Rich, Dense, and Not for the Faint of Heart

The Polyvagal Theory: Neurophysiological Foundations of Emotions, Attachment, Communication, and Self-regulation by Stephen W. Porges.

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How could it be, as an academic neonatologist and neurodevelopmental pediatrician, I had not heard of Stephen W. Porges and the polyvagal theory? Since the 1980s, Porges' research and theory have been published widely in the pediatric, developmental and psychological literature. *The Polyvagal Theory: Neurophysiological Foundations of Emotions, Attachment, Communication, and Self-regulation* includes nineteen chapters, previously published independently, that detail underlying evolutionary principles of the polyvagal theory and applications to early development (especially assessment of stress vulnerability), social engagement, psychopathology, and social behavior and health.

The polyvagal theory elaborates a paradigmatic shift in our understanding of the evolution of the mammalian autonomic nervous system and its role in promoting and maintaining prosocial behavior and engagement—from the inside (self-regulatory processes) to out (successful social interactions). The theory builds upon the work of evolutionary biologists such as Darwin who noted early the relationship of the autonomic nervous system and emotions. As Darwin (1872) wrote:

> …when the heart is affected it reacts on the brain; and the state of the brain again reacts through the pneuma-gastric (vagus) nerve on the heart; so that under any excitement there will be much mutual action and reaction between these, the two most important organs of the body. (p. 69)

Porges painstakingly details the phylogenetic development of the vagus nerve of the parasympathetic nervous system, including both neuroanatomic and physiologic phenomena. He distinguishes between the role of the mammalian-specific myelinated vagus, originating in the nucleus ambiguous, and the phylogenetically older reptilian unmyelinated vagus, originating in the dorsal motor nucleus. Both the dorsal motor nucleus and the nucleus ambiguous originate in the brainstem. Their vagal functions, however, are distinct as the nuclei deriving from the unmyelinated vagus of the dorsal motor nucleus project subdiaphragmatically to the stomach, intestines and rectal/urinary sphincters—primitive vegetative functions. Most neurons of the myelinated vagus of the nucleus ambiguous project to supradiaphragmatic structures, including the heart, bronchi, larynx,

pharynx, soft palate and esophagus. The larynyx, pharynx, and soft palate, for example, are the targets of the effector neurons involved in emotional expression and communication. As such, the "polyvagal" vagus is not one nerve—it is several nerves, originating in unique areas of the medullary brainstem, with both efferent and afferent pathways, asymmetry and lateralization with a right hemispheric bias.

Aligned with their neuroanatomic phylogeny are the physiologic defense strategies associated with both the myelinated and unmyelinated vagus. Consistent with their evolutionary phylogeny are the adaptive responses associated with the physiologic functions of the mammalian vs. reptilian vagus. The reptilian unmyelinated vagus is responsible for the immobilization [feigning death, neurogenic bradycardia (i.e., slowing of the heart rate), or behavioral shutdown] responses that are adaptive in decreasing metabolic demand and shielding the prey from the predator.

Phylogenetically higher are mobilization ("fight or flight") responses modulated by the sympathetic nervous system. Cardiac function is a delicate balance between parasympathetic/vagal inhibitory responses and the sympathetic nervous system-driven catecholamine responses that increase heart rate and cardiac output. Here, cardiac vagal inhibitory tone is suppressed, allowing the sympathetic nervous system to respond quickly to a perceived predator.

Finally, and phylogenetically highest in the hierarchy, is the social communication or engagement system of the myelinated vagus that inhibits sympathetic influences to the heart, dampens the HPA (hypothalamic-pituitary-adrenal axis), and creates the respiratory sinus arrhythmia (RSA), an assessment tool of cardiac vagal tone. The social communication/engagement system is a result of the ventral shift of the vagal pathways from the dorsal motor nucleus, to the nucleus ambiguous. In doing so, they became linked to the visceral efferent pathways regulating the striated muscles of the face.

Porges also elaborates the evolutionary underpinning of the critical importance of early caregiving and caregiver responsiveness—the eye gaze, head turning, orientation, prosody, and vocal tone—in responding to an infant, who thereby initially learns self-regulation through the co-contingent responsivity of a caregiver. As van der Kolk comments in the Foreword: "Porges…gave us an explanation why a kind face and a soothing tone of voice can dramatically alter the entire organization of the human organism—that is, how being seen and understood can help shift people out of disorganized and fearful states" (p. xvi).

