Music asTherapy:

Insights from the Polyvagal Theory

Stephen W. Porges, Ph.D.
Department of Psychiatry
University of North Carolina

Music asTherapy:

Exploring the common mechanisms mediating autonomic regulation, vocalizations, and listening

Stephen W. Porges, Ph.D.
Department of Psychiatry
University of North Carolina

Music as Therapy

1. Our nervous system evolved to detect intonations in a specific frequency band. Prosodic voice and music capitalize on this phenomenon.
2. Tempo is linked heart rate. Tempo is associated with the heart rate needed to conduct the activity characterized in the music such as a march or lament.
3. Phrasing is based on breathing rates (3 to 8 seconds) and even endogenous blood pressure “waves” (10-20 seconds).
4. Manipulating tempo, phrasing, and frequency bannd (e.g., melody or music prosody) can influence the physiological of the listener.

Music as Therapy

1. Physical features of music emphasize modulation of frequencies exaggerating features of human prosody and trigger states of safety.
2. Low frequencies are associated with danger and predator and can trigger state changes that preclude the processing human voice.
3. Therapeutic engagement emphasizes face-to-face interactions, which require “exercise” of the striated muscles of the face and head (facial muscles, oromotor activity, laryngeal, pharyngeal, respiratory, and neck).
4. Therapy requires contingent interactions in which the role of “leader” is shifted among participants.

Music as Therapy:
Deconstructing

1. The importance of face-to-face interactions.
2. Polyvagal Theory: Explanation of adaptive physiological and behavioral responses to safety, danger, and life threat.
3. Neuroception: Neural feature detectors trigger adaptive states to promote social engagement behaviors or defensive strategies.

Music as Therapy:
Deconstructing

1. The importance of face-to-face interactions.

The importance of the face-to-face interactions in music as therapy

1. Why are face-to-face interactions so important?
2. How do face-to-face interactions change our physiology to promote states of social awareness?

The importance of the face-to-face interactions in music as therapy

- Features of safety (neuroception)
- Reciprocity in music as a neural exercise
  - Listening
  - Expressing
  - Role reversal

Music as Therapy:
Deconstructing

- The importance of face-to-face interactions.
- Music and vocalizations
  - Common acoustic features (pitch, prosody)
  - Common emotional and psychological meaning
- Polyvagal Theory
  - Adaptive physiological and behavioral responses to species specific acoustic features that trigger physiological states of safety, danger, and life threat.
  - Successful composers are masters of the above

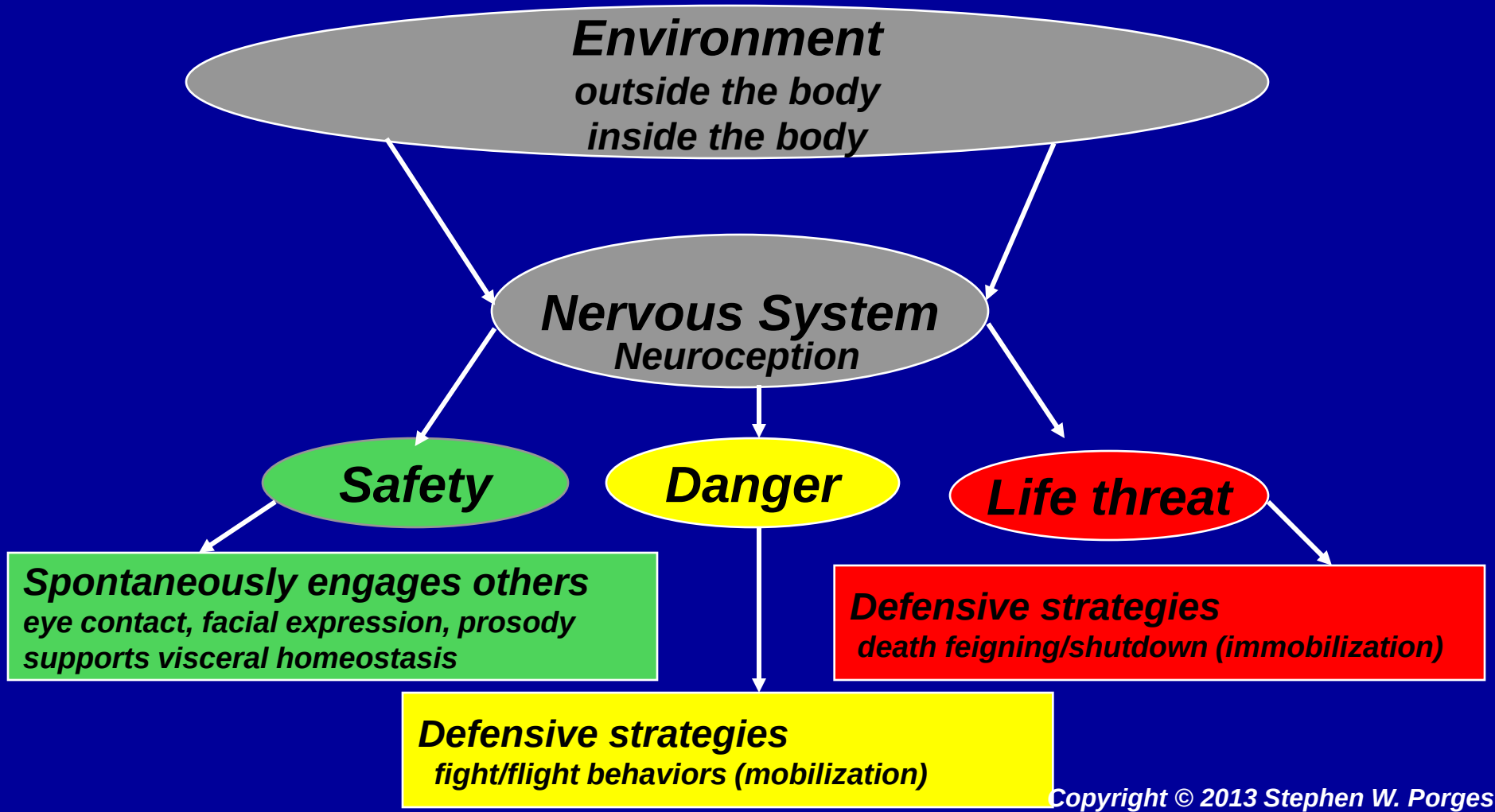
The Polyvagal Theory

1. How did mammals survive in a world that was dominated by reptiles? *(Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A Polyvagal Theory)*
2. Mammals required social interactions to support their young.
3. Mammals required a social communication system – outside the frequency band of reptiles – to “signal” safety and alarm to conspecifics.
4. Mammals required a social communication system to convey to their conspecifics whether they were safe to approach.

The Polyvagal Theory

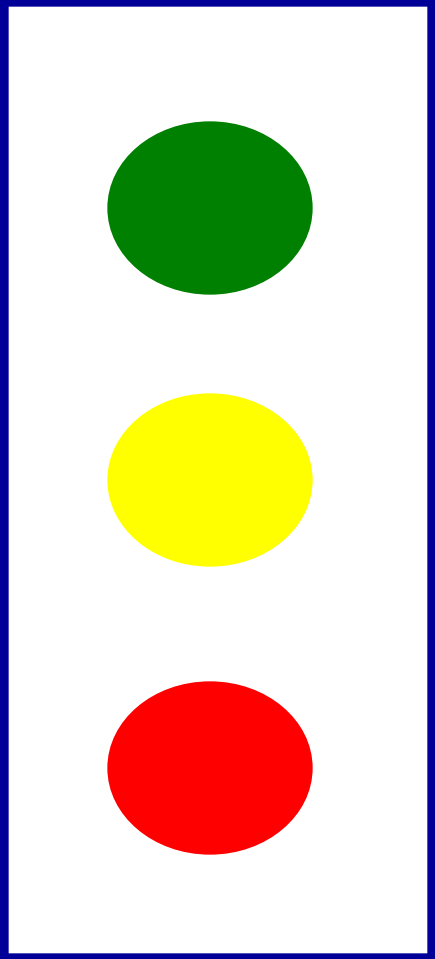
1. Evolution provides an organizing principle to understand neural regulation of the human autonomic nervous system as an enabler of social behavior.
2. Three neural circuits form a phylogenetically-ordered response hierarchy that regulate behavioral and physiological adaptation to safe, dangerous, and life threatening environments.
3. "Neuroception" of danger or safety or life threat trigger these adaptive neural circuits.

