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Research Article

From Self-Vitality System to Well-Coordinated Patterns - I. Neuro-Circulatory Perfusion

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Abstract

Maintenance of homeostasis starts with organ systems with their set reflexive responses in reactive mode. Without psychological adjustments, an individual would presumably not develop well-coordinated patterns enough to adapt through life with many environmental uncertainties. This paper introduces self-vitality systems, which evolved with energy efficiency for recurring similar situations, could function in autonomised responses in active and reactive modes through patterned wholesome adaptations of the mind and body as an integrated interface to environment, sustaining integrality. Here, an example is described on neuro-circulatory perfusion as it offers the individual well-patterned emotive or motive responses to various situations wherewith remodeling in time from anticipating, actuating, and adjusting allows a pattern-transforming ability for circulatory shifts needed to cater for endeavor-performance preparedness. Then conscious control from above would be facilitated to maneuver over these motive or emotive patterns to achieve snug-fit self-actualization without much undue adjustments and perturbations in emotions. Since development, the nervous system and cardiovascular system are integrated from the patternable Upper Heart System to the stabilizing Lower Heart System in their matching processes. The self-vitality system enhances preparedness to encounter new and past-similar situations through life. More self-vitality systems in subsequent articles should enlighten academia for describing away from mind-body dichotomy since Descartes.

Keywords: Energy efficiency; Neuro-circulatory perfusion; Self-vitality systems; Subconscious snug-fit patterns Upper Heart System

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Self-Vitality System and Well-Coordinated Patterns

Endowed biological robustness

Embryogenetic and organogenetic mechanisms of development, highly conserved among species at tissue, cellular, and molecular levels [1,2], unfailingly prepare for a sustainable body at birth. The body later develops in momentum while well preserving its innate characteristics to overcome living demands.

In the developing embryo, the production of functional tissues and operational organs that match the physiological needs of the organism requires a tightly regulated organization in time and space. The neural, perfusional, and the interconnective (NPI) matrix spread out their contextual assembly over the body, mutually sustaining and enhancing each other during development [3]. Together with the hardcore of organ systems under a body mantle, they steadfastly maintain and sustain the individual throughout life. Developmental windows open during pregnancy to allow the primal setup varying degrees of adaptations to its environment. All these establish an individual with biological robustness at birth [4] so that individuals sustainably grow and develop in momentum. With biological robustness, doubly assured mechanisms are built in to make sure that the outcomes of biological processes are stereotypical and preserved even when environments vary or perturbations arise [5].

The biological robustness endowed from birth would lose its integrality-sustaining effect when the body grows older and develops in demanding surroundings as patterns tends to go off track with its many different directions. In its substitute, to function adaptively in its environment, the body have to develop well-coordinated patterns during maturation for many areas in the environment to keep the individual well through life over many uncertainties and constraints.

Self-vitality systems, an asset for well-coordinated patterns

In the changing environment, forming well-coordinated body patterns adaptively may seem difficult. In the orthodox view of a body, its organs and organ systems are functioning out not with consciousness. Thereon, it needs the mind, psychology, to be really adaptive to the surroundings. Just habits not good enough to build wholesome adaptations of the mind and body as an integrated interface to environment for sustaining integrality. The use of orthodox Western dichotomous mind-or-body approaches alleged to be related to descent from Descartes 1637 [6,7] would view the body like a clockwork machine, and organs thus classified were started through reductionistic attempts to provide explanation in terms of smaller fundamental entities, each operating system functioning for a designated purpose. The mind would be separately reacting with the body [8,9]. Most texts nowadays would view the body adapting mainly with organ systems for internal adjustments away from conscious control, and then link up the physical body and mind, at its best using a mirror neuron system to try to relate to interpersonal and behavioral problems or mental disorders [10].

On the whole, the body's physical interface ambient to environment would often require adapting to surroundings integrally. The body is in fact endowed with integral machineries to mount the body into a formation facilitating development of well-coordinated patterns. The neuro-vascular coupling is endowed underneath for allowing information and perfusion to go together [11]. Self-vitality systems function as the body's integrated interface to environment contingently, being supported by the organ systems operationally so as to bring out wholesome patterned adaptations of the mind and body to environment. It may functions in terms of discriminative acquisition, option generations related to readiness of resources and coded memories of success-scenarios, and a patternable energy-process driver amongst others [12]. All these when well patterned and continually remodeled tends to furnish surplus resourcefulness, which further provide fluidity in adaptivity and useful patterns to suit survival and allow individuals to achieve snug-fit states positively [11]. The neuro-circulatory example will be described in the next section.

The understanding of self-vitality systems is one step forward to view the body and brain or mind as one totality adapting to the surrounding environment. Remarkably, away from orthodox mind-body dichotomy, it views the body using its innate and cumulatively attained assets to develop for whole-body environmental adaptive big systems, achieving adaptiveness as a whole through body preparedness and mental discretion upon these body self-vitality systems – mind and body together understood in physiology terms [12].

Essentially, the organ systems have their set reflexive responses in reactive mode. These systems are well studied. The cardiovascular system, respiratory system, and endocrine system would best exemplify the feedback systems that work to sustain the body during strenuous or demanding situations and return the body to its homeostatic internal state afterwards.

Over these in the body, there are bigger integrated systems which have been prepared for self-vitality over environments with set autonomised responses in active and reactive modes. These having evolved to cater for situations recurring with repeated similarities through life, would support the body through these situations with less energy costs.

Energy Efficiency

The whole body, physically and mentally, interreact with its environment. The internal organisation of each human being is well equipped. Yet organismal energetics may be constrained to face the many different situations in a frequently changing world [13]. Use of less energy to perform the same task or produce the same result is advantageous for energy efficiency.

