Practical Implications of Neuroplasticity to Brain Injury Rehabilitation

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Disclosures

• Financial: Jerry Hoepner received conference registration, travel and lodging

• Non-financial: Jerry Hoepner is a member of ANCDS and the right hemisphere damage writing group; an affiliate of Aphasia Access and interviewer for the Aphasia Access Conversations Podcast; Associate Coordinator of the ASHA SIG 20: Counseling, and Editor of Teaching and Learning in Communication Sciences and Disorders (TLCSD)
Learning Outcomes

- Plasticity is relevant to typical development, aging, and recovery following neurological lesions.
- There are two main types of neuroplasticity — neural (cellular) and behavioral.
- Vascular remodeling is both a developmental process and mechanism of recovery after stroke/brain injury.
- Long-term potentiation is a process of strengthening neural networks through stimulation and is critical for memory and learning.
- Plasticity can be adaptive or maladaptive.
- Several factors are associated with experience dependent neuroplasticity.
- Personal factors contribute to the degree of engagement and participation, which in turn affect adaptation.
- Reactivation of a brain region following recovery and reorganization via recruitment of another brain region to carry out functions.
Neural (cellular) & Behavioral Plasticity

- Neural plasticity is what happens at the cellular level – changes to synapses through learning
- Behavioral plasticity is when a change in behaviors and environment changes brain structures and functions
- Behaviors drive neural plasticity

Vascular Remodeling

Aerobic exercise is main factor

Before angiogenesis

After angiogenesis
Synaptogenesis & Dendritic arborization

Cognitive exercise is a primary driver for synaptogenesis and dendritic arborization

Not all plasticity is adaptive

• Remember the old expression, “Practice makes perfect”? 
• In truth, “Practice makes permanent” 
• What we do matters! 
  • Needs to be accurate 
  • Needs to be contextually sensitive 
  • Needs to be repeated (a lot) 
  • Complexity needs to match the real deal (see examples in spinal cord injury recovery) 
  • Doing it “wrong” can make the it permanently wrong (or at least hard to undo)
What do we mean by maladaptive?

- How many of you walk like this?
- What are the potential problems with walking like this?

Continuous passive motion...

How close can you get to the real deal?

What is the difference from our previous “walker”?
What about arms?

How can we change the threshold for communication? or Attention? Memory? Self-regulation? etc.
Long-term Potentiation (Fig. 15-1)

1. pre-synaptic cell
   glutamate
   polarized membrane
   post-synaptic cell
   NMDA receptor
   AMPA receptor

   When a pre-synaptic neuron fires, releasing glutamate, it activates AMPA receptors. Activation allows Na⁺ to enter the post-synaptic neuron, depolarizing it. (#2)

2. depolarized membrane

   NMDA receptors have a Mg²⁺ block that only opens when the post-synaptic neuron is depolarized. Depolarization causes influx of Ca²⁺ (#3)

Moral of the story...
neurons that fire together wire together

Long-term Potentiation (Fig. 15-1 continued)

3. Once depolarized, glutamate activates NMDA receptors, leading to Ca²⁺ influx.

4. The influx of Ca²⁺ leads to two forms of LTP, early- and late-LTP. Early-LTP (#4) occurs when Ca²⁺ binds with kinase (#3), which increases AMPA receptors in the post-synaptic neuron. This increases sensitivity to depolarizations and strengthens the connection between neurons (strengthens the circuit).

5. Late-LTP occurs when Ca²⁺ binds to cAMP response element binding proteins (#5), which results in increased gene expression, increased protein synthesis, and most importantly -- increased synaptogenesis.
Did you know that Neuronal activity can also be depressed?

• The opposite of LTP is LTD
• In this case, pathways can be deactivated through lack of use
• This goes with the expression “Use it or lose it”

Plasticity: Kleim & Jones, 2008
Ludlow et al., 2008

- Use it or lose it
- Use it and improve it
- Specificity – ecologically valid, authentic, environment matters
- Repetition matters – errorless repetition = adaptive plasticity
- Intensity matters – how much? Recovery continuum
- Time matters – when is optimum time? Recovery continuum
- Salience matters – person-centered, motivation, goal setting
- Age matters – while young is better, change remains possible
- Transference matters – generalization depends on authentic intervention
- Interference - one experience affects others (can be constructive or deconstructive)
Experience Dependent Plasticity (Fig. 15-3)

Blake & Hoepner’s (2023) clinical implications

Social vs. Impairment models: how do they stack up?

- From a neuroplasticity standpoint, this question relates to ...
  - **Specificity**: is the activity and/or environment similar to the real-life context?
  - **Salience**: are the activities and tasks motivating, person-centered/relevant one’s goals?
  - **Transference**: are the activities and tasks generalizable to what the person wants and needs to do?
Specificity Matters

- Lof & Watson, 2008; McCauley et al. 2009 on non-speech oral motor tasks
- Blowing bubbles is not equivalent to the act of speaking!

