Emotional Entropy: Appraisal and Survival

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For my brother Dr. Kelley Wells, whose ideas concerning inferential entropy helped inspire my inquiry into this topic.

Abstract

Efforts to understand and cope with emotions have been evidenced since the beginning of recorded human history. Throughout the centuries, Western thinkers sought to define emotional experience and teach methods for regulating emotions. Modern psychological researchers continue this tradition. Application of the Second Law of Thermodynamics and information theory into biophysiological function has led to new neuroscientific entropic brain research. This proposal is a recommendation for further research. Drawing on the work of diverse disciplines and integrative historical analysis, a new model for emotional entropy will be introduced. It is proposed that entropy is manifested as increasing levels of dysregulation in emotions. There is a natural tendency toward complete dysregulation and this represents a threat to humans and animals. Emotions in their completely unregulated condition (equilibrium) quickly induce death. Secondly, it is proposed that emotional episodes spontaneously self-organize much like the self-organization which occurs in the growth and development of all living organisms. It is postulated that it is an extension of this biological process.Emotions, it is submitted, emerge and assemble into emotion schemas, or arrangements of emotional reaction based largely on learning and socialization. Thirdly,it is advanced that there is an appraisal of threat, harm, and coping within emotional content. This involves likes and dislikes, wants and needs. Appraisals may be unconscious, preconscious or conscious, but it is proposed that they are goal-driven. This appraisal mechanism is conceived of as a tool for survival, and it includes iterative assessments based on new information obtained through perceptions. Appraisals are also bidirectional (i. e., they are top down and bottom up).

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Introduction

The attempt in present-day research to interpret emotional experience has its origins in antiquity. Over thousands of years, many paradigms for deciphering affect have been offered and most have fallen into disuse because of the limitations they present in application. Contributing to this quandary has been the difficulty in defining emotion, and this problem persists in modern inquiries. For purposes of this investigation, emotion will be operationally defined as a psychophysiological episode involving measurable, elevated mental activity and sensory experience, using energy to work toward a survival goal. But although this is a functional definition, it should be made clear that attempting to define a "discrete" or "basic" set of emotions appears to be impossible at this time. As yet, there is no consensus on the existence of discrete emotions and neuroscientific evidence remains unclear (Hamann, 2012).

Providing some definitions of key terms is necessary. For the sake of clarity, some of the definitions which follow will be alluded to at essential points within the analysis. According to Drake (2018), entropy is defined as,"…the measure of a system's thermal energy per unit temperature that is unavailable for doing useful work. Because work is obtained from ordered molecular motion, the amount of entropy is also a measure of the molecular disorder, or randomness, of a system" (para. 1). As presented throughout this discourse, this definition of entropy will be applied broadly to physics, information theory, biology and psychology to describe the natural physical tendency of order to disorder, or organization to decay. The Second Law of Thermodynamics states that heat will always tend to flow from a hotter object to a colder one and never flow spontaneously from a colder object to a hotter one without some application of work (Kafri and Kafri, 2016, p. 20). The Second Law is concerned with the direction of natural processes. A natural process can only run one way and is not reversible. This is explained in terms of entropy.

Maximum disorder or randomness in an entropic system describes the term equilibrium. According to Physics Ohio State (2004), "The equilibrium configuration is the situation of greatest disorder or maximum entropy" (p. 68). As applied in this context, the term equilibrium refers to a state or condition of complete emotional dysregulation inducing death. Therefore, it should not be confused with how some

psychological researchers define equilibrium as homeostasis (Plutchik, 2000, p. 67). Indeed, as used in this evaluation, equilibrium refers to the opposite of homeostasis. It is proposed that in emotional terms, it is maximum instability.

Hermann Haken (2013) states that spontaneous self-organization (or self-organization) refers to,"…a process by which systems that are in general composed of many parts spontaneously acquire their structure or function without specific interference from an agent that is not part of the system. Examples are provided by the growth of plants and animals" (para. 2).Pointing to evidence in brain scans, many neuroscientists contend that the thinking processspontaneously self-organizes into patterns in a manner which resembles the self-organization in the growth of all living organisms. However, Haken (2013) also observes that self-organization can occur in both animate and inanimate matter (para. 4). Both Caroll Izard (2007) and Marc Lewis (2004) also argue that emotions self-organize into emotion schemas. It is in this sense that self-organization will be postulated in this analysis.

Of emotion schemas, Izard, Ackerman, Schoff, and Fine (2000) assert, "Individual emotions also coassemble with other emotions to form contingent emotion patterns that stabilize over repetition and time" (p. 15). As conceived of in this analysis, individual emotions spontaneously self-organize into arrangements of emotional patterns that interpret the environment. Izard (2007) notes, "Emotion schemas are similar to affective-cognitive structures (Izard, 1977), emotional interpretations (M.D. Lewis, 2000, 2005), ideo-affective organizations (Tomlin, 1962), and the appraisal – emotion/feeling – cognition phenomena described in many appraisal theories…" (p. 265). Adaptive emotion schemas successfully interpret environmental cues (i. e. they apply effective strategies for environmental engagement). It is argued that such schemas support self-regulation, aiding the capacity of the affective-cognitive processes in remaining detached from equilibrium. Conversely, maladaptive emotion schemas present ineffective interpretations of environmental cues (Izard, 2007, p. 265). As asserted in this discussion, synonyms for maladaptive emotion schema include psychopathology, mental disorder, and emotional dysregulation. It is posited that such emotion schemas tend toward equilibrium.

As defined by Kelly Korner (2012), emotional dysregulation is, "…the inability, despite one's best efforts, to change or regulate emotional cues, experiences, actions, verbal responses, and/or nonverbal expressions under normative conditions" (p. 4). Thus, emotional dysregulation can be defined as lacking

control over how, when and with what intensity (positive/negative valence) emotions are experienced and expressed. Korner (2012) notes that the term emotional dysregulation has been adapted for use across disorders including substance abuse, bulimia, antisocial and personality disorders. (p. 4). As indicated, emotional dysregulation will be applied here broadly to refer to any mental disorder and substance addiction. It will be understood as a maladaptive emotion schema or psychopathology. Conversely, emotional regulation is the ability to modulate one's emotions (Nugent, 2013, para. 1). Synonyms include "self-regulation," "self-control," and "emotional control." Thus, in this proposal, emotional entropy is considered to be the natural *tendency* toward increased emotional dysregulation. It is submitted that this is a tendency toward maladaptive emotion schemas which can increase in frequency and intensity, posing a threat to emotional normality and ultimately to life.

The term free energy will be referenced throughout this discussion. Free energy is defined in thermodynamics as the, "…capacity of a system to do work" (Physics Stack Exchange, 2019, para. 2). In other words, it is the amount of work a thermodynamic system can perform or the amount of energy available to do work. Thus, free energy has an inverse relationship to entropy. As used here, synonyms for free energy will include Gibbs free energy, negative entropy, and negentropy. As Erwin Schrodinger (1944/1992) noted, his use of negative entropy had the same meaning as free energy (p. 498). Thermodynamics is often described in terms of the "exchange" of energy (Waitz, 2000, p. 1). Schrodinger (1944/1992) describes the process of free energy exchange in living organisms as "metabolism" (p. 496). Underscoring that this is not a literal exchange of material, he observes that this is a process by which living things avoid decay (entropy) by producing negative entropy, thereby using energy which paradoxically increases entropy (p. 497). This concept is important in understanding how the term environmental exchange will be used in this discussion. It is argued that in addition to metabolism, emotions participate in an environmental exchange. Environmental exchange is defined as the constant interchange between the affective-cognitive processes and environmental stimuli from which information is collected and stored. It often forms the basis of emotion schemas and appraisals. This is not a literal exchange of material but a survival device within affect directed at remaining aloof from emotional dysregulation (greater entropy) and it paradoxically uses energy that increases entropy.

The term cognitive appraisal (or appraisal) will also be employed throughout this discussion. As defined by Richard Lazarus and Susan Folkman (1984), a cognitive appraisal is, "…an evaluative process that determines why and to what extent a particular transaction or series of transactions between the person and the environment is stressful" (p. 19). Thus, it is proposed that cognitive appraisals are assessments of threats or safety, pleasure or pain, and likes or dislikes which initiate an emotional reaction. According to Lazarus (1991), appraisals address goal relevance and goal congruence (p. 222). As asserted in this analysis, therefore, appraisals occur with emotional episodes as well as emotion schemas and they are goal-driven (i. e. they work toward a goal). By implication then, the cognitive appraisal process expends energy to do work. It is advanced that appraisals may be unconscious, preconscious or conscious and they may involve high-level or more primitive levels of cognition.

In general, psychological entropy can be understood as the effects or influence of entropy (i. e., the tendency toward disorder) in the mind or emotional states. As will be shown, psychological researchers use a variety of metrics to measure psychological entropy and a clear consensus on standardized metrics appears to be lacking. However, in this analysis, the term emotional entropy will be employed. While fitting within the general definition of psychological entropy, as used here, it has a specific meaning. For this analysis, emotional entropy is operationally defined as increasing levels of dysregulation in emotions, as noted.This is conveyed in measurable neurologic thought patterns and observable behaviors in this model. As has been expressed, it is argued that emotions and moods have a natural tendency toward complete dysregulation, and this represents a threat to humans and animals. It is hoped that this operationalization can aid in standardizing the measurement of psychophysiological entropy.

A good deal of initial discussion in this presentation is devoted to the meaning of emotions (Chapter 2). It is argued that before one can reasonably describe emotional entropy as a psychophysiological phenomenon, it is necessary to examine the ways in which culture and history have influenced conceptions of emotions. Western thought is often characteristically mind-body dualistic, and this perception continues to misconstrue research designs and outcomes. However, it is submitted that the additional error of omission affecting much of current psychological research is the failure to incorporate the effects of psychophysiological thermodynamics on brain neural information into the

analysis of emotions. Psychophysiological thermodynamics refers to the sensory-stimuli processes which are affected by heat and temperature. As envisioned in this analysis, the affective-cognitive processing must be viewed as a dynamic system. This premise is derived from the principle first discovered by Rudolf Clausius. The Second Law of Thermodynamics influences any interactions involving heat in the universe. It is a tendency toward disorder which Clausius called entropy (Kafri and Kafri, 2013, p. 31). It is difficult to overstate the importance of this law of physics. Since heat exists everywhere, its influence is universal. Therefore, the impact of entropy on the body and mind cannot be ignored (Morowitz, 1987).