The body can develop patterns for energy efficiency to benefit living in situations that are repetitive and common. From neuroplasticity for brain rewiring with stronger and deeper neural paths [14-16], to locomotion [17] and handling of repeated loads [18], the body's functional reorganisation would shape itself along the repetitions, limiting with constraints when overdone [19,20]. Energy efficiency refers to systems that provide the same level of output or benefit with less energy consumption, and is important for optimizing physiological functions within organisms, both simple and complex, including mammals [21].

Neuro-Circulatory − Basic Survival And Self-Vitality System

As an example of self-vitality systems, the cardiovascular big system would best illustrate this autonomization of responses in reactive as well as active modes over life situations. As neural and vascular elements are co-directed since development and nervous directives and perfusion provision coupled to go hand in hand [11], it would not be unexpected that the nervous system and cardiovascular system are integrated in their matching processes to the environment for new changes over the existing balanced life unit. In 1994, the concept of functional 'heart brain' was introduced, noting the Intrinsic Cardiac Nervous System (ICNS), with around 40,000 neurons, gathers information about the heart to the brain medulla and the higher brain centers to influence perception, decision making and other cognitive processes [22,23].

The person's life and living experience, current climate, and environmental exposures may all affect the individual's behavior in actuation and adaptation. For the brain to adapt and actualize appropriately for a change in circumstance, the body needs be prepared to be readily maneuverable. The required body parts have to be well perfused and irrigated with essential materials to suit the needs, which may be different in motion and in emotion. The body develops for a two-tier structure: (1) an external user interface, over (2) an internal stabilization layer. The Lower Heart System serves to stabilize basic circulatory demands and needs with associated interactive components, whereupon the Upper Heart System patterns neuro-circulatory perfusion through upper brain-heart-body interacting and remodeling processes to support the body adaptively in various living circumstances.

This self-vitality system offers the individual patterned emotive or motive responses to various situations wherewith remodeling in time from anticipating, actuating, and adjusting allows an endeavor-performance preparedness. Then conscious control from above can be better schemed and maneuvered over these motive or emotive patterns for endeavours or actions to achieve snug-fit self-actualization without much perturbations in emotions.

There are multiple nested feedback loops involved between the central nervous system and the heart in the neural regulation of cardiac function. In fact, sensing internal and external environment, information is processed at multiple levels by interneurons, resulting in the interdependent network interactions between brainstem, spinal, intrathoracic, and cardio-cardiac reflexes [24-27]. The whole self-vitality system will be described in three levels.

The Lower Heart System − basic survival system

Much has already been studied in classical medical literature to clarify the stabilizing homeostatic mechanisms of the circulation in body motion and activities. The lower heart complex, as the heart with its associated lower nervous with connections up to medullary centers (Figure 1, Lower Heart System), provides the needed stabilizing mechanisms to maintain circulation. The integral body needs essential materials transported all over, and circulation is well described (while the mechanisms to guarantee perfusion are more complicated). This needs be constant as cell and tissue metabolism is a continuous process, and is supported by maintenance of a steady arterial pressure.

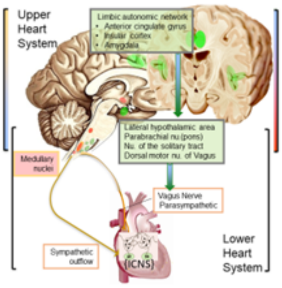

Figure 1: From central control, hypothalamic control to autonomous system and cardio-cardiac feedbacks in Lower Heart System and Upper Heart System. Bottom up centers (red), Top down centers (green), ICNS: Intrinsic cardiac nervous system.

Circulatory dynamics are maintained by intrinsic structural functional characteristics of the heart, including (i) its functional relationship between myocardial contraction energy and diastolic filling (Starling's Law) as this provides inbuilt properties to enable the heart to adjust Stroke Volume (SV) to varying rates of filling related to venous return decreases or increases as in exercise, and (ii) cardiac response to arterial pressure changes (an after-load effect) to enable the heart to adjust SV to maintain arterial pressure.

The integration centers in the medulla, connecting the heart, are part of the ANS of the brain. The sympathetic and parasympathetic ANS regulates inflow-outflow of the heart and blood vessels, and is particularly important for regulation of arterial pressure. Cardio-excitatory and cardio-inhibitory centers are reciprocally innervated and mutually inhibitory to control autonomic outflow to the heart. They are also connected to mutually inhibitory medullary vasomotor centers that control sympatho-adrenal outflow to vascular smooth muscle as reciprocal vasoconstrictor and vasodilator centers.

The ANS, as a major regulator of the cardiovascular system [28,29], regulates instant heart rate and blood pressure to cope with everyday situations. Parasympathetic (vagal) modulation decreases the heart rate and cardiac contractility, whereas sympathetic activity opposes these effects and regulates peripheral vasoconstriction.

Basically to start with, heart rate and cardiac output have to vary in response to the needs of the body's cells for oxygen and nutrients under varying conditions. The sympathetic system becomes active for body needs for energy expenditure, emergency or stressful situations, classically categorised as fight or flight. On the other hand, the parasympathetic system is more active under restful conditions, counteracting the sympathetic system after a stressful event and restores the body to a reposeful state. Notably, most blood vessels do not have parasympathetic innervations and vascular diameter is regulated with the varying sympathetic tone.

Both sympathetic and parasympathetic pathways are composed of a two-neuron chain: a preganglionic neuron and a postganglionic neuron. The parasympathetic component acts through the vagus nerve [30]. The sympathetic component through the spinal cord acts via C7 to T6 rami and cervical and cervicothoracic ganglia [31,32]. Adrenergic stimulation of the heart result in positive inotropic (increases contractility), chronotropic (increases heart rate), dromotropic (increases rate of conduction through AV node) and lusitropic (increases relaxation of myocardium during diastole) effects [33]. The effects of autonomic and endocrine control on cardiovascular function may be better understood in reviews [29,34,35].

