The Brain – is wider than the Sky
For – put them side to side –
The one the other will contain
With ease – and You – beside –

The Brain is deeper than the sea
For – hold them – Blue to Blue –
The one the other will absorb –
As Sponges – Buckets – do –

The Brain is the weight of God –
For – Heft them – Pound by Pound –
And they will differ – if they do –
As Syllable from Sound –

Emily Dickinson
The Reading Brain

Dr. Eddie Frasca-Stuart
Director, Staff & Program Development
Bucks County Intermediate Unit #22
Wednesday, February 29, 2012
The Reading Brain – Part 1

AGENDA

- Welcome and Introductions
- Big Ideas
- Neurons
- The Brain
- The Reading Brain
- The Dyslexic Brain
- Neuroscience and Reading Instruction
Welcome and Introductions

- Good Morning!
  - Dr. Eddie Frasca-Stuart
  - Director, Staff and Program Development
  - BCIU22

- Your Introductions
  - Name tents
  - Table groups
  - *What do we know about The Reading Brain?*
  - Recorder – record responses on flip chart paper
  - Reporter - whole group intro’s and responses
The Role of Neurons
The Role of Genetics
The Role of Culture
The Role of Experience
ANTICIPATION GUIDE – True or False

- Babies are born with 100 billion neurons.
- Neurons are the only type of brain cell.
- Old neurons are replaced by new neurons.
- Most neurons have pre-destined jobs in the brain.
The Brain contains two types of brain cells: neurons and glial cells.

90% of the cells are Glia and 10% are Neurons, however, despite their smaller number, neurons make the brain a thinking and learning organ.

Approximately 100 billion neurons are found in the brain and in the spinal cord at birth.
Glia cells are helper cells of the brain.

“Glia” is derived from Greek word meaning “glue.”

Four types of Glial Cells

1. **Radial Glia**: Guide neurons in the development of the fetal brain.

2. **Macrophage Glia**: assists in removing the debris of dead cells following damage to brain areas.

3. **Oligodendrocytes**: play a role in neural maturation. They lay down myelin.

4. **Astrocytes**: have a star-like appearance and their job is to maintain an appropriate chemical environment around the neuron.
A trillion connections are made as the baby experiences life.

Experience **sculpts** the brain.

<table>
<thead>
<tr>
<th>At Birth</th>
<th>6 Years Old</th>
<th>14 Years Old</th>
</tr>
</thead>
</table>

**SYNAPTIC DENSITY:** Synapses are created with astonishing speed in the first three years of life. For the rest of the first decade, children’s brains have twice as many synapses as adults’ brains.

*Drawing supplied by H.T. Chugani.*
Neural Connections

Chemical to Electric to Chemical Communication Between Neurons
Neural Connections

It is only by neurons making connections with one another that learning can occur.

- “Neurons that fire together, wire together!”
In utero, the neurons create the brain

The neurons are guided by the glial cells to make up the different macro and microstructures of the brain.

*The Secret Life of the Brain*, PBS
Reflection and Discussion
ANTICIPATION GUIDE – True or False

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- Old neurons are replaced by new neurons.
- Most neurons have pre-destined jobs in the brain.
THE BRAIN

ANTICIPATION GUIDE – True or False

- The brain is composed of two hemispheres.
- The brain is composed of four major lobes primarily located in the left hemisphere.
- Each lobe has specialized responsibilities.
- The brain’s lobes and hemispheres work in collaboration with each other.
Parts of the Brain

- Parts of the brain
  - Two Hemispheres
  - Four Lobes
    - Frontal Lobe
    - Parietal Lobe
    - Temporal Lobe
    - Occipital Lobe
  - Cerebral Cortex (Bark)
  - Cerebellum
  - Brain Stem
  - Microstructures
- Receives Tactile Information
- Processes higher sensory & Language functions