Thanks in part to improving neuroscientific modalities, researchers have started to include entropy measurements in brain research (Wang, Li, Childress & Detre, 2014). One of the difficulties has been the artificial barriers between the biophysical sciences and psychology. But neuroscientists increasingly demonstrate a fundamental understanding of the Second Law of Thermodynamics and are developing measures for calculating brain entropy (Boccardi, Commanducci, Baroni & Mecocci, 2017; Grandy, Garrett, Schmiedek & Werkle-Bergner, 2016). This exciting new research views the brain as a dynamic system in which the whole is greater than the sum of its parts (i. e., the brain is synergetic). It has allowed researchers to learn how entropy affects both the normal and abnormal brain, providing measurable differences (Brookes, Hall, Robson, Price, Palaniyappan, E. Liddle, P. Liddle, Robinson and Morris 2015). It has also offered vital new insights into the correlation between brain entropy and aging (Yao, Lu, Xu, Li, Lin, Waxman, and Feng, 2013). Closely related to brain entropy and representing a new frontier in neuroscience, has been the study of psychological entropy (Peters, McEwen & Friston, 2017; Nastase, Lacovella, Davis and Hasson, 2015; Sokunbi, 2014).

The line between brain and psychological entropy research has usually been the close connection of brain entropy to central nervous system (CNS) function while psychological entropic measurement has focused primarily on emotive reactions. Nevertheless, there continues to be a large body of modern psychological research which makes no place for thermodynamic theory (Sznycer, Tooby, Cosmides, Porat, Shalvi, Halperin, 2016; Klonek, Guntner, Lehmann-Willenbrock & Kauffeld, 2015; Fiske, 2015; Mitchell, 2009). This research may offer important insights into psychology, but its sole focus on social factors to the exclusion of psychophysiological entropy raises questions about the veracity of its conclusions.

Another important element to the entropy discussion is spontaneous self-organization. It was Erwin Schrodinger (1944/1992) who suggested that in living things, there is an “order-from-order” process which opposes the tendency toward equilibrium (perfect disorder and death) (p. 501). Since Schrodinger, other researchers such as Stuart Kauffman (1993) and John Scales Avery (2012) have theorized on how spontaneous self-organization occurs in biology. It was Claude Shannon who upon publication of his *A Mathematical Theory ofCommunication* in 1948 established the fundamentals of information theory. He applied the Second Law of Thermodynamics discovered by Rudolph Clausius and the entropy equation of Ludwig Boltzmann to reduce uncertainty in signal transmission (Soni & Goodman, p. 125). Based on Shannon’s information theory, Avery (2012) in particular focuses on how DNA/RNA information gets encoded in living cells to spontaneously self-organize and maintain a distance from disorder (p. 95).

These understandings have informed neuroscientists about ways to apply self-organization models to brain function. Ground-breaking study of self-organizing spatiotemporal thought patterns has been led by J.A. Scott Kelso (1995) and Teuvo Kohonen (1989). Nevertheless, numerous other researchers deserve credit (Renner, Lancaster, Bian, Choi, Ku, Peer, Chung and Knoblich, 2017; Connolly and van Deventer, 2017; Jung, Hwang and Tani, 2015). These are only a few examples and unfortunately, their new insights (premised on an understanding of the Second Law of Thermodynamics) are not considered in many other research models. Perhaps most relevant to this discussion is the research into how emotion factors into self-organizing thought patterns. As mentioned, some researchers theorize that patterns of emotion assemble into emotion schemas (Izard, 2007; Lewis, 2004). As noted, these schemas represent adaptive interpretations. This represents a central component of the present discussion.

Appraisal theory is also essential to the understanding of emotions. Based largely on the foundational work of Richard S. Lazarus and Susan Folkman (1984), cognitive appraisal theory has seen extensive application in psychological studies (Tohmiya, Tadaka, and Arimoto, 2018; Hermsen, van der Wouden, Leone, Smalbrugge, van der Horst and Dekker, 2016; Oginska-Bulik, and Kobylarczyk, 2016). It is worth observing that the application of cognitive appraisal theory has not been confined to human studies. There is a considerable body of animal research as well (Faustino, Oliveira, and Oliveira, 2015). Many appraisal theories view this process as a "top-down" one-way cognitive assessment which triggers

an affective (feeling) response. However, as presented here, appraisal is recognized as a bidirectional process which occurs from the bottom- up to the top down (Lewis, 2004).

The primary purpose of this examination is to propose and defend a new entropy theory of emotions, as has been defined. To accomplish this, both a discussion of how emotions have been perceived in Western culture and a review of the historical research into entropy theory will precede a detailed description of the proposed theory. A review of some representative evidentiary studies for the hypothesis will then be detailed. This will be followed by refutations of some other psychological research.

Following the Introduction, Chapter Two which is titled *Emotional Meaning,* describes how emotions have been perceived in Western culture since antiquity, with the aim of identifying motifs which influence modern emotion research. It will be proposed that the ancient Stoic writings of Zeno, Cleanthes, Chrysippus and the views of Aristotle (trans. 1992) concerning the passions shaped early Christian moral teachings and greatly influenced the thinking of Thomas Aquinas (trans. 1992). It is asserted that these value judgments about "good and "bad" emotions endure in the Christian tradition. Similarly, the ontology of Plato (trans. 1992) established a mind-body dualism, the influence of which, persists to the present day in psychological research. Many authors carried forth these cultural norms into the Renaissance including Niccolò Machiavelli (1532/1992), Thomas Hobbes (1651/1992) and René Descartes (1684/1992). For example, Descartes viewed any emotional experience as a distraction impeding his ability to understand the truth with pure reason. By contrast, the Renaissance also included the monistic writings of Benedict de Spinoza (1677/1992) who argued that mind and body must be unified. It is contended that Spinoza viewed emotions as natural properties which warranted study and understanding. It was Charles Darwin (1872/2015) in the modern era who laid the foundation of modern psychological research based on evolution. For Darwin, emotions were closely linked to animal instincts and he claimed that all animals experience emotions (Darwin, 1872/2015). William James (1890/1992) expanded on Darwin's theories with new ideas about consciousness, unconsciousness, the stream of thought and attention. Edward Thorndike (2004), Ivan Pavlov (2004), John Watson (2004) and B. F. Skinner (1974) established the behaviorist school of psychology largely in reaction to introspection. It is maintained that focusing on behavioral outcomes to the exclusion mental experience necessitated the imposition of a mind-body dualism in which emotions appeared to often be denied essence.

In Chapter Three, *The Historical Background,* a review of the research into the Second Law of Thermodynamics and information theory will be discussed to lay the groundwork for what follows. Though the chapter is a historical narrative, its purpose is to convey fundamental conceptual understandings of thermodynamics, entropy and information theory which are central to a nuanced appreciation of the hypotheses in this discourse. This chapter will also preliminarily introduce some evidence for brain and psychological research to aid in associating the primary discussion focus of the chapter (physics and biology) to mental processes. The discovery by Clausius that heat will transfer from a warmer body to a colder body but not the reverse, came to be known as the Second Law of Thermodynamics (Kafri & Kafri, 2013, p. 32). He referred to this as entropy, and its initial application as a property of heat and temperature in physics revolutionized science. Using probability statistics, Ludwig Boltzmann developed an equation describing the order to disorder tendency of atoms in entropy (Cercignani, 2010, p. 86). Joshua Willard Gibbs is credited with identifying how free energy is expended in an entropic system (Rukeyser, 1988, p. 235). Related to this is a discussion of the asymmetrical (one-way) arrow of time, and how the psychological arrow of time cannot be separated from the physical arrow. The chapter also describes how Schrodinger (1944/1992) was the first to articulate a theory of entropy in living organisms, and argue that there was also an opposing force in living things which he called "negative entropy." However, it was Claude Shannon who applied Boltzmann's equation to solve a signal transmission problem (Soni & Goodman, 2017, p. 125). Shannon's maximum error-free channel capacity was maximum entropy (i. e. all the desired messages have the same probability of reaching the receiver). Both the theories of Schrodinger and Shannon informed the work of many other scientists in how encoded information flow in biological functions. Authors such as Stewart Kauffman (1993) and John Scales Avery (2012) theorize on how spontaneous self-organization and DNA/RNA encoding processes operate, and their research is also discussed.

Chapter Four, *The Entropy Theory of Emotions,* is a presentation of the central hypotheses and core defenses. The chapter will begin with a narrative description of each of the three major hypotheses: 1) emotional dysregulation (entropy), 2) spontaneous self-organizing emotions and 3) appraisals in emotional content. Under the heading *Free Energy*, there is a description of how energy is used (and unused) by the brain. As mentioned, entropy is defined as a measure of energy unavailable to do work

(unused energy). The narrative under the next heading of *Memory and Emotion*describes the close association of memory function within the hippocampus with the limbic system and emotional response. This is followed by a discourse under the heading *Sleep*which proposes that sleep and downtime may be a necessary means of restoring some lost (unused) brain energy and that sleep deprivation may lead to emotional dysregulation. It is under the next heading titled *Emotional Content*that the appraisal hypothesis is detailed. This will be followed by an analysis of the relationship of substance dependence (addiction and abuse) to emotional dysregulation under the heading *Emotional Entropy,Addiction and Substance Abuse*. Evidence for the hypotheses will be offered, under the heading *Evidence for Emotional Entropy.*Representative examples of recent neuroscientific studies will be cited as suggestive evidence for emotional entropy and for spontaneous self-organization. This includes the wealth of research conducted by J. A. Scott Kelso (1995) and the research of Donald Pfaff (2006) into the relationship of arousal, the autonomic nervous system (ANS) entropy and emotions. Additional theoretical support will be cited in the work of Izard (2007) and Lewis (2004). Psychological studies employing appraisal theory to study stress and coping will be provided as examples and validation of the cognitive appraisal theory refined by Lazarus and Folkman (1984).

The analysis under the *Inferential Statistics* heading of Chapter Four proposes an extension of this evidentiary investigation. Schrodinger (1944/1992) contended that living organisms continually increase in entropy by paradoxically using the energy available to do work derived from the natural world (p. 497). It is submitted that if it assumed that entropy occurs in emotional states, it must be viewed as a subprocess of a dynamic living system. It is reasoned, therefore, that emotional entropy is a tendency largely influenced by natural environmental conditions. As conceived of in this analysis, entropy states involving emotions, are influenced in significant ways by the process of environmental exchange. There is some evidence to suggest increases in brain entropy are correlated with aging (Yao, et. al., 2013). Additional evidence suggests that childhood emotional trauma may correlate with high levels of entropy in the brains of adults (Dvir, Ford, and Frazier, 2014; Hervas 2017). In another small scale study, Erra, Mateos, Wennberg, and Velazquez (2017) found evidence suggesting that consciousness may be a byproduct of brain entropy. Is it possible, therefore, that emotional entropy is correlated to lifespan? Using data on life expectancy, a statistical analysis original to this examination is performed to interrogate

whether reduced life expectancy associated with mental disorders and substance addiction is a reliable indicator of emotional entropy. While this statistical analysis is inconclusive in part because it does not adjust for independent factors which may influence how long one lives, it is argued that because emotional entropy cannot reasonably be viewed as an autonomous process, this analysis may lay the groundwork for a new way of understanding the influence of entropy on lifespan. That is, it may suggest that increasing emotional dysregulation results in death sooner than normal in part because emotional entropy is influenced by environmental factors. Finally, if the dysregulation of emotional disorder and addiction accelerating death are evidence of emotional entropy, then it is argued that the inverse must also be true. Research into longevity will be cited as evidence that conscientiousness (self-regulation) may prolong life (Friedman and Martin, 2011).

