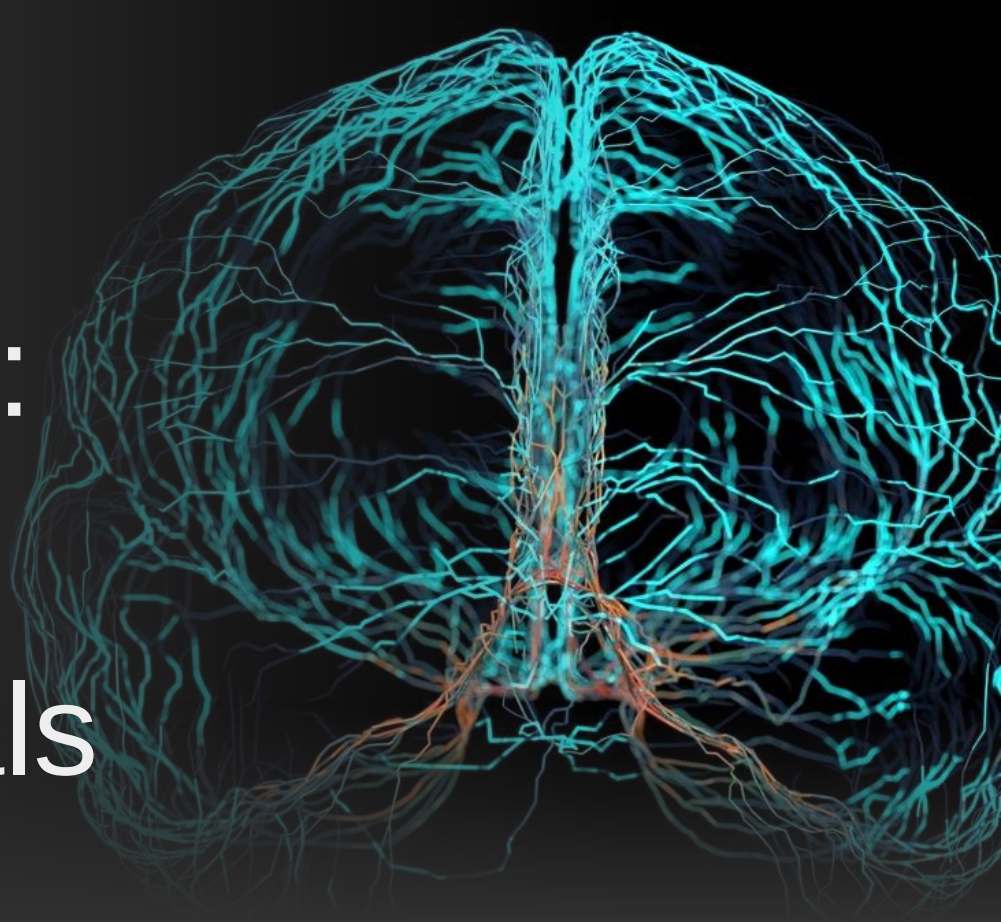
University of CINCINNATI

Neuroplasticity: How the Brain Deals and Heals with Disorders



Amu De Silva PT, MS, DPT, GCS, NCS, CEEAA

Objectives

1. Investigate the mechanisms of neuroplasticity in brain disorders

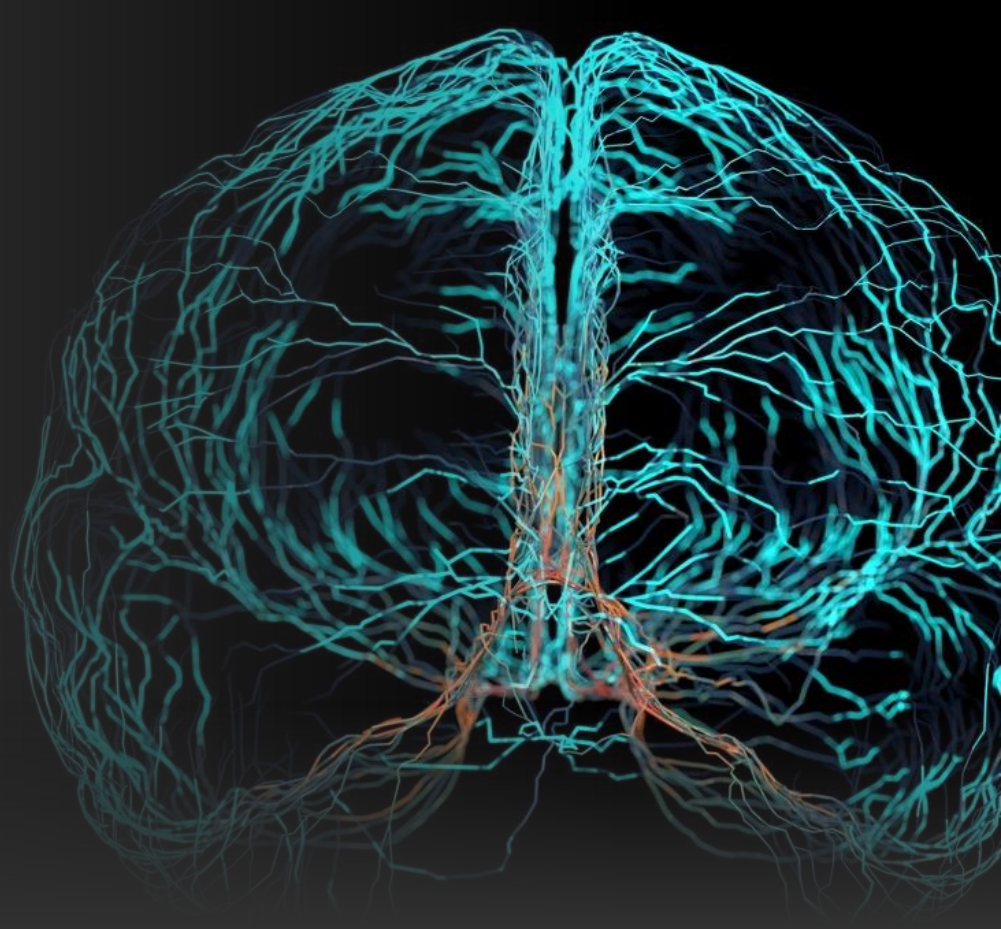
2. Analyze neurophysiology and neuropsychology to comprehend the brain's adaptive processes.

3. Implement evidence-based exercises in stroke, Parkinson's disease, and brain injury rehabilitation.

4. Utilize motor learning theories, practice, and feedback mechanisms to actively facilitate neuroplasticity and optimize patient recovery.

