PHYSIOTHERAPY: PRINCIPLES AND TRANSLATION TO BALANCE REHABILITATION

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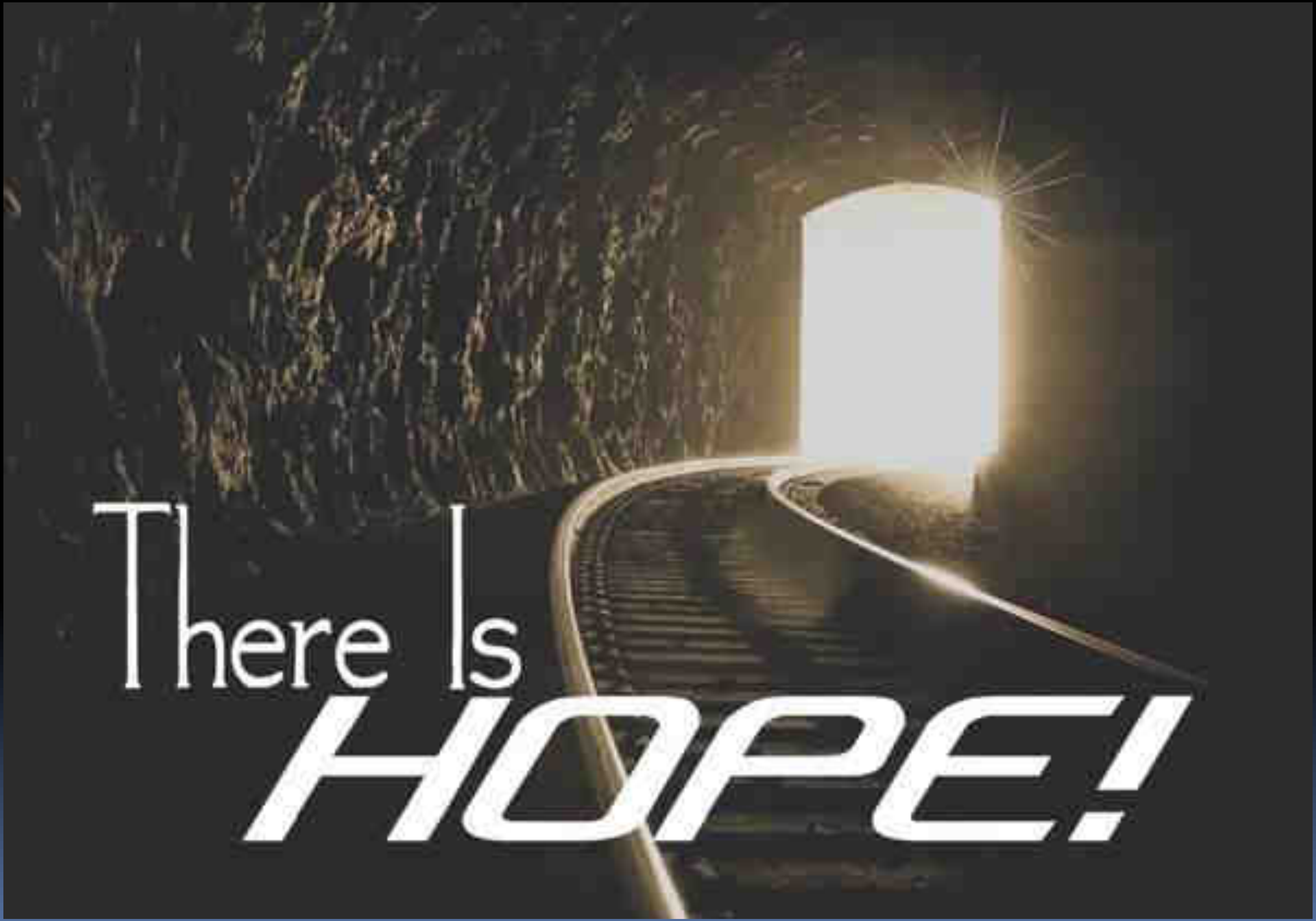
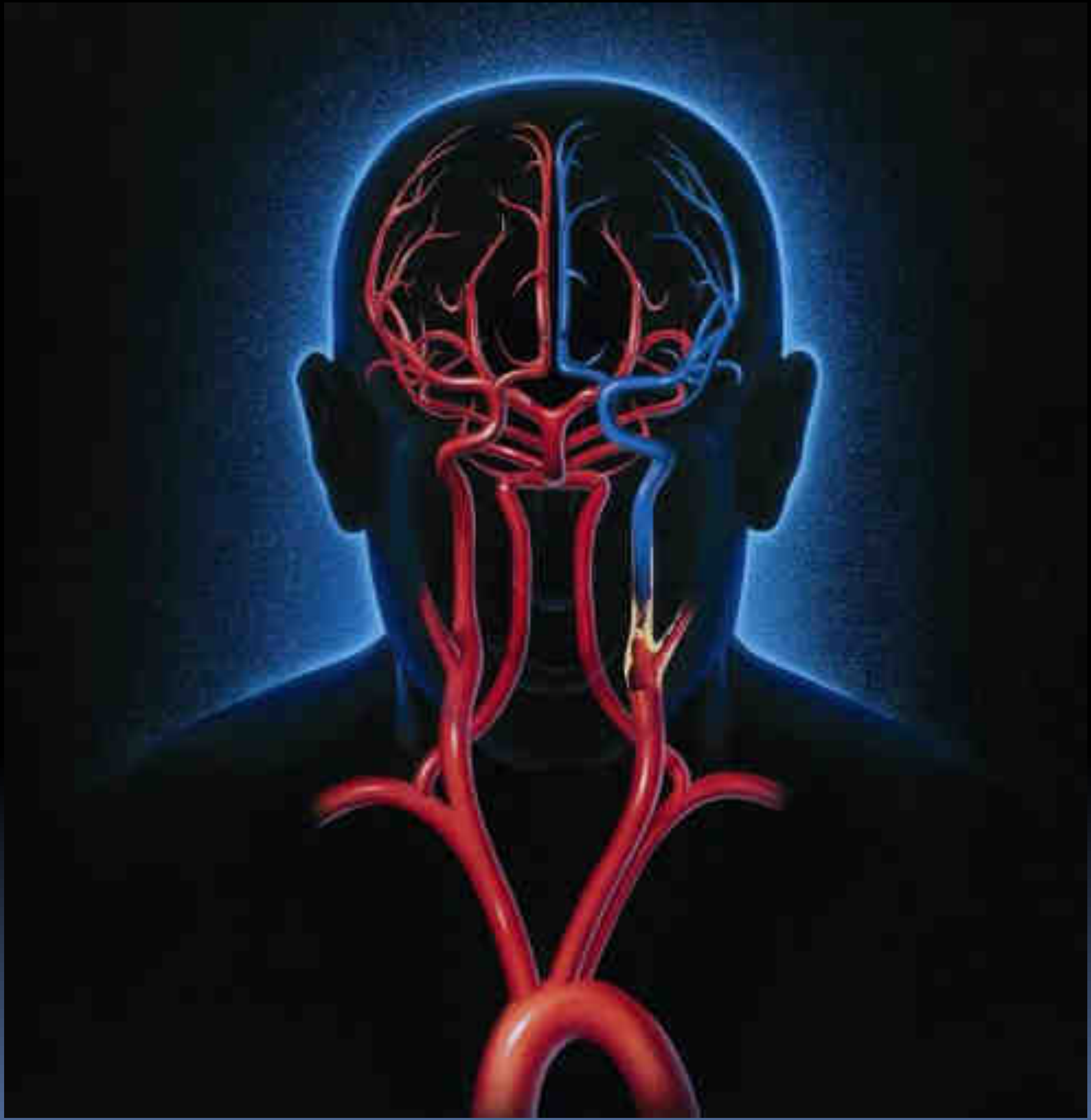

There Is
HOPE!

POST STROKE RECOVERY – THE MODEL



Stroke Recovery

- 15% die shortly after the stroke
- 10% of stroke survivors recover almost completely
- 25% recover with minor impairments
- 40% experience moderate to severe impairments requiring special care
- 10% require care within either a skilled-care or other long-term care facility

75% of Stroke survivors need help

Stroke Recovery with Rehabilitation

- 80% Independent mobility
- 70% Independent personal care
- 40% can go outside home
- **30% can return to work**

