

Chapter 22

Yoga and Polyvagal Theory: Effects and Applications for Well-Being

Marlysa Sullivan

Maryland University of Integrative Health, USA

ABSTRACT

This chapter explores yoga as a salutogenic intervention supportive of eudaimonic well-being with its wide-spread health effects for various patient populations. Autonomic nervous system regulation and resilience are considered as important mediators for the promotion of biopsychosocial health. Polyvagal theory offers a novel perspective on how underlying neural platforms support combined physiological, psychological, and behavioral states—inclusive of eudaimonic well-being. This chapter describes the convergence of neurophysiological ideas of neuroception, interoception, and neural platforms with yoga foundational concepts such as discriminative wisdom and the gunas. This translatable language of eudaimonic well-being and polyvagal theory offers a framework for yoga to be understood and integrated into current healthcare and research contexts while maintaining its unique perspective and foundational wisdom.

INTRODUCTION: CONCEPTUALIZING WELL-BEING

Health and well-being can be considered from two complementary perspectives. The pathogenic viewpoint looks to identify specific causes of a condition or disease. Interventions are then identified to target the pathology. Alternatively, the salutogenic perspective seeks to explore and then direct interventions to support the contributors of optimal health. These two perspectives, salutogenesis and pathogenesis, can be utilized together to facilitate both the alleviation of pathology and the optimization of health (Sullivan & Robertson, 2020).

Yoga Therapy aligns with this salutogenic perspective as it addresses the many contributors to complex or chronic conditions and seeks to promote self-management and lifestyle change. Ananda Balayogi Bhavanani (DSc (Yoga), Director CYTER of Sri Balaji Vidyapeeth) teaches this importance of yoga therapy as a salutogenic intervention as opposed to applying the practices for symptom management from a pathogenic perspective—calling the latter *yogopathy* (Bhavanani, 2011; Bhavanani et al., 2019). When

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yoga therapy is practiced consistent with this salutogenic framework the tools (e.g. *asana*, *pranayama*, meditation, ethical principles) are applied synergistically to uncover the sources of suffering for the promotion of greater well-being.

Eudemonic well-being is a term that is useful for the practical application of the salutogenic perspective. Additionally, this term offers a translatory language for the wisdom teachings of yoga to be understood in current healthcare/scientific contexts. This term comes from Aristotle's teachings of eudemonia describing the sentiment of a person looking back on their life and feeling as if they reached their optimal potential and lived an excellent, purpose-filled life (Aristotle et al., 2004).

Two types of happiness are described by Aristotle- eudemonic and hedonic. Eudemonic happiness stems from this realizing of one's potential and is described as a non-transitory, steadfast contentment or joy. Hedonic happiness is considered a more transitory emotional experience, such as cheerfulness (Aristotle et al., 2004).

The significance of eudemonic well-being is demonstrated by the growing body of research that supports its widespread and positive health effects for various patient populations. These benefits include:

1. Lower levels of fatigue, disability, pain intensity, pain medication use, depressive symptoms, and improved patient functioning and life satisfaction in people with chronic pain conditions (Dezutter et al., 2013; Dezutter et al., 2015; Schleicher et al., 2005).
2. Decreased all-cause mortality independent of factors such as age, physical inactivity, conditions such as cardiovascular disease or cancers (Keyes & Simoes, 2012; Pressman et al., 2019).
3. Eudemonic well-being is differentiated from hedonic wellbeing with its effect on inflammatory and immune processes. While eudemonic well-being is associated with a down-regulation of gene profiles related to healthier inflammatory and immune processes affecting neurodegenerative, cardiovascular conditions and cancers- hedonic well-being is associated with its up-regulation (Cole et al., 2015; Fredrickson et al., 2013; Fredrickson et al., 2015).
4. Eudemonic well-being is correlated with decreased levels of salivary cortisol, pro-inflammatory cytokines, and lessened cardiovascular disease risk, hedonic well-being has minimal effect on these biomarkers (Ryff et al., 2004).

These myriad and distinct health benefits demonstrate eudemonic well-being as an important contributor to physical, psychological, and social health.

YOGA AND EUDEMONIC WELL-BEING

Yoga has demonstrated an effect for improving eudemonic wellbeing (Ivtzan & Papantoniou, 2014). Additionally the component measures of eudemonic well-being (Huta & Waterman, 2014) share a similar focus with foundational philosophical teachings of yoga (Sullivan, 2019; Sullivan & Robertson, 2020). Eudemonic constructs of authenticity, personal expressiveness, self-actualization, and self-realization are both foundational to and can be facilitated through yoga's teachings. Yoga provides a methodology to foster insight into how the relationship to bodily state or condition, thoughts, emotions, and behaviors contribute to suffering. This process helps facilitate greater authenticity, self-expression, and self-actualization as the person finds positive ways to relate to their body and mind as well as to explore actions that improve well-being.

The emphasis on ethical inquiry in both yoga and eudemonia helps to bring the person in harmony with their values. This value-driven process empowers the individual for right action for a meaningful, purpose-filled, flourishing life and to realize their potential. The teaching of *dharma* in yoga encompasses this harmonious right action to support the individual, as well as people and the life circumstance in which they are situated. The *yamas* and *niyamas* (social and personal disciplines relating to interactions with others and ourselves, respectively) encompass ethical qualities which are foundational to yoga practice and help align the person with *dharma* (Mallinson & Singleton, 2017; Smith, 2009; Stoler-Miller, 1998). Yoga also teaches the recognition of inherent connection between all beings which, with the *yamas* and *niyamas*, support meaningful and healthy relationships—a key component of eudemonic well-being.

A recent paper explored this context of eudemonic well-being in relationship to yoga therapy (Sullivan et al., 2018). Yoga's methodology offers a path for the individual to inquire and develop insight into the relationships with the body, mind, and environment that may either promote suffering or its alleviation. The person is supported in practices to align with values, meaning, and purpose such that steadfast contentment and equanimity is realized even amidst adverse or difficult life circumstances. Resultantly the person experiences eudemonic well-being and a healthy, adaptive relationship to the body, mind, and life circumstance (Sullivan, 2019; Sullivan et al., 2018; Sullivan & Robertson, 2020).

WELL-BEING AND THE AUTONOMIC NERVOUS SYSTEM (ANS)

The ANS serves as a mediator between the external environment, bodily state, thoughts and emotions (Cole, 2013; Cole, 2014; Porges, 2011). As such, the ANS is key to creating synchronistic change in the body-mind and behavior. Positive states such as eudemonic well-being may be catalyzed through autonomic regulation and its support of improved biopsychosocial health.

This chapter explores the function of the ANS and polyvagal theory to illuminate these connections between physiological, psychological, and behavioral states for the cultivation of eudemonic well-being and improved whole-person health. The convergence with yoga's philosophy, teachings, and practices will also be described to explore its unique framework to support these intentions and goals.

