The Early Development of the Autonomic Nervous System Provides a Neural Platform for Social Behavior: *A Polyvagal Perspective*

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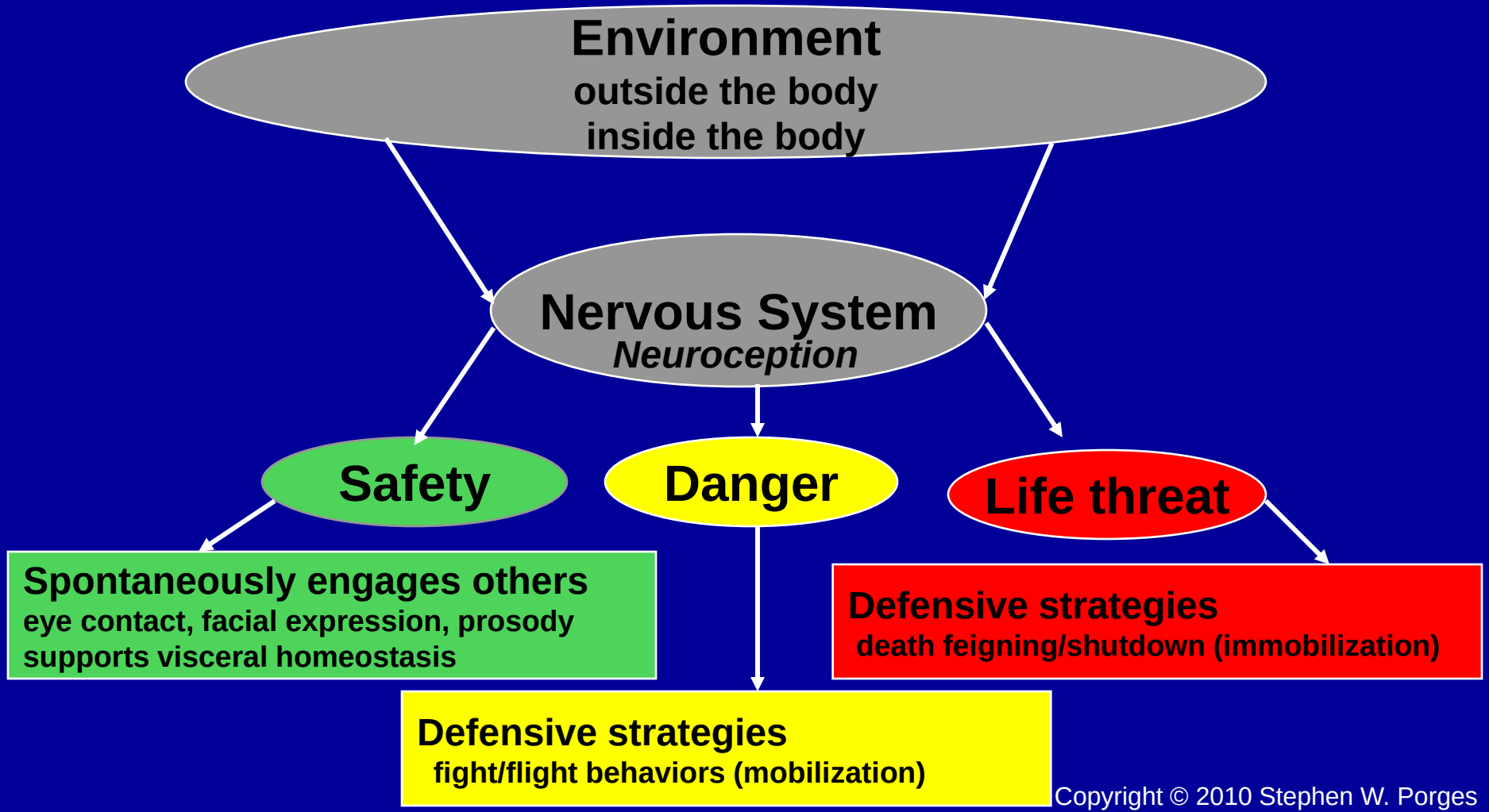
The Polyvagal Theory:
Adaptive Functions



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The Vagal Paradox

- Bradycardia are mediated by the vagus and a risk index
- Heart rate variability is primarily mediated by the vagus and a protective factor

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Functions of the Vagal System

The vagal system involved in the regulation and coordination of heart rate, sucking, swallowing, digestion, vocalizations, and breathing

The vagal system mediates apnea and bradycardia!

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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.

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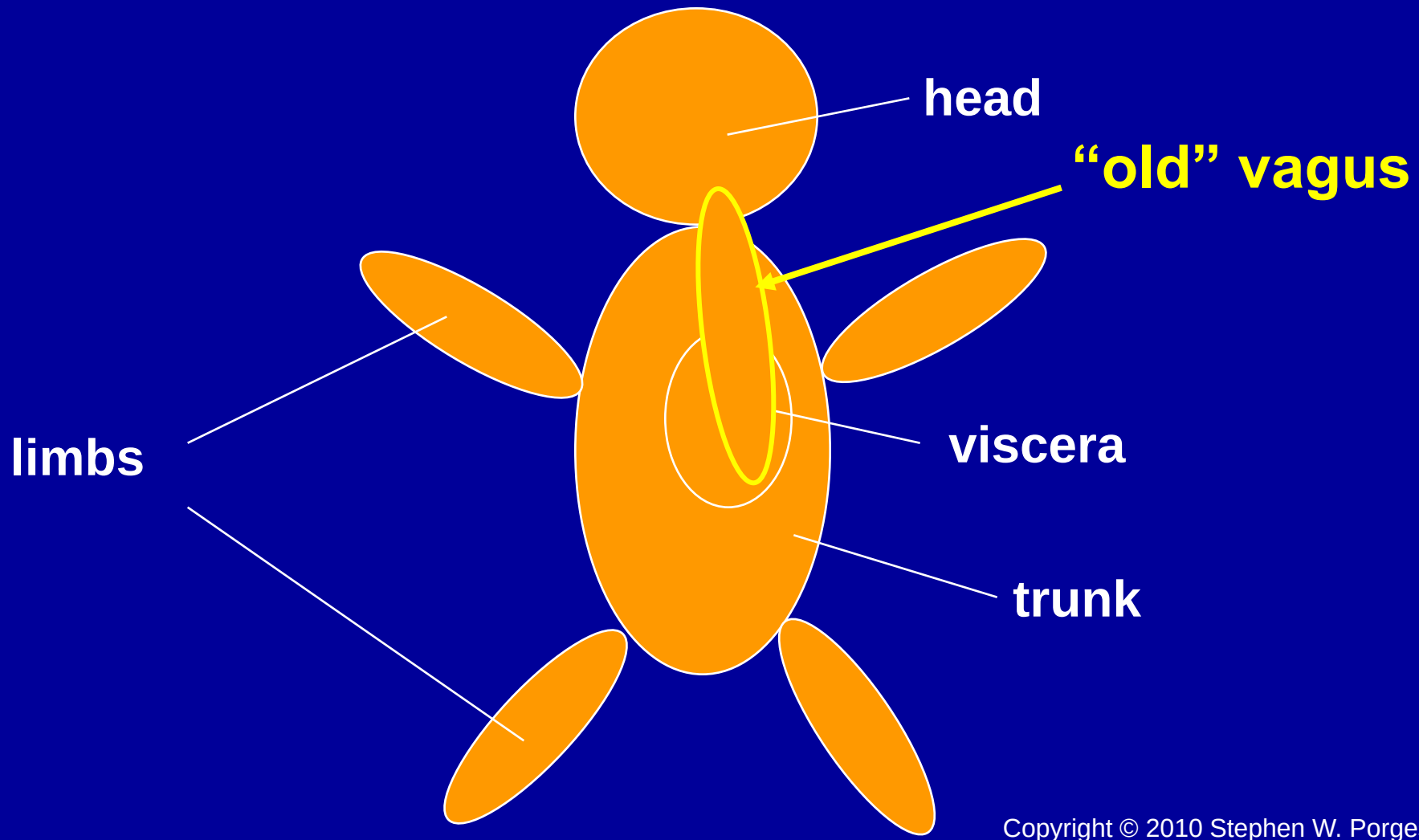
Phylogenetic Organization of the ANS: The Polyvagal Theory



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Apnea/Bradycardia

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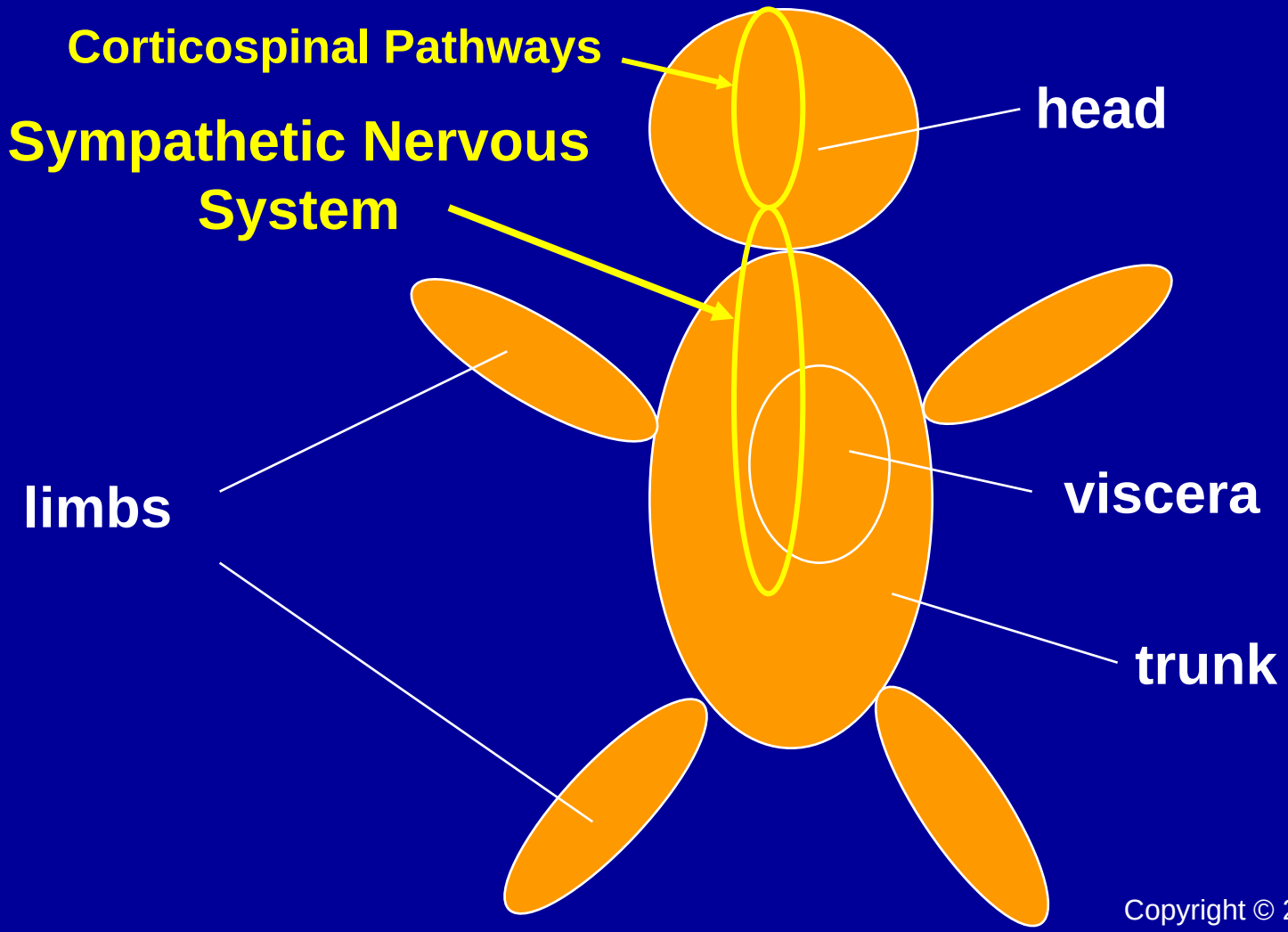