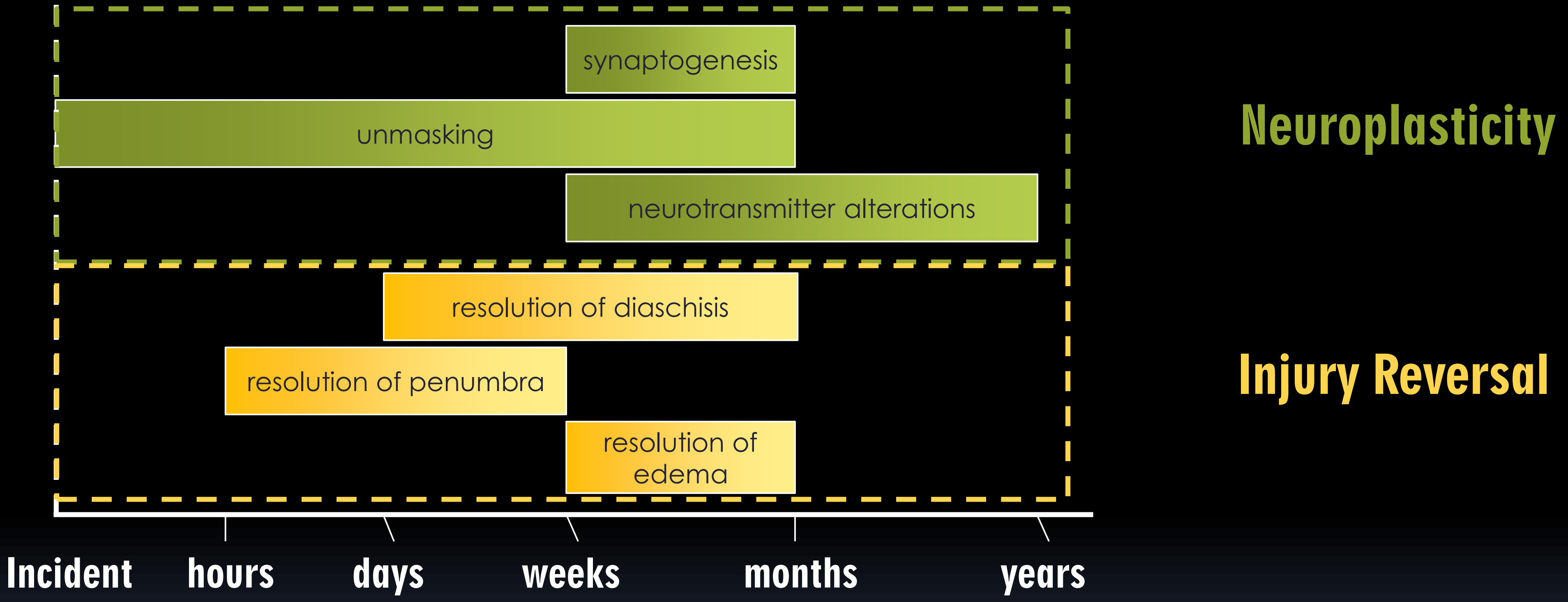
NEUROREHABILITATION IN STROKE

Neurorehabilitation = Brain Repair

"Stroke rehabilitation is a progressive, dynamic, goal orientated process aimed at enabling a person with an impairment to reach their optimal physical, cognitive, emotional, communicative and/or social functional level"

NEUROPLASTICITY IN NEUROREHABILITATION

Mechanisms of Recovery

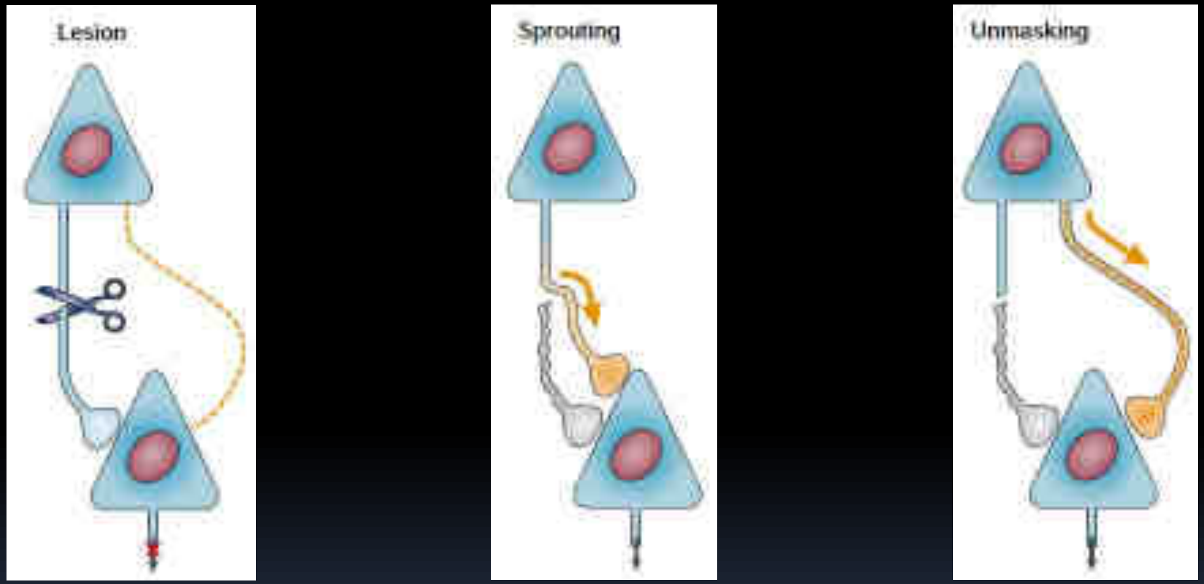


! Recovery is a combination of reversal of injury related factors (edema, diaschisis) and neuroplasticity.

Neuroplasticity

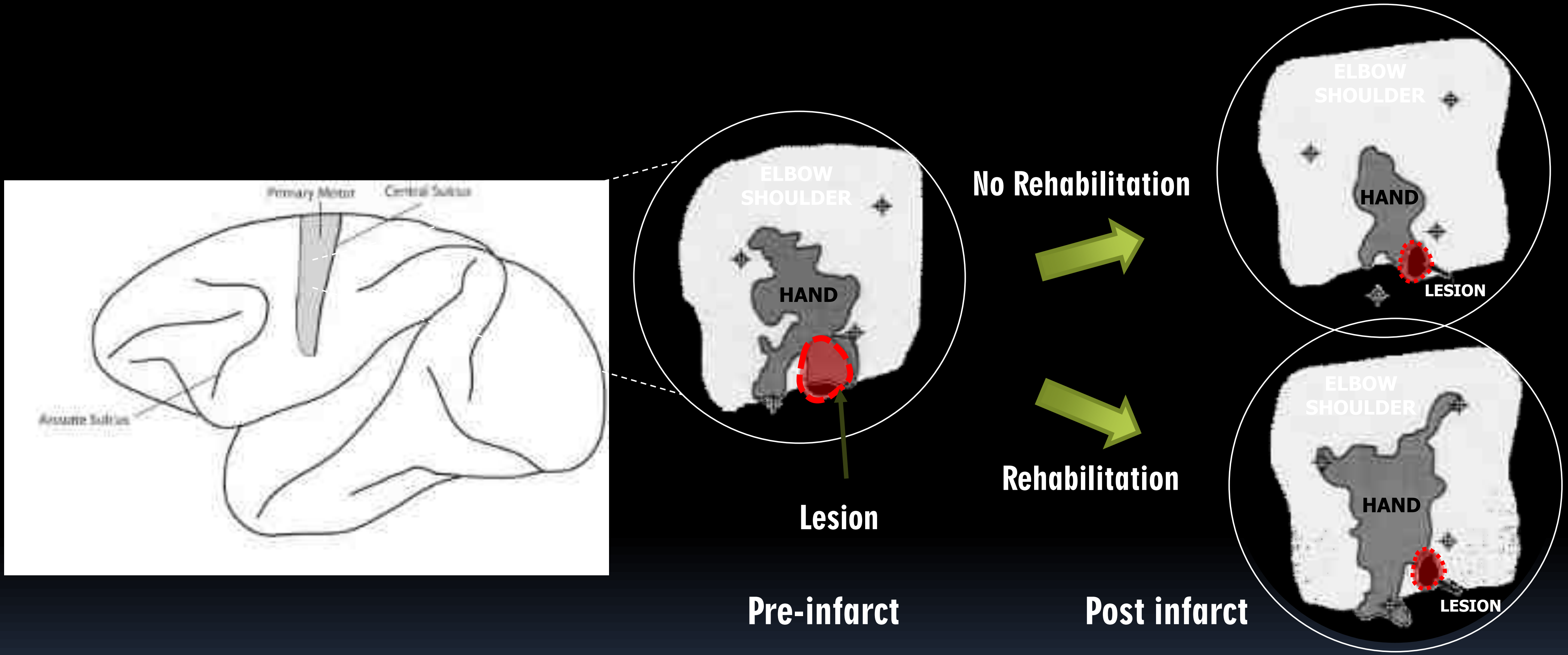
The ability of the nervous system to respond to intrinsic or extrinsic stimuli by reorganizing its structure, function and connections.

Harnessing neuroplasticity for clinical applications, Cramer et al. 2011



! Neuroplasticity is the modification of the nervous system on a cellular and behavioral level. It is triggered by injury or activity/training.

Activity-Induced Neuroplasticity



! Active training enhances neuroplasticity and results in reorganization of cortical maps.