The ANS as a Link Between Body, Mind and Behavior

The ANS is responsible for evaluating and generating appropriate responses to what is perceived in the body, mind, and environment. Once information from the environment is picked up by the five senses it is integrated with information about bodily state (physiological activations and processes) and the mind (e.g. thoughts, emotions, beliefs, memories). This information is processed, evaluated, and assessed to create an integrated physiological, psychological, and behavioral response. The ANS is thus crucial to healthy, adaptive responses to stimuli as it connects our perception to the environment with activation of the systems of the body (e.g. cardiovascular, respiratory, digestive, endocrine, immune), psychological processes, and behavior.

The response of the ANS can be conceptualized as a continuum of integrated physiological, psychological, behavioral responses from states of activation and mobilization to restoration and relaxation. Optimal function includes the ability to respond accurately and appropriately to actual or perceived threat and to return to states of homeostasis, stability, and restoration efficiently.

The two broad divisions for these integrated actions are termed the sympathetic and parasympathetic nervous systems. The sympathetic is often referred to as “fight or flight” and is responsible for the activation of physiological systems for quick, efficient response to actual or perceived danger. The parasympathetic, referred to as “rest and digest”, is responsible for the activation of physiological restoration and homeostasis in response to perceived safety.

The primary conduit of the parasympathetic nervous system is the vagus nerve. As a mixed nerve, it carries both afferent (sensory) and efferent (motor) functions. It is thought that about 80 percent of the vagus nerve has this sensory function, while the remaining 20 percent is responsible for the majority of parasympathetic response (Porges, 2011). A major significance of this nerve is this shared capacity for both perception of inner physiological state as well as the initiation of the action termed the “relaxation response”.

The sensory component of the vagus nerve is part of a larger process called interoception which is important for promoting healthy states of the body, mind, and behavior. Historically, interoception referred to the perception of visceral information and inner bodily states such as heart rate and digestive processes (Ceunen et al., 2016). More recently, its meaning has broadened and includes a more complex process. This includes sensory pathways (including the vagus nerve) carrying perception of physiological state and psychological processes (thoughts, emotions, memories) for an integrated motor response of the body, mind, and behavior (Ceunen et al., 2016; Craig, 2015; Porges, 2011).

Healthy interoceptive processes indicates the person is able to accurately perceive, interpret, and respond to stimuli for optimal body-mind regulation and resilience (Farb et al., 2015; Haase et al., 2016). The ability for an individual to accurately match the response of the body and mind to the perceived stimuli is thought to be important for recovery and well-being in various patient populations such as pain conditions and addiction (Ceunen et al., 2016; Craig, 2015; Farb et al., 2015; Haase et al., 2016; Porges, 2011; Strigo & Craig, 2016). The vagus nerve is important to the development of healthy interoception as it relays information about viscera and bodily state to the brain.

The motor component of the vagus nerve is responsible for majority of the parasympathetic activation of the body. Its widespread connections throughout the body makes it crucial to systems-wide homeostatic responses including cardiovascular, respiratory, digestive, muscular and immune (Porges, 2011). The motor function of the vagus nerve has two source nuclei in the brainstem—the dorsal motor nucleus and the nucleus ambiguus—which provide for a range of parasympathetic responses as will be described below with polyvagal theory (Porges, 2011). These extensive motor and sensory functions make the vagus nerve a crucial bidirectional pathway for the ANS to support body-mind-behavior regulation, resilience, and biopsychosocial health.

ANS Regulation, Resilience, and the Promotion of Well-being

The term regulation describes the capacity to return to or maintain homeostatic, stable states of the body and mind through managing one’s responses to threat or adversity (Gard et al., 2014). Self-regulation refers to the individual having the capacity to consciously activate these homeostatic physiological states, calm and positive psychological qualities, and pro-social behaviors such as compassion, connection and empathy. The individual learns to recognize, manage, and even alter thoughts, emotions, behavior, and physiological states in response to various stimuli. This ability to self-regulate is an important contributor to improved health and wellbeing in various conditions including: irritable bowel syndrome, anxiety, neurodegenerative disorders, trauma, and pain (Muehsam et al., 2017; Taylor et al., 2010).

The ANS is vital to self-regulation as it includes widespread connections to bodily systems, psychological processes, and behavioral characteristics. The significance of these extensive connections is the capacity for concurrent effects on the body, mind, and behavior by affecting the underlying autonomic state. Both top-down neuro-cognitive (e.g. practices for control of attention or regulation of emotion) and bottom-up neurophysiological (e.g. practices of movement or breath control) processes can be utilized to shift autonomic state for self-regulation. This ability to regulate the ANS is associated with positive attentional and emotional regulation and control as well as appropriate or accurate responses to environmental demands (Park & Thayer, 2014; Porges, 2011; Streeter et al., 2012; Strigo & Craig, 2016; Thayer & Lane, 2000). Lower capacity for ANS regulation is associated with poor self-regulation and adverse health outcomes or conditions such as depression, anxiety, lupus, rheumatoid arthritis, trauma (Muehsam et al., 2017; Park & Thayer, 2014; Thayer & Lane, 2000; Tsuji et al., 1994).

Various conditions including fibromyalgia, irritable bowel syndrome, headaches, and other chronic pain conditions include different expression of ANS dysregulation (Azam et al., 2016; Barakat et al., 2012; Koenig et al., 2016; Kolacz & Porges, 2018; Maletic & Raison, 2009; Meeus et al., 2013; Staud, 2008; Tracy et al., 2016). ANS dysregulation includes excessive, inadequate, or inaccurate sympathetic or parasympathetic responses to the demands of the environment. This altered capacity to adequately respond to stimuli can be both a contributor as well as a result of chronic health conditions. In other words, chronic conditions can lead to diminished resilience and ANS dysregulation and/or this dysregulation may be a sign of the diminished resilience resulting from the condition (Sullivan, 2019).

Resilience adds a factor of efficiency and timeliness to the concept of regulation. A resilient system is one that recovers quickly from difficulty or adverse stimuli while conserving physiological and psychological resources (Resnick et al., 2011; Tugade & Fredrickson, 2004; Whitson et al., 2016). The more resilient the individual, the more likely they are to respond to stressors appropriately, adequately, and return quickly to regulated body-mind-behavioral states. The positive health outcomes of resilience includes less perceived stress, greater motivation in recovery from illness or trauma, improved management of chronic pain and dementia (Resnick et al., 2011; Tugade & Fredrickson, 2007).

Polyvagal theory offers a nuanced understanding of how the ANS affects body-mind-behavioral states in a synchronistic fashion for improved regulation and resilience.

POLYVAGAL THEORY: DEEPER LOOK AT THE ANS RELATIONSHIPS BETWEEN BODY, MIND, AND BEHAVIOR

The sympathetic and parasympathetic divisions of the ANS are not meant to be understood as a dichotomous system where one branch is activated at the expense of the other. They are not antagonistic and do not operate as a simple “turned on or off system”. When one activates it does not mean the other automatically “shuts off” or deactivates. Rather the branches work together to create a continuum of fine-tuned responses to the environment (Berntson et al., 1991; Porges, 2011). This complexity allows the individual to have a range of responses from mobilization to restorative or homeostatic states.

