

# BRAIN FITNESS 2

VICKI SIEGEL, MA, CEP CSCS  
SOUTH DENVER CARDIOLOGY ASSOCIATES

## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

The 7 Tenets of plasticity required to drive change in the brain:

### Tenet #1

**Change can occur only when the brain is in the mood**

Brain plasticity is enabled by behavioral circumstances

Change comes from things that you pay attention to

When alert, engaged, “on-the-ball”, ready for action, the brain releases those chemical neurotransmitters that enable brain change



## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

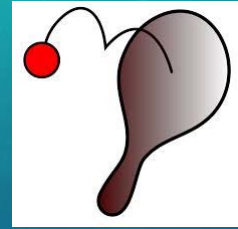
### Tenet #2

**Change strengthens connection between neurons engaged at the same time**

Sometimes the brain knows immediately that it has a good outcome

Sometimes it creates a model of activity (bounce a ball on a paddle), and once you achieve a short pattern (bounce 3 times in a row) the brain saves the combinations of connections that contribute to the good try, and it's making the connection a little stronger.

The magic is in the selectivity, the brain is saving this combination of connections selectively



## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

### Tenet #3

**Neurons that fire together wire together**

Things that we see or hear usually have many complexly related parts

Helps the brain recall memories that remind you of other things (ex. Farm, pastures, cows, tractor, horses, etc.)

The brain is constructing a sequence



## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

### Tenet #4

#### Initial changes are just temporary

When the brain engages in something it knows is important, we never forget it

The brain is deciding what to record

By doing something over and over, repetitive per se, that is how you get major brain change that is more lasting



## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

### Tenet #5

#### Brain plasticity is a two-way street and we can either drive brain change positively or negatively

Overall the discovery of brain plasticity is very uplifting, however,

There are a number of disorders that scientists have discovered, that are explained in terms of plasticity, i.e. some of the chronic pain syndromes:

The plastic brain becomes very good at firing the pain signal

Virtually every bad habit we have ever formed is a product of negative brain plasticity – then it becomes very hard to break or change (smoking, biting finger nails)

The brain is very malleable, and is much more easily altered by the environment



## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

### Tenet #6

#### Memory is crucial for learning

The brain is continually setting models, as to where learning is heading

The brain also remembers from moment to moment how we are doing in the progression of learning and improving our skills and abilities

Also evaluating against a model, that is held in memory (ex. Hitting a golf ball)



## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

### Tenet #7

#### Motivation is a key factor in brain plasticity

Dr. George Bach-y-rita – father (Pedro) had a stroke, and was not going to sit still, he hated being dependent

Taught him to walk with the only model of walking he had - infant

Father first got on all fours, then crawled, then crawled up stairs, then walked, and regained the skills he had lost with his son's training. Little by little things came back; the more he struggled with it, the more he regained. He then remarried, and returned to City College of New York as a professor and enjoyed a very active life.



## SEVEN TENANTS OF PLASTICITY IN THE BRAIN

Paul Bach-y-rita – other son becoming a leading neuroscientist and requested an autopsy when his father died



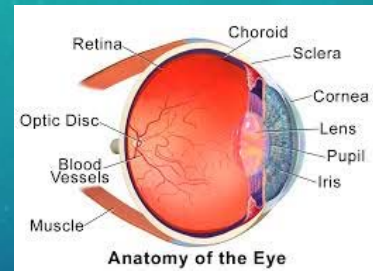
Father's brain showed that the parts of the brain that had been destroyed and obliterated by the stroke were there to be seen, despite the massive damage that occurred with the stroke

What his father's brain had done while working with George was to reorganize itself – realizing that the brain of an older person could be fantastically PLASTIC!

George Bach-y-rita put his focus not on the skill, BUT how that skill was acquired, the learning process

## SIGHT & SOUND

- The ability to maintain processes as we age, is dependent on how much we are using them.
- The function of the visual system is to extract information from the environment using the pattern of light that falls on the retina.
- Our brain is a powerful filter and integrator of all the information we get from the outside world.
- Every moment of our lives we make decisions based on information derived from our senses. The information gives us the cues we need to survive and thrive.



