

**REASON FOR HEALTH BENEFITS OF DEEP MEDITATION: SELF ORGANIZED
CRITICALITY RESTORES REGULATION TO OPTIMAL**

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ABSTRACT

Traditionally, deep meditation is said to improve health. Research into the health benefits of meditation techniques like Mindfulness including MBSR, Zen Meditation, Vipassana, Self Transcending meditation techniques, and Cyclic Meditation has been extensive, and has yielded conclusive evidence of sustained reduction of hypertension and stress by regular practice, until normal healthy levels are reached. Other studies have documented benefits for general health: reductions in every category of health problem studied, and numerous instances of improved quality of life. Here we present a scientific theory accounting for such wide-ranging health improvements, in terms of a new theory of health based on complexity biology. Health has recently been defined as optimal regulation, leading to optimal responsiveness and optimal function, specifically related to complexity biology's state of criticality. Related work has shown that criticality supports self-awareness. The natural model of mind and body, where the nervous system both supports the mind and controls the body, means that when criticality is attained in the mind, it restores criticality to physiological systems as well. This means that meditation systems, which put the mind into a state of criticality, encourage the rest of the physiology to be restored to its natural state of criticality, or health. Hence such meditations are able to improve levels of health in a completely all-encompassing manner.

KEYWORDS: Criticality, Complexity, Meditation, Optimal regulation, Health.**INTRODUCTION**

The Indian government is currently encouraging medical application of Yoga techniques, including systems of meditation, because there is increasingly good evidence that they benefit health^[1], and can improve the quality of life of people of all ages.^[2] However, the kind of health benefits that accrue from various kinds of Yoga practice are highly dependent on the system selected, and require ongoing regularity of practice. To this date the mostly highly researched systems of Yoga and associated techniques are the Transcendental Meditation technique^[3], a self-transcending system^[4], and the Integrated Approach to Yoga Therapy^[5] including Cyclic Meditation^[6], where Yoga techniques are specifically applied to medicine, and to improving health levels of professionals.^[7]

The former has over 650 papers and reviews describing every aspect of practice, physiological, psychological and sociological^[8], and applications to education^[9], business^[10,11] and society^[12] at large, as well as to medicine.^[13] The latter has over 300, many of them RCT's concerning most aspects of medicine^[14], and physiological^[15], psychological^[16] and related areas of investigation.^[17] Yoga's applications to mental health are particularly important^[18], and an entire issue to

Indian Journal of Psychiatry has reported on them^[19], focusing on possible mechanisms.^[20] Here we focus on the Transcendental Meditation technique^[21], because its extensive health benefits^[22,23] challenge medical science for a coherent explanation.

A study by Orme-Johnson^[22] evaluated hospitalization costs of 2,500 Blue Cross-Blue Shield health insurance subscribers in the state of Iowa over a one year period, comparing them to 500,000 non-meditating subscribers. The study found across the board benefits for every class of pathological condition – only childbirth costs were greater than for the rest of the population. In particular, heart disease costs were reduced by 85%. A subsequent study by Herron^[23] evaluated GP costs for those learning the technique, over the first few years of practice, finding a mean, ongoing reduction in GP costs of 7% per year. The implications of this study are that regular practice of Transcendental Meditation produces cumulative benefits leading the practitioner's system slowly back to states of improved health. It does not happen overnight; persistence in regular practice is essential.

Moreover, Transcendental Meditation is currently the only treatment within the world of Complementary and Alternative Medicine (CAM) recommended by the

American Heart Association (AHA) for hypertension^[24], or for any disorder, for that matter. A set of eight RCT's was systematically reviewed in 2010^[25], and a qualified report suggested that it would be acceptable for general practitioners to prescribe its use for mild hypertension. In the last two years, another such RCT has been performed in India, with patients recruited at a hospital in Bangalore, and Nitte University in Mangalore as the parent, responsible institution.^[26] The study reported a mean reduction of 12 mm Hg in SBP over the six month study period, with no sign of the steady 2 mm Hg reduction per month leveling out at the end of the study. Clearly these are highly substantial benefits.