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Mobilization: Fight/Flight Behaviors

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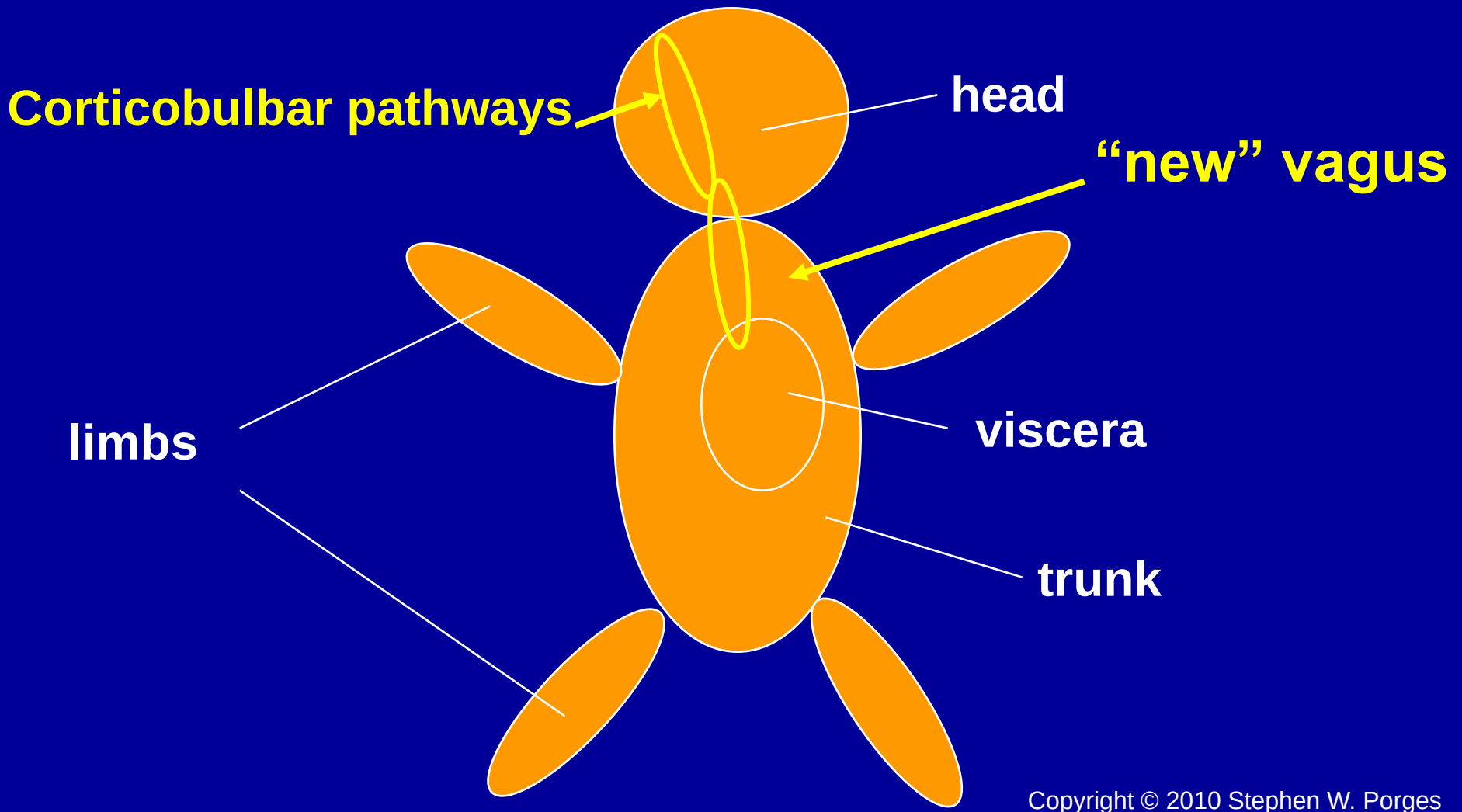
Phylogenetic Organization of the ANS: The Polyvagal Theory



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The Heart-Face Connection:
A Critical Component of a Social Engagement System

- At birth, the face is “hardwired” to the neural regulation of visceral state via a mammalian “neural circuit.”

- Metabolic demands, stress, trauma and illness retract the “mammalian” neural circuit with the resultant symptoms of a face that does not work and social engagement behaviors are absent.

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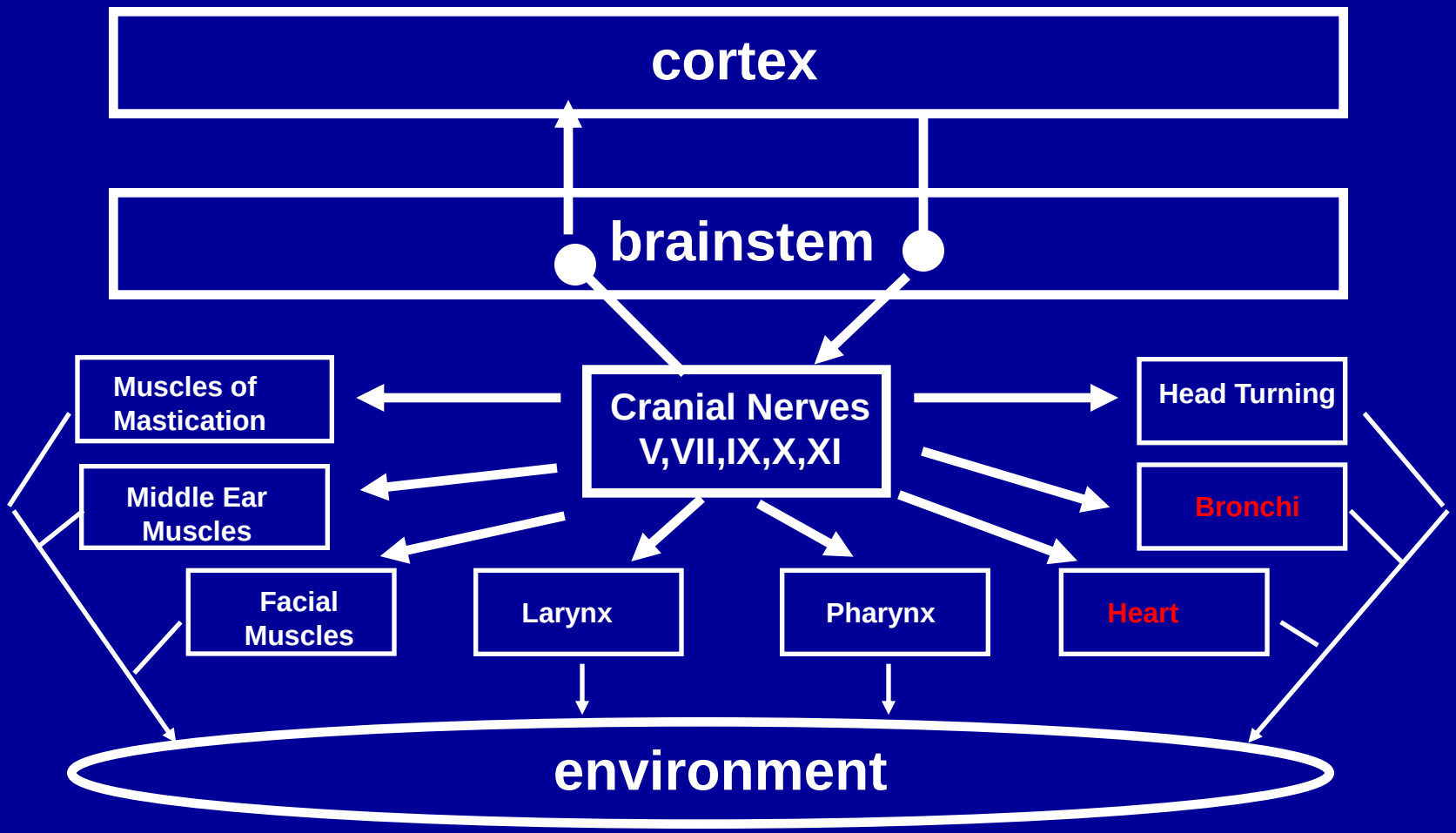
The "*Mammalian*" Vagus and Social Engagement System



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Social Engagement

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Social Engagement System:
Emergent Behaviors at Birth