5. Engage in hands-on sessions, practicing vital exercises to stimulate neuroplasticity.

6. Acquire and implement actionable strategies for clinical settings, empowering immediate integration into patient care and rehabilitation protocols.

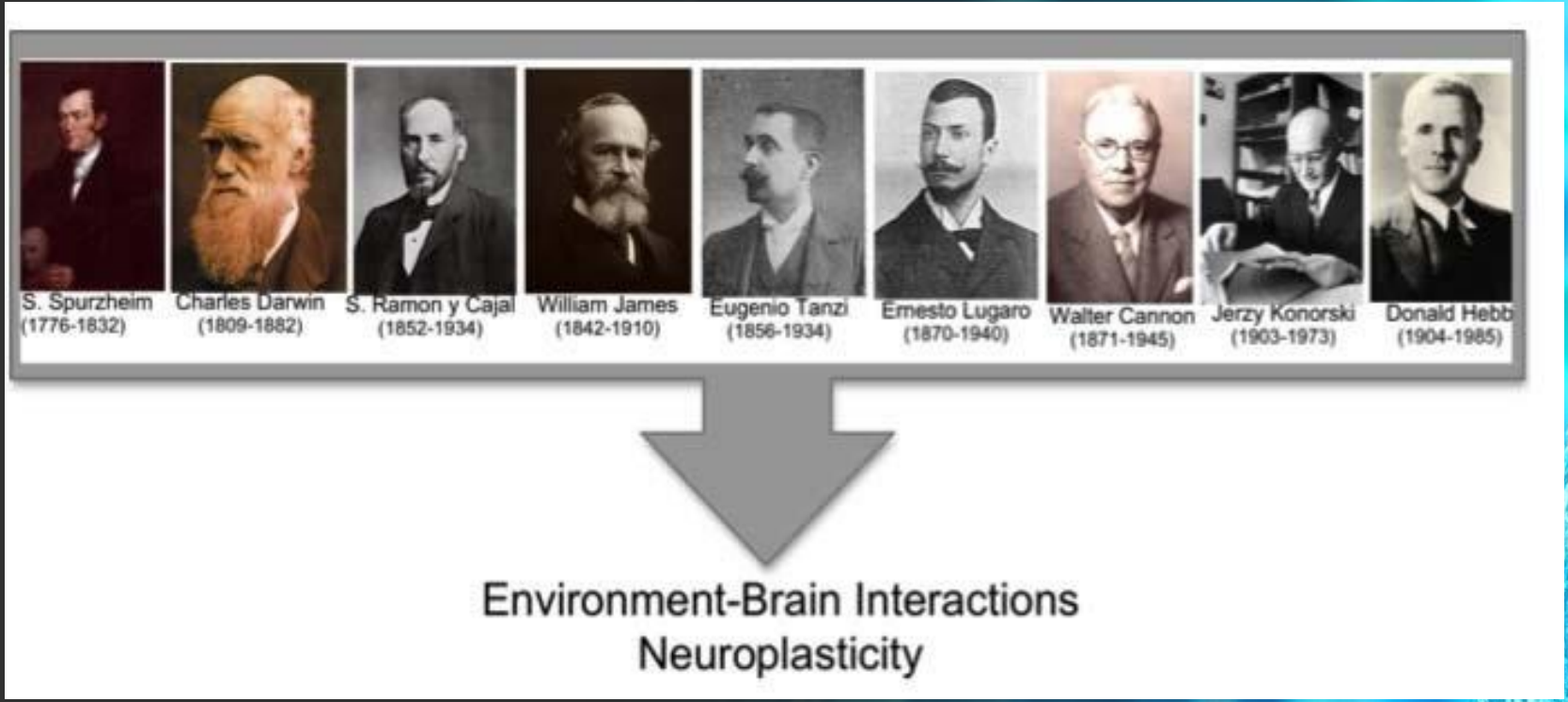


Neuroplasticity

The brain's ability to change, adapt, and reorganize structurally and functionally in response to learning, experience, or injury

Rigidity

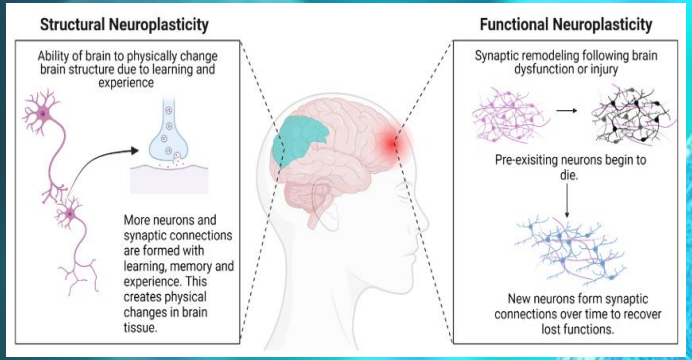
Plasticity



Early View: Brain is a static organ, stops developing after the first few years of life

Neurophysiology

Structural	Functional
Synaptogenesis	Denervation Supersensitivity
Dendritic Arborization	Potentiation/Depression
Collateral Sprouting	Synaptic strengthening



*Neurotrophins support (activity-dependent) neuroplasticity

Exercise upregulates cellular processing of neurotrophins, i.e. synthesis, release, absorption, and degradation (Knaepen et al., 2010) and induces structural plasticity (Rogge et al., 2018)

Neuropsychology

Human brain comes with rough blueprint of cerebral organization that must be shaped by experience.
− flexibility (possibility to make errors)
+ learning complex skills

Cerebral functions are distributed throughout brain & body (Kolb & Whishaw, 2001)

To be functionally meaningful,
neuronal change ↔ behavioral change
(Repetition Matters)

Neuroplasticity principles

Principle	Description
1. Use It or Lose It	Failure to drive specific brain functions can lead to functional degradation.
2. Use It and Improve It	Training that drives a specific brain function can lead to an enhancement of that function.
3. Specificity	The nature of the training experience dictates the nature of the plasticity.
4. Repetition Matters	Induction of plasticity requires sufficient repetition.
5. Intensity Matters	Induction of plasticity requires sufficient training intensity.
6. Time Matters	Different forms of plasticity occur at different times during training.
7. Salience Matters	The training experience must be sufficiently salient to induce plasticity.
8. Age Matters	Training-induced plasticity occurs more readily in younger brains.
9. Transference	Plasticity in response to one training experience can enhance the acquisition of similar behaviors.
10. Interference	Plasticity in response to one experience can interfere with the acquisition of other behaviors.