- Functional restoration relies upon the ability of spared neurons to compensate for lost function by growing neurites and forming new synapses to rebuild and remodel the injured networks
- Achieved in traditional rehabilitation strategies by targeted training of the weakened function

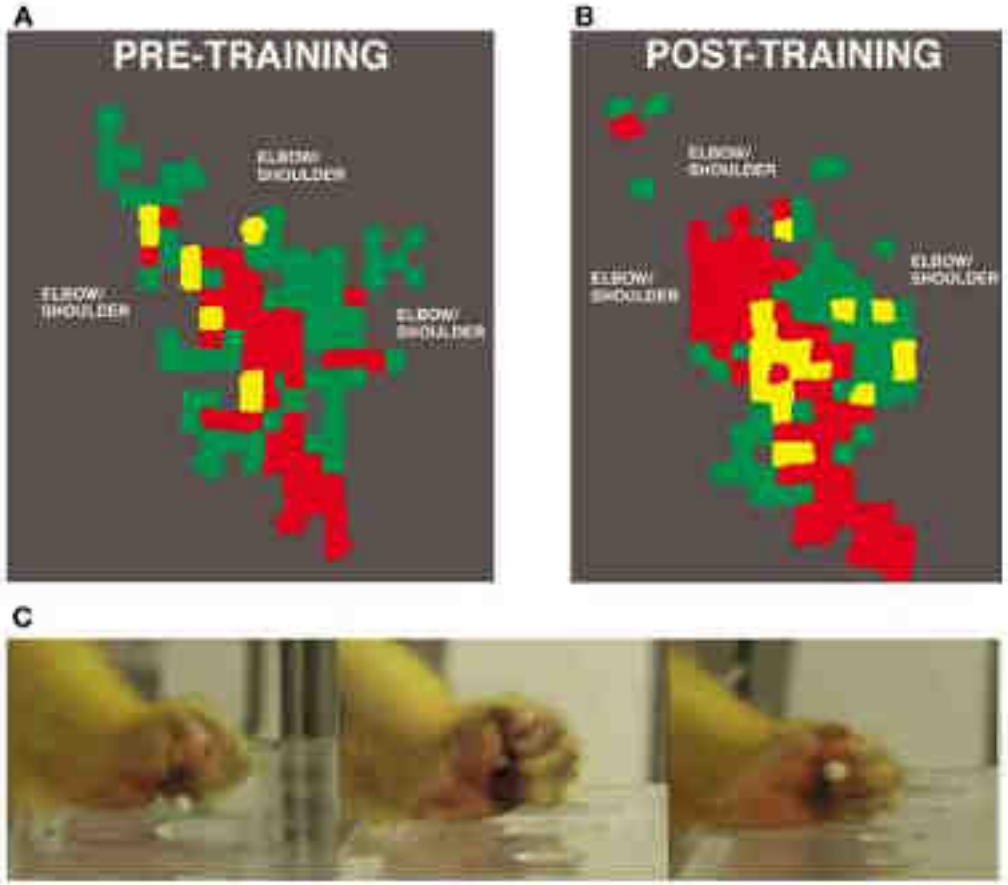


FIGURE 2 | Representation of distal forelimb representations in motor cortex after digit skill training as defined by intracortical microstimulation. Digit areas (red) expand after only 12 days of training. Combination movements that reflect the individual kinematics that the monkey employs also expand their representations. **(A)** Pre-training map. **(B)** Post-training map. **(C)** Still images of squirrel monkey retrieving food pellets from small wells (Nudo et al., 1996a).

Nudo 2013

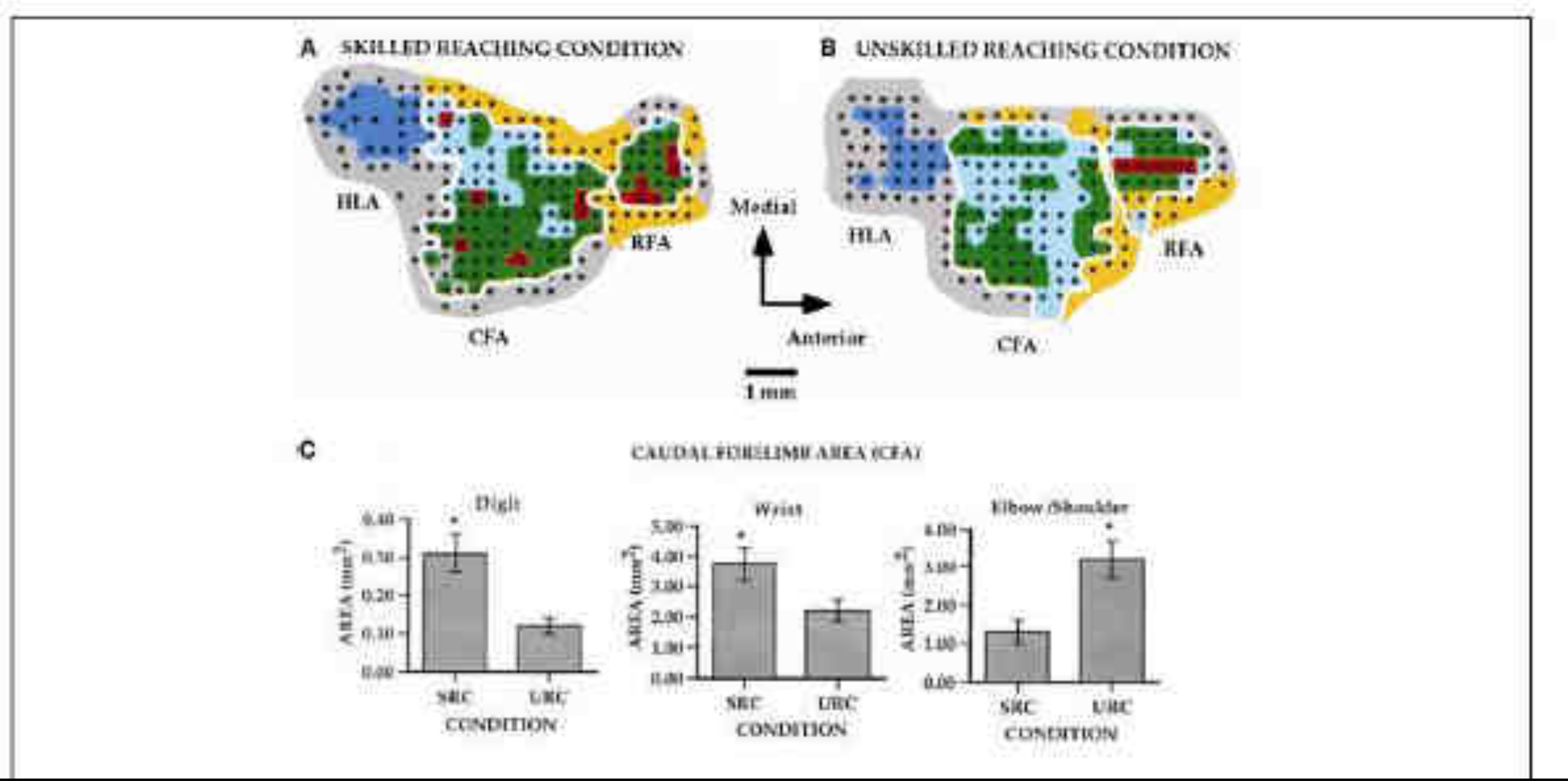


FIGURE 3 | Differential affects of skill vs. use. **(A)** ICMS-derived motor map (digit, red; wrist, green; elbow/shoulder, light blue) of a rat that learned a skilled reaching movement. **(B)** ICMS-derived motor map of a rat that learned to press a bar. The two forelimb areas are outlined in white. The caudal forelimb area (CFA) is separated from the rostral forelimb area (RFA) by a band of head/neck representations (yellow). The hindlimb area (HLA) is shown in dark blue and nonresponsive sites in gray. **(C)** Note the enlarged digit and wrist/forearm representations in the skilled reaching condition (SRC), and enlarged should representation in the unskilled reaching condition (URC, bar press). **(D)** In the CFA, synapses per neuron were significantly increased ($*p < 0.05$), but no changes occured in RFA or HLA (Kleim et al., 2002a).

