Chapter 1: Introduction

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Chapter 1:

1. Introduction:

Humans from several countries travel to the natural laboratory – Antarctica, to conduct scientific experiments on evolution, astrophysics, psychology, biology and more in the pursuit of finding answers to nature's several unanswered questions – just for the reason that nature has been preserved in Antarctica in its crude form (Carrère, Evans, & Stokols, 1999). The harsh climatic conditions prevailing in Antarctica makes it the most hostile, least explored and coldest continent on the planet Earth. The isolation in capsule environment with the lesser availability of resources, adverse weather conditions, psychological stress and altered circadian rhythm in individuals' charecterised by variety of physical and psychosocial stressors including but not limited to capsule environment, isolation, social tensions, boredom, monotony and danger are best suited for understanding the human adaptation in extreme stressful conditions (Suedfeld, 2001).

The international committees, COMNAP (The Council of Managers for National Antarctic Program) and SCAR (Scientific Committee of Antarctic Research), in addition to the organisers of the expedition from individual countries, are primarily concerned to enhance the overall wellness of the members sent to the Antarctic stations. Even though scientific research is the primary goal of Antarctic expedition, equal importance is given to take care of the physical and psychological health of the expeditioners starting from selection of expeditioners to emergency evacuation to involving behavioural scientist and psychologists to offering periodic support through online group or individual psychological counselling sessions for helping expeditioners deal with the stress (Suedfeld & Steel, 2000). Primary conclusions from Polar Sciences Research Board Study (1982) of biomedical and socio-cultural issues was that, in polar regions, socio-cultural factors, as compared to strictly medical factors were responsible

for a disproportionate number of human problems. Although evidence on the importance of individual behaviour on the outcomes has been fragmented, observations suggest that behavioural and social problems have occurred in long-term missions and that, such problems will become exacerbated as missions become more complex, challenging or extended. Significant advances are required to be made in understanding the outcomes of better interpersonal relationships, benefitting performance and adjusting in demanding situations. Emphasis remains to be made on identification, and implementation of conditions that facilitate human adaptation, in which one can expect to stay healthy, happy and effective in family life, work, and interpersonal relationships without any crippling emotional symptoms such as fear, loneliness, anger, envy or greed (*Polar Biomedical Research*, 1982).

1.1. Antarctica: An Introduction

Antarctica is the least accessible continent, representing 10% of the planet's landmass. Life forms are least supported by the geographical south pole due to the prevailing harsh climatic conditions. Hence, Antarctica is considered as the planet's most isolated, least explored and coldest continent covered by an ice sheet. The average thickness of ice is about 1.9 km and the thickest being about 3.6 Km near the South Pole. Antarctica also has the highest average elevation among all the continents. The ice sheets represent 97% ice and 70% fresh water of the planet. The average precipitation is less than 50mm per year (Krinner, Magand, Simmonds, Genthon, & Dufresne, 2006) making it a desert as per the standard definitions. However, the continent experiences almost constant blizzards with a maximum recorded wind speed of 327 km/hr. The humidity is extremely low and the temperature ranges from 0^{o} to -65^{o}C across the year, with Vostok, the Russian research base recording -89^{o}C as the lowest temperature on earth(Turner et al., 2009). The duration of day-night cycle across the year, changes across stations based on their location in the Antarctic continent. Antarctica is a no man's land and a treaty involving 12 countries was signed in 1959 at Washington, prohibiting any military

activities, nuclear explosions, mineral explorations, waste disposal and shall restrict the activity only to science. Its geopolitics is governed by a treaty declaring the continent for science. Presently there are 50 countries that are added as members in this treaty. Oil and mineral exploration has been banned in this region until 2048(The Antarctic Treaty, 2011). The location of the Antarctic Stations depends upon the context of research and interest of the participating country. Geologists have found evidence supporting that the present day India and Srilanka had drifted from the East Antarctica (M, Sathish-Kumar; Y, Motoyoshi; Y, Osanai; Y, Hiroi; K, 2008) thus explaining the location of the Indian Antarctic stations exactly to the south of India.