## THE VISUAL BRAIN

- Within our head, we have the capacity in our brain to change it, to improve it, to strengthen and refine it
- Having a clear view of our world is largely dependent on our ability to get good information from our senses:
  - Taste
  - Touch
  - Smell
  - Hearing
  - Vision, the dominant sense

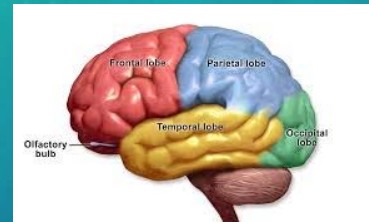


## THE VISUAL BRAIN

- It is simple to think about seeing and hearing as a function of just the eyes and ears, but those sense organs are a mere fraction of the whole story
- There about a million fibers in the eyes which join to form the optic nerve
- Receptor cells in our senses encode information and relay it to the brain
- These signals are refined in transmission to the cortex where the information is decoded for use in the control of action and thought

## PARTS OF THE BRAIN

- **Temporal lobes** – wrap around the sides, usually where your auditory cortex lies (hearing)
- **Occipital Lobe** is in the back – where the visual cortex lies
  - Information from the eyes reaches the back of the head (visual cortex) and is split off into two components: the “what” and the “where” systems
  - These are two distinct processing streams in the brain that handle this information
  - There are interconnections between them so you can link them (i.e. see a ball moving, you can identify that it is a ball, and it is moving in space)



## PARTS OF THE BRAIN

- **Two visual systems:**
  - One that we share with other mammals, that doesn't see color, it sees the world in black and white
    - Important for navigating through the environment, spatial organization, depth, distance, motion
  - One that is our object recognition system  
Sees and recognized faces, sees color and recognizes objects in much finer detail



## THE VISUAL SYSTEM

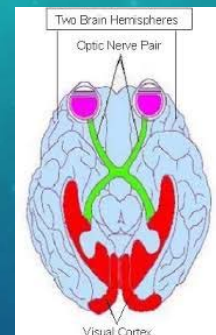


- The main purpose of the visual system is to extract information
- HOW DO WE KNOW THIS – “THE BLIND SPOT” – parts of the retina where the optic nerve leaves the eyeball (no photo receptors there)
- The eye delivers information to the brain in a highly resolved form in color, with a time and a place-
- Then the brain takes all this information and reconstructs it in all its complexity (ex. Complex painting, moving pictures)
- Half of the brain is used for processing

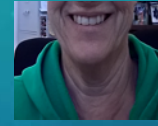
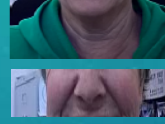
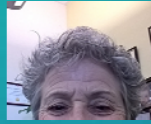


## THE VISUAL SYSTEM

- Our brain is interested in contrast, spatial as well as temporal contrast, discontinuity in an image
  - We do this with lateral inhibition - the brain itself is a binary computer, cells either fire or not
- If the visual system did not change throughout our lifetime it would not work very well
  - The yellowing of the lens increases as we get older, therefore less blue light reaches the back of the eye
  - If we weren't able to readjust our vision for those changes, then what would be called “white” by a 30 year old, would be called “yellow” by a 70 year old (this is a form of neuroplasticity)
  - Visually we have two flat retinal images, and the visual system uses perspective, distance, depth, relative motion, and stereopsis (you have two eyes that see things from slightly different angles) This is how your visual system calculates information about the world



## VISUAL SYSTEM



- When you look into the eyes of a young person, their eyes SPARKLE
  - They are sparkling because they are moving, and you want your eyes to MOVE AGAIN!
- The brain is constantly generating successive high resolution views of the world through rapid movements of the eyes called SICODS
  - Each SICOD provides the brain with a series of rapid fire snapshots of the scene
  - The fidelity of the signal the brain receives depends on the sampling rate – how quickly one processes information within a given eye movement