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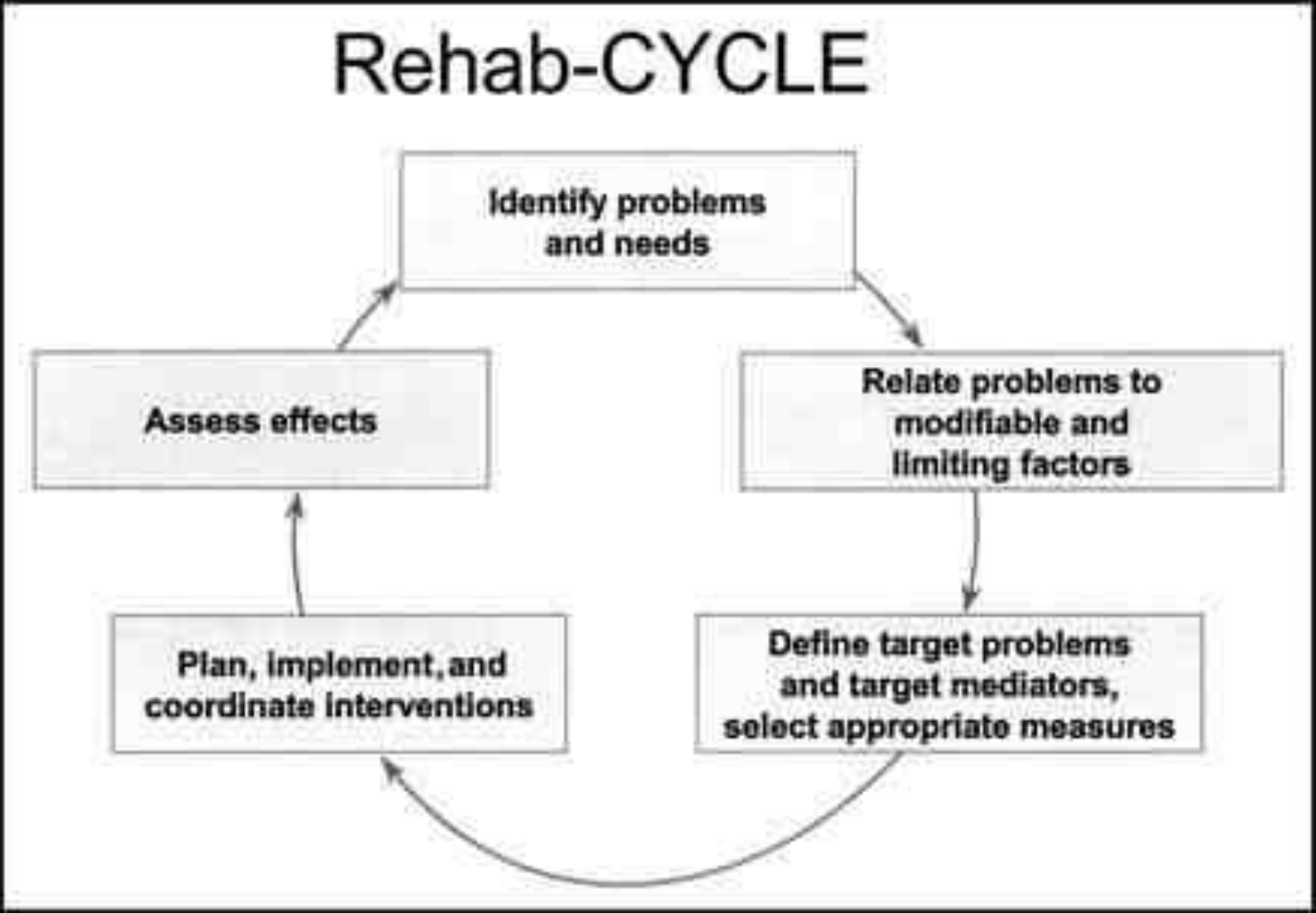
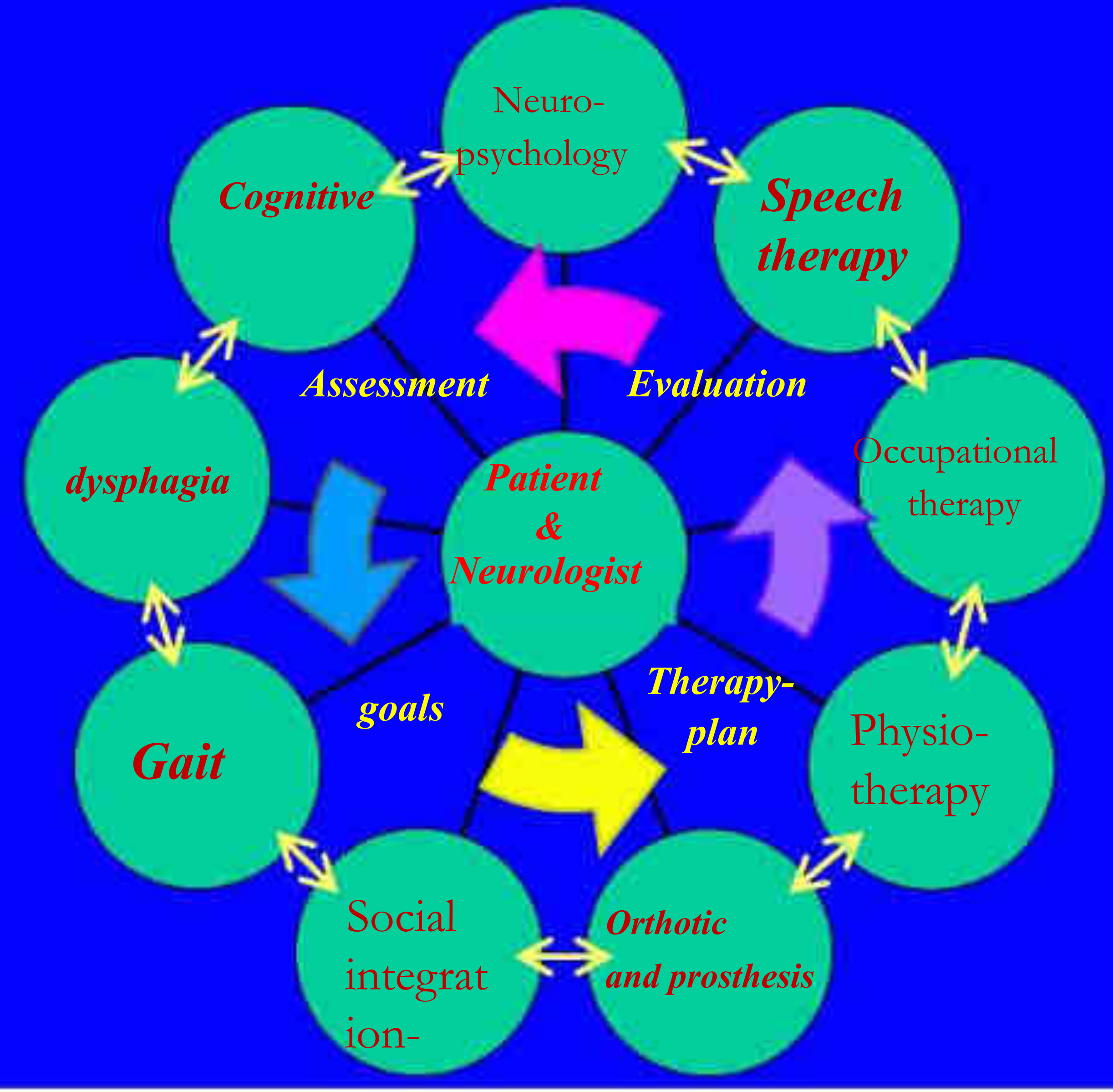
APPLYING THE PRINCIPLES TO PRACTICE


Rehab-CYCLE
Identify problems and needs
Relate problems to modifiable and limiting factors
Define target problems and target mediators, select appropriate measures
Plan, implement, and coordinate interventions
Assess effects

Neurorehabilitation



Key Factors for Recovery

Intensity

- Repetitions
- Duration
- Distribution / Frequency
- Effort
- Difficulty

Psychological Factors

- Motivation

Manner

- Task segmentation
- Specificity / Functionality
- Variability
- Initiation
- Shaping

Information

- Instructions
- Feedback

! Neuroplasticity and learning can be driven by several key factors taken from motor learning theory.

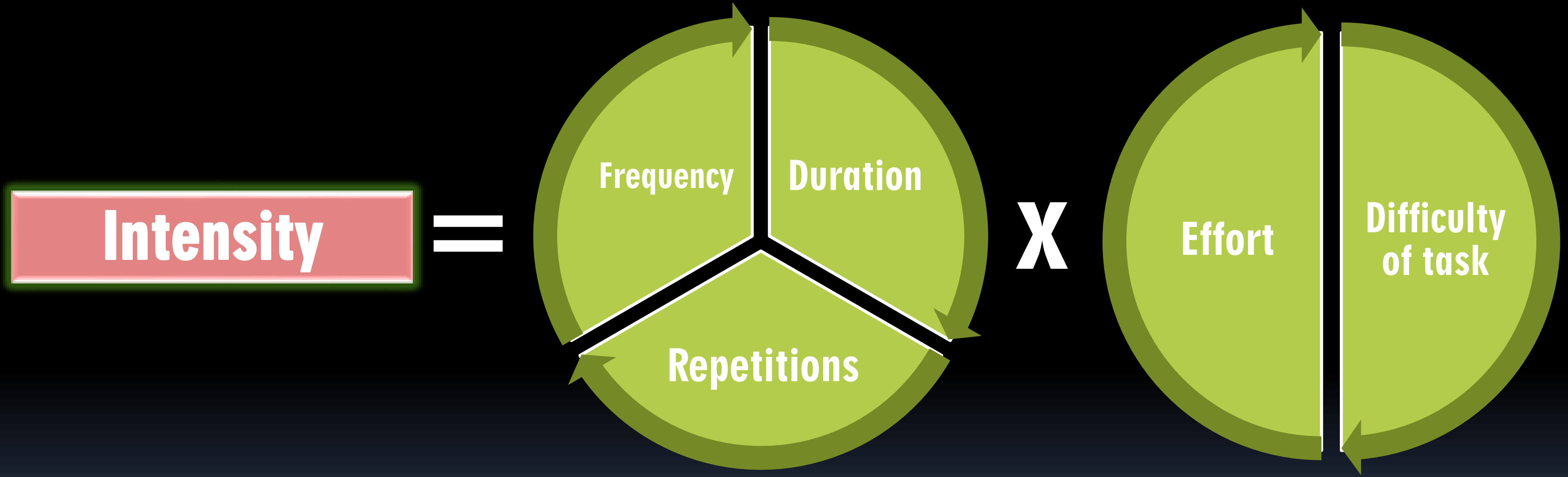
Intensity: Overview

Intensity

- **Repetitions** — *Repeated performance of a movement/task*
- **Duration** — *Time of a single therapy session or entire therapy*
- **Distribution / Frequency** — *Amount of rests between repetitions or therapy sessions*
- **Effort** — *Active participation of the patient (physical and mental)*
- **Difficulty** — *Level of challenge during therapy sessions*

! Therapy needs to be intensive, active and challenging for optimal recovery to take place.

Intensity: Overview



PHYSIOTHERAPY

Moving your Body – Exercise Therapy

- Neurodevelopmental techniques (NDT) by Bobath stresses exercises that tend to **normalize muscle tone** and prevent excessive spasticity through special reflex-inhibiting postures & movements
- Rood- involves **superficial cutaneous stimulation** using stroking, brushing, tapping & icing or vibration to evoke voluntary muscle activation
- Brunnstrom- emphasized synergistic patterns* of movement that develop during recovery from hemiplegia. Encouraged the development of **flexor & extensor synergies** during early recovery, hoping that synergistic activation of muscle would, with training, transition into voluntary activation.

