Overview: The Polyvagal Theory

1. **Evolution** provides an organizing principle to understand neural regulation of the human autonomic nervous system.
2. Three neural circuits form a phylogenetically-ordered response hierarchy that regulate behavioral and physiological adaptation to safe, dangerous, and life threatening environments.
3. Neuroception of danger or safety or life threat trigger these adaptive neural circuits.
4. New models relating neural regulation to health, learning, and social behavior may be reversed-engineered into treatments.

Alternative Organizing Principles

The metaphor of safety: A basic principle of our nervous system

- Environment outside the body inside the body
- Nervous System Neuroception
- Safety Danger Life threat
- Defensive strategies mobilization (mobilization)
- Defensive strategies flight/fight/shutdown (immobilization)

Evolution

<table>
<thead>
<tr>
<th>CHM</th>
<th>DMX</th>
<th>SNS</th>
<th>AD/m</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclostomes</td>
<td>X+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chimaera</td>
<td>X+</td>
<td>X-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teleosts</td>
<td>X+</td>
<td>X-</td>
<td>X+</td>
<td></td>
</tr>
<tr>
<td>Amphibians</td>
<td>X+</td>
<td>X-</td>
<td>X+</td>
<td></td>
</tr>
<tr>
<td>Mammals</td>
<td>X+</td>
<td>X-</td>
<td>X+</td>
<td>X+</td>
</tr>
</tbody>
</table>
Polyvagal Theory: Emergent “Emotion” Subsystems

<table>
<thead>
<tr>
<th></th>
<th>VVC</th>
<th>SNS</th>
<th>DVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>heart rate</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>bronchi</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>gastrointestinal</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>vasoconstriction</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>sweat</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>adrenal medulla</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>tears</td>
<td>+ / -</td>
<td>+ / -</td>
<td>+ / -</td>
</tr>
<tr>
<td>vocalization</td>
<td>+ / -</td>
<td>+ / -</td>
<td>+ / -</td>
</tr>
<tr>
<td>facial muscles</td>
<td>+ / -</td>
<td>+ / -</td>
<td>+ / -</td>
</tr>
<tr>
<td>eyelids</td>
<td>+ / -</td>
<td>+ / -</td>
<td>+ / -</td>
</tr>
<tr>
<td>middle ear muscles</td>
<td>+ / -</td>
<td>+ / -</td>
<td>+ / -</td>
</tr>
</tbody>
</table>

Polyvagal Theory: Phylogenetic Stages of Neural Control

<table>
<thead>
<tr>
<th>Stage</th>
<th>ANS Component</th>
<th>Behavioral Function</th>
<th>Lower motor neurons</th>
</tr>
</thead>
<tbody>
<tr>
<td>III</td>
<td>Myelinated vagus (VVC – ventral vagal complex)</td>
<td>Social communication, self-soothing and calming, inhibit sympathicoadrenal influences</td>
<td>Nucleus ambiguus</td>
</tr>
<tr>
<td>II</td>
<td>Sympathetic-adrenal system (SNS – sympathetic nervous system)</td>
<td>Mobilization (active avoidance)</td>
<td>Spinal cord</td>
</tr>
<tr>
<td>I</td>
<td>Unmyelinated vagus (DVC – dorsal vagal complex)</td>
<td>Immobilization (death feigning, passive avoidance)</td>
<td>Dorsal motor nucleus of the vagus</td>
</tr>
</tbody>
</table>
Polyvagal Theory: A Phylogenetic Hierarchy of Response Strategies

<table>
<thead>
<tr>
<th>Structure</th>
<th>Function</th>
<th>VVC</th>
<th>SNS</th>
<th>DMX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>Communication</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limbs</td>
<td>Mobilization</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Viscera</td>
<td>Immobilization</td>
<td></td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

The Face: A Critical Component of a Social Engagement System

- Unlike reptiles, the mammalian nervous system needs a “caregiver” to survive and signals the caregiver via the muscles of the face and head.
- The face is “hardwired” to the neural regulation of visceral state via a mammalian “neural circuit.”
- Physical and mental illness retract the “mammalian” neural circuit with the resultant symptoms of a face that does not work.

Unveiling Darwin

Social Engagement System: Observable Deficits in Several Psychiatric and Behavioral Disorders

- Prosody
- Gaze
- Facial expressivity
- Mood and affect
- Posture during social engagement

Phylogenetic Organization of the ANS: The Polyvagal Theory

My Child’s Face Does Not Work!

© 2003 Stephen W. Porges. All rights reserved
When Other Faces Do Not Work!

