Introduction to Neuroplasticity with Emphasis on Aging

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While We Can’t Control the Wind
We Can Adjust the Sails
Believe in Yourself

“In spite of illness, even of the archenemy sorrow, one can remain alive long past the usual date of disintegration if one is unafraid of change, insatiable in intellectual curiosity, interested in big things, and happy in small things.” - Edith Wharton
... even when it seems hopeless.
NEWBORN REFLEXES
Babies are born with many reflexes that help them survive. Examples include:

- Startle reflex: A sudden loud noise causes the baby to flinch or arch their back.
- Root reflex: When the baby’s mouth is touched, they open their mouth and suck into the touch.
Arms are used to help balance the body.

Child is ready to progress from standing on two feet to walking.

Brain such they on us.
Do you ever do any exercises, Grampa?

Oh, sure.

Did you know it requires the use of seventy-two muscles to speak a single word?

Yup. Just now I’ve done enough exercise for a week.

Really?
PRIMARY AREAS

Motor Cortex
Sensory Cortex
Prefrontal Cortex
Visual Cortex
Broca's Area
Speech Control
Auditory Cortex
Wernicke's Area
Speech interpretation
EINSTEIN AREA:
Angular gyrus... metaphorical and abstract thinking.
Cerebellum
Peripheral hypersensitivity that causes pain can persist even after the original injury has healed. Often such pain can become chronic, which triggers a state of hypersensitivity. The pain can be maintained by a variety of mechanisms.

**GLIAL FACTORS**
- Glutamate
- ATP
- Nitric oxide
- Substance P
- BDNF

**Neurotransmitters**

**INFLAMMATORY CYTOKINES**
- IL-1β
- IL-6
- TNFα

Astrocyte

Microglia

Spinal pain neuron

1. **DISTRESS SIGNALS**
- Glutamate
- ATP
- Nitric oxide
- Substance P
- Fractalkines
- Potassium ions
Applied Neuroplasticity

How neuroplasticity can work in health & disease.

ROLF S LULLOFF, MD
Disclosure

- Investor in stock of Helius Medical Technologies (a publicly traded corporation with the symbol HSDT)
How did I get into this?

- Born and raised in Dodgeville, Wisconsin
- Physician (MD) graduate of the University of Wisconsin
- Strong family history of Alzheimer's
- 52 yrs. of marriage to a wonderful lady who has had Parkinson's disease for 30+ years
- Personal experiences with how injuries and diseases affect patients’ bones, joints, muscles and nerves - but also affect their brains
How did I get into this? (cont.)

- Became a caregiver
- Dr. Norman Doidge’s book “The Brain’s Way of Healing”
- Parkinson’s Disease
- Alzheimer’s Disease
- Personal experiences as a Physician and Orthopedic Surgeon
- Personal activities (i.e. the golf swing and running)
Today We Will Talk About...

- How we can use neuroplasticity and our amazing brain to be of help in dealing with degenerative neurological diseases
- My personal experiences with dealing with the challenges of Parkinson's disease

NOTE: Parkinson’s is one of many common neurological diseases and conditions.
Parkinson’s Disease & Neuroplasticity

- What is Parkinson’s Disease?
- PD is a progressive neurodegenerative disease involving many areas of the brain.
- PD results in significant motor impairment.
- PD has many other neurological symptoms, often with cognitive impairment and mood disorders.
Pathology of PD

- Degeneration of dopaminergic neurons in the substantia nigra and pathways leading through the basal ganglia and into the cerebral cortex
- Other areas of the brain affected involving other neurotransmitters
Theories of PD Causation

- Toxic exposure +/- genetic pre-disposition
- True genetic inheritance
- Prion like alpha synucleon cellular deposits
- Inflammation
- Mitochondrial abnormalities
- Glial abnormalities
- Other possibilities???