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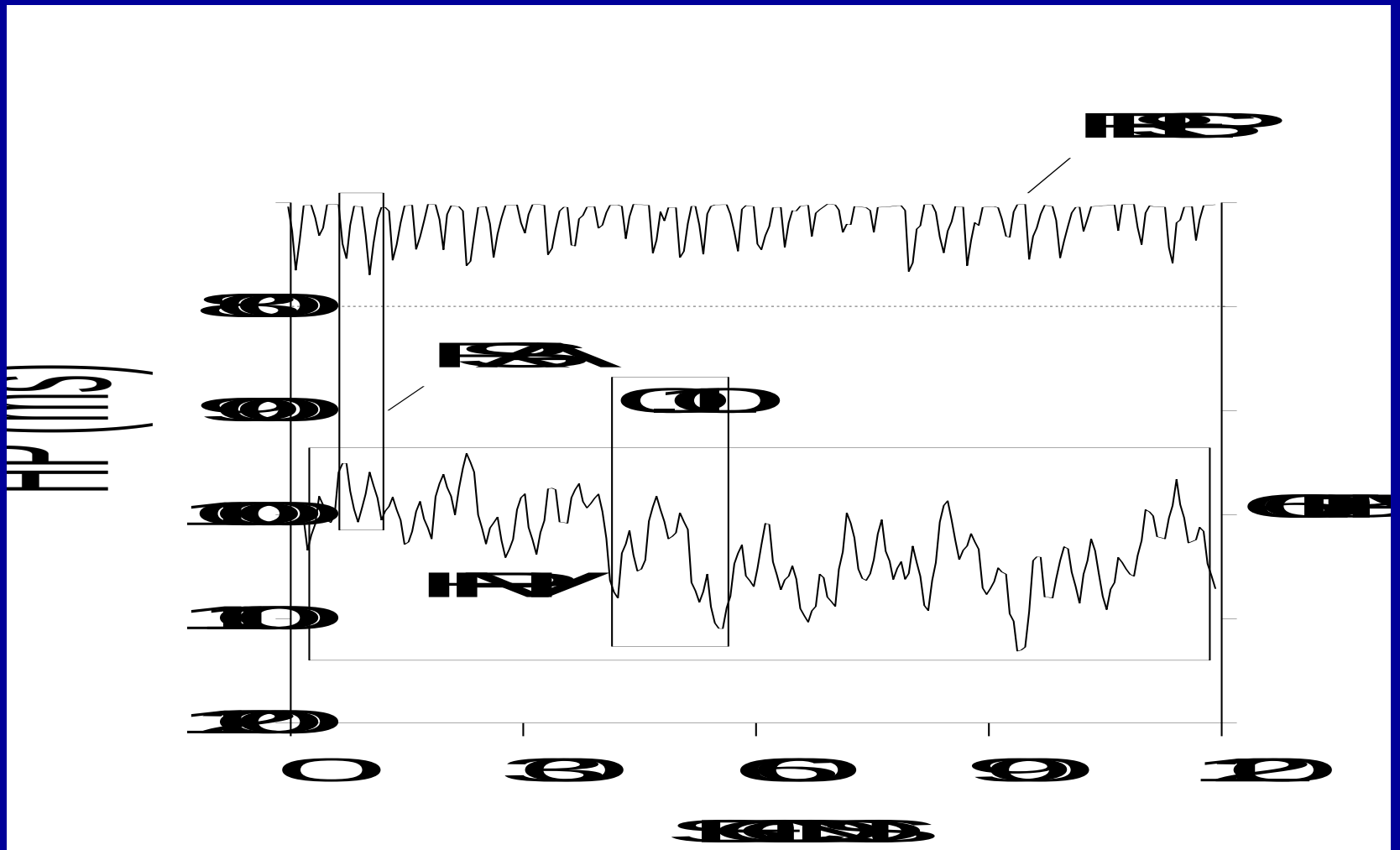
Social Engagement System:
Self Regulation

Heart Rate Rhythms



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

- Prosody
- Gaze
- Facial expressivity
- Mood and affect
- Posture during social engagement
- State regulation
- Auditory hypersensitivites

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Social Engagement

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Violation of Face-to-Face: An experimental manipulation

The Face-to Face Still Face Procedure

(Tronick, Als, Adamson, Wise, & Brazelton, 1978)

3 Phases:

- 2 minutes Social Play
- 2 minutes Still Face
- 2 minutes Reunion Play

Senta Furman (dissertation, in progress)

Reciprocal Interaction (play)

Senta Furman (dissertation, in progress)

Still Face (1)

Senta Furman (dissertation, in progress)

Still Face (2)

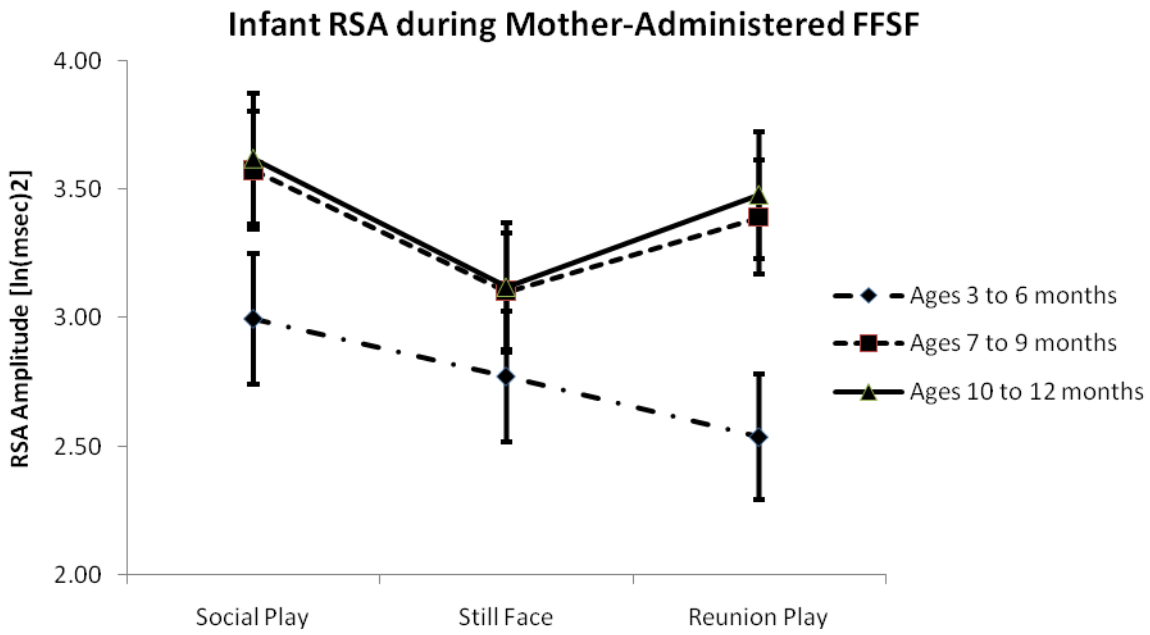
Senta Furman (dissertation, in progress)

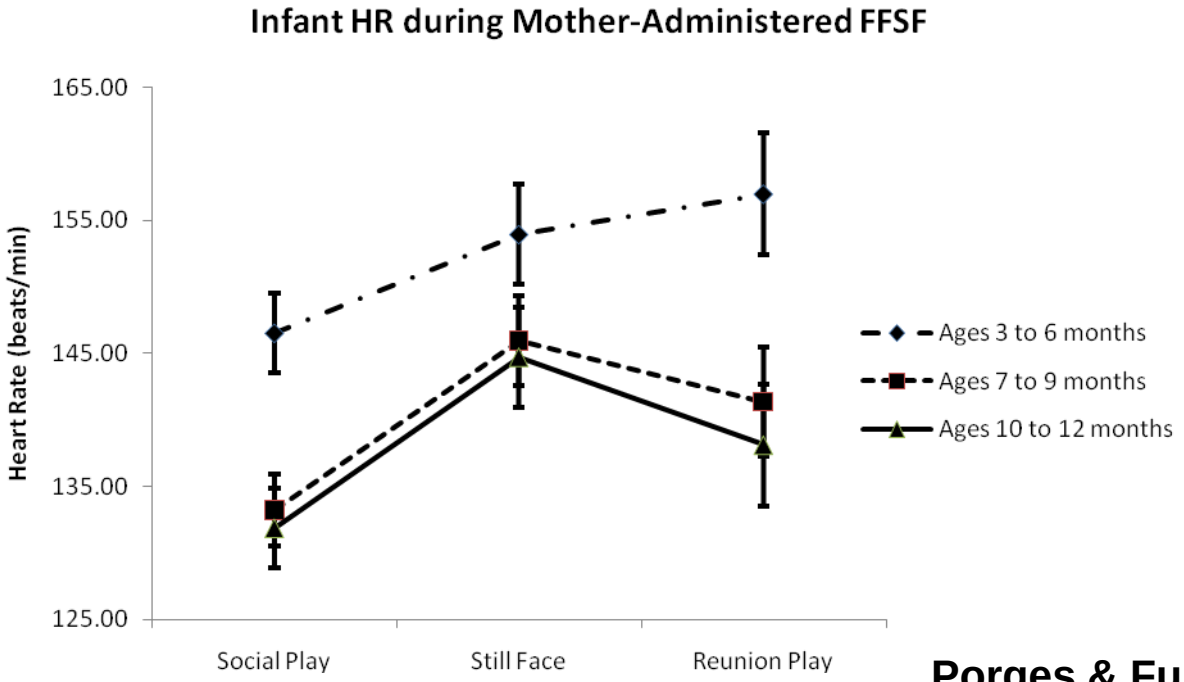
Still Face (3)

Senta Furman (dissertation, in progress)

Violation Repaired

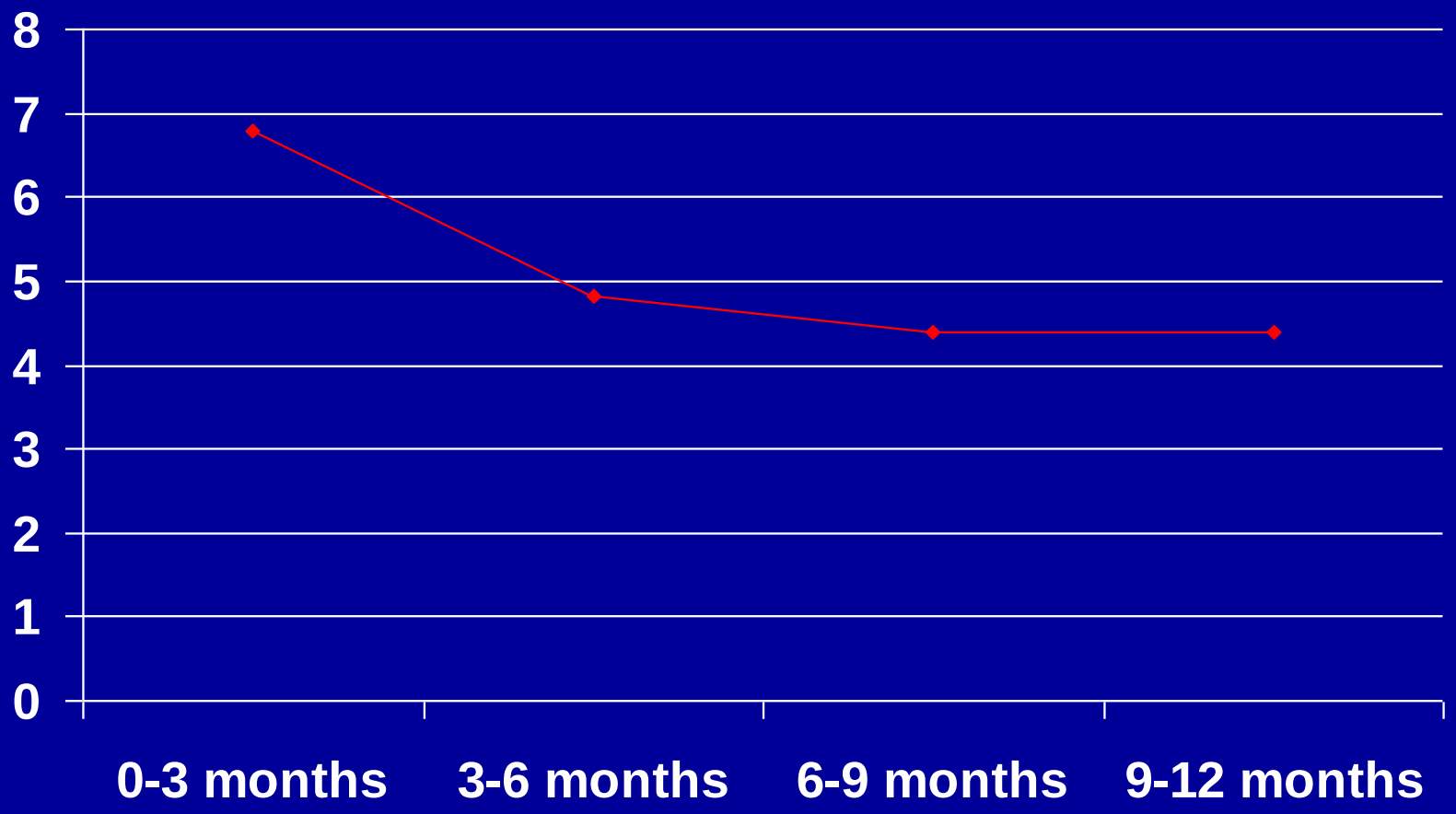
Senta Furman (dissertation, in progress)