In the past quarter century, technology has afforded the capability of ensuring the survivability of more and more vulnerable infants and children. Extremely preterm infants weighing barely a pound now survive in large numbers. Although survival has improved dramatically, especially at the lowest gestational ages, morbidity—especially poor neurodevelopmental outcomes, including behavioral disorders—remains high. Young adults who were very low birth weight infants (< 3 lbs. 5 oz.) have increased rates of anxiety/depression, thought problems, and attention disorders (Hack et al., 2004). By middle childhood, a three-to-four-fold increase in psychiatric disorders is noted, with a markedly increased prevalence of autism spectrum disorders (Johnson, 2011).

As the chance of a *technologic* solution to producing a "better baby" has receded, neona-

tologists and other pediatric professionals look increasingly to enhancing the quality of early caregiving for the most vulnerable infants and children as a resource for improved neurodevelopmental outcomes. We know the following:

1. Stress in pregnancy is associated with perturbations of the maternal HPA axis that can have significant long-term impact upon child behavioral outcomes (Brunton, 2010).
2. Placement of high-risk young orphans in loving, caregiving environments decrease the rate of serious psychiatric disorders in later childhood (Smyke et al., 2012).
3. Stress/trauma in childhood is strongly associated with premature mortality in adulthood (Brown et al., 2009).

Much of Porges' early work, detailed in this volume, focused upon high-risk infants, including preterms, measuring cardiac vagal tone, a reflection of parasympathetic, homeostasis-related function, using RSA technology. Simply put, RSA measures the rhythmic vagal efferent influences on the cardiac pacemaker, the sino-atrial node. Since there is two-way communication between the brainstem and the target organ, in effect, RSA is a sensitive indication of the function of the central nervous system. As expected, the higher the heart rate variability or RSA, the more flexibility of responses and behavioral repertoires available to the infant for regulating both his or her internal state and dealing with external demands, for example, temperature, noise, and painful stimuli. Not surprisingly, healthy full-term infants have higher RSA than preterm infants, even when corrected to full-term.

In earlier work, Porges has also studied the RSA as a measurement of vagal regulation of metabolic and gastrointestinal concerns of preterm infants. The vagal-gustatory theory hypothesizes that vagal tone, as measured by RSA, is critical to appropriate cardiac responsivity to feeding and other activities that increase metabolic demand for the vulnerable preterm. In a study of preterm infants, Porges and colleagues found that older preterms have more flexible responses to ingestion and digestion as measured by reduction of RSA during feeding—that is, cardiac vagal tone is reduced allowing for increased heart rate to meet the enhanced metabolic demand of feedings. The researchers speculate that the delayed maturation of cardiac vagal tone in younger preterm infants may be a marker of ongoing stress vulnerability and perhaps an early indicator of subtle neurodevelopment concerns (Suess et al., 2000).

Of significant interest to neonatologists is the relationship between cardiac vagal tone and apneic and bradycardic spells seen in preterm infants in the neonatal intensive care unit (NICU) often significantly past correction of their prematurity to term. Porges notes that his interest in the application of cardiac vagal tone to preterm infants was spurred by a letter from a neonatologist who questioned the implications of excess vagal tone in the etiology of severe, potentially lethal bradycardia. For neonatologists, these profound episodes of bradycardia, often requiring substantial resuscitative efforts, are frequently (and apparently appropriately) labeled "death" spells by the staff. In the course of addressing the neonatologist's concern, Porges' "vagal paradox theory" evolved. Drawing upon his understanding of the "two vagal motor systems" (p. 48), Porges hypothesized that such massive, life threatening bradycardias were mediated by the phylogenetically older and hierarchically more primitive, dorsal motor nucleus. These immobilization, death-feigning episodes are a "vestigial relic of the reptilian brain" (p.

40) and a withdrawal of the "smart vagus" mediated through the nucleus ambiguous.

The polyvagal theory sheds significant light upon the potential neuroanatomic/neurophysiologic roots of commonly reported outcomes for preterm infants, including executive function, attentional, externalizing, and social cognition concerns. It takes little imagination to move from the developmental vulnerability of preterm birth and its impact upon vagal maturation to alterations in the capacity to engage in the co-contingent caregiving experiences that link mother and infant in prosocial behaviors and ongoing engagement. Porges discusses the relationship between the evolving functions of the vagus and the link to vocalization, so critical for social engagement and communication. He details the phylogenetic maturation of the middle ear in mammals that resulted in anatomic changes in middle ear function that facilitate extraction of frequencies associated with the human voice—the same frequencies as those manifested in lullabies, sung so often to calm infants—and attenuation of low frequency sounds. As he writes: "Vocal music duplicates the effect of vocal prosody and triggers neural mechanisms that regulate the entire social engagement system with the resultant changes in facial affect and autonomic state. Basically, we start to look and feel better when we listen to melodies" (p. 210).