Kleim & Jones 2008

Unlocking Brain's Adaptive Potential (aka) Motor Learning!

Brain change ↔ Behavior change

Motor learning → process of acquiring/refining motor skills through practice and experience

What is happening? (Roberta et al, 2020)

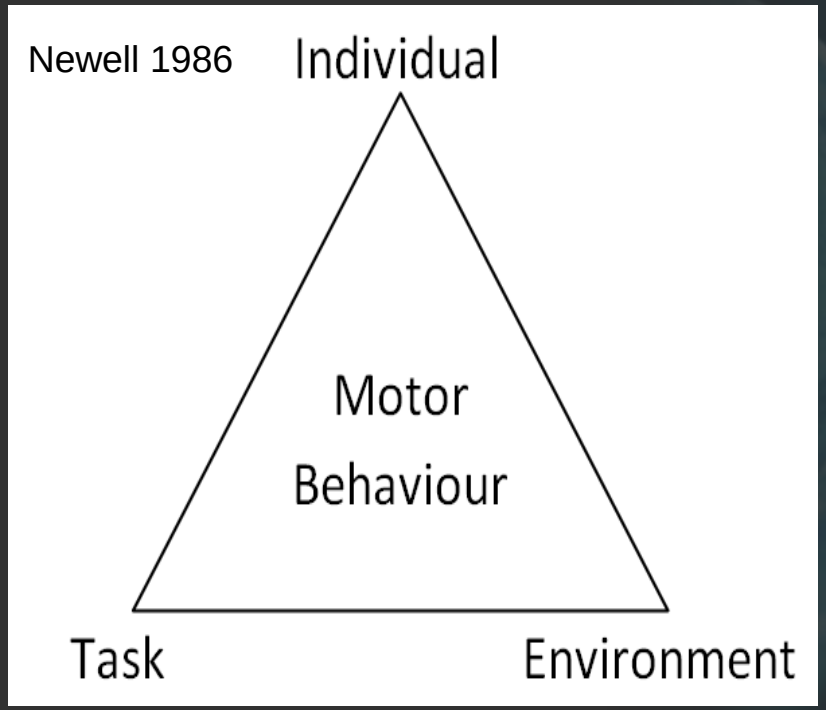
1. Strengthening of existing connections
2. Creation of new connections
3. Pruning of unused/less used connections

How is it happening? (Fitts 1964)

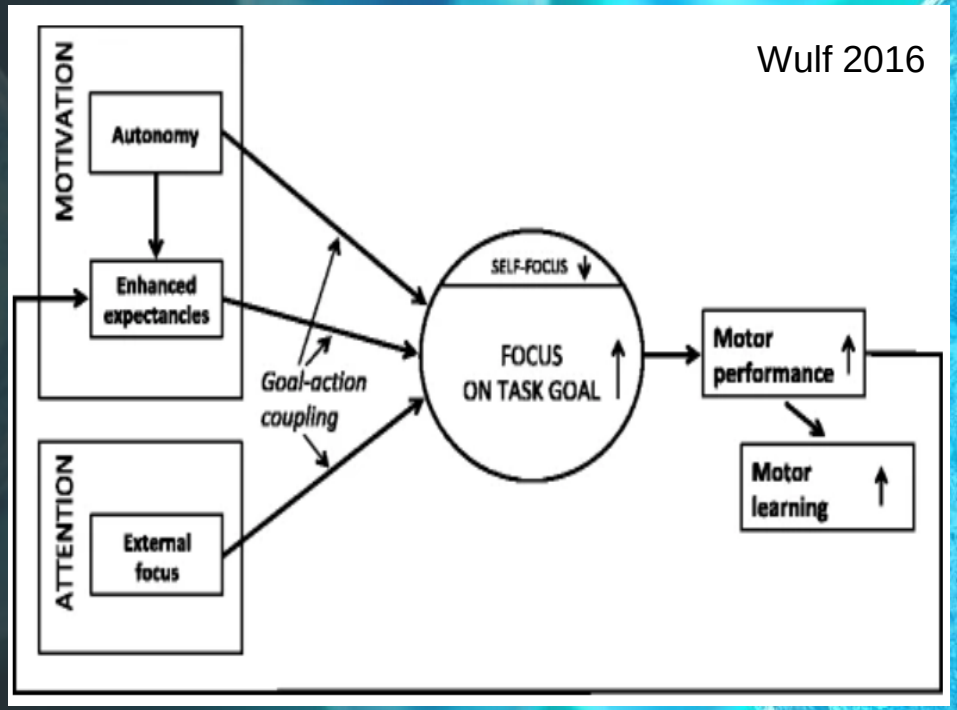
1. Cognitive phase
2. Associative phase
3. Autonomous phase

Theories behind…

Newell 1986



Wulf 2016



1. Practice

Massed vs. Distributed practice
Constant practice vs. Variable practice
Blocked vs. Random practice
Guidance vs. Discovery practice
Error-driven (enhanced) vs. Errorless learning
Whole practice vs. Part practice

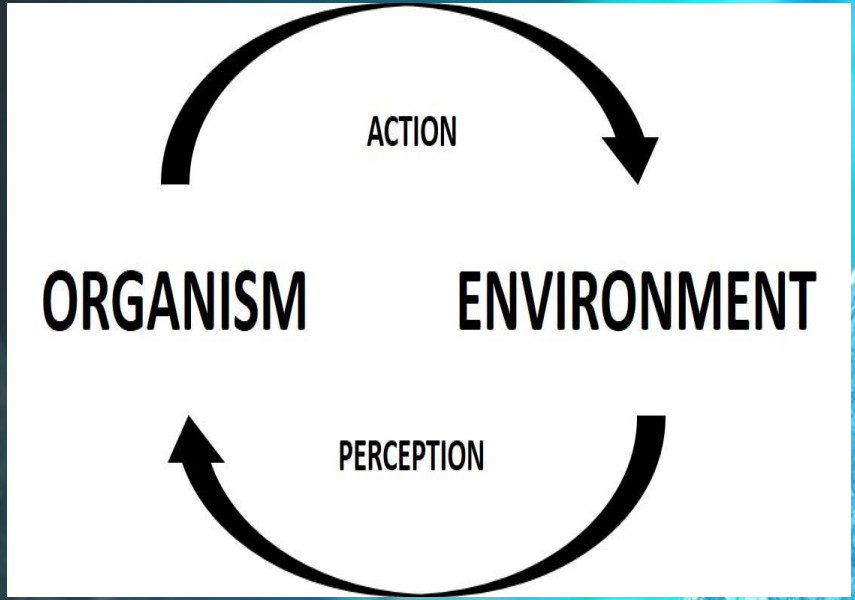
structure, repetitions, variability, and specificity