The Quest for Safety:
Emergent Properties of Physiological State



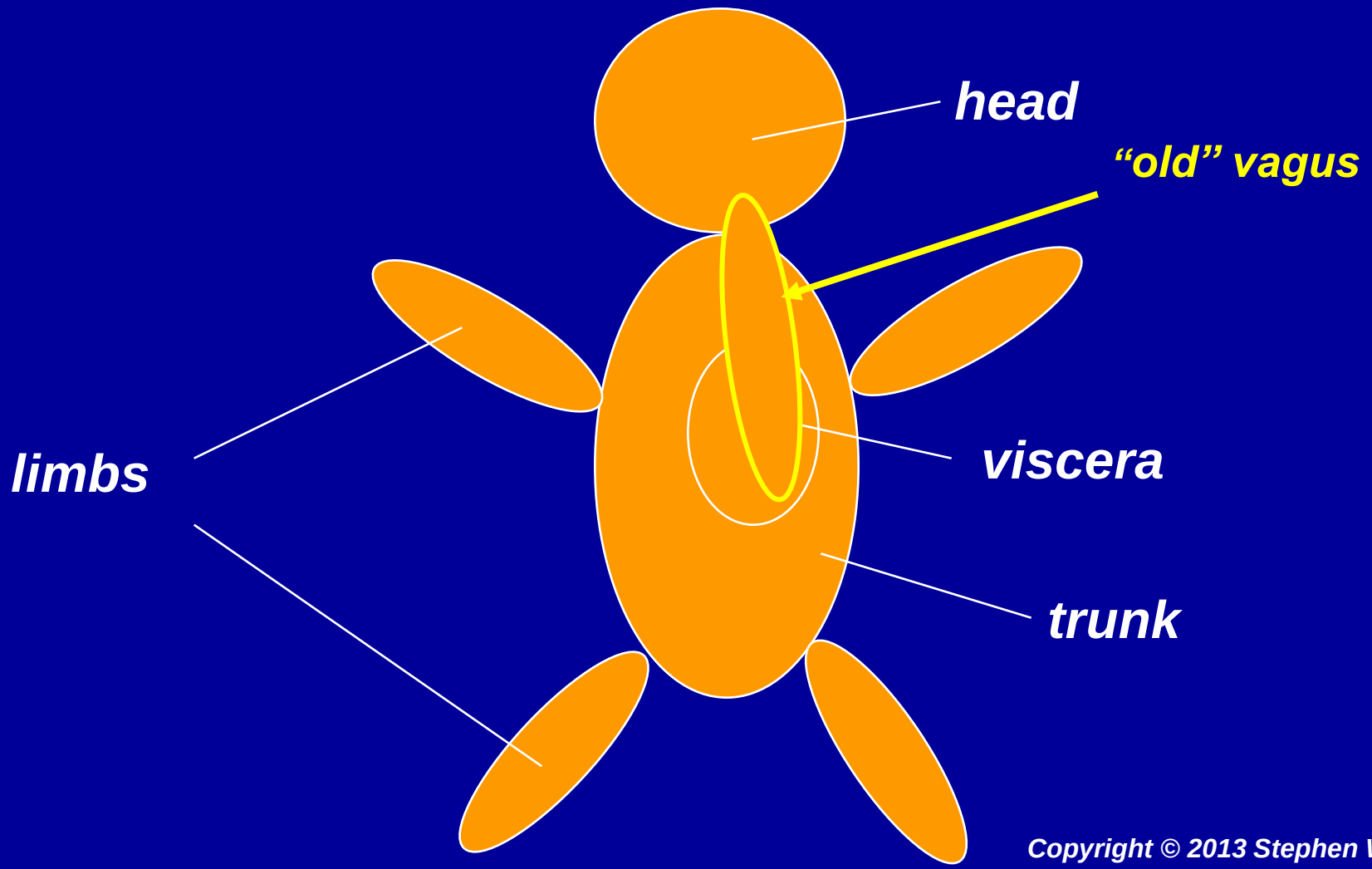
Physiological State Colors our Perception