*Refutations*is Chapter Five of the discussion. At present, there are many other paradigms for understanding psychological entropy, emotions, and psychology. This chapter will present some of these and propose counter-arguments. It will be argued that in some instances, the problems are the result of poor research design or methodologies. Some models of emotions appear to be untestable and ambiguous and they omit any consideration of emotional entropy (Plutchik, 2000). Under the heading *Emotional Constructionism,* the chapter will present the theory of psychological constructionism (Barrett & Russell, 2015). It will be proposed that its heavy reliance on deterministic linguistic relativism imposes an artificial top-down mandate on raw affect that operates in the reverse of the central nervous system (CNS) to mind evolution. This chapter will be followed by the *Conclusions* which is a summation of the major observations, hypotheses, and defenses.

Mental illness and substance addiction affect millions of people throughout the world. By conceptualizing these problems as emotional dysregulation, it may offer applications for measuring and observing the threat to self-regulation. It may aid psychologists in developing applications inducing behavioral strategies that replicate or promote patterns of conscientiousness (Friedman and Martin, 2011). Emotional dysregulation is already recognized by psychologists as a problem in children and adults related to poor socialization and heredity (Monoka, Howard, Caldeira, Wang & Arria, 2018; Dvir, Ford, Hill & Frazier, 2014; Schore, 2003). It is hoped that the value of this inquiry will be to illuminate the connection between this and elevated measurable entropy either locally or globally within the brain and to

better appreciate how emotional disorder is a disintegration of personality which is life-threatening. Perhaps this construct could have application in neuroscientific research, to better understand the affective-cognitive connection operating in mental entropy through better analysis of brain scan data. Perhaps it can assist researchers in arriving at a common metric for measuring emotional entropy. This may lead to better therapies and interventions for persons suffering from emotional dysregulation of all forms. Diseases like schizophrenia, dementia and Alzheimer's might be better understood through the lens of emotional entropy. Likewise, it may hold out possibilities for substance abuse and dependence, autism and learning disabilities.

Chapter 2: Emotional Meaning

Interpreting and evaluating how emotional experience is understood in Western thought requires a discussion of the changing ideas of the great thinkers concerning the emotions. Sometimes called passions or affects, the topic of emotions has been explored since ancient times and continues to the modern era. This exploration suggests not only how the understanding of emotions has evolved over centuries but also proposes connections between important theories and those put forward in other disciplines.

The Ancients:

Since ancient times, thinkers have always attempted to better understand and come to terms with emotional experiences. Ancient thinkers both in China and the West clearly demonstrated their keen awareness of the powerful impact of emotions (Larre, Root and De La Valle, 1996; Oatley, 2004). It is evidenced in the West at least as far back as Hippocrates. For example, Hippocrates (trans. 1992) described the relation of emotion to the body:

> Those who are mad from phlegm are quiet, and do not cry out nor make a noise; but those from bile are vociferous, malignant, and will not be quiet, but are always something improper. If the madness be constant, these are the causes thereof. But if terrors and fears assail, they are connected with derangement of the brain, and derangement is owing to its being heated. (p. 337)

Hippocrates was asserting that certain emotions and moods are causally connected to physical conditions while others are connected to serious mental problems. For Hippocrates then, emotions could

be explained by medicine and they were not mysterious. He was also showing an awareness that emotions originate in the brain. Even during later centuries, some writers were incorrectly attributing the emotions to organs in the body or, as in the case of Descartes, perceiving pure cognition as a spiritual condition separate from emotions and the body.

But for other ancient thinkers, the topic of emotions was often a source of a great deal of discomfort. For example, in The Republic, Plato (trans. 1992) had his character Socrates in dialogue with Glaucon assess emotional expression as it relates to the state and governance. Plato devoted a long portion of this dialogue to a description of the decline of government. In Book IX, he addressed the lowest form of governance, namely tyranny. In part of this, he had Socrates describe the degeneration of emotions. In describing the "appetites," Socrates said:

> I mean those which are awake when the reasoning and human and ruling power is asleep; then the wild beast within us, gorged with meat or drink, starts up and having shaken off sleep, goes forth to satisfy his desires; and there is no conceivable folly or crime – not excepting incest or any other unnatural union, or parricide, or the eating offorbidden food – which at such a time, when he has parted company with all shame and sense, a man may be ready to commit. (Plato, trans. 1992, p. 416)

Plato was clearly warning about the dangers of uncontrolled emotion. In the most degenerate society, emotional expression becomes the unleashing of "the wild beast within us" (Plato, trans. 1992). Thus, emotions will bring down the civilized world. The remedy for Plato was found in the nature of the state. Plato saw courage (strength in the face of fear), for example, as a virtue when discussed in the context of the guardians of the state (Plato, trans. 1992, p. 347). But this is to be understood as the courage to know and apply what the laws of the state ordain. The soldier would be instructed in music and gymnastics, so he is sufficiently knowledgeable and could, therefore, demonstrate the courage to apply laws with justice (Plato, trans. 1992, p. 347).

But Plato's philosophy had another potent impact on Western thought, and it influenced how thinkers have viewed emotions for centuries. Plato defined reality in dualistic terms (Robinson, 2017, para. 11). His ontology of dualism saw the changing world of experience as an illusion and asserted the existence of an invisible perfect world. In Book VII of Plato's *The Republic*, Plato (trans. 1992) through the

character of Socrates, relayed a story famously known as the Cave Allegory. Describing prisoners chained in a cave who view only the shadows of puppets reflected on the wall from fires behind them, Socrates said the following to Glaucon:

> And now look again, and see what will naturally follow if the prisoners are released and disabused of their error. At first, when any of them is liberated and compelled suddenly to stand up and turn his neck round and walk and look towards the light, he will suffer sharppains; the glare will distress him, and he will be unable to see the realities of which in his former state he had seen shadows; and then conceive some one saying to him, that whathe saw before was an illusion, but that now, when he is approaching nearer to being andhis eye is turned toward more real existence, he has a clearer vision… (Plato, trans. 1992, p.388)

This narrative represents Plato's metaphysical metaphor. Everyone is a prisoner living in a cave of illusion and if one is liberated, he can discover a reality of brilliant perfection beyond what one experiences. Plato's dualism between the perfect "real" world and imperfect illusion emerged in Western thought in a variety of ways. Perhaps the most significant way was the emergence of mind-body dualism. According to (Robinson, 2016), the problem of mind-body dualism can be broken down as follows:

> The mind-body problem concerns the relationship between these two sets of properties. The mind-body problem breaks down into a number of components.
>
> 1. The ontological question: what are mental states and what are physical states? Is one class a subclass of the other, so that all mental states are physical, or vice versa? Or are mental states and physical states entirely distinct?
> 2. The causal question: do physical states influence mental states? Do mental states influence physical states? If so, how?(Robinson, 2016, paras. 6 – 8)

It will be shown that in the writings of some, the mind becomes detached from the body and is often attributed to soul, spirit or God. Pure reason without the sway of emotion is sometimes enshrined and emotion is seen as a threat. In modern psychology, the word cognition is often used to describe discrete mental functions such as attention, perception, and memory (Johnston and Olson, 2015, p. 315). Thus, they are often treated as though emotion plays no role in shaping them.

By contrast, Aristotle saw emotion as an essential component of virtue. In *Nicomachean Ethics*, Aristotle (trans. 1992) argued:

> This then is the case with virtue also; by doing the acts that we do in our transactions with other men we become just or unjust, and by doing the acts that we do in danger, and being habituated to feel fear or confidence, we become brave or cowardly. The same is true of appetites and feelings of anger; some men become temperate and good-tempered, others self-indulgent and irascible, by behaving in one way or the other in theappropriate circumstances. (p. 349)

Emotions, as expressed in behaviors, are what measure the virtue or vice of an individual, according to Aristotle (trans. 1992). In other words, emotions are not always suspect, and they can be good. A person is habituated to feel one way or another, and this will determine the morality of their actions. For Aristotle then, good emotions are necessary to virtue.

However, during this time there emerged a different philosophy which proved to have a lasting effect on how emotions are understood and accepted. Around 300 B.C., Zeno of Citium was the founder of the philosophy known as Stoicism and he began teaching his disciples. More than one source records that Zeno was greatly influenced by Socrates. Pigliucci (n.d.) observes, “It was influenced by Socrates and the Cynics, and it engaged in vigorous debates with the Skeptics, the Academics, and the Epicureans.” Two other important teachers of Stoicism in Hellenistic Greece were Cleanthes and Chrysippus. But of these three, there is only a fragmented record of the works of Chrysippus (Baltzly, 2018, para. 2). Nearly all of what is known about Stoicism is annotated in the writings of followers and the philosophy has strong proponents into Roman times (Baltzly, 2018, para. 2). Modern understanding of stoicism captures part of its original meaning, but not entirely:

> Our phrase ‘stoic calm’ perhaps encapsulates the general drift of these claims. It doesnot, however, hint at the even more radical ethical views which the Stoics defended, e.g.that only the sage is free while all others are slaves, or that all those who are morallyvicious are equally so. (Baltzly, 2018, para. 1)

Thus, as taught by Zeno, Cleanthes and Chrysippus, the desirable state for one to achieve was that of Stoic calm (or dispassionate reasoning). This meant striving to be unemotional so that one’s judgment was clear. Stoics claimed that passions of any kind occurred because of false reasoning, and a person attaining perfect sagely wisdom would not experience passions (Baltzly, 2018, para. 56). The premise

underlying Stoicism was that external events are neither good nor evil, though Stoics contended that evil, as well as unhappiness, existed because of ignorance:

> …the Stoic God is immanent throughout the whole of creation and directs its development down to the smallest detail. The governing metaphor for Stoic cosmology is biological, in contrast to the fundamentally mechanical conception of the Epicureans. The entire cosmos is a living thing and God stands to the cosmos as an animal's life force stands to the animal's body, enlivening, moving and directing it by its presence throughout. (Baltzly, 2018, para. 6)

Hence, if God is within all things, then all things are acting in accordance with God. The Stoics believed living according to reason and virtue was to live in harmony with the divine order of the universe and to recognize the common reason and essential value of all people (Baltzly, 2018, para. 37). To do this, one must become self-disciplined in thinking. Stoics practiced methods for improving one's ethical and moral well-being to accomplish this. Because of the Stoic's insistence that only bodies are capable of causing anything, as Baltzly, (2018) notes, their idea of cosmic life force was in some way corporeal (para. 5).