This lower medullary-heart complex is concerned with regulation for stabilization of the basal circulatory dynamics. The ANS, which works together with the heart, is classically regarded as an "involuntary" system regulated by hypothalamic centers and is beyond direct conscious control [22,23,36]. The complex receives afferent nerves from receptors, high-pressure baroreceptors (presso-receptor) in the carotid sinus and aortic arch, to monitor systemic arterial pressure and its rate of change. The effect of stimulation would activate medullary vasodilator center and medullary cardio-inhibitory center, and reciprocally inhibit the vasoconstrictor and cardio-excitatory centers. The net effect of stimulation is to reduce systemic arterial blood pressure. Decreased pressure at the baroreceptors would produce the opposite effect.

High-pressure baroreceptor reflexes are important for immediate short-term regulation in stabilizing systemic arterial blood pressure. A low-pressure baroreceptor is present also, in the heart atria, which regulates venous pressure and body fluid volume through renal physiology. The baroreceptor with aortic body and carotid body, and the renin-angiotensin system with renal juxtaglomerular apparatus provide the most important reflex systems for homeostasis.

These processes act on peripheral vascular resistance, the heart's SV and cardiac output to regulate circulation. It directs blood vessels regulations in carrying and transporting nourishment during perfusion to skin, bones, muscles, and organs.

Maladjustment and pathologies

In the orthodox "fight or flight" model (Figure 2a), the body when challenged by physical or psychological stressors display a transient sympathetic overactivity. Mainly with active coping mechanism, the body releases a series of hormones that makes one hyper-alert, focused, and energised, and this chemical cascade causes increased heart rate, respiratory rate, and perspiration. Put simply, as an adaptive part of the short-term survival machinery, increased heart rate may be due to a circulatory drive from exercise or high temperature, as sympathetic stimulation increases heart rate and myocardial contractility. In nervousness on the other hand, palpitation is stressed with increased sympathetic or adrenal activated increase in adrenaline. The scenario explained in terms of need for self-vitality (Figure 2b) will be addressed in a later section.

At the level of the myocardium, cardiac sympathetic nerve density, electrical excitability, and neurotransmitter content are altered in disease states [37-39]. In myocardial infarction and heart failure, there is aberrant remodeling of the sympathetic nervous mechanisms [40- 42]. The atrial innervation is modulated by a sophisticated cross-talk between the two limbs of the cardiac autonomic nervous system [43]. Heart period, measured as the time distance between two consecutive QRS complexes from the electrocardiogram (RR), exhibits spontaneous fluctuations usually referred to as RR variability (RRV), which analysis provides useful markers to infer the state of the cardiac autonomic control [44].

On cardiac rhythm, ANS imbalance causes overtly firing of cholinergic fibers contributing to vagotonic atrial fibrillation (AF), and adrenergic axons contributing to sympathetic AF [45]. Cholinergic

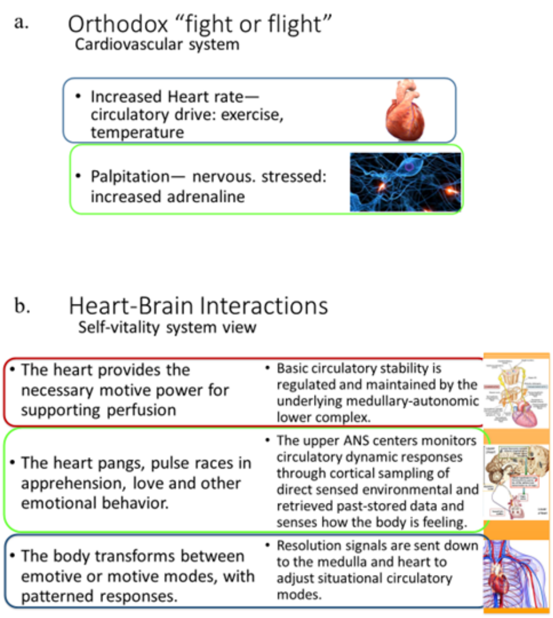

Figure 2: Increased heart rate and palpitation. a) "Fight or flight" simplified model; b) Self-vitality system view.

and sympathetic events trigger AF [29]. Arrhythmogenesis can be driven up by strong adrenergic impulses related to exercise, emotional changes and stress conditions. Patients suffering from "vagal trigger" AF are mostly healthy individuals with notably no evidence of cardiac disease. Conversely, patients with "sympatotonic" AF are usually elderly with different comorbidities and structural heart frailty.

Considering sympathetogenicity, the rostral ventromedial medulla (RVMM) (especially the midline raphe) which contains the brain's most abundant sympathetic premotor neurons [46] generate stress-evoked increases in cardiac sympathetic activity [47], while the Rostral Ventrolateral Medulla (RVLM) is activated when cardiac sympathetic activity is increased reflexively by inputs from peripheral receptors [48]. Unexpected stress from periphery (e.g. air-puff stress) induces neuronal activation (shown by an increase in c-Fos expression) in the RVMM, but not in the RVLM [49].

Balanced cardiac ANS function is associated with lower risk of cardiovascular complications [49]. Fainting episodes or Vasovagal Syncope can be triggered by exposure to heat, prolonged periods in static positions, and excessive alcohol intake and is often attributed to sympathetic and/or parasympathetic nervous system activity being stimulated.