- Takes in Visual Stimuli
- Visual Cortex

- Balance
- Posture
- Motor movement
- Memory

Brain Stem
- Regulates heart beat & breathing
- Filters motor & sensory info

Cerebral Cortex
- “tree bark”
- ¼ inch top layer

- Planning
- Problem Solving
- Creativity
- Judgment
- Decision-Making

- Auditory Cortex
- Takes in auditory stimuli
- Hearing
- Meaning & Language
- Controls the production of speech and memory
ANTICIPATION GUIDE – True or False

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- The brain is composed of four major lobes primarily located in the left hemisphere.
- Each lobe has specialized responsibilities.
- The brain’s lobes and hemispheres work in collaboration with each other.
ANTICIPATION GUIDE – True or False

- We are genetically programmed to walk and talk.
- There is no biological imperative for us to read and write.
- Oral language provides the foundation for learning to read.
- Our brain’s reading system is restrained by genetic mandates.
- The characteristics of the eye has made it possible for us to be able to read and write.
- Reading is processed similarly in all brains, regardless of the type of writing system used by a particular language.
“The existence of the text is a silent existence, silent until the moment in which a reader reads it. Only when the able EYE makes contact with the markings on the tablet does the text come to active life. All writing depends on the generosity of the reader.”

Alberto Manguel, *The History of Reading*
The Reading Brain

Our brain is built on the genetic blueprint that allowed our hunter-gatherer ancestors to survive. NOTHING in the blueprint could have prepared us to ABSORB LANGUAGE THROUGH VISION.

Writing is only 5400 years old. There was not time for evolution to play a role.

Yet brain imaging demonstrates that the adult brain contains FIXED circuitry attuned to reading.
What happened?
Our Visual System

- Our VISUAL SYSTEM is the first step in the complex process that we call READING.

- This is so even though our vision system involves a human brain architecture that obeys strong genetic constraints, but some circuits evolved to tolerate A FRINGE OF VARIABILITY (plasticity).

- Visual plasticity gave the ancient scribes the opportunity to invent reading. This is called the "neuronal recycling" hypothesis – new jobs for existing neural connections.
Within our visual system, written word processing starts with our eyes, specifically, the RETINA.

The retina receives photons reflected off the written page via two types of resolution cells:

- Coarse resolution cells
- High-resolution cells located in the FOVEA.
The FOVEA is in the central part of the RETINA & occupies 15 degrees of the visual field. It is the only part of the retina that is genuinely useful for READING.
The FOVEA

- Cones are tightly packed in the fovea
- Cones are widely spaced in the periphery
Our eyes impose a lot of constraints on the act of reading.

The structure of our visual sensors forces us to scan the page by jerking our eyes around every two or three tenths of a second.

- $\frac{1}{20}^{th}$ of a second – word is recognized
- Another $\frac{1}{2}$ of a second is needed to access meaning

These movements are called EYE FIXATIONS or SACCADIES.
Today is Tuesday, May 7, 2013.
The Eye

- These restraints cannot be affected by training
  - 400 – 500 words/minute is optimal
  - Eye movements are the rate-limiting step in reading.

- And we read most every word.
- When reading, almost all content words such as nouns and verbs have to be fixated on at least once.
Reflection and Discussion
Size is not a factor for the FOVEA.

The **NUMBER** of letters is a factor – not the space they occupy on the retina.

**ONE** Eye Fixation – we identify only 10 to 12 letters/saccade
- 3 or 4 to the left
- 7 or 8 to the right

**DIRECTIONALITY** imposes asymmetry on our span of vision.
- In the West, visual span is much greater toward the right.
- In Arabic or Hebrew languages, the visual span is much greater toward the left.
- In China, character density is greater, saccades are shorter and visual span is reduced accordingly.
A Moving Window of Text

Xx xxx people of txx xxxxxxx xxxxxxxx, xx xxxxx xx
Xx xxx xxxxxxx xx the United xxxxxxx, xx, xxxxx xx
Xx xxx xxxxxxx xx xxx xxxxxxxx States, ix xxxxx xx
Xx xxx xxxxxxx xx xxx xxxxxxxx xxxxxxx, in order to
Reading is nothing but the word-by-word mental restitution of a text through a series of snapshots.
The Invariance Problem