*FITT

2. Feedback

Knowledge of performance (quality of movement)
Knowledge of results (outcome of the movement)

frequency, mode, direction, bandwidth, source, and focus

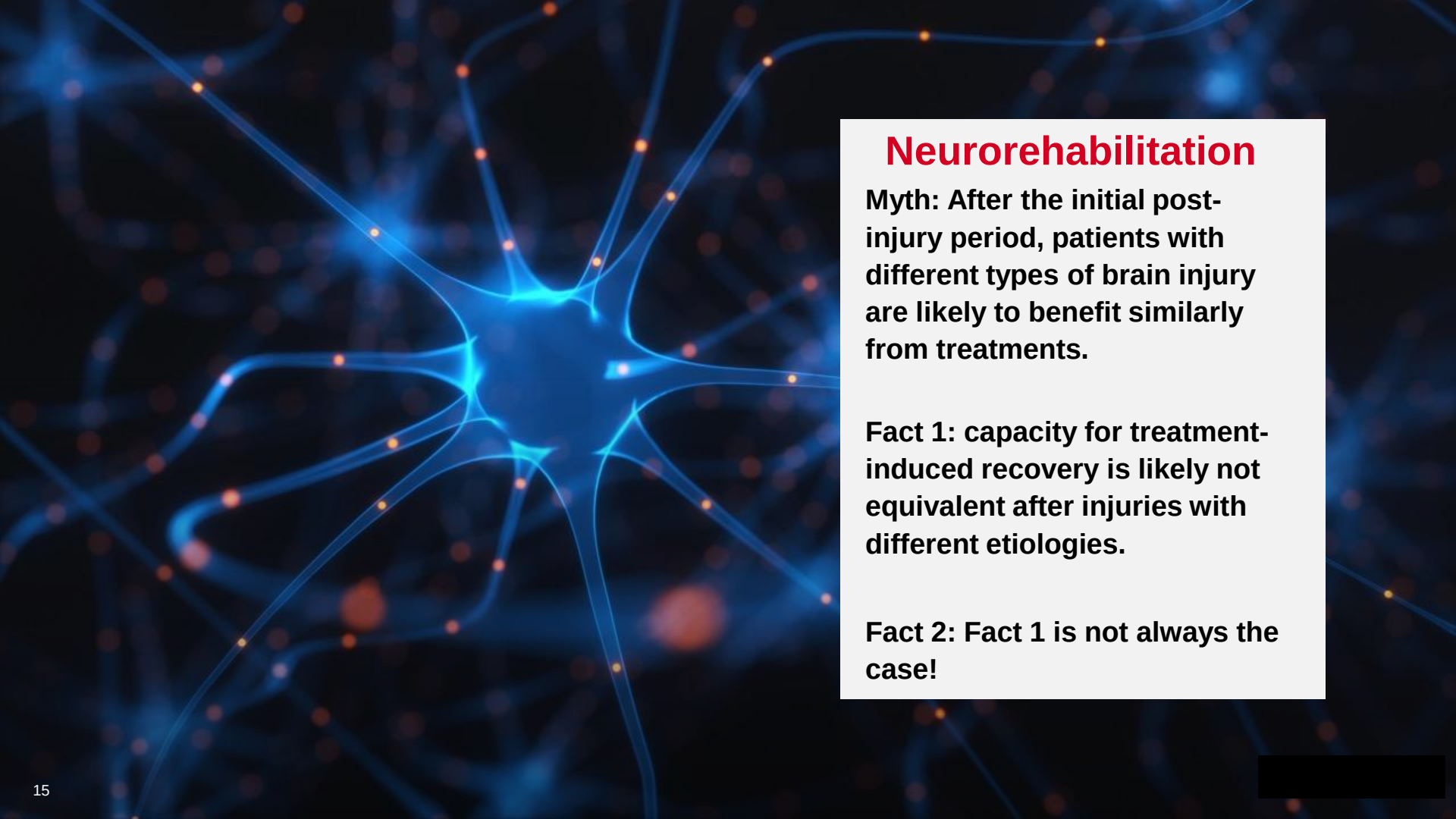


(not-so-secret) Ingredients of Neuroplasticity

1. Salience (Autonomy)
2. Intensity (Specificity)
3. Repetition (Habituation)
4. Variability (Dual tasking)
5. Practice (Overload)
6. Feedback (Motivation)
7. Time and Space
8. (Implicit) Learning via Distraction

Understanding normal Neuroplasticity gives us key to fixing broken brain

Brain Disorders



Neurorehabilitation

Myth: After the initial post-injury period, patients with different types of brain injury are likely to benefit similarly from treatments.

Fact 1: capacity for treatment-induced recovery is likely not equivalent after injuries with different etiologies.

Fact 2: Fact 1 is not always the case!

Stroke

Forced use/CIMT (Etoom et al 2016)

Bilateral function (Stewart et al 2006)

HIIT (Wiener et al 2019)

Graded motor imagery (Lopez et al 2019)

Robotic assistance (Kwakkel et al 2008)

Brain–computer interface (Cervera et al 2018)

Locomotor and BWSTT (Munari et al 2018)

Virtual Reality (Henderson et al 2007)

Parkinson’s Disease

HIIT (Hirsch et al 2003)

Dual Task Training (Li et al 2020)

Locomotor and BWSTT (Miyai et al 2000)

Virtual Reality (Sarraso et al 2021)

Art Therapy (Cucca et al 2021)

Error Augmentation

External Focus (Wulf et al 2009)