The polyvagal theory, developed by Stephen W. Porges Ph.D. (Neuroscientist, University of North Carolina and Indiana University), illuminates the connected relationships of the body, mind, and behavior influenced by underlying autonomic neural states or “neural platforms”. Each neural platform activates the likelihood of particular physiological activations, psychological processes, and behavioral characteristics. Recognizing and altering these underlying neural platforms provides a mechanism for

the promotion of systemic body-mind-behavioral regulation, resilience, and whole- person health and well-being.

As mentioned above, two different origination sites for the vagus nerve in the brainstem are detailed in polyvagal theory. The finding of these two different source nuclei is significant in explaining a range of parasympathetic responses. There is a continuum of activations that slow the system down spanning from a homeostatic relaxation response to an extreme slowing or shutting down to essential survival needs and conservation—seen in situations of immense life threat. This complexity of autonomic function spanning a range of parasympathetic activations to co-activation of the sympathetic and parasympathetic branches in differing proportions as well as the effect of these neural platforms on body-mind-behavior are key to the importance of polyvagal theory.

Neuroception, coined by Dr. Porges, describes a process of subconscious perception of both inner processes (interoception) and the external environment (exteroception) that individuals use to gauge the present level of safety or danger (Porges, 2003, 2004, 2011). These interoceptive and exteroceptive inputs help to activate an autonomic neural platform that readies the person for a quick, efficient response to the environment. A key piece to neuroception is how this subconscious detection and subsequent neural platform gives rise to particular and connected physiological, psychological and behavioral responses before any conscious attention or deliberation.

As will be discussed below, yoga practices empower the person to recognize these habitual tendencies and provide strategies to help the individual change the reaction and relationship to subconscious stimuli. Without this conscious attention, these neural platforms give rise to instinctive reactions of physiological state, thoughts, emotions, and behavior.

Polyvagal theory describes how these divisions of the vagus nerve, the neural platforms arising from neuroception, and the activation of neural platforms influence shared physiological, psychological, behavioral characteristics. The three main autonomic neural platforms are named according to the behaviors that arise from their activation. They are described below to include the physiological foundation and effect on psychological and behavioral attributes.

Social Engagement Neural Platform

This neural platform is made up of a network of nerves including: the branch of the vagus nerve originating from the nucleus ambiguus in the brainstem as well as the glossopharyngeal, spinal accessory, trigeminal, and facial nerve. This branch of the vagus is responsible for the production of respiratory sinus arrhythmia- the measure of heart rate variability used to demonstrate a parasympathetic dominant and resting state of the heart.

This neural platform is activated in response to perceived safety in the environment. It is termed social engagement because it links physiological restoration (slowed heart rate, greater HRV, improved peristalsis for digestion) and expressive and receptive domains of communication (motor control of facial expression to express safety to others, control of middle ear muscles to attune to human voice distinct from other noise, control of muscles of the throat for improved vocalization pleasing to other humans).

The result of this activation is a combination of physiological and psychological calm enabling the potential for positive prosocial behaviors and connection with others including compassion and eudemonic well-being (Porges & Carter, 2017; Porges, 2011, 2017; Sullivan, 2019; Sullivan et al., 2018).

Defensive Mobilization Neural platform

This neural platform involves activation of the sympathetic nervous system with defensive behaviors often referred to as “fight or flight”. In response to perceived threat, the body’s resources are mobilized for defensive strategies and include: increased muscle tone, heart rate, release of stress related hormones such as cortisol, and inhibition of digestive processes. The brain is also activated for greater vigilance and focused attention to potential threats. Alongside these physiological activations, emotions that support these protective responses such as fear, anger, anxiety, or worry and behaviors of “fight or flight” are likely to emerge. In sum, in response to perceived threat this autonomic neural platform supports mobilization of the system to include a physiological, emotional, behavioral response to assist in the finding of safety and protection (Porges, 2011; Sullivan & Robertson, 2020).

Defensive Immobilization

This neural network is thought to be activated in response to extreme danger, threat, or terror. It results in a dramatic slowing of the body’s resources to the minimum necessary for survival. The branch of the vagus nerve originating out of the dorsal motor nucleus is thought to be part of this response to extreme threat. Sometimes referred to as death-feigning it signifies a passive response to life threat and is a combined state of physiological immobilization or shutdown with emotional and behavioral states including disembodied or dissociative characteristics.

These three primary neural platforms arise from the predominance of either the sympathetic mobilizing activations or one of the vagal branches precipitating a slowing down of the system along a continuum of optimal restoration to immobilization. Polyvagal theory describes two more states that arise from the combination of these three neural platforms to create a wide and nuanced array of possibilities for human behavior and response.

Two more neural platforms from the combination of the above:

1. Safe Mobilization

When the person simultaneously perceives safety and the need for mobilization there is a co-activation of the neural platforms of social engagement and defensive mobilization. This is seen in situations such as dance, play, exercise, or creative endeavors. The person is both mobilized for action and perceives safety so there is relative balance in the neural platforms of social engagement and mobilization. As a result the person experiences safety in the midst of activation.

Safe mobilization is a key to improving regulation and resilience. The person finds a greater capacity to find safety within an activated system. This functions to create a wider tolerance to life’s stressors and stimuli. Rather than becoming overwhelmed by stimuli, the person learns to manage stressors more effectively and efficiently. Yoga practices that mobilize the physiological systems such as active postures alongside relaxed breath patterns, or calming visualizations or affirmations are examples of this state of safe mobilization. This combination of activity of the body with attention to breath, thought, emotions enables the person to find safety amidst activation. This learning in yoga practice can be extended to the individual’s life situations to mirror those that require a level of activation while maintain relative calm and safety.

2. Safe Immobilization

Co-activation of the social engagement and immobilization neural platforms arise from a perception of safety alongside a slowing down of the system. This would be present in certain meditative states where physiological resources are slowed and the person may even experience levels of dissociation but safety is perceived (Porges, 2011).

Altogether these five global states provide a continuum of autonomic response to help the individual both mobilize and find homeostatic balance across a range of situations of perceived safety or danger. Self-regulation is fostered through activation of the social engagement neural platform for shared physiological, psychological, and behavioral states of homeostasis, peacefulness and calm. Resilience can then be supported by helping the person find greater ease in moving between neural platforms and cultivating a broader range of safe mobilization to safe immobilization. This will be described in more detail below.

Yoga is one mind-body practice that can help the individual learn to recognize and alter these underlying autonomic states. Yoga practices such as meditation and ethical inquiry provide top-down neurocognitive practices while movement and breath control provide bottom-up neurophysiological practices for this effect on the ANS. Integration of such practices supports autonomic regulatory states, parasympathetic activation, and an integrated autonomic, emotional and attentional effect (Chu et al., 2017; Dale et al., 2011; Mackenzie et al., 2014; Sarang & Telles, 2006; Telles et al., 2016; Tyagi & Cohen, 2016). The yoga practitioner becomes empowered in their capacity to influence physiological activations, thoughts, emotions, and behavior through the recognition and change of autonomic states. This capacity for self-regulation and resilience demonstrates a primary mechanism through which yoga positively affects physical and mental health for various patient populations (Gard et al., 2014; Muehsam et al., 2017; Schmalzl et al., 2015; Streeter et al., 2012; Sullivan et al., 2018; Taylor et al., 2010).

