Neuro-Occupation:

Nonlinear Dynamic Approach to Rehabilitation

MAOT 2007
Neuro-Occupation

- Is the conflate of occupation and neuroscience

- The amalgamation of concepts and views of nonlinear science, defining occupation as an ever constructing life experience

- The neuroscientific understanding of how the mind-brain-body works, influenced and shaped by the ever-changing occupations of a lifetime
“[Wo] Man, through the use of his hands as they are energized by mind and will, can influence the state if his own health.”

(Reilly, 1962)

Occupation is the self-organized and self-actualized process driven by meaningful experiences. It is the vehicle of change.

(Lazzarini, 2003)
Nonlinear Science

Underlying assumptions:

- A dynamical system is complex and changes over time

- Biological organisms are complex, multidimensional, cooperative, interdependent & self-organizing systems
Nature uses only the longest threads to weave her patterns; so each piece of the fabrics reveals the organization of the entire tapestry...

The brain is embodied and the body is embedded!
Definitions

- **Brain**
  - Structure and function

- **Mind**
  - The brain is a nonlinear organ that changes through the process of doing!
  - Attractor is the shape that is left after a nonlinear process if complete.
The human brain is “fundamentally a pattern forming, self-organized, dynamical system poised on the brink of instability”

(Kelso, 1999, p.xvii)

Being poised on the brink of instability affords A natural flexible change!...the basic mechanism of self-organization
Self-organization

- Refers to the *spontaneous* formation of patterns and pattern change in NONEQUILIBRIUM systems composed of many components that are open to the exchange of matter, energy and information with its surroundings.

- Self-organization is a fundamental characteristic of the brain and essential to understanding how the brain is shaped by development, learning and disease.
Who Are We? How do we learn?

- The brain is embodied and the body is embedded.
- We learn through experience.
- Learning is NOT a program simulation of complex interactions.
What we have to learn to do, we learn by doing?

Aristotle
Learning, in this view, occurs as the specific modification of already existing behavioral patterns in the directions of the task to be learned. (Kelso, 1995, p.161)
Overarching Definitions

Learning

“As we start a new school year, Mr. Smith, I just want you to know that I'm an Abstract-Sequential learner and trust that you'll conduct yourself accordingly!”
Some Overarching Definitions

- **Learning** is the acquisition of knowledge by study.
  - (19th century theory)

- **Learning** is a permanent change in behavior brought about by reinforcement of stimulus-response.
  - (Behaviorist theory)

- **Learning** is the sudden or slow acquisition of insight into the rules governing certain relationships in the environment.
  - (Discovery learning)

- **Learning** is the assimilation and accommodation of convergent information.
  - (Piagetians)

- **Learning** is the discovery of new facts and relating them to those already known.
  - (Fundamental/active learning; store/retrieval system)
Embedded in learning are the following:

- **Knowledge:**
  - learning is the means by which we acquire information, knowledge or understanding of something.

- **Skill:**
  - learning is the means by which we gain skills or capabilities in a particular area.

- **Memory:**
  - learning is the means by which we commit information to memory.

- **Behavior:**
  - learning is the means by which we change and modify our behavior.

- **Awareness and Attention:**
  - learning is the means by which we come to realize something we were previously unaware of.
Historical Map of Learning Theories

- **Behaviorism**
  - 1900s
  - **Skinner**
  - **Thorndike**
  - **Watson**
  - **Pavlov**

- **Cognitivism**
  - 1950s
  - **Bandura**

- **Constructivism**
  - 1970+
  - **Piaget**
  - **Bruner**
  - **Vygotsky**
Historical Perspective

- **Thomas Hobbes** (1588-1679)
  - Speculated math calculating concepts and modeled mechanism of mental operation

- **David Hume** (1711-1776)
  - *Principia of Mathematica*
  - Dynamics of matter would be paralleled by dynamics of the mind
  - Could not escape the messy details of actual human learning and behaviors

Humean- Cognitivism
Cognitivism - meant as interdisciplinary

- Psychology, neuroscience, linguistics, analytic philosophy and computer science

- Emerged in 1940, to reconcile analytical problems left unsolved by introspection, psychoanalysis and behaviorism

- Its goal to provide a precise, pervasive, and uniform paradigm and methodology for operationalizing and emulating the essential aspects of the mind