  * *synergy-a whole series of muscles are recruited when just a few are needed*
- Kabat's Proprioceptive Neuromuscular Facilitation (PNF)-Relies on **quick stretching and manual resistance** of muscle activation of the limbs in functional direction, which are often **spiral and diagonal**

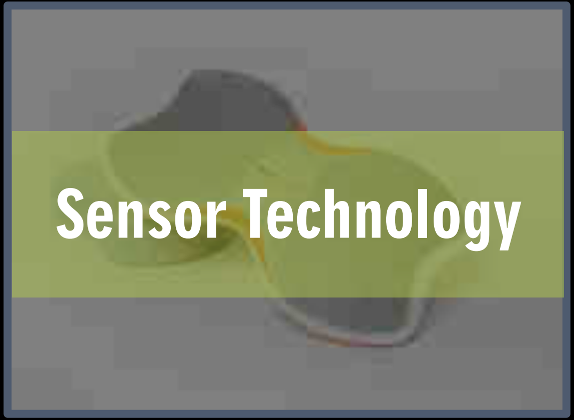
New Technologies

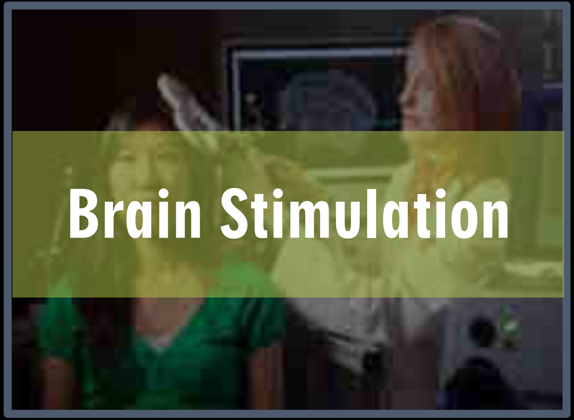
«Application of robotic devices to assist, enhance and intensify therapy.»

«Use of non-actuated devices (no motors) such as body weight support systems to facilitate rehabilitation.»

«Application of electrical stimulation to create functional movements and improve recovery.»

New Technologies





«Use of virtual reality and environments for enhancing movement therapy.»

«Use of sensors (motion, force etc.) for assessing and enhancing therapy.»

«Application of electrical stimulation to the brain for enhancing recovery.»

PERIPHERAL STIMULATION

FES: Odstock Dropped-Foot Stimulator (ODFS)

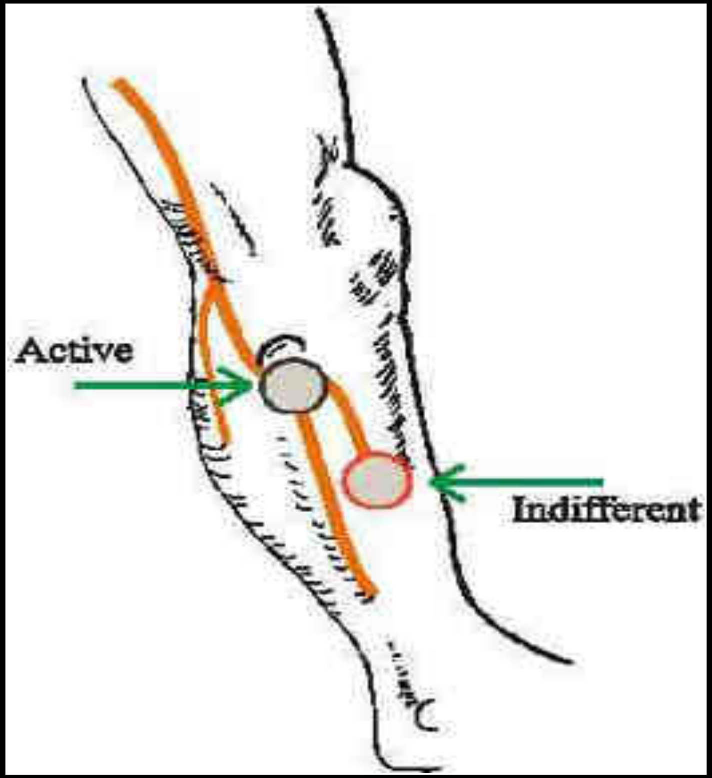


Figure courtesy of Salisbury District Hospital
http://fescenter.case.edu/Start_Here/Patients/
Stroke/stroke_programs.htm

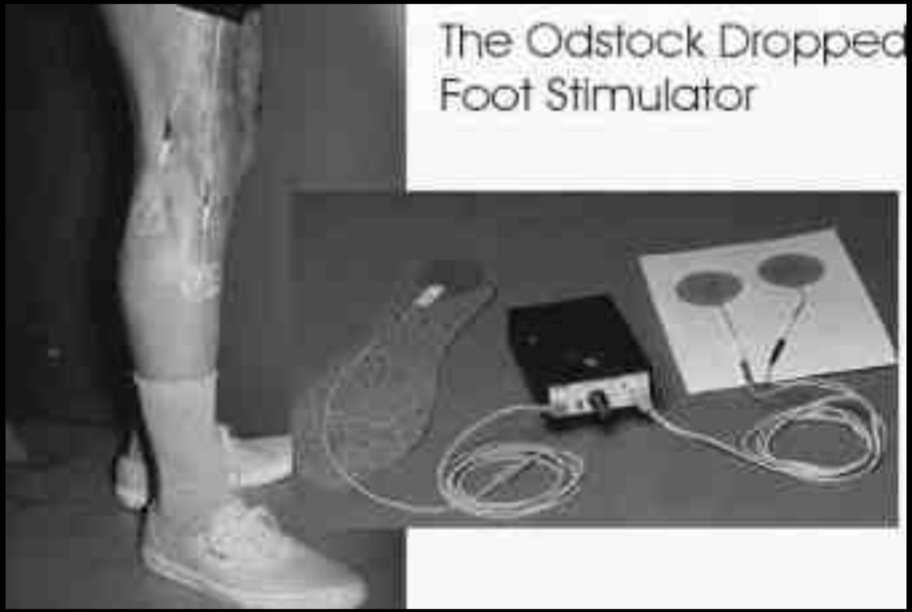
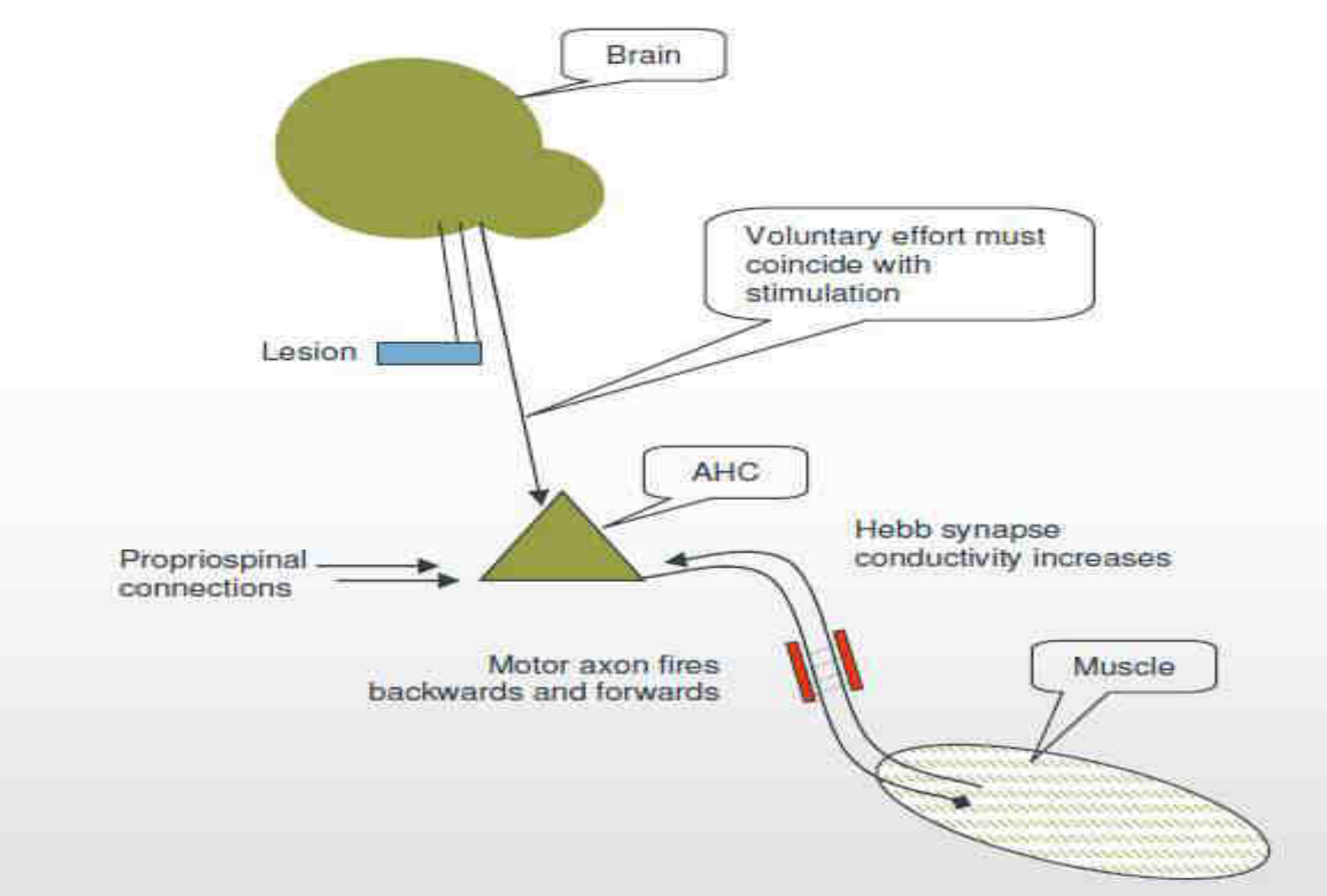