YOGA AND THE ANS: SHARED THEMES

Yoga and Self-Regulation, Interoception and Discriminative Wisdom

Essential to yoga teaching is the recognition of suffering arising from the misperception and misidentification with the fluctuating stimuli of the body, mind, and environment. Yoga teaches the person to compassionately notice the relationship and reaction to what arises and to distinguish these stimuli from a deeper recognition of unchanging awareness. While awareness experiences the rise and fall of bodily sensation (physiological activations/sensations), mental and emotional phenomena (thoughts, emotions, ego-identity), and life's situations—it is separate from them. This realization brings about an underlying equanimity, contentment, and abiding joy that is present amidst all circumstances and fluctuations of the body, mind, and environment.

Discriminative wisdom is a term to describe this insight into the distinction between changing stimuli and unchanging awareness. Nonjudgmental, compassionate observation and exploration of body-mind sensation and life circumstance enables the person to identify habitual patterns of response and behavior that contribute to suffering. The person develops new, adaptive, healthy relationships to body, mind, and environmental stimuli to alleviate suffering and support equanimity and well-being amidst all stimuli. Consequently, the person develops a greater capacity to navigate the changing stimuli and situations of life while remaining situated in an unwavering equanimity that arises from this recognition of awareness.

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As an example, the person might become aware of how particular life circumstances, such as a work situation, create a change in the state of their body and/or mind. A certain stressor may be linked to a dysfunctional breathing pattern, tension in the body, worry or anxiety. Yoga teaches the person to both notice these patterns and to manage or alter these reactions to support healthier, more adaptive states of the body-mind. Skills are learned to inquire into the causes of body-mind disturbance and to mitigate them for improved regulation and resilience, and greater well-being. Ultimately the person learns to work with the natural stressors and changes of life with greater skill and ease.

The previously described neurophysiological concepts of neuroception and interoception are helpful in understanding the practical application of discriminative wisdom in yoga. Neuroception describes the habitual activations of neural platforms based on subconscious detection of safety or danger. Yoga teaches a process of inquiry to support these subconscious reactions being brought to conscious attention and control. This recognition of habitual reactions enables the person to regulate these neural activations, support experiences of equanimity and eudemonic well-being, and to choose healthy, adaptive responses. Interoception is a key piece to developing this skill of noticing subconscious physiological activations and altering or regulating one's response. As explained above, interoception is a complex concept that includes the recognition of bodily states, relationships to thoughts, emotions, beliefs, and resultant behavior (Craig, 2015; Farb et. al., 2015; Porges, 1993; Strigo & Craig, 2016). Yoga teaches the individual to notice and tease apart the various stimuli of the body, mind, and environment. They develop insight to support the navigation of these stimuli with greater ease and well-being. The person learns to notice what arises, to self-reflect, and self-discover so that new relationships can be fostered for improved regulation and resilience. Foundational to yoga is a learned methodology to accurately discern body, mind, and environmental stimuli; to bring subconscious or unconscious habits to conscious attention; and to build healthier and more accurate relationships to these stimuli. The person is able to build interoceptive skills to distinguish between physiological and psychological activations and their relationships with one another for the cultivation of healthier responses. This learning of interoception is key to the explanatory framework of yoga whereby the person learns to distinguish body, mind, environmental phenomena from awareness for the promotion of eudemonic well-being and the alleviation of suffering (Sullivan et al., 2018; Sullivan et al., 2018).

Yoga and Neural Platforms: The *Gunas*

In addition to building interoceptive skills and helping neuroceptive processes become conscious, yoga offers its own perspective on how underlying substrates influence connected body-mind states and behavior. Yoga teaches that all changing phenomena (including the components of the body, mind, and environment) are made up of three qualities—the *gunas*. These *gunas*—*sattva*, *rajas*, *tamas*—give rise to all of the various manifestations of the body state, mental and emotional characteristics, behavior, and environmental phenomena.

Sattva is the quality of lightness, buoyancy, luminosity and supports bodily states of homeostasis and relaxation; psychological qualities of peace, equanimity, and calm; and behaviors that align with compassion, connection, and one's values and ethics (Burley, 2012; Miller, 2012; Sullivan & Robertson, 2020). *Rajas* is the quality of mobilization and is responsible for the wide range of activations in the body, mind, and behavior. This includes a continuum from creativity, play, and inspiration to turbulence, fight/flight responses, anxiety, fear, and anger. The third quality, *tamas*, encourages states of stillness along a continuum from groundedness and stability to fatigue, delusion, obscuration, and dissociation.

When the *gunas* are balanced *sattva* provides the clarity for discriminative wisdom and insight, including developing interoceptive skills, and inner and outer harmony in alignment with one's values for a meaningful and purpose-filled life. *Rajas* provides the motivation and creativity for change and determination of right action. *Tamas* offers the stability and groundedness for disciplined practical action and practice. When *rajas* is predominant over the other two *gunas* activation and agitation builds to those body-mind states seen in the neural platform of defensive mobilization. This includes physiological, psychological, and behavioral states of fight/flight response. When *tamas* is predominant the stillness and slowing can eventually produce body-mind and behavioral states similar to the neural platform of defense immobilization such as intense fatigue, dissociation, or obscuration.

Polyvagal theory offers a neurophysiological description and convergent theory to the *gunas* of yoga. From these underlying neural platforms (polyvagal theory) and *gunas* (yoga) arise concurrent changes in physiological and psychological activations and behaviors (Sullivan et al., 2018; Sullivan & Robertson, 2020). By affecting these underlying substrates the person can enact change in the body, mind, and behavior simultaneously. While not reducing one to the other, the shared characteristics of *gunas* and neural platforms illustrate how they support one another. When one is activated (neural platform or *guna*) it is likely to be reflected in its counterpart (related *guna* or neural platform). In other words, a *guna* is supportive of a particular neural platform and vice versa and affecting these substrates produces a synergistic effect on physiology, emotion, and behavior.

This translatable language is important to the application and understanding of yoga for regulation and resilience as well as the promotion of whole-person health and eudemonic well-being. A more complete description of these convergences of neural platforms and *gunas* is described in an article by Sullivan et al. (2018) and is summarized below.

Social Engagement and Sattva Guna

This neural platform and *guna* give rise to shared physiological states such as homeostasis and relaxation; psychological states including calmness, peacefulness, and equanimity; and behavioral states such as compassion and connection. These shared attributes demonstrate that when one is activated or predominant it is likely reciprocated by the activation or predominance of the other. When *sattva* is predominant with its characteristics of clarity and calmness, the social engagement neural platform is likely activated with its components of interoceptive accuracy and sensitivity, parasympathetic response, psychological calm and equanimity, and prosocial features such as compassion and connection. Likewise when the social engagement neural platform is activated the attributes of *sattva* such as clarity, luminosity, equanimity are likely to emerge. This neural platform and *guna* are essential to the development of discriminative wisdom and self-regulatory skills, as it supports healthy interoceptivity, physiological and psychological calm, equanimity and prosocial connection, compassion. Moreover these qualities of healthy connection to body-mind states, positive relationships with others, and alignment with values may facilitate greater eudemonic well-being.

