

# BRAIN FITNESS 1

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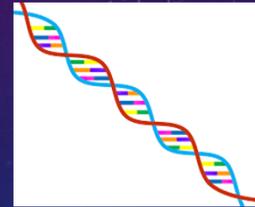
## “CAN WE TEACH AN OLD DOG NEW TRICKS?”

- YES!!!
- Cognitive decline does not happen to everyone
- We joke about having “senior moments”, however most of us are concerned about losing cognitive ability



## FACTORS INFLUENCING COGNITIVE DECLINE

- Cognitive decline is influenced by two factors:
  - Genetics
  - Environment
- The relationship between these two factors determines the degree by which gray matter is lost
- You can influence your environment by staying active physically and stimulating your brain, however you cannot influence genetics



## BELIEFS ABOUT THE BRAIN

Neurosciences have told us:

- The brain is fixed in its physical and anatomical organizational development, after an early stage that ends in childhood
- NOW scientific research is showing that the brain is not “hard wired” in childhood, and that we are not doomed by our DNA



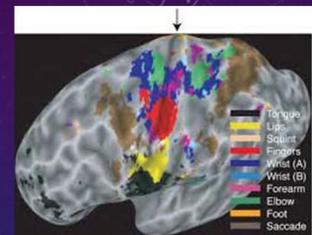
## NEW BRAIN RESEARCH



- Is our brain pliable, plastic, and changeable throughout our lifespan, regardless of our age or genetics?
- Can we change our brain, and will our brain heal itself with our guidance? From injury? From mental disabilities such as autism? Parkinson's?

## NEUROPLASTICITY

- **NEUROPLASTICITY** is the **KEY** to Brain Fitness:
  - Brain plasticity (from the Greek word 'plastos' meaning molded) refers to the extraordinary ability of the brain to modify its own structure and function following changes within the body or in the external environment
  - Understanding the plasticity in our brain allows us to stimulate it and therefore slow down the degenerative progression during aging



• [www.brainfacts.org/about-neuroscience](http://www.brainfacts.org/about-neuroscience)

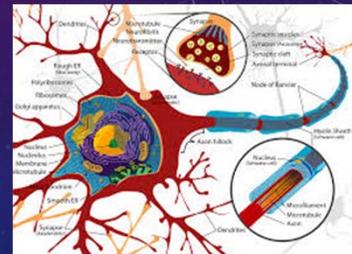
## BRAIN PLASTICITY

- Brain plasticity functions differently throughout our lives:
  - At BIRTH we are born with a “super highway” of neurons
    - As we learn the brain revises itself:
      - From super highways the brain develops streets, then bike paths, then walking trails, etc.
  - Infancy and early Childhood – critical period where plasticity is taking place on a large scale
    - Set up our “machinery” to take off and learn
    - At this stage the brain cannot control itself, the brain, at this stage, learns how to establish control



## NEURONS

- It was believed that we were born with a certain number of neurons at birth and this number expanded until the age of 1
- NOW there is scientific evidence that we continue to grow neurons throughout our lives
  - Each time we acquire a new skill or ability, neurons are created : **NEUROGENESIS**
  - Not only do we grow more neurons, the synapses (connections between the neurons) increase



## NEUROGENESIS

- **Neurogenesis** – the production of new neurons in the brain
- As we continue to learn, the brain continues to revise itself
- Each time we acquire a new skill or ability neurons and synapses are created
- **\*\*It is still UNKNOWN** what stimulates the increase in neurons**\*\***
- Originally it was thought that we developed neurons until about age 1 and then it stopped

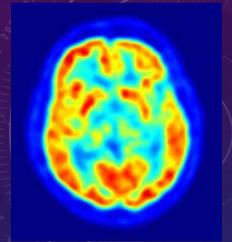
## NEUROGENESIS

- Experiment – consenting cancer patients participated in a study where dye was put into the brain and labeled on the dividing cells. After death the brains of these people were dissected and new neurons were found. (Participants were ages 50-70s)
- Now research shows that you speed up the rate of production of neurons, not by doing crossword puzzles, but by doing physical activity, 1 hour, 5 times per week)
- Neurogenesis is also amplified by a certain kind of mental activity, a kind of activity that is measurable, with increasing difficulty that will challenge the brain to grow and stay healthy