Figure from: www.salisburyfes.com/ infoms.htm

Sensori-motor integration



Functional Electrical Stimulation (FES)

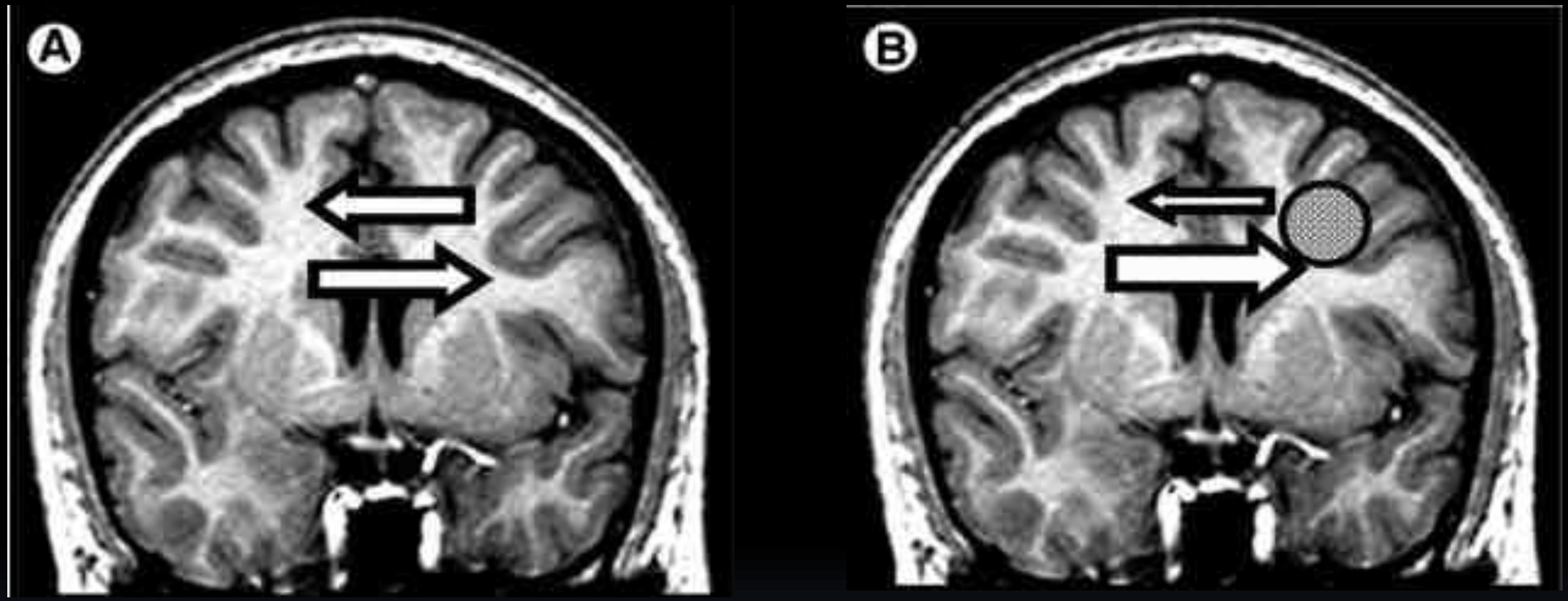
- Active muscle contraction
- Computer or therapist sequenced activation
- Produces functional movement

(FES Resource Guide, 2004)

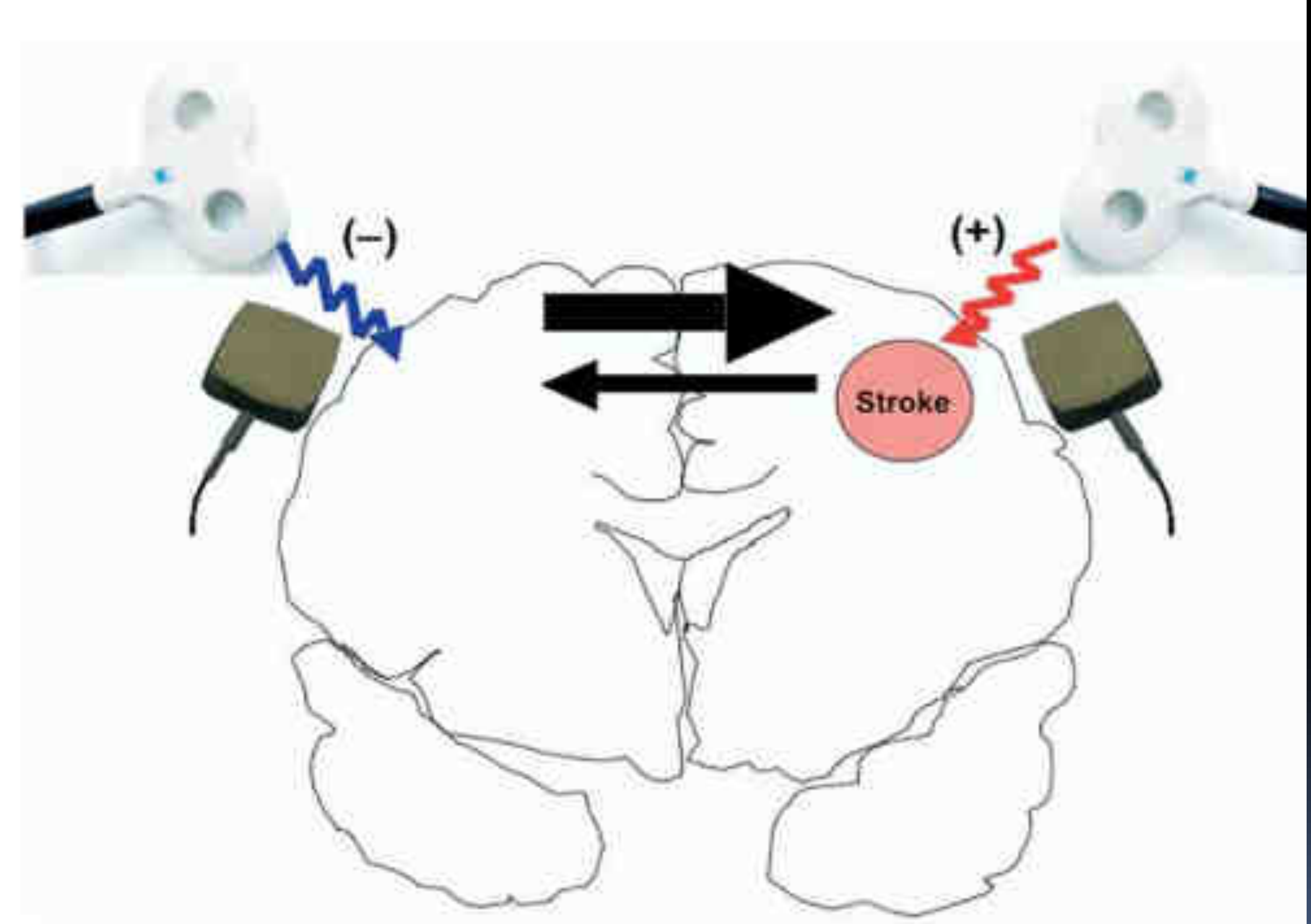
- Benefits
- Enhance walking abilities,
- Increases gait speed while lowering effort

BRAIN STIMULATION

Interhemispheric rivalry



How to utilize it



TMS

tDCS

OCCUPATIONAL THERAPY

Getting you back to work

CONSTRAINT INDUCED MOVEMENT THERAPY (CIMT)

1. Constraint 2. Repetitive Practice 3. Transfer Package

MIRROR THERAPY

Moves on verbal command - “shaping”

Improves bilateral coupling – Michielson 2010

Photo: Courtesy Dr Jack Tsao; VA, Bethesda, MD

CROSSING OVER:
VESTIBULAR REHABILITATION THERAPY

GOALS

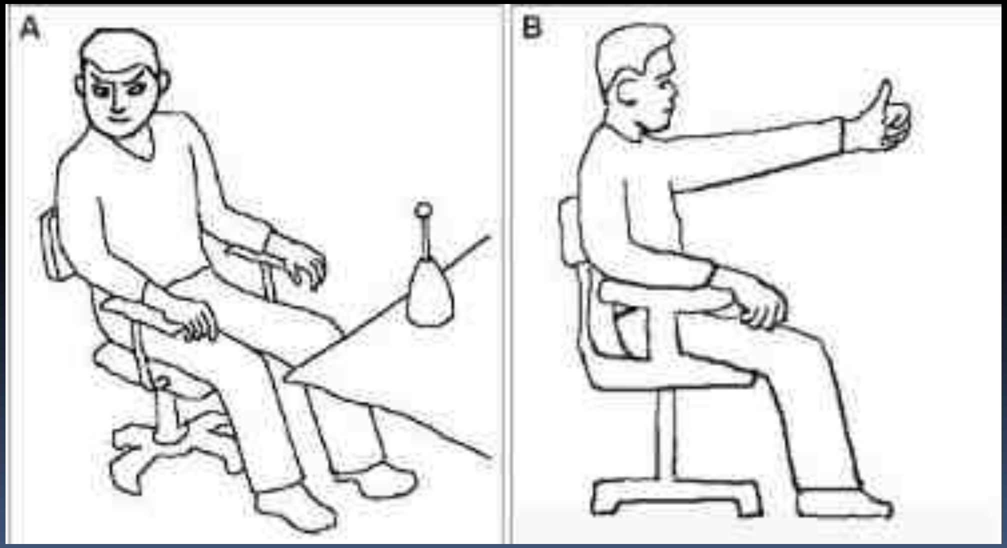
- 1) Enhancing gaze stability
- 2) Enhancing postural stability
- 3) Improving vertigo
- 4) Improving daily living activities

