



Introduction to Neuroplasticity

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“Recovery”

- Traditional view:
 - “static” brain
 - Change can only occur in younger individuals

Cortical Injury,
Resolution of the
penumbra, &
Subsequent
spontaneous recovery
(occurs for 3-6 months)

PLASTICITY →



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Neuroplasticity

- The brain’s ability to reorganize throughout the life span
- Neuroplasticity allows neurons in the brain:
 - To adjust neural activities in response to new situations and/or changes in the environment (developmental plasticity)
 - To compensate the loss from injury and neural diseases (adaptive plasticity)

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Developmental Plasticity versus Adaptive Plasticity

	Developmental Plasticity	Adaptive Plasticity
Definition	Changes in neural connections as a result of interactions with the environment (our experiences during childhood) as a consequence of developmental processes. e.g. Development of visual cortex	The brain's ability to compensate for lost functionality due to brain damage as well as in response to interaction with the environment by reorganizing its structure
Occurs in response to	It is predetermined and occurs in response to the initial processing of sensory information by the immature brain	Compensation for brain injury and in adjustment to new experiences .
Neuronal changes	Synaptogenesis, synaptic pruning, neural migration, myelination	Sprouting Rerouting
When it occurs	Over the lifespan , but diminishes with age	Over the lifespan , but is more efficient and effective during infancy/early childhood

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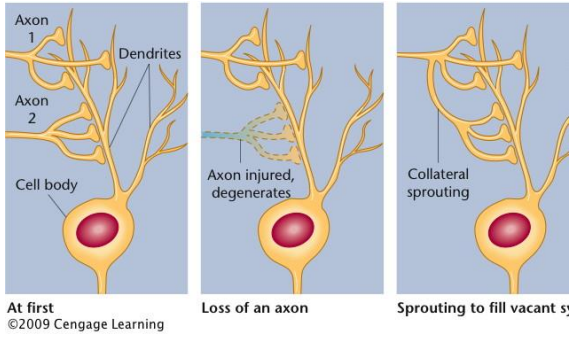
What's the clinical importance of adaptive plasticity in stroke?

- **What we do:** The goal of rehab can change from compensation to restoration of function (which is what patients want anyways)
 - The way we spend time in rehab should necessarily change
- **What we measure:** Measurement - and what is measured – necessarily changes
- **What we say and do:** Can happen years after stroke
 - The "6 month myth"
 - Reimbursement
 - "Late recovery" and "Second chance" clinics

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Basic Mechanisms of Adaptive Neuroplasticity in Stroke

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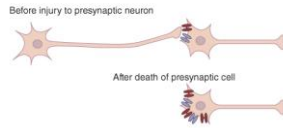


“Sprouting”/Dendritic Arborization

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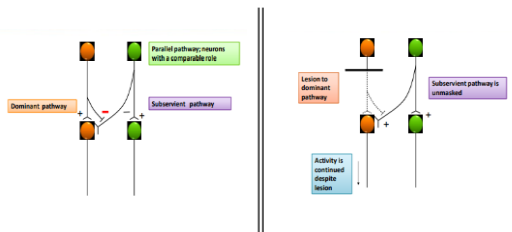
“Rerouting”

- Denervation hypersensitivity
- new receptor sites develop on postsynaptic membrane.
 - WHY? Less neurotransmitter → development of additional receptor sites
 - Receipt of neurotransmitters from adjacent sites

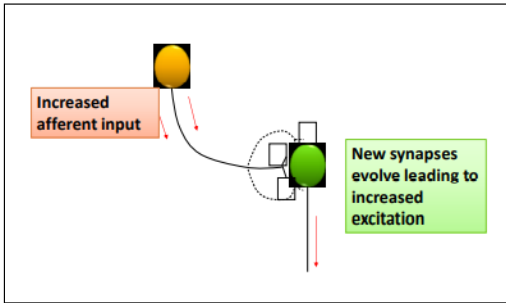


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“Rerouting”
“Unmasking” of silent synapses



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“Rerouting”
New Synapse Development

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The Conditions Under Which Adaptive Plasticity Occurs

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, JA, Jones, TA. (2008). *Journal of Speech, Language, and Hearing Research*, 51, S225-S239

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Interventions
that promote
adaptive
neuroplasticity

- Functional task training
- Modified Constraint-Induced Movement Therapy
- SOME Robot-assisted therapies
- Repetitive task training
- Circuit training for the LE and UE

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Interventions that do NOT promote adaptive neuroplasticity


- Facilitation
- Stretching
- Strengthening

Be thoughtful about your rationale for using the above approaches, and the amount of time allotted to them.



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Other Factors to Consider

 Environmental stimulation significantly influences neuroplastic changes in the brain.

 *Aerobic* exercise significantly influences neuroplastic changes in the brain.

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Enriched Environment

- **Stimulating Resources**
 - Newspapers
 - iPads
 - Books
 - Games
 - Cards
- Around the Ward
- At the Bedside
- **Communal meals**
- **Group Activities:** Relaxation Group, Bingo, Movie Night



I THINK MY WORK HERE IS DONE.