1.2. Indian Scientific Expedition to Antarctica:

1.2.1. History

The Indian Scientific Expedition to Antarctica is a multidisciplinary program involving multiple organisations from the country to study the atmosphere, geology, biology, oceanography and medical sciences. The Indian Scientific Expedition to Antarctica is co-ordinated by the nodal agency National Centre for Antarctic and Oceanic Research, Goa under the Ministry of Earth Sciences. India joined the elite club of nations conducting expeditions to Antarctica in 1981. The first permanent Indian station, '*Dakshin Gangotri*' (70°05′37″S 12°00′00″E) was established at the *Dakshin Gangotri* Glacier commissioned during the 3rd Indian Expedition to Antarctica in 1983– built by an 81 member team in 8 weeks. Dakshin Gangotri base eventually submerged into ice leading to its decommissioning on the 25th February 1990.

1.2.2. Location and Climatic conditions

Later, the second Indian station *Maitri* (70°46′00″S 11°43′56″E) was established and made operational in 1990 at a moderate climatic, rocky mountainous zone called Schirmacher oasis at a distance of 90 Km from Dakshin Gangotri. Eventually, the third Indian station, Bharati

was built about 3000 km east of *Maitri,* between Thala Fjord & Quilty bay, east of Stornes Peninsula in Larsemann Hills, Antarctica at 69° 24.41' S, 76° 11.72' E approximately at 35 m above sea level. Both Bharati and Maitri bases support year-round scientific research activities. Indian expeditioners to Antarctica reach the stations either by air or through sea voyage.

1.2.3. Lifestyle at Antarctic Station

Bharati, the Indian Research base can house 47 members in the winter and 72 members in the summer (25 members accommodated in the summer camps). The team stationed consists of a team leader, communication officer, engineers for station maintenance, scientific members, carpenter, electrician, plumber, cook, crane operator, logistics team, a medical doctor and a paramedic staff. Apart from the respective duties, every member of the station will have routine duties in monitoring the health parameters of the station, routine cleaning of the station and helping the cook in preparing the food for the fellow members.

Fresh fruits and Vegetables are not available in the station. The vegetables, fruits, and groceries are supplied to the Indian station by the ship carrying voyage team members. The food items are usually stored for its shelf life under appropriate conditions (-20 C / 4 C / room temperature). A nutritious diet is administered to the expeditioners. However, the options available for the vegetarians might be limited. Scientific activities at Bharati base include meteorology, oceanography, atmosphere, glaciology, wildlife, flora and fauna, and medical sciences. Satellite communication systems are established and the station is well connected with internet.

Apart from the regular menu, packaged fruit juices, milk, bread, cheese, butter, jam, coffee, dry fruits, and chocolates will be available in the dining area for the members to consume during any time of the day. Members are free to have their personal stock of Alcohol apart from that provided as a part of the expedition.

An entertainment room with table tennis and other games and musical instruments are available for the members. A large collection of movies and books are available in the library. The members are free to watch movies of their choice in the common room. (*Colour Plate 1*)

1.3. Expedition Voyage to Antarctica

The Voyage expedition to Antarctica starts from Cape Town, South Africa. For the period 2014-2017, the Russian ice-class vessel *Ivan Papanin* was commissioned for Indian Scientific Expedition to Antarctica (*Colour Plate 1*). The vessel comprised of Russian crew to run and maintain the vessel and Indian Scientific Expeditioners to Antarctica. The Indian crew typically consists of a leader, deputy leader, scientific crew, logistics crew, an electrician, a heavy vehicle mechanic, a cook and a medical doctor.

The Sea Voyage to Antarctica does not involve much of scientific activity except for those involved in understanding the Oceanography or those studying the animal/bird inhabitation in the course to Antarctica and those studying the ice shelves near the Antarctic continent. The sea voyage is considered more difficult because of the adverse sea conditions with huge tides, strong sea currents and dislodged ice-bergs hampering the ship movement. The availability of food is similar to that of the station. A satellite-based communication system is available on the ship. The expedition members shall communicate with their family members using a common mail ID and a limited telephone communication is available over satellite telephone subject to better climatic conditions. An entertainment room with a large collection of movies and games are also available for the expeditioners.