## BRAIN PLASTICITY

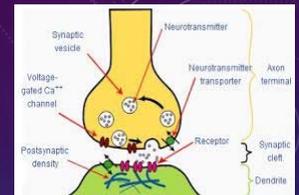
- From the end of the critical growth period in early childhood until the end of life the brain controls its self-development, its plasticity.
- During this time the brain establishes machinery that is specialized to fit into its environment, and most importantly it can change this machinery
  - Ex. Children born with a cleft palate – inherited disability. If you fix the problem so the baby can hear properly, it can change and specialize
  - Injury – when you engage in trauma (lose eyesight) normal signals go to the visual cortex. The brain compensates by increasing hearing, somatosensory cortex, and the visual cortex changes roles and begins processing sensations from the ears, etc.

\*\*\* Improvement and adaptation is a must throughout our lives for preservation of skills, senses and memory. Learning doesn't just change our knowledge, it physically alters our brains and our body chemistry



## SYNAPSES

- Synapse - the gap between neurons where our neurotransmitters float
- As we learn, we strengthen existing synapses and create new ones
- Donald Hebb, Canadian psychologist: Hebb Rule
- “Neurons that fire together, wire together”
  - The synapses connect our neurons one to another, strengthening our brains
  - Hebb showed how changes in synaptic strength could account for learning



## SYNAPSES

- The connections in your brain become stronger with repeated exposure, however it is the coincident activities that are generated by any important experience
- Neurons are co-strengthened because they co-occur
- By having particular patterns in the brain that occur over and over again, the synapses become stronger
- Hebb showed that our experiences can leave indelible imprints in the brain and that is what underlies all of learning

## STRENGTHENING SYNAPSES

- The firing and wiring has become key to learning, plasticity and brain fitness
- The synapses that are activated together, are mutually strengthened
- As you practice any simple skill, you engage populations of neurons that represent the details of that skill, moment by moment in time – these neurons are engaged simultaneously in time
- The brain is able to strengthen connection as several neurons are activated at the same time...these neurons are co-strengthened, and they can mutually strengthen one another
- The coordinated activation of populations of neurons is what drives us to higher learning

## TECHNOLOGY BEHIND THE DISCOVERIES

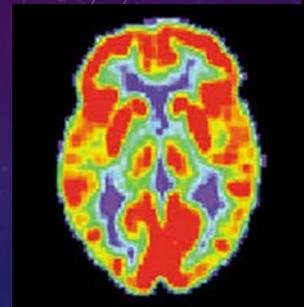
### Functional Brain Imaging

- Scientists can put a person's brain into a scanner and watch their brain function
- They can ask a person to count backwards by 3s and see which circuits are activated – you can see the brain functioning while a person performs a task



## TECHNOLOGY BEHIND THE DISCOVERIES

- They can watch the blood flow to the brain and see which parts of the brain are getting more blood at any given time
- They can see which parts of the brain are more active when a patient is experiencing different emotional states
- It has revolutionized the ability to study the human brain
- We now know that our brains change according to the lives we lead and the experiences we have



## WAYS THE BRAIN CAN CHANGE

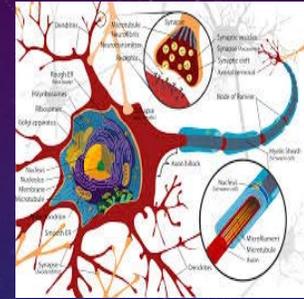
- Scientists have repeatedly documented the remarkable capacity of human brains of all ages to change
- These changes result from the experiences we have and the lives we lead
- These changes come about when you think new thoughts, learn a new skill
- As we age we need to work to maintain our figure as well as our mental acuity, And if we DON'T...
- The brain's reliability, agility, and flexibility gradually decline

## WAYS THE BRAIN CAN CHANGE

- Then the brain's ability to recall information or complete a simple task may become a struggle
- The typical 30 year old has a command of about 30,000 words, the typical 80 year old uses about 10,000
- It is a fact that the mature adult has a 50/50 chance of ending life non-compos mentis (not of sound mind),
- HOWEVER with brain plasticity we can change these odds, strengthen our brains well past the critic period, and possibly regain some of what we have lost...
- INORDER to understand how the brain can change, we must understand how the brain ages