## ATTENTION – A TENET OF PLASTICITY

- **Attention** is the way we exert control over our visual and its unusual method for extracting information from the environment
- All of our senses and the millions of receptors are constantly being bombarded, but we are not aware of them...we only become aware of things when we pay attention to them
- Our plasticity as seen through our visual world exists at many levels:
  - Perception
  - Attention
  - Memory



## AGING AND OUR SENSES

- Sharpened senses are one of the most important components to positive aging
  - Our vision declines as we age
  - Most of us will go 10 years of diminished hearing without a hearing aid, and in those 10 years we have rewired our brain either not to hear, or not to hear well
  - Our sensory inputs decline as we age, we cope and if we do not use aids, we hear and see less, interpret less, and in a sense rewire how we communicate with the outside world
  - As the quality of sensory input to the brain declines, the power of predictive thinking, can also send us down a dangerous path (i.e. driving)
  - Broadening our window of attention, and increasing the speed with which we process information dramatically impact how we interact with the world around us

## AGING AND OUR SENSES

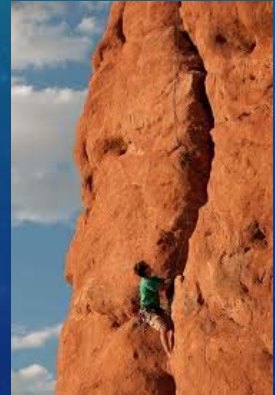
### USEFUL FIELD OF VIEW

- The older we get, the harder it is to take it all in...the harder it is to take in things other than in the center of gaze...our “useful field of view” declines (how much information a person can absorb and make useful in one brief glance)
- We focus more on the center and then the peripheral field gets cut off (driving)...the peripheral field is where we detect motion
- Driving the brain to change and expand the useful field of view is not about taking in more detail, it is about attending to more details and ignoring distracting elements
  - This is where we are detecting objects that may become threats, when we perceive the peripheral fields less, there is definitely an implication for safety
  - The contraction of the useful field of view impacts all areas of mobility

## ATTENTION

Our perception is influenced by our attention. There are two types of attention:

- **Top Down – goal directed**, this is what we choose in our mind
- **Bottom Up- attention imposed on us by the environment**, loud noise, flash of light, someone calls our name
- The intersection between “top down” and “bottom up” processing is directly tied to plasticity, influenced by the power of our focus and attention

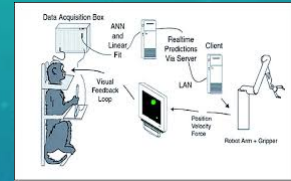


## ATTENTION

- The memory problems we see in older adults, stem from attention problems (not that they are not focusing on what they want to, they are not ignoring what they should)
- Navigating sensory information is further complicated by **noise**, and distinguishing the “signal” and blocking out extraneous noise (cocktail party)
- One of the most powerful tools for engaging our neuroplasticity is ATTENTION, focused, results driven attention
  - We can strengthen our brains by improving the quality and quantity of information we receive through our senses



## FOCUSED ATTENTION



- **Hippocampus** – small centrally located, seahorse-shaped part of the brain, is where we synthesized information and package it into memories
  - Studied individuals studying to become cab drivers in London (7 days/week, up to three years)
- Sensory substitution devices – pioneering research Brainport Balance Device for people with balance or vestibular disorders to rewire the brain
  - Brainport Vision device, used for the blind – taking a visual scene recorded from camera on head, and being displayed by impulses on the tongue

## FIVE KEYS OF INDEPENDENT AGING



1. Keep what you have – maintaining good health and vision
  - a. Healthy nutrition and exercise
  - b. Sunglasses
2. Be socially active
  - a. Continue learn and engage as many people as possible
3. Maintain focus and attention
  - a. Push your cognitive abilities to the max on a daily basis
  - b. Try to be more engaged in the environment in front of you, refine your abilities to take in more details