- We must read words regardless of how they appear:
  - In print
  - Hand written
  - Upper case
  - Lower case
  - Different sizes

- The most important feature is the **SEQUENCE OF THE LETTERS**.
Visual Invariance

six seven eight
six seven eight
six seven eight
six seven eight
six seven eight
six seven eight
six seven eight
six seven eight

six seven eight
six seven eight
six seven eight
six seven eight
sex severs sight
Our word recognition device meets two seemingly contradictory requirements:

- It neglects irrelevant variations in character shape, even if they are huge...

- It amplifies relevant differences, even if they are tiny (*sight* for *eight*).
Types of Visual Invariance

1. Word size can vary fiftyfold without having much impact on reading speed – (newspaper headlines and classified ads).

2. Visual invariance allows us to disregard the location of words on the page, in other words, we can recognize the word regardless of where it is on the page.
Character shape usually does not affect word recognition

- Font
- Upper case and lower case
- Weight of a font (Bold)
- Inclinations (Italics, originally invented in Italy)
- Underlined
- Any combination of the above
Types of Visual Invariance

A MYSTERY - how our visual system learns to categorize letter shapes
Experiments show that very little training suffices to DeCoDe, At An EsSeNtIaLtY NoRmAl SpEeD, EnTiRe SeNtEnCeS WhOsE LeTTerS HaVe BeEn PrInTeD AlTeRnAtElY iN uPPeRcASe AnD iN LoWeRcASe.
Global word shape does NOT play a role in reading.

Our visual system pays no attention to the contours of words or to the pattern of ascending and descending letters.

It is only interested in the LETTERS they contain.
Reflection and Discussion
Every Word Is a Tree

The visual system likes MORPHEMES

**Morphemes** – the smallest units that carry some meaning (*free* morphemes & *bound* morphemes)

Boy(s)
Wait(ed)

The decomposition of a word into its morphemes is an essential step on the path that leads from vision to meaning.
The “Priming” Effect – the reading of a word primes the recognition of related words.
Then it likes **GRAPHEMES** – A letter or series of letters that map(s) onto a phoneme in the target language.

- Not always a direct process.
- Groups letters into higher-level graphemes (e.g., ae, oa, ey).
- Graphemes are automatically grouped into syllables.
Examine the following words and mark those that contain the letter “a”:

- garage
- metal
- people
- coat
- please
- meat
Graphemes

Our visual system automatically regroups letters into higher level graphemes, thus making it harder for us to see that groups of letters such as “ea” actually contain the letter “a.”
In turn, graphemes are automatically grouped into SYLLABLES.
This area is still a topic of research, however, it appears that multiple levels of analysis can coexist: a single letter, a bigram (a pair of letters), the grapheme, the syllable, the morpheme, and finally the whole word.
The Hierarchical Tree

- These elementary components of the word will be used by the rest of the brain to compute sound and meaning.
The Silent Voice

In the middle of the seventh century, the theologian Isidore of Seville, simply marveled that “letters have the power to convey to us silently the sayings of those who are absent.”
Two Reading Routes

- Phonological Route – Vision to Sound
  - We first decipher the letter string, then convert it into pronunciation, and finally attempt to access the meaning of the sound pattern.

- Lexical Route – Vision to Meaning
  - When confronted with words that are frequent or whose pronunciation is exceptional, our reading takes a direct route that first recovers the identity and meaning of the word and then uses the lexical information to recover its pronunciation.

- Both reading routes exist and both are simultaneously active. The two routes operate in parallel and reinforce each other.
Angel of the Odd
by Edgar Allan Poe

“Who are you, pray?” said I, with much dignity, although somewhat puzzled; “how did you get here? And what is it you are talking about?”

“Az vor ow I com’d ere,” replied the figure, “dat iz none of your pizzness; and as vor vat I be talking apout, I be talk apout vat I tink proper; and as vor who I be, vy dat is de very ting I com’d here for to let you zee for yourzelf…Look at me! Zee! I am te Angel ov te Odd.”

