Brain Function Secrets Revealed
Brain Tour Itinerary:

- Thesis: Secret to the brain is **Unity**
  - The problem: focused on “parts”
  - A sample of the parts
  - The “binding” issue
  - White matter really matters
  - “Binding Deficiency Disorders”
  - Education implications
  - When a brain become a person
First a memory task:

- Sour
- Candy
- Sugar
- Bitter
- Good
- Taste
- Tooth
  [now remember these words for later]

- Honey
- Soda
- Chocolate
- Heart
- Cake
- Tart
- Pie
The Problem: Focus on gray matter (cortex) and specialization...

- The new phrenology ---- fMRI
...(over) white matter and unity
A sample of the parts: Communication and Math

Positive emotions

Literal associations
He kicked the...

Speech production
[Click to see video]
Grammar

Math calculation

Spatial organization

Wohle wrod radenig

Negative emotions

Metaphors, Idioms, Jokes

Prosody Production

Prosody comprehension

Whole face perception

A sample of the parts, Vision

Face feature analysis

Form and Size
Spatial location

Whole face perception
{note, web site link may not work, if it does, scroll down to 9. Visual Information Processing: Perception}
[Imbedded video removed]
See the following link to view this video

https://www.youtube.com/watch?v=AiaAA34XKbE
The binding problem

- The problem of how objects, background and abstract or emotional features are combined into a single experience
  - Where does this happen?
    - No unified area?
    - How does this happen?
Peter Milner: features of individual objects are bound via synchronization of the activity of different neurons in the cortex.
Anne Marie Treisman suggested that binding between features is mediated by the features' links to a common location.
White matter really matters: DTI
Small-World Network Theory:

- Left Hemisphere
- Right Hemisphere

Modularity; Nodes (hubs); Cluster Coefficient; Path distance
Evidence for the value of white matter and binding.

- **Cognitive functions correlate with white matter architecture in children (DTI Study)** (Schmithorst et al, 2005)
  

- **Sex Differences in Brain Gray & White Matter: Correlates with Cognitive Performance** (Gur et al, 1999)
  - Men: Left WM < **Right WM**; Women Left WM = Right WM
  - WM highly correlated with IQ (especially women)

More Evidence: Verbal Learning

- White matter “anisotropy” in the ventral language pathway predicts sound-to-word learning success

More evidence: using fMRI to find small world networks

- Small-world networks
  - correspondence of activation between networks

[Copyrighted images removed. Images displayed areas of the brain that show greater connectivity and act as significant “nodes” or “hubs” connecting to many other areas of the brain. So there appear to be certain areas that are especially critical for “binding.” Images also revealed more such hubs in the right hemisphere than the left.”]
Learning:
Hippocampus activation in learning occurred only when task required binding 3 or more elements. (Cohen et al, 1994)
Studies consistently show the importance of: “...modularity, small-worldness, and the existence of highly connected network hubs. Importantly, these quantifiable network properties were found to change during normal development, aging, and various neurological and neuropsychiatric diseases such as Alzheimer’s disease and schizophrenia.”

“Moreover, several studies have also suggested that these network properties correlate with behavioral and genetic factors.”

“Binding Deficiency Disorders”

- Schizophrenia, Autism, Dyslexia
- Verbal and Non-Verbal Learning Disabilities

- Agenesis of the Corpus Callosum (large world connection problems)
Agenesis of Corpus Callosum (AgCC)
Another view
Left / Right Binding Problems

- **Motor:** Left-right coordination

- **Language:**
  - Metaphors, Idioms, Verbal Humor, non-literal meanings
  - Prosody, production and comprehension

- **Social:**
  - Social comprehension; Negative feedback
  - “Theory of mind”

- **Cognitive:**
  - Complex math
  - “Complex novel problem solving”
A video about autism / AgCC – But first a quiz...Which words were on that list you memorized?

- Bitter?
  - Yes
- Candy?
  - Yes
- Grape?
  - No
- Tooth?
  - Yes
- Sweet?
  - NO! – but 98% say yes.
Kim Peek: Has both AgCC and Autism – but also an incredible memory.
[click on link to see you tube video]
Education Implications

- Understand individual differences
- Increase Complex Novel Problem Solving
When a brain becomes a person

- “Merging” (binding) of modules gives rise to consciousness and a rich mental life.
- But we are not islands, individuals become persons when in relation with other “mind modules”

**Philippians 2:2 (NIV)**
- ²then make my joy complete by being like-minded, having the same love, being one in spirit and of one mind.