## FIVE KEYS OF INDEPENDENT AGING

### 4. Positive Attitude and Effort

- a. Harness the power of positive plasticity
- b. Be ready to learn and make the task strenuous enough to make a difference in your brain

### 5. Don't accept decline as inevitable

- a. As science advances, we will be able to intervene and avoid loss (cataract surgery, cochlear implant)
- b. Be unwilling to "go down" without a fight, DO NOT settle for LESS (sight, hearing, money, interaction)
- c. Demand more from yourself and others to EXTEND LIFE, not just extend age

**MAINTAINING WHO WE ARE IS WHAT BRAIN FITNESS IS ALL ABOUT!!!**



## BRAIN FITNESS PEAK PERFORMANCE

How much can you learn???

- Simultaneous Interpreter
- Baseball player
- Musician



**OUR BRAIN CAN BE PHYSICALLY AND FUNCTIONALLY CHANGED THROUGHOUT OUR LIVES BASED ON HOW IT IS UTILIZED!!!**



## BRAIN FITNESS PEAK PERFORMANCE

- As change occurs our brains become specialized in the skills we practice
- NEUROPLASTICITY takes place throughout our lives
  - Driving and rapid response to unexpected things that are happening
  - Any situation where the visual world is coming at you and you are not able to predict, these skills can be improved
  - BRAIN PLASTICITY is the great human adaptability, every skill and ability that we have, in a refined sense, is a product of brain remodeling



## BODY MAPS

- Just like we have a “mind’s eye” we also have a “mind’s body”
  - Your body is mapped by your brain, we have an auditory map, a touch map, a visual map, an olfactory map, and the space around your body is mapped out to the ends of your fingers
  - These body maps are DYNAMIC, they can grow or shrink dependent on use
  - Body parts are mapped based on touch receptors in your skin

## BODY MAPS

- We also have a motor map derived from signals sent from your brain to your muscles – experience shapes these maps
- People used to think these maps were set, because of strokes and the massive paralysis that would not come back
  - New research shows that they are plastic throughout life and can be fundamentally changed by experience
  - Current stroke rehabilitation now is working to re-animate these maps
- We can become EXPERTS to anything in which we pay concerted attention

## SKILL OF LANGUAGE INTERPRETATION



- An exacting skill humans learn is LANGUAGE
  - Fluency in two languages is very difficult – simultaneous translator (United Nations)
    - Listen to the input stream, which are chunks of sound, break these into the correct brain code, and then make contact with the stored information, hold this information in memory, and then reconstruct with the grammatical knowledge of the second language and verbalize it . They are able to use both sides of the brain in a more balanced way
    - Mastering the ability to talk and listen at the same time

## MUSICIANS BODY MAP

Musicians body maps:

- If you practice and practice and practice at something, your body map gets larger
- As you become adept at the skill your body map becomes more refined and smaller
- And then as you become more expert it gets larger again
- When studying musician brains, the hand representation is larger, especially the movement control side of the hands
  - Novel association between hearing (sensory modality) and a different motor effector (fingers)
- Mirror neurons – a neuron system that fires during action as well as during observation of action
- Attention is at the core of skill acquisition



## MOTIVATION

- Motivation is a key to developing any skill, especially at the brain level
- Motivation leads to engagement, and the engaged brain is a learning brain
- “USE IT, OR LOSE IT!” – continual practice of gradually increasing difficulty is necessary to drive positive plastic changes in the brain
- \*\*We are all experts at the skills we practice on a daily basis, whether it is driving a car or using a computer
- To make the best of our own performance as we age, we need to stay both mentally and physically active

## MOTIVATION

- EXERCISE is critical to maintaining high-functioning brain fitness!
- Elderly participants with the pre-disposition for Alzheimer's, that are APO-E4 carriers, when you contrast those that are vigorous exercisers, you get a clear early distinction and cortical responses to things that are later affected in Alzheimer's...physical exercise has very clear potential neuro-protective effects
- We can create new neurons in the brain at any age though PHYSICAL ACTIVITY!
  - Recommendations are an hour of AEROBIC exercise five times a week, will dial up the rate of production of new neurons in the brain
  - There are neurological consequences of giving up all of the skills or abilities that have made you the interesting person that you are!