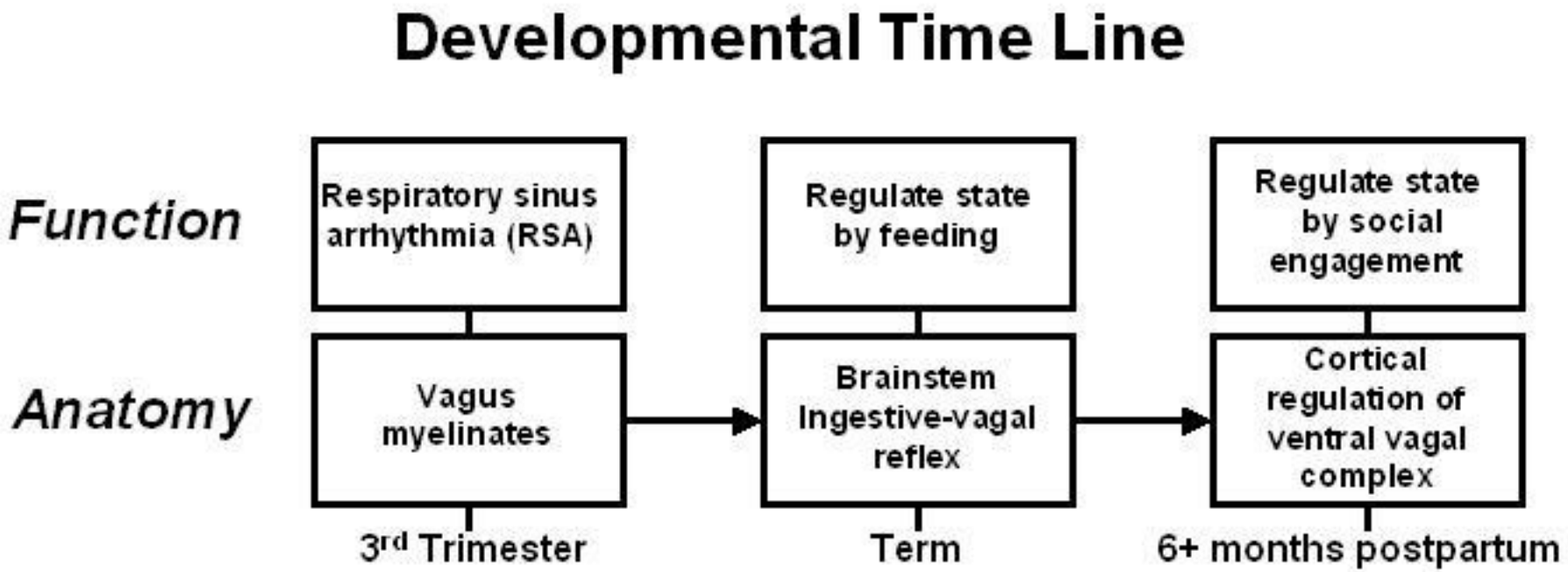
Porges & Furman (2010).

Ratio of Axon Densities During Early Infancy:
Unmyelinated to Myelinated Vagus Fibers (UVF/MVF)



Pereyra, Zhang, Schmidt & Becker (1992), Journal of Neurological Sciences, 10, 107-113.

Neural Platform for Social Behavior: A Developmental Model



Porges & Furman (2010) *Infant and Child Development.*

Building Blocks of Self-Regulation

Environmental interactions

Coordinated biobehavioral processes

Coordinated neurophysiological processes

Homeostatic functions

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Hierarchical Model of Self-Regulation

Level IV: Appropriate Social Interactions

Level III: Motor Behavior Control

Level II: Regulation of the Vagal Brake

Level I: Baseline Vagal Tone (RSA)

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Level I Assessments

Homeostatic Functions

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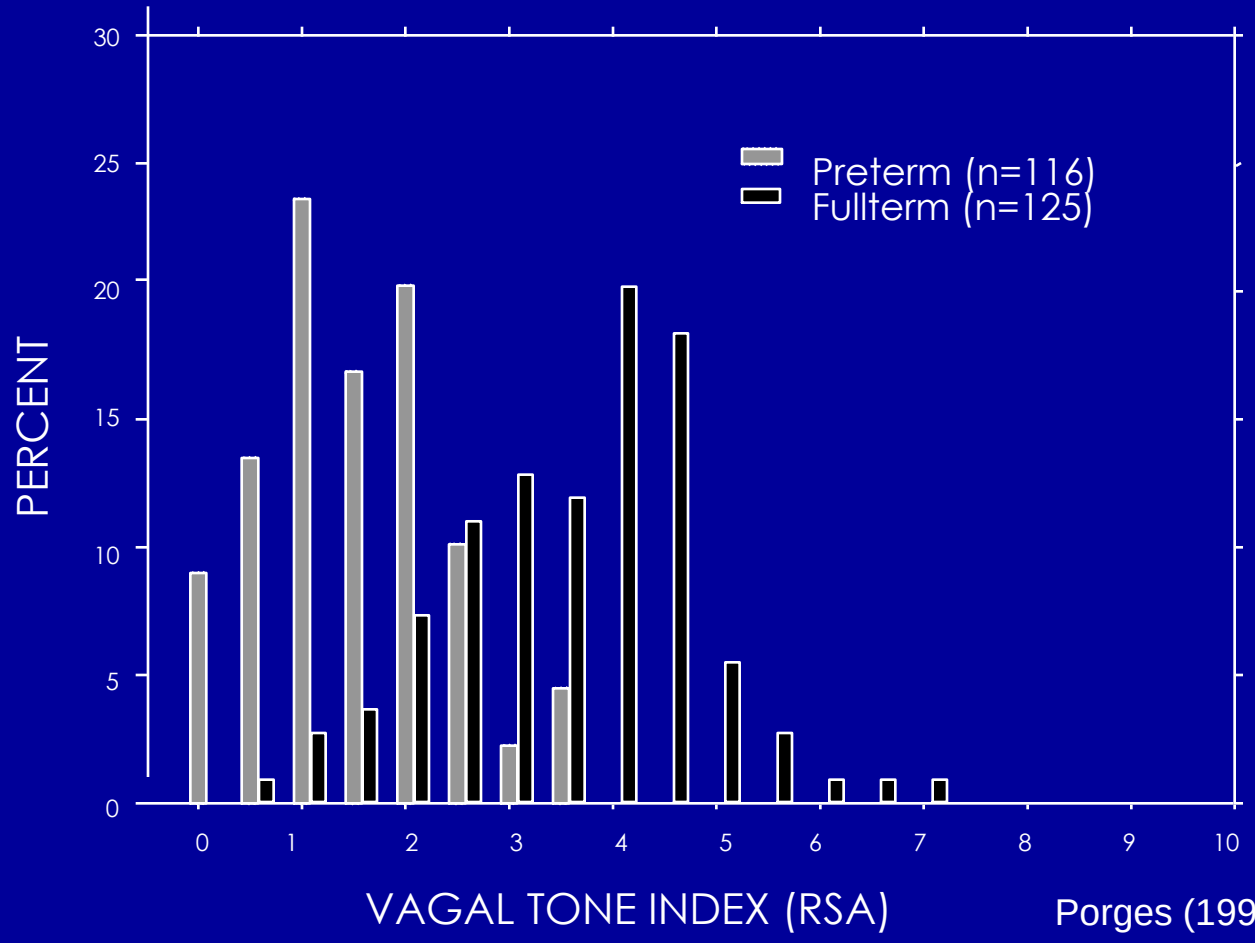
Homeostasis



Porges (1992), Pediatrics

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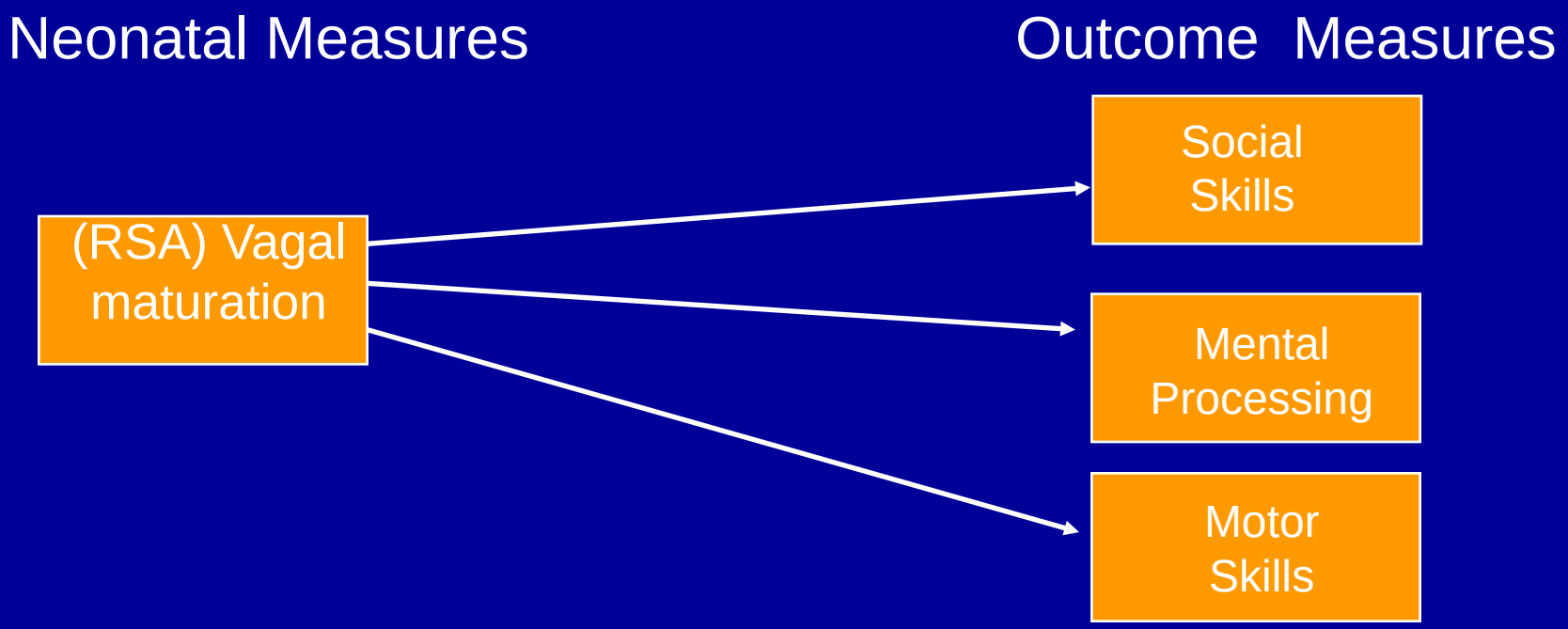
Neonatal Vagal Measures and Outcome at 3 Years