S - - R

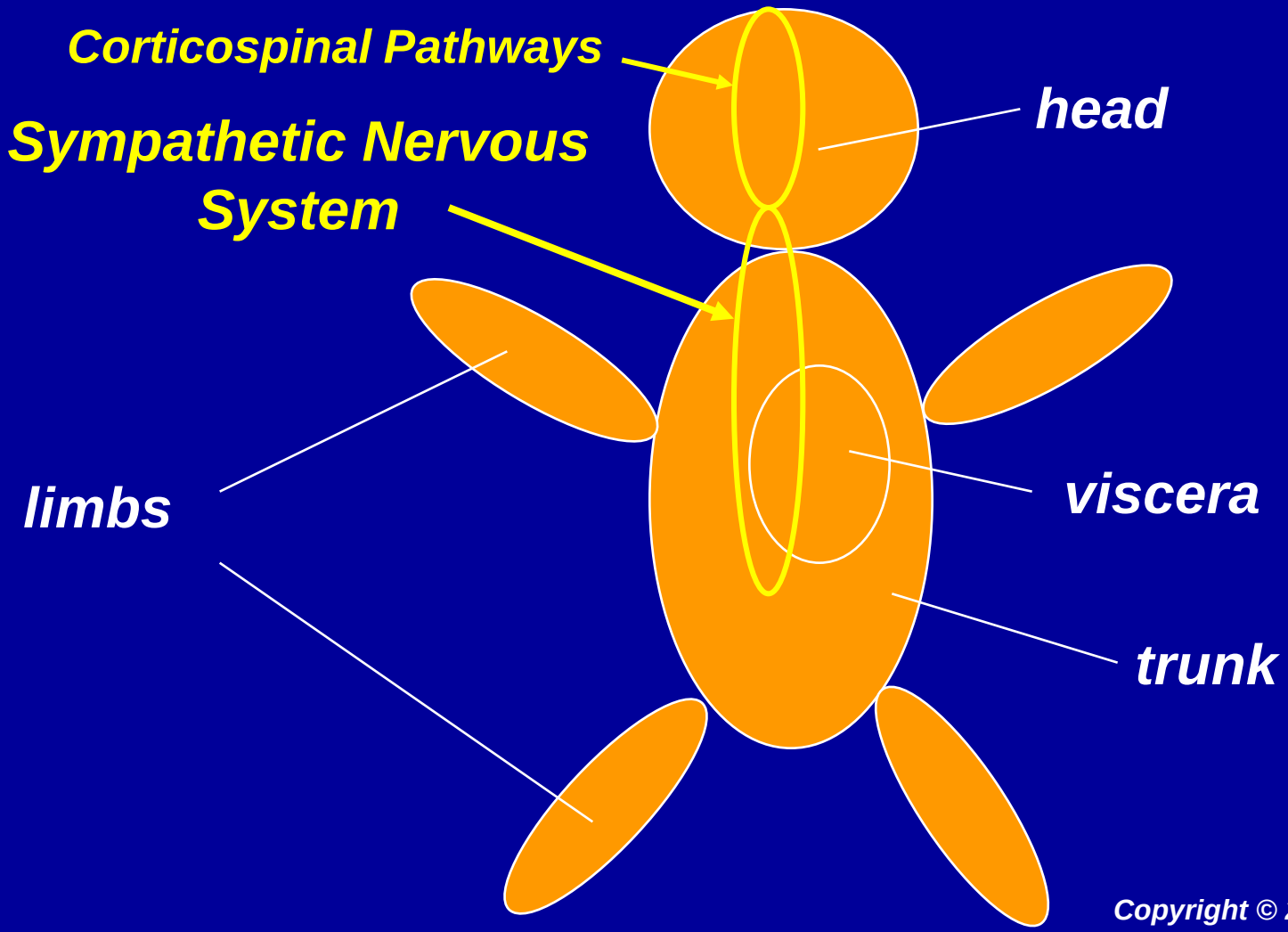


Physiological State

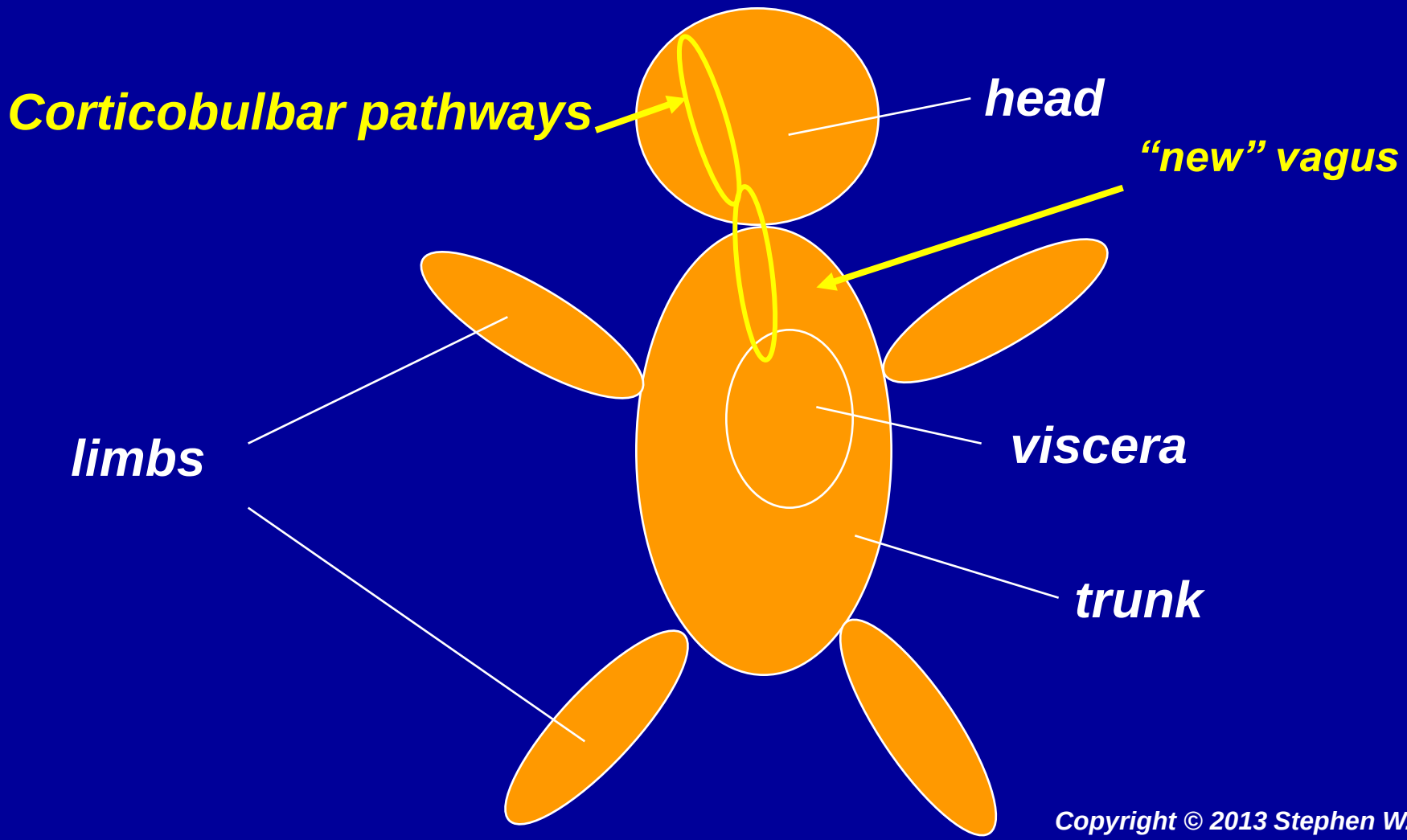
Phylogenetic Organization of the ANS: The Polyvagal Theory



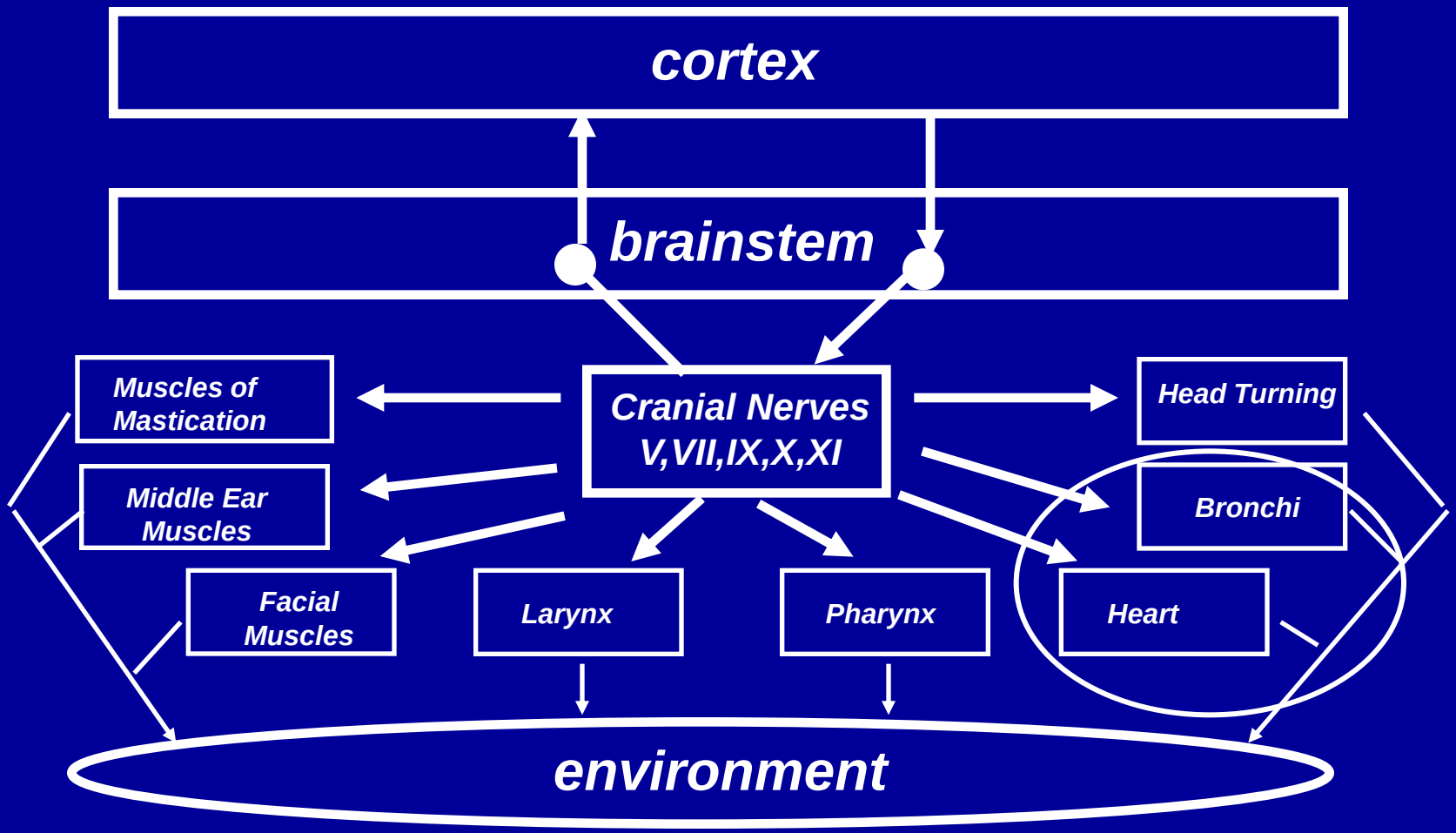
Phylogenetic Organization of the ANS: The Polyvagal Theory



Phylogenetic Organization of the ANS: The Polyvagal Theory



Deconstructing the "*Mammalian*" Social Engagement System



The Heart-Face Connection:

A Critical Component of a Social Engagement System

- In mammals, at birth the bidirectional neural communication between the face and the heart forms the core of a Social Engagement System.

- Metabolic demands, perceived danger, life threat, and illness retract the Social Engagement System resulting in a face that is not “social” and a physiological state (removal of the vagal brake on the heart) that promotes defensive behaviors.

Social Engagement System:
Observable Deficits in Several Psychiatric Disorders

- Prosody
- Gaze
- Facial expressivity
- Mood and affect
- Posture during social engagement
- State regulation
- Sound hypersensitivities

