META-LANDSCAPE ARCHITECTURE: A NEW PERSPECTIVE ON RESEARCH

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Abstract

Recent advances in technology have allowed scientists to gain important insights into the mechanisms responsible for the psychobiological response to stress; however, despite impressive scientific progress in biology and medicine, little headway has been made toward the understanding of stress in its wider, environmental context. As a result, the present study evaluates an ample selection of traditional and emerging paradigms on the subject of stress, and posits a new research method; broad enough in scope to concurrently address the specificity of biological mechanisms and the abstract dynamics of natural systems. To that end, a new model based on *meta-landscape architecture* is introduced and demonstrated via a recent survey by the American Psychological Association entitled *Stress in America*. Results confirm that using meta-landscape architecture, an integrated model of dissimilar systems can be successfully conceptualized, built and tested with statistical data. Ultimately, it is anticipated that the utilization of meta-landscape architecture will allow researchers to put forward scientifically testable hypotheses regarding the heretofore inaccessible areas of confluence between developmental organisms and self-organizing natural systems.

Keywords: stress, model, meta-landscape, architecture, ecology, perception, HPA axis.

Overview

Since the 1930's, when Walter Cannon first introduced the *fight-or-flight* theory, significant progress has been made in the understanding of the biological and psychological systems that characterize the stress response. Notwithstanding the impressive gains into the psychobiology of stress, there has been very little ground gained in the understanding of its etiology, or regarding the context in which it occurs. Research into the symbiotic relationship between environmental stressors and the psychobiologic stress reaction, has primarily concentrated on finding one-to-one correlates among discrete actors; taken in isolation. For example (Clougherty et al, 2007; Schembri, 2007; Chen et al, 2008) found statistically significant linkages among diesel contamination, stress and asthma; Henckens et al (2009) found significant correlation between heightened levels of environmental stress and the inhibition of memory formation; and Matheson et al (2006) reported statistical links between acute stress, urban living and symptoms of depression. However, applying linear correlates to a comprehensive model that would make sense of the data has proven elusive.

While biological systems can be modeled in ways that explain the causal pathways involved in a given process, accounting for the myriad of potentially confounding variables involved in the stress syndrome has proven to be beyond the reach of current research methodologies. In fulfillment of the 2010 Summer Undergraduate Research Fellowship at the University of Houston (SURF-UH), a multidisciplinary effort was undertaken to address this question.

The project entailed a comprehensive search and review of a wide array of available scientific literature on traditional and emergent research paradigms. Of particular interest were publications with applications in the social and physical sciences, mathematics, and computing information systems. From a review of several hundred publications, a new, integrated research method was developed, loosely based on existing linear modeling methodology and the emergent conceptualization of complex systems as spatial representations.

In order to provide a practical basis for the new methodology, a recent study carried out by the American Psychological Association (APA) on stress perception was chosen as a test case. From the APA study data and current understanding of the psychobiological mechanisms of the stress response, a model based on meta-landscape architecture was conceptualized and represented.

In broad terms, the stress meta-landscape is an architectural construct which can be viewed from multiple perspectives. The stress problem space was therefore illustrated from three perspectives: two elevations, and a plan view. An elevation of the stress response was developed based on the work of Cannon (1914), Selye (1956, 1976), and others. A second elevation was derived from the data acquired by the APA. Finally, a plan view of the conceptual ecology of stress was developed in order to establish the lines of confluence between the components. By establishing a credible boundary between the two complex systems of stress (the individual and the environment) a perception interface was produced.

Introduction

Stress is *something* which is very familiar to everyone; it is common for people to speak of being "stressed out" at work, of feeling "the stress" of marriage, or define driving in rush hour traffic as a "stressful thing"; indeed, stress is part of everyday life.

But what is stress?

Current wisdom places the etiology of stress on the environment. The U.S. Department of Health and Human Services (DHHS), the federal agency entrusted with protecting the health of the American public, lists family, work and illness as the most frequent sources of stress among Americans (2010). However, the likely origins of stress are not limited to psychobiological and social causes. A number of recent studies have shown a relationship between stress and living in urban environments, crime and being female (Matheson et al, 2006; Clogerty, 2007). Moreover, stress has been correlated with being exposed to traffic related air pollution, suffering from asthma or being traumatized (Chen et al, 2008; Shembry, 2007), as well as with unhealthy environmental ozone levels and density of indoor particulate matter (Fielder et al, 2005). It is clear therefore, that stress is such an integral part of everyday living; that is, in one way or another, related to what people do, think, and feel; how they interact with others and how others interact with them; as well as to how social networks, governments, industry, and nature influences them.

