The Concept of Allostasis in Polygraph Testing

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Abstract

This paper introduces the polygraph profession to the concept of *allostasis*, as a model of physiologic regulation. We compare here the regulatory models of allostasis and homeostasis as potential causes of differential arousal as measured in field polygraphy. In polygraphy, the term homeostatsis is often incorrectly used to describe a waveform observed when an examinee's physiological condition is stable. Allodynamic regulation (Berntson & Cacioppo, 2007) is a result of integrative processes occurring within the central nervous system and mediated by the neuroendocrine systems (Janig, 2006). This concept of regulation is proposed to describe a portion of the physiological arousal observed during polygraph testing.

Classic Homeostasis

Homeostasis is a term used within the scientific community to describe the maintenance of the internal viability of organisms (Schulkin, 2003). The word homeostasis is derived from the Greek homeo, means "same," while stasis means "stable;" thus, "remaining stable by staying the same." Cannon (1932) coined the term "homeostasis" to refer to the processes by which constancy of the fluid matrix is maintained (Berntson & Cacioppo, 2007). Claude Bernard (1878) declared "All the vital mechanisms have only one object, to preserve constant the condition of the internal environment." Studies in physiology and medicine have interpreted that statement to mean certain aspects of the internal milieu are clamped or fixed at a specific setpoint. The historical concept of homeostasis is the basis of modern concepts of autonomic regulation and control (Berntson & Cacioppo, 2007).

Much like a thermostat in a home, homeostatic reflexes adjust to maintain a constant setpoint or level. Homeostasis involves what is called a negative feedback loop because it waits for something to happen before acting. A feedback loop involves a central control module which receives input regarding a condition, processes it and sends an output signal to maintain a setpoint. The central control center in a negative feedback system sends a correction to reverse the change from a setpoint to maintain a constant or fixed state. Positive control feedback systems enhance a stimulus that is already present. The classic feedback control model of homeostasis in psychophysiology describes compensatory responses to restore detected imbalances rather than enhancing what is already there (Berntson & Cacioppo, 2007) and thus is considered negative. Homeostasis describes the regulation of the body to a balance, by single point tuning such as blood pressure, blood oxygen level, blood glucose or blood pH. Baroreptor reflex in blood pressure is the classic, prototypic homeostatic system whose inputs, outputs and controls are well characterized. But blood pressure setpoints can, and do, change depending on the circumstances. Additionally, blood pressure can be changed through a variety of ways, not necessarily through one simple negative feedback system.

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Allostasis

The use of the term allostasis more accurately describes the physiologic mechanisms at work during polygraph testing. Sterling and Eyer (1988) introduced the term allostasis to describe the complexities of visceral regulation (Berntson & Cacioppo 2007), suggesting the model of homeostasis was insufficient to describe the phenomena of changing physiological parameters to meet challenges. While some physiologic regulators maintain a stable setpoint, this is not the case with all physiologic regulation. Mean values of certain parameters are not necessarily fixed points, but rather a setpoint most frequently demanded (Sterling, 2004).

Allostasis is the process of achieving stability, or homeostasis, through physiologic or behavioral change. This term is derived from the Greek: *allo* meaning change, and *stasis* meaning "stable." That is, some changes are necessary to maintain stability or viability. These changes are presumed to be aimed at ensuring the overall viability of the organism. Allostasis encompasses both behavioral and physiologic processes directed towards maintaining adaptive states of the internal environment. One common example is the ever changing relative blood pressure in a person over the course of the day. Researchers have found mean arterial blood pressure fluctuates to meet demands or in an anticipation of a demand (Bevan, Honour, & Stott, 1969).

Therefore, a person in an allostatic state will seek refuge or recovery from that state once the condition causing that state has passed. It is not proper to assert they are out of homeostasis during periods of reaction to the test stimuli. Certain physiologic system parameters of polygraph test subjects seek homeostasis, despite the impositions of stress or stimuli. Reactions during polygraph examinations are an allodynamic regulatory attempt to maintain homeostasis in response to the application of the stimulus. What is commonly referred by polygraph examiners as "relaxation," "recovery" or "relief" is also an allodynamic adjustment to maintain homeostasis with the passing of the stimulus. Allodynamic regulatory systems are not switched on but are always present and respond to help the organism adapt to changes in environmental stimuli or demands.