*These changes may be a cause, but may be the result of the disease. Much research is ongoing and needed.*
Braak Stages of Parkinson’s Disease

Stages 1 & 2:

- Alpha Synucleon deposits present in lower brainstem of dorsal motor nucleus of the vagus nerve (DMV) and anterior olfactory structures.
- Minimal or no signs of PD.
- Often loss of smell and early psychological symptoms.
Stages 3 & 4:

- Spread of Alpha Synucleon deposits into medulla, pontine tegmentum, midbrain and basil forebrain.
- Onset & progression of PD motor symptoms (tremor, brady kinesia, rigidity, gait and balance symptoms).
**Braak Stages of Parkinson’s Disease**

**Stages 5 & 6:**

- All of the above with progression into the cerebral cortex.
- Progression of motor symptoms and cognitive impairment.
MY CHALLENGING JOURNEY WITH PARKINSON’S DISEASE

...and how it relates to Neuroplasticity.
1976 (age 36)

- Anosmia: rather abrupt loss of sense of smell
The Late 1970’s and Early 1980’s

- Panic attacks
The 1970’s and Beyond

- Visual disturbances
- Diplopia
- Oscillopsia
The Mid and Late 1980’s

- Intermittent but significant musculoskeletal pain
- Pain most prominent in shoulders, hips, and low back (bursitis like symptoms)
The Late 1980’s

- Tennis service tossing dysfunction
- Stress related micrographia
- Intermittent unilateral tremors
Late 1989

- Formal diagnosis of Parkinson’s Disease
Early 1990’s

- “Nuisance” intermittent mild to moderate PD symptoms
Classic Symptoms of PD

- **Tremors**
- **Rigidity**
- **Bradykinesias** (slowness of movement)
- **Balance issues** (postural instability)

Mnemonic **TRouBBle**
Nonmotor Symptoms of PD

- Mood disorders
- Cognitive impairment
- Motivational impairment
- Memory problems
The Early to Mid 1990’s

- The “sneakiness of this creepy disease”
- Short term ups and downs
- Longer term downward trend
1990’s

- The need for medication
- L-Dopa (Sinemet)
- Dopamine agonists
THE GOODS AND THE BADS OF MEDICATION
2000 – Present

- The dangerous duo
- Lapses with poor judgment
- Lapses with poor balance
In the Last 5 Years – 4 Major Falls

- Three broken ribs
- Left hip fracture requiring surgery
- Skull fracture with subdural hematoma
- Severe concussion
Where Does This Lead?

- The devastating loss of independence
We Must Remember

- Most, if not all, of the problems that arise in the person with Parkinson’s Disease are the fault of the disease – not the fault of the person.
Those of us who don’t have Parkinson’s Disease but are involved because of family members, friends, or patients with PD...

MUST TRY TO SEE AND UNDERSTAND THEIR PD THROUGH THE PATIENT’S EYES (BRAIN) AND NOT THROUGH THEIR OWN.
Answers to the Challenges and Obstacles of PD

• First and foremost, the answers are constant attention and “aggressive management” of those challenges and obstacles.
FALLING IS NOT ALLOWED – EVER!

Judgment and cognitive lapses must be delicately, but effectively, overridden.
All caregivers, family, and friends must be flexible to the minute by minute, hour by hour and day by day variations in the symptoms and manifestations of the PD patient and the needs for flexibly dealing with them.
Effectively Dealing with PD Requires...

- Love and understanding – build trust
- Physical and emotional support
- Education and guidance
- Physical exercise
  - ADL’s, PT, OT, speech therapy
- Mental exercise and stimulation
- Medication
With Parkinson’s Disease, some areas of the brain, and their connections, are permanently malfunctional (such as the basal ganglia)...

And many areas of the brain are relatively normal.

This is where neuroplasticity comes in.
We need to maximize the functions of the non-affected areas of the brain.

