Development 4

- Flexibility in brain development
- Recovery of children from focal brain damage
- Recovery in adults from stroke

- In one study, cells in a very early-stage salamander embryo that would have developed into skin were transplanted to the embryo's mouth region. The most likely results were that the transplanted cells

A. became teeth, as was appropriate for their new location.
B. developed into skin, as was appropriate for their original location but not for their new location.
C. remained undifferentiated.
D. died, leaving the salamander to develop without a section of skin and teeth.

Reconciling Innateness with Flexibility in Fetal Development

- Evidence for Innateness: The brain, like the body, assembles itself without help
- All cells have the same genome
- How do cells know what to become?
- How do neural cells know what connections to make?

The Myth of Genome as Blueprint

- In blueprints, there is a direct correspondence between the elements of the drawing and the elements of the building it describes.
  - There is no such one-to-one correspondence between genes and the cells and structures that make up an organism.
- Two blueprints that differ by 1 percent yield buildings that differ by 1 percent
  - A 1 percent genetic difference produces a different organism
- Identical genomes do not yield identical minds

What the Genes Encode

- Three characteristics of the genome
  - Genetic information consists of
    - Instructions to create semi-autonomous *processes*
    - Detectors for when to use a process
    - Mechanisms to regulate the activity of processes and link them in sequence
  - Genes work in combination, not isolation
  - Most genes gets used many, many times

Relative Specifications, Gradients, and Redundancy

- To be reusable, genetic specifications must be relative, not absolute

Relative Specifications, Gradients, and Redundancy

- To be reusable, genetic specifications must be relative, not absolute
- In both brain and body, cells express a particular gene to different extents depending on the cell's position within genetic signaling gradients
- Redundancy

Summary

- Innateness vs. Flexibility
  Self-organization vs. Reorganization
  - These are each two sides of the same coin
  - Each the product of the staggering power of coordinated sets of autonomous yet highly communicative genes
- Gene Shortage: Is not an issue because the genome encodes processes that work together and are reused throughout the body rather than a blueprint.

- Are significant changes in the functional organization of the human brain possible after birth?

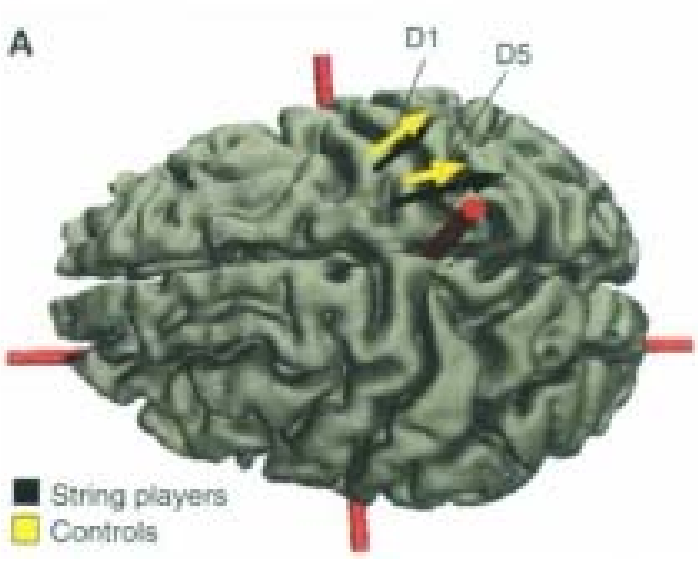
A. Yes
B. No
C. I don't know

Neuroplasticity

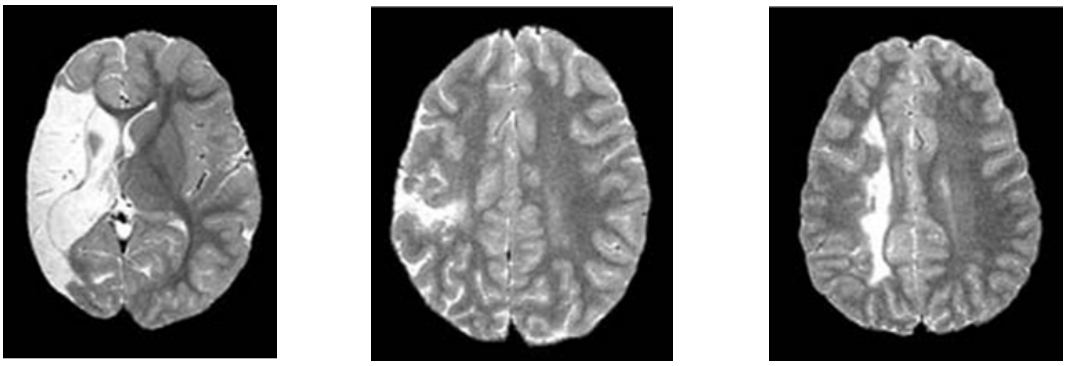
- *Neuroplasticity* (aka *brain plasticity* or *cortical plasticity* or *cortical re-mapping*) refers to the changes that occur in the *organization* of the brain *after birth* due to experience or trauma
  - Learning and memory involve changes in the number and strength of synapses within a given area
  - Neuroplasticity is a change in the function of an area
- Neuroplasticity challenges the idea of functional localization