Upper Relay Centre to the Lower Heart Complex

The lateral hypothalamic area, parabrachial nucleus (pons), nucleus of the solitary tract, and the dorsal motor nucleus of vagus are the relay centres up and down between the Lower and Upper Heart Systems (Figure 1)

The hypothalamus as a link between the endocrine system and the nervous system, depends on the body state. The body state refers to the individual's energy reserves, condition or vigor, physiology including metabolic rates, hormone levels, or immune state. Further up, memory consolidation, and stabilization modes worth remodeling on becomes the body's daily processes.

In immediate response to unexpected psychological stress, the changes in cardiac response in heart period are often biphasic, due to co-activation of cardiac sympathetic and parasympathetic nerves, consistent with an orienting response to the arousing stimulus [50,51].

Sympathetic overactivity is thought to be the common denominator between major cardiac pathologies and neurological catastrophes [52]. The descending pathway from the right dorsomedial hypothalamic nucleus (DMH) projection to the RVMM may contribute to stress-related increases in cardiac sympathetic activity [53], which is a main cause of malignant tachyarrhythmias [54]. The right DMH has a direct projection to the midline raphe of RVMM.

The Upper Heart System − self-vitality system

Only recently is it clearer that the higher cortical autonomic network in the brain is important [55]. While the Lower Heart System provides for basic needs in reflexively stabilizing the circulation to maintain homeostasis and adapt to stressors, connections up the higher cortical autonomous system in the central nervous system provides regulation for situational circulatory responses, motive or emotive as necessary [56]. This needs be contingent to situations as tissue metabolism in different body parts open up for the necessary processes, and is supported by variations of ANS balance and cardiac output for steadfast perfusion. Not just efficiency, but also adaptability is needed for redistributing perfusion in expectant and unexpected situations.

The upper heart complex, as further connections up higher cortical autonomous system (Figure 1, Upper Heart System), provides circulatory responses by situational recognition primed with past experiences and memories. Concordantly, the Upper Heart System facing the surroundings provides the needed mechanisms to tune the pattern of circulation along similar recognized scenarios, or to drive circulatory dynamics in case of a thrust for an impulsive move or along an impetus or against an impactful incident.

Conscious efforts can mode cardiovascular function through the classical involuntary ANS [22,23,57]. Cortical function through projections, to autonomic control centers having direct control over sympathetic and parasympathetic activity, provides mechanisms for volitional control of cardiovascular function [22,36,58,59]. These cortical regions include the insular cortex, the somatic and motor sensory cortex, the medial Prefrontal Cortex (mPFC), and the Anterior Cingulate Cortex (ACC) as well as interconnected brain structures, including the amygdala and relay centers in the Bed Nucleus of the Stria Terminalis (BNST), the lateral region of the hypothalamus and the Paraventricular Nucleus (PVN) and Dorsomedial Hypothalamic (DMH) nucleus, the Periaqueductal Grey (PAG) matter of the midbrain, the parabrachial Kölliker–Fuse region of the lateral pons [60,61].

These central components are a part of the limbic brain, which regulates autonomic and endocrine responses in response to emotional stimuli, setting the level of arousal. The insular cortex has a "representation of the ANS" [22] as well as "viscerotopic and cardiac sensory inputs" [36]. The insular cortex is a viscerosensory and visceromotor region [62] and has a central role in both the processing of physiological signals and the regulation of emotions [63,64] as well as cardiovascular control [55]. The insular cortex, the central nucleus of the amygdala and the BNST constitute a corticostriatal–pallidal circuit that processes emotional information with autonomic responses [65]. The ACC, which integrates the emotional and cognitive activities with body physiological responses, has projections to autonomic control centers [66,67]. As for event-specific control of autonomic states, both the initiating event and the emotional response would be encoded by ACC ensemble activity patterns. These patterns would then be shaped by the local mixture of neuromodulators present within the ACC. The modulated patterns would act on downstream regions to create the emotional reactions evoked by contexts, events or thoughts [68]. The network consisting of the insular cortex, ACC and amygdala has been shown by positron emission tomography and functional magnetic resonance imaging to play a crucial role in the regulation of central autonomic nervous system [55]. The ACC and mPFC together integrate emotional and cognitive components of the mind with autonomic cardiovascular control [69].

Some relevant interactions can be sketched for a brief understanding (Figures 3a & 3c). Emotional stimuli from the environment or from memory may be presented to the amygdala or orbitofrontal cortex, which are trigger sites for emotion. Emotional reactions are released through hypothalamus, the basal forebrain, and the nuclei in the brainstem tegmentum, with visceral response and associated heart changes. In reverse, reacting from threat, stress or kindness, visceral sensations would reach the anterior insular cortex with the stimulating event represented, and then reach the ACC for second-order mapping and reflective coding. Circulatory modes are driven by the resolution signals from the cortical-autonomic-system, and memory is a feature of the setup. There are of course other patterns from the life and living experience, current climate, and environmental exposures in actuation and adaptation (Figures 3b & 3d). Central and lower medullary autonomic centers then interact for further processing regulatory dynamics.