Doussard-Roosevelt, Porges, Scanlon, Alemi, & Scanlon (1997), Child Development

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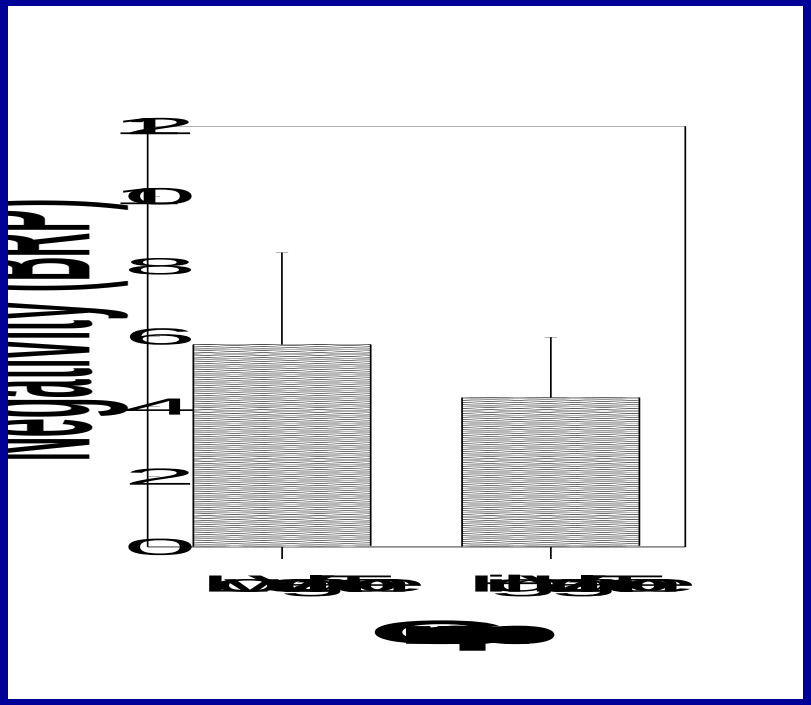
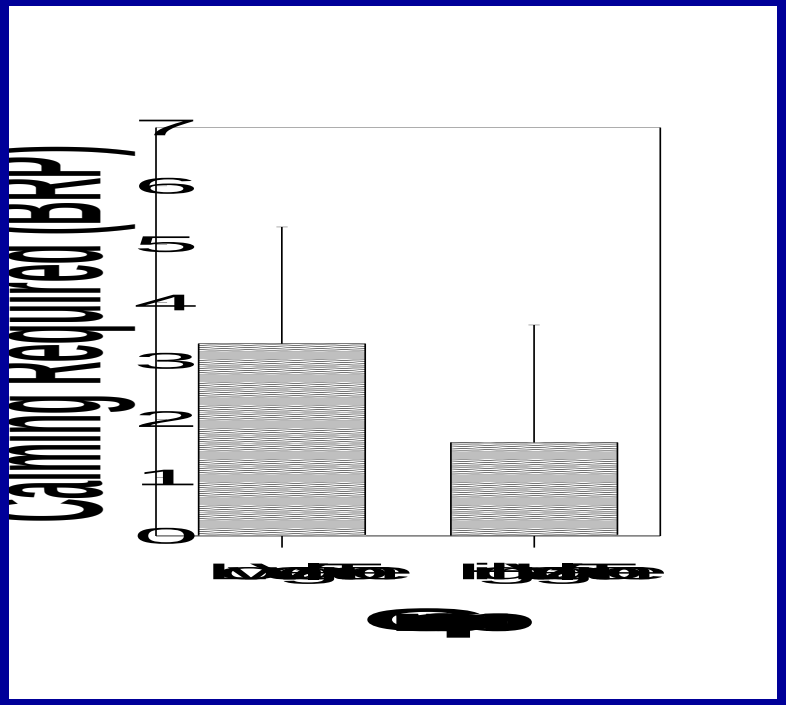
Infant Vagal Tone (RSA) and Temperament (12 wks)





Huffman, et al., 1998, Child Development

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Level II Assessments

Challenge to and Regulation of Homeostasis
("The cost of doing business")

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The *Vagal Brake*

an index of self-regulation

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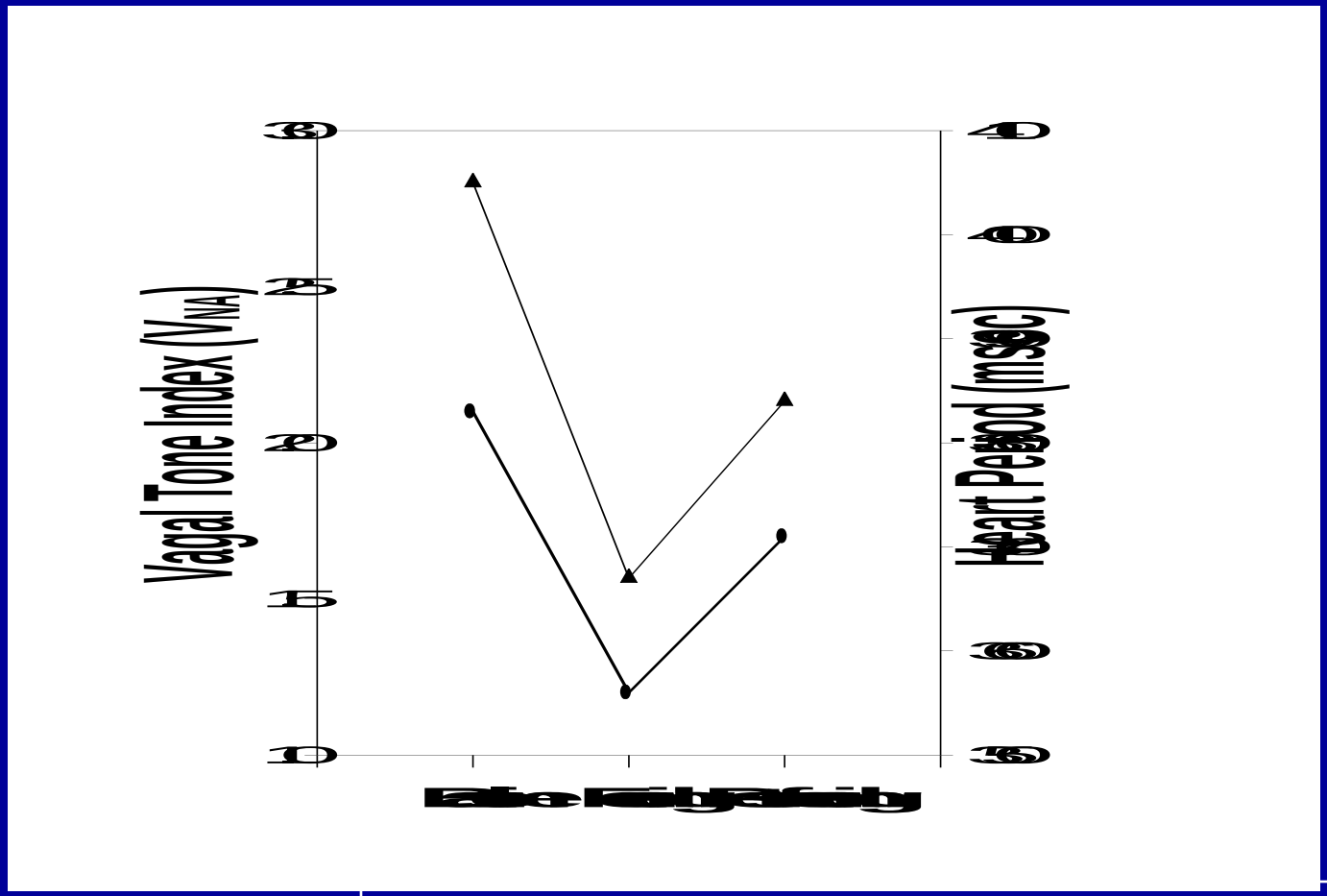
Vagal Regulation: Observed in the Neonate During Feeding



Portales, et al., 1997, Developmental Psychobiology

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RSA during Feeding:

Vagal Regulation of Metabolism, Ingestion, and Digestion in Preterm Infants

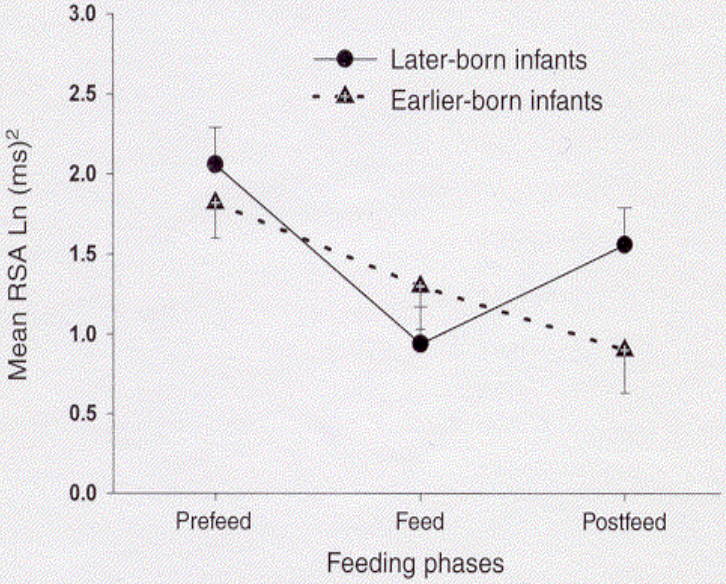

Figure 1: *Mean RSA natural logarithm of (ms)² during prefeeding, feeding, and postfeeding by gestational age groups.*