Distractions

Traumatic Brain Injury

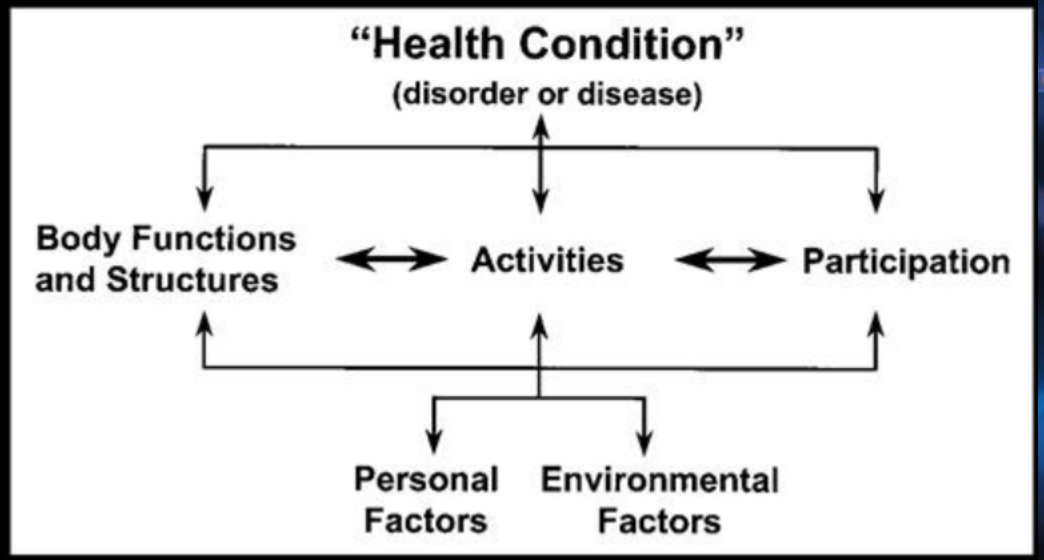
Somatosensory reweighting (Janicek 2021)

Habituation, Adaptation, and Substitution (Herdman 2013)

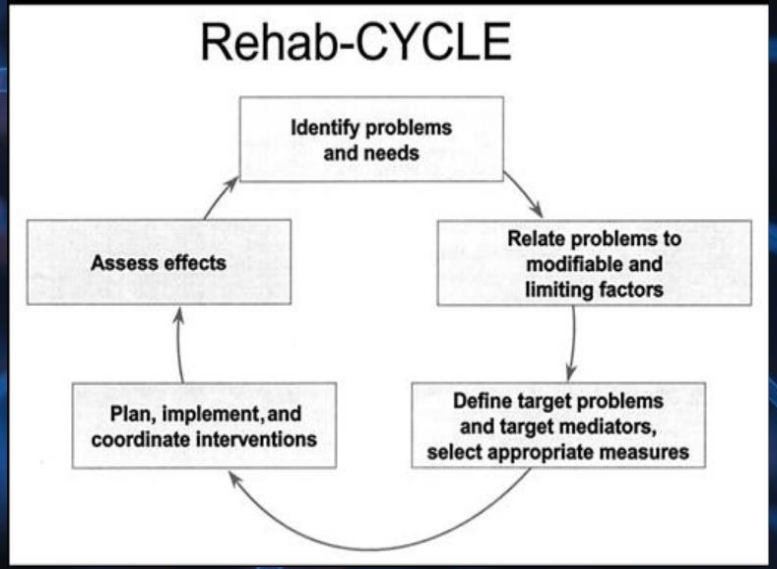
Attention (Waldron et al 2013)

Engagement (Knutti et al 2022)

ICF MODEL



World Health Organization, 2001



Steiner et al, 2002

What we did (the BEST we knew at that time)

Weight-bearing (closed chain) before non-weight-bearing (open chain)

Gross motor to fine motor

Isometric to eccentric to concentric

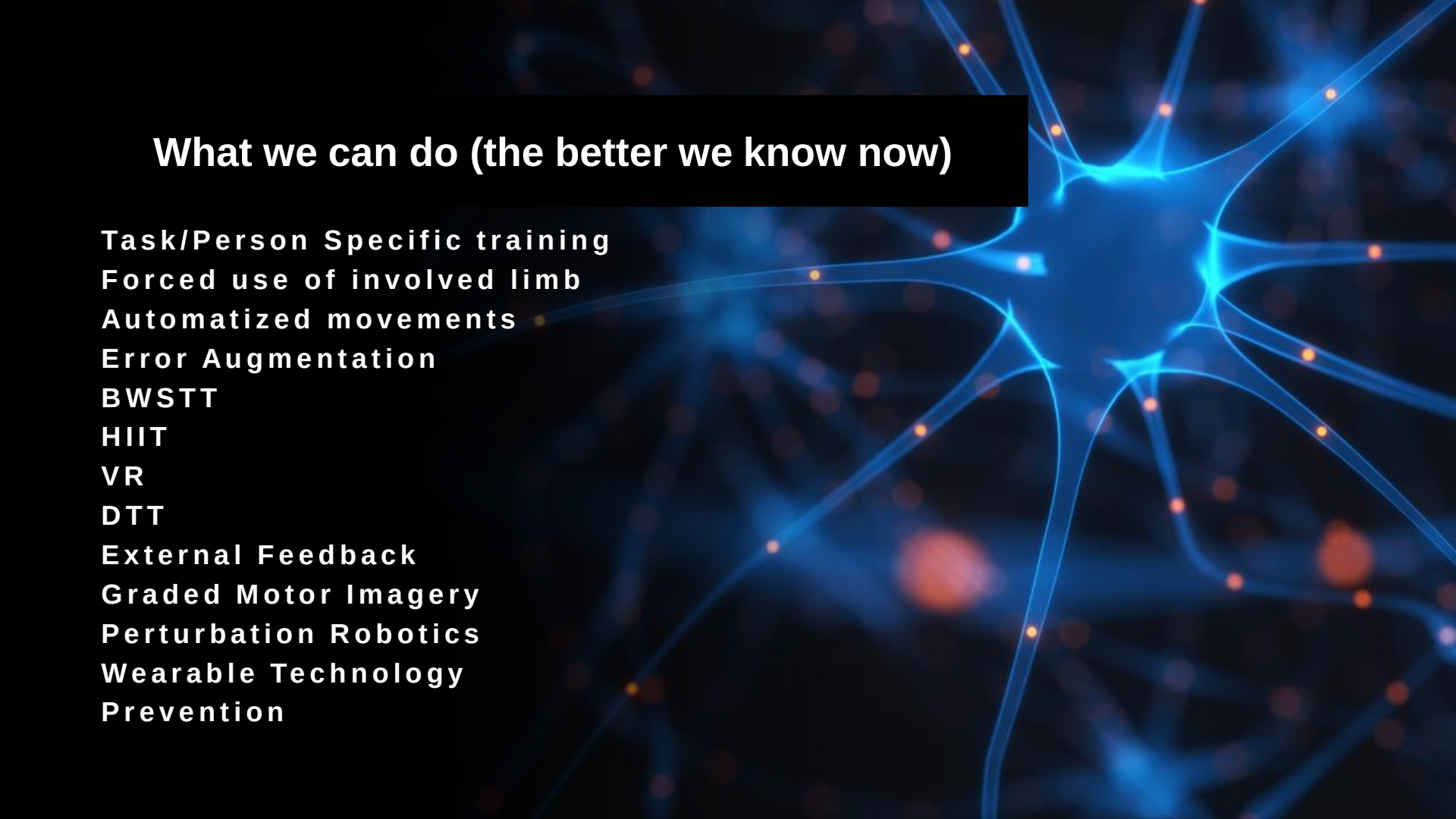
Short lever arm to long lever arm

Within synergy to combining synergies to isolated
Gravity assisted to gravity eliminated to antigravity
Cognitive to automatic/habitual