As mentioned, Stoicism was heavily influenced by Socrates. It was, of course, the ideas of Socrates which were captured in dialogues of Plato and represented the genesis of Platonic thought (Graff, 2015, para. 2). Baltzly (2018) also notes that there is evidence that the Stoic philosophers during the period of Middle Stoicism (130 – 45 BCE) explicitly turned to Platonism and especially the Plato Dialogue *Timaeus* (para. 55). Stoics directed their will to agree with Nature, and they practiced the four cardinal virtues (derived from Plato's teachings: wisdom, courage, justice, and temperance) (Oatley, 2004, p. 49). However, the modern meaning of Stoicism - to suppress one's suffering - is not very close to its original meaning in ancient times. Keith Oatley (2004) observes:

> Although much of the argument about reaching non-attached states of mind is distinctiveto the Stoics, the attitude that a Stoic achieves comes close to Buddhism. In Buddhism,one realizes that the notion of a self who is successful, or accomplished, or indeed hasany fixity in time, is an illusion. As with Stoicism, there are practices and exercises toachieve a certain frame of mind. In this frame, it's not that emotions don't happen. It israther that one observes them and lets them pass, rather than being caught up in thevortices. (pgs.49-50)

Much like in the practice of Buddhism then, Stoicism was about detachment from emotions. This is radically different from the modern conception of enduring one's suffering by denying or burying feelings. As noted, however, the ancient Stoics did take the view that all passions were the product of false judgments and this is similar to how Stoicism is understood today. Yet, in common parlance today, becoming stoic is equated with suppressing one's emotional suffering. Without further research, it is hard to know exactly how and when this redefining of Stoicism occurred. But in the view of this writer, it is unfortunate, particularly because of the way this misconception may help promote a variety of emotional dysfunctions.

Another philosophy from Hellenistic Greece which shaped how emotions have been viewed was Epicureanism. This philosophy, named for its founder Epicurus, was originally conceived as a challenge to Plato's teachings (Konstan, 2018, para. 1). The philosophy taught that the greatest good is happiness, and it should be sought through the attainment of modest pleasures in order to achieve a state of tranquility, freedom from fear and the absence of bodily pain (Konstan, 2018, para. 1). David Konstan (2018) notes that this tranquility is obtained through knowledge of the workings of the world, the leading of a simple, moderate life and the limiting of desires (para. 1).

According to Konstan (2018), "The philosophy of Epicurus (341–270 B.C.E.) was a complete and interdependent system, involving a view of the goal of human life (happiness, resulting from the absence of physical pain and mental disturbance) …" (para. 1). Epicureanism was a philosophy with the goal of attaining human happiness absent physical pain and mental disturbance. It embraced an empirical theory of knowledge, atomistic materialism and a naturalistic account of evolution (Konstan, 2018, para. 7). Epicurus's radical empiricism also meant he rejected Plato's dualistic ontology.

Today, the word "Epicureanism" means devoted to the pursuit of pleasure (Oatley, 2004, p. 50). But this is far from its original meaning. Those who adhered to the teachings of Epicureanism in ancient times argued that delaying gratification for the sake of longer-term gain will lead to greater happiness (Oatley, 2004, p. 50). They argued that to become more properly human, one must free himself from the chaos of emotional impulses. They saw their task as employing philosophy as medicine, to divert attention from the ephemeral (fame, power, money, possessions) and thus, freeing themselves from the emotions such as greed, lust, anger and envy (Oatley, 2004, p. 50). Like the Stoics then, the Epicureans

were seeking to detach themselves from destructive emotions, though the two philosophies stood in opposition to each other.

This view of emotions as destructive, interfering with clear reasoning and unacceptable was carried into Christianity according to Oatley (2004):

> One of the most profound and far-reaching of such transformations occurred among early Christians like Origen and Evagrius. For them, as explained by Richard Sorabji, the bad emotions, which the ancient Stoics strove to extirpate, became sins.Evagrius nominated eight bad thoughts which were like Chrysippus' first movements:thoughts of gluttony, fornication, avarice, distress, anger, depression, vanity and pride. (p. 50)

Clearly, humans cannot help having these thoughts. The value judgments made about these emotional experiences only has meaning when viewed in the social and cultural context in which they are made. It must be true that both within ancient Greek philosophy and within Christianity it was extremely important to articulate rules for human conduct for the maintenance of social order. Implicitly these can also be interpreted as rules for emotional regulation. The latter church settled on the number of sins that were more resonant than eight. These came to be known as the seven deadly sins of gluttony, lust, avarice, envy, anger, sloth and pride (Oatley, 2004, p. 51). According to Oatley (2004), "All are emotions, or have an emotional quality. They endanger the soul not when one experiences their first movements. The danger and the sin occur, according to the church teaching, when one indulges them with full consent" (p. 51). Hence, an essential link was established here between the ancient understandings of emotions and modern ones. The concept of evil emotions, unacceptable thoughts and sin were deeply connected and carried forward in religious tradition. This also forms the basis of the dualism of emotion or what one might call the dichotomy of good versus evil (Robinson, 2017, para. 1).

The Middle Ages:

During the Middle Ages, Aristotle was given further legitimacy in the writings of Thomas Aquinas. As noted, it was the view of the Greek Stoics that "passions" (emotions) were a hindrance to reason. However, Aquinas (trans. 1992) argued:

> …if the passions be taken for inordinate affections they cannot be in a virtuous man, in such a way that he consent to them deliberately, as the Stoics maintained. But if thepassions be taken

> for any movements of the sensitive appetite, they can be in a virtuousman, in so far as they are subordinate to reason. (p. 47)

Aquinas thus echoed the views of both Aristotle and the Stoics that some emotions can be good if kept in check by reason. Unrestrained emotion leads to inappropriate expression and can never be virtuous but if it is understood as part of a sensitive appetite, its expression can be virtuous, according to Aquinas (trans. 1992, p. 47). It also seems evident that Aquinas viewed mental processes hierarchically, placing reason at the top above the passions. Emotions appear to be provisionally acceptable, but only as junior partners to reason.

Aquinas (trans. 1992) used "sorrow" to show how passion can be either with or without virtue (p. 48). He said, "Accordingly we must allow that sorrow for things pertaining to virtue is incompatible with virtue, since virtue rejoices in its own. On the other hand, virtue sorrows moderately for all that thwarts virtue, no matter how" (Aquinas, trans. 1992, p. 48). Hence, for Aquinas "sorrow" within reason was virtuous, but it can be inappropriate (perhaps evil) when it is misdirected or uncontrolled. Consistent with this view, he argued, "The passions of the soul, in so far as they are contrary to the order of reason, incline us to sin; but in so far as they are controlled by reason, they pertain to virtue" (Aquinas, trans. 1992, p. 728). He also asserted that passions consisting in aversion from good and tending one to evil are themselves evil (Aquinas, trans. 1992, p. 730). Therefore, Aquinas identified the existence of evil emotions in much the same way the Stoics expressed emotions which were a threat to deliberative reason and yet like Aristotle, he saw certain emotions as enhancing one's character. Perhaps Aquinas also agreed that the sinful emotions are embodied in the seven deadly sins.

Renaissance Period:

In the 16th and 17th centuries, important thinkers expressed a cynicism about emotions, particularly as reflected in political life. For example, in *The Prince*, Niccolò Machiavelli (1532/1992) described the character traits important to a prince during his time (p. 24). Machiavelli intended to write a guide to leaders on how best to acquire and maintain power. Concerning leadership, he posed the following, and then provided his answer, "Upon this a question arises: whether it be better to be loved than feared or feared than loved? It may be answered that one should wish to be both, but because it is difficult to unite them in one person, it is much safer to be feared than loved, when of the two, either must

be dispensed with" (Machiavelli, 1532/1992, p. 24). Without ambiguity, he made a recommendation to the prospective prince. Being loved by his subjects is a good thing and it will aid the prince in maintaining influence. However, ideally, this love should be balanced with fear because he thought it was only when his subjects fear the prince that they would truly respect him. Therefore, he concluded, given a choice between one or the other, it is better for a prince to be feared than loved. He believed that it was very unlikely that the two qualities (being loved and feared) would be embodied in the same prince. Hence, he did not view this emotional choice in the abstract. For Machiavelli, it was a real choice and that was why he argued this way.

The way Machiavelli framed this line of reasoning is revealing of his attitude about emotions. He appeared to be asserting that people are not trustworthy and not readily prone to noble emotions. This is why he thought being loved as a prince was not sufficient. For if a prince was loved only, he would not be respected. This lack of respect may result in political threats to the power of the prince. Love was a desirable thing to have around, but it was not indispensable. Fear was indispensable, according to Machiavelli (1532/1992), because only fear could guarantee the rule of the prince (p. 24). Hence, it can be inferred that he viewed fear as a much more powerful emotion than love. One might reasonably characterize this as deeply cynical, even emotionally shallow. But it should also be remembered that Machiavelli was pragmatically writing based on political observations of his environment.

In *Leviathan,* Thomas Hobbes (1651/1992) also had much to say concerning emotions. He believed in addition to education, the "wit" (intellect) was tied to "the passions" and originated in the body. He said, "It proceeds, therefore, from the passions; which are different, not only from the difference of men's complexions, but also from their difference of customs and education" (Hobbes, 1651/1992, p. 68). Thus, he saw the emotions as derived from the body and not the brain (Hobbes, 1651/1992, p. 68). Furthermore, the passions most connected with differences of wit were those principally associated with a desire for power and riches. In connection with this, Hobbes (1651/1992) observed that, "…riches, knowledge and honour are but several sorts of power" (p. 68). If a man lacks great passion for these things, he cannot have good judgment, even if he committed no offense. Adding to this, Hobbes (1651/1992) argued that to lack desire is to be dead, weakness in passion is dullness, and to have passions more vehement than ordinarily seen in others is madness (p. 68). Thus, the picture Hobbes

painted of emotions begins to emerge. The smartest men are those who express a strong passion for power. The lack of passion (for power) in a person is a measure of dullness. But expressing extreme passions which others do not express was madness.