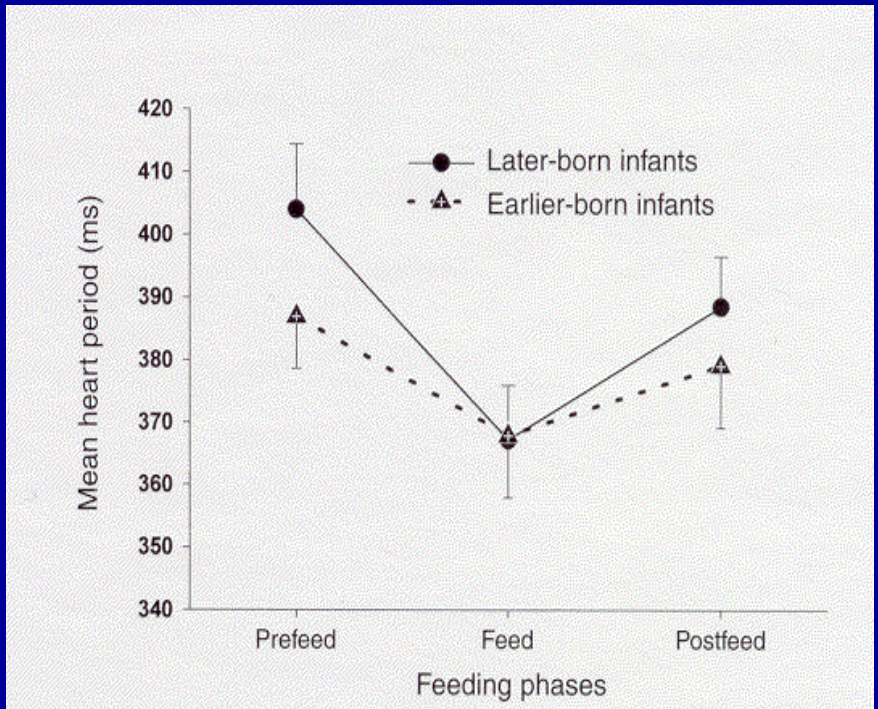

Figure 2: *Mean HP during prefeeding, feeding, and postfeeding by gestational age groups.*

Suess et al., 2000, Developmental Medicine and Child Neurology

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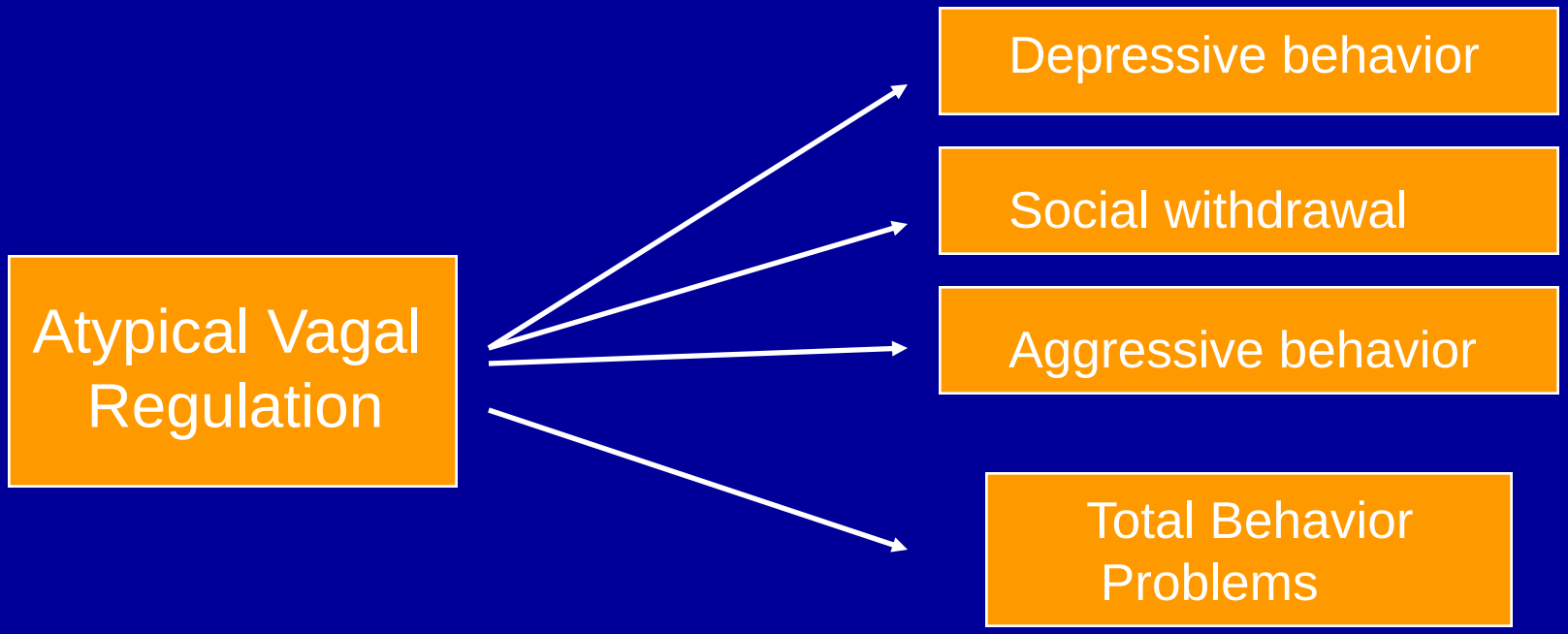
Vagal Regulation at 9 months of age and Preschool Behavior Problems



Porges, Doussard-Roosevelt, Portales, & Greenspan (1996), Developmental Psychobiology

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Infant Crying and Developmental Outcome: A Biobehavioral Approach

NICHD Grant NIH Grant R01 HD053570

Research Team:

UIC: S.Porges, K.Heilman

Erikson Institute: Z.Boukydis, L.Gilkerson

Univ of Chicago: L. Gray

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A Violation of Social Engagement

http://www.babyreference.com/nutritionconsultations.htm

Atypical Vagal Regulation: Common Mechanisms

- Difficulties in social behavior
- Difficulties in state regulation

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Defining A Fussy Infant

Group classification:

1. Infants defined as “excessive criers,” if they manifest distress (fussing, crying, and/or unsoothable crying) for more than 3 hours per day for 3 or more days in one week between 6 and 10 weeks of age.
2. Age when extreme fussiness is resolved (3 or 6 months).

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Frequency of Excessive Crying

- Excessive crying at or before 3m – 20%
- Excessive crying NOT resolved by 3m – 7%
- Excessive crying NOT resolved by 6m – 3%

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Specific Aims

1. To evaluate whether infants at ***6***-months, who are prone to excessive crying (but not crying or fussing while being tested), have a distinguishable autonomic response profile that can be measured during laboratory-based experimental procedures.
2. To evaluate whether infants, who are prone to excessive crying, have a compromised developmental outcome at 12 and 24 months.
3. To evaluate whether the autonomic response profile at ***6***-months, with or without the behavioral feature of persistent crying, is a marker for a compromised developmental outcome at 12 and 24 months

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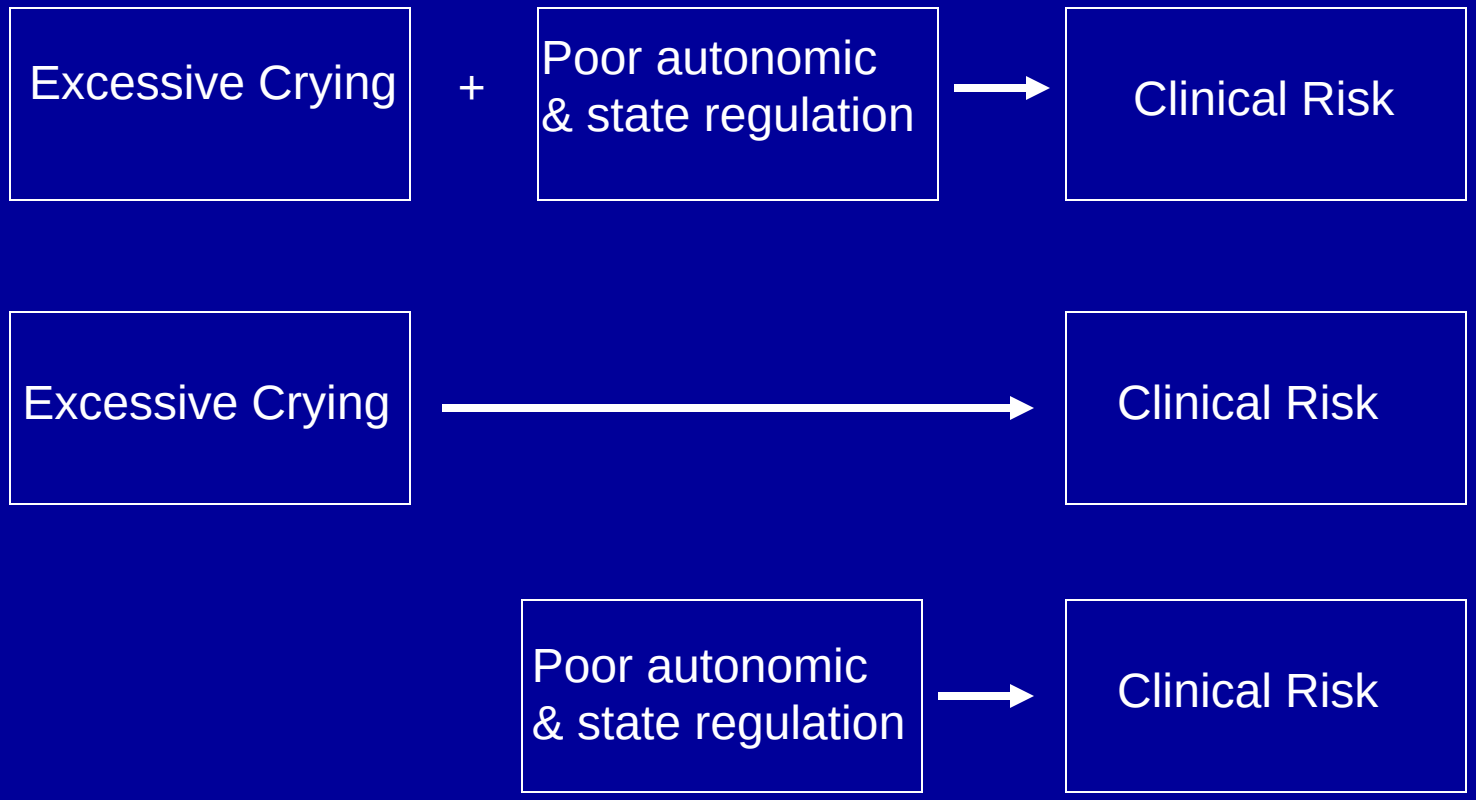
Competing Hypotheses



