How Therapy Changes the Human Brain

Martha S. Burns, Ph.D.,ccc-slp
Joint Appointment Professor
Northwestern University

Selected Neural Plasticity References


Reference Source for more specific Neural Plasticity Rehabilitation Research


References of neurochemistry of plasticity

- Neuron (2012) 76(1) Reviews on Neuromodulatory Mechanisms
- Ott, T. et al. (2014) Dopamine receptors differentially enhance rule coding in primate prefrontal cortex neurons. Neuron 11.012
References on issues related to when to begin treatment after stroke

• Dromerick, A.W. et al.(2009) Very Early Constraint-Induced Movement during Stroke Rehabilitation. *Neurology* 73;195-201
• Turkstra, Lyn (2013) Inpatient cognitive rehabilitation, is it time for a Change? *Journal of Head Trauma Rehabilitation*. Vol. 28, No. 4, pp. 332–336

Experience-Dependent Plasticity of the Cerebral Cortex

• “The ability to adapt in response to the changing environment is the most fundamental property of the nervous tissue and constitutes the basis for learning.”

  • **Neural plasticity** - neurobiological basis for ability to adapt & learn in an experience-dependent manner
  
  — At the structural level, neural plasticity could be defined in terms of
  
  — dendritic and axonal arborization,
  
  — spine density,
  
  — synapse number and size,
  
  — receptor density,

  — and in some brain regions also the number of neurons.

Experience-Dependent Plasticity of the Cerebral Cortex

• The structural constituents of neural plasticity jointly determine

  — the complexity of *neuronal networks* and their activity and

  — contribute to habilitation of skills in the developing brain as well as recovery of function after stroke and other CNS injury

Hebbian Axiom - Neurons that fire together wire together in networks
Cortical Map Rearrangements

- Occurs in sensory systems within the cortex including auditory and visual
- The reorganization that occurs after rehabilitation is associated with upregulation chemical neuromodulators in relation to the parameters of the stimulation that occurred

But beyond early infancy, plasticity is modulated as a function of:

1. novelty
2. attention
3. judgment of error
4. punishment
5. Reward
6. et alia

Different dimensions of adult cortical plasticity are enabled by the behaviorally-context-dependent release of:

- acetylcholine (focused attention/reward) (Kilgard, Bao)
- dopamine (reward, novelty) (Bao)
- norepinephrine (novelty) (Bollinger)
- serotonin (Bollinger)
- et alia

In infants, exposure-based plasticity is relatively uniform. In adults, learning-induced changes are complexly “nuanced” by differences in behavioral context that result in the differential release of 6 or 7 modulatory neurotransmitters.
In older animals and humans, the brain **controls** its own plasticity.

**Cortical Map Rearrangements** (Pekna, M., Pekny, M., Nilsson, M., 2012)

- When normal input to a specific area of the primary somatosensory cortex is altered because of genetics or because of experience
  - rapid structural and functional reorganization results in this area being activated by sensory stimulation of the surrounding intact body regions
Neuroimaging research on effects of therapy

- Early research on constraint induced therapy after paralysis
- Neuroimaging research on effects of therapy in developing brains
  - Language and reading disorders
  - In adult brains after injury especially visual working memory training
  - Power attained by combining bottom-up and top-down processing activities

Importance of Intensive Intervention

Taub – Constraint Induced therapy

And the effects of treatment indicate functional connections seen in nonimpaired readers are achieved (Dehaene, *Reading in the Brain*, pp 260).

Specific characteristics of effective language-based therapies

The emerging consensus from neuroscience is that combining of cognitive (executive function) top-down interventions with bottom-up (perceptual and attention) interventions may be most effective.
Q & A