However, Hobbes (1651/1992) introduced another concept which seems to carry theological overtones and also echoed Plato and Aquinas. In referring to what he labeled as “pride and self-conceit,” he claimed:

> Sometimes the extraordinary and extravagant passion proceedeth from evil constitution of the organs of the body, or harm done them; and sometimes the hurt, and indisposition of the organs, is caused by vehemence or long continuance of the passion. But in both cases, the madness is of one and the same thing. (Hobbes, 1651/1992 p. 68)

In this way, the person who was prideful and self-conceited was insane, as perceived by Hobbes. But this sort of instability is not confined to the brain and body. The clear implication was that Hobbes saw this as an affliction of the spirit and thus it was evil. With Leviathan, Hobbes presented an image of a mechanized body and head as his metaphor for the state aimed in part at containing this emotional evil. Hobbes adopted a kind of cynical pragmatism concerning human emotions which was similar to Machiavelli. Emotions were suspect, and they must be controlled, particularly as expressed in the unruly subjects of the state. But they could be useful as a measure of success and power for those who rightfully controlled power. Thus, Hobbes then might concur with Machiavelli that being feared was more essential to the monarch than being loved.

René Descartes (1684/1992) also factored prominently in the ideas of the 17th century. For Descartes, the true nature of humans could be found exclusively within the province of reason. As reflected in his celebrated assertion “I think, therefore I am,” Descartes introduced a paradigm of mind-body dualism in the Platonic tradition. Thus, he dispensed with all emotional examination as a distraction. He regarded emotional experience as unreliable and often leading to false conclusions, so it was not to be trusted. According to Descartes (1684/1992), “Thus, because our senses sometimes deceive us, I wished to suppose that nothing is just as they cause us to imagine it to be…” (p. 275). He, therefore, embarked on an experiment of thought in which he purposefully attempted to sever his reasoning from his perceptions, including his emotions. It was pure cognition that Descartes revered, and it was geometry

which he believed provided the tools of arithmetic logic needed to make it possible to attain the truth. In describing the rules necessary for sound reasoning, he asserted:

> This furnishes us with an evident explanation of the great superiority in certitude ofArithmetic and Geometry to other sciences. The former alone deal with an object so pureand uncomplicated, that they need make no assumptions at all which experience renders uncertain, but wholly consist in the rational deduction of consequences. (Descartes,1684/1992,p. 225)

Hence for Descartes, it was experience (which is necessarily subjective), that could not be relied upon to access the truth. This view of pure form manifested in mathematics is the essence of Platonism (Cohen, 2015, para. 2). As mentioned, Plato saw the world of our experience as an illusion and his ontology was one of dualism. The resulting dichotomies of mind and body, emotion and reason and good versus evil emotions left their imprints on generations of philosophers, theologians, and scientists including, of course, psychologists. As Antonio Damasio (2005) observes, "…as the sciences of mind and brain flourished in the twentieth century, interest went elsewhere and the specialties which we loosely group today under neuroscience gave a resolute cold shoulder to emotion research" (p. ix).

In his far-reaching book titled *Descartes' Error*, Damasio (2005) writes about the essential role emotions play in the brain and tries to correct the misconceptions long held because of this false dichotomy between mind and body. He says, "…the processes of emotion and feeling are part and parcel of the neural machinery for biological regulation, whose core is constituted by homeostatic controls, drives, and instincts" (Damasio, p. 84). More will be said about these important ideas. It is clear, however, that Descartes had a powerful role in shaping intellectual inquiry and his influence has formed attitudes about emotions.

Writing antithetically to Descartes about emotions during this period is Benedict de Spinoza (1677/1992). For Spinoza, the mind and body were united (Spinoza, 1677/1992, p. 612). He argued, "…we see not only that the human mind is united to the body, but also what is to be understood by the union of the mind and body" (Spinoza, 1677/1992, p. 612). By this, Spinoza meant that it is not possible to understand one's mind without understanding one's body. His concept of mind and body was connected to his unique monistic ontology (Dutton, n.d., para. 37). He contended that there cannot be any substance except God

and as a consequence, nothing else is conceivable (Spinoza, 1677/1992, p. 593). God is therefore infinite, according to Spinoza.

Thus, he appeared to extend the concept of the ancient Stoic immanentism in his writing. This view also informed Spinoza's concepts about "the affect." In a sharp departure from Descartes and other thinkers, he stated the following:

> The affects, therefore, of hatred, anger, envy, considered in themselves, follow from the same necessity and virtue of nature as other individual things; they have therefore certain causes through which they are to be understood, and certain properties which are just as worthy of being known as the properties of any other thing in the contemplation alone of which we delight. (Spinoza, 1677/1992, p. 629)

This observation was striking for its tone of modernity. Spinoza was declaring the affective experience an entirely legitimate area of serious inquiry. Spinoza's willingness to take a dispassionate look at emotions seems to echo the Greek Stoicism. He then presented his theory about the role emotions play in the mind. For example, Spinoza (1677/1992) claimed, "Hence it follows that the human mind is part of the infinite intellect of God, and therefore when we say that the human mind perceives this or that thing, we say nothing else than that God has this or that idea…" (p. 611). This seems to follow from Spinoza's premise that God is all substance. But Spinoza (1677/1992) also asserted that the mind does not know itself other than through perceptions of the affections of the body (p. 629). He defined affect as, "…the affections of the body, by which the power of acting of the body itself is increased, diminished, helped, hindered, together with the affections" (p. 629). Thus, he appeared to tie emotions to physiological responses. He argued for a kind of reciprocity between mind and body. On the one hand, affections are caused by things affecting the body. On the other hand, affections cause things to happen in the body.

He discussed the important role of "appetites" or "desires." In modern parlance, this might be called motivation, and this is one of the ways Spinoza's writing seems to foreshadow modern psychology. Describing the mind being conscious of itself, Spinoza (1677/1992) declared:

> …when it is related at the same time both to the mind and the body, is called *appetite*, which is therefore nothing but the very essence of man, from the nature of which necessarily follow those things which promote his preservation, and thus he is determined to do those things. (p. 633)

These remarks set the groundwork for his description of how various affects (emotions) occur. He also appears to be the case that he was arguing that it is possible to understand the affects using reason.

For example, according to Spinoza (1677/1992), "The affect of joy, related at the same time both to the mind and the body, I call *pleasurable excitement (titilatio)* or cheerfulness; that of sorrow I call *pain* or *melancholy."* (p. 634). Later, he argued that a man is affected by an image of past or future things (joys, sorrows or desires) as much as present things (Spinoza, 1677/1992, p. 635). He asserted that he who imagines what he loves is destroyed by sorrow, but finds it is preserved, will rejoice. He who imagines that what he hates is destroyed will also rejoice. In this way, he detailed the different motives which cause emotions, and he addressed hate, envy, and anger as well as joy and sorrow. Raised in the tradition of Judaism, his views were increasingly regarded as unorthodox (Dutton, n. d., para. 7). There is evidence, however, that Spinoza enjoyed great respect during his life among the Quakers in Amsterdam (Popkin, 2018, para. 16). Nevertheless, for whatever reasons, his ideas concerning mind and body unity and emotions as natural properties did not command quite the attention as the views articulated by Descartes. One wonders what the trajectory of western thought might look like in a world where his ideas had greater sway.

Modern Era:

It was in the 19th century that emotions were given formal analysis as a part of scientific research and it was Charles Darwin who was first credited with doing so. It was within his transformational theories on evolution that Darwin theorized about the role of emotions in the life of humans and animals. After the publication of *The Origin of Species* in which he argued that populations evolve over the course of generations through a process of natural selection, Darwin (1859/1992) followed it two decades later with his *The Descent of Man, and Selection in Relation toSex.* In *Descent*, Darwin (1871/1992) applied his evolutionary theory to human beings. This book addressed many interrelated issues and one important topic was evolutionary psychology (Griffiths, n.d., p. 1). However, Darwin viewed the role of emotions in animals and man as necessitating more consideration. Darwin (1872/2015) therefore published *The Expression of the Emotions in Man and Animals.*

Perhaps one of the most important points to be made is that Darwin's theory of evolution has been confirmed to such a degree by observation and experiment that it is accepted as fact by the

scientific community. Nevertheless, for many people, it is not accepted even today. As Quammen (2004) notes, “It's such a dangerously wonderful and far-reaching view of life that some people find itunacceptable, despite the vast body of supporting evidence” (para. 3). Quammen (2004) observes that many Fundamentalist Christians, Orthodox Jews, and Islamic creationists take alarm at the notion that human descent from earlier primates contradicts their religious dogma (para. 3)As theologians and philosophers scramble to either discredit or find alternative explanations which fit their religious tenets, one cannot help being puzzled as to why. The validation of the facts of evolution appears to be replicated inexorably. Yet some seem purposefully out of touch with them.

In *Descent,* Darwin (1871/1992) asserted that the human species is very nearly alike in its intellectual capacities. Darwin referenced his famous voyage on the H.M.S. Beagle during which he collected data for his research. He observed:

> The Fuegians rank amongst the lowest barbarians; but I was continually struck with surprise how closely the three natives on board H.M.S. *Beagle*, who had lived some years in England, and could talk a little English, resembled us in disposition and in most of our mental faculties. (Darwin, 1871/1992, p. 287)

At the time this was written, no doubt many reading this found it hard to believe. Darwin was boldly asserting that the most primitive people known during this time were on the same level cognitively as those regarded as the most highly civilized. But perhaps more compelling was that Darwin (1871/1992) claimed the cognitive gulf between these primitive people and the nearest high mammal was far greater. He noted:

> …even if we compare the mind of one of the lowest savages, who has no words to express any number higher than four, and who uses hardly any abstract terms for common objects or for the affections, with that of the most highly organized ape. The difference would, no doubt, still remain immense… (Darwin, 1871/1992, p. 287)

Thus, all humans are vastly more like other humans than they are like other animal species demonstrating lower mental faculties. While by contemporary standards, Darwin’s use of pejorative words like “barbarians” and “savages” can be criticized as ethnocentric and chauvinistic, the underlying message he conveyed must not be lost. Despite his cultural prejudices, it was science which had

informed his thought concerning humans. Humans are all a part of the same species and variation in cognitive abilities within the species are insignificant compared to the differences cognitively between humans and other animals.