1.4. Challenges to humans in Antarctica

Several psychological and physiological changes are observed in Antarctic expeditioners. Psychological changes range from behavioural changes like aggression, mood swings to psychiatric problems like depression(Gunderson, 1963). Isolation seems to have a considerable

effect. Isolation and inherent danger associated in the Antarctic environment might enhance the extent of repetitive negative thinking based on the personality of the individual. Reports suggest an increase in smoking, loneliness, homesickness and a reduction in rapport during the isolated dark winter months (Bhargava, Mukerji, & Sachdeva, 2000). Physiologically, decreased immune responsiveness accompanied with variations in circulating insulin, thyroid stimulating hormones, testosterone, cortisol, melatonin, pro-inflammatory cytokines, 25-OH-vitamin D and a significant increase in total cholesterol have been recorded (Farrace et al., 1999; Muller, Lugg, Ursin, Quinn, & Donovan, 1995; Sawhney et al., 1998; Steinach et al., 2016). Some studies also suggest that such challenging environments also turn to be *salutogenic* in certain individuals. With limited access to health care in the Antarctic environment, strategies that facilitate better adaptation to the extreme environment are required to be adopted to promote overall psycho-physical wellness of an individual and also the group.

1.5. Adaptation key to survival

Throughout the evolution, adaption is considered to play a vital role in determining the fate of a species and an organism. Initially, we put forth the most accepted theory of evolution of species. Charles Darwin explains the process of adaptation in three postulates: the struggle for existence; variation in fitness and the inheritance of variation(Boyd & Silk, 2009). Darwin's theory claims that, in case of an extreme condition, the organisms compete for survival as a group and individual organisms strive to adapt themselves to overcome the drastic environment and pass on the adaptation to the offspring. In another acclaimed theory of evolution, Hamilton asserts that altruism is required to ensure better coping-up of the entire group and the coping-up of the entire group can be made efficient if there are more altruistic members. Hamilton's rule further states that "*altruistic behaviours will be favoured by selection if the costs of performing the behaviour are less than the benefits discounted by the coefficient of relatedness between actor and recipient*". The selection i.e., the identified change meant for adaptation -

works at an individual level to favour adaptation – which might not be good for the entire group. Combining the two theories, it could be inferred that even though the adaptation happens at individual level only those adaptations which are good for the entire group are propagated. Thus, survival of the fittest at the cost of others does not influence evolution. Thus, there are differences between different theories trying to explain the driving force of evolution(Bourke, 2014; Hamilton, 1963, 1964).

Most of the theories on evolution have been made through observations on the primates and organisms like finches and birds but not on humans. Stress has a remarkable role in facilitating the overall adaptation. In primates, exposure to stress evokes one or more of the three classic responses: fight, flight or freeze. But with evolution, humans developed complex behavioral patterns including interpersonal trust, anger, love, lust, rage and much more demanding a specific and optimally regulated physiological response. More interestingly, as an evolutionary defense mechanism against the adverse environment, the human brain biases itself to produce a strong response to negative stimuli than a positive or a neutral stimuli (Ito, Larsen, Smith, & Cacioppo, 1998). Perseverative cognition is defined as the cognitive representation of the stressor (Brosschot, Gerin, & Thayer, 2006). The extent of presence of Perseverative Cognition is known to influence the physiological outcomes of stressor and also determines the prognosis of a pathology (Ehrenthal, Herrmann-Lingen, & Fey, 2010; Ottaviani et al., 2016; Zavagli, Varani, Samolsky-Dekel, & Brighetti, 2012, Brosschot, 2010). In the due course of evolution, in humans, the tenth cranial nerve – the *Vagus* got differentiated into two parts: the Ventral Vagal Complex (*Smart vagus)*, the myelinated part which specifically innervates heart, lungs and few other viscera and the Dorsal Vagal Complex (*Old vagus/Vegetative Vagus)* - the unmyelinated part that innervates the abdominal viscera in a diffused fashion (Porges, 2001). On exposure to a stressful environment, the limbic cortex processes the stimuli and amygdala sorts the information and make an individual experience the situation and downstream, in

association with the hippocampus, the dorsal nuclei of the vagus is regulated to manifest either as a sympathetic or parasympathetic arousal. Simultaneously, the amygdala interacts with the insula. Based on the subjective feeling produced by the integrated afferent activity, a physiological response is arrived (Craig, 2003). Even though, the amygdaloid complex has been designed for acute stress in a way – 'to act first and think later' to lower the response time necessary for protective behaviour (reviewed in (Lévêque, 2014). But, in states of chronic psychological stress, vagal inhibition is prolonged – eliciting chronic stressful stimuli, affecting the neural, hormonal and immune systems – which are implicated in the development of pathologies (Brosschot et al., 2006). Incidentally, it is also observed that stimulation of the vagal nerve is capable of modulating plasticity by promoting extinction of conditioning that facilitates rapid action to a stimuli in the amygdala (Pena et al., 2014).