The allostatic model acknowledges the organism can use prior information to predict demand and adjust proactively before the demand is needed. Cannon (1928) recognized the body can respond in anticipation of a disturbance or agitation. For example, blood pressure typically rises slightly during the moments just before a person stands after sitting or relaxing. The anticipatory increase in blood pressure is adaptive, and serves to prevent lightheadedness by preventing the gravitational pull of blood to the feet by this positional change. The anticipatory increase in blood pressure is not in response to environmental or physiologic feedback, but can be thought of as a form of adaptive learning from past experiences with the action of standing (Dworkin, 1993). If a subject takes medication which blocks these blood pressure changes, the feed forward action can be blocked and the subject becomes dizzy.

Emotionality and Allodynamic Regulation

Emotionality can be used to describe a response based on the perceived value of a stimulus and may include such things as fear and anxiety. Generally fear is an emotional reaction to a present and threatening stimulus, from which the organism seeks refuge, relief or escape, and anxiety is concern of *what might happen* (Le Doux, 2002). Both are an adaptive response, rooted in our evolutionary past, regulated by neuroendocrine events that control behavioral and autonomic responses (Schulkin, 2003). The emotion of fear is dependent upon the neural activity of the amygdala (a small walnut-shaped part of the brain located in the anterior pole of the temporal lobe and being part of the limbic system). Parts of the amygdala have been called the sensory gateway as they receive information from numerous processes of the brain (Aggleton & Mishkin, 1986). The amygdala has been associated with our ability to predict fear (Sterling 2004), and damage to the amygdala has been linked to a reduction in fear-related responses (Le Doux, 1996). Anxiety has been described to be associated with the septal-hippocampus (Gray & Mc Naughton, 2003) or the bed nucleus of the stria terminalis, a

portion of the extended amygdala (Heimer, Van Hoesen, Trimble & Zahm, 2008; Walker, Toufexis & Davis, 2003). Because any number of things may contribute to the underlying cause of reaction during polygraph examinations, we will use the term emotionality to more safely subsume the potential causes.

There is no clear setpoint for any particular emotion and thus it is better described under the concept of allostasis than homeostasis. Allostasis describes the changes that occur behaviorally and physiologically to facilitate survival based on an assessment of the stimulus. Once the dangerous condition has passed and the organism experiences relief, the arousal state should subside, and allodynamic regulation should function to restore setpoints.

Allostatic load is a term used to describe the wear and tear on the body as a result of psychophysiologic change. McEwan and Wingfield (2003) propose two types, Type 1 and Type 2 allostatic loads which result in different responses. For each system of the body, there are both short-term adaptive actions (allodynamic regulations) that are protective, and long-term effects that can be damaging (allostatic load).

Type 1 allostatic loads occur when energy demand exceeds supply. The organism moves into a survival mode in an effort to mitigate allostatic load. Once the emergency has passed, the animal returns to a "normal" level of existence. Type 1 allostatic loads are those we are likely to encounter during polygraph testing.

Type 2 allostatic overload begins when there is sufficient or even excess energy consumption accompanied by social conflict and other types of social dysfunction. Type 2 allostatic overload does not trigger an escape response, and can only be counteracted through learning and changes in the social structure.

Arousal through the Emotional and Motivational Path during Polygraph Testing

The exact nature of emotionality underlying arousal during polygraph testing may not be known, may vary by test subject and may present a lofty challenge to "tease out" in scientific testing. There does, however, seem to be face validity around the idea that some degree of emotionality may be present during field examinations. Davis (1961) provided three possible explanations for reactions during polygraph testing. These include the theories of: conditioned reactions, fear of punishment and conflict. All of these are based on an emotional or motivational component as the underlying cause of arousal which he may have linked to fear. The conditioned reaction theory states that involvement in the issue under investigation has created a learned or conditioned response potential, through the action of classical conditioning. A polygraph question becomes a conditioned stimulus and response magnitude may be commensurate with the amount of salience that stimulus holds for that examinee. When the examiner discusses the crime with a guilty examinee during the pre-test interview, the contextual recall will result in autonomic arousal. The fear of punishment (fear of consequences) theory postulates a guilty examinee will experience autonomic arousal as a result of fear of consequences of discovery or false accusation. The conflict theory suggests a "guilty" examinee will experience arousal due to internal conflict arising from the motivational forces that cause him or her to answer the questions falsely.

