

# NEUROPLASTICITY:

fun(ctional) PT intervention to optimize movement & improve motor learning.

AN INSERVICE PRESENTATION / J. ETHAN MENG, SPT

## Background + Outline/Objectives:

- Learners will be warmly welcomed and thanked for showing up
- Learners will be provided with an overview of neuroplasticity & the 2 main mechanisms of how it occurs in the CNS
- Learners will be familiarized with the 10 principles of experience-dependent neuroplasticity and how to provide optimal experiences for motor learning
- Learners will get out on time



# What is neuroplasticity? Why does it matter?

- **Definition:** *“the ability of the central nervous system to change its activity in response to intrinsic or extrinsic stimuli by reorganizing its structure, functions, or connections”.* <sup>1</sup>
  - “Change”. <sup>2</sup>
- It is the brain’s ability to process new and complex info/experiences, & to “rewire” in order to act/react in ever-changing ways throughout life.
  - Research on the neurobiology of learning and memory suggests that, for each new learning event, there is some necessary and sufficient change in the nervous system that supports the learning (Cooper, 2005; Donegan & Thompson, 1991; Hebb, 1949; Kandel, 2001; Rose, 1991).
- Clinically, it is the process of recovery after brain injury, such as a stroke (CVA), spinal cord injury (SCI), or traumatic brain injury (TBI), or simply the process of brain changes to learn/master a new belief, skill, or movement.
  - “Currently, learning is our best hope for remodeling the damaged brain.”





# How does neuroplasticity happen?

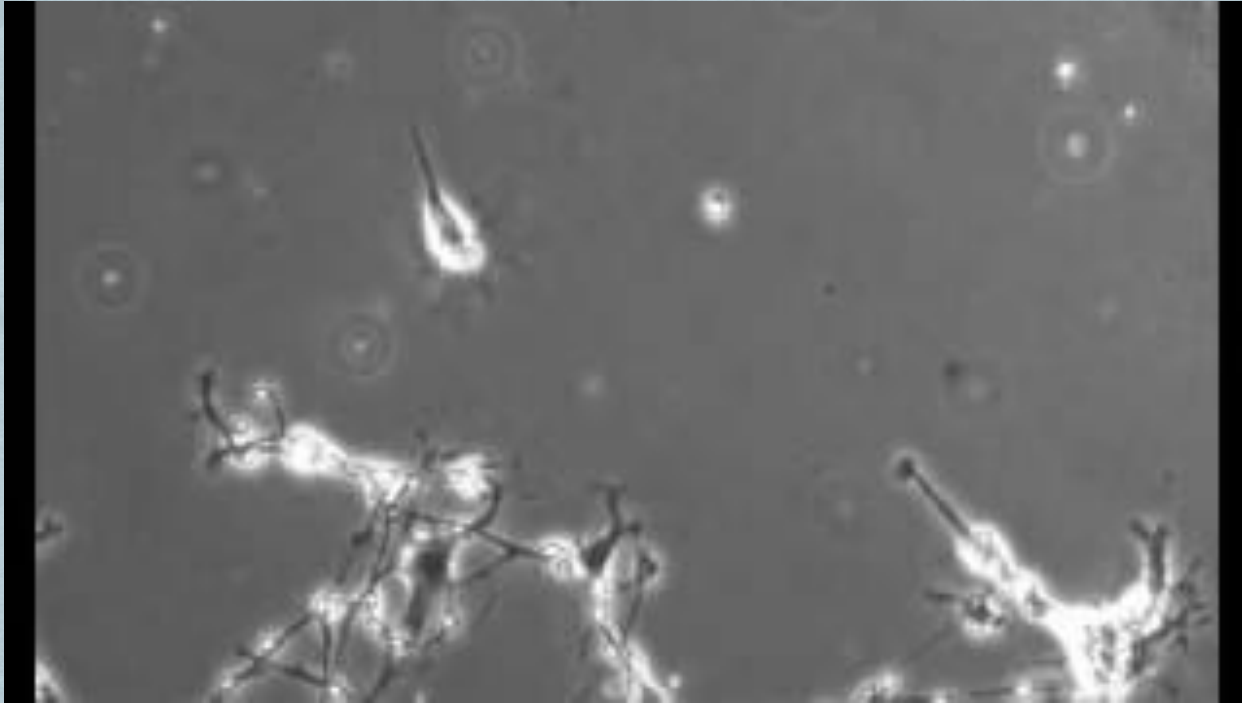
## 2 Main Mechanisms:

### 1) “Experience-Independent Plasticity”

- **Neurogenesis:** “the ability to create **new neurons and connections** between neurons throughout a lifetime.”<sup>1</sup>
  - Seen mostly in development, no convincing evidence for adult neurogenesis in humans.<sup>2</sup>
- **Functional Reorganization (Compensation):** changes in grey/white matter in order to increase or recover function. <sup>3,4,5</sup> “Redundancy” = disproved / “masking” = questionable <sup>5</sup>
  - **Equipotentiality:** in the event of damage to one area of the brain, other parts can sometimes assume the role of the damaged region.
  - **Vicariation:** the brain’s ability to reorganize other portions of the brain to overtake functions that they were not intended to.



# Experience-Independent Plasticity



# How does neuroplasticity happen?

## 2 Main Mechanisms:

- 1) ~~“Experience Independent Plasticity”~~ **PT-Independent Plasticity**





# How does neuroplasticity work?

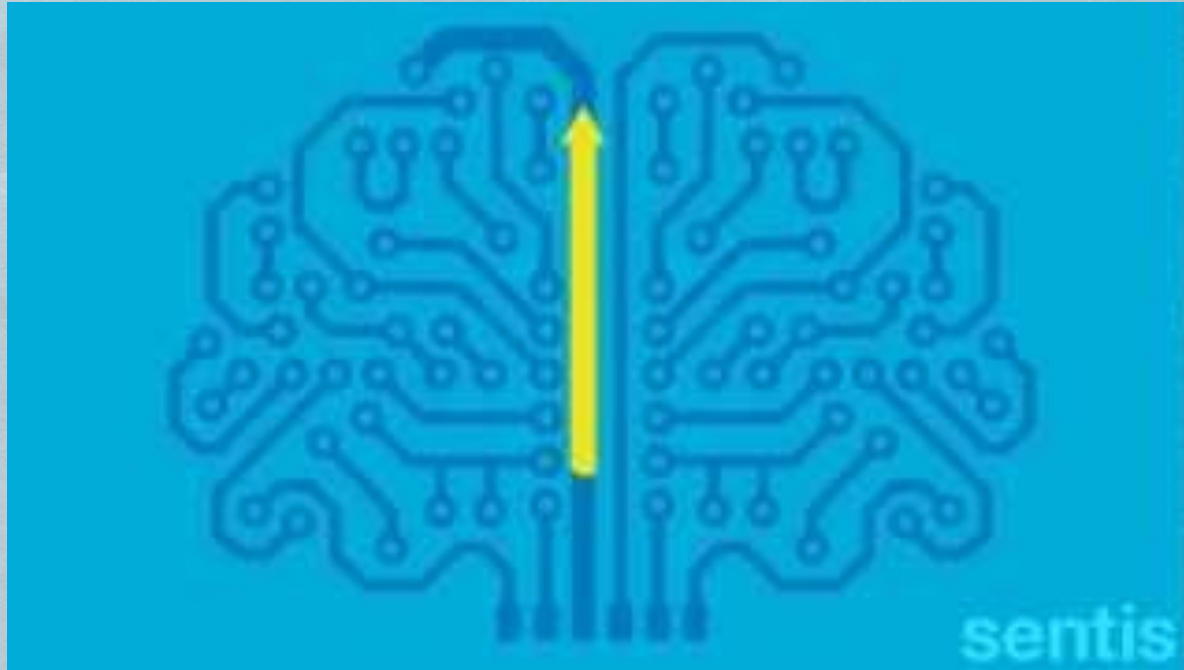
## 2) “Experience-Dependent Plasticity”