In summary, it is evident that several neural centres in coordination with the vagus moderate the individual's response and determine the extent of adaptation to the presenting stressor. In humans, apart from the involvement of the neurological centres, the physiological systems are designed such that, on exposure to a same stressor repeatedly, instead of alerting the entire system only few systems / processes are directed to act. Alerting the entire system is more damaging and is only required in states of acute stress. Whereas, adaptation to activate few critical systems might be minimally harmful and sufficient to address the prevailing repetitive stressor contacted.

The findings from studies on physiological and psychological stress conditions indicate that the body elicits a similar physiological response to both – by triggering inflammation and increasing immune surveillance (Kiecolt-Glaser et al., 2010) – which appears as an evolution conserved stimulus. This might be beneficial in case of an acute stress. But, in case of prolonged psychological stress, where there is no pathogens present, alerted immune systems and inflammation for prolonged periods might cause immunosenescence and inflammaging

(Bauer, 2008; Franceschi et al., 2006). This possibly raises a doubt – and a possibly indicate – that the systems that differentiate psychological from physiological stressors are not completely evolved, if not, the process of which is not clearly demarcated. Hence, such interventions are required which increase the connectivity of processes that enable appropriate response for both psychological and physiological stimulus.

1.6. Yoga - A benefactor for health and wellness

Yoga, an ancient Indian science, and way of life has been of interest to many. Multiple direct and indirect evidence point yoga to facilitate shifting of physiology towards homeostasis. Though Yoga was considered to be a spiritual practice a few decades ago, research studies have proven Yoga to be effective in promoting wellness, benefit humans irrespective of underlying pathologies including obesity (Bernstein, Bar, Ehrman, Golubic, & Roizen, 2014), diabetes(Nagarathna et al., 2012), hypertension(Hagins, States, Selfe, & Innes, 2013), cancer (Rao, Nagendra, et al., 2008), auto-immune disorders (Dash & Telles, 2001) and even Acquired Immuno Deficiency Syndrome (Agarwal, Kumar, & Lewis, 2015). Further, Yoga practices are proven to enhance sleep (Khalsa, 2004; Patra & Telles, 2009), performance, memory(Subramanya & Telles, 2009) and quality of life (Woodyard, 2011). Most studies on Yoga indicate its beneficial role through regulation of Autonomic Nervous System. However, recent studies indicate the role of Yoga practices in regulating the Central Nervous System, which might in-turn influence the response through the Autonomic Nervous System.

Studies conducted on Yoga practices and various meditation techniques show a pattern of regulation in the neural activity. The neuroplastic and cognitive effects observed in few meditation practices have interested the scientific community and common man for its therapeutic benefits. Several novel findings on regulating the brain function and anatomy through Yoga practices have been made.

The default mode network, the network of activated, highly interacting brain regions when no actual task is performed reflects the structural connectivity (Greicius, Supekar, Menon, & Dougherty, 2009), implicated in mind-wandering and self-related thinking, the signature of which differentiates the brain from Alzheimer's disease to natural aging (Greicius, Srivastava, Reiss, & Menon, 2004; He & Evans, 2014). Interestingly, meditation has been associated with less activity of the default mode network (Eyre et al., 2016; Garrison, Zeffiro, Scheinost, Constable, & Brewer, 2015; Hasenkamp, Wilson-Mendenhall, Duncan, & Barsalou, 2012; Tang, Hölzel, & Posner, 2015). Yoga practices necessitate sustained awareness throughout its practice influencing the default mode network. In response to the awareness of mind-wandering and subsequently shifting to sustained attention, insula and anterior cingulate gets activated initiating a variety of physiological cascades through its modulation of both peripheral sympathetic nervous system and the central locus coeruleus nor-epinephrine systems, to maximise receptivity and adaptation in changing environments.