Open hand to grasp

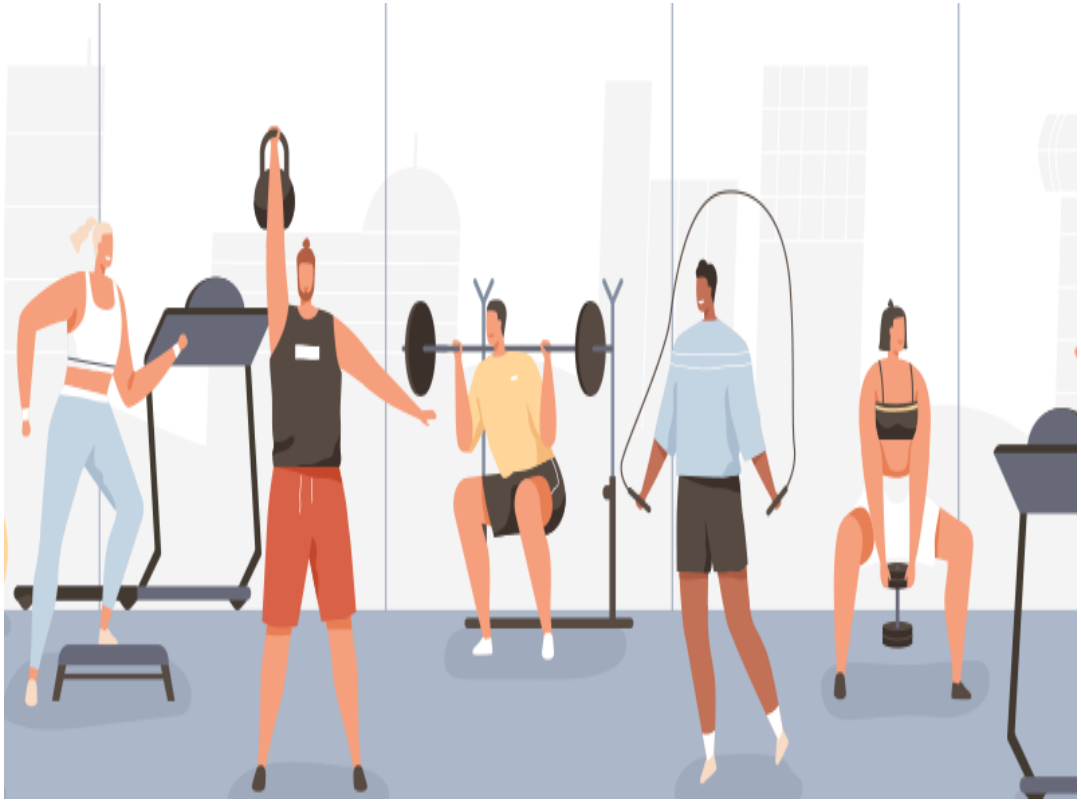
Mass grasp to pincer

Internal Feedback



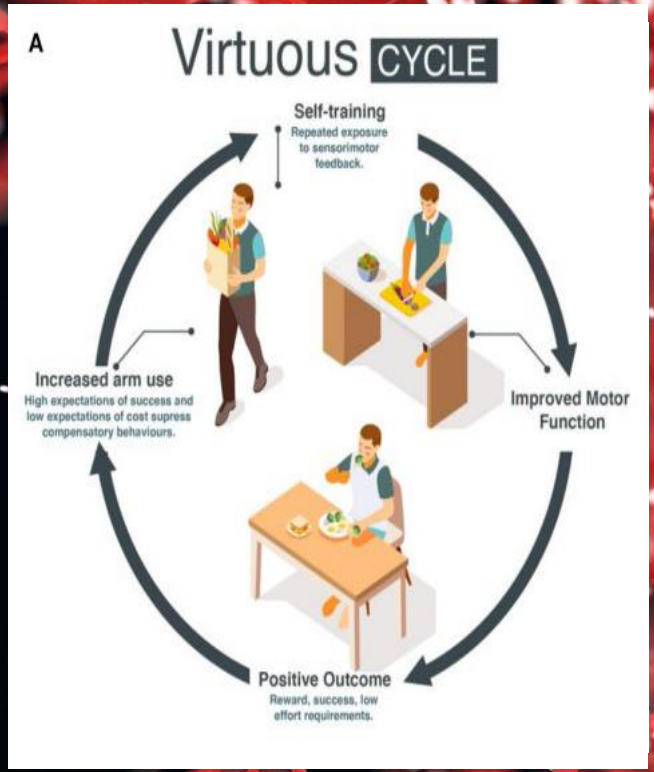
What we can do (the better we know now)

- Task/Person Specific training
- Forced use of involved limb
- Automatized movements
- Error Augmentation
- BWSTT
- HIIT
- VR
- DTT
- External Feedback
- Graded Motor Imagery
- Perturbation Robotics
- Wearable Technology
- Prevention