Having made this essential point, however, Darwin (1871/1992) was also asserting that human beings share much in common with other animals because humans are the inheritors of the same biological, psychological structures and mechanisms observed in other animals. He stated:

> As man possesses the same senses as the lower animals, his fundamental intuitions Must be the same. Man has also some few instincts in common, as that of self-preservation, sexual love, the love of the mother for her new-born offspring, the desire possessed by the latter to suck, and so forth. (Darwin, 1871/1992, p. 287)

It is no accident that man shares intuitions and instincts with the other animals. Man is not separate from the other animals. Darwin was reinforcing his point that man has evolved from the lower animals. To some reading Darwin during this period, this was undoubtedly a shocking insinuation. It can be inferred that Darwin included human emotions in this inheritance as well.

However, he elaborated on this point. He claimed that animals experience all the same emotions as humans. He contended, "…the lower animals, like man, manifestly feel pleasure and pain, happiness and misery" (Darwin, 1871/1992, p. 289). He cited evidence for this in a variety of species including kittens, puppies, elephants, and monkeys. He also argued that evidence for emotions could be found in the muscular responses of animals (Darwin, 1871/1992, p. 289). It should be noted that some of what Darwin (1871/1992) used as evidence was anecdotal. Perhaps most of his evidence comes from his own direct observations of animals and fossils, but it appears much was also obtained from the reports on observations of other scientists. While this research approach was not always consistent with twenty-first-century scientific standards, it was very common during his time. Of course, as previously noted, however, Darwin's theories have been so validated by modern science that they are regarded as fact.

He expanded on the subject of instincts. Regarding animals that tend to associate together to provide aid to each other in many ways, Darwin (1871/1992) asserted that in most cases they are impelled by the same feeling of satisfaction or pleasure they derive when performing other instinctive actions (Darwin, 1871/1992, p. 308). He stated, “What a strong feeling of inward satisfaction must impel a

bird, so full of activity, to brood day after day over her eggs" (Darwin, 1871/1992, p. 308). He discussed dogs and squirrels as some examples of the numerous social animals displaying satisfaction in their activities, and he contrasted this with the dissatisfaction which occurs when they are socially cut off and left alone. Thus, he asserted:

> Hence the common assumption that men must be impelled to every action by experiencing some pleasure or pain may be erroneous. Although a habit may be blindly and implicitly followed, independently of any pleasure or pain felt at the moment, yet if it be forcibly and abruptly checked, a vague sense of dissatisfaction is generally experienced. (Darwin, 1871/1992, p. 308)

By using the word "habit," Darwin might have been describing something instinctual and thus, not learned. Nevertheless, Darwin seems to hint at the idea of unconscious thought. It is unclear, however, just how much Darwin considered the construct. One is intrigued by its suggestion here, however. Darwin was also making the point that the drive for satisfaction can override one's desire for pleasure or the drive to avoid pain.

Darwin (1871/1992) contended that the capacity to be sympathetic as well as loving also exists within many animals (p. 309). He said, "It is certain that associated animals have a feeling of love for each other, which is not felt by non-social adult animals. How far in most cases they actually sympathise in the pains and pleasures of others, is more doubtful…" (Darwin,1871/1992, p. 306). But he did emphasize that animals certainly sympathize with each other's distress or danger (Darwin, 1871/1992, p. 306). For Darwin, the ability to sympathize involved the identification by one animal of another animal's pain or suffering. This may result from having the experience of pain and recalling it upon seeing it in another. The fact that Darwin observed love between animals but not always sympathy may imply the absence of some higher-level brain functions, though Darwin made no mention of this. However, he clearly drew a line with social animals. That is, Darwin was claiming that the ability to experience love and/or sympathy emerges only out of creatures for whom affiliation is central to their survival. These animals have adapted through association and they are the higher-level animals (Darwin, 1871/1992, p. 310).

A sense of morality is connected to the ability of an animal to experience certain emotions, according to Darwin (1871/1992, p. 592). In other words, it is expressed in the social animals where the

community is important to survival. He asserted that animals must be capable of feeling "love" and "sympathy" for another animal in their community. Concerning moral qualities, he observed:

> The foundation lies in the social instincts, including under this term the family ties. These instincts are highly complex, and in the case of lower animals give special tendencies towards certain definite actions; but the more important elements are love, and the distinct emotion of sympathy. Animals endowed with the social instincts take pleasure in one another's company, warn one another of danger, defend and aid one another in many ways. (Darwin, 1871/1992, p. 592)

A community is necessary for these animals to survive against all kinds of potential threats. Love and sympathy aid greatly in ensuring community cohesion and it is out of this that Darwin asserted that morality develops. That Darwin saw love and sympathy as necessary for community survival suggests that he did not create a dichotomy between emotion and cognition. He appears to have grasped that emotion and cognition must act together to preserve the survivability of social animals and especially humans.

Darwin (1871/1992) defined a moral being as "…one who is capable of reflecting on his past actions and their motives – of approving of some and disapproving of others" … (p. 592). He argued because man is known to be the only being fitting this designation, that, "...it is the greatest of all designations between him and the lower animals" (Darwin, 1871/1992, p. 592). However, one wonders if this is an accurate assessment. Can it be claimed that the ability to judge good from bad is the exclusive province of humans? A body of recent research applying appraisal theory to study animals suggests evidence that some lower animals may do evaluations of good and bad (i. e. likes and dislike) (Faustino, Oliviera and Oliviera, 2015). Indeed, appraisal theorists Richard Lazarus and Susan Folkman (1984) also make this argument (p. 24). If all social animals feel emotions, it seems reasonable to conjecture they also do appraisals in connection with them. This will be discussed at greater lengthin Chapter 4. The central point made by Darwin (1871/1992) however, was that moral understanding evolves gradually from complex emotions which are connected to social relationships among animals that associate for survival.

In *The Expression of the Emotions in Man and Animals,* Darwin (1872/2015) further developed his concepts about emotions. Within this short volume, he argued notably that emotions manifest themselves as expressions in the face and body and that the chief expressions are shared by man

universally throughout the world. There are three general principles of expression, according to Darwin (1872/2015, P. 144). These he described as 1. The principle of serviceable habits, 2. The principle of antithesis, and 3. The principle of actions due to the Nervous System. He explained the first principle as follows:

> The first of principles is, that movements which are serviceable in gratifying some desire, or in relieving some sensation, if often repeated, become so habitual that they are performed, whether or not of any service, whenever the same desire is felt, even in a weak degree. (Darwin, 1872/2015, p. 144)

Thus, through repetitive learning or practice, an animal or man will perform a physical movement in response to a desire or sensation. One might describe these habitual movements as becoming unconscious through repetition.

Concerning the second principle of antithesis, Darwin (1872/2015) stated, “The habit of voluntary performing opposite movements under opposite impulses has become firmly established in us by the practice of our whole lives” (p. 144). As one develops habitual movements, one also develops opposing movements. This appears to be an unconscious result.

Finally, of the third principle, Darwin (1872/2015) said, “Our third principle is the direct action of the excited nervous system on the body, independently of will, and independently, in large part, of habit. Experience shows that nerve-force is generated and set free whenever the cerebro-spinal system is excited” (p. 144). He indicated the direction followed by the nerve-force is largely determined by the lines of connections between the “nerve-cells” but to some extent is directed by habit. In this third principle, it is evident Darwin recognized the important relationship between emotion and the nervous system. Most significant is his identification of nerve-cells. It is worth observing how Darwin completely embraced the mind-body connection. There was no place for dualism in his science.

Darwin (1872/1992) placed much importance on instincts and innate characteristics which are inherited traits from lower animals involved in shaping emotions. He proclaimed, “That the chief expressive actions, exhibited by man and by lower animals, are now innate or inherited, - that is, have not been learnt by the individual, is admitted by everyone” (Darwin, 1872/1992, p. 145). He cited as examples the way children of two or three years of age, including those who are blind, will blush from shame, and

how the scalp of very young infants will redden from passion (Darwin, 1872/2015, p. 145). However, some modern psychologists argue that these sorts of inferences based on observation cannot be made. For example, Lisa Feldman-Barrett and James Russell (2015) contend:

> Thus, ‘anger', ‘sadness', ‘fear,' and some other types of emotion words are each assumed to refer to a physical type that is observable in nature. Because the pattern is the type's essence, it is assumed that the pattern will occur during each instance of anger. In the science of emotion, essentialism is often labeled as a ‘straw man’ argument. It is often said that no one is really expecting the pattern for a given emotion to occur each and every time in an obligatory way. (p. 51)

Barrett and Russell appear to argue that because physical expressions are not always well correlated to the emotional episode, they must, therefore, be regarded as an unreliable measure (a straw man) of emotional experience. The study of emotional expressions must, therefore, be a complete waste. This sort of contraction seems more than a little ironic. Of course, meteorologists do not regard imprecise measures used to forecast future weather events as "straw men" because they, in fact, offer enough reliability to make a weather prediction based on percentages. Also, long before any formal science, humans were interpreting how others feel in exactly this manner absent any symbolic language. Needless to mention, many errors were made in interpretations of emotions using this nonverbal communication. However, this form of expression is sufficiently reliable for humans from very different cultures to make general inferences about each other without language. Indeed, nonverbal communication is arguably the primary way in which humans obtain information about the emotions and thoughts of others.

According to Thoman and Browder (1987), “Dr. Paul Byers, a nonverbal-communications expert at Columbia University, suggests that when we know people well, we detect changes in their feelings (whether they’ve become tired, angry, scared, or restless, for example) by unconsciously ‘reading’ the subtle changes in their rhythms.” (p. 123). Hence, Thoman and Browder argue that it is through one’s unconscious awareness that one receives cues from others about their emotions and this is connected to what they call “rhythms” by which they mean patterns of human behavior. They add that the reading of these signs is more reliable with those one knows. But it is used when one encounters strangers as well (Thoman and Browder, 1987, p.123).

Finally, if facial expressions and body language are not always a precise gauge of how one is feeling, then it should be asked if emotion words and language are superior. How often are psychologists misled by the words used in the self-reporting of research subjects? The answer is, words are often so unreliable, psychologists structure their studies to measure behavioral outcomes or neuroimaging more often than through the collection of survey questionnaires. This is because people often cannot select the best words to describe how they feel, they misuse words, or they purposely misrepresent how they feel by using misleading words.

It is clear that Darwin laid the foundation for evolutionary psychology and few who have studied in the field have been able to persuasively contradict or alter his thesis in fundamental ways. In *Expression,* Darwin (1872/2015) detailed how different emotions will express themselves in physical ways with the body or on the face. These expressive traits he contended, are developed in man very early in his evolution. To the present day,Darwin's research in evolution has indelibly altered the trajectory of biology in addition to the natural sciences, and it has launched the new discipline of evolutionary psychology.