We need to minimize and reverse (if possible) the abnormal negative functioning of the affected areas of the brain.
The Importance of Rest

- Stress (emotional and physical) can be devastating to the health of the brain (especially to the basal ganglia) in PD.
- Illness and or injury can be a major short-term, and occasionally long-term, set back to someone with PD.
- Fatigue will interfere with attempts to exercise.
- Rest is as important as exercise.
Treatments for the Patient with PD

- Neurological evaluation and care
- Appropriate medications
- Intensive lifestyle care
Stimulate Our Brains with Healthy Activities

- Physical activities
- Stimulatory activities such as music, art, theater, etc.
- Lifelong learning
- Social stimulatory activities
Nurturing Our Brain

- Healthy nutrition
- Healthy lifestyle
- Avoid brain trauma
- Avoid poisoning our brains with:
  - Smoking
  - Drugs
  - Alcohol
Applying Neuroplasticity in PD

- Teach the brain how it is going to work
- Deny reinforcing the bad habitual movement patterns that are dictated by the PD-afflicted parts of the brain
- As seen with ADL’s:
  - Walking
  - Sitting
  - Moving
  - Reaching
Dealing with Physical Impairments

- Safety. Falling is not allowed, EVER!
- Activities of daily living (ADL’s)
  - Safe walking
  - Safe sitting and standing (transfers)
  - Eating and drinking
  - Reaching
  - Stair climbing
Exercises – Keep it Simple

- Quad sets/straight leg raises
- Chair exercises
- Sitting balance exercises
- Standing balance exercises
- Aerobic exercises, such as walking or exercise bike
Ancillary Exercises

- Exercise classes
  - Tai Chi
  - Pilates
  - Yoga
  - Physical fitness classes
- Physical therapy
- Occupational therapy
- Speech therapy
All Physical Exercise Needs to Be...

- Safe [technique]
- Simple
- Supervised
- Motivational
- Balanced between too much and not enough
- Enjoyable
- Encourage able
The Positives of Physical Exercise

- Cardiovascular stimulation
- Brain stimulation
  - Structural
    - Cellular: Neuronal, Glial, Mitochondrial, Microvascular, Synaptic, Circuits
  - Physiological
    - Biochemical (Neuro transmitters, Neurotrophic factors)
    - Bioelectrical
  - Psychological
    - “Runner’s high”
    - Anti-depression
    - Anti-anxiety
Healthy Physical Exercise Requires...

- Medical clearance
- Appropriate type of exercises
- Appropriate frequency of exercises
- Appropriate intensity of exercises
- Appropriate amount of exercises
- Appropriate variety of exercises
Motivation

- Wake up your body
- Wake up your brain
- Motivate your brain
- Find, develop, and energize your brain and your body
Thank you for your attention today.

Questions?
Definition of Neuroplasticity

- Neuroplasticity is the ability of the brain to reorganize its operation in response to:
  - New information sources
  - New functional needs and/or
  - New communication pathways

and

Is the process underlying all learning, training, and rehabilitation.
Our Brain

Our brains have the ability to:

- Change
- Grow
- Adapt
- Learn
- Lead

...throughout our lives.
Our Brain: Internal Inputs

- Inherited genetics from our parents that guide the development of our bodies & our brains
- Remembering with many parts of our brain
- Learning with many parts of our brain
- Thinking with many parts of our brain
Our Brain: External Inputs

- Seeing with the help of our eyes
- Hearing with the help of our ears
- Smelling with the help of our nose
- Tasting with the help of our tongue
- Feeling with the help of our skin
- Guiding and controlling movement with the help of our muscles, joints, and bones
- Balancing with the help of our eyes, ears, muscles, and joints
All of this “brain stuff” and this “neuroplasticity” has life long potential and is a life long process.

Although much of it is “automatic”, much of it is “up to us”, to realize it, to use it and to make it happen.

MAKE THINGS HAPPEN
How Does the Brain Do All of This?