“And odd enough, too,” I ventured to reply; “but I was always under the impression that an angel had wings.”

“Te wings!” he cried, highly incensed, “vat I pe do mit te ving? Mein Gott! Do you take me vor a shicken?”
Two Reading Routes?

- In children, the two routes are often poorly coordinated.

- Years of practice are needed before the two routes become close enough to give the impression, in expert adults, of a single integrated reading system.

- The latest neuroscience is indicating that there may be MULTIPLE ROUTES FOR READING.

- The cortical architecture is organized into multiple parallel paths.
Word Length

**Novice Readers**
- During the first few years of reading acquisition, reading time is strictly related to the number of letters in a word.
- This word length effect takes years to vanish.

**Skilled Readers**
- Our visual system processes all letters simultaneously and in parallel rather than one after the other.
- Word length is not usually a factor, unless new, involved words are confronted.

*Reading in the Brain: The Science and Evolution of a Human Invention*
Stanislas Dehaene, 2009
The Brain’s Letterbox

- The left occipito-temporal area
  - Lies at the boundaries of the occipital & temporal lobes of the brain

- Also called the **VISUAL WORD FORM AREA**.

- Also called **THE BRAIN’S LETTERBOX**.
  - Identifies letter strings
  - Is a funnel for **ALL** visual information about written words
  - Transmits to higher multiple areas that compute pronunciation & meaning
  - Left-hemispheric areas
The role the speech and language parts of the brain play in our ability to read.
Information leaving Wernicke’s Area travels along the Arcuate Fasciculus, a band of neural fibers, to the frontal language regions of the brain.

"Are the incoming phonemes meaningful?"

Appears to convert words into a code to direct the muscle movements in the production of speech.
The Language Pathway

- **Broca’s Area**: Processing of Syntax
- **Motor Cortex**: Production of Speech
- **Wernicke’s Area**: Comprehension of Words
- **Arcuate Fasciculus**: Connecting Broca’s and Wernicke’s areas
- **Thalamus**: Auditory Cortex
- **Auditory Cortex**: Speech production

The pathway begins with **Broca’s Area**, processing syntax, and proceeds to **Motor Cortex** for speech production. **Wernicke’s Area** handles word comprehension, bridged by the **Arcuate Fasciculus** to Broca’s Area. **Thalamus** and **Auditory Cortex** complete the cycle.
Wernicke’s Area

- Named after Austrian neurologist, Karl Wernicke
- Group of cells located at the juncture of parietal and temporal lobes in the left hemisphere.
- Semantic processing center.
- Appears to contain a **lexicon** that stores **memories of the sounds** that make up words - “Are the incoming phonemes meaningful?”
Wernicke’s Area

- Plays a major role in the conscious comprehension of the words by the listener and the speaker.

Next stop on the language pathway:
- Information leaving Wernicke’s area travels along a band of neural fibers to the frontal language regions of the brain. This band of neural fibers is called the **ARCUATE FASCICULUS**.
Broca’s Area

- Paul Broca, French neurologist, late 1860’s
- Located in the left hemisphere at the back of the frontal lobe.
- Appears to convert words into a code to direct the muscle movements involved in speech production.
- Recent studies indicate that it plays a major role in processing syntax, assembling words into sensible phrases that are grammatically correct - this is essential for making meaning.
"Are the incoming phonemes meaningful?"

Information leaving Wernicke’s Area travels along the Arcuate Fasciculus, a band of neural fibers, to the frontal language regions of the brain.

Appears to convert words into a code to direct the muscle movements in the production of speech.
Auditory Cortex, Wernicke’s Area, Broca’s Area

In the case of language, the sound stimulus is sent to the Auditory Cortex – the thalamus and auditory cortex determine if the sound is “language.”