Another contributor to the advancement of the study of emotion was, of course, the American philosopher and psychologist, William James (1890/1992). His study of emotion was extensive, and he developed a foundational theory of emotions which had a great impact. According to James (1890/1992), "Every passion in turn tells the same story. A purely disembodied human emotion is a nonentity" (p. 20). Thus, he understood emotions as experiences always connected to physiology and influenced by behavior.

Undoubtedly one of James's most influential works was *The Principles of Psychology*. However, equally important were his later publications on the James-Lange theory of emotion. Concerning the theory, Reevy, Malamud, Ozer, and Ito (2010) write:

> James's theory of emotion is called the James-Lange theory because Danish psychologist Carl Lange introduced the same ideas at the same time. The James-Lange theory is based on the principle that emotional feeling is a result of physical reactions to a stimulus; the body reaction to a stimulus precedes the feeling aspect (subjective experience) of the emotion. Specifically, James and Lange suggested that the perception of a stimulus produces a specific body reaction and that the body reaction produces an emotional feeling. (pgs. 333-334)

Thus, according to James, one feels sad because one is crying. One feels fear because one is running from danger. This counterintuitive theory was always controversial, to say the least. But because it represented the first formal theory of emotion put forth in the field of psychology, it is very significant. James and Lange (1922) argued that regarding emotions as "absolute individual things" is seriously problematic because it prevents psychologists from understanding the true causes of emotions (p. 100). This insight foreshadows the twenty-first-century view that discrete emotions cannot be found within affect. James and Lange (1922) therefore claimed:

> …if we regard them as products of more general causes (as 'species' are now regarded as products of heredity and variation), the mere distinguishing and cataloguing becomes of subsidiary importance. Having the goose which lays the golden eggs, the description of each egg already laid is a minor matter. Now the general causes of emotions are indubitably physiological. (p.100)

This insight of William James about emotions is quite consistent with research conducted today in neuroscience. It is understandable how his rejection of this concept led him to reason that all emotions are based in physiology. But James appeared to often use physiological response interchangeably with behavioral response. Evidence suggests that physiology is strongly connected to emotions, but most often physiology reacts to emotion and not the other way around (Kassam and Mendes, 2013). Behaviors may or may not occur in this interaction, but they too most frequently occur as a reaction to emotions (Porath and Pearson, 2012).

Reevy et. al. (2010) point out that the James-Lange theory had an enormous impact on research into the differential physiological responses that occur with various emotions (p. 336). However, the theory was heavily criticized in particular by the physiologist, Walter Cannon. Cannon's research showed that hormonal and autonomic nervous system actions are too slow to cause emotions and while it would be expected that people with spinal cord injuries would experience numbed emotion, the results in experiments were mixed (Reevy et. al., p. 336).

James and Lange both deserve credit also for recognizing the intrinsic reciprocity between mind and body. But the James-Lange theory has been harshly refuted by subsequent scientific studies and is largely rejected by psychologists today. On the other hand, Coleman and Snarey (2011) take a more

nuanced position. They state, “Not until the 1980s, however, did ‘neuroscience research on the role ofpeptides and receptor cells establish that (both) James-Lange and their critics were rightin that emotions originate in both the body changes and the mental perceptions’…” (p. 845). Hence, James understood that stimuli reactions are in part, taught by association and this has been supported by empirical evidence, according to Coleman and Snarey. However, it was not until the 1980s that neuroscientific evidence suggested that both the James-Lange theory and its critics are correct. That is, emotions are at times initiated by physiological responses and at other times, physiological responses are caused by emotions. It is apparent that more neuroscientific study of this is necessary to determine the complete dynamic range of this mind-body interaction. At present, however, the consensus among most psychologists is that emotional episodes initiate physiological responses more often than the reverse. Though James makes no mention of it, his insights concerning physiology and emotion appear to lend some validity to the thermodynamic influence of the body on the mind, because they recognize emotions at least in part as a response to physiology. The relationship of thermodynamics to physiology is described in greater detail in Chapter 3.

It was within *The Principles of Psychology* that James (1890/1992) put forward his theory of functional psychology. According to Goodman (2017), “…this thousandpage volume of psychology, physiology and philosophy has proved to beJames's masterwork, containing early statements of his main philosophical ideas…” (para. 10)His handling of topics such as the stream of thought, the consciousness of self, the emotions, and the will, presented new ways of understanding mental processes which endure to the present time. In many ways, James was following the lead of Darwin who as noted, founded the study of evolutionary psychology. He said, "The labours of Darwin and his successors are only just beginning to reveal the universal parasitism of each creature upon special things, and the way in which each creature brings the signature of its special relations [stamped] on its nervous system with it upon the scene" (James, 1890/1992, p. 15). Thus, James adopted Darwin's thesis that the neural machinery of living organisms is inherited by humans, and it is out this evolution that emotions have an expression in physiology.

It is in *Principles*, James (1890/1992) described how the consciousness in the evolving brain and nervous system of all animals reacts to the environment to maintain “harmonious co-operation” between

the parts within this system (pgs. 51 – 52). The brain and the nervous system of every animal evolve functionally in response to the environment, according to James (1890/1992, pgs. 51 - 52). This evolution is passed from ancestor to descendant and the process occurs in two directions. Essential functions evolve upward into the larger intellect, while lower functions evolve to become more automatic. James (1890/1992) speculated that functions which can easily grow uniformly (perhaps because they operate like machines) and are fatal (perhaps because they are not essential) become the least connected to mind (p. 52). One wonders how heartbeat and breathing (both of which occur automatically as a part of the Autonomic Nervous System) factored into James' thesis. These functions can hardly be viewed as nonessential. However, this is understood in James, much of what he detailed seems to foreshadow neuroimaging and mapping of brain functions.

In *Principles,* James (1890/1992) devoted a chapter to "The Stream of Thought," sometimes referred to as the stream of consciousness by psychologists (Morsella, 2015). James described five characteristics of thought:

1) Every thought tends to be part of a personal consciousness.
2) Within each personal consciousness thought is always changing.
3) Within each personal consciousness thought is sensibly continuous.
4) It always appears to deal with objects independent of itself.
5) It is interested in some parts of these objects to the exclusion of others, and welcomes or rejects – chooses from among them, in a word – all the while. (James, 1890/1992, p. 146)

One's thoughts are personal to oneself or are part of other thoughts belonging to oneself. Personal thoughts always change, and this change occurs continuously (without breach), according to James. He seems to want to make it plain that personal thoughts cannot occupy more than one consciousness.

One wonders if this assertion is made at least in part with the intention to rule out any speculation concerning the question of mind reading. If thoughts are entirely personal, no one claiming to read one's mind is credible. These personal thoughts are also continuous and changing. By inference then, one's emotional experience is personal and changing. This is James' stream of thought. Consciousness also always appears to deal with objects (images, perceptions) independent of itself and it welcomes some while rejecting others. What James wrote in part, gives one the sense he was describing cognitive

appraisals described in greater detail in Chapter 4 (Lazarus and Folkman, 1984). They seem to occur below consciousness and are involved in selective attention. He said:

> The phenomena of selective attention and of deliberative will are of course patent examples of this choosing activity. But few of us are aware how incessantly it is at work in operations not ordinarily called by these names. Accentuation and Emphasis are present in every perception we have. We find it quite impossible to disperse our attention impartially over a number of impressions. (James, 1890/1992, p. 184)

This partiality involves a selection of what one is drawn to and therefore, what one must consider important over other choices. It is this subjective rapid appraisal of stimuli which seems quite similar to the Cognitive Appraisal theory of Lazarus and Folkman (1984). James (1890/1992) asserted that in sentences, words are "felt" and understood differently than when they are read in isolation (p.171). He lent credence to this argument when he claimed:

> Hegel's celebrated dictum that pure being is identical with pure nothing results from this taking the words statically, or without the fringe they wear in a context. Taken in isolation, they agree in the single point of awakening no sensorial images. But taken dynamically, or as significant, as thought, – their fringes of relation, their affinities and repugnances, their function and meaning are felt and understood to be absolutely opposed. (James, 1890/1992, p. 172)

James was claiming that because Hegel viewed pure being and pure nothing as static words, he, therefore, saw them as devoid of felt meaning. It is not until one sees them in a context of a dynamic thought that they can be understood as absolutely opposed. But it seems doubtful that words in isolation offer no emotional content. Surely, James would not have disagreed that words are concepts (ideas) stored in memory and linked to some feelings. But recognizing the way words and sentence structures are evidence for how thoughts process does seem quite valid, and James (1890/1992) made it clear that he saw feelings and cognition as inseparable (pgs. 161 – 162). The reference to Hegel is also interesting because of Hegel's dialectic. James seemed to be suggesting that Hegel's metacognitive construct was possibly operating dynamically in selective attention. Finally, it seems also apparent that these ideas have been very influential in the Attention Schema Theory (AST) as formulated by Webb and Graziano (2018).

James (1890/1992) was also arguing that the object of every thought is neither more nor less than all the thought it thinks, regardless of how complicated or symbolic (p. 179). He contended that the memory can seldom accurately reproduce an object, once its conception has been formed in the mind, and that despite how complex a thought might be, the conception of it is one undivided consciousness (James, 1890/1992, p. 179). For example, James was contending that the thought of forest is not divided into individual trees. Rather, it is a singular idea no different than the thought of an individual tree. Thus, for James, perception, and conception were subjective. Therefore, he contended that emotions are always involved in processing new information within consciousness (James, 1890/1992, p. 738).

Also, James (1890/1992) observed, “We believe the brain to be an organ whose internal equilibrium is always in a state of change, - the change affecting every part.” (pgs. 159 – 160). This observation appears to hint at the concept of brain entropy – or entropy of consciousness. Whether James was suggesting this is not known, but it is clear he does not see thought processes as naturally ordered. Added to this suggestion is James’s thesis that attention is selective (p. 184). This selection of attention is suggestive of the self-organization of thought and emotions (i. e. schematic patterns of mental processes). Taken together, these two ideas seem to hint remarkably at the construct of brain entropy as well as the opposing force of spontaneous self-organization (Kelso, 1995). It is not known how familiar James was with the theory of entropy in physics. The theory of spontaneous self-organization does not emerge in biology until much later, however.