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Embedding an enriched environment in an acute stroke unit increases activity in people with stroke: a controlled before–after pilot study

Ingrid CM Rosbergen^{1,2}, Rohan S Grimley³, Kathryn S Hayward^{1,4,5,6}, Katrina C Walker², Donna Rowley⁷, Alana M Campbell¹, Suzanne McGufficke², Samantha T Robertson², Janelle Trinder⁷, Heidi Janssen^{6,8} and Sandra G Brauer¹

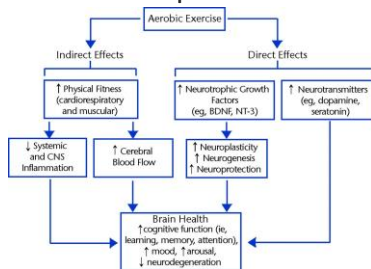
Self-directed exercise programs, iPads loaded with apps, iPods loaded with music, books, board games, puzzles, magazines, newspapers, and music will be available during and outside of therapy hours. During these 6 weeks, staff focus towards enabling activity will be reinforced through interdisciplinary education sessions

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- Daily group sessions focus on different aspects of stroke recovery such as **education, emotional support, communication, and physical activities**.
- Three weekdays: interactive breakfast, and every weekday, an interactive lunchtime. These **interactive mealtimes** are aimed to increase the frequency of mobilization, encourage sitting upright for mealtimes, and stimulate social interaction.
- **Stimulating equipment and individualized activity cards** placed at the participant’s bedside tailored to the stroke survivor’s goals.
- Family and staff advised to bring **personal items and hobby activities** for the participant and to encourage the participant to engage in these **activities outside therapy hours and on weekends**.

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“Promoting Neuroplasticity for Motor Rehabilitation After Stroke: Considering the Effects of Aerobic Exercise and Genetic Variation on Brain-Derived Neurotrophic Factor”



Phys. Ther. Volume 93, Issue 12, 1 December 2013, Pages 1707–1716, <https://doi.org/10.1093/pt/93.12.1707>
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Circuit training for mobility

Standing	Improve postural control in standing	Standing with constrained base of support, with feet in parallel and tandem conditions	Narrow base of support Stand on foam Eyes closed Turning upper body Cross arms Stand on one leg	Dean et al., 2000; Pang et al., 2005; Marigold et al., 2006; English et al., 2007; Mudge et al., 2007
		Reach for objects, including down to the floor. Trace spiral on a whiteboard	Practice in pairs by passing objects Constrain and narrow base of support (eg stand with feet together, or in tandem)	Dean et al., 2000; Yang et al., 2006; English et al., 2007; van de Port et al., 2009; Marsden et al., 2010

†The usual progressions such as increasing weights, increasing numbers of repetitions and decreasing therapist support are not mentioned in this table

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Circuit training for mobility in “functional space stations” in acute care

Examples of Exercises Included in Circuit Training for Each Severity Level

Four activities were practiced within each 60-minute session, 13 to 14 minutes per activity:

- Nonambulatory group**
 1. Bedding
 2. Seaweed in cup
 3. Socksliding to sit
 4. Static sitting balance/Equal weightbearing
 5. Dynamic sitting balance
 6. Seaweed in sitting
 7. Transfers
 8. Standing
 9. Sit to stand
- Severe group**
 1. Bedding
 2. Socksliding to sit
 3. Dynamic sitting balance
 4. Transfers
 5. Sit to stand
 6. Standing
 7. Pagan
 8. Gait
- Moderate group**
 1. Transfers
 2. Sit to stand
 3. Dynamic standing balance
 4. Gait
 5. Stepping onto a block
 6. Stair
- Mild group**
 1. Dynamic standing balance
 2. Sit to stand
 3. Gait
 4. Dual task gait
 5. Gait with adaptability
 6. Stair

Table 6. Change Scores Between Admission and Discharge

Outcome Measure	SPT	CTPT
Lower-extremity Fugl-Meyer motor score	3.35 ± 5.48	4.51 ± 4.69
Lower-extremity Fugl-Meyer sensory score	0.48 ± 2.19	1.23 ± 2.32
Berg Balance Scale	9.46 ± 9.93	12.63 ± 13.03
Gait speed (m/s)	0.13 ± 0.22	0.21 ± 0.25*
FIM motor score	9.88 ± 4.73	10.26 ± 5.89
Discharge to home	78%	75%

Abbreviations: SPT, standard physical therapy; CTPT, circuit training physical therapy; FIM, Functional Independence Measure.
*Statistically significantly different between the SPT group and the CTPT group at P < .05.

[Feasibility and Effectiveness of Circuit Training in Acute Stroke Rehabilitation; NNR; 25 \(2\) \(2011\).](#)

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Cochrane Results Summary on Circuit Training



“Ten studies (835 participants) measured walking capacity (6 min walk) demonstrating that CCT was superior to the comparison intervention.”



“Eight studies (744 participants) measured gait speed, again finding in favour of CCT compared with other interventions”

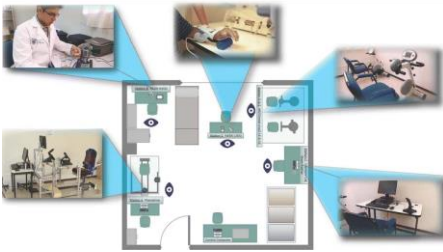


“We were able to pool other measures to demonstrate the superior effects of CCT (Timed Up and Go; Activities of Balance Confidence scale).”

[Circuit class therapy for improving mobility after stroke. Cochrane Review \(2017\)](#)

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Circuit training for the upper extremity???



[BustamanteValles, K., Montes, S., Madrigal, M. et al. J NeuroEngineering Rehabil 13, 83 \(2016\).](#)

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Take Home Points

- Adaptive neuroplasticity is skill and motor learning dependent
 - Strategies incorporating mere repetition, facilitation, and/or positioning **do not** induce functional reorganization
 - Strengthening **does not** induce functional reorganization
- BUT...**
- Aerobic exercise complemented by strengthening increases effective participation in ADLs



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THANK-YOU

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