## PHYSICAL AND MENTAL EXERCISES AND AGING

- Physical and Mental Activity are important components of healthy aging, as well as remaining socially connected.
- While the brain seeks out the new and novel, plasticity is a two-way street and can be driven both positively and negatively
- By actively challenging ourselves, we can combat negative plasticity
  - Taking it easy is going to simplify the brain, negatively

## PHYSICAL AND MENTAL EXERCISES AND AGING

- Living on a cobblestone street, we know your balance will be better, your cardiovascular system is better, and a lot of things about your health and vigor mentally and physically are better, because each time you take a little step, you have to make adjustments, and you have to make those adjustments continually, and so does your cardiovascular system, it has to change the way it pumps its blood a little bit (what we look for is smooth pavement, easy street)
- UNCERTAINTY is something we have to continually train our brains to deal with to operate in the real world



## GEOCACHING

- Geocaching is an outdoor recreational activity, in which participants use a Global Positioning System (GPS) receiver or mobile device and other navigational techniques to hide and seek containers, called "geocaches" or "caches", anywhere in the world.
- It combines an array of skill that your brain and body crave – it is a game and designed to be rewarding which is important for brain change
- It uses billions of dollars worth of satellite technology and computer internet technology to get you out into the woods to find a piece of Tupperware, it is also a very social event
- It also takes place in cities and towns
- Caching is also rated in the difficulty in locating the cache



## PREDICTION AND PRACTICE

- **Prediction** in neuron behavior strengthens brain connections
- Our experiences can leave indelible imprints in the brain, which underlies all of learning
- The synapses become stronger and they become permanent memories
- **Practice** – if you do something repeatedly and increase it incrementally, that is how you get major, lasting brain change

## MEMORY AND MOTIVATION

### Memory

- The brain is also continually setting models of where learning is heading, and remembering from moment to moment where you are in the progression of the development of any skill or ability
- The brain evaluates the progression against the model that is held in memory

### Motivation

- The brain asks for new challenges to conquer.
- These are the keys to motivating a brain and driving peak performance
- If you don't practice your abilities, you are in decline

## THE BRAIN AND AGING

- The brain wants you to refine the abilities that are slipping
- The brain wants you to be engaged again, so that when you are listening to a conversation, you are really listening, not just half-listening
- So that when you are out in the world you are really paying attention, and you see flowers again, and the reflections when the sun shines on it
- The brain is asking you to be young again in your attitude, to have your eyes sparkle again with life
- The brain is asking you to take up new challenges, to take life seriously again
- The brain is asking you to be engaged with power, vigor, and energy, and intensity

## KEEPING YOUR SKILLS SHARP

General heuristics to keep these skills sharp:

- Be active – having an active lifestyle puts yourself inherently into unpredictable situations, keeping your mind sharp having to handle and successfully deal with not just one task at a time, but a myriad of different tasks that really keep you challenged
- Put yourself into non-predictable, non-routine situations
- If we undertake tasks that invigorate our brains, engage us socially and keep our bodies healthy and active, we can remain the masters of our lives!
- We can expand our view of the world and combine the wisdom of our years with the unending joy of discovery as we harness the power of our brain's plasticity, helping us reach our own peak performance.