**Synaptic Plasticity - the basis of all learning and practice.**

- “The Neural Garden” - constant pruning/deletion of old connections and growing of new connections.
- “Functional changes lead to structural changes”
- “Synapses that fire together wire together”.
  - Denervation supersensitivity
  - Long-term potentiation / depression / synaptic strengthening
  - Re-Routing



# Experience-Dependent Plasticity





# 10 principles of experience-dependent neuroplasticity



## Use What You Have.

- **Use it or lose it:** *Neural networks not actively engaged in training can degrade.*
  - “Still, there is also a need for some caution, since intense early activity may actually increase lesion size, with exaggerated functional loss”
- **Use it and improve it:** *Training that drives a specific brain function can lead to enhancement of that function.*
  - Strong evidence<sup>1</sup> that PT intervention improves outcomes and prevents further impairment after stroke
- *It's not rocket surgery.*



# 10 principles of experience-dependent neuroplasticity

- **Interference:** *changes (plasticity) that result in bad habits can interfere with learning good habits.*
  - Negative neuroplasticity: synergy, spasticity, ataxia, compensations, gait deviations, etc
- Interference for motor learning: correcting bad/harmful movement habits that interfere with learning good habits
- Feedback/input: “providing explicit instruction on how to perform a motor sequence task was found to improve implicit motor learning in healthy controls, whereas the same instructions interfered with learning in subjects with strokes”
  - “you talked too much”- laura





# Salience.

- *The experience must be meaningful to the person in order to cause change (plasticity).*
- Importance of functional mobility - ability to WALK is most meaningful
- Salience is necessary for learning:
  - Importance of perception & past experience
    - Impacts of Trauma / Fear / Negative Perceptions on healing process
    - Impact of Fun / Love / Compassionate Care / Positive Interactions
  - Role of patient education, validating feelings, positive re-framing, positive feedback
    - Active listening / individualized patient-centered care / building resilience / providing safe environment for healing
- *Never judge a book til you've walked a mile in its cover.*



# Identity Based Habits

## OUTCOMES.

WHAT someone does.  
(Results/Achievements)

## PROCESSES

HOW someone does what they do  
(Habits/Systems/Actions).

## IDENTITY.

WHO someone believes they are.  
(Worldview, Self-image, Beliefs,  
Biases, Perceptions, Feelings)

### ***“Atomic Habits”***

*“There are three layers of behavior change: a change in your outcomes, a change in your processes, or a change in your identity.”*

*“With outcome-based habits, the focus is on what you want to achieve. With identity-based habits, the focus is on who you wish to become.”*

*“The ultimate form of intrinsic motivation is when a habit becomes part of your identity. It’s one thing to say ‘I’m the type of person who wants this’. It’s something very different to say I’m the type of person who **is** this.”*



# Identity Based Habits<sup>1</sup>

## Starting an Identity Based Habit:

1. *Decide the type of person you want to be (Set the goal)*
2. *Prove it to yourself with small wins (Make a system)*

## Following through:

- **Goal Elimination/Prioritization**
- **Implementation Intention:** Stating how you intend to implement a particular habit. The two most common cues are time and location.
  - Opt in: "I will [BEHAVIOR] at [TIME] in [LOCATION]."
  - "When situation X arises, I will perform response Y." / "If \_\_\_\_\_, then \_\_\_\_\_".
- **Habit/Goal Stacking:** Identify a current habit you already do each day, and then stack your new behavior on top.
  - "After/Before [CURRENT HABIT], I will [NEW HABIT]"
- **Measure Backward, then get a little bit better:** Use recent results. What did you do last time? How can you improve your system by just a little bit?