Mobilization (Safe and Defensive) and Raja Guna

Rajas guna and sympathetic activation mobilize the system for action from a range of safe mobilization to defensive states in response to actual or perceived threat. These underlying substrates mobilize the body, mind and behavior for action on a continuum from safe and balanced to defensive and unbalanced

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mobilization. In safe mobilization or balanced *rajas* there is activation of the systems of the body, mind and behavior alongside perceived safety. This state is seen in any creative endeavor, activity, or play where the systems are primed for action but the activation does not overwhelm the perception of safety. In defensive mobilization or a predominance of *rajas* the body, mind and behavior are mobilized for action in response to perceived or actual threat. When one is activated (*rajas* or sympathetic) the other is more likely to be activated as well. The continuum from safe mobilization/balanced *rajas* to defensive mobilization/predominant *rajas* allows the activation of the systems as appropriate to the environment.

Immobilization (Safe and Defensive) and Tama Guna

This neural platform and *guna* provide relative stillness or immobilization on a continuum from solidity, groundedness and stability to dullness, inertia, and dissociative states. The stillness of *tamas* supports the activation of the neural platform of immobilization. In safe immobilization or balanced *tamas* there is both the perception of safety with stillness, as in meditative states. Defensive immobilization or predominant *tama guna* may result in states of immobilization, obscurity, dullness, lethargy, dissociation, death-feigning, inertia.

Polyvagal theory and yoga provide a language for directing interventions towards the alteration of underlying neural platforms (polyvagal) or *gunas* (yoga) for whole-person health and well-being. This synergy between perspectives enables yoga to be understood for its positive health effects in various patient populations in alignment with its unique framework, perspective, and philosophical context.

BODY-MIND REGULATION, RESILIENCE THROUGH POLYVAGAL THEORY AND YOGA

The *gunas* and polyvagal theory offer a novel perspective on how altering underlying substrates (neural platforms or *gunas*) can help support regulation and resilience for widespread health effects (Sullivan et al., 2018; Sullivan & Robertson, 2020).

In this model, self-regulation can be conceptualized as the promotion of *sattva guna* and the social engagement neural platform. The practices of *yoga* can be directed in a synchronistic fashion towards the promotion of this neural platform and *guna*. This would include activation of the parasympathetic nervous system through both top-down neurocognitive and bottom-up neurophysiological practices. From a neurocognitive perspective practices of meditation, focused attention, mantra, affirmation, and ethical inquiry to align with one's values would promote these calm, relaxed states of the body and mind as well as prosocial behavior. From a neurophysiological perspective breath practices such as alternate nostril breath, longer exhales, and movement such as restorative postures can facilitate these characteristics of *sattva* and social engagement neural platform.

Furthermore, the components of eudemonic wellbeing can be supported by the activation of this neural platform and *guna*. Healthy interoceptive skills help the person notice and manage habitual, subconscious reactions of the body, mind, and behavior to various stimuli. The person becomes able to recognize the ways in which one's actions (including physiological activations, psychological qualities and behavior) either supports or detracts from a process of self-realization and self-actualization. This insight empowers the person to live more authentically in alignment with one's values for a flourishing, meaningful, and purpose-filled life. In addition, improved relationships with others are fostered from

this *guna* and neural platform. *Sattva guna* supports the inherent recognition of connection between all people and the social engagement neural platform strengthens both expressive and receptive components of communication. Lastly, *sattva guna* is described as supporting dharma of which the *yamas* and *niyamas* (ethical practices) are taught as essential to this harmonious living for a purpose-filled and meaningful life (Burley, 2012; Miller, 2012; Smith, 2009; Sullivan & Robertson, 2020). Likewise, a foundation of eudemonia is the recognition of the virtue ethics as guideposts to a purpose-filled and meaningful life (Aristotle et al., 2004).

When all the practices of yoga are utilized for the promotion of *sattva* and social engagement neural platform, the person finds an improved capacity for regulation, perceived safety, equanimity, contentment, connection, and eudemonic well-being. This provides an anchor and foundation of safety and calm that the person can stay connected or return to even amidst difficult life circumstances.

Promoting Resilience Through Polyvagal Theory and Yoga

While regulatory states of the body and mind are key to physical and mental health, they are not meant to be present at all times during all levels of activity. Resilience helps clarify the need for differing levels of activation for a healthy, adaptive response to life's natural needs and stimuli. Polyvagal theory and yoga help to conceptualize the practical application of resilience as the capacity to work with changing neural platforms or *gunas* (Sullivan et al., 2018).

The *gunas* and neural platforms are constantly shifting and changing, which contributes to the natural occurring fluctuations present in the body, mind, and environment. Yoga teaches that the *gunas* are always in motion—all phenomena of the body, mind, and environment are in constant flux. Rather than disregarding or ignoring this intrinsic part of life, yoga teaches the person to navigate and develop healthier relationships with fluctuating stimuli for the alleviation of suffering and realization of well-being. By learning to recognize, adapt, and develop healthy relationships to the rising and falling of *sattva*, *rajas*, and *tamas* the person learns to navigate these experiences with greater ease. In addition, the person may realize the presence of an unchanging sense of equanimity, contentment, or eudemonic well-being amidst these changing stimuli. From a perspective of polyvagal theory, as the person learns to become aware of changing neural activations they are able to move between neural platforms to re-establish parasympathetic dominant states and they may be able to find a wider tolerance for safety amidst mobilizing or immobilizing activations.

Once a foundation in regulation is found through practices that support *sattva* and social engagement neural platform, the person can move to the work of building resilience. The person learns to recognize when they shift from states of regulation, how to return to them, to be present with the changing activations without being overwhelmed, and to manage or alter the relationships and reactions to the *gunas* and neural platforms. Three types of resilience are described from this perspective of polyvagal theory and yoga.

Moving Between Neural Platforms and *Gunas*

The practices of yoga can be utilized to create a foundation in *sattva* and the social engagement neural platform as well as to move between neural platforms or *gunas*. An example is rotating between practices that foster parasympathetic and sympathetic activations. Starting with parasympathetic and *sattvic* activation through practices such as longer exhales, restorative or comfortable postures, and medita-

tions with a focus on peace and ease would be followed by mobilizing practices that support *raja guna*. These activating practices could include active postures that increase muscle tension and breath rate, or breathing practices that are activating to the system. The person would cycle back and forth between these practices that create a relaxation response and those that require physiological activation, helping the person learn to move between neural platforms or *gunas* with greater ease. The person learns to recognize these different neural platforms and *gunas* and to have confidence in their ability to return to social engagement and *sattva*. This skill can be translated to life as the person notices when these different activations arise and can develop proficiency in regulating back to states of homeostasis or calm after times of activation.