Beauty is a journey that starts with a choice…

Learn about your Choices

When the nervous system fails use Botox!

Autism

The “Social Nervous System”

Voodoo Death: Insights into PTSD

His cheeks blanch, and his eyes become glassy, and the expression of his face becomes horribly distorted. He attempts to shriek but usually the sound chokes in his throat, and all that one might see is froth at his mouth. His body begins to tremble and his muscles twitch involuntarily. He sways backward and falls to the ground, and after a short time he appears to be in a swoon. He finally composes himself, goes to his hut and there frets to death.

R. Herbert Basedow (1925), The Australian Aboriginal

Voodoo Death: Insights into PTSD

- Voodoo Death was defined as death due not disease or injury, but do to emotional stress.
- Cannon assumed that even this “immobilized” response would be associated with increased sympathetic nervous system excitation.
- “If in the future, however, any observer has opportunity to see an instance of voodoo death, it is to be hoped that he will conduct the simpler tests before the victim’s last gasp.”

Hopelessness: Vagal or Sympathetic Mechanisms?

“...we believe that human victims, like our rats, may well die a parasympathetic rather than a sympathetic death, as Cannon postulated”

C.P. Richter (1957)

A New Paradigm?

- If social behaviors are not learned, are they emergent properties of specific neurophysiological states?
- If dysfunctional social behavior is a spontaneously occurring emergent property of the nervous system (i.e., part of a feedback loop), could intervention strategies be focused on manipulating or supporting the neurophysiological states (e.g., engaging and exercising feedback loops) from which social behavior would spontaneously occur?

New Model

- Mobilization
- Behavioral/Psychological Outcomes
- Social Nervous System
- Social Communication
  - State regulation
  - Hypertension
  - Gut problems
  - Anxiety disorders
- Hypovagal
  - Vasovagal syncope
  - Fibromyalgia
- “Insult”
- Hyperarousal
- Hypervigilance
- Avoidant Social Withdrawal
- Affect Limitations
- Self-medication
- Dissociative states
- Risk of Suicide

Reverse Engineering:
A Treatment Model

- Behavioral/Psychological Outcomes
- Social Nervous System
- Social Communication
  - Mobilization
  - Immunization
- Intervention
- Enhanced social behavior
  - Affect regulation
  - State regulation

The Listening Project:
Principles of Intervention

- **Principle 1.** *Less is more* (fragile system)
- **Principle 2.** The intervention must occur in a “safe” environment (“neuroception”)
- **Principle 3.** The auditory system has an efferent component that actively *select* human voice from background sounds (corticobulbar)
- **Principle 4.** Due to common embryological development in the nervous system, the cortical regulation required to select human voice will improve state regulation and social behavior (special visceral efferent pathways - SVE)
Measuring Eye Gaze

The Listening Project: Effects of the Intervention?
- Triggers the “Social Engagement System”
- Stimulates processes associated with attention, intention, and contingency
- Increases looking, listening, vocalizing and responding
- Increases the “integration” of social engagement behaviors

What we know?
- Noticeable effects on the Social Engagement System in 3-5 year old ASD
  - Effects observed in about 80% of approximately 100 subjects
  - Parental reports
  - Behavioral coding of video tapes

What Needs to be Done?
- Apply The Listing Project to other psychiatric diagnostic categories that have affect regulation problems.
- Validate the neural mechanisms mediating the behavioral changes (fMRI, NIRS, ANS, facial EMG & IR thermography) to demonstrate the involvement of frontal areas of cortex (i.e. corticobulbar pathways).
- Expand intervention strategies to efficiently trigger neural circuits to support social behavior
Summary

• “Neuroception” of safety or danger mediates the beneficial consequences of social behavior.
• Autonomic reactions to challenges are organized in a phylogenetically-determined hierarchy.
• Various atypical behaviors are adaptive for short periods.
• Several psychopathologies are expressed as deficits in the Social Engagement System.
• Biologically-based behavioral interventions can trigger neural circuits that mediate positive social behavior.

The Future of Biobehavioral Research: New Organizational Principles

- Several physical and psychiatric diseases are emergent properties of the neural regulation of the autonomic nervous system (feedback, evolution, development)
- New diagnoses and new treatments will emphasize measurement and manipulation of the neural regulation of the autonomic nervous system
- Environments will be designed that support the functions of the nervous system
  - Computers that modulate neural regulation of the ANS
  - Quiet environments
  - Nervous system “friendly” classrooms
  - Improved social behavior: People need people – a biological basis

Blissful, but not social!