For most people the left hemisphere is specialized for language. Broca’s area, near the motor cortex, is involved in language production, whereas Wernicke’s area, near the auditory cortex, is specialized for language comprehension.
The Reading Pathway

- **Broca’s Area**
  - Processing of Syntax

- **Wernicke’s Area**
  - Comprehension of Words

- **Angular Gyrus**
  - Written words translated into sounds of words

- **Thalamus**

- **Visual Cortex**
  - Recognition of visual pattern of a word
primary motor cortex

Broca's area

supramarginal gyrus

angular gyrus

primary auditory area

Wernicke's area
Prefrontal cortex
The pathway is no longer thought to be a serial model. It is now replaced by a parallel and “bushy” model.

The left occipito-temporal “letterbox” identifies the visual form of letter strings.

It then distributes this invariant visual information to numerous regions simultaneously, spread over the left hemisphere, that encode word meaning, sound pattern, and articulation.

Learning to read consists of developing an efficient interconnection between visual areas and language areas.

All connections are bidirectional.
The old neurological model of reading
(After Déjerine, 1892; Geschwind, 1965)
A Modern Vision of the Cortical Networks for Reading
A modern vision of the cortical networks for reading

Access to pronunciation and articulation

Access to meaning

Top-down attention and serial reading

Visual inputs

Visual word form area (« the brain's letterbox »)
Farther forward in the **INFERIOR FRONTAL CORTEX** in concert with temporal regions – select one meaning out of many whenever we hear sentences that contain many ambiguous words, such as, “The shell was fired near the tank.”

**REGIONS NEAR THE FRONT OF THE TEMPORAL LOBE** – concentrate on the combinations of meanings that words achieve when they are assembled into sentences.

The **LEFT, MIDDLE TEMPORAL CORTEX** Dedicated to the meaning of individual words.
Ambiguous Words
Inferior Frontal Cortex

- Some pieces of Rock Hudson sold at auction
- Deaf Mute Gets New Hearing In Killing
- Two Convicts Evade Noose, Jury Hung
- Mill Drinkers are Turning to Powder
- Dealers Will Hear Car Talk at Noon
- Sex Education Delayed, Teachers Request Training
Reflection and Discussion
Visual Invariance

six seven eight
six seven eight
six seven eight
six seven eight
six seven eight
six seven eight

six seven eight
six seven eight
six seven eight
sex severs sight
Making Meaning

- The brain network that analyzes word meaning is quite distinct from that which converts letters into sounds.
This network activates as soon as we THINK about concepts conveyed by spoken words or images.

- **Posterior temporoparietal region**

- **Ventral regions of the left temporal lobe** – The Letterbox

- **The left, middle temporal cortex** – dedicated to the meaning of individual words

- **Regions near the front of the temporal lobe** – concentrate on the combinations of meanings that words achieve when they are assembled into sentences.

- **Farther forward in the inferior frontal cortex** in concert with temporal regions – select one meaning out of many whenever we hear sentences that contain many ambiguous words, such as “The shell was fired toward the tank.”
The Mystery

- How meaning is actually coded in the cortex remains a frustrating issue for neuroscientists.

- The process that allows our neural networks to snap together and “make sense” remains utterly mysterious!

- We do know:
  - Meaning cannot be confined to a few brain regions
  - Frontal and temporal regions do not store meaning but facilitate it being sent to other parts of the brain “convergence zones”
The word “Bite”

- **The lateral temporal region** plays an essential role in the mediation between the letters of words and the elements that constitute their meaning
- Subdivided into subregions that specialize in different categories of words
- Faces, people, animals, tools, vegetables, etc
- Collect fragments of meaning from different sources
  - The parietal lobe for numbers and body parts
  - The occipital area V4 for colors
  - The area V5 for motion
  - The precentral and anterior parietal areas for action and gestures
  - The Brodmann area 10 for intentions and beliefs
  - The temporal pole for proper names
Brain’s response to words that all belonged to the same category of action verbs, but had different detailed contents

- *Bite* or *kiss* – evoked mouth movements
- *Write* or *throw* – evoked hand movements
- *Kick* or *walk* – evoked legs and feet movements

Each of the verb types activated a distinct sector of the premotor cortex, at the location represented in the map of our body.