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Experimental Model

Parent reports
Cry Diary
Clinical history

Vagal brake
(neural mechanisms of self-soothing & calming)

ADD, PDD, LD, etc
(disorders associated with state regulation deficits)

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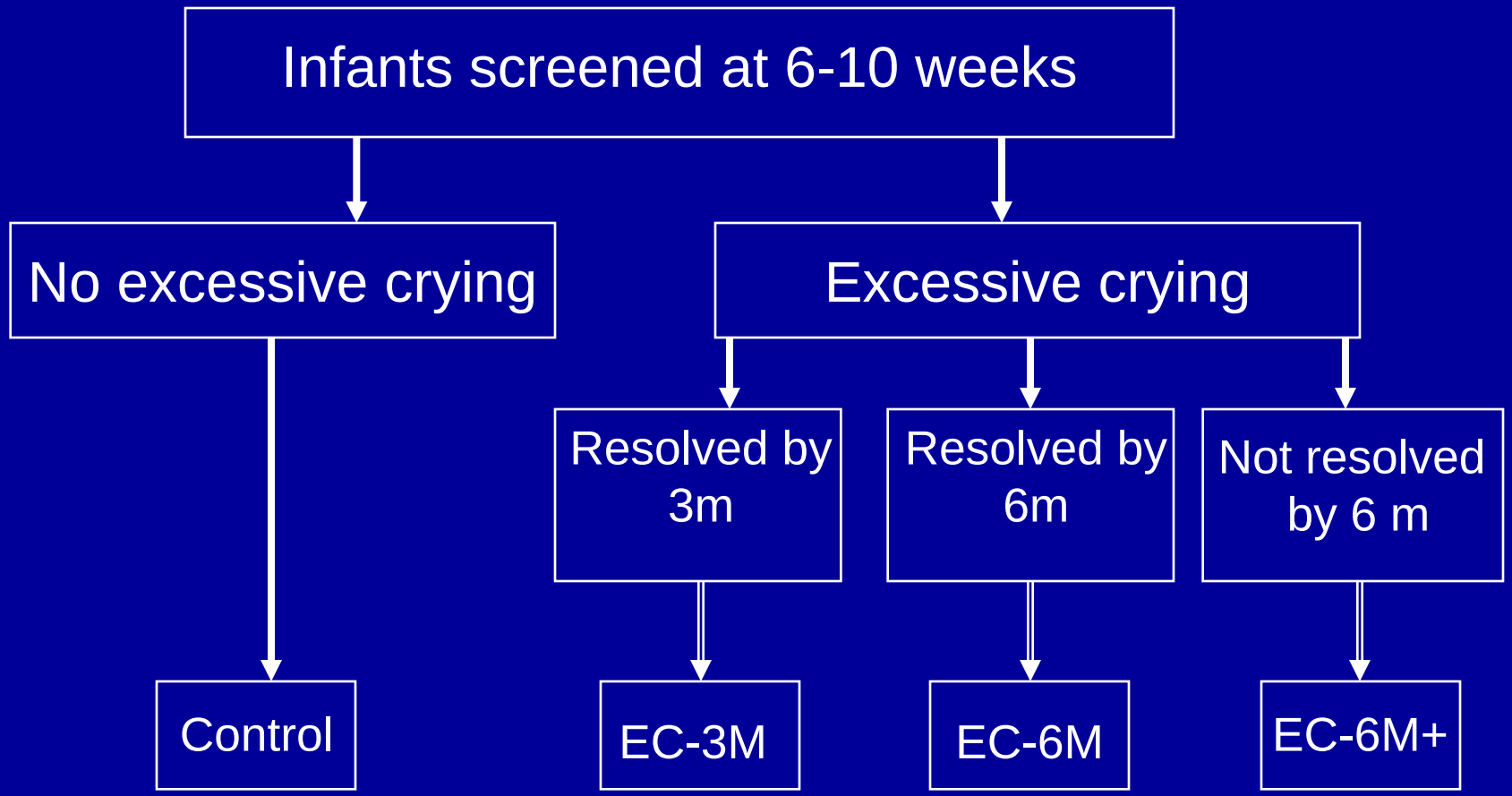
Recruitment Model



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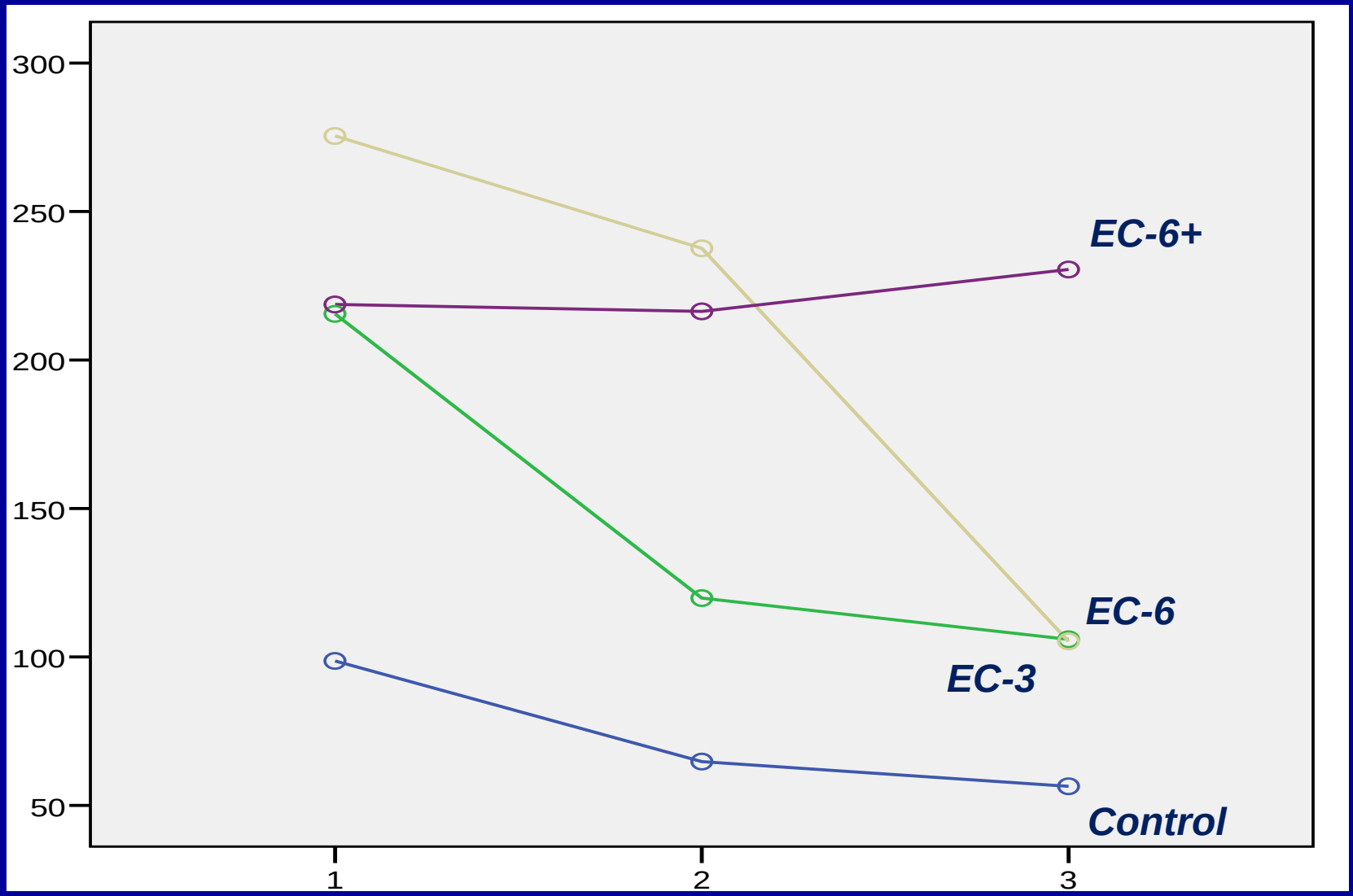
Cry Diaries



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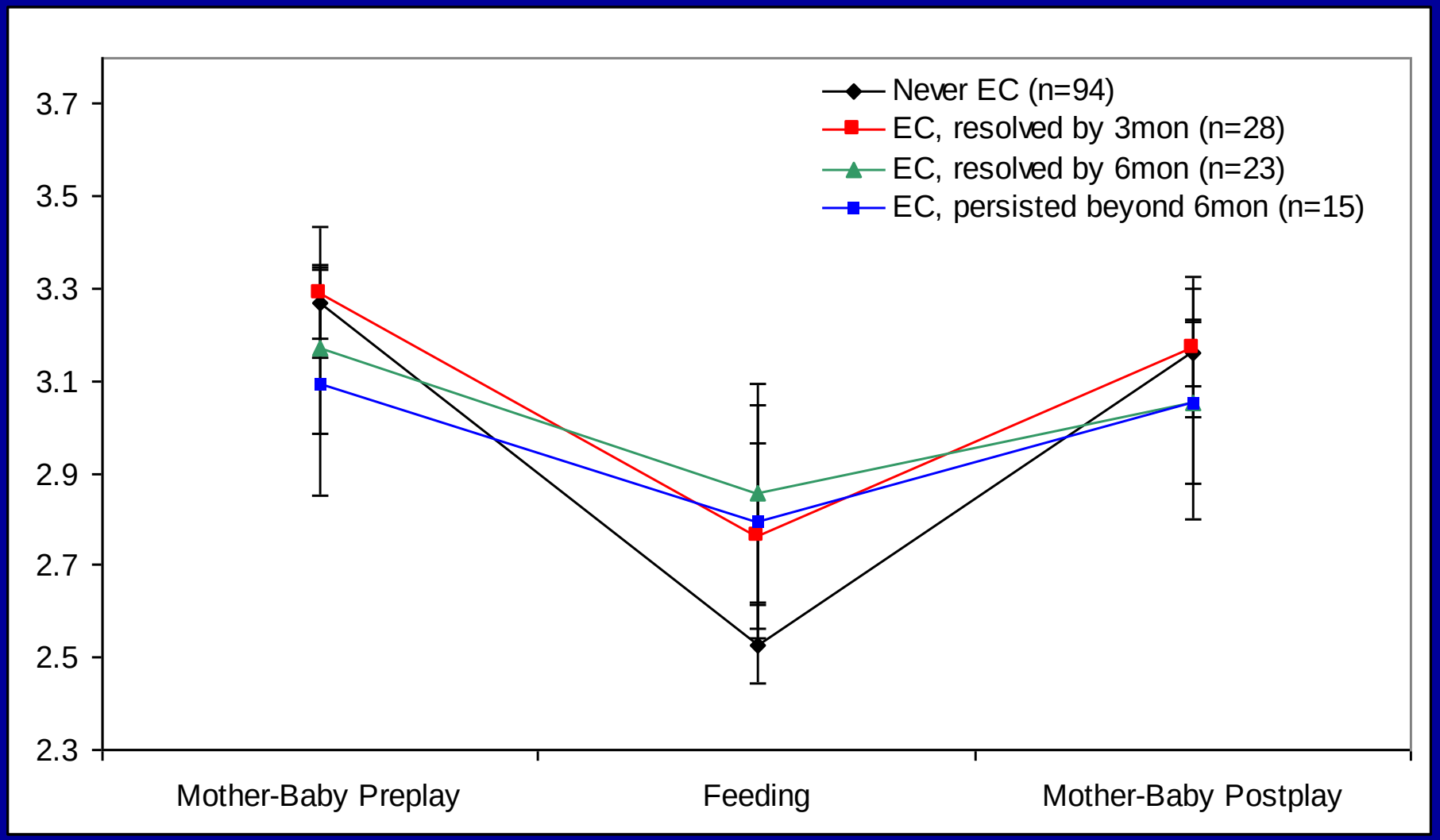
EC infants have dampened vagal reactivity