Other studies on the Transcendental Meditation technique have obtained equally remarkable results.^[27] eCAM It is known to enhance power in EEG alpha waves^[28] which enhance health^[29], with alpha spindles beginning at the back of the head in the visual cortex, and spreading all over the cortex.^[30] Regular practice increases power and coherence in alpha EEG waves, and most importantly, very slowly and steadily decreases the dominant frequency^[31], guaranteeing that even in old age, alpha and its associated peace of mind will be available. Other major changes include decreased CO₂ expiration^[32], often interpreted as decrease in metabolic rate, decreases in both anxiety and depression^[33], decreased auditory thresholds^[34], and increased field independence.^[35] Somehow practice greatly strengthens the internal frame of reference. Thermal imaging shows increases in temperatures in the periphery.^[36]

Two of these major changes are suggestive of the mechanism by which reductions in SDP occur. Increased peripheral temperature is associated with capillary dilatation^[37], while increased CO₂ concentration in the blood leads to increased blood flow in the brain.^[38] A study by Jevning specifically found large increases in blood flow in every area of the brain.^[39] Both cortex and subcortical areas are flooded with blood during the practice of Transcendental Meditation. While these two factors begin to offer a reasonable physiological explanation for the specific benefit of reduced hypertension, in both SBP and DBP, they obviously cannot account for the observed benefits to other pathological conditions.^[22,23]

This paper offers a completely new kind of explanation for how health benefits accrue from the regular practice of the Transcendental Meditation technique. It is based on a recently published series of results concerning regulation of the physiology^[40,41]: first, a scientific definition of health based on complexity biology^[40] and, second, a new account of how self-awareness is supported in complex biological systems.^[41] The relevant concepts in complexity biology are described in the next section. From these are derived the results in the results section.

COMPLEXITY BIOLOGY

Recently, it has been shown how complexity biology offers a scientific account of health,^[41] principally because complexity biology concerns fine tuning of organism regulatory systems. Study of the concept of health present in all TCAM systems of medicine suggests that loss of health is associated with degradation of quality of regulation.^[40] Examples of how poor regulation leads to poor quality physiology and its function: poor immune system regulation and function lead to failure to eliminate invasive microorganisms, or circulating cancer cells; Thalidomide interferes with morphogenesis; failure to maintain sufficient antioxidants leads to excess reactive oxygen species; under conditions of mental stress, glucocorticoid resistance represents a failure of cells to respond adequately to cortisol in the blood stream; in diabetes, insulin resistance constitutes a failure of cells to take up glucose in response to the presence of insulin; examples are endless, every chronic condition owes its presence to departure of regulation from optimal, or its failure. As a corollary, improving regulation tends to improve health – something that needs to be stated with careful qualifications. Obviously, the culmination of improving regulation is its optimization, which can thus be taken as a major property of the state of health: in a certain, precise sense, optimizing regulation in an individual's physiology will optimize the state of health available to them, other circumstances notwithstanding. This leads to a new, fundamental principle of health: *Optimal Regulation is Optimal Health.*^[40]

The importance of this in complexity biology is that optimal regulation seems to be a central concept in the field,^[41] though realization that this is the case seems to have been a long time emerging. Complexity biology therefore seems capable of giving a scientific description of the state of organism health. That this should be the case may initially seem remarkable, but from an ecological perspective it seems obvious that this must be the case.

The development of complexity biology was largely stimulated by the work of Stuart Kauffman and his collaborators at the Santa Fe Institute,^[42] one of whom was John H. Holland, who developed the theory of complex adaptive systems.^[43] In this view, every organism evolves as a member of its ecological niche(s), while genetic crossing is the most efficient means to produce organisms that will maintain the highest level of competitiveness within their niche. Health is a key to competitive function. Regions where conditions constrain an organism to function less effectively will constitute the extremities of its niche. This is obvious to anyone walking up a mountain and observing the differing populations of animals and plants in different climatic zones. Each zone has a population of fauna and flora adapted to function optimally within its chosen range. Going beyond that range compromises function and survival. Function is optimized within the chosen

climatic zone; health is maximum there, and consequently the ability to compete effectively.