A string of letters only makes sense if it evokes, in a few hundred milliseconds, myriad features dispersed in sensory, motor, and abstract brain maps for location, number, intention.
When we learn a language each word becomes solidly attached, by temporal lobe connections, to the many dispersed neurons that give it a meaning.
A tidal bore occurs along a coast where a river empties into an ocean or sea. A tidal bore is a strong tide that pushes up the river, against the current. A tidal bore is a true tidal wave.

A tidal bore is a surge. A surge is a sudden change in depth. When a channel suddenly gets deeper, it experiences a positive surge. When a channel suddenly gets shallower, it experiences a negative surge. Tidal bores are positive surges.
The Cerebral Tidal Bore
The Cerebral Tidal Bore

- STRINGS OF LETTERS
  - PGQLST

- FOUR CATEGORIES OF WORDS
  - Numbers
  - Proper names
  - Animals
  - Action verbs
A Quarter of a Second

- EEG with 64 electrodes, determined the duration of two essential stages of reading:
  - The ORTHOGRAPHIC FILTER, which accepts legal letter strings, and
  - The SEMANTIC FILTER, which sorts words according to meaning.
    - 180 milliseconds for consonant strings to be separated from real words
    - Took place in the left occipital-temporal letterbox region
    - An additional 80 milliseconds – to begin to activate distinct sectors of the cortex for meaning
Mental Lexicon(s)

- Orthographic Lexicon
  - Orthographic memories
  - Stored in the form of hierarchical trees of letter, graphemes, syllables, and morphemes.
  - [ca] +[rrot]

- Phonological Lexicon
  - A mental dictionary of the pronunciation of words.
  - carrot is pronounced “carat”

- Grammatical Lexicon
  - “carrot” is a noun, its plural is regular

- Semantic Feature Lexicon
  - a carrot is an edible vegetable, elongated in shape, usually an orange color, etc.
Reflections and Discussion
Dyslexia

- A number of indicators point to the cerebral origins of dyslexia.

- Since the 1950’s, it has been found to run in families.

- University of Colorado
  - Longitudinal studies
  - John DeFries, et. al.
  - Twin Studies – if a child suffers from dyslexia, his siblings have a 50% chance of being dyslexic

- Yale University
  - Shayowitz
  - The Connecticut Longitudinal Studies
Dyslexia

A range of risk factors and a bunch of genes collectively conspire to disrupt the acquisition of reading.

“…Expert reading depends on a fortuitous combination of cerebral connections that luckily preexist in our primate brains and take years of training to convert to a new use. One mishap in the circuitry is enough to bring the fragile process of neuronal recycling to a grinding halt.”

_Reading in the Brain: The Science and Evolution of a Human Invention_  
Stanislas Dehaene, 2009, p.238
Dyslexia

- Etiology
  - Phonological processing of speech sounds
  - Spatial attention deficits
  - It remains extremely difficult to sort out the causes, consequences, and coincidental associations of dyslexia.
  - The question is what is co-occurring and what is causal.
    - Processing of speech sounds
    - Impairments in auditory perception
    - Impairments in the discrimination of pure pitch, detection of a brief noise pause, or attention to the order of a fast auditory sequence
A Case of a Missing Letterbox

- A problem with the NEURON MIGRATION.
  - Anomalies occur during pregnancy
  - Neurons end up in the wrong places
  - The role of testosterone

- Connected to THREE GENES so far

- A dyslexic brain ends up without the BRAIN’S LETTERBOX.
  - Thus, cannot send any visual information to the sound areas of the brain
Dyslexia

Claims supported by the latest brain imaging studies:

- Often lies at the interface between vision and speech, inside the web of connections found in the left temporal lobe.
- Dyslexia is hardly ever diagnosed in Italy.
- Less frequent in France than in Britain and the USA
Two theories