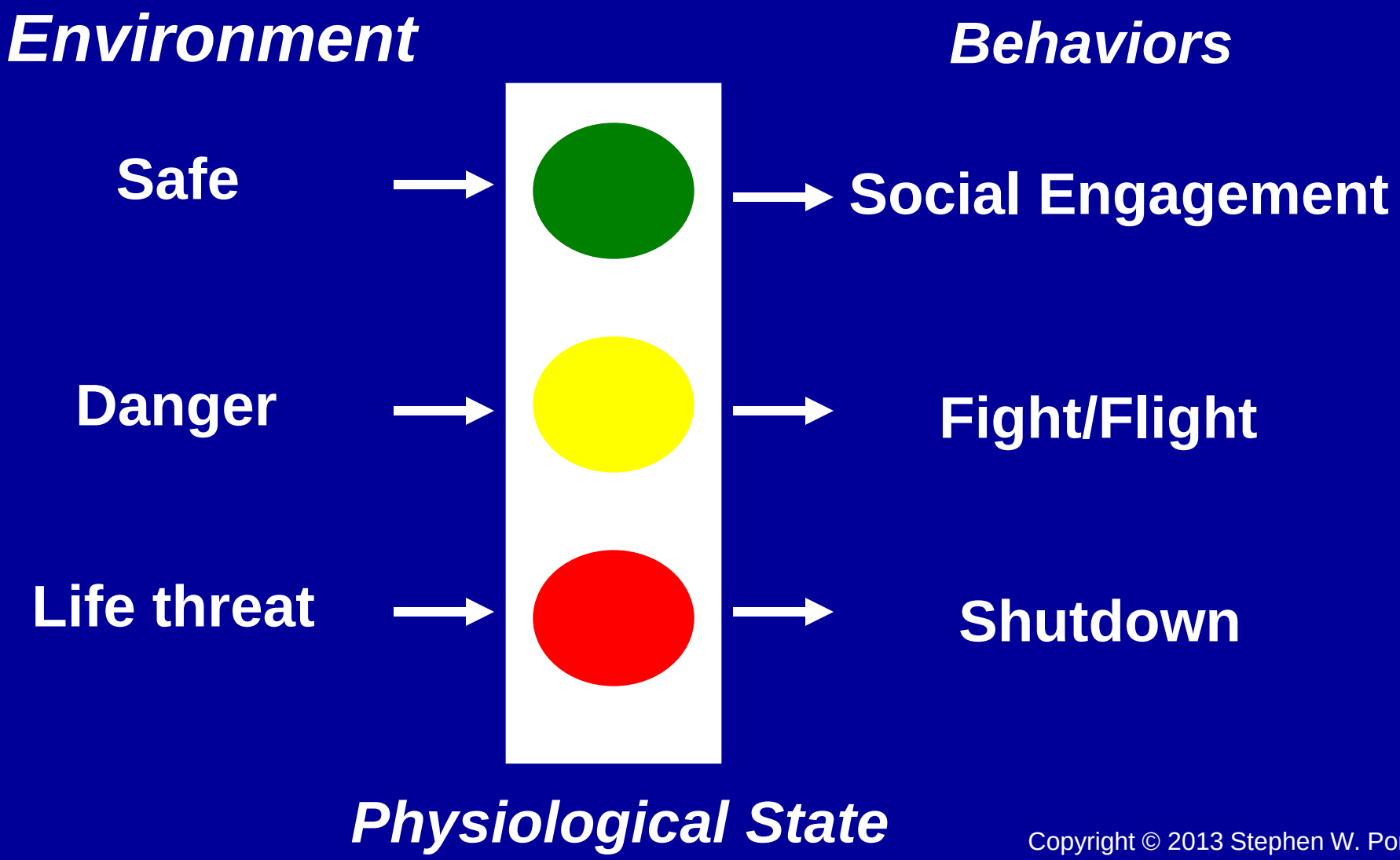
Music as Therapy:
Neural exercises rehabilitating and optimizing the Social Engagement System

- Active and interactive
  - Facial expressions
  - Vocalizations
  - Listening
  - Breathing
- Passive
  - Listening
  - Acoustic features of safety

Music as Therapy:
Deconstructing

1. The importance of face-to-face interactions.
2. Polyvagal Theory: Explanation of adaptive physiological and behavioral responses to safety, danger, and life threat.
3. Neuroception: Neural feature detectors trigger adaptive states to promote social engagement behaviors or defensive strategies.