- *The mind as a rational calculating device!*
  - Leibnez and Descartes, expounded by Craik (1943) and Turing (1950)
    - Electronics provided the key tool
History... technology was not the only culprit

- Built in substance dualism (mind-body)
- Framework -
  - No sociological or cultural instances
  - Divorced from the biological or neurobiological

Reduced MIND and thus learning to a passive input-output device that process information!
The result…. Cartesian Methods

- Mind - Body Split
- Brain - Body Split
- Subject - Object
- Nature – Nurture
- Holism - Reductionism
- Mental-Spiritual
- Learning- Teaching

Linear causality- the stimulus directly correlated to Responses or outcomes;
Strengthening of synaptic connections
Comparison of Views

Classical Science
- Causality
- Linear
- Objective
- Isolated events
- Matter
- Focuses on stability
- Closed systems
- Reductive
- Predictability
- Explicit/observable
- Time is uniform

Nonlinear Science
- Emergent properties
- Non-linear
- Includes subjectivity
- Emphasizes context
- Process
- Focuses on sensitivity
- Open systems
- Complex
- Chaotic/stochastic
- Implicit/hidden
- Sensitive to critical periods
Comparison of Views

Classical Science
- Sequential
- Mechanistic
- Fixed relationships
- Objects/parts
- Occupation: process vs. product

Nonlinear Science
- Experience dependent
- Self-regulating
- Network interconnections
- Relationships with parts
- Occupation: experiential process (occupation as means) which give rise to product (occupation as ends) that by circular causality becomes the new process
Linear approaches to cognition state that the behavior of a system is easily predictable from the behavior of individual neurons or brain structures!

- Easily predictable effects as opposed to tendencies
- Small changes – small effects
- Big changes – big effects

As a consequence behavior is the end result of chains of billiard ball type interactions among representations.
Nonlinear dynamics is useful in conceptualizing how relatively healthy human beings remain resilient in the midst of variability, multiplicity, and change - human system’s flexibility.

Conversely, pathology is characterized by the repetitive, periodic, self-same quality of mental states - decreased system’s flexibility.

The goal of the nonlinear dynamics approach is to describe human cognition as an intentional, self-organizing process in which pattern formation and neural organization develop through internal interactions.
NLD Terminology: An Introduction

- Chaos Theory and Nonlinear Dynamics
- Attractor
- Bifurcation
- Perturbance
- Edge of Chaos
- Sensitivity to Initial Conditions
- Phase Transition
- Control Parameter
- Order Parameter
- Pattern Formation
Basins of Attraction

The stronger the attractor the deeper the basin

www.itee.uq.edu.au/.../Hopfield/Attractors.gif
Landscape Diagram

Agreement

Certainty

Close to

Far from

Small

Tight

Close to

Few

Large

Loose

Many

Differences

Exchanges
Edge of Chaos: Learning and creativity

http://www.nada.kth.se/~asa/Ethics/attractor.html
Neuro-occupation & Learning?

By learning, we generate an attractor state

Haken, 2003
According to Dr. Scott Kelso (1999), as the classic dichotomy of structure and function fades, and we begin to sense the intimate relation between them, all we are left with is dynamics, self-sustaining and persisting on several space-time scales, at all levels from the single cell up (p. 15).

Professor/Dr. Herman Haken, German Physicist-founded the interdisciplinary science of Synergetics. A science explaining the formation and self-organization of patterns and structures in open, far from equilibrium systems. LAZER!
Historical Essence!

- New learning is anchored with intrinsic tendencies or constraints already present in the learner
  - Capacities, background are evaluated prior to exposure to a new learning experience.
Learning is defined as the process by which the pattern becomes stable through practice or experience.

Once learning is achieved, the stable pattern constitutes *an attractor*.

A stable state of the now modified pattern dynamic.

*A MEANINGFUL ONE!*
Learning, viewed as the mere strengthening of synaptic connections, *tacitly ignores the presence of any meaningful relationship* between the things being learned and the intrinsic organization of the system doing the learning.

The principles of dynamic mechanisms proposed may account for adaptive change across different *space* and *time* scales.
Both in Theory & Practice

- Entire attractor layout changes with learning, not simply the particular behavior being learned.