For this project, a survey carried out by the APA was selected as a case study. The APA study was conducted in 2009 with the intention of measuring the perception of stress; specifically focusing on the main sources of stress among Americans. Results from the APA survey showed that the primary sources of stress in the United States are: money, work, the economy, family responsibilities, relationships, personal health, family health, housing costs, job stability, and personal safety. These findings are in line with those listed by the DHHS.

The statistical results of the APA survey in isolation shed little light on the reasons why such a broad spectrum of environmental factors result in the perception of stress. Nor are they particularly helpful in the understanding of how stress is manifested psychologically and physiologically by the individual. To understand how stress is manifested within the individual, let us take a look at the stress response mechanism as initially proposed.

The Stress Response Apparatus

No single person has influenced stress research more profoundly than Professor Hans Selye of the University of Montreal. Indeed, the *General Adaptation Syndrome,* which he proposed, is the dominant model today in the study of stress. Although ground-breaking at the time, the experimental work of Selye was firmly rooted in earlier efforts by Walter Cannon, who in the 1930's introduced the concepts of *homeostatic regulation* and *the fight-or-flight response*. Cannon posited that the body as a whole seeks to maintain a state of optimum equilibrium or homeostasis via biological regulation; similarly to the manner in which a thermostat maintains room temperature at a comfortable, steady level throughout the day. Homeostatic regulation is especially important in the fight-or-flight response, which is the psychological and biological mechanism the body employs to deal with survival threats.

Following Cannon's lead, Selye noticed a recurring symptomatic presentation during laboratory experiments with rodents. Animals placed under biological stress (toxins, noise, mutilation, etc.) reliably exhibited a triad of symptoms: enlargement of the adrenal cortex, inhibition of lymphatic structures, and ulceration of the gastrointestinal tract. These observations led Selye to postulate that the consistency in the physiological response to external insult shown in mice implied the existence of a unified reaction mechanism.

However, since the 1950's, extensive research has been undertaken, and the evidentiary results have shown that the stress response includes, not just one mechanism as proposed by Selye, but an entire apparatus that includes a host of psychological and physiological pathways; some of which are activated while others are inhibited depending on the threat context (see Figure 1).

In real or perceived life-threatening circumstances, the human sympathetic nervous system releases epinephrine (adrenalin) from the adrenal medulla; this hormonal discharge primes the body's defense mechanisms in preparation for action. Simultaneous with the release of epinephrine, the Hypothalamic-Pituitary-Adrenal (HPA) axis, releases cortisol by way of a cascade of hormonal signals. Cortisol is a hormone that inhibits certain functions of the immune system (Vedhara & Irwin, 2005) by restricting the production of selected cykotin proteins (Elenkov & Chrousos, 2002).

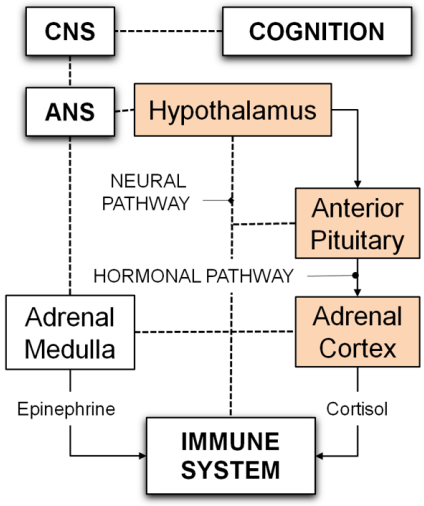

Figure 1 - The Stress Response Apparatus. Adapted from Ader, (2000); Cannon (1914); Selye (1956, 1976); Kemeny (2003).

In conjunction with the activities of the peripheral nervous system and the immune response mechanisms, there is a growing body of evidence that supports a mediating role of the central nervous system, and its concomitant cognitive functionality, in the executive control of threat assessment and response. Studies have shown (e.g. Goldstein & Kopin, 2007.; Kemeny, 2003; Heckens et al, 2009), that cortical and limbic functions are activated under perceived threat, and function as executive (decision-making) control in *allostasis* (Sterling & Eyers, 1988; Sterling, 2004), a clinical term used to describe the intricate regulatory regime responsible for the mobilization of the body's threat response resources.