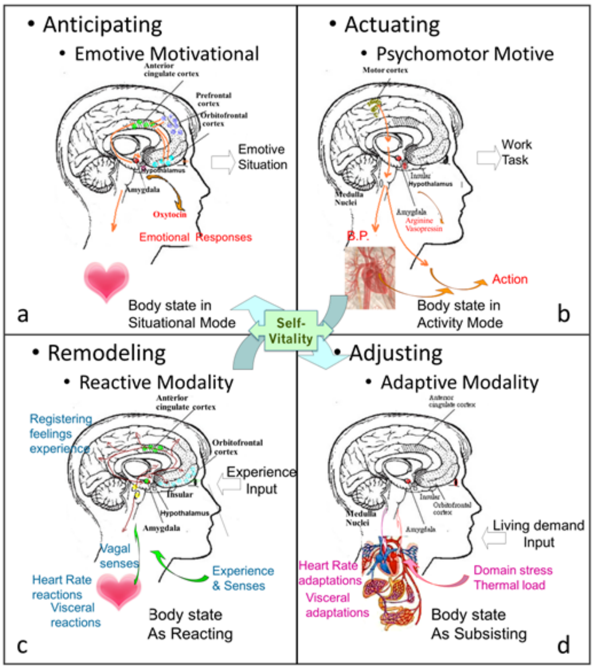

Figure 3: Self-vitality cycling for neuro-circulatory patterns for motive or emotive modes – anticiping in situations; actuating in activities; remodeling body state to react; adjusting body states to subsist action and endeavours.

An individual's mental interpretation may view happenings around him as continuous or discreet, with varying ties to his own domain. These mental activities associated with interdependent parts of the brain may be linked with conscious and subconscious processes involving the body to the environment. Energy-efficiency leads to adaptive and adapted brain and body patterns formed for matching common scenarios after many similar happenings repeatedly come by.

Maladjustment and pathologies

Problems can occur at organ level. Organ system problems occur when reactivity changed. Self-vitality systems may have problems with adaptive patterns.

Palpitations and vasovagal syncope not just catecholamine level: Palpitations are felt as heart racing, pounding or missed heartbeats. Most common causes are strong emotional responses, such as stress, anxiety or panic attacks, while depression, stimulants or thyrotoxicosis can cause it. Palpitations related to fever or strenuous exercise is well expected. Heart rate increase may not be consciously felt, while palpitations distinctly felt are more noticeable in stressful and anxiety conditions.

While a resting heart rate in adults in the range 60 to 100 beats per minute is normal, a lower heart rate at rest implies more efficient heart function or better cardiovascular snug. During rest, sleep, or emotional quietude, the parasympathetic nervous system predominates and controls the heart rate at an idling rate of 60-75 bpm [34]. This would be a sign of an individual being reposeful rather than stressed.

The orthodox "fight or flight" model (Figure 2a), solely relying on the catecholamine system, however cannot well explain why youngsters have palpitations when they meet a pretty girl or face a big prize. Not for flight nor for fight. Actually, the individual does not have the developed inner neuro-cardiovascular information-perfusion pattern to face that situation: he really would not palpitate if he has not considered approaching that girl. Without the coded neuro-cardiovascular pattern to face up to the situation, the heart palpitate noticeably. Stress has been defined as a condition in which expectations, whether genetically programmed, established by prior learning, or deduced from circumstances, do not match current or anticipated perceptions of the internal or external environment, and the discrepancy elicits patterned, compensatory responses [70]. However, the catecholamine system is not necessary stimulated from below. And not everything is stress which would produce compensatory responses; the Upper Heart System can also give resourceful inputs in the active coping for attempts to match conditions by its repertoire of patterned responses so as to allow a mental mastery of the situation (Figure 2b).

Vasovagal syncope may be used as another example that solely relying on the catecholamine system may not be the best explanation. Vasovagal syncope is often attributed to Lower Heart System problems with sympathetic and/or parasympathetic stimulated. Syncope in emotional or social situations is thought to be due to the same physiological systems being activated. Nevertheless, the sight of blood, anticipated frightful scenes (e.g., pain, needles) can caused such syncope [71-73]. An inadequate preparedness with a needed repertoire of patterned responses to allow a mental mastery would certainly be a more direct explanation. In fact, the patterned responses are malformed, such that facing psychological upset (e.g., shadow of humiliation, loss of status) or confronting the possible consequences of fainting episodes (e.g., injury, death or losing control) can similarly re-trigger it. And cognitive behavioural intervention may help [74]. Upper coded patterns malformed at its basic processes.

Mismatches: Mismatched environments will incite internal patterned responses which magnitude would depend on resilience of the individual and how the mismatches deem salient.

Resilience has been defined as the capacity of a dynamic system to adapt successfully through multisystem processes to challenges that threaten system function, survival, or development. The multisystem protective network [75] would act as if there is a Resource Capital, which if not overdrawn would allow the body recalibration systems [76] to reprogram the maturation of patterns from remodeling mechanism. Such resilience, as the inner capacity to withstand and ability to spring back in recovery from deflecting odds, may be related to inner strength, recruitment from resourceful assets, flexibility in core and match processes [77], and spontaneity in righting self, that is developed and remodeled during living, performance and development. Aerobic exercise training could enhance vagal modulation of the heart [78-80] and decrease sympathetic tone [81]. Taking the body as if a closed loop system, robustness is the ability to be insensitive to change even when system parameters are varied over a wide range. While resilience is the process and outcome of successfully adapting to challenges, robustness is the quality of being strong to resist deflections and still keeping in good condition. Exercise tends to confer robustness with more reserves, while flexi-heartminds offers resilience.

In terms of neuro-circulatory perfusion provision, no pattern is one useful for all, and the repertoire may not be sufficiently wide to cater to new demands in the fast changing environment. Chronic stress states, in contrast to acute stimuli, are associated with fatigue in matching processes, with compensatory reactions. The chronicity results in passive or withdrawal coping mechanisms and elicit a long-term autonomic response referred to as a 'hyperarousal state' and chronic sympathetic and hypothalamo-pituitary-adrenocortical system activation. Vagally mediated heart rate variability may also decrease with chronic stress, and shown in neuroimaging studies, may implicate the extent to which threat representations encoded in the amygdala are inhibited by the ventral mPFC based on the external and internal perceptions of safe contexts [82].