Widening the Range of Tolerance for Neural Platforms and *Gunas*

Proficiency in identifying and moving between neural platforms and *gunas* can progress to helping the person build a greater tolerance to stimuli. The person can learn to be present to different neural platforms or *gunas* while still perceiving safety or ease. Rather than becoming overwhelmed by these different activations, the individual fine-tunes their response to stimuli of the body, mind, and environment. An example would be in a *yoga* practice where the person is physiologically mobilized with an active posture while they maintain a breath pattern to stimulate a relative parasympathetic response and/or meditative focus for comparative calm or ease. A broader range of safe mobilization can be found so that the person can be with a greater level of activating stimuli without becoming overwhelmed. As this is translated to life the person finds they can be present to a wider range of circumstances and life situations, to a range from safe mobilization to safe immobilization.

From a *yoga* standpoint, they can perceive the quality of *sattva*—clarity and calm—amidst greater turbulence from *rajas* or dullness/obscuration from *tamas*. In life this translates to the person being able to be present to and tolerate a greater variety of stimuli and intensity of body and mind fluctuations and life circumstances while maintaining a degree of ease or calm.

Equanimity within Fluctuating *Gunas* and Neural Platforms

As a progression of resilience the individual moves from being able to return to relaxed states after activation, to the ability to be with differing levels of activation while maintaining a measure of ease, to the recognition of all stimuli as a part of awareness with equanimity or eudemonic well-being.

In this type of resilience, the individual recognizes everything that arises in the body, mind, and environment as awareness. Rather than moving back and forth between activations, or finding a platform of ease from which to be with greater variations in activations, there is the potential to experience all activations as awareness. A sense of welcoming arises as each stimuli of the body, mind, and environment are seen as pointers to and inherent facets of awareness. Deep equanimity, abiding joy, and eudemonic well-being are found within and amongst all *gunas* and neural platforms. The person comes to experience their pain, anxiety, and worry as an aspect of themselves that does not detract from this eudemonic well-being. Their depressive or anxious thoughts, medical conditions, or pain are understood as a current characteristic being experienced by the body or mind—but they do not misidentify or over identify with them. The person recognizes that these symptoms are an expression of the body, mind, or life circumstance, but that they do not define the totality of who they are nor their experience. In this type of

resilience the person recognizes neural platforms and *gunas* as awareness and experiences abiding joy, and eudemonic well-being simultaneously with these fluctuations of the body, mind, and environment.

CONCLUSION

Yoga and polyvagal theory share a perspective whereby affecting underlying substrates can help build regulation and resilience to support eudemonic well-being for improved physical, mental, and social health.

The person is able to consciously activate healthy and positive physiological, psychological, and behavioral states such as eudemonic well-being through the social engagement neural platform and *sattva guna*. This foundation of safety, calm, and relaxation supports a process of self-inquiry for self-realization and self-actualization. Interoceptive and neuroceptive skills are developed as subconscious reactions of the body, mind, and behavior come to conscious attention. Healthy, accurate recognition of these activations supports discriminative wisdom for transformative change. The person is empowered to discover a life of greater authenticity and alignment with one's values for a meaningful, purpose-filled, and flourishing life—they discover the agency to consciously cultivate relaxed physiological, positive psychological, and prosocial behavioral attributes supportive of health or well-being.

From these positive and healthy states of the body, mind, and behavior resilience can then be cultivated. By working with changing neural platforms or *guna* states through yoga practice the person learns to both notice and navigate between them with greater ease. The person is then able to widen the window of tolerance to these shifting neural platforms and *gunas* to find relative balance within mobilized or immobilized states. Finally, there is a potential for the person to change the relationship with activations to find eudemonic well-being amidst the neural platforms and *gunas*. In other words, the person learns to experience these fluctuating stimuli without over-identifying with them.

Yoga practices like movement, breathwork, ethics, and meditation can be used synchronistically for both regulation and resilience. The person builds self-regulatory skills through practices that facilitate the social engagement neural platform and *sattva guna*. Resilience is then fostered by finding the practices that activate the other neural platforms and *gunas*. This convergence of polyvagal theory and yoga enables the practitioner to understand how the practices are used together to influence body, mind, behavior through affecting underlying neural platforms or *gunas*. The practices of yoga can then be applied in a synergistic fashion in alignment with yoga's philosophical context for optimal well-being. This is also important as yoga becomes integrated in both research and healthcare contexts so that it is understood as a distinct, unique profession for various patient populations.

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REFERENCES

- Aristotle, Thomson, J. A. K., & Tredennick, H. (2004). *The nicomachean ethics*. Penguin Books.
- Azam, M. A., Katz, J., Mohabir, V., & Ritvo, P. (2016). Individuals with tension and migraine headaches exhibit increased heart rate variability during post-stress mindfulness meditation practice but a decrease during a post-stress control condition – A randomized, controlled experiment. *International Journal of Psychophysiology*, 110, 66–74. doi:10.1016/j.ijpsycho.2016.10.011 PMID:27769879
- Barakat, A., Vogelzangs, N., Licht, C. M. M., Geenen, R., Macfarlane, G. J., de Geus, E., ... Dekker, J. (2012). Dysregulation of the ANS is associated with pain intensity, not with the presence of chronic widespread pain. *Arthritis Care and Research*, 64, 1209–1216. PMID:22422576
- Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1991). Autonomic determinism: The modes of autonomic control, the doctrine of autonomic space, and the laws of autonomic constraint. *Psychological Review*, 98(4), 459–487. doi:10.1037/0033-295X.98.4.459 PMID:1660159
- Bhavanani, A. B. (2011). Are we practicing yoga therapy or yogopathy. *Yoga Therapy Today*, 26–28.
- Bhavanani, A. B., Sullivan, M. B., Taylor, M. J., & Wheeler, A. (2019). Shared foundations for practice: The language of yoga therapy. *Yoga Therapy Today*, 19, 44–47.
- Burley, M. (2012). *Classical samkhya and yoga: an indian metaphysics of experience*. Routledge.
- Ceunen, E., Vlaeyen, J. W. S., & Van Diest, I. (2016). On the origin of interoception. *Frontiers in Psychology*, 7, 743. doi:10.3389/fpsyg.2016.00743 PMID:27242642
- Chu, I. H., Wu, W. L., Lin, I. M., Chang, Y. K., Lin, Y. J., & Yang, P. C. (2017). Effects of yoga on heart rate variability and depressive symptoms in women: A randomized controlled trial. *Journal of Alternative and Complementary Medicine (New York, N.Y.)*, 23(4), 310–316. doi:10.1089/acm.2016.0135 PMID:28051319
- Cole, S. W. (2013). Social regulation of human gene expression: Mechanisms and implications for public health. *American Journal of Public Health*, 103(S1), S84–S92. doi:10.2105/AJPH.2012.301183 PMID:23927506
- Cole, S. W. (2014). Human social genomics. *PLOS Genetics*, 10(8), e1004601. doi:10.1371/journal.pgen.1004601 PMID:25166010
- Cole, S. W., Levine, M. E., Arevalo, J. M. G., Ma, J., Weir, D. R., & Crimmins, E. M. (2015). Loneliness, eudaimonia, and the human conserved transcriptional response to adversity. *Psychoneuroendocrinology*, 62, 11–17. doi:10.1016/j.psyneuen.2015.07.001 PMID:26246388
- Craig, A. D. (2015). *How do you feel?: an interoceptive moment with your neurobiological self*. Princeton University Press. doi:10.1515/9781400852727
- Dale, L. P., Carroll, L. E., Galen, G. C., Schein, R., Bliss, A., Mattison, A. M., & Neace, W. P. (2011). Yoga practice may buffer the deleterious effects of abuse on women's self-concept and dysfunctional coping. *Journal of Aggression, Maltreatment & Trauma*, 20(1), 90–102. doi:10.1080/10926771.2011.538005