Dosing Matters

- Some tasks benefit from massed practice (high intensity & high dose in a short period of time)
  - ICAPS & post-acute/chronic interventions (Babbitt et al., 2015; Cherney, Patterson, & Raymer, 2011)
- Some tasks benefit from distributed practice (low intensity & low dose over a long period of time)
  - Early rehabilitation (Sohlberg & Turkstra, 2011)
- Dosing refers to the number of teaching episodes per session. It is defined as the number of properly administered therapeutic inputs or client acts per session, and it includes not only what the clinician does but also the quality or accuracy of the client’s response (Babbitt et al., 2015; Baker, 2012; Harvey et al., 2020)
Continuum of transference from clinical to community environments (Fig. 15-4)

- What happens in real life environments is likely different than what happens in clinical or controlled environments.

**Functional Reactivation**

- Assume the ischemic area at the core of a lesion is no longer functional but that the penumbra was functioning poorly.
- Functional reactivation is neuronal and/or vascular plasticity:
  - Collateral dendritic regrowth (synaptic remodeling) of peri-infarct region
  - Vascular remodeling (new vessels) in peri-infarct region
Functional Reorganization

- Another area of the brain “takes over” functions of the damaged area
  - Perilesional area takes over OR
  - Increased activation of the opposite hemisphere

Neuromodulation techniques

Figure 1: The mechanism of neuromodulation to enhance neural plasticity following stroke.
• Hmm… it’s starting to look like what we do!

Wang, 2022

Types of neuromodulation

So, what does this all mean to you?

1. You need to learn who you’re working with and what matters to them (what they want and need to do)

2. You need to set and measure goals and goal achievement with them

3. Therapy needs to parallel what they want and need to do in environments that are comparable to the environments they will need to do them in

4. You will need to use communication supports to help them express their identity, what they want and need to do, etc. (see tools on the slides that follow)
Bordin’s (1979) 3 KEYS to Therapeutic Alliance

- client and clinician agree on the therapy tasks
- client and clinician agree on goals
- the interpersonal bond between client and clinician

Personal Values Card Sort
(Miller, C’dé Baca, Matthews, & Wilbourne, 2001)

- 83+ items
- Not communication-friendly
- Great framework
Q-Sort
(Stephenson, 1953; Rogers, 1954)

Talking Mats
Activity Card Sort(s)

- Adult version – categorical sorts
  - Healthy adults
  - Institutional version
  - Recovering version
- Infant-Toddler
- Preschool
- Adolescent and Young adults

LIV Cards

<table>
<thead>
<tr>
<th>LIV Cards Activity Score Sheet</th>
<th>Home and Community Activities</th>
<th>LIV Cards Activity Score Sheet</th>
<th>Creative and Relieving Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check activities the PWA wants to do more. Circle any activity number where the PWA and FPM give different responses.</td>
<td></td>
<td>Check activities the PWA wants to do more. Circle any activity number where the PWA and FPM give different responses.</td>
<td></td>
</tr>
</tbody>
</table>
There is also a partner version of the inventory.

### Obligatory vs. Non-Obligatory Inventory

<table>
<thead>
<tr>
<th>Before Injury/Illness</th>
<th>After Injury/Illness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do because you have to</td>
<td>Do because you have to</td>
</tr>
<tr>
<td>Do because you want to</td>
<td>Do because you want to</td>
</tr>
</tbody>
</table>
Adjuncts for accessible interviews

- Along with tools like Talking Mats...
  - Written choice for readers
  - Rating scales across lifespan, depending on cognitive level
  - Photographs to express idea or augment verbal expression
  - Drawing

### Setting Collaborative Goals
(Hoepner & Hersh, 2022)

<table>
<thead>
<tr>
<th>GOAL COMPONENT:</th>
<th>WHO: Name, Ms., Mrs., Mr., Dr., etc.</th>
<th>SKILL/TARGET: (production of /phoneme/, attention to task, orientation to..., recall of..., self-assessment, etc.)</th>
<th>PERFORMANCE LEVEL: (for X min., for X times, in X context, with X level of accuracy)</th>
<th>CONDITION: (w/ X type of cues or support, in the presence of X demands, environment)</th>
<th>PURPOSE: (in order to achieve activity/participation outcomes)</th>
</tr>
</thead>
</table>

A client might see it more like this (personal communication with Deborah Hersh):

1. **I want to be able to do x**
2. **To do that, I need to practice these sounds/words/sentences/exercises.**
3. **For that, I need x support, with x cues, and practice it x number of times.**
4. **I will look at x results on x measure to see if it is getting any better.**

### Goal Mapping (Turkstra)

- **Work backwards towards end goal to identify steps**

```
My primary goal is ...

Client’s Goal: Return to socializing with friends on Facebook
Short-Term Rehab Goal: Post a message on Facebook
Sustain attention to read one Facebook post
Find the Facebook icon on a computer screen, with a distracting background
Find the Facebook icon on a computer screen, with a blank background
```

Other steps will be added as the client progresses.
Formulations  
(Fish et al., 2021)  

- Considers multiple domains

SMARTER GOALS  
(Hersh et al., 2012)  

- How do we assure our SMART goals are collaborative?
All of this so...

- WE CAN FOSTER MORE PARTICIPATION
- PROJECT BASED INTERVENTIONS
- MOTIVATIONAL INTERVIEWING
- GROUP INTERVENTIONS
- CAMPS

And...?