More Conscious Heart Matters

The interactions between cortical-ANS, medullary-ANS and heart are of course not a self-contained closed loop. Matters of the mind related to matters of the heart are further related to closely interactive mechanisms connecting these structures with the rest of the nervous system and the whole body.

The body often needs to transform between emotive and motive modes in response to particular environments. Neuro-circulatory patterns are formed during daily life. With neuro-circulatory perfusion patterned according to coded body memory for situations, conscious mental activity over encounters and domain attentiveness would be facilitated when facing different environmental situations. Conscious efforts drawn in when making endeavours would be supported to have a feeling of mastery of integral uprightness, or integrity, as if it has good control of the whole body.

On the motive side, the individual from motivational endeavours or motional requirements would express his actions or actuations supported by his cardiovascular characteristics over tasks and terrains. On the emotive side, faster than cognitive processing, the individual from former reflection and evaluation with trust and love or fear and disgust would face the circumstance with a subjective experience, elicit a patterned physiological response and an expressive behaviour. Though heart contraction through ANS is involuntary, heart palpitations become conscious when driven up. Between motive acts (when the heart reflexively increases its heart rate and output) and emotive responses (when the heart pangs, pulse races in apprehension, love and other emotional behavior), the heart would be acting as a sophisticated information encoding and processing center [56,83] whence heart feelings turns into cognitive recognition and emotions drives the heart up. The system thereby provides self-vitality support for conscious discretion. Basically, during endeavors in living, nervous activities and perfusional support are actually closely coupled together to accomplish it. In fact, the core directives for life necessitate the heart and brain to evolve and work together as a unit to bring forward the whole person to live for life [56].

Motion wise, heart reactions are more dependent on the body's oxygen demand on the circulation. Autonomic changes result from the integration of the baroreceptor and exercise pressor reflexes with central autonomic commands [84,85]. During assertive motional actions, endeavours or exercise, the vitality of the heart and circulation would tend to be more significant than mental assertion. Essentially, the operating point of the arterial baroreceptor reflex towards higher values of blood pressure and heart rate would be reset by central commands and the exercise pressor reflex [84,86]

The cardiac pump at onset of exercise is related primarily to parasympathetic withdrawal [87]. At steady exercise, with the continuum of balanced sympatho-vagal control, lower workload has less upside in cardiac dynamics, also mainly related to the parasympathetic withdrawal [88]. The degree of the cardiovascular response is determined by the demands placed on it by the physical activity in a linear relationship. Heart-pumping aerobic exercise also strengthen and improve circulation [89] even in the elderly [90].

On the emotive side, patterns are recognized consciously or subconsciously in the individual himself. There are cardiac changes related with affect regulation as shown in correlative studies [91,92]. Studies have noted how the brain and heart interact in a mode not separate. Top-down, anxiety often cause faster beating of the heart [93-95]. The pattern of the heart's rhythm would reflect the emotional state [96]. The state of daily physiological functions of the body are relayed to the brain through the vagus. Bottom-up cardiac interoceptive processing is also active and has been verified by whole-brain activity screening and electrophysiology noting that the posterior insular cortex be activated by imposed cardiac rhythms through optical cardiac pacing [97].

Emotion is a complex of mind as related to many concerns maintained by the limbic system of the brain as composed of limbic cortex, a rim of cortical tissue around the hilus of the adjoining cerebral hemispheres, and a number of associated deep structures as these cumulate inputs and memories from other parts of the body. When sensory or visceral nerve impulses and hormones mount up to these emotional centers, the brain once identifies what the signals mean, the individual would react in conscious modes or patterned ways. An accustomed situation with well-recognized, coded and well-patterned neuro-circulatory reactions produce fewer emotions. A new unrecognized pattern means indeterminate neuro-circulatory responses to face the environment and more emotional upset. But as the emotion complex may vary in degrees and interpretation, from noxious pains or unfound blankness, to curiosity impulses and positive materialization, the output may be varied.

All these as a self-vitality system are responsible for pattern-transforming needs for circulatory shifts unconsciously between motion or emotion in preparing for adaptation and actualization for any action or endeavor. In supporting conscious performance at will over these,, matching perfusion with activity is crucial. Conscious encounter of new and past-similar situations would have a better supportive body tuned for situation-appropriate mode of response. In the case of a lack of a matching response mode, the body would mount up heartbeat and circulation for an excess of resourceful input to cater for that encounter or endeavour. Correlations between cardiac interoception with anxiety and functional alterations in the insular cortex is noted [63,64] when inadequacy to snug-fit situations felt.

Maladjustment and pathologies

Acute events at a magnitude above robusty level: Acute events depend on their magnitude evoking body responses. Events of high magnitude such as an earthquake, a televised high-drama soccer game, job strain or the death of a loved one can trigger cardiovascular events [98]. It may affect haemodynamic and electrophysiological pathways increasing sympathetic output, impairing endothelial function and creating a hypercoagulable state as demonstrated in animals with acute negative emotion stressors [99]. Initiated by exposure to a traumatic event, post-traumatic stress disorder is associated with increased risk of incident coronary heart disease and mortality [100].

Nervous activities and perfusional support out of phase: Though the blood supply of nervous tissues are well guarded for, the functional role of the nervous system is much more complex, wherein its new connections and selectivity are much higher than that in the vasculature [101,102]. During activity, blood flow needs to reach the local tissues at the right time and place and in the right amount, especially in the brain which cannot stand interruption of cerebral blood supply for a few minutes. While nervous directives and perfusion that go hand in hand are needed for new changes over the existing balanced life unit, the balanced system would have a certain resilience and reserve, a neuro-cardiovascular self-vitality Resource Capital [56], which would sustain and tolerate a certain degree of change even with dry assertion by just nervous directives alone. The calculative central brain with its massive capabilities over the body certainly can direct any assertive action it behooves. Though the individual could react in conscious modes or patterned ways, the brain can only function up to body capacity. Dry assertion cannot last long when Resource Capital overdrawn.