The Defense Academy for Credibility Assessment (DACA), formerly the Department of Defense Polygraph Institute (DoDPI) Anatomy and Physiology for the Forensic Psychophysiologist chapter (DoDPI, 1994) handout states the reactions we expect (or hope to see) during a polygraph examination result from fight, flight or freeze reactions. These include increases in blood pressure, heart rate increase, increase in the contractile force of the heart, redistribution of blood in the body, increase in skin conductance, decrease in skin resistance, dilation of the bronchi and faster deeper breathing.

Many of the physiologic changes reported to occur during fight, flight or freeze can account for changes we see in polygraph tracings following the presentations of a stimulus (test question). Arousal during polygraph testing may be due to fear, stress, guilt, anger, excitement or an examinee's

orienting response to information (National Research Council, 2003).

Lying is an avoidance reaction that can induce arousal through anxiety, stress or guilt. Motivation can increase arousal and in polygraph testing motivation can be great if the consequences of failing are serious (Gustafson & Orne, 1963). It is clear that measurable physiologic reactions occur in response to polygraph questions, and that a number of psychological processes are related to those physiologic reactions, including conditioned response, anxiety, fear, conflict, complexity and other phenomena. The degree to which each may contribute to the allostatic state remains unknown and hence our use of the term emotionality.

Conclusion

The concept of allostasis and allodynamic regulation is not incongruent with the longstanding model of homeostasis. Allodynamic regulation is a conceptual expansion of a single setpoint model and well describes a multi-systemic response aimed at adjusting internal setpoints to meet the demands of the moment. The concept of homeostasis is grounded in the idea of a single optimal level for any given bodily measure. Optimal levels may change at any given moment, based on the current or anticipated circumstances. The marvel of the concept of allostasis (and allodynamic regulation) is it describes how the body can prepare for an inevitable change in any setpoint without having to wait for it to happen. Allostasis takes into consideration the idea that the central nervous system accomplishes these feats through an integration and combination of actions. Sapolsky (1994) provides one example of explanation from which we will draw to describe some of the difference between homeostasis and allostasis. Say we have a gasoline shortage in America. A homeostatic solution might be to build smaller engines for our cars. The allostatic approach would include: smaller car engines, tax rebates for car pooling, encouraging checking and maintaining proper tire pressure.

The term homeostasis has served us well for almost 80 years to describe changes on a small scale normally restricted to individual set points. Allostasis refers to an overall centrally mediated, orchestration aimed at maintaining viability, while adjusting numerous set points in preparation for or in response to a threatening situation. Sterling (2004) stated: “All scientific models eventually encounter new facts that do not fit, and this is now the case for homeostasis.” Allostasis describes an additional regulatory process of reestablishing homeostasis of the internal milieu through a physiologic change manifested to meet a real or perceived demand.

Allostasis and allodynamic regulation describe phasic arousal in field polygraphy where differential arousal is most likely associated with an emotional or motivational impetus. The short-term phasic arousal is well-described as an allostatic state. Allodynamic regulation describes the centrally mediated, integrative marshalling of bodily systems and resources to the perceived emotionality of the test questions.

The ever expanding science of psychophysiology has embraced this terminology and uses it when describing complex psychophysiologic interactions (Berntson & Cacioppo, 2007) and the science of polygraphy will benefit by the acceptance of sister disciplines. This is more likely to happen if we share a common language, one that adheres to the spirit of parsimony. If the polygraph profession is serious in its pursuit of general acceptance, it must be prepared to expand and embrace the common language and concepts of other sciences. Incorporating the concept of allostasis and allodynamic regulation into our profession is an important step in that direction.

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