)

- **TCI: Transient Cognitive Impairment (K-N-Trenite):**
  - ◆ Studied 6 children having epileptiform discharges (10 seconds or less)
  - ◆ Left sided discharges > increased reading problems  
Right sided discharges > increased visual spatial problems
  - ◆ Anti-epileptic medication significantly improved functions in two of the children

# Electrophysiological-Behavioral Link

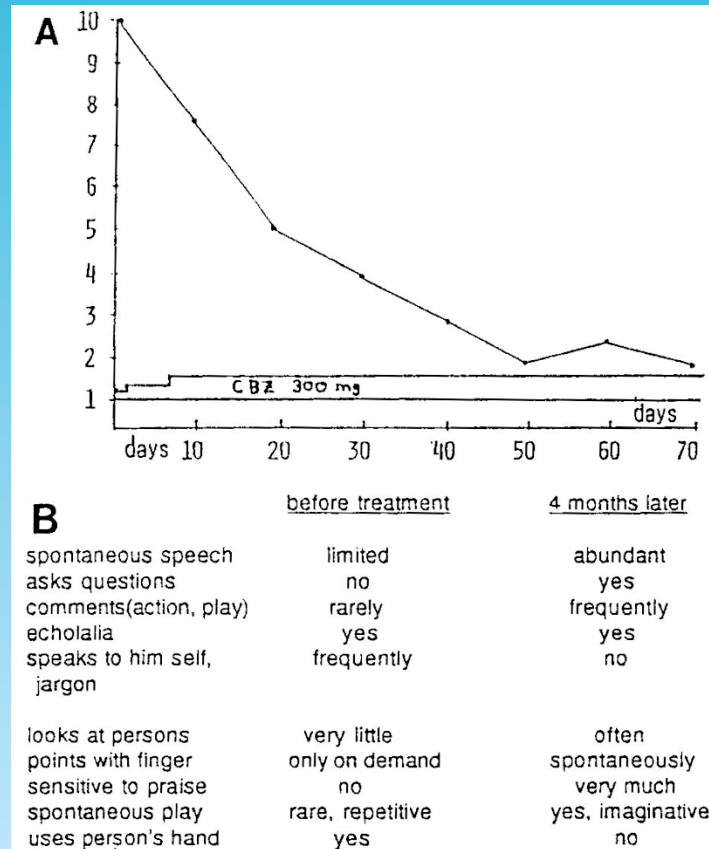
(Seminars in Pediatric Neurology)

## ■ Behavioral Regression (T. Deonna)

- ◆ 3 year old girl with 2 month history of regression in play and mood
- ◆ EEG showed no clinical seizures, yet did show anterior-frontal variant
- ◆ Medication resulted in rapid improvement

# Electrophysiological-Behavioral Link

(Seminars in Pediatric Neurology)



## ■ Behavioral Regression (T. Deonna)

# Electrophysiological-Behavioral Link

(Seminars in Pediatric Neurology)

- **Language Regression (onset 2-10 years) associated with seizure activity (E. Perez)**
  - ◆ Bitemporal-Frontal discharges
  - ◆ Partial motor seizure
  - ◆ Posterior discharges in waking state
  - ◆ Increase of continuous spike-wave discharges in sleep associated with increased language regression



# Electrophysiological-Behavioral Link

(Seminars in Pediatric Neurology)

## ■ Seizure-Pervasive Developmental Disorder

(I. Rapin)

- ◆ 157 children: 19% having clinical seizures; 25% abnormal EEG
- ◆ Seizures peaked as toddlers and 2<sup>nd</sup> peak in adolescence
- ◆ Three diagnostic categories
  - ◆ Autistic regression
  - ◆ Childhood Disintegrative Disorder
  - ◆ Landau-Kleffner Syndrome: acquired epileptic aphasia

# Electrophysiological-Behavioral Link

Neuropsychology Diagnostic Center/Nowinski 1998

Digitrace Case of the Month

- Landau Kleffner Syndrome
  - ◆ Refer to clinical case example in packet

## ANTIEPILEPTIC MEDICATIONS

SEIZURE OR SYNDROME TYPE	EFFECTIVE DRUGS		
<i>Partial</i> Simple Complex, and secondarily generalized	<i>First Line</i>		
	Carbamazepine	Tegretol	
	Phenytoin	Dilantin	
	Valproate	Depacon Injection	
	Gabapetin	Neurontin	
	Lamotrigine	Lamictal	
	Topiramate	Topamax	
	<i>Second Line</i>		
	Phenobarbital		
	Primidone	Mysoline	
	Felbamate	Felbatol	
	<i>Generalized</i> absence  myoclonic  tonic-clonic  Lennox-Gastaut	Ethosuximide	Zarontin
		Valproate	
		Clonazepam	Klonopin
Valproate			
Valproate			
Carbamazepine		Tegretol	
Phenytoin		Dilantin	
Valproate			
Felbamate		Felbatol	
Clonazepam		Klonopin	
Valproic Acid	Depakene		