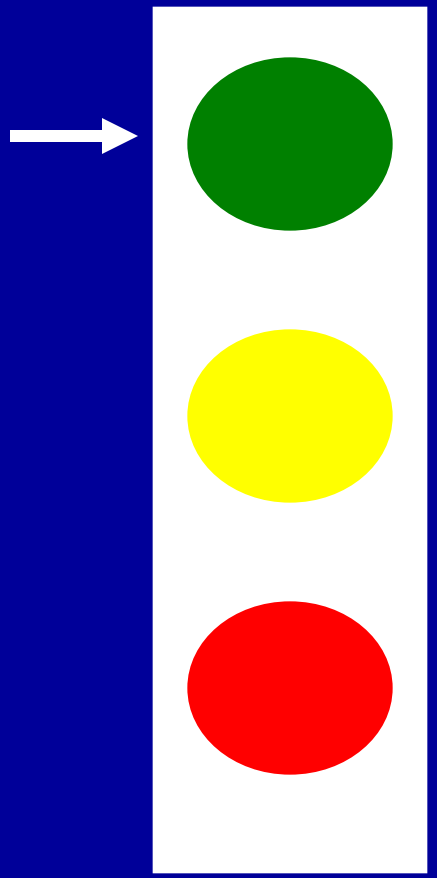
Neuroception



Neuroception

Environment

Behaviors



Safe

Social Engagement

Play

Loving Behaviors

Physiological State

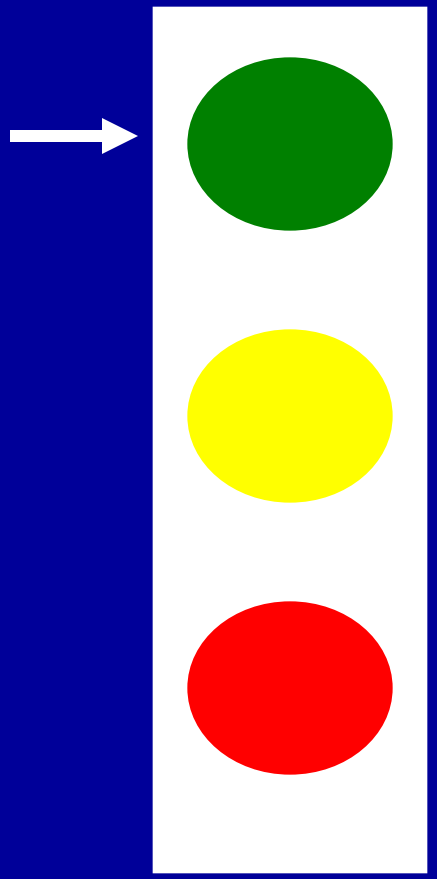
Immobilization Without Fear

Neuroception:
Impact of music

Environment

Feelings

Safe



Safe, social, loving

Playful

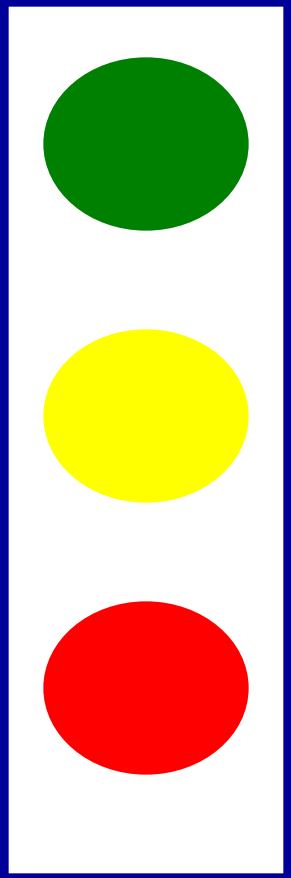
Intimacy

Physiological State

Neuroception:
Impact of music

Environment

Feelings



Dangerous →

→ **Dangerous, patriotic**

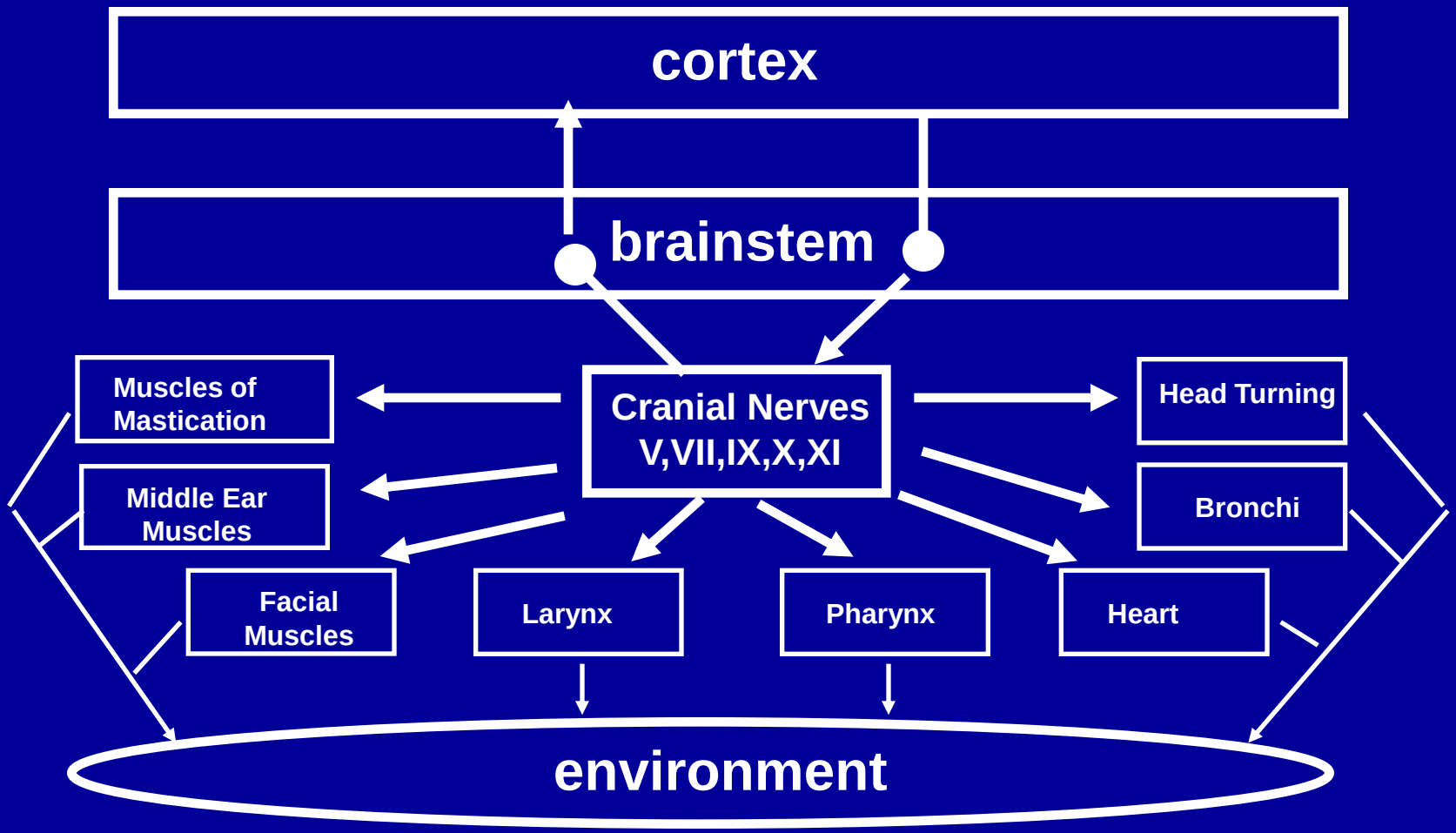
→ **Impending doom**

Physiological State

Music Therapy:
Deconstructing

1. The importance of face-to-face interactions.
2. Polyvagal Theory: Explanation of adaptive physiological and behavioral responses to safety, danger, and life threat.
3. Neuroception: Neural feature detectors trigger adaptive states to promote social engagement behaviors or defensive strategies.
4. Social Engagement System: A common mechanisms mediating autonomic regulation, vocalizations, and listening.

The "*Mammalian*" Vagus and Social Engagement System



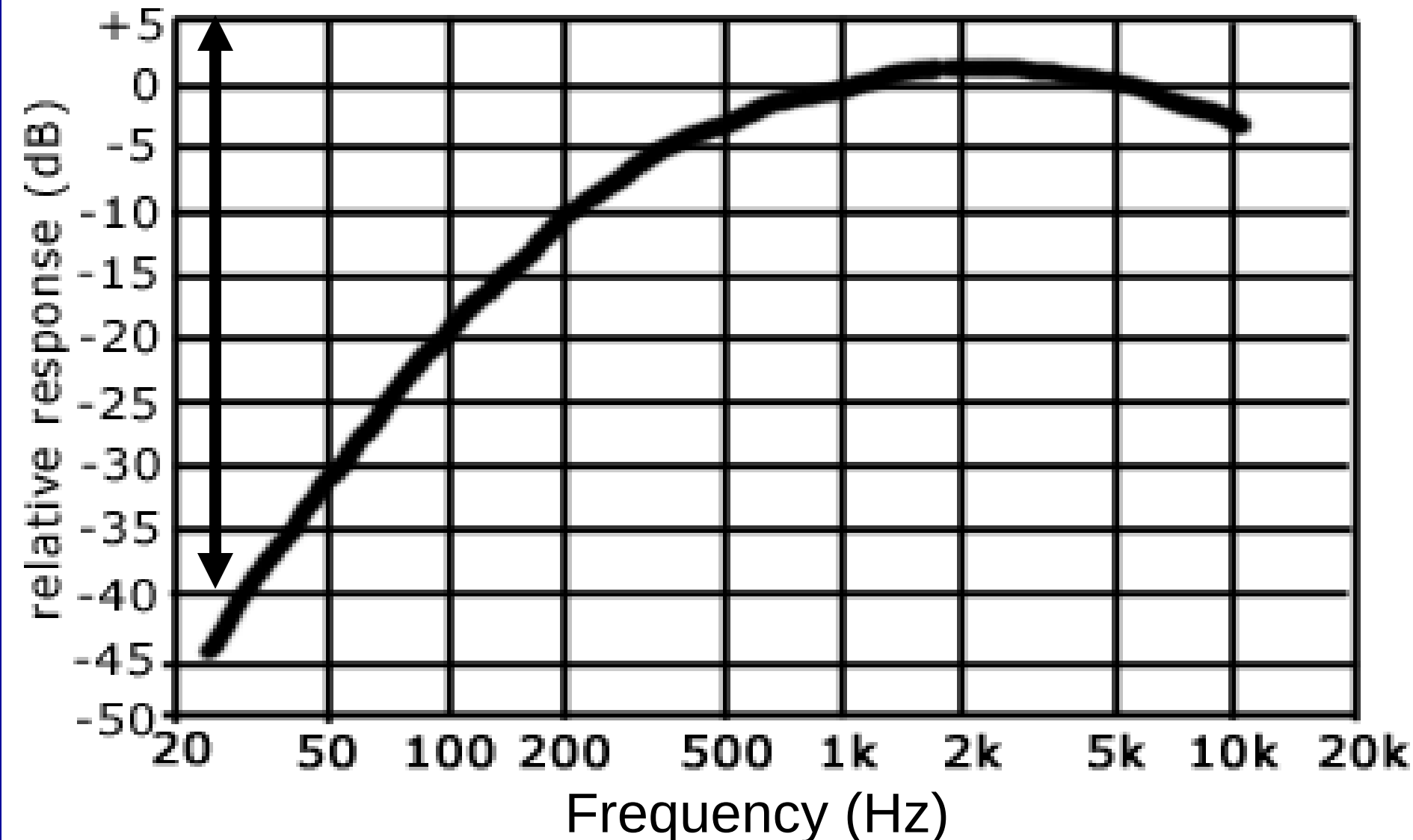
Detached Middle Ear Bone:
A mammalian feature

- Detached middle ear bones are a defining feature of mammals.
- Living mammal species can be identified by the presence in females of mammary glands. Since mammary glands and other soft-tissue features are not visible in fossils, detached middle ear bones are used.
- Without “detached” middle ear bones, low amplitude sounds in higher frequencies would not be heard. Thus, enabling mammals to communicate in a frequency band that is difficult to hear for reptiles.
- Without functioning middle ear muscles we are hypersensitive to the low frequencies that signal predator!