Experience-Based, Cortical Remapping

- Learning to play the violin increases the cortical area used to represent the left hand
  - This area expands towards the center and back of the brain
- The size of these effects is correlated with years of practice



Focal Brain Damage in Adults and Effects on Language



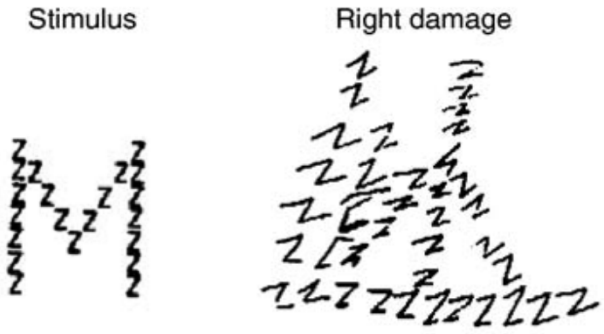
- In adults, focal brain damage (typically due to stroke) in language centers often results in permanent deficits

Effects of Early Brain Damage on Language Development

- Stiles et al. (2005) report on longitudinal studies of perinatal brain damage
- Early linguistic milestones are delayed
- At 5 years of age these children have largely ‘caught up’
- However, when tested carefully there remain some underlying deficits beyond the age of 5

Effects of Adult Brain Damage on Spatial Cognition

Global-Local Task

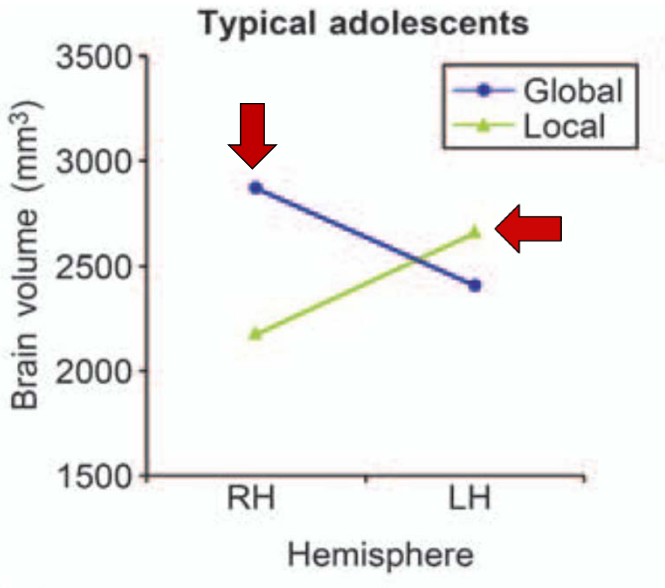


LH = Feature (local)
RH = Configural (global)

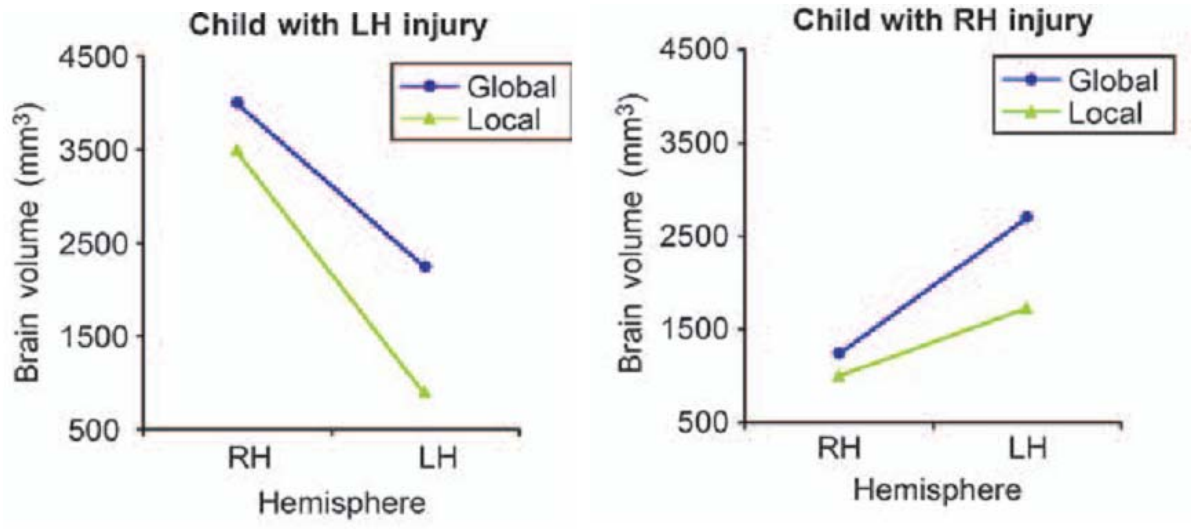
Brain Imaging of Spatial Cognition in Normal Adolescents