## HOW THE BRAIN AGES

- The brain loses mass, just as we lose muscle, as we age
  - If you look at the brain on MRI you can see the valleys widen and fill up with fluid, representing a loss of tissue
  - The ventricles, filled with fluid in the center of the brain, get larger...so the amount of brain tissue decreases over time
  - It used to be thought that as we age we lose neurons, however the theory now is that we are losing synapses, the connections between the neurons, and a loss of myelin (electrical tape) made by oligodendrocytes and insulates the long skinny axon of the neuron and allows each neuron to send its message faster
  - If you lose a little myelin it can slow down your processing, and if you lose a lot of myelin it can be devastating



## HOW THE BRAIN AGES

- Wrinkles and loss of muscle mass are an obvious sign of aging, but the impact upon our brains is even more startling:
  - Moments of memory loss
  - Loss of balance
  - Difficulty hearing...it all starts with the brain



## HOW THE BRAIN AGES

- As we get older the speed with which we think and retrieve things slows down
- If you then introduce distractors, such as
  - A noisy room
  - Alcohol
  - Late at night
  - Lots of people talking at once
- ...you can look like you're having a memory problem



## NOISE IN THE BRAIN

- The cooperation of actions of neurons in the brain contributes to generating a clear signal even in the presence of lots of noise
- It is a weakening of the cooperation of neurons in an older brain that contributes and accounts substantially for why older individuals have difficulty and may struggle operating in the presence of noisy environments



## NOISES IN THE BRAIN

- Older adults also have a fear of falling, and it really starts in our brains, it is not just a physical strength issue
  - When we walk, our brains are very actively involved in processing our environment, and our movements, and orienting us
  - Most older people watch their feet as they walk and rely on their visual system
    - As we rely more on our vision for our balance, we are not using our actual balance system
    - **POSITIVE PLASTICITY CAN BE USED FOR POWERFUL CHANGES**



## NEGATIVE PLASTICITY

- By using near vision while walking, you plastically train the brain to be more susceptible to falls
- PLASTICITY is a two-way street:
  - Plasticity give rise to flexible behaviors, but sometimes used in a certain way, can give rise to rigidities



## NEGATIVE PLASTICITY EXAMPLE



- Once you find a path you like, you continue to use this path until you form a rut. This creates rigidity.
- This is how our brains work – our plastic brains can give rise to rigid behavior
- Negative plasticity can also result in mental disorders as well, i.e. OCD (over activity in a certain region of the brain called the “worry circuit”
  - OCD training – changing the thought patterns in a study had just as much of an affect as taking medication
  - Ex. Snow on a mountain in winter – snow is very pliable so you can choose many different paths

## MINDFUL ATTENTION

- Thinking about your thoughts differently, acted to quiet the brain, and in some cases patients were able to shed their illness
- Mindful attention is believed to transform the mind and free it from the symptoms of disease
- In the same way it can increase the quality of information we receive through our sensory inputs and can help us refine our thinking and behavior
- Paying attention can create plasticity, and we can only change things that I am aware of and am attentive to; it is a function of the focus of my attention



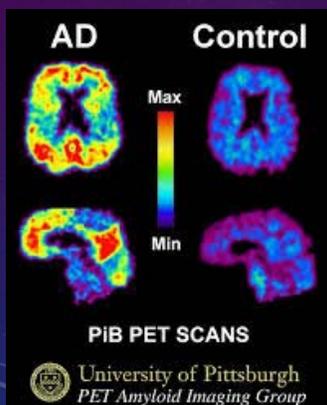
## MINDFUL ATTENTION

- ATTENTION is actually regulating what is allowed to change
- Being able to focus your attention enables the brain to enhance blood flow to the surrounding neurons and only things that I am attentive to will be able to change (plasticity)
- When you are in a learning mode, it is CRITICAL that your ATTENTION be FOCUSED, SHARP because this becomes a strong enabler of change which drives positive learning, positive brain change



## PLASTICITY – BRAIN CHANGE

- It takes an intensive learning experience to get the modulatory or the regulating mechanisms of plasticity in good shape