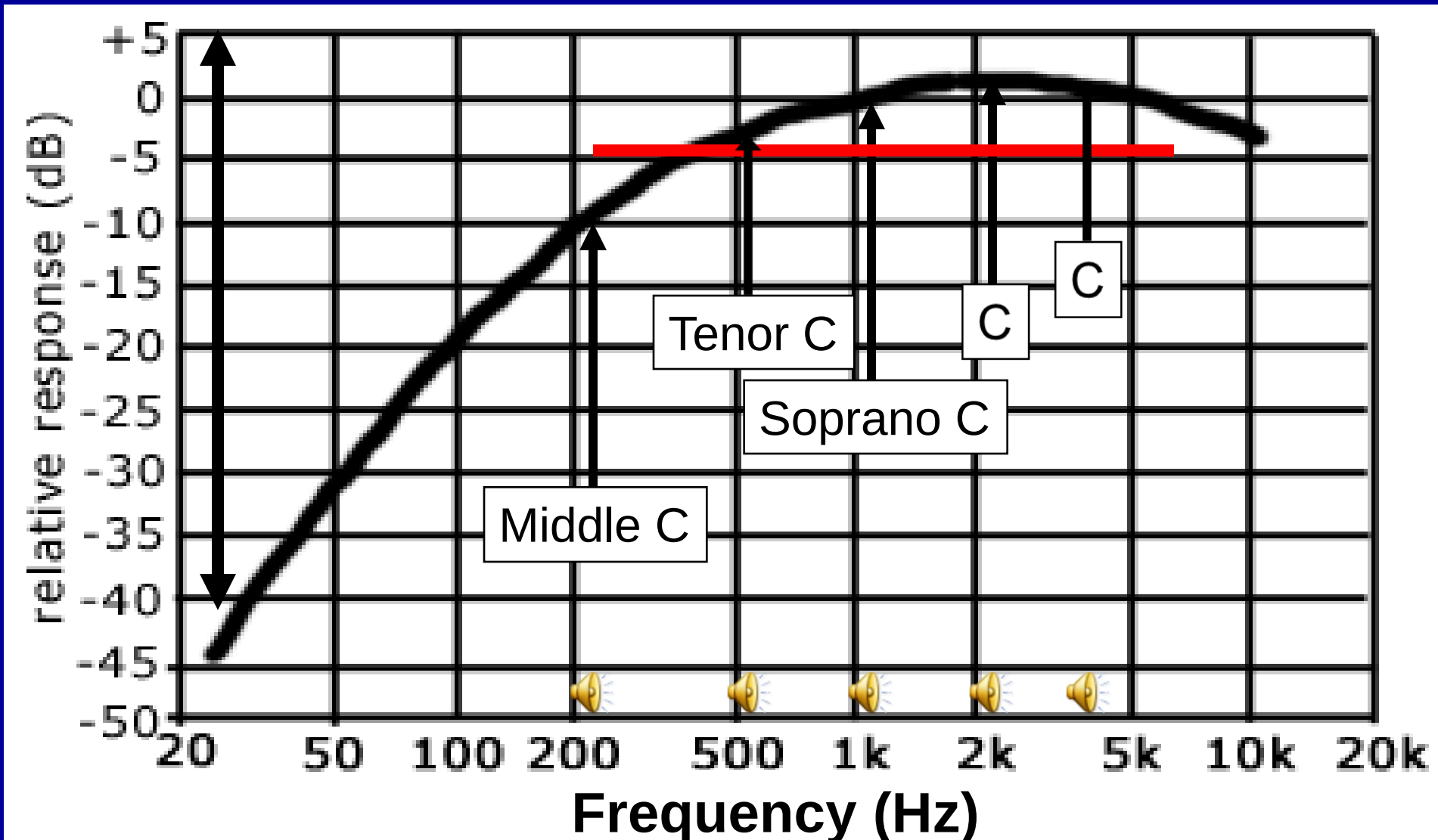
The Role of the Middle Ear:
Extraction of Human Voice

- Evolution and middle ear bones
- Transfer function of the middle ear
- Frequency band of perceptual advantage

What Normal Ears Hear:
Low Frequency Attenuation



Articulation Index:
Determining intelligibility of voice



What happens when the middle ear muscles are not working correctly?

Auditory Hypersensitivities:
A Feature of Autism?

46% autism (n=146)

Porges et al. (under review)

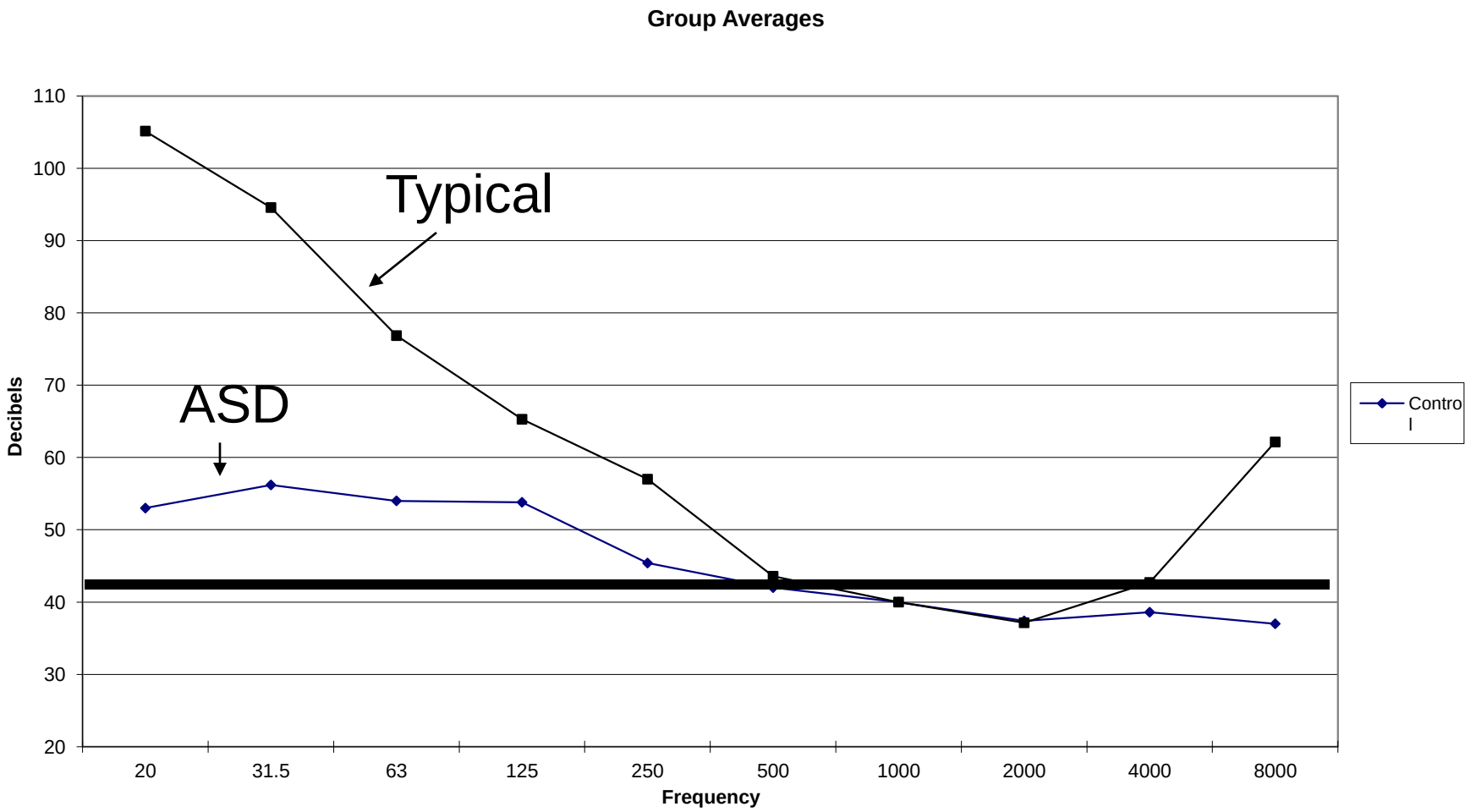
46% autism (n=230)

Dr. Ira Cohen (personal communication)

57% autism (n=177)

Dr. David Skuse (personal communication)