Harnessing Neuroplasticity for Accelerated Patient Recovery

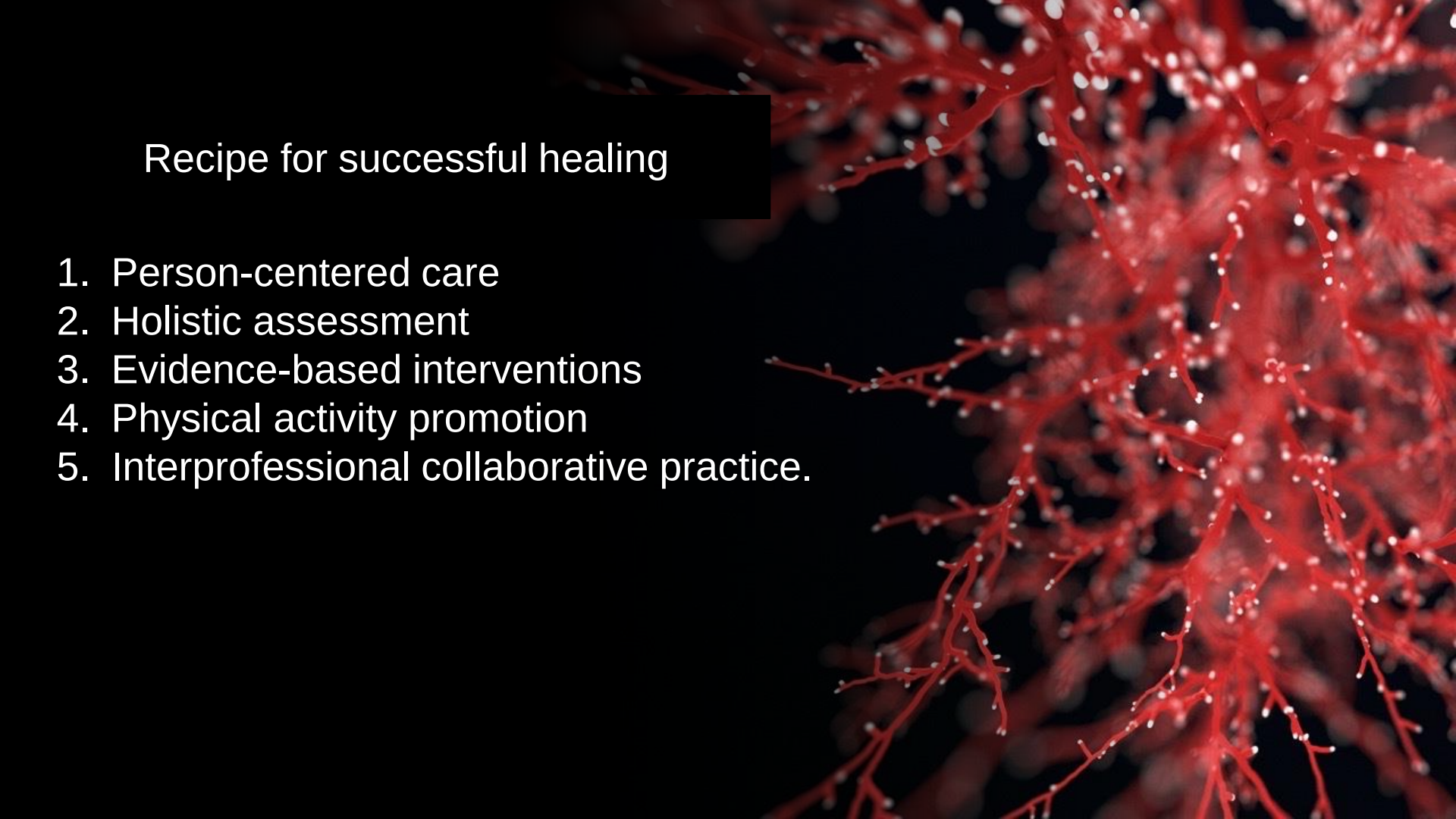
- How do we do it?

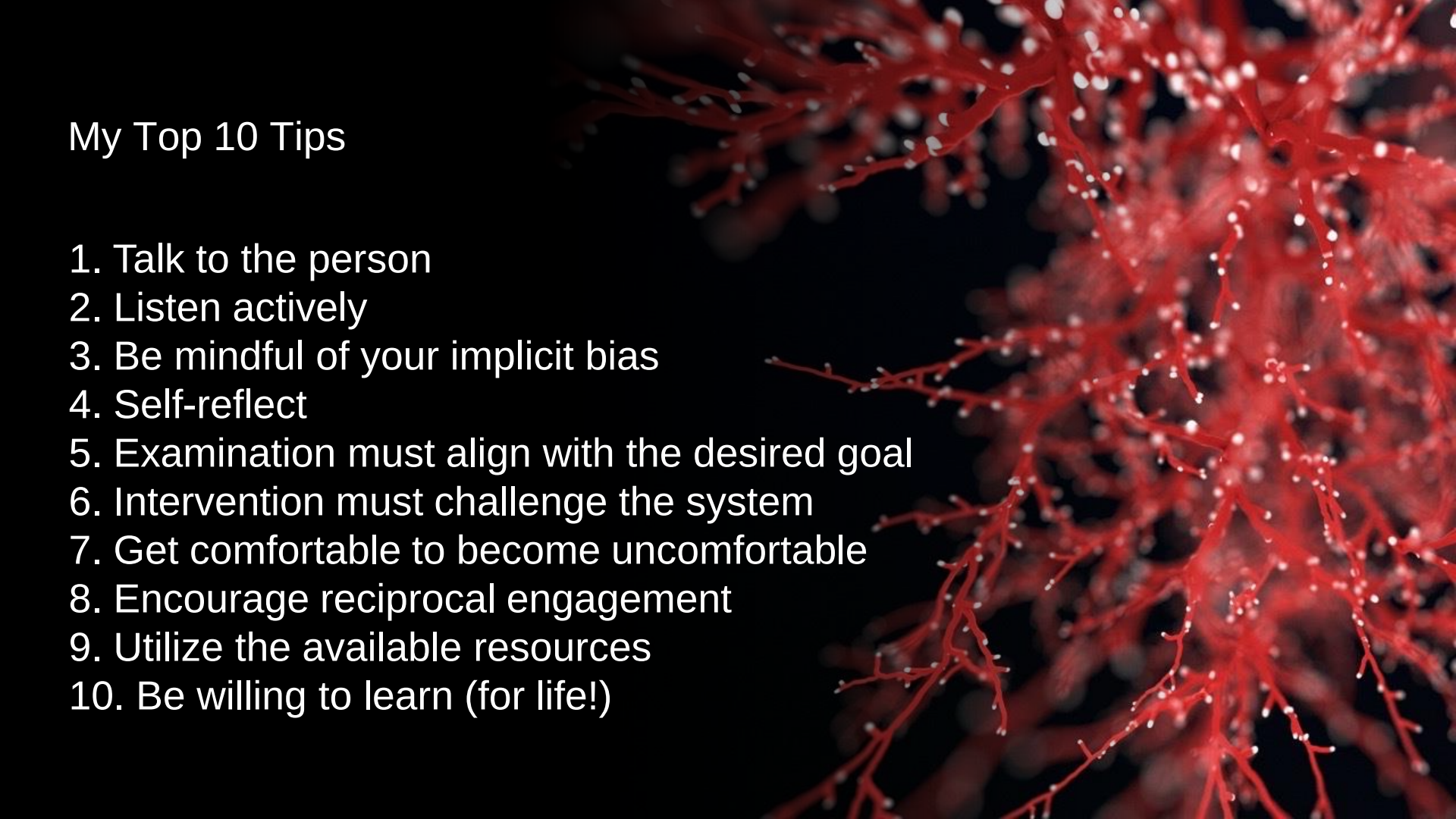


Ballester et al., 2022

Recipe for successful healing

1. Person-centered care
2. Holistic assessment
3. Evidence-based interventions
4. Physical activity promotion
5. Interprofessional collaborative practice.