## THE BRAIN AND AGING

- One of the deadliest things that happens in modern life is that we imagine that a good life, in a sense, is to withdraw
- We reduce ourselves, we simplify and become the older person that has relatively little to talk about, especially new
- We seek comfort rather than novelty, as opposed to a new perspective or ability



## TIPS FOR OPTIMAL PLASTICITY

**FOUR** things you need to do to improve your brain:

1. Keep your HEART in decent shape

Your heart supplies your brain with blood and oxygen, and it needs that to run  
CARDIOVASCULAR EXERCISE is VERY IMPORTANT

2. Training should be INCREMENTAL, and start just below where you are
3. Training needs to be TAXING and systematically improving

Training that is difficult to do, but you can still manage with a bit of a effort to do it

4. Training should be interesting to engage the motivation circuits in your brain  
It should be interesting because of the chemistry involved in motivation



## NEUROPLASTICITY



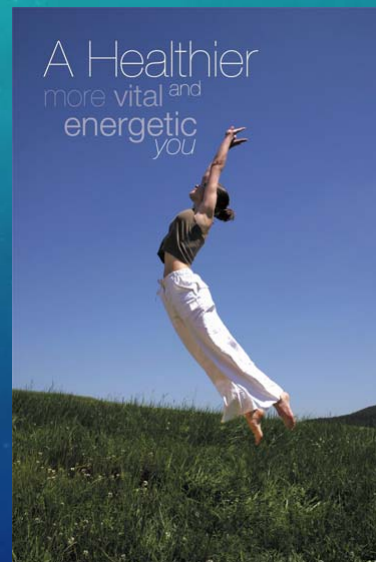
**NEUROPLASTICITY** is something that can be tapped in ordinary life through normal activities that you undergo everyday and through the thoughts that you think

**"It's not so much about getting OLD, it is about BEING A BETTER OLDER PERSON!"**

**"Living to the end of life 'just full of it!'"**

## BRAIN FITNESS

- By undertaking a program of brain fitness the payoffs can be enormous
- It's all about giving your brain span a chance to eclipse your life span!
- As we get older, be encouraged to know that if you exercise our very plastic brain in the right ways, you'll be surprised how much the JOY, the SPIRIT, the dancing of body and mind will return.
- It's far beyond remembering the face or word, it about retaining your VITALITY, your INDEPENDENCE, and your SELF!!!



## RESOURCES BRAIN FITNESS 2

- Dr. Richard Frackowiak, Wellcome Centre for NeuroImaging, London
- Dr. Adam Gazzaley, Director, Neuroscience Imaging Center, UCSF
- Dr. Margaret Livingstone, Professor, Harvard University
- Dr. Shannon Moffett, Author, "The Three-Pound Enigma"
- Dr. Michael Merzenich, Professor, University of California-San Francisco
- Dr. Jack Werner, Professor, University of California-Davis
- Dr. Aimee Arnoldussen, Neuroscientist
- Dr. Bryan Reimer, Research Scientist, MIT AgeLab
- Dr. Joseph Coughlin, Director, MIT AgeLab
- Dr. Karlene Ball, Professor, University of Alabama at Birmingham
- Dr. Jerri Edwards, Developmental Psychologist, University of South Florida
- Sandra Blakeslee, Author, "The Body Has a Mind of Its Own"
- Dr. John Houde, University of California, San Francisco
- Dr. Sri Nagarajan, University of California, San Francisco
- Wesley Clapp, Phd, Co-Founder, Neuroscouting
- Dr. Norman Doidge, Author, "The Brain That Changes Itself"
- Geocaching, [www.geocaching.com](http://www.geocaching.com)

## RESOURCES BRAIN FITNESS 1

- Dr. Arthur Toga, Professor UCLA , Lab of Neuro Imaging
- Dr. Michael Merzenich, Professor University of California, San Francisco
- Dr. Shannon Moffett, Author, The Three-Pound Enigma
- Dr. William Jagust, Professor UC Berkeley
- Sharon Begley, Author, Train Your Mind, Change Your Brain
- Dr. Jason Karlawish, Associate Professor, University of Pennsylvania