- The brain depends on a complex physical structure, complex biochemical processes, and complex electrical circuitry.
- We are just learning about most of these processes.
Human Brain Development

- Conception
- Gestation (weeks)
- Birth
- 4 months
- Adolescence
- Adulthood

- Neurulation
- Neuronal proliferation
- Neural migration
- Myelination
- Synaptogenesis
- Apoptosis
Early Brain Cell Formation

- Approximately 4.6 million neurons are formed per hour during pregnancy and early life.
- Approximately 42 million synapses are formed per minute during early life.
Anatomy

- Approximately 86 Billion Neurons
  - Cell body (soma)
  - One axon with multiple axon terminals
  - Many dendrites
Anatomy (cont.)

- Approximately 1-2 X more Glia Cells
  - These are the supporting “nanny” cells
  - Supply the neurons with nutritional support and oxygen
  - Remove wastes
  - Probably many other critical supportive activities yet to be discovered/defined

- Far more synapses (estimated 164 trillion synapses)
Stages of Neuroplasticity

- *Prenatal to Early Adulthood* – high ability/potential
- *Throughout Adulthood* – lower ability/potential
- In Response to Injury, Illness, or Degenerative Disease or other neurological conditions
Conscious vs. Subconscious Activities

- Activities of Daily Living
  - Brushing teeth
  - Sitting
  - Standing
  - Walking

- Good Habits
  - Bad Habits
  - Where Did I Leave My Glasses/Keys?
  - Where Do I Find My Glasses/Keys?
Examples of Neuroplasticity at Work

- Healthy Neuroplasticity
  - Normal child development
  - Learning a language
  - Learning to walk
  - Learning a sport
  - Learning to play the piano
Neuroplasticity & Dealing with Brain Dysfunction

- Birth/Neonatal/Developmental Challenges
  - Cerebral Palsy
  - Autism
  - Attention Deficit Disorder
  - Other Learning Disabilities
Neuroplasticity & Dealing with Brain Dysfunction

- Brain trauma and other injuries that directly affect or rely upon the brain for recovery.
- Strokes
- Degenerative Neurological Diseases
  - Parkinson’s Disease (PD)
  - Multiple Sclerosis (MS)
- Neuropsychiatric Conditions
- Dementias
Neuroplasticity & Dealing with Brain Dysfunction

- Conditions not directly of neural causation:
  - Arthritis
  - Musculoskeletal trauma and fractures
  - Medical illnesses
  - Inactivity
  - Aging
Inputs and Brain Activities

- Can be positive
- Can be negative
- Can be stimulatory
- Can be inhibitory
- Can result in actions
- Can result in memory
- Can result in many emotions
- Can be conscious
- Can be subconscious
How does Neuroplasticity Actually Work?

- Some, or more, or all of these brain activities:
  - Neuron cell formation
  - Interneuronal synapse formation
  - Multiple synaptic pathway formations (electrochemical circuits)
  - Strengthening all of the above by repetitive use
  - Inhibiting non-used and unwanted pathways (circuits)
Ongoing Lifelong Neuroplasticity Involves...

- Strengthening/weakening of neuronal and glial cellular functions
- Competitive strengthening/weakening of neuronal circuits
- Triggering of neuronal and glial growth factors leading to new cell formation
- Improved brain circulation
New Developments in PD

- Research in medications
- Deep brain stimulation
- Understanding and attacking intracellular toxic chemical buildups (such as Lewy bodies and alpha synuclein)
- PoNS noninvasive neurostimulation
References & Work Cited


Sources of Information

- Doidge, Norman, M.D. The Brain’s Way of Healing (2015) Viking (an excellent source of information about neuroplasticity and all of our brains)
- Kobeissy, Firas PhD Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects (2015) CRC Press, Pages 605-630
Sources of Information (cont.)

- Wikipedia
- Tactile Communication and Neurorehabilitation Laboratory (TCNL) UW Madison
- McNamara, Patrick The Cognitive Neuropsychiatry of Parkinson’s Disease (2011) Massachusetts Institute of Technology

A Pioneer of the Field of Neuroplasticity: Paul Bach-y-rita, M.D. (1934–2006)

https://tcnl.bme.wisc.edu/laboratory/founder


The Brain Book, Ken Ashwell.