1.7. Yoga in Stress

Studies have shown that Yoga practices immediately downregulates the sympathetic nervous system axis response to stress. Yoga practices decrease the levels of Salivary cortisol (Michalsen et al., 2005; West, Otte, Geher, Johnson, & Mohr, 2004), Glucose (Gokal, Shillito, & Maharaj, 2007; Khatri, Mathur, Gahlot, Jain, & Agrawal, 2007) as well as plasma renin, 24-hour urinary nor-epinephrine and epinephrine levels (Selvamurthy, Sridharan, & Ray, 1998). Yoga practices also decreases the systolic and diastolic blood pressure (Damodaran et al., 2002; McCaffrey, Ruknui, Hatthakit, & Kasetsomboon, 2005; Selvamurthy et al., 1998). Yoga practices decrease the adverse effect of stress on the immune system by increasing the levels of immunoglobulin A (Stück, Meyer, Rigotti, Bauer, & Sack, 2003) as well as natural killer cells (Rao, Telles, et al., 2008). Pro-inflammatory biomarkers such as hs-CRP, interleukin-6 (Pullen et al., 2008) and lymphocyte-1B and marker of oxidative stress malondialdehyde also

decreased with Yoga practices. Heart rate variability patterns indicate parasympathetic components to be higher in age matched Yoga practitioners as compared to non-yoga practitioners. With these studies, the results appear that there is an overall parasympathetic shift in yoga practitioners through direct vagal stimulation. This profound vagal stimulation might be contributed by decreased rate of breathing and increased awareness((Bud) Craig, 2009; Eckberg, 1983).

1.8.Yoga and Exercise: A comparison of efficacy

Exercise is the commonest intervention used as a comparison to Yoga. However, studies conducted comparing both the interventions have indicated yoga to be equal or superior to exercise in relieving certain symptoms associated with diabetes (Gordon et al., 2008), multiple sclerosis (Oken et al., 2004), menopause (Chattha, Raghuram, Venkatram, & Hongasandra, 2008), kidney disease (Yurtkuran, Alp, Yurtkuran, & Dilek, 2007), and schizophrenia (Duraiswamy, Thirthalli, Nagendra, & Gangadhar, 2007). Yoga practices apart from being beneficial than exercise in clinical conditions, studies have demonstrated yoga to be effective in relieving symptoms associated with natural life events in women such as pregnancy (Chuntharapat, Petpichetchian, & Hatthakit, 2008; Narendran, Nagarathna, Narendran, Gunasheela, & Nagendra, 2005). Interestingly, yoga also appears to shorten the labor time and increase maternal comfort (Chuntharapat et al., 2008) as compared to the exercise. In another study, elders practicing yoga performed better than exercise on all levels of fatigue and multiple measures of quality of life including pain, social functioning and exhibited improvements in flexibility and balance (Oken et al., 2004).

Studies comparing efficacy of yoga and exercise in healthy population have shown that Yoga affects on the sympathetic nervous system differently. Following six weeks (twice a week) intervention, yoga group had less heart rate than exercise group at submaximal exercise threshold (VO_2max) and the para sympathetic component was greater in the yoga

group(Bowman et al., 1997). Limited studies also show a significant increase in strength, muscle endurance, flexibility and VO_2 max following yoga practice (Tran, Holly, Lashbrook, & Amsterdam, 2001).

1.9. Yoga: An Evolution friendly way of life

In summary, the centres associated with memory and attention [Hippocampus]; reward, learning and motivation [striatum]; centre for sensory awareness and perception of self [Insula](Acevedo, Pospos, & Lavretsky, 2016) and the principal neuro-modulatory system [Locus Correleus] (Craigmyle, 2013) are consistently regulated with Yoga practices. Voluntarily enhancing awareness with Yoga practices, may facilitate coordination between insula, anterior cingulate cortex, and amygdala to respond to the environment at the present moment, rather than eliciting an emotional response from the subjective memory or perception. So, in-order to facilitate adaptation, the response based on the associated memory may be selectively inhibited and the sensory awareness of the present environment shall be cognitively appreciated and processed.

Representing the above process in a simpler form, synchronisation between physiology and psychology observed in yoga, limits the negative bias induced by subjective perception, experience-based self-appraisal of the environment and facilitates actual perception of the environment/situation through sensory perception and promotes better adaptation. This attribute of Yoga might strengthen the evolutionarily weak network that differentiates psychological stress from the physiological stress and elicits a response appropriate to the stressor.