This may seem elementary, but it has a dynamic consequence central to understanding organism health: all organisms have the capacity to dynamically optimize their state of function, in particular their state of regulation; by these means they maintain their health. These processes are instantiated by complexity biology and its principles. That is probably the reason for their widespread distribution – probably a universal presence in all organisms throughout the various kingdoms of life. The principles of complexity biology include the unusual concepts of ‘criticality’ and ‘self-organized criticality’, the latter constituting the means by which the former is maintained. Criticality can be equated with the concept of ‘critical instability’ in the theory of regulation. It has been shown to have two major kinds of application in biological systems. First on signaling pathways, maintaining a feedforward loop on the pathway close to criticality is a means of signal amplification, and helps optimize sensitivity of system response, which constitutes a means of optimizing regulation.^[41] Poor sensitivity of response is specifically involved in such conditions as insulin resistance and glucocorticoid resistance. Their reasons are not properly understood, though they definitely represent degradation of quality of regulation, one cause for which could be departure of some aspect of regulation from criticality or approximate criticality.

Second, at the apex of control systems, information states of a system at criticality can support the sense of self, together with its inherent sense of the passing of time; the sense of personal existence, and the sense of being.^[41] This has been demonstrated by showing that criticality supports a kind of information different from either digital information or quantum information, one with a feedback loop attached to its information vectors. It is easy to reason that such an internal information loop makes the system a ‘self-observing system’ of a very special kind^[40], and that one can then attribute to it these commonly accepted aspects of human experience.^[41]

Together, these two different properties of criticality combine to link states of deep meditation to improvements of health. The state of pure consciousness, where the mind’s information content has been eliminated, is a state of criticality, lying at the apex of the regulatory hierarchy controlling mind and body. When a person enters such a state, criticality can then be slowly restored to all organism subsystems lower down the hierarchy. This means that deep meditation will lead to the restoration of criticality, or optimal regulation, throughout mind and body, and with it optimal regulation.

In Naturopathic medicine, cure is said to be produced by giving complete rest to both mind and body – not consuming food, and not giving the mind the need for

information processing. Such a state of total rest would offer the principle of self-organized criticality to restore all organism subsystems to criticality – their states of optimized regulation and optimal function. Procedures such as the 8 limbed path of Ashtanga-yoga^[44] including its three limbs concerned with meditation^[45] constitute formal systems of training people to attain such goals reliably.

RESULTS

In practice, organism regulation is conducted by an overall integrated structure that includes both top-down and bottom-up signaling and sensitivity. Information from tissues at the periphery leads to changes in messages sent out from the center, while the main aim of control is to maintain optimal function to the extent that is possible. In this structure the role of self-organized criticality is to maintain criticality: optimal regulation and optimized function. Since the brain cortex can support states at criticality, the role of the central nervous system (CNS) is to help maintain health. When health is compromised, then given rest, the system can restore health. In this context, the role of sleep may be to maintain criticality in the mind to support awareness. Both TM and Cyclic Meditation have been found to reduce metabolic rate deeper than sleep^[46,47], and may benefit health to a correspondingly greater extent.

The role of self-organized criticality in the mind is (1) to bring the brain physiology to criticality when the chance is offered, and thus, (2) to enable the physiology to maintain criticality states at the basis of awareness. Hence the role of self-organized criticality in meditation is to bring the awareness to pure consciousness, and thereby to bring both mind and body to states of health.

DISCUSSION

These results explain why deep meditation has such wide-ranging, powerful and non-specific health benefits. Yoga is not alone in this ability. Other CAM systems, such as Naturopathy, TCM and Ayurveda, are able to have the same kind of general benefit, because they offer deep, accurate insights into how physiology works, with therapeutic modalities to improve regulation.

Regarding criticality and pure consciousness, everyone knows what it is like to be awake and to experience life. It is something we all take for granted, but the whole phenomenon of experience contains elements that have completely baffled scientists, even those who have thought about them in detail. For example we all have a ‘sense of our own presence’. When we were in a class at school and a role call was held, we replied, ‘Present’, when our name was called. We all have a sense of our own ‘self’, whatever that may be, a sense of being here in the ‘now’, as it were, and a sense of time passing.