- Learning may take the form of instabilities or phase transitions depending on the relationship between what is to be learned and the existing coordination tendencies.
As learning occurs, the dynamic landscape of the system evolves.....

- Some collective states are **eliminated**, some **created** and others **stabilized**

- **Learning** doesn’t just strengthen the memory trace of synaptic connections between input and output.
Implications

- Chaotic destabilizations become apparent when an individual is exposed to *new learning experiences* and demonstrates the ability, or lack of ability, to assimilate the new into the old.

- The therapist’s role is to assess and recognize these chaotic states in order to begin to comprehend the meaningful patterns of brain activity—*tendencies*—from which therapeutic interventions may be facilitated and organized.

- ND is natural subject matter for occupational therapy cognitive approaches.
Learning is the acquisition of knowledge by study.
  ■ (19th century theory)

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Occupational Crises
Neuro-occupation:
The Self-organized Process of Intentionality

The inter-relationship and inter-dependence of microscopic, mesoscopic and macroscopic states and Intention, Meaning & Perception
Microscopic Level: Intention

- Activity expressed by action potentials is sensory-informed and intentional

- Sensory-driven action potentials condense into mesoscopic wave packets

- Major function is: the self-organization of homeodynamics

(Lazzarini, 2004)
Mesoscopic Level: Meaning

Bridges the gap between microscopic and macroscopic in a nonlinear fashion, through the formation of wave packets (Wps) (Freeman, 2002).

Wps resultant of microscopic sensory stimuli; are hemisphere wide, self-organized patterns of neural activity, largely broadcast through the forebrain.

Wps form when sensory driven input destabilizes the primary receiving areas by local state transitions and are the precursors of awareness.

Key function: Meaning-making!

(Lazzarini, 2004)
A wave packet is revealed by an oscillation in brain potential called a burst; may be measured using EEG.

(Walter Freeman, 1973)
Macroscopic Level: Perception

The activity of the entire forebrain is expressed by the actions and behaviors we observe.

Key state: **Awareness**

(Lazzarini, 2004)
Circular Causality

According to Dr. Walter J. Freeman, circular causality occurs when fluctuations in microscopic activity exceed a certain threshold, giving rise to a new macroscopic oscillation, which forces the cooperation of the very neurons that brought the pattern into being.

(Walter J. Freeman, 1999)

Consider the correlation to the study of habits in occupational therapy.
Hypothesis Testing

- Experiencing the sensory consequences of one’s actions
Habitual Experiences

- The strengthening of habits (attractors or patterns) through continued experiential process; the deepening/strengthening of the attractor
During phase transitions,
- new habits are created
- some existing habits may dissipate
- while others are reinforced

The intent is to shift from a less flexible to a more complex attractor pattern.
Applications for OT Process

- Identify the system to be observed & the scale of observation
- Identify the attractor pattern
  - A particular pattern; the absence of a pattern; vacillation between patterns?
- Facilitate a perturbation of the pattern at the point of instability

2 ways to view attractor instability:
- Facilitate a perturbation and identify how long it takes to bounce back
- Identify and manipulate the control parameter
Case in Point: Maya

General case information
- 24 year-old single mother
  - 4 year old daughter
- She deeply values her relationship with her daughter, and is close to her mother and father
- Lives with her daughter in an apartment
- Enjoys playing with and caring for her daughter, arts/crafts, exercise, music, shopping and going to the movies
- She is not currently employed but has worked as a waitress in the past
- She hopes to go to college when her daughter begins school

Champagne, Ryan, Saccamando, Lazzarini (in press)
Upon admission to an acute inpatient unit she presented with symptoms of mania and was intoxicated. She has stopped taking medications over the past month.

She reported she was feeling “unsafe”, abusing alcohol, overspending, and an inability to care for her child.

She was tearful as she explained that her continued “relapses” of mania and alcohol had compromised her relationship with her four-year-old daughter.

The case of Maya demonstrates both the rigidity of a dynamic human system with patterns (habits) in need of change and the potential for self-organization in space and time through change in attractor layout (new learning).

Champagne, Ryan, Saccamando, Lazzarini (in press)
Maya

- Approaching stasis lead to feelings of disconnectedness, disunity, and disrupted deeply embedded habits.