- Dezutter, J., Casalin, S., Wachholtz, A., Luyckx, K., Hekking, J., & Vandewiele, W. (2013). Meaning in life: An important factor for the psychological well-being of chronically ill patients? *Rehabilitation Psychology, 58*(4), 334–341. doi:10.1037/a0034393 PMID:24295525
- Dezutter, J., Luyckx, K., & Wachholtz, A. (2015). Meaning in life in chronic pain patients over time: Associations with pain experience and psychological well-being. *Journal of Behavioral Medicine, 38*(2), 384–396. doi:10.1007/s10865-014-9614-1 PMID:25537924
- Farb, N., Daubenmier, J., Price, C. J., Gard, T., Kerr, C., Dunn, B. D., Klein, A. C., Paulus, M. P., & Mehling, W. E. (2015). Interoception, contemplative practice, and health. *Frontiers in Psychology, 6*, 763. doi:10.3389/fpsyg.2015.00763 PMID:26106345
- Fredrickson, B. L., Grewen, K. M., Algoe, S. B., Firestone, A. M., Arevalo, J. M. G., Ma, J., & Cole, S. W. (2015). Psychological well-being and the human conserved transcriptional response to adversity. *PLoS One, 10*(3), e0121839. doi:10.1371/journal.pone.0121839 PMID:25811656
- Fredrickson, B. L., Grewen, K. M., Coffey, K. A., Algoe, S. B., Firestone, A. M., Arevalo, J. M. G., ... Cole, S. W. (2013). A functional genomic perspective on human well-being. *Proceedings of the National Academy of Sciences, 110*, 13684–13689. 10.1073/pnas.1305419110
- Gard, T., Noggle, J. J., Park, C. L., Vago, D. R., & Wilson, A. (2014). Potential self-regulatory mechanisms of yoga for psychological health. *Frontiers in Human Neuroscience, 8*, 770. doi:10.3389/fnhum.2014.00770 PMID:25368562
- Haase, L., Stewart, J. L., Youssef, B., May, A. C., Isakovic, S., Simmons, A. N., Johnson, D. C., Potterat, E. G., & Paulus, M. P. (2016). When the brain does not adequately feel the body: Links between low resilience and interoception. *Biological Psychology, 113*, 37–45. doi:10.1016/j.biopsycho.2015.11.004 PMID:26607442
- Huta, V., & Waterman, A. S. (2014). Eudemonia and its distinction from hedonia: Developing a classification and terminology for understanding conceptual and operational definitions. *Journal of Happiness Studies, 15*(6), 1425–1456. doi:10.1007/s10902-013-9485-0
- Ivtzan, I., & Papanтониου, A. (2014). Yoga meets positive psychology: Examining the integration of hedonic (gratitude) and eudemonic (meaning) wellbeing in relation to the extent of yoga practice. *Journal of Bodywork and Movement Therapies, 18*(2), 183–189. doi:10.1016/j.jbmt.2013.11.005 PMID:24725784
- Keyes, C. L., & Simoes, E. J. (2012). To flourish or not: Positive mental health and all-cause mortality. *American Journal of Public Health, 102*(11), 2164–2172. doi:10.2105/AJPH.2012.300918 PMID:22994191
- Koenig, J., Falvay, D., Clamor, A., Wagner, J., Jarczok, M. N., Ellis, R. J., ... Thayer, J. F. (2016). Pneumogastric (vagus) nerve activity indexed by heart rate variability in chronic pain patients compared to healthy controls: A systematic review and meta-analysis. *Pain Physician, 19*, E55–E78. PMID:26752494
- Kolacz, J., & Porges, S. W. (2018). Chronic diffuse pain and functional gastrointestinal disorders after traumatic stress: Pathophysiology through a polyvagal perspective. *Frontiers in Medicine, 5*, 145. doi:10.3389/fmed.2018.00145 PMID:29904631

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- Mackenzie, M. J., Carlson, L. E., Paskevich, D. M., Ekkekakis, P., Wurz, A. J., Wytsma, K., Krenz, K. A., McAuley, E., & Culos-Reed, S. N. (2014). Associations between attention, affect and cardiac activity in a single yoga session for female cancer survivors: An enactive neurophenomenology-based approach. *Consciousness and Cognition*, 27, 129–146. doi:10.1016/j.concog.2014.04.005 PMID:24879038
- Maletic, V., & Raison, C. L. (2009). Neurobiology of depression, fibromyalgia and neuropathic pain. *Frontiers in Bioscience*, 14(1), 5291–5338. doi:10.2741/3598 PMID:19482616
- Mallinson, J., & Singleton, M. (2017). *Roots of yoga*. Penguin Classics.
- Meeus, M., Goubert, D., De Backer, F., Struyf, F., Hermans, L., Coppieters, I., De Wandele, I., Da Silva, H., & Calders, P. (2013). Heart rate variability in patients with fibromyalgia and patients with chronic fatigue syndrome: A systematic review. *Seminars in Arthritis and Rheumatism*, 43(2), 279–287. doi:10.1016/j.semarthrit.2013.03.004 PMID:23838093
- Miller, R. (2012). *The samkhya karika*. Integrative Restoration Institute.
- Muehsam, D., Lutgendorf, S., Mills, P. J., Rickhi, B., Chevalier, G., Bat, N., Chopra, D., & Gurfein, B. (2017). The embodied mind: A review on functional genomic and neurological correlates of mind-body therapies. *Neuroscience and Biobehavioral Reviews*, 73, 165–181. doi:10.1016/j.neubiorev.2016.12.027 PMID:28017838
- Park, G., & Thayer, J. F. (2014). From the heart to the mind: Cardiac vagal tone modulates top-down and bottom-up visual perception and attention to emotional stimuli. *Frontiers in Psychology*, 5, 278. doi:10.3389/fpsyg.2014.00278 PMID:24817853
- Porges, S. W. (1993). The infant's sixth sense: Awareness and regulation of bodily processes. *Zero to Three: Bulletin of the National Center for Clinical Infant Programs*, 14, 12–16.
- Porges, S. W. (2003). Social engagement and attachment. *Annals of the New York Academy of Sciences*, 1008(1), 31–47. doi:10.1196/annals.1301.004 PMID:14998870
- Porges, S. W. (2004). Neuroception: A subconscious system for detecting threats and safety. *Zero to Three*, 24, 19–24.
- Porges, S. W. (2011). *The polyvagal theory: Neurophysiological foundations of emotions, attachment, communication, and self-regulation*. W. W. Norton.
- Porges, S. W. (2017). *The Oxford handbook of compassion science*. Oxford University Press.
- Porges, S. W., & Carter, C. S. (2017). *Complementary and integrative treatments in psychiatric practice*. American Psychiatric Association Publishing.
- Pressman, S. D., Jenkins, B. N., & Moskowitz, J. T. (2019). Positive affect and health: What do we know and where next should we go? *Annual Review of Psychology*, 70(1), 627–650. doi:10.1146/annurev-psych-010418-102955 PMID:30260746
- Resnick, B., Galik, E., Dorsey, S., Scheve, A., & Gutkin, S. (2011). Reliability and validity testing of the physical resilience measure. *The Gerontologist*, 51(5), 643–652. doi:10.1093/geront/gnr016 PMID:21402647