Normal and Autistic Loudness Contours



The Role of Breath in Music:
Triggering Neural Regulation of State

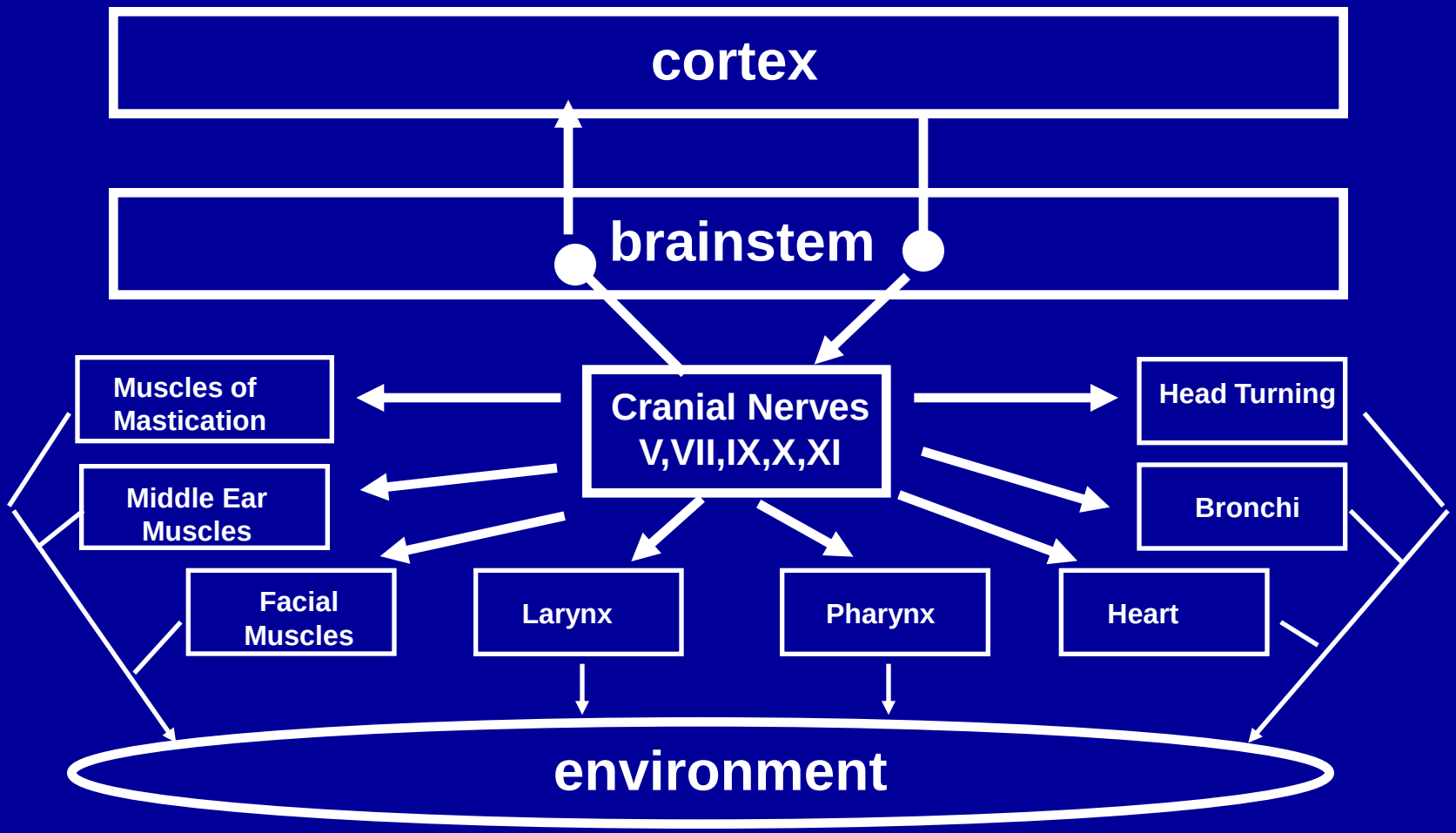
The Role of Breath

- Breathing modulates the “ventral” vagus
- Inhalation turns off the vagal brake (i.e., heart rate increases)
- Exhalation turns on the vagal brake (i.e., heart rate decreases)
- Breathing therapies exercise the vagal brake

Common Features between Wind Instruments and Pranayama Yoga

- Pranayama yoga is yoga of the Social Engagement System
- Exercising the Social Engagement system
  - Striated muscles of the face to play and listen (embouchure, middle ear muscles)
  - Respiratory-heart rate regulation (diaphragmatic breathing)

The "*Pranayama*" Social Engagement System



Can Sound Regulate State?

Sound and Neuroception

- Do the acoustic features of voice, music, or background noise influence our ability to feel safe?
- Do therapies use “listening” as a portal of treatment?

Listening to Music: A method to feel safe

- Principles
  - Frequency band
  - Modulation of frequencies (e.g., prosody, melody)
  - Rhythm (heart beat, breathing)
  - (Syntax?)

Prosody

- Prosody describes the perception of feelings expressed in speech.
- Predates the evolution of human language.

Prosody

“Even monkeys express strong feelings in different tones — anger and impatience by low, fear and pain by high notes.”

Charles Darwin, The Descent of Man (1871).

The Adaptive Function of Prosody

Feature detectors for prosody (not specific to music) are in our “genes” (e.g., Polyvagal Theory) and have an adaptive function to signal safety.

The modulation (prosody) of higher frequencies trigger states of safety.

The low frequencies signal danger and trigger states of fight/flight.

Can we trigger “circuits” of safety to promote spontaneous social engagement via an “imposed” computer exaggeration of prosody?

Sound and Neuroception

- Composers use different acoustic frequencies to express their musical narrative.
  - Frequencies of human voice (especially female) signal safety
  - Lower frequencies signal predator.

Can Sound Regulate State?

- Do the acoustic features of voice, music, or background noise influence our ability to feel safe?

Can Sound Regulate State?

- What are the influences of frequency band (e.g., bass, no bass) and modulation of frequency (e.g., melody, prosody)?
  - Chants
  - Popular examples
    - Disney
    - Barry White
    - Rap
    - Lullabies

Music and Emotion:
Peter and the Wolf (Prokofiev)

What emotions (pleasant or unpleasant) do the sounds represent?

- Peter
- Grandfather
- Bird
- Cat
- Duck
- Wolf
- Hunter

Safety and Fear in the "Frequencies" of Music

Bird – Flute
Cat – Clarinet
Duck - Oboe
Peter - Strings

Grandfather - Bassoon
Wolf - Horns

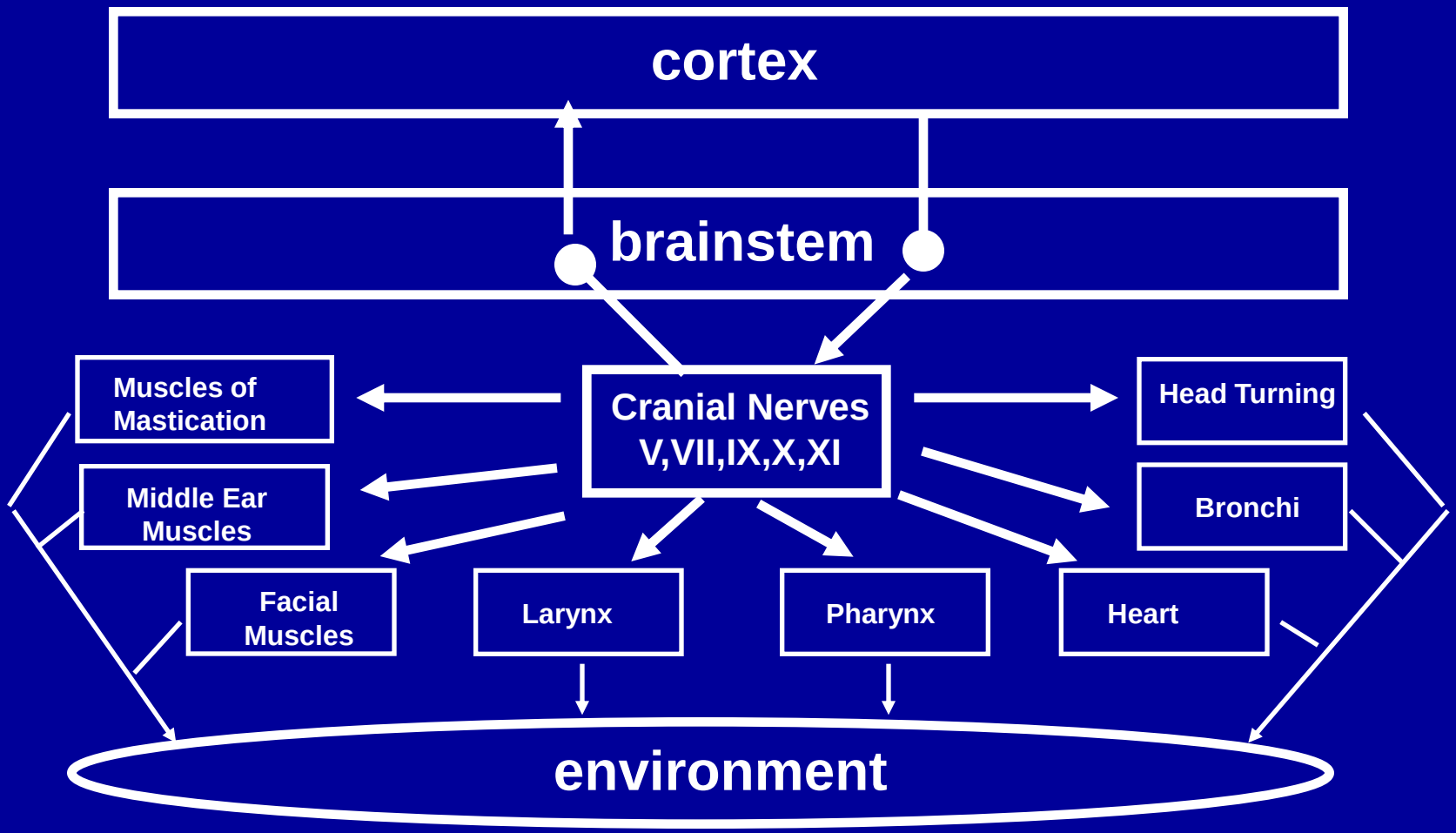
Hunters - Timpani (Kettle drums)

Music and Human Speech:
Common "Neuroceptive" Features

- Our nervous system may process music similar to prosody in human voice.
- Music may be more salient than voice to neural "feature detectors" scanning the environment for risk.
- Vocal music (chants) might be very effective in triggering a neuroceptive state of safety and dampening defense systems.

Is there a simple biobehavior explanation?