Though we all take this for granted, no scientist has previously been able to give an adequate account of how the ‘sense of self’ with its continuing ‘sense of existence’,

or 'being', is able to be supported by known aspects of the physiology; of how the body supports the mind. Clearly the mind processes information. But none of the kinds of information previously described by science could possibly support the properties of awareness described in the previous paragraph.

Previously described kinds of information are due to (1) Cambridge Professor Ronald Fisher who described the information derived from statistical analysis of scientific experiments^[48], (2) the kind of information used in control systems, formulated almost simultaneously by US scientist, Claude Shannon, for digital computers^[49], and by M.I.T. mathematician, Norbert Wiener for earlier kinds of control system^[50], and (3) by 'Quantum Information'^[51] due to Oxford physicist, David Deutsch, to describe the information contained in microscopic systems of atoms, molecules and elementary particles, described by quantum theory.

None of these kinds of information can support a 'sense of self' or an internal 'sense of time passing', a fact which has led many scientists to conclude that these taken-for-granted aspects of awareness are illusions. Such has been the scientific animosity to the concept of 'self' that philologists have even stopped using it in dictionaries. In the 1980's, the word, consciousness, used to be defined as 'That with self-knowledge'. Nowadays dictionaries merely state, 'Awareness', but when you look up awareness, you find, 'Consciousness', which means that the philologists have been forced into the tacit admission that they do not have the first idea how to define either word properly. Not only that, but the scientific community has bounced them out of using common sense!

The sophisticated new proposals^[41] may hopefully allow common sense to be restored in this central area of human knowledge. The approach is based on new discoveries in experimental biology made in the last thirty years, and a particular theoretical interpretation put on them. Everything depends on the (relatively) new subject of 'Complexity' and its application to biology as 'Complexity Biology', to which the paper^[41] devotes considerable time and space.

Everything reduces to the concepts of 'stability' and 'instability' in scientifically studied systems. We are used to dealing with matter with its stable properties; scientists have always assumed that the function of biological systems also depends on stable properties. When experiments are performed on physical systems, we do something to them, or let them do something, and record the results. If we don't get the same results every time, to within experimental errors, we would be very worried. Biologists have traditionally been taught to have the same expectations. They are taught that life is made of chemicals, albeit special arrangements of chemicals, and that physiological systems should behave like any other material system studied in the 'hard' sciences.

Enter complexity: Complexity Biology^[42] is the study of how biological systems give variable responses to fixed stimuli^[52], essentially of vagrancies in organism physiology. Variability of response turns out to be fundamental, and to have a simple explanation: physiological systems prefer to control themselves from instabilities.^[41] Norbert Wiener's theory of control^[50] provides a simple account of how instabilities arise within control systems. All control systems have at least one such point of instability. What is only now being realized is that biological organisms prefer to control themselves from that instability.

"Why on earth should that be?, you may ask. Well, apart from anything else, it offers species of organism increased chances of survival in difficult situations.^[41]

If a species of organism always make the same response to the same stimulus, they might all die when they encounter a condition in their environment not previously experienced. Should all chose the same, inappropriate, response, all will perish. However, if all respond differently, there is at least a small chance that one or more of the organisms will chose an appropriate response and survive, and with them the species. The ability to make different responses in changing environments demanding adaptation is therefore akin to a superior level of adaptive intelligence for a species as a whole.^[41]

This scenario offers some insight into why organisms' preferred 'locus of control' should be at instability. The next point of investigation concerns the properties of the information states that instability will support. Arguing by analogy, 'reasoning' rather than logically proving, one can show that instability states support a completely new kind of information, which has never been previously suggested.^[41] Furthermore, these information states can support a 'sense of self', and also a sense of 'being', an internal 'sense of time passing', or personal continuing existence. All these are regarded as essential attributes to understand by philosophers and scientists who concern themselves with such matters.^[53,54]