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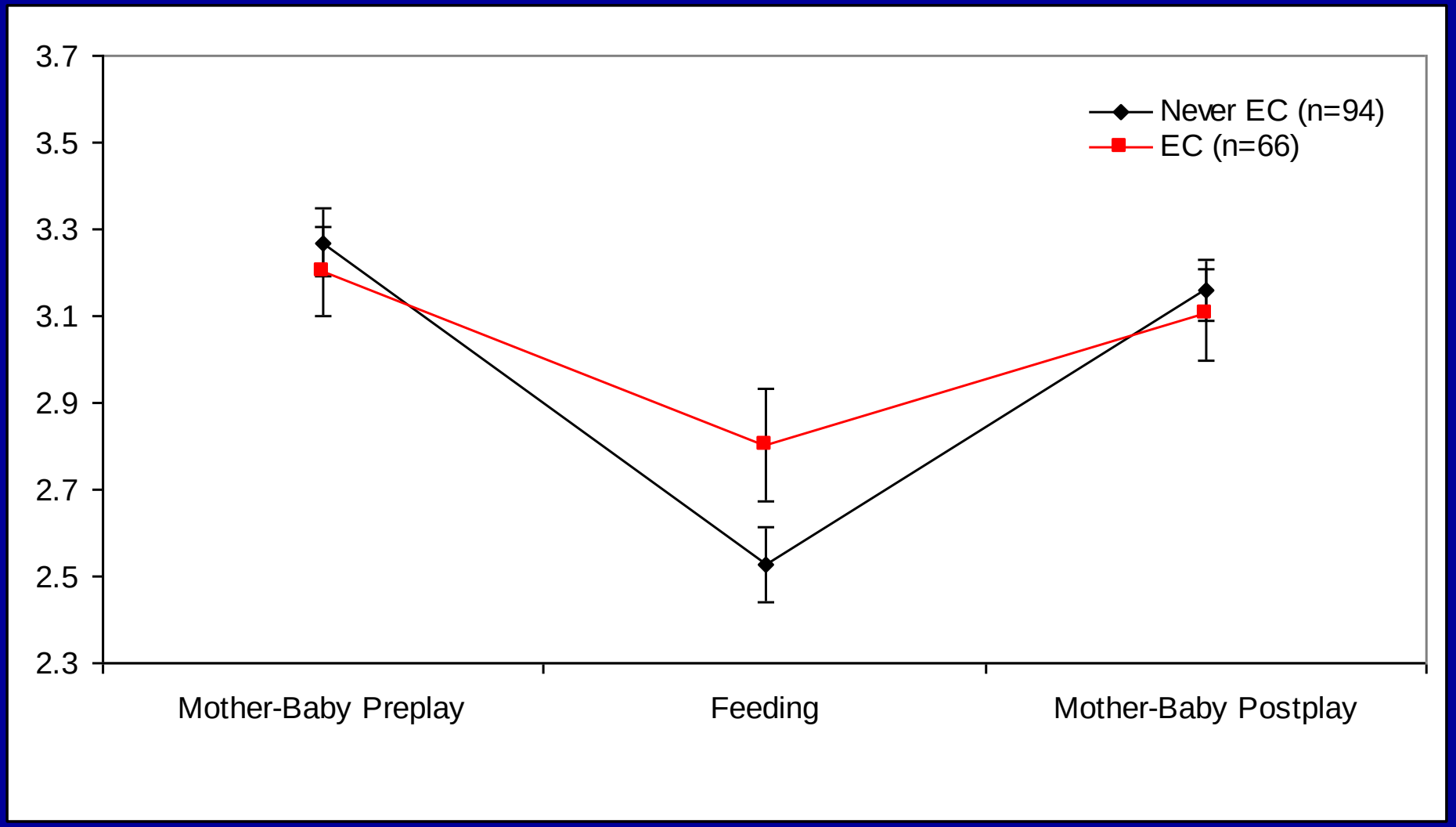
EC infants have dampened vagal reactivity



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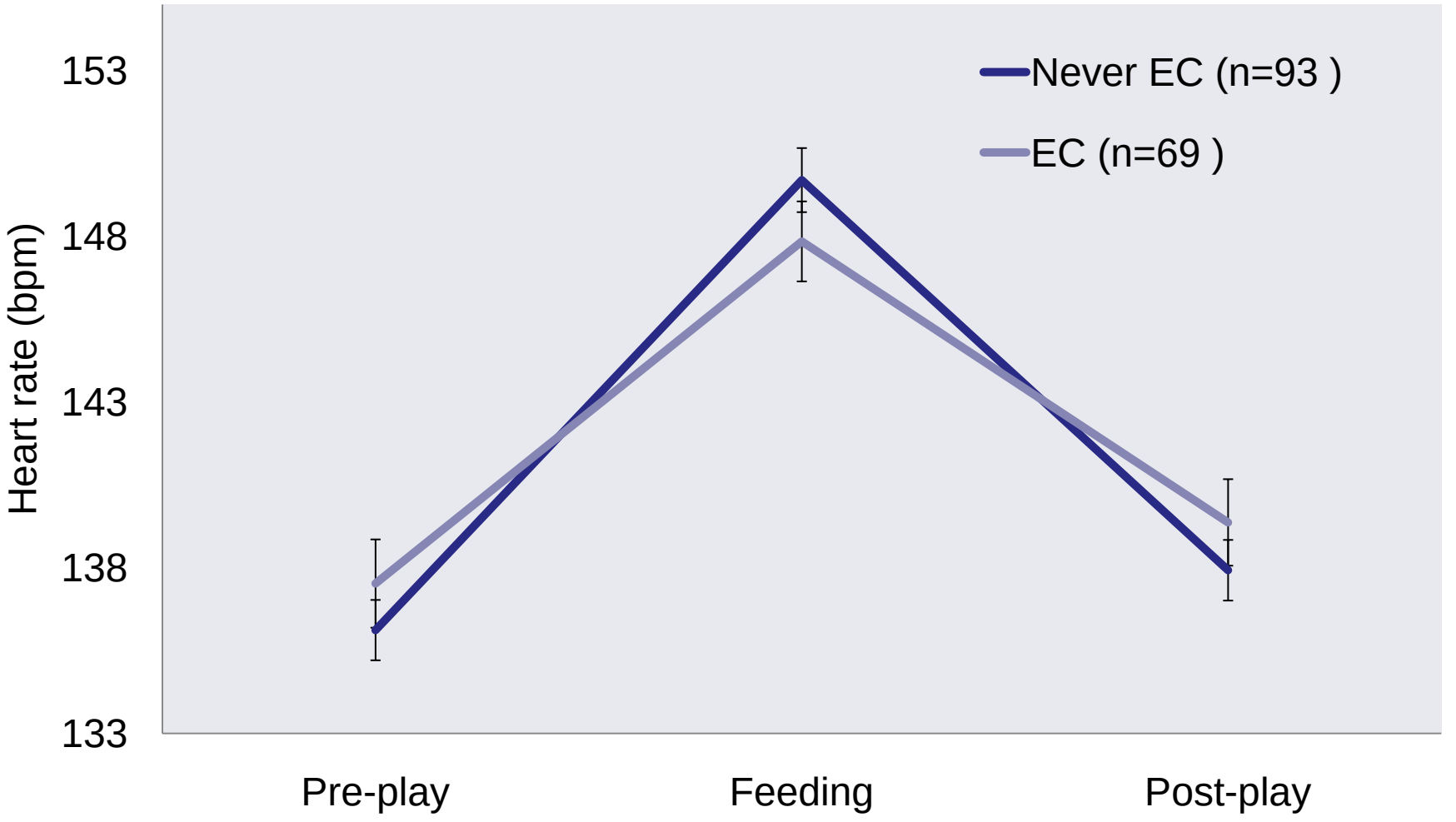
EC infants have dampened heart rate reactivity



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12 month assessments

- Infant Toddler Social Emotional Assessment (ITSEA) (Carter & Margaret Briggs-Gowan)
- Internalizing behaviors: depression/withdrawal, general anxiety, separation distress, inhibition to novelty
- Externalizing behaviors: activity/impulsivity, aggression/defiance, peer aggression

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Predictors of 12-month Behaviors

Model 1: Cry/Fuss 3 months* + Vagal Reactivity* => Internalizing

Model 2: Cry/Fuss 3 months* + Vagal Reactivity* => Externalizing

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Conclusions

- The Social Engagement System is an emergent neurophysiological system that phylogenetically developed to regulate contact with the external world and to modulate physiological and behavioral state.
- As the infant matures, the Social Engagement System shifts from a reflexive brainstem system, to a system under cortical control with an ability to initiate social behavior.
- RSA, a measure of vagal regulation measured in infants, is related to developmental outcome and especially to behavioral and psychological processes associated with social behavior, ingestion, and state regulation.
- Fussy-difficult infants, who by definition have state regulation problems and excessive bouts of crying, have atypical vagal regulation that may deprive them from the soothing effects of feeding.

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Conclusions

- During the first 6-months of life the measurement of vagal regulation during feeding provides an early marker of the developmental status of the neural platform for social behavior.
- During the first year of life, cortical pathways develop that regulate the striated muscles of the face and head and the vagus continue to myelinate to form an integrated social engagement system - the same circuits involved in feeding (ingestion) and state regulation.
- As the infant matures, social context displaces feeding as the most important regulator of behavioral state.

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