# Specificity.

- **The nature of training dictates the nature of the plasticity.**
- Setting Proper Goals/ Ruthless Elimination of Competing Goals / Proper Systems to Reach Goals
- *“The primary benefit of having a goal is that it tells you what sort of system you need to put in place. However, the system itself is what actually achieved the results.”<sup>1</sup>*
  - Row Boat Analogy - Direction + Action
- What do you want? Strengthening? Balance? Motor Control? Function? Safety?
- MSK impairments vs. neuro
  - Motor learning -> extrinsic feedback / knowledge of results / task-based<sup>2</sup>
- *When all you have is a doctor, everything looks like an apple..*



# Time and Age Matter

- **Time matters:** *Different forms of plasticity occur at different times during training*
  - The acuity or chronicity of the condition will impact how a pt responds.
  - Critical time window - 3-6 months post stroke<sup>1</sup>. Emerging research suggests that the critical window can extend well past 1 year.<sup>2</sup> Either way, try!
  - *When life gives you a bird, get the worm.*
- **Age matters:** *Training induced plasticity occurs more readily in younger brains.*
  - The patient's age will guide & inform prognosis/planning.
  - *You can (and should) teach an old dog a new trick. But a younger dawg will probably learn it better (and be more open to change).*



# Repetition.

- *Sufficient repetition is required to induce lasting neural change.*
- -impulse-> neuron <-stimulus-> neuron: “Neural Echo” with repeated experience
- Animal studies:<sup>1,2</sup>
  - several days of repetition before rat neuroplasticity occurs
  - minimum 1000-2000 steps/session to improve stepping/step quality in cats
  - “Animals trained on a skilled reaching task to perform 400 reaches per day had increases in synapse number within motor cortex (Kleim, Barbay, et al., 2001), whereas animals trained to reach 60 times per day did not have such increases” (Luke, Allred, & Jones, 2004)
- for humans... it depends.
- **If at first life doesn't give you lemons, make lemonade again.**





# Transference

- *The ability of plasticity within one set of neural circuits to promote concurrent or subsequent plasticity.*
- Role of general exercise in transference
  - After traumatic brain injury or spinal cord injury in animal models, appropriately timed exercise has been found to robustly elevate neurotrophic factors and other plasticity-related molecules and to improve functional outcome (e.g., Griesbach, Gomez-Pinella, et al., 2004; Molteni, Zheng, Ying, Gomez-Pinilla, & Twiss, 2004; Ying, Roy, Edgerton, & Gomez-Pinilla, 2005).
- Skill transfer in motor learning - pick relevant functional activities.
  - Don't need to necessarily go with lowest level skills first
- *If you give a man a fish, he'll eat for a day. If you teach a man how to fish, he will flex on his social media networks for a lifetime.*



# Intensity

- *A sufficient intensity of stimulation is required to induce plasticity.*
- Underloading: huge problem in our profession
- Overloading: also can cause huge problems
- How to monitor intensity?
  - HR response/variability, RPE, changes in programming since last session
  - Target training zones / progressions
    - HIT > MAT for locomotion<sup>1</sup>
- LiteGait: Allows us to safely push intensity
- *“Don't smile because it's over, cry because it happened”*



# HIVE MIND:

- How can we change our intervention to optimize neuroplasticity in meaningful ways?
- How can we modify patient experiences to address gait impairments s/p CVA?
- Individual / task / environment:
  - 6 Functional Strengthening Movements: Squat, Lunge, Hinge, Push, Pull, Carry
    - \*Gait/Locomotion/Stepping -> Hip flexion
    - \*Rotate: bonus pattern, can be added to any of the 6
  - 6 Transfers: Supine <> Sitting, Bed<>Chair, Sit<>Stand, Floor <> Chair, Floor <> Stand, Stairs,
  - 6 ADLs: Eating, bathing, dressing, transferring, toileting, walking or moving around.
- Unlimited meaningful activities/tasks that we can use to be creative.
- Constant learning/improvement/teamwork needed.
  - “How you do *anything* is how you do everything.” “If you want to go fast, go alone, if you want to go far, go together.”





# The End

- Thank you!
- Hopefully we are doing good on time
- Open to feedback and further discussion
  - by “feedback and further discussion” I mostly mean if you want to give me a compliment right now or in the future then you can
  - just kidding
  - but really
- 1 more week here left
- Thank you again everyone! Especially Laura, Kara, and Amber
  - UBUNTU: “I am, because you are.”