"How could all those properties possibly arise at the same time?," you may inquire. Here is an explanation of how and why presented through an analogy. Consider what happens at the onset of turbulence, the main instability in fluid dynamics. Turbulence consists of little whirlpools, technically known as 'vortices'. Large ones can be seen in fast flowing rivers, or in a steamer's wake. At the onset of turbulence, fluid flow becomes unstable, because although vortices would like to form, they cannot quite do so. Every fluid flow 'vector' representing the size and direction of fluid flow at every point in the fluid gains one or more tiny, infinitesimal, vortices attached to it. Vortices are present, but not finite, unmanifest, rather than manifest. They make the fluid flow ever so slightly variable and also variable in response to external stimuli (or they should do!).^[41]

Flow vectors in fluids represent information about the (mean) direction of fluid flow at each point in the fluid. So the analogy tells us something not only about the structure of fluid flow vectors at instability in fluids, but about information vectors at instability in information systems. Consider, therefore the same condition happening to information flows in an information system at an atomic or molecular level. Such information is also represented by 'vectors' (arrows). At instability, the information vectors may also be considered to contain internal vortices – loops. Preferred loci of control of physiological systems are at instabilities, so their information states also develop an attached loop, indicative of the instability.^[40,41] What could such a loop do? What could it represent? What might its applications be?

To those schooled in meditation and its philosophy brings familiarity with the idea of a 'self' at the foundation of mind. The philosophy of meditation holds that the deepest state of meditation, *samadhi*, is a state in which 'the Self experiences itself, through itself, by itself'.^[55] This statement is the essence of Vedanta philosophy. It can be represented by a pure information loop.

In other words the essence of our 'subjective experience' has all the behavior of being like a loop of information. When I look at my own body, a loop of information is formed as my body (eyes) sees itself. At a deeper level, when I reflect on my own understanding, a 'loop of information' is formed as my mind considers its own contents. At the deepest level, when all mental excitations cease in deep meditation, we still maintain a sense of 'self' experiencing the passage of time. The nature of this 'self' may be taken to be an information loop.^[41] The above physical model suggests that information states with an appropriate internal loop structure occur when a system is at an information flow instability. This fulfils the traditional statements about the 'Self' that: 'It knows Itself, through Itself, by Itself'.^[55] 'Self-knowledge', the traditional definition of 'consciousness', is the inherent nature of the 'Self'! The simple presence of an information loop as part of the information state is all that is necessary for consciousness to fulfill this definition.

Such a loop must generate some kind of 'continuity' in awareness, our sense of time continuously passing; and thus the sense of our own existence or 'being'. All these properties were set out as incontrovertible and fundamental by the original philosophers of phenomenal experience, Edmund Husserl^[53] and his student Martin Heidegger.^[54] All three properties arise from one simple addition to normal information structures, the proposed loop in the information state, a major point in its favor. Although it is not outwardly a dynamically changing state, an instability seems to have its own inherent dynamism, simply because certain aspects of it are unstable – they seem not to be fixed, but rather to be

fluctuating. This internal dynamism is also able to give rise to the dynamic properties that we take for granted. We can make decisions, move in the direction of something we like, or take evasive action when we see something unwanted coming our way.

CONCLUSION

The advent of complexity biology with its profound implications for the non-mechanical nature of organisms, and their inbuilt ability to maintain optimal regulation at criticality, combined with the identification of criticality states as the ground for a novel structure of information that can support self-aware consciousness has profound implications for health and healing: the mind is designed for its loci of control to function at criticality, while controlling the body. As criticality is a state of optimum regulation, this means that, should the regulatory state of part of the body depart from criticality, the conscious mind in its pure states has the power to restore the physiology back to criticality: ideal states of mind have intrinsic healing power. When a person practices a genuine technique of Dhyana which enables the brain cortex to enter more powerful states of pure consciousness, the brain state will then promote the restoration of corresponding states of ideal regulation throughout the physiology. This picture is able to explain the very general and non-specific observed ability of self-transcending meditation systems to improve qualities of life and health. This advance in theory should lead to more research on such health benefits from epidemiological and social perspectives. With better evidence to back this deeper level of understanding, health administrators should widely employ such programs to improve the health of societies and nations.

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