- Just like your cardiovascular health – in order to get in good shape you have to push yourself, challenge your system
- You really have to push yourself to increase your cognitive ability, AND reading the paper WON'T do it
  - Dancing the old dances won't do it either, but dancing new dances where you have to learn the new steps will do it
- Attentional control can be far WEAKER later in life, than when we're young

## MODULATORY NEUROTRANSMITTERS

- Modulatory neurotransmitters – small chemical molecules whose release result in turning on the plasticity switches in our brain
  - These neuro modulators are contributing to your sense of well-being
    - **Dopamine** is contributing to how positive, how pleasurable, how fun life is
    - **Noradrenaline** is contributing to how awake, alert, how bright you feel, as well as contributing to signals of alarm, danger and trouble when they appear
    - **Acetylcholine** is contributing to your feelings of brightness, alertness, engagement with others

## MODULATORY NEUROTRANSMITTERS

\*\*\*As this machinery dies off, guess what else is happening????

The bright, energetic, enthusiastic person that you are is slowly fading.  
So.....

**IT IS CRUCIAL THAT YOU KEEP THIS MACHINERY IN TIP TOP SHAPE**, AND if you have let it DECLINE, that you “buck it up” again and improve its functionality!!! WHY???

You won't just get the bonus of better learning, and stronger vivid memory, you'll get the addition of having a brighter life, a more cheerful, more engages, joyful life

## PLASTICITY SWITCH

- When tasks are too easy or routine, everyday activities, our actions don't release the neurotransmitters
- Instead of learning, we're using the skills that the brain already knows, this turns the **PLASTICITY SWITCH to OFF**, and nothing changes in the brain.
- Our ability to affect change in our brain, is also effected by our **DRIVE**, and our willingness to leave our "comfort zone!"



## PLASTICITY SWITCH

- When we are young we spend most of our time creating new abilities and skills, and as we age we become **USERS**, using the abilities we have acquired in our past.
  - We are relying on the things we know about
  - We want to do those things that we've mastered

## LEARNING AND MEMORY



- Learning new tasks and challenging our minds in a very focused way, is the best way to slow mental aging
- Acquiring new skills is important, BUT without remembering, the brain CANNOT harness its true power
- One of the keys to our memory lies in our Hippocampus
- Initially our memories are brought in to the hippocampus, and it is only at that time that they are sent out to the cortex

## HARNESSING PLASTICITY

- **CONSTRAINT-INDUCED THERAPY** –
- used in patients who have suffered a stroke or traumatic brain injury
- Edward Taub's therapy, pioneered at the University of Alabama, Birmingham:
  - Developed in the service of rehabilitation of brain damage, no matter the cause of the injury

## HARNESSING PLASTICITY

- If you constrain the good arm and then through intensive therapy (8 hour/day, 5 days/week for 2-3 months) and encourage the patient to use the “seemingly paralyzed” arm, they can make tiny little movements
  - Then you build on those movements, they can regain function, based on simplistic repetition of movement
  - This type of training requires tremendous commitment on the part of the patient and therapist
  - The more you work the brain, the more it heals itself
  - The main theme of this therapy is: you either use it or you lose it, and if you’ve already lost it, its okay, you can get it back if you keep trying



## 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

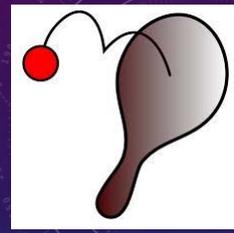
### Tenet #2

**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 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

## 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

## 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 need 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 strain 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

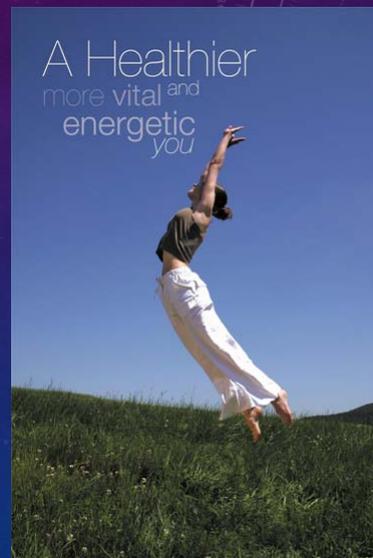
**NEUROPLASTICITY** is something that can be tapped in ordinary life through normal activities that you undergo everyday and through the thoughts that you think

**“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

- 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