Dry assertiveness or endeavors by simply willing and pressing forward is not vigor, cannot last long and toils the brain [11], and overly assertive use of supportive resources for diversifying endeavors creates gaps. Notably an observation from the classic in Chinese medicine, Huangdi Neijing, which contains well-described astute observations apart from being a theoretical treatise, described “the brain working in dry worry for a problem first days” is covered by the body reserves. “After some days”, the brain overused would be compensated by increase in heart perfusion, with “the Zang Heart heated up. The face over the area is hyperperfused” [56,103]. Interesting, understood recently, cerebral hyperaemia is one of the fundamental mechanisms for the central nervous system homeostasis [104]. The endeavor-perfusion imbalance affects the neuro-circulatory synchrony.

Fatigability and related immunological effects: The concept of arousal is state-dependent. When awake, the cerebral, autonomic and behavioural activation contributes, being in a response to internal and environmental stimuli [105]. Arousal and whether the individual can be highly spirited is affected by the body state.

While stress often leads to a distress maladaptive physiological response, the body in its deflecting environment displays matching processes that has been categorically called eustress, referring to tough encounters as beneficial for being manageable or motivating for the individual. Mental mastery falls apart when its Resource Capital is fatigued or overwhelmed with nothing to carry [106]. Slowly progressive autonomic failure frequently results from neurodegenerative disorders, even depression. Imbalanced brain–heart interaction have a negative impact on health. Chronically bordered immunologically and psychosocial reactions are committed with cardiovascular problems [107].

Heart Systems as A Whole

Continual Remodeling

Self-regulatory functions and neurobehavioral correlates develop since infancy [108]. The mind-body interactions that evolve with repeated remodeling are developed early, from interactions between mothers and infants [109], probably through communicative rhythms as well as being induced through external rhythms [110]. Infants are able to adjust their cardiorespiratory patterns to their mother when passively lying on her body [111]. Biological and physiological synchrony between the mother and infant’s heart rhythms, support the development of infant’s physiological regulation, autonomic response and ANS maturation [112,113]. Biobehavioral synchrony last up to later childhood [114] and contribute to the development of self-regulatory capacities [115,116].

As neural and circulatory networks evolve together with repeated remodeling since development, their interactions produces patterned responses to stimuli or stress, so that perfusion and nervous activity can be in balance and matched during endeavors or actions to fit various living domains From anticipating, actuating, adjusting and remodeling (fig. 3), and the process recycled through these endeavor-performance remodeling mechanisms, such synchrony between self-vitality system and conscious control plays an important role in the maturation of brain circuits that support social engagement, and contributes to cognitive, social, and emotional growth [117-119].

As one grows up, matching may involve internalizing and externalizing, reciprocity and returns for expression, directing expectations and anticipations as well as reality confrontation and interaction, so that the whole person functions coherently, facilitating a more adaptive autonomic response to stress [120].

The Body as a Whole with Heart systems

The body form, the body state and body disposition represent the basic assets during adaptation to the environment. Mastery with integrity and integrality is good control of the functional mode in response to environment. The whole neuro-circulatory setup as a self-vitality system governs a delicate subliminal reflexive system to condition the circulation, patterned for motional assertions and emotional body reactions [56].

The Upper Heart System monitors circulatory dynamic responses through cortical sampling of direct sensed environmental and retrieved past-stored data and senses how the body is feeling. Resolution signals above are sent down to the Heart Systems to adjust situational circulatory modes. It may just well be that the heart is uniquely positioned as a powerful central mediating point interconnecting body and mind, motivity and emotion. Unhappy emotional events, threatening life situations and motivational plans referring to previous memory banks for a charted course are registered with adaptive changes of heart and body arousal. The balance to be motive or emotive depends on both the mental emphasis and body strategic position to prepare for a body well perfused and readily maneuverable. The brain senses and works out for the body itself for that environment to determine its mobility or motivation as directed by motives or emotive moves according to their importance, other than "fight or flight" responses. Remodeling between anticipating and actuating with adjustments build up a repertoire of patterned responses for the mind to master in matching environments with energy efficiency. When well-patterned, it enables the body to face emotional events or stress environment, with autonomous circulatory dynamics runs reflexively in stability, unless conscious mentality drives the body into wrong patterns or dry assertions without warm-ups.

The thermal influence of the environment may also induce neurocardiologic consequences, sometimes clinically significant [56,121], indicated by a temporal variations in cardiovascular effects of heat over the past decades [122] and in the elderly [123], though not conclusive in meta-analyses [123,124] generally. Circadian circulatory rhythms would follow the patterned climate in perfusion function [125].

Maladjustment or pathologies

One with poor mentality may consciously choose endeavours driving the body into wrong patterns or dry assertions without warm-ups. For individuals with poor body states to start with, the formation of the repertoire of patterns may be less effective and efficient. Childhood adversity is a strong prognostic indicator for relapsing depression [126] and depression and cardiac problems are well associated [127]. Biased or deviated responses occur in those with early life trauma, having significant increases in baseline and stress-induced neuroimmune activation [128]. Biased responses are also seen in depression when episodes follow a pattern of repetition, suggesting evolution of pathways that progressively facilitate a depressed mood [129]. Negative self-concept has itself been related to multiple relapses [130]. Similarly, with frailty, the formed patterns may be degenerative and work not so well. The average age of those suffering more than one depressive episode is significantly older [131,132].