Volume in the occipital-temporal region activated by different tasks

- More in the RH for global tasks
- More in the LH for local tasks



Effects of Early Brain Damage on Spatial Cognition

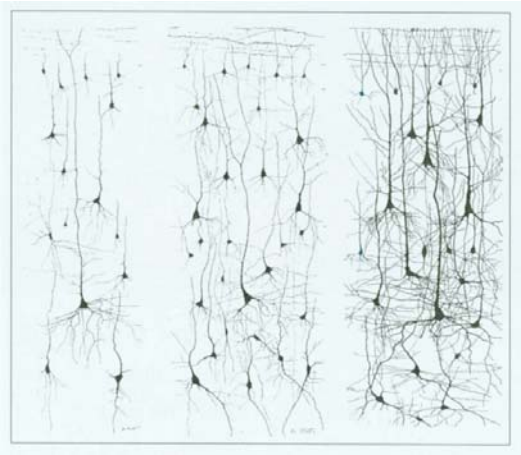


Summary: Neuroplasticity after Perinatal Brain Damage

- For both language and spatial cognition
  - Perinatal brain damage results in developmental delay followed by subtle, long-term deficits
- Implications
  - Although some brain systems have a high level of genetic predisposition and thus suffer long-term harm when disrupted
  - Brain plasticity also exists, at least early in development, so that the cognitive functions that suffer early damage develop in an alternative manner.

Possible Mechanisms of Neuroplasticity

- Neuroplasticity does not result from addition of new neurons
- Changes in strength of existing synapses
- Changes in neural interconnections
  - Addition and pruning of synapses, not neurons



Birth 3 Months 15 Months

- Someone you know has had a major stroke. After 3 months of rehabilitation he/she still cannot walk, talk comprehensibly, or feed and take care of him/herself. At this point, you are advised by doctors that no further improvement is likely. The patient is discouraged by the his/her lack of improvement. Is it time to stop therapy and put the patient in a care facility?

A. Yes
B. No
C. I don't know

Neuroplasticity Following Stroke

- Prognosis after a non-fatal, major stroke is usually grim
  - Typically, there are profound sensory and motor deficits on at least one side of the body
  - Some loss of language ability and, if the stroke is in the "dominant" hemisphere, severe speech production deficits
  - Memory loss and, if the hippocampus is involved, anterograde amnesia
  - Recovery of some function in the first several months at which point a plateau is typically reached
- In individual cases remarkable subsequent improvement can occur

What Differentiates Patients with Better Recovery from Stroke

1. Use it or lose it	Failure to drive specific brain functions can lead to functional degradation.
2. Use it and improve it	Training that drives a specific brain function can enhance that function.
3. Specificity	The nature of the training experience dictates the nature of the plasticity.
4. Repetition matters	Induction of plasticity requires sufficient directed practice.

Source: Kleim & Jones, 2008

What Differentiates Patients with Better Recovery from Stroke

5. Intensity matters	Induction of plasticity requires sufficient training intensity.
6. Timing matters	Different forms of plasticity occur at different times during training.
7. Rewards matter	The training experience must be sufficiently salient to induce plasticity.
8. Age matters	Training-induced plasticity occurs more readily in younger brains.

Summary: Innate Brain Structures, Neuroplasticity, and Remapping

- Localization emerges during development
- It results from genetically determined processes
- The processes (and the resulting localization) are not unchangeable
  - They can be altered by environmental factors, experience, and damage
- Cortical remapping does happen
  - Although possible even in older adults
  - It is more prevalent in younger brains

Looking Ahead

- Wednesday
  - Chapter Test 5 – Development
- For Friday
  - No reading assignment
  - Please do the course evaluation on EEE
- Final Exam - Monday, Dec. 15th, **8:00-10:00am**
- Two Review Sessions:
  - Friday, Dec. 12th, at 2:00 PM in SSL 248
  - Saturday, Dec 13th, at 2:00 PM in SST 220A+B
- I will go to Phoenix Grill for coffee