VESTIBULAR ADAPTATION

- Progressively increase the gain of the vestibular response
- Best Stimulus – Retinal Slip I motion of image during head movement
- Tips – Variable range

and frequency, Progressive

- OKN
- Training VOR suppression



SUBSTITUTION BY OTHER EYE-MOVEMENT SYSTEMS

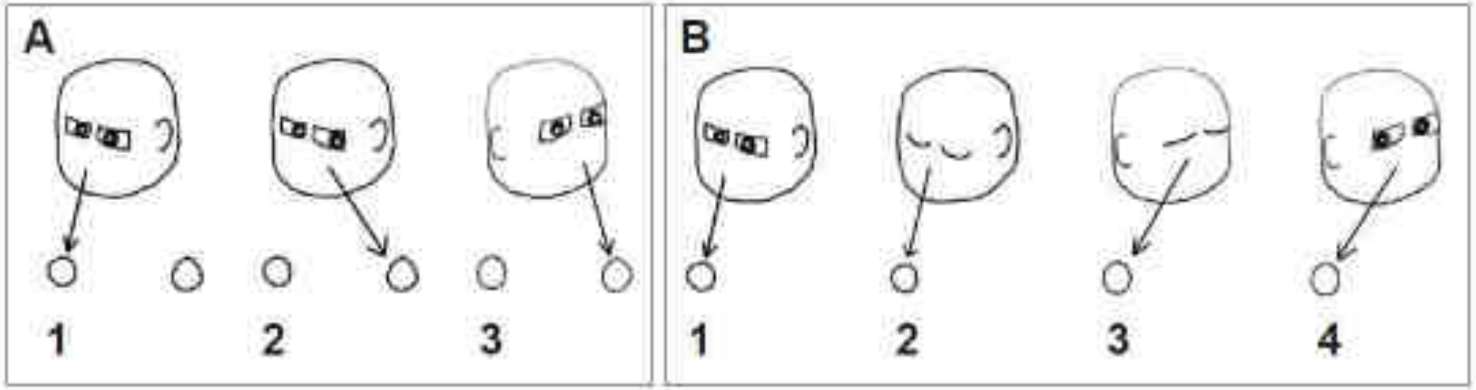


Fig. 2. Exercises for enhancing eye movements. A: Exercise for saccade and vestibulo-ocular reflex: 1, look directly at a target, ensuring that your head is aligned with the target; 2, look at the other target; and 3, turn your head to the other target. B: Exercise for imagery pursuit: 1, look directly at a target, ensuring that your head is aligned with the target; 2, close your eyes; 3, slowly turn your head away from the target while imagining that you are still looking directly at the target; and 4, open your eyes and check to see whether you have been able to keep your eyes on the target; if not, adjust your gaze on the target.

CENTRAL PREPROGRAMMING

- Central preprogramming is more effective for maintaining gaze stability as eye movements occur before head movement

- Eye Blinking
- Cervico-Ocular Reflex (COR)

ENHANCING POSTURAL STABILITY

- Substitution - increasing reliance on the visual and somatosensory cues
- Adaptation - improving the vestibular responses
- Recovery of normal postural strategies is required in patients with temporary deficits
- Compensatory strategies, such as relying on alternative somatosensory cues

1. Exercises for enhancing gaze stability

1) Head turns: Rotates the head side to side horizontally with gaze fixed on a stationary target. Do the same exercise with vertical head turns (Fig. 1A).[15,17,52]

2) Head-trunk turns: Rotates the head and trunk together (en block) horizontally with gaze fixed on the thumb while the arm moving together with the trunk [modified from Zee's exercise (Fig. 1B)[60]].

3) Head turns while walking: While walking in a straight line, the patient rotates the head horizontally to the left and right with gaze fixed on a stationary target. Do the same exercise with vertical head turns.[60]

2. Exercises for enhancing eye movements.

1) Saccade: Keeps the head still and moves only the eyes. Imagine horizontally placed two targets close enough together that while looking directly at one. Look at one target and quickly looks at the other target, without moving the head. These movements are repeated several times (one of the Cawthorne-Cooksey exercise[60]).

2) Pursuit: Keep the head still and moves only the eyes. Extends one arm forward and make the thumb (target) up, and turn the arm side to side while focusing on the thumb (modified from one of the Cawthorne-Cooksey exercise[60]).

3) Saccade and vestibulo-ocular reflex: Horizontally placed two targets are imagined. For example, two arms are extended forward with two thumbs (target) up. Look at a target, being sure that the head is lined up with the target. Then, look at the other target and turn the head slowly to the target. Repeat in the opposite direction. Repeat both directions several times (Fig. 2A).[52]

4) Imagery pursuit (remembered target exercise). Look directly at a target, being sure that the head is lined up with the target. Close the eyes, and the head is slowly turned away from the target while imagining that one is still looking at the target. Then, open the eyes and whether the target is kept in focus is checked. If not, adjust the gaze on the target. Repeat in the opposite direction. It should be as accurate as possible. Repeat both directions several times (Fig. 2B).[52]

3. Exercises for enhancing postural stability.

1) Stand on one leg. Stay for 15 seconds. Switch to the other leg (one of the Cawthorne-Cooksey exercise[60]).

2) Standing with the feet heel-to-toe with both arms extended. Stay for 15 seconds. Switch to the other leg.[15,17]

3) Sway back and forth. Locate the patient behind a chair and before a wall. This prevents the patient from falling. The patient starts with bending low and move the center of body backward with the toes up. Next is bending backward and move the center of body forward with the heels up. Repeat 10 times (one of the authors' exercise)(Fig. 3).

4) March in place.[17]

4. Exercises for decreasing vertigo

Stand with one arm elevated over the head, with the eyes looking at the elevated hand. Bend over and low the arm diagonally with the eyes continuously looking at the hand until the hand arrives at the opposite foot. Repeat 10 times (one of the authors' exercise)(Fig. 4).

5. Exercises for improving activities of daily living

1) Gait with sharp or wide turns to the right and left.[17]

2) Go from a seated to a standing position, then return to sitting (One of the Cawthorne-Cooksey exercise[60]).