Similarly, much deliberation without perfusion support in synchrony will not produce joy. Anxiety disorders have been associated with an excess risk of about 26% for the development of coronary artery disease in healthy participants [133]. Anxiety disorders might also be an independent risk factor in the development of cardiovascular disease [133-136]. When anxiety was measured in patients with stable coronary artery disease, anxiety was associated with poor outcomes in nearly all analyses [137]. In a meta-analysis, anxiety was associated with a 41% higher risk of cardiovascular mortality and coronary heart disease, a 71% higher risk of stroke, and a 35% higher risk of heart failure [136]. Anxiousness is characterized by somatic tension and hyperarousal. Indulgent computer games should cause the same problems, though not well studied.

Poor synchrony means poor internal health and risks. To start with, the functional balance of the vegetative nervous-circulatory system would help multi-organ perfusion matching needs. Mismatch between the tissue demand for oxygen and the supply capacity of the circulatory system can get progressively worse in thermal demand, adverse environment or dry assertiveness, so that tissues became hypoxemic, or the body hyper-reacts seriously to compensate. Along the individual's endeavoring achievement, cardiac performance may not suffice for the body needs, with an increasing likelihood that the cardiovascular perfusion is compromised and limits tissue oxygen delivery to important structures. Stroke occurs as a mismatch perfusion to assertive behaviors [56], commoner in jeopardized patients with large vessel or small vessel disease.

When well patterned, the neural-circulatory-perfusional interrelationship would synchronize when each and every component and feed in positively, and good lifestyle can strengthen the Resource Capital. Short of virtuous interactive components, both depression and anxiety disorders are associated with the development and progression of heart failure [138]. The prevalence of depression increases sharply with the severity of heart failure symptoms [139], and depression carries a risk for heart failure [140]. Heart failure patients with depression could have four times risk of death [141].

In fact, heart problems may cause brain problems. A heart-brain tie is demonstrable even in the absence of manifest stroke. Cerebrovascular accidents and transient ischaemic attacks are often caused by cardiac arrhythmias [142] or congestive heart failure [143-145]. Although lacunar strokes may be related to thromboembolism in atrial flutter and atrial fibrillation [146], reduced cardiac output and low cerebral blood flow are contributing mechanisms [147]. Atrial fibrillation is a risk factor for cognitive impairment and hippocampal atrophy [148]. Cognitive impairment can occur before atrial fibrillation [149]**.** Atrial fibrillation could contribute to cognitive decline and dementia through hypo-hyperperfusion events occurring during cardiac arrhythmias [150]. Furthermore, the insular cortex (of upper zHeart) tends to be vulnerable to cerebrovascular disease [55].

In the setting of diseased states, sympathetic nervous system activation in heart failure is closely associated with adverse myocardial remodeling, arrhythmias, sudden cardiac death, and overall poor prognosis [151]. In heart failure, there is aberrant remodeling of the sympathetic nervous mechanisms [37].

Conversely, brain-heart concomitant problems are also seen. Acute stroke leads to imbalance of central autonomic control. It can cause overactivity of sympathetic or parasympathetic control, myocardial injury, ECG abnormalities, cardiac arrhythmias [152]. Subarachnoid bleeding may lead to serious electrocardiographic changes and even ventricular fibrillation with QT-interval prolongation [153,154]. Proarrhythmic shifts in cardiac sympathovagal balance occur after human stroke, particularly in left insular lesions [155].

Panic disorders and emotional distress such as the Takotsubo syndrome may give rise to supraventricular tachycardias with associated transient left ventricular dysfunction [156]. Cardiovascular complaints are among the most frequent in panic disorder, accompanied by marked anguish [157,158] and appear to be an independent risk factor for cardiovascular morbidity and mortality in older women [159] though a recent analysis found a tenuous relationship [160].

Conclusion

The word heart in ancient form denotes both heart and mind, well depicted in a review of the heart system for Chinese medicine [56]. The nervous system and cardiovascular system are integrated from the patternable Upper Heart System to the stabilizing Lower Heart System in their matching processes to environment. Together with other body parts, the self-vitality system enhances preparedness to encounter new and past-similar situations through life. The neural-circulatory-perfusional interrelationship should synchronize when each and every component feeds in positively. Evolved with energy efficiency, its function in autonomised responses in active and reactive modes through patterned emotive or motive responses to various situations allows a pattern-transforming ability for circulatory shifts needed to cater for motion or emotion and endeavor-performance preparedness. Then conscious control from above would be facilitated to maneuver over these motive or emotive patterns to achieve snug-fit self-actualization without much undue adjustments and perturbations in emotions.

An individual may be set in different degrees of dynamics and stability as being adaptably matching in snug or mismatching and prone to stress. Well snug-fit would make room for adaptivity, and strengthening the Resource Capital by restorative lifestyle to allow reserves to maintain resilience, or else, illness and even disease. In maladjustment or pathologies, single organs, organ systems or self-vitality systems may be involved. Now apart from those related to the Lower Heart System for its sympathetic and parasympathetic activation, cardiovascular dysfunctional patterns for the complex neuro-circulatory reaction patterns, involving experiential, behavioral and physiological elements can be understood at each level. From causal neurobiological basis from motive-emotive discrepancies apart from the link between emotional and cardiovascular events that contribute to morbidity and mortality, management therefore could be broader to cover from disease recovery to health augmentation.

The understanding of self-vitality systems should overcome mind-body dichotomy and address better situational endeavor-perfusional matches for adaptive performance in the environment. Through environmental manipulation and situational experiential reprogramming, patients need to commit time and lifestyle change to reduce imprudent mismatches. Reviving the neural-circulatory-perfusional match for the body should help preventing pathology.

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