Hence, we postulate that ‘When the individual organisms are exposed to the same drastic environment and when provided the optimal chance, each organism can efficiently adapt itself to survive’ [*Fig 1.1*]

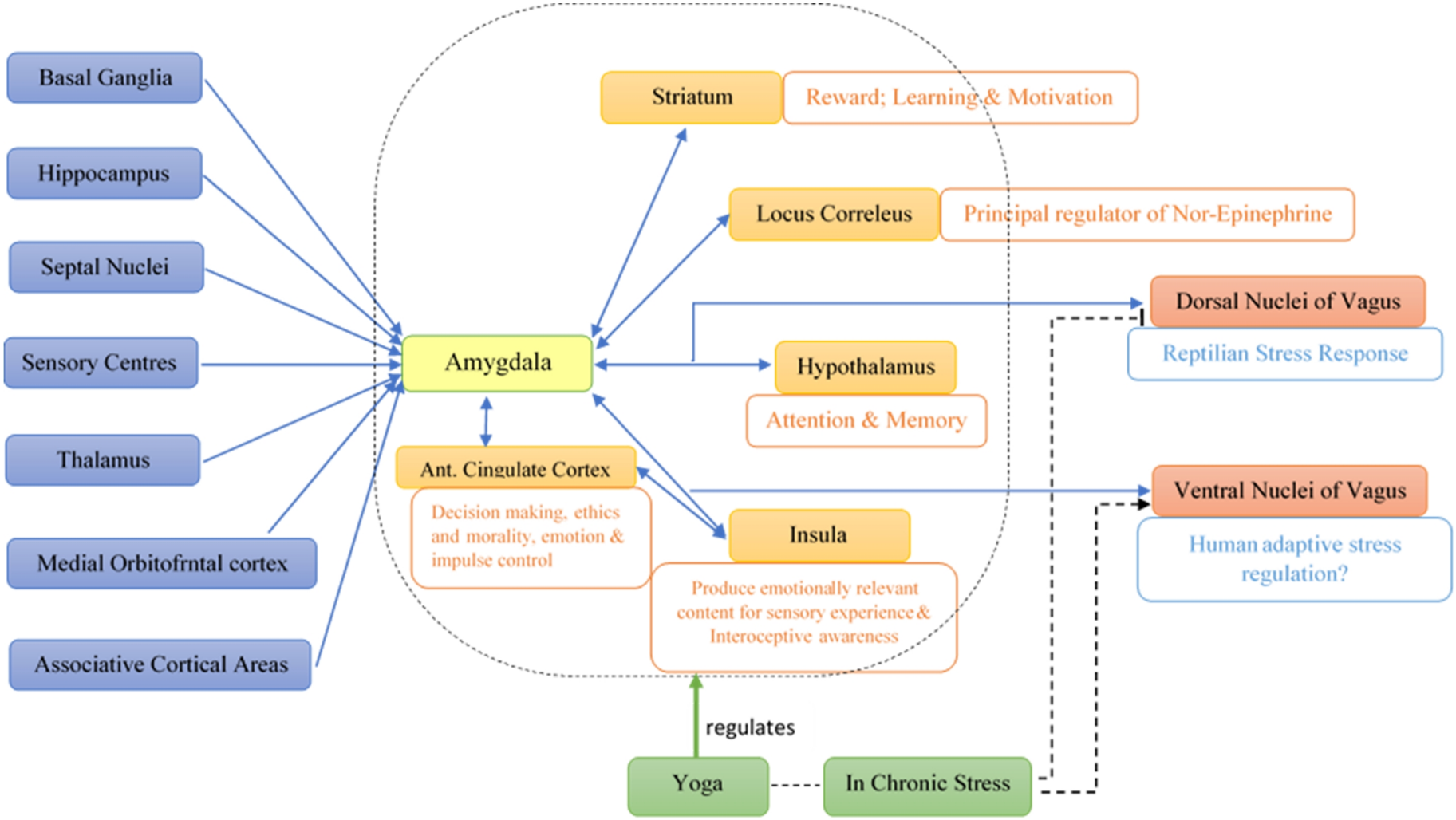

Fig1.1: Model representing neurological regulation of chronic stress by Yoga

1.10. Motive for the Study

Antarctica, being a natural laboratory of stressful environment will act as an environment to best study the effect of Yoga practices in regulating physiological and psychological processes.

Owing to the limited data available on human psychological and physiological changes in Antarctica, this study will throw light on two aspects:

1. Gene expression changes in Antarctic environmental conditions on the Indian Expeditioners to Antarctica
2. To understand the role of Yoga practices in facilitating adaptation in the Indian Antarctic Expeditioners.

We hypothesise that yoga is 'evolution-friendly' – where it is capable of differentiating and executing the optimal and efficient process required by the body to enable better, effective and efficient adaptation to the environment exposed (both physical and mental).