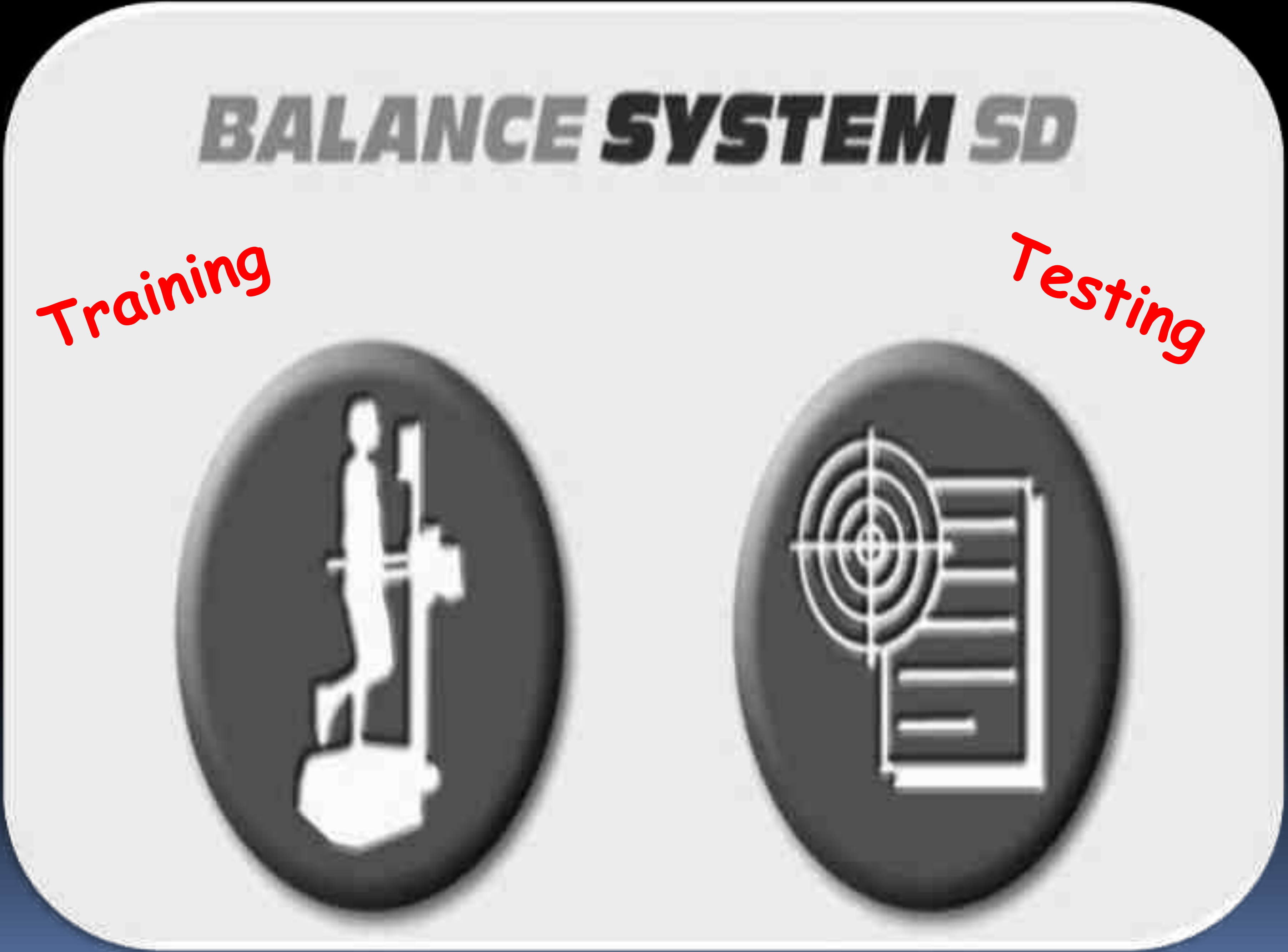
Issues

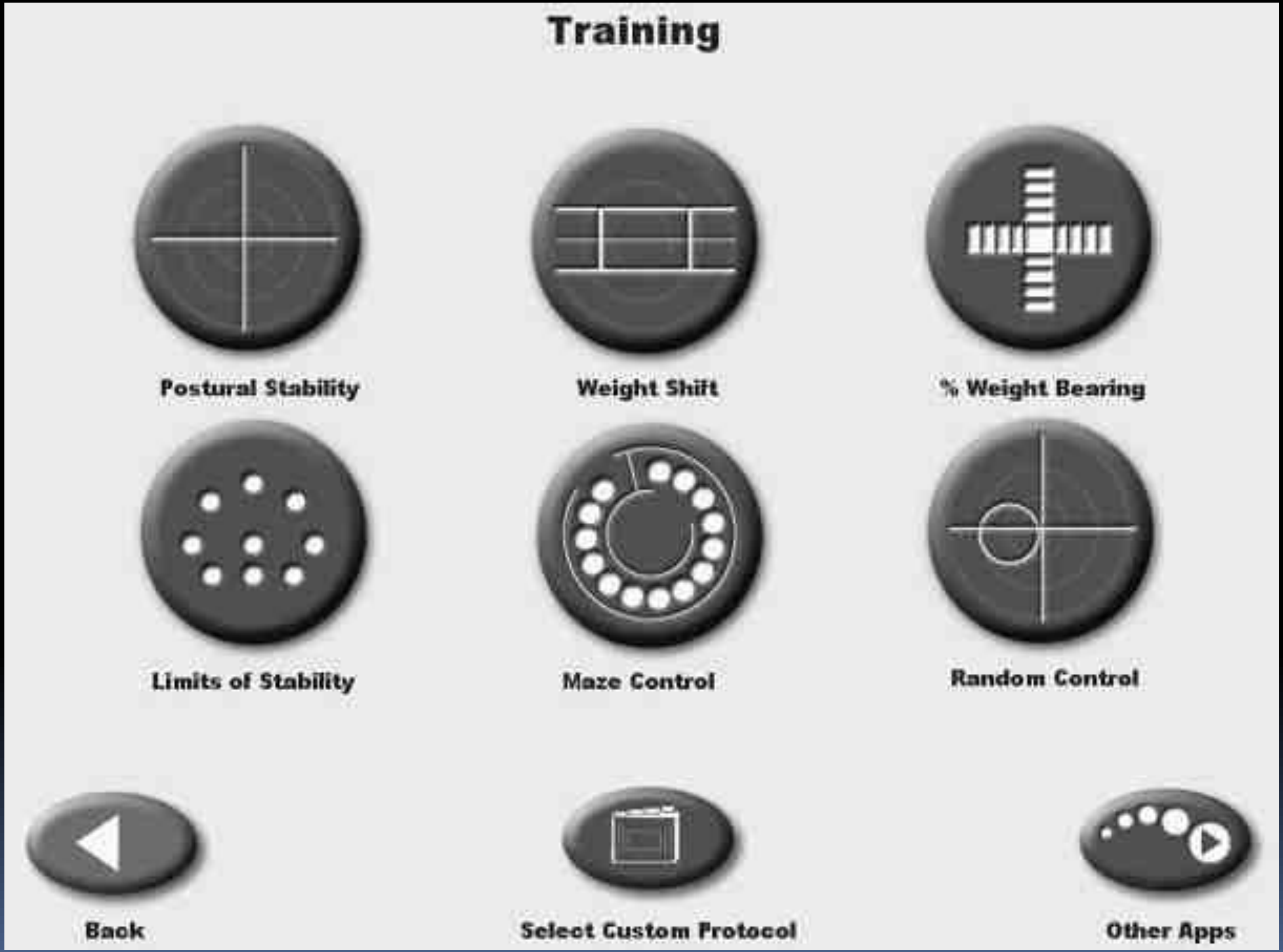
- Generic – not organ specific
- Not utilizing the whole system together
- Dosage is not determined

RECENT ADVANCES

Biodex Balance System

- 6 interactive training modes in Static and Dynamic: Postural Stability, Maze Control, Weight Shift, random Control, Limits of Stability, Weight bearing. Large Color Touch Screen, Interactive, game-like balance. 4 Standardized tests: Static Measuring Capability, Increased Dynamic resistance, Standardized Fall Screening Test Protocol, Athlete Knee Injury Screening Test protocol.


BALANCE SYSTEM SD
Training
Testing


Training
Postural Stability
Weight Shift
% Weight Bearing
Limits of Stability
Maze Control
Random Control
Back
Select Custom Protocol
Other Apps


Postural Stability Training
Time 00:00
Score 0
Place Target
Clear Target
Clear Tracing
STATIC
Press START to Begin
START
Back


Limits of Stability Training
Time 00:00
Score 0
Full
Pattern
Skill Level
Clear Tracing
STATIC
Press START to Begin
START
Back


Weight Shift Training
Time 00:00
Score 0
Rotate Target
Skill Level
Clear Tracing
STATIC
Press START to Begin
START
Back


Maze Control Training
Time 00:00
Score 0%
Skill Level
Clear Tracing
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Press START to Begin
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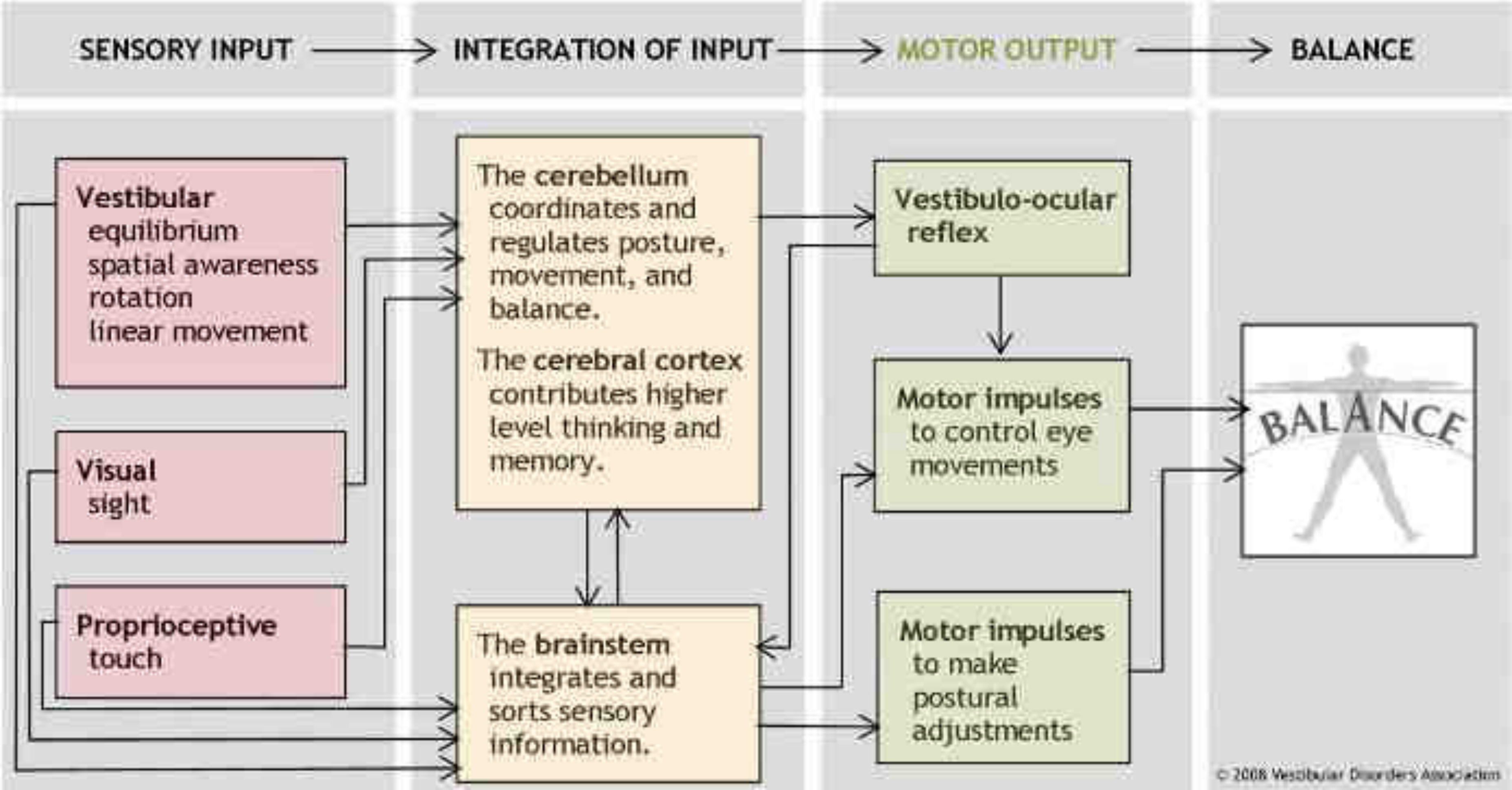
Back



VIRTUAL REALITY: CAREN


Speed
91

DO NOT FORGET THIS



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