Music (active & passive) exercises the Social Engagement System



Listening to Music and Voice as Therapy

1. Does music share features with human voice?
2. Is there a biobehavioral basis to support the hypothesis that listening to music and/or human voice will facilitate social, emotional, and cognitive function?

Music and Human Speech:
Common "Neuroceptive" Features

- Our nervous system may process music similar to prosody in human voice.
- Music may be more salient than voice to neural "feature detectors" scanning the environment for risk.
- Vocal music (chants) might be very effective in triggering a neuroceptive state of safety and dampening defense systems.

What happens when the middle ear muscles are not working correctly?

Atypical Sensory Experiences

…the prevalence of abnormal sensory phenomena may be over 60% for individuals with autism. …..

…abnormalities are particularly evident in hearing (Goldfarb, 1963; Ornitz, 1974; Grandin & Scariano, 1986) and a hyper-reactivity to auditory stimulation (i.e., hyperacusis) (Grandin & Scariano, 1986; Rosenhall, Nordin, Sandstrom, Ahlsen, & Gillberg, 1999).

An increased awareness of environmental noises and difficulty in hearing speech in background noise are also prominent auditory features in autism (Grandin & Scarianoi, 1986; Boatman, Alidoost, Gordon, Lipsky, & Zimmerman, 2001).

Music and Human Speech:
Common Features

Music functions similar to “exaggerated” prosody and triggers “feature detectors” in our nervous system that scan the environment for risk.

Music is effective in triggering a neuroception of safety and dampening defense.

Music as Therapy:
Deconstructing

Music “exercises” the neural regulation of the middle ear muscles?

If middle ear muscles are rehabilitated in function what implications does this have on the physical and mental health of the individual?

Auditory Processing: Autism

Contents lists available at SciVerse ScienceDirect

International Journal of Psychophysiology

journal homepage: www.elsevier.com/locate/ijpsycho

Respiratory sinus arrhythmia and auditory processing in autism: Modifiable deficits of an integrated social engagement system?

Stephen W. Porges [a,c,*,1], Matthew Macellaio [a,b,2], Shannon D. Stanfill [a,b,3], Kimberly McCue [a,b,4], Gregory F. Lewis [a,c,5], Emily R. Harden [a,6], Mika Handelman [a,7], John Denver [a,8], Olga V. Bazhenova [a], Keri J. Heilman [a]

[a] Brain-Body Center, Department of Psychiatry, University of Illinois at Chicago, 1601 W. Taylor St., Chicago, IL 60612, USA
[b] Easter Seals Therapeutic School and Center for Autism Research, 1939 West 13th St., Chicago, IL 60608, USA
[c] Research Triangle Institute (RTI) International, 3040 East Cornwallis Road, Research Triangle Park, NC 27709, USA

ARTICLE INFO

Article history:
Received 2 July 2012
Received in revised form 3 November 2012
Accepted 20 November 2012
Available online xxxx

Keywords:
Respiratory sinus arrhythmia
Heart rate variability
Autism
Auditory processing
Polyvagal Theory

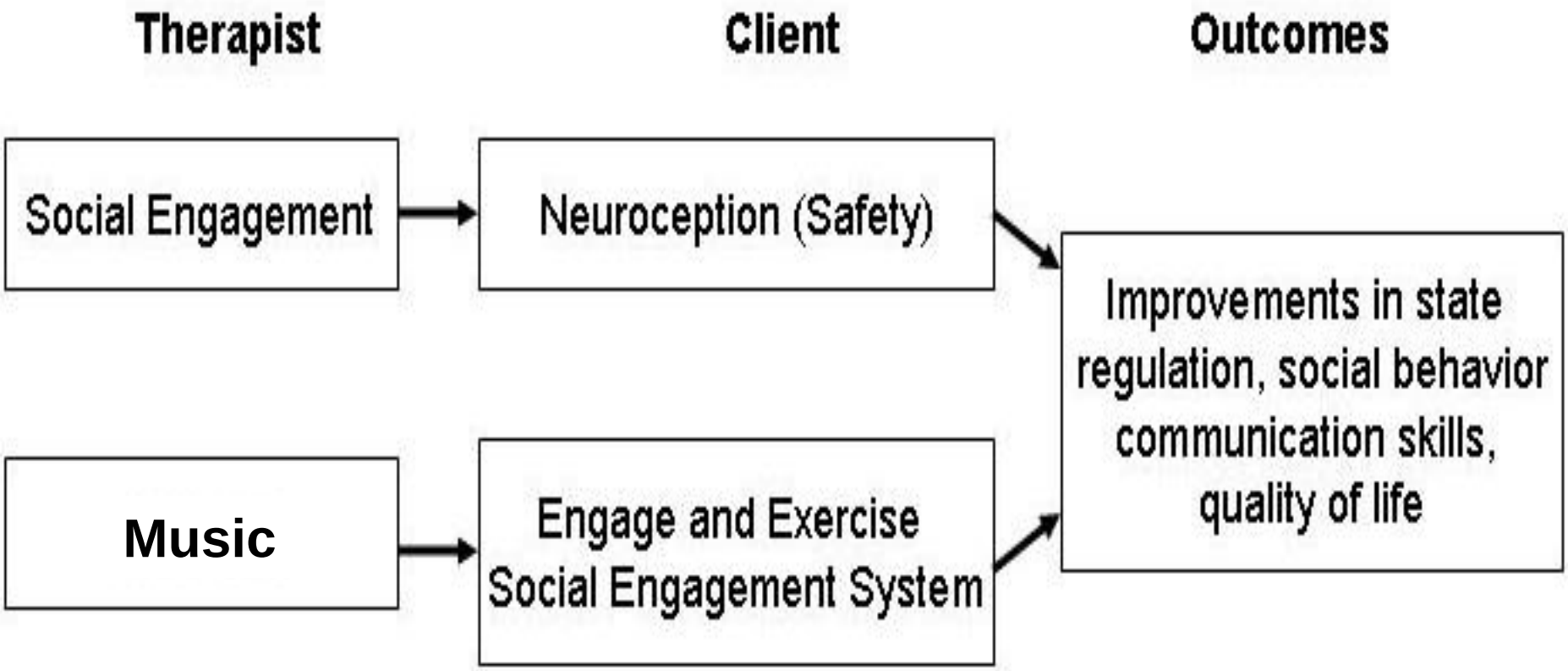
ABSTRACT

The current study evaluated processes underlying two common symptoms (i.e., state regulation problems and deficits in auditory processing) associated with a diagnosis of autism spectrum disorders. Although these symptoms have been treated in the literature as unrelated, when informed by the Polyvagal Theory, these symptoms may be viewed as the predictable consequences of depressed neural regulation of an integrated social engagement system, in which there is down regulation of neural influences to the heart (i.e., via the vagus) and to the middle ear muscles (i.e., via the facial and trigeminal cranial nerves). Respiratory sinus arrhythmia (RSA) and heart period were monitored to evaluate state regulation during a baseline and two auditory processing tasks (i.e., the SCAN tests for Filtered Words and Competing Words), which were used to evaluate auditory processing performance. Children with a diagnosis of autism spectrum disorders (ASD) were contrasted with aged matched typically developing children. The current study identified three features that distinguished the ASD group from a group of typically developing children: 1) baseline RSA, 2) direction of RSA reactivity, and 3) auditory processing performance. In the ASD group, the pattern of change in RSA during the attention demanding SCAN tests moderated the relation between performance on the Competing Words test and IQ. In addition, in a subset of ASD participants, auditory processing performance improved and RSA increased following an intervention designed to improve auditory processing.

Music as Therapy:
re-constructing

1. Physical features of music emphasize modulation of frequencies exaggerating features of human prosody and trigger states of safety.
2. Low frequencies are associated with danger and predator and can trigger state changes that preclude the processing human voice.
3. Therapeutic engagement emphasizes face-to-face interactions, which require “exercise” of the striated muscles of the face and head (facial muscles, oromotor activity, laryngeal, pharyngeal, respiratory, and neck).
4. Therapy requires contingent interactions in which the role of “leader” is shifted among participants.

Therapeutic Model



The Biology of Music

Our nervous system evolved to detect intonations in a specific frequency band. Prosodic voice and music capitalize on this phenomenon.

Tempo is linked heart rate. Tempo is associated with the heart rate needed to conduct the activity characterized in the music such as a march or lament.

Phrasing is based on breathing rates (3 to 8 seconds) and even endogenous blood pressure “waves” (10-20 seconds).

Manipulating tempo, phrasing, and frequency bannd (e.g., melody or music prosody) can influence the physiological of the listener.

Music as Therapy:
Neural exercises rehabilitating and optimizing the Social Engagement System

- Active and interactive
  - Facial expressions
  - Vocalizations
  - Listening
  - Breathing
- Passive
  - Listening
  - Acoustic features of safety