- Ryff, C. D., Singer, B. H., & Dienberg Love, G. (2004). Positive health: Connecting well-being with biology. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 359(1449), 1383–1394. doi:10.1098/rstb.2004.1521 PMID:15347530
- Sarang, P., & Telles, S. (2006). Effects of two yoga based relaxation techniques on heart rate variability (HRV). *International Journal of Stress Management*, 13(4), 460–475. doi:10.1037/1072-5245.13.4.460
- Schleicher, H., Alonso, C., Shirtcliff, E. A., Muller, D., Loevinger, B. L., & Coe, C. L. (2005). In the Face of Pain: The relationship between psychological well-being and disability in women with fibromyalgia. *Psychotherapy and Psychosomatics*, 74(4), 231–239. doi:10.1159/000085147 PMID:15947513
- Schmalzl, L., Powers, C., & Henje Blom, E. (2015). Neurophysiological and neurocognitive mechanisms underlying the effects of yoga-based practices: Towards a comprehensive theoretical framework. *Frontiers in Human Neuroscience*, 9, 235. doi:10.3389/fnhum.2015.00235 PMID:26005409
- Smith, J. D. (Ed.). (2009). *Mahābhārata*. Penguin.
- Staud, R. (2008). Heart rate variability as a biomarker of fibromyalgia syndrome. *Future Rheumatology*, 3(5), 475–483. doi:10.2217/17460816.3.5.475 PMID:19890437
- Stoler-Miller, B. (1998). *Yoga: discipline of freedom*. Bantam Books.
- Streeter, C. C., Gerbarg, P. L., Saper, R. B., Ciraulo, D. A., & Brown, R. P. (2012). Effects of yoga on the ANS, gamma-aminobutyric-acid, and allostasis in epilepsy, depression, and post-traumatic stress disorder. *Medical Hypotheses*, 78, 571–579. doi:10.1016/j.mehy.2012.01.021 PMID:22365651
- Strigo, I. A., & Craig, A. D. (2016). Interoception, homeostatic emotions and sympathovagal balance. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, 371(1708), 20160010. doi:10.1098/rstb.2016.0010 PMID:28080968
- Sullivan, M., & Robertson, L. (2020). *Understanding Yoga Therapy: Applied philosophy and science for health and well-being*. Taylor & Francis Group. doi:10.4324/9780429507243
- Sullivan, M. B. (2019). *Yoga and science in pain care: Treating the person in pain*. Jessica Kingsley Publishers.
- Sullivan, M. B., Erb, M., Schmalzl, L., Moonaz, S., Noggle Taylor, J., & Porges, S. W. (2018). Yoga therapy and polyvagal theory: The convergence of traditional wisdom and contemporary neuroscience for self-regulation and resilience. *Frontiers in Human Neuroscience*, 12, 67. doi:10.3389/fnhum.2018.00067 PMID:29535617
- Sullivan, M. B., Moonaz, S., Weber, K., Taylor, J. N., & Schmalzl, L. (2018). Toward an explanatory framework for yoga therapy informed by philosophical and ethical perspectives. *Alternative Therapies in Health and Medicine*, 24, 38–47. PMID:29135457
- Taylor, A. G., Goehler, L. E., Galper, D. I., Innes, K. E., & Bourguignon, C. (2010). Top-down and bottom-up mechanisms in mind-body medicine: Development of an integrative framework for psychophysiological research. *Explore (New York, N.Y.)*, 6(1), 29–41. doi:10.1016/j.explore.2009.10.004 PMID:20129310

- Telles, S., Sharma, S. K., Gupta, R. K., Bhardwaj, A. K., & Balkrishna, A. (2016). Heart rate variability in chronic low back pain patients randomized to yoga or standard care. *BMC Complementary and Alternative Medicine*, 16(1), 279. doi:10.1186/12906-016-1271-1 PMID:27514611
- Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders*, 61(3), 201–216. doi:10.1016/S0165-0327(00)00338-4 PMID:11163422
- Tracy, L. M., Ioannou, L., Baker, K. S., Gibson, S. J., Georgiou-Karistianis, N., & Giummarra, M. J. (2016). Meta-analytic evidence for decreased heart rate variability in chronic pain implicating parasympathetic nervous system dysregulation. *Pain*, 157(1), 7–29. doi:10.1097/j.pain.0000000000000360 PMID:26431423
- Tsuji, H., Venditti, F. J. Jr, Manders, E. S., Evans, J. C., Larson, M. G., Feldman, C. L., & Levy, D. (1994). Reduced heart rate variability and mortality risk in an elderly cohort. The Framingham Heart Study. *Circulation*, 90(2), 878–883. doi:10.1161/01.CIR.90.2.878 PMID:8044959
- Tugade, M. M., & Fredrickson, B. L. (2004). Resilient Individuals use positive emotions to bounce back from negative emotional experiences. *Journal of Personality and Social Psychology*, 86(2), 320–333. doi:10.1037/0022-3514.86.2.320 PMID:14769087
- Tugade, M. M., & Fredrickson, B. L. (2007). Regulation of Positive Emotions: Emotion regulation strategies that promote resilience. *Journal of Happiness Studies*, 8(3), 311–333. doi:10.1007/10902-006-9015-4
- Tyagi, A., & Cohen, M. (2016). Yoga and heart rate variability: A comprehensive review of the literature. *International Journal of Yoga*, 9(2), 97. doi:10.4103/0973-6131.183712 PMID:27512317
- Whitson, H. E., Duan-Porter, W., Schmader, K. E., Morey, M. C., Cohen, H. J., & Colón-Emeric, C. S. (2016). Physical resilience in older adults: Systematic review and development of an emerging construct. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, 71(4), 489–495. doi:10.1093/gerona/glv202 PMID:26718984