- No biological origins – blame on the educational system OR

- In all countries, the same proportions of children suffer from genetic predisposition to dyslexia, but its symptoms only appear in some cultures – Was it conceivable that dyslexia turned into a full-blown pediatric problem in countries whose writing systems were so opaque that they put a major stress on the brain circuits linking vision to language?
Non-impaired/Dyslexic Brains

Broca’s area
Inferior frontal gyrus
(articulation/word analysis)

Parieto-temporal
(word analysis)

Occipito-temporal
(word form)

Nonimpaired

Dyslexic

Broca’s area
Inferior frontal gyrus
(articulation/word analysis)
Complexity of the English Spelling System

- Related to the number of years that it takes our children to learn how to read well
  - Italy
  - Germany
  - France
  - USA
The Hidden Logic of our Spelling System

- English has a complicated Spelling System.
- Italians have a transparent spelling system:
  - Every letter maps onto a single phoneme, with virtually no exceptions.
  - It takes only a few months to read.
  - Italian children’s reading skills surpass ours by years.
  - They do not need to spend time spelling out loud.
  - They also have a decreased rate of dyslexia.

- English phonemes – 40 to 45
- Italian - 30
Overcoming Dyslexia

- Neuronal migration anomalies, when they are present, affect only very small parts of the cortex. The child’s mind contains millions of REDUNDANT circuits that can compensate for each other’s deficiencies. Each new learning episode modifies our gene expression patterns and alters our neuronal circuits, thus providing the opportunity to overcome dyslexia and other developmental deficits.
Interventions – Retraining the Brain

- **FOCUS ON** (solicit the child’s pleasure attention & networks)
  - Phonological Awareness Continuum
  - The Alphabetic Principle
  - Fluency

- **INSTRUCTIONAL DESIGN**
  - Frequency/Intensity/Duration
    - Intense and prolonged re-training
    - Small group instruction
    - Short daily sessions spread over a period of several weeks
Phonological Awareness

The ability to clearly perceive and effectively manipulate the sounds of language. It is the awareness that language is composed of sounds.

It is the ability to manipulate sound in the ABSENCE of print.

This ability is a critical precursor to future proficient reading and spelling skills.
Phonological Awareness Continuum

- Rhyming
- Sentence Segmentation
- Syllable Segmentation and Blending
- Onset-rime segmentation and blending
- Segmentation and blending of individual phonemes
The Alphabetic Principle

- A key factor in learning how to read is the understanding that words are composed of letters that represent sounds, in other words – letter-sound correspondence.

- It is also knowing how to use systematic relationships between letters and phonemes (letter-sound correspondence) to retrieve the pronunciation of an unknown printed string or to spell words. This is known as Phonological Recoding.

- We teach the Alphabetic Principle through PHONICS instruction.
Wrap-Up

- Using our word wall words, create a visual representation of your understanding of *The Reading Brain*.
  - Table groups
  - Flip chart paper and markers

- Whole group sharing

- Next Steps
Reflection and Discussion
Some patients after a stroke lose the ability to quickly compute the pronunciation of written words.

- Deep dyslexia or phonological dyslexia
- No longer can read words such as “sextant.”
- No longer can read invented words.
- May still be able to read words used frequently, and generally manage to read aloud irregular but common words like “eyes,” “door,” or “women.”
- May substitute “ham” for “meat” or “painter” for “artist.”
Surface Dyslexia

- No longer have access to word meaning.
- Must sound out most words.
- Can still read regular words such as “banana,” or neologisms such as “chicopar.”
- Cannot read irregular words such as “enough.”
Reflection and Discussion
Real word or not?

rabbit
bountery
culdolt
money
dimon
karpit
nee
A piece of brain the size of one grain of rice has approximately 10,000 neurons.

Each neuron can make 1 to 10,000 connections.
Neurons differ from other cells in the body in two ways:

- They do not regenerate on a regular programmed basis - the neurons a baby has are the same neurons the senior citizen has!
- They are able to communicate with one another via electrical impulses and chemical exchanges.
  - Electric nerve impulses
  - Synapses
  - Neurotransmitters
- This is how they make connections.