The generalized model of stress and the models which have been developed from it (Ader, 2000; Kemeny, 2003) have proven to be valuable in the understanding of the psychological and physiological mechanisms of arousal under survival threat. However, the Selye-inspired stress research prototype has proven to be inadequate in accounting for the interaction of environmental, ecological, and existential sources of stress; specifically, when attempting to provide a credible rationale for the onset of the stress response when there are no apparent survival threats, for example at home or work, or where the sources of stress are indirect or abstract such as stress caused by environmental pollutants.

Intersecting Landscapes

The inability of linear modeling to address the complex issues of modern research has brought about a number of promising research paradigms based on landscape theory; among these, several concepts were reviewed.

Fitness landscape theory (Wright, 1932; Inkpen & Pettley, 2000; Smith et al, 2002), deals primarily with evolutionary biology, and attempts to visualize the environmental peaks and valleys of the genetic struggle. Another influential theory is landscape aggregation (Axelrod & Bennett, 1993; Ashby, 1962; Ghalam, 1998; Stadler, 2002; Milne, 1992) which has been utilized to predict the alignment of political and corporate groups with some success. The theory of aggregation is based on the assumption that social systems are self-organizing (Ashby,1962; Guerin & Kunkle, 2004; Kay, 2000), that is, they will tend to join together or break apart spontaneously; according to some underlying affinity or aversion. The landscape research paradigm has also spun applications in a wide variety of disciplines, from ecology and geography to epidemiology and ethnography (e.g. Bélisle, 2005; Drake, et al, 1993; Gulinck et al 2000; Olwig, 1996; Øyen, 2005; Mitman 2005). The abstract nature of landscape theory is self-limiting however. Genetic peaks and valleys, self-organizing social constructs and the like, serve to show how dynamical systems seem to an unbiased observer, yet these conceptualizations fail to provide a clear path from the abstract to the empirically testable.

While there is little agreement on the specific application of landscape theories, there is consensus on its basic definition. Landscapes can be understood to be conceptual spaces utilized by scientists to establish graphically the flux of natural systems (Burnett & Blaschke, 2003).

Thus, the term **meta-landscape** expands the basic premise of landscape theory, by providing a conceptual space that is at once multidimensional and controlled, wherein multiple dissimilar landscapes intersect. More concretely, the meta-landscape (landscapes within a landscape) is constructed based on an architectural metaphor. That is to say, a given problem is conceptualized as a three dimensional space which can be viewed from different perspectives and of which sectional views can be taken. The ability to

view the problem space from "outside the box" allows researchers to see beyond the limited boundaries of linear modeling, and the over-broad generalizations of conceptual topographies.

Thus, it is now possible to formally define a meta-landscape as *the multidimensional, graphical integration of two or more dissimilar intersecting systems*.

A Case Study

In order to test meta-landscape architectural functionality, an existing study on stress was utilized. The *Stress in America* survey was conducted online by Harris Interactive on behalf of the American Psychological Association. The survey was carried between July 21 and August 4, 2009 among a sample of 1,568 adults (18 or older), living in the U.S. The survey assessed the perception of stress among the general public and found that the most significant sources of stress among Americans were: money (71%), work (69%), the economy (63%), family responsibilities (55%), relationships (51%), personal health (47%), family health (47%), housing costs (47%), job stability (41%), and personal safety (27%). The values shown represent the percentage of people who rate the specific issue as a "significant" or "very significant" source of stress. The data gathered by the study was arranged in a logical pattern and a landscape arrangement. Figure 2, shows the stress constellation.

The perception stress landscape is called *a constellation* because it places the statistical data points as they are observed from the specific perspective of the average American adult; in other words, the APA stress landscape lack depth perception. In reality, stressors are not equidistant to the line of system confluence.