William James (1890/1992) also delved into what he called "The Consciousness of Self.". He described one's multidimensional tendency for self-reflection (introspection). James advanced a concept of self that evaluates the 'soul' theory, associationism, and the transcendentalism of Immanuel Kant (James, 1890/1992, pgs. 223 – 232). Associationism in psychology refers to the theory that complex mental processes such as thinking, and memory can be explained by the associative links that connect ideas according to specific laws and principles. The laws and application of association were advanced and developed by John Locke, George Berkeley, John Stuart Mill, and David Hume, to name a few (Nugent, 2013, para. 1). Immanuel Kant argued that thehuman experience of things is only similar to the way they exist (i. e. humans know reality with a priori certainty only through spatial representation and by intuiting time) (McCormick, n.d., para. 22). This implies a fundamentally subject-based component, rather

than being an activity that directly comprehends the things as they are in themselves. Humans intuit the essential aspects of reality such as time and space (James, 1890/1992, p. 233 – 234). For James at least, while thought processes are subjective in this way, thinking is not separate from reality. It is connected to the body. William James began by examining the self empirically. He asserted:

> *In its widest possible sense*, however, *a man's Self is the sum total of all that he* CAN *call his*, not only his body and his psychic powers, but his clothes and his house, his wife and his children, his ancestors and friends, his reputation and works, his land and horses, and yacht and bank account. All these things give him the same emotions. If they wax and prosper, he feels triumphant; if they dwindle and die away, he feels cast down… (James, 1890/1992, p. 188)

The self is the aggregation of one's body and psyche with all of what one claims ownership in addition to that which all one feels entitled. This includes physical possessions as well as people. The self also identifies through its reputation (how others perceive it), according to James (1890/1992, p. 188). The description of self in relation to what it owns is strikingly masculine in this passage. Absent is any sense of identity connected to serving others, for example. One wonders how a woman might view this sense of self. Nonetheless, the salient point is that self-definition and self-possession are key to self-consciousness.

James (1890/1992) argued further that the self can be divided into three parts: the constituents, the feelings and emotions they arouse, and the actions prompted by the self. He described the feelings and emotions as "*Self-feelings*" and the actions as "Self-seeking and Self-preservation" (p. 188). Regarding the constituents of the Self, James (1890/1992) listed: "a) The material Self, b) The social Self, c) The Spiritual Self, d) The pure Ego" (p. 188).

He then methodically described his definition for each of these selves. As described by James (1890/1992), the material Self can be characterized as that with which one physically identifies (pgs. 188 – 189). It begins with the innermost parts of one's body, the clothes one wears, and the physical appearance of one's body. It also includes one's immediate family. The social Self according to James, is preoccupied with getting social recognition or notice (James, 1890/190, pgs. 189 – 191). James (1890/1992) said, "No more fiendish punishment could be devised, were such a thing possible, than that

one should be turned loose in society and remain absolutely unnoticed by all the members thereof" (p.189). He claimed that one has as many social selves as there are persons who carry an image of one in their mind. This means that a person's fame, honor or dishonor are names for his social Self, according to James (1890/1992, p. 190).

The spiritual Self, described by William James, is one's inner subjective being. It is a person's psychic faculties or dispositions. James (1890/1992) declared:

> These psychic dispositions are the most enduring and intimate part of the self, that which we most verily seem to be. We take a purer self-satisfaction when we think of our ability to argue and discriminate, of our moral sensibility and conscience, of our indomitable will, than when we survey any of our other possessions. Only when these are altered is a man said to be *alienatus a se*. (p. 191)

Here James appeared to advance that there exists a deeply moral self which discriminates based on conscience. The defense of this moral sensibility is the most enduring and brings one a purer self-satisfaction than argumentation for any other of one's possessions. It is only when this moral sense is changed that this sense of self is withdrawn.

The next self of importance to James (1890/1992) is the pure Ego (p. 213). James divided the consciousness of self into the "I" and the "Me." Characterizing the pure Ego as the "Me," he indicates it is one's total empirical selfhood in the sense that it represents the collection of objective facts of one's belongings. He proclaimed:

> In what capacity is it that I claim and demand a respectful greeting from you instead of this expression of disdain? It is not as being a bare I that I claim it; it is as being an I who has been treated with respect, who belongs to a certain family and 'set,' who has certain powers, possessions, and public functions, sensibilities, duties, and purposes, and merits and deserts. All this is what your disdain negates and contradicts; this is 'the thing inside me' whose changed treatment I feel the shame about; this is what was lusty, and now, in consequence of your conduct, is collapsed; and this certainly is an empirical objective thing. (James, 1890/1992, p. 207)

James was, therefore, contending pure ego is everything the "I" claims as a possession. It is what one holds up to be scrutinized by others and can be subjected to shame. He was claiming it is the sum-total of selves which he identified as the "Me." He summed this up by asserting there is no reason to suppose self-love is primarily, secondarily or ever, love of one's exclusive principle of conscious identity. It is also love for which compared to the principle is superficial, transient and liable to be taken up or dropped at will. Based on these elements, James (1890/1992) summarized his notion of the consciousness of self:

> *The sense of our own personal identity, then, is exactly like any one of our otherperceptions of sameness among phenomena. It is a conclusion grounded either on theresemblance in a fundamental respect or on the continuity before the mind, of thephenomena compared.*(p. 215)

He was arguing that there is a subjective synthesis in self between the subject of self and its objects. This occurs automatically like any other perception of objects or ideas. This involves a comparison between subject and object according to James (1890/1992, p. 215). This sense that one defines oneself in relation to the perceived world, stands in striking contrast to Descartes' famous dictum, and surely it is evidence that James viewed self as inseparable from empirical experience.

However, another way to understand this is to see self as existing when a separation from other things conceptually occurs. According to James (1890/1992) therefore, "The consciousness of self is a stream of thought, each part of which as 'I' can 1) remember those which went before and know the things they knew; and 2) emphasize and care paramountly for certain ones among them as 'me,' and *appropriate tothese* the rest" (p. 258). One's bodily existence is the "Me" felt at the present moment as whatever remembered past feelings resemble this present feeling, according to James (1890/1992, p. 258). He also observed that the "Me" is an empirical aggregate of things objectively known but the "I" which knows them cannot be an aggregate. According to James (1890/1992), "…neither for psychological purposes need it be considered to be an unchanging metaphysical entity like the Soul, or a principle like the pure Ego, viewed as 'out of time.' It is a *Thought*, at each moment different from the last moment…" (p. 259).Hence, one is subjectively self-aware in the same way they are aware of tables, houses, music, memories, and dreams. It must logically follow from this that James believed one acquires knowledge of the self through learning like one acquires knowledge of the world. It must also certainly mean he saw the sense of self in continuous revision.

Another important topic to James was instinct. It is in his discussions of this that the influences of Darwin are especially evident. According to James (1890/1992), "*Instinct is usually defined as the faculty of acting in such a way as to produce certain ends, without foresight of the ends, and without previous education in the performance"* (p.700). But he argued that the common way of attributing these behaviors to self-preservation, defense or care of eggs and young, etcetera is not accurate because it means animals must obey some abstraction which must have a very remote chance of occurring (James, 1890/1992, p. 700).

James (1890/1992) alleged, "The strict physiological way of interpreting the facts leads to far clearer results. *The actions we call instinctive allconform to the general reflex type;* they are called forth by determinate sensory stimuli in contact with the animal's body, or at a distance in his environment." (p. 700). By comparison, Charles Darwin also discussed reflexive movements in connection with what he called "innate" or instinctual expressions. But Darwin (1872/2015) stated for example, "The first of these principles is, that movements which are serviceable in gratifying some desire, or in relieving some sensation, if often repeated, become so habitual that they are performed, whether or not of any service, whenever the same desire or sensation is felt, even in a very weak degree" (p. 144).

Thus, Darwin made two observations which James chose to downplay. First, while these movements are seemingly involuntary and not consciously directed, they develop as responses in animals through a repetitive effort by these animals to service a desire. In Darwin's view, this repetition occurs with such frequency that the movement or action becomes habitual. One can infer from this that Darwin believed this is how instincts are formed. This seems to suggest that learning is involved early on. It, therefore, would appear to be a point of departure from James's definition since as noted, James stated previous education is not involved in the performance. But Darwin may have also been saying that instincts are passed along through natural selection. Darwin (1872/2015) stated, for example:

> … it is far more satisfactory to look at such instincts as the young cuckoo ejecting its foster-brothers, – ants making slaves, – the larvae of ichneumonidae feeding within the live bodies of caterpillars, – not as specially endowed or created instincts, but as small consequences of one general law leading to the advancement of all organic beings, – namely, multiply, vary, let the strongest live and the weakest die. (p. 135)

This means Darwin saw instincts created as a result of adaptations with the most successful adaptations winning out over the weaker ones in the struggle for survival.

Secondly, Darwin (1872/1992) was stressing that these movements or actions are purposeful. This is true even if the action or movement does not provide any service. Darwin understood this as being connected to how animals evolve. It may be that in the evolutionary past, the movement or behavior did provide a service, for example. James (1890/1992) may have been viewing them as purposeful, but he described this as "…naming abstractly the purpose they subserve…" (p. 700).

Furthermore, James (1890/1992) also went so far as to say that there are many instinctual behaviors for which there is no evidence of a purpose. He argues:

> Why does the maiden interest the youth so that everything about her seems more important and significant than anything else in the world? Nothing more can be said than that these are human ways, and that every creature likes its own ways, and takes to the following them as a matter of course. Science may come and consider these ways, and find that most of them are useful. (p. 702)

No doubt there is a layering of cultural, social and biological reasons which can provide some answers to these questions and many of these were not yet understood as James wrote this. Still, it seems a bit reductionist to ignore the observable, which offers probable explanations for common animal behaviors. James's understanding and acceptance of Darwinism should have also made him aware of how species evolve in many varied ways through adaptations.

William James (1890/1992) however, placed primary emphasis on instincts as motivations. In this approach animals and humans are born with a set of behaviors which direct them to produce certain ends, though as James noted, it is often unclear why. Writing in *Nautilus,* Gazzaniga (2018) says, "As I look at James's work now, I recognize a schema that fits the module/layering ideas. James appears to suggest that the structural aspects of instincts are modular. Each instinct can function independently for simple behaviors, but they also work as a confederation" (para. 2). James was advancing that instincts employ modules to build structures, according to Gazzaniga. Each instinct can operate independently for simple behaviors, but they also work together. Gazzaniga (2018) adds that individual instincts look like higher order instincts (such as language) when they can be sequenced in a coordinated fashion. It is the

"avalanche" of these sequences which Gazzaniga contends is consciousness and he suggests that William James understood the relationship of instincts to consciousness in this way (para. 2). This appears to be a "the whole is greater than the sum of its parts" reasoning. By rooting mental process in instinct evolution, it unifies mind and body intriguingly as one physiological phenomenon.

While one may criticize the methodological mistakes of James, Darwin, and others from an earlier period, it does not follow from this that science should dismiss this examination out of hand. It is clear that both Darwin and James saw instincts as both linked to, and providing important information about emotions. Writing