Why, then, would a journal dedicated to advancement of a unified psychotherapy and clinical sciences ask a neonatologist to review the work of an eminent neuroscientist/psychologist? What relevance does Porges' work with vulnerable and high-risk infants have to the promotion of a "truly unified clinical science from which unified psychotherapy will emerge" (Anchin, Magnavita, & Sobelman, 2012)? Just as there are several "vagi," there are multiple roads to mental distress, perhaps organized in a similiar phylogenetic hierarchy.

At the most simplistic level, the inclusion of a high-risk infant population (and its representative, a neonatologist) recognizes the explosion of interest and data supporting the ecobiodevelopmental framework proposed by Shonkoff and others recognizing the impact of toxic levels of stress, often beginning in the prenatal period, upon the developing brain, reflected in poor physical, behavioral, and developmental outcomes. As the work of McEwen (1998), Meaney (Weaver, 2004), Felliti (Dong et al., 2004), Bronfenbrenner (1979), and others finds it way into the pediatric literature, pediatrics as a discipline is seeking new conversations with colleagues from other disciplines engaged in professional caregiving (Shonkoff & Garner, 2012).

There are approximately 500,000 preterm (< 37 weeks' gestation) infants born annually and many more vulnerable infants born into environments challenged to provide early-caregiving that promotes optimal health and well-being (Mathews, Minino, Osterman, Strobino, & Guyer 2011). Imagine beginning your post-womb existence in a plastic box, with a tube in your throat, being fed through a tube in your stomach, and physically separated from your primary caregivers, your parents, for the majority of the day? Attachment researchers have long reported the relationship between prolonged separation from mother with altered attachment security and subsequent serious behavioral problems (Bowlby, 1982).

In later chapters of his book, Porges discusses implications of the polyvagal theory for clinical psychopathology, including autism and borderline personality disorder as well as post-traumatic stress disorder. In each chapter, he

argues for the role of vagal regulation in associated presenting symptoms including challenges in prosocial engagement and appropriate assessment of "risk," potentially precipitating behaviors reflecting "fight or flight" or immobilization, as opposed to social engagement reflective of the mammalian vagus.

So, in the end, for those of us who care for babies and families at the beginning of life when the groundwork for social communication and successful attachment are laid and for those of you who care for children and adults who suffer from mental distress in its many forms, Porges' *The Polyvagal Theory* has much to offer. The book is extraordinarily dense and complex with much repetition. Given that it is a compilation of Porges' prior work, some degree of repetition is unavoidable. While it may be tempting to argue the repetitiveness could be decreased, the "average" educated reader with a strong background in neuroscience will be challenged to develop a working understanding of the polyvagal theory without the detail and repetition provided by Porges.

It is rich with many clinical examples from diverse patient populations, including high-risk newborns as well as persons with personality disorders, autism spectrum diagnoses, and those with a history of abuse and/or neglect. Consistent with the goal of unification, the polyvagal theory is not a "how to," and does not direct us to any particular school of treatment. Instead, it addresses the commonalities that characterize seemingly disparate populations. Thus, it challenges professionals who interact therapeutically, educationally, clinically or even socially with vulnerable populations to share knowledge and work across our specific disciplines, to prevent, identify and treat mental distress.

The polyvagal theory is NOT for the faint of heart. This is not a bedtime read. It will challenge the reader both intellectually (as s/he will do much page-turning to verify understanding) and affectively, as s/he moves toward an evolving understanding of the body-brain connection and questions deeply held prior hypotheses of distress and methodologies of treatment.

It helps us understand why pharmacopeia will never be the magic bullet for serious psychological problems as it will address only "symptoms" that themselves are reflective of pervasive alterations in stress management, often rooted in the earliest of relationships. The drugs may manage, but kindness, compassion, and "being with" will potentially be the vectors for the affective neural plasticity necessary for the troubled to thrive.

Finally, in the spirit of this journal, Porges' *The Polyvagal Theory* challenges us as professionals to develop new collaborations and platforms for deepening and enriching our understandings. Placing Noam Chomsky in close physical proximity to the departments of biology, psychology and computer sciences in MIT's famous Building 20 resulted in "knowledge spillovers" that brought us Chomskyian linguistics (Lehrer, 2012). There is good reason to believe bringing child and adult health care providers, mental health professionals, neuroscientists, and others into virtual and face-to-face collaborations may be the portal to a "Decade of the Brain" that will result in substantive improvements in our understanding of the prevention, nature and treatment of mental distress.

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