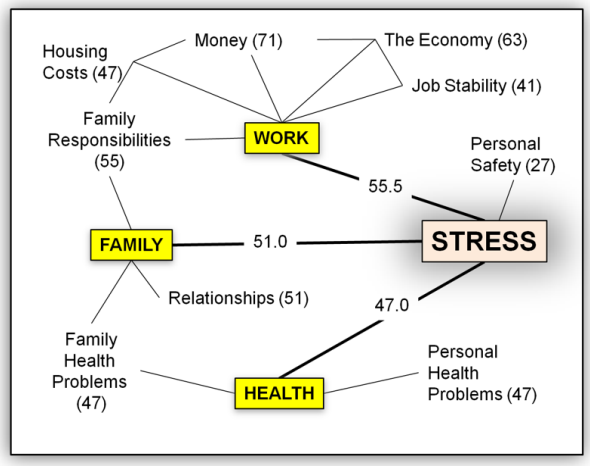

Figure 2 - The Stress Constellation.
Based on APA (2009) and DHHS (2010)

The Stress Meta-Landscape

Until now, the line of confluence between complex organisms and dynamical natural systems has been breached in research only in a one-to-one statistical correlation; that is to say, discrete systems are treated in isolation and assumed to have causal links. Meta-landscape architecture breaks with linear correlation in favor of planes of convergence; essentially framing the problem space as composed of multidimensional intersecting planes.

The final step in developing the stress meta-landscape entailed looking at the problem space from the plan view to define the border between the environmental stressors and the internal coping mechanism; in effect making a non-linear perception interface (see Figure 3).

By observing the stress problem space from the plan view, it appears clear that the convergence of individual and environment occurs along the borderline of perception; on one side there is a host of potential stressors, and on the other there is a coping mechanism capable of mobilizing the entire psychological, neurological and immunological resources of the individual. How these

resources are mobilized is dependent on how stressors are perceived.

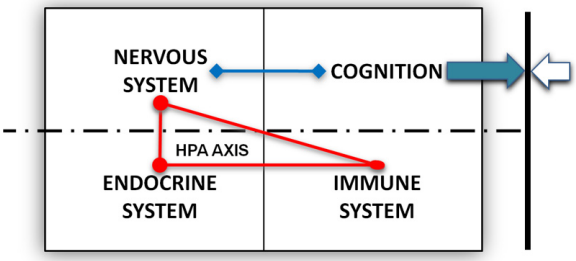

Figure 3 - The Stress Interface

So, what is stress?

Taken as an interaction between two dynamic systems (the individual and the environment), stress can be understood as the energy which is generated in both systems at the perceptual interface as they near each other. In more concrete terms, as the individual approaches the environment or the environment constraints the individual, energy builds up on either side of the interface.

From the meta-landscape model of the APA study, the stress interface is most active at work, that is to say, that not only is working a necessity for most adults in the United States, but also a place where the constraints of the environment are most at odds with the need of the individual to carry out his or her job, maintain social harmony with coworkers, and earn enough to maintain a home or a family.

But the plan view of stress does not provide the whole picture; the internal psychobiological processes of threat detection or avoidance must also be taken into account. How the individual reacts biologically and psychologically to environmental opposition, depends on a complicated convergence of the components of the stress response mechanism. In real time, when stress is perceived and energy builds up at the interface, the fight-or-flight response becomes engaged and the individual must deal with it. When the coping mechanism is viewed on elevation, it becomes evident that perceived stress triggers a concerted stereotypical response from the endocrine, nervous, and immune systems. Because the stress response is triggered by perception, the amount of fight-or-flight response is proportional to the amount of perceived threat. Thus, when the same stressor is perceived by different people, it will certainly result in a wide variation of stress responses, from panic to indifference.
The complete architectural representation of the meta-landscape of stress is shown in Figure 4.

Conclusion

It should be sufficiently clear, that scientific research methodologies are changing in interesting and promising ways. Clearly, the need to seek new research alternatives is driven by the failure of linear models to provide answers to vital research questions where there are no clear causal connections, or when the numbers of potentially confounding variables makes research findings statistically unmanageable and conceptually incoherent. Likewise, it is also abundant-ly clear that emerging paradigms such as landscape theory can account for some but not all of the complexity that is inherent in the interaction of complex natural systems; essentially, landscapes by themselves fail to provide a research pathway to the empirical evaluation of abstract spaces.

As shown in the present study, meta-landscape architecture provides for the integration of both concrete and abstract research models, via a multi-dimensional approach to the problem space. Future applications of the meta-landscape method may include the epidemiology of asthma, whereby researchers might develop longitudinal landscapes at the confluence of the asthma interface with complex systems such as air pollution, population density, or childhood trauma.