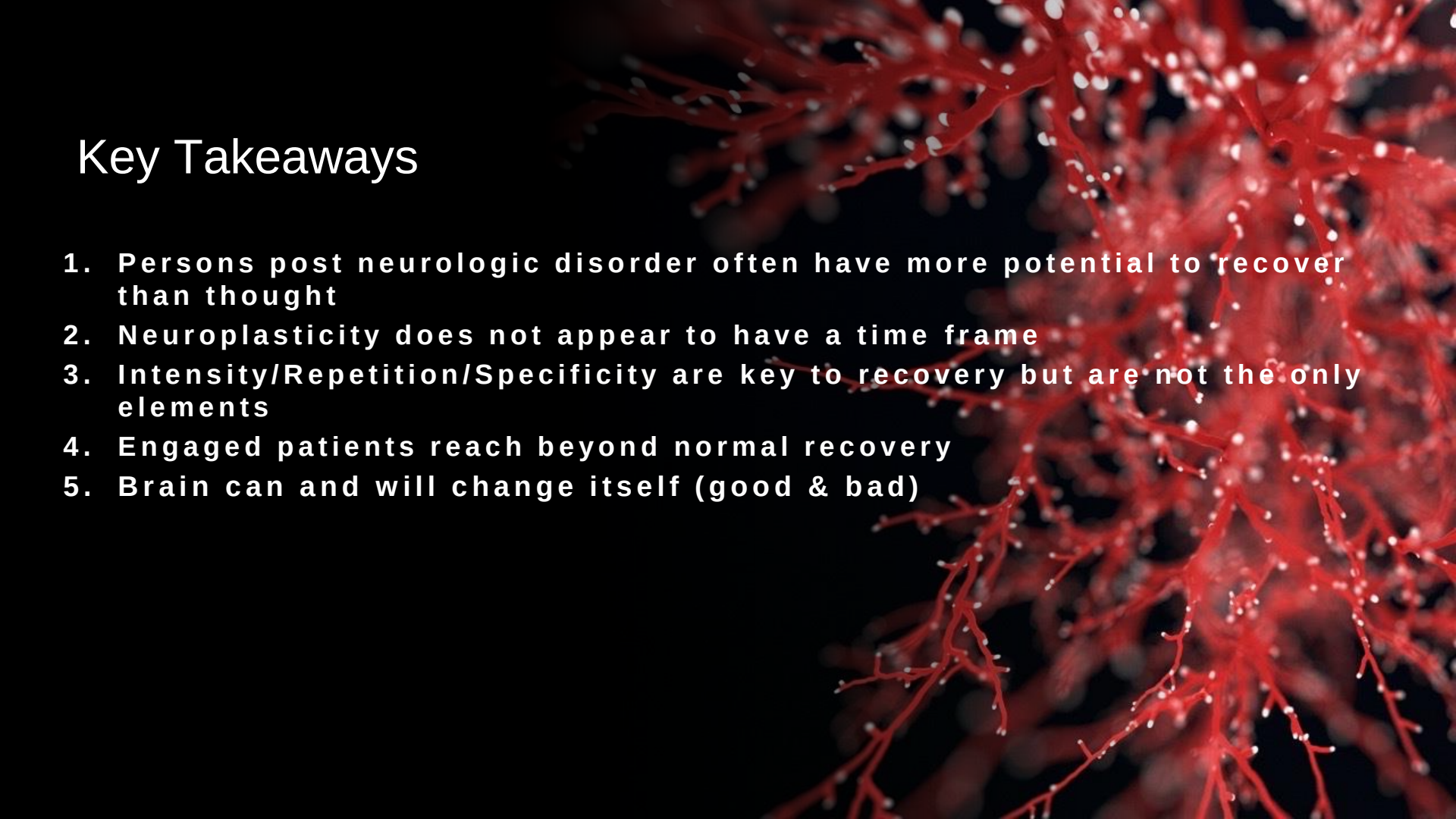
My Top 10 Tips

1. Talk to the person
2. Listen actively
3. Be mindful of your implicit bias
4. Self-reflect
5. Examination must align with the desired goal
6. Intervention must challenge the system
7. Get comfortable to become uncomfortable
8. Encourage reciprocal engagement
9. Utilize the available resources
10. Be willing to learn (for life!)

What is the most important skill humans possess?

Key Takeaways

1. Persons post neurologic disorder often have more potential to recover than thought
2. Neuroplasticity does not appear to have a time frame
3. Intensity/Repetition/Specificity are key to recovery but are not the only elements
4. Engaged patients reach beyond normal recovery
5. Brain can and will change itself (good & bad)



Useful Resources

PubMed

MEDBRIDGE

APTA Geriatrics
An Academy of the American Physical Therapy Association

PTJ

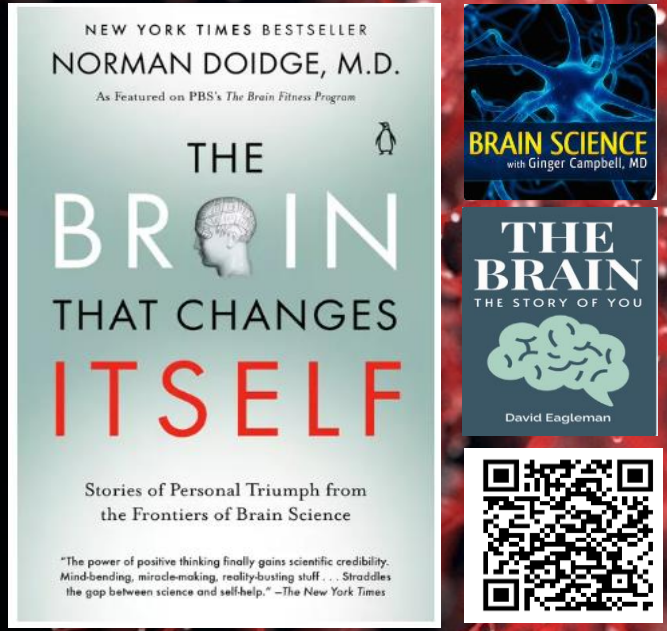
SfN Society for Neuroscience

re+active

ACADEMY OF NEUROLOGIC PHYSICAL THERAPY

APTA American Physical Therapy Association

CDC



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