Neuroplasticity: Implications for Treating Cognitive-Communication Disorders

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Abstract
Neuroscience research has revealed the brain to be more plastic than ever before realized. Principles have emerged about recovery of function after brain damage that can guide clinicians who treat cognitive-communication disorders. The purpose of this presentation is to define neuroplasticity, explain emergent principles and specify clinical techniques supported by these principles.

Learner Outcomes:
At the conclusion of this presentation, participants will be able to:
- Define neuroplasticity (NP).
- Explain principles of NP.
- Describe clinical strategies, supported by NP research, for treating cognitive-communicative disorders.

I. Neuroplasticity defined -
A. The lifelong ability of the brain to reorganize as a result of experience (Kolb & Gibb, 2008)
   1. The brain is constantly laying down new pathways and rearranging existing ones.
B. Nature vs. nurture.
   1. Genes and experience are inseparable.
   2. Experience controls whether neural connections endure and strengthen.
   3. Genes are affected by the experiences of the organism.
   4. "Nature forms a rough blueprint of cerebral organization that must be shaped by experience..." (Kolb & Gibb, 2008)
C. Memory (learning) is the product of NP; results from experience; can be positive or negative.
D. A memory is a stored pattern of interneuronal connections.
E. Memory formation requires a change in the nervous system:
   1. Stimulation
   2. Chemical changes - Neurochemical events create long-term enhancement of signal transmission between the simultaneously stimulated neurons;
   3. Long-term potentiation (LTP) - Improves the post-synaptic cell’s sensitivity to signals from the pre-synaptic cell; increases the activity of existing receptors and the number of receptors on the post-synaptic cell surface.
      a. PKMzeta - Appears necessary and sufficient for the creation and maintenance of LTP at synapses.
   4. Increase receptors
   5. Dendritic arborization
   6. Regeneration
      a. Stem cells - master cells of an organism; can renew themselves; can differentiate into many cell types.
      b. 3 types of stem cells: embryonic, fetal, adult (including neural)

II. Principles of NP (Kleim, 2006; Kleim & Jones, 2008; Kolb & Gibb, 2008)
   1. Simultaneity: When two things happen simultaneously, they become linked.
   2. Relatedness: Concepts, events, words that are related are linked in the brain.
   3. Attention: The tool that creates brain change.
   4. Repetition: With more repetitions the connections between the sending and receiving neurons strengthen.
   5. Intensity: Intense experience is needed for significant organization to occur.
   6. Duration: Short-term stimulation produces transitory change; long-term stimulation produces more permanent structural change.
   7. Specificity: Type of training influences the nature of plasticity.
   9. Age: Plasticity greater in youth.
   10. Use or lose: Failure to engage specific brain functions can cause functional degradation 11. Use and improve: Use of the function/skill is critical.
   13. Timing: Too early and relevant systems may not be ready. Too late and may pass window of opportunity.
III. Clinical Strategies for Treating Cognitive-Communicative Disorders
The brains of individuals with aphasia and TBI must reorganize for recovery of function. Cognitive stimulation, of the correct type, can trigger NP and facilitate recovery. In individuals with dementia, cognitive stimulation is needed to sustain knowledge/function against degenerative forces. The following techniques from NP research are tools clinicians can use to facilitate recovery and/or sustain function.

Stimulation (cognitive and/or linguistic) -
Underlying NP principles: Use or lose, Use and improve
Without stimulation, NP is not triggered.
Research indicates a need for intensive stimulation over a lengthy period.

Involve multiple modalities -
NP principle: Simultaneity; Relatedness; Intensity
Multimodal stimulation builds more elaborate and enduring mental representations because fact memory is distributed across sensory association areas (Eichenbaum, 2002)

Learner engagement through choice and self-generation -
NP principles: Attention, Relevance, Intensity
Choose therapy activities that engage patients.
People learn better if actively (vs. passively) engaged.

Use of stimuli that evoke positive emotion -
NP principles: Emotion, Attention

Repetition -
NP principles: Repetition, Duration, Intensity
Repeated retrieval triggers the chemical process that strengthens the memory engram.
Repetitive transcranial magnetic stimulation (TMS) can enhance recovery in aphasia (Naeser et al., 2005)
Spaced-retrieval can provide repetition (Landauer & Bjork, 1978).
Distributed (spaced) practice is best (Donovan & Radosevich, 1999; Shebilske et al., 1999)

Minimization of error response -
NP principle: Repetition, Emotion
Errorless learning through vanishing cues (Baddeley & Wilson, 1994).

**Elaborate encoding -**
NP principles: Association, Intensity, Specificity
Improved learning when individuals have to engage in greater *depth of processing* of to-be-remembered material (Kliegl, Smith, & Baltes, 1989; Verhaeghen, Marcoen, & Goossens, 1992; Yesavage, Rose, & Bower, 1983).
Ways to stimulate elaborate encoding
* Visualization
* Identification of attributes
* Specification of superordinate categories
* Physically acting on target
* Restating
* Answering questions about target
* Linking target to related information
* Using information/skill in new context

**Work within schemas -**
NP principles: Specificity, Relatedness, Simultaneity
Schemas are structural units of semantic memory.
Activation of one item in a schema produces increased activation of related items (Arkin, Rose, & Hopper, 2000).
* Relearning a semantic category is facilitated if therapy focuses on atypical as well as typical category members.
* Focus on atypical stimulates a broader array of category features.

**Use enrich environments -**
NP principle: Stimulation, Intensity
Rich environments stimulate growth factor levels increasing neurogenesis.

**Priming -**
NP principle: Stimulation, Relatedness, Simultaneity
Retrieval is advantaged by prior related stimuli.
Types of primes: repetition, associative
Force use of target skill -
NP principle: Specificity, Use or Lose
One way is through constraint induced therapy - leads to cortical reorganization (Elbert et al., 1995; Liepert et al., 2000; Sterr et al., 1998) and is supported by scan evidence (Musso, Weiller, Kiebel et al., 1999; Thompson, 2000).

IV. Conclusion - Repetitive, intense stimulation, that forces use of knowledge/skills, and is of relevance to the client, is crucial for triggering NP processes and recovery.

References