Other likely candidates for the application of the meta-landscape method, are the intersecting problem spaces of ethnography and ecology; philosophy and mathematics; as well as electronic systems and intelligent agents. It is hoped therefore, that the present study, will add a relevant voice to the growing conversation regarding research methodologies which might be better suited in resolving the apparently chaotic problem spaces of 21st century science than what is available today.

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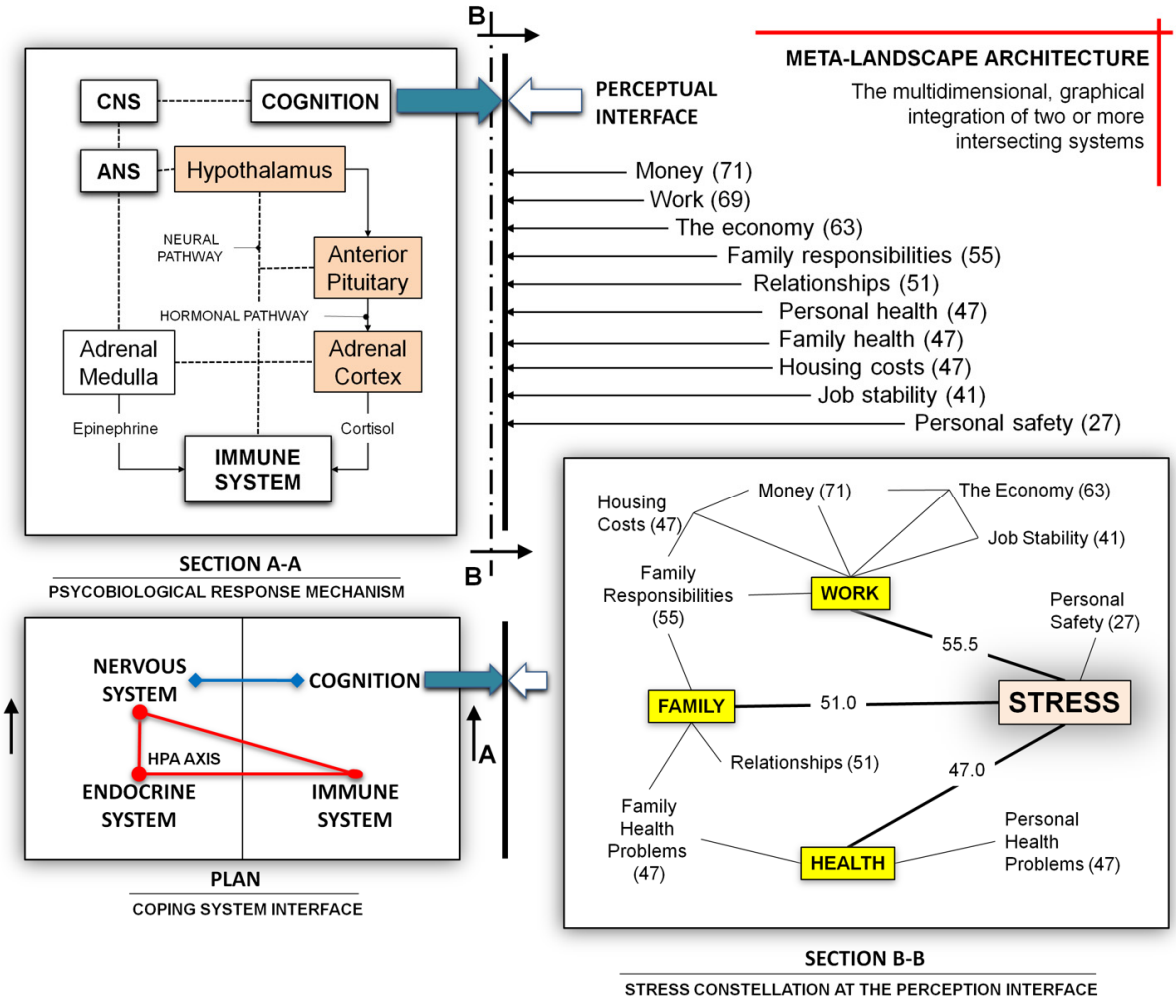

Figure 4 - The Stress Meta-Landscape

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