- Maya, who is able to function without the assistance of caregivers when feeling well, becomes increasingly dependent and highly inflexible when manic, depressed and using alcohol.

- This led to a critical point, facilitating the wild chaotic fluctuations of instability necessary to bring Maya’s occupational habits to bifurcation, where new patterns self-organize, and to a phase shift.

- Critical periods provide therapeutic opportunities to further facilitate the awareness of rigid, self-destructive patterns and for learning ways to increase flexibility (health) through spiritual occupation.

Champagne, Ryan, Saccamando, Lazzarini (in press)
Facilitating Change

- **Order Parameter:** it was not until this admission that, from Maya’s cumulative changes of intention-meaning-perception over time, emerged a new awareness of the need to change some of her habits and tendencies. Additionally, the deeply meaningful role of being a mother helped to reinforce the awareness of the need to change due to the fear of losing custody to DSS.

- **Control Parameter:** engaging in broad and deep spiritual occupation facilitated the bifurcation processes necessary for the dissolution or unlearning process of unhealthy attractors and prepared the self for a dramatic transformation.

- Health is the patterning of life supporting interactions characterized by flexibility, variability, and difference, allowing the ability to self-transform (Stacey, 2003).
Hypothesis Testing

First day of admission
<table>
<thead>
<tr>
<th>Broad Spiritual Occupation</th>
<th>Deep Spiritual Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contributes to self-transformation</td>
<td>Contributes to self-transcendence</td>
</tr>
<tr>
<td>Structures one’s sense of self</td>
<td>Structures one’s identity</td>
</tr>
<tr>
<td>May be easily perturbed</td>
<td>Not easily perturbed</td>
</tr>
<tr>
<td>Affords a sense of identification with a social class or role: unity</td>
<td>Affords a sense of unity and wholeness within the universe</td>
</tr>
</tbody>
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(Champagne, Ryan, Saccamando, Lazzarini (in press))
Habit Shaping

- **Broad Spiritual Occupations**
  - Mindfulness activities
  - Art expression
  - Yoga
  - Fully engaging in therapeutic groups

- **Deep Spiritual Occupations**
  - Meditation
  - Self-reflection through journaling
  - Working on the 12 steps with her sponsor
  - Prayer
Initially, Maya believed she would need to chase and cling to each moment of sobriety to be able to stay sober and experience serenity.

She needed to learn that, by allowing herself to experience and reflect upon the unity and wholeness of spiritual occupation, she would realize the transcendence of old self-perceptions and habits (attractors) over time and freely flow into new and more adaptive patterns (create a new attractor landscape).

Over time she learned how to allow rather than try to force or control her spiritual experiences.
During phase transitions,

- **New habits were created** - Spiritual Occupation
- **Some existing habits dissipated**
  - mania, alcohol abuse, poor self-care and parenting
- **While others were reinforced**
  - meaning of the role of being a mother

The intent is to shift from a less flexible to a more complex attractor pattern

**Outcome** = *Increased occupational complexity*
Self-transcendence: Spiritual Occupation

Champagne, Ryan, Saccamando, Lazzarini (in press)

Macroscopic: Perception
Development of new patterns of self & social awareness
“I am changing” “I can do this” “I have new skills”

Mesoscopic: Meaning
Development of new meanings.

Microscopic: Intention
Neurochemical changes in the brain.
e.g. through detoxification, medication stabilization, unlearning and new learning
Spirit-Mind-Body-World
Inter-connected & Inter-dependent Process

Butterfly: Symbol of change

Lorenz Attractor
“Butterfly Effects”
In this way occupation serves as the vehicle of change in which self-controlled performance can be facilitated by the endogenous process of self-organization of the brain–mind–body embedded in its environment.

Ilazzarini, 2005
IMPLICATIONS

- The concepts discussed in this presentation may help clarify how neural patterns are formed in complex systems providing occupation with scientific validation as a therapeutic tool to elicit change.
Hence, allowing therapists to envision their clients as a:

- Constantly shifting dynamical system;
- More like a river of experiences, in which patterns emerge and disappear and where a static view of life has no meaning.
Neuro-occupation is your life as you timelessly construct it, experience it and live it across the lifespan.

(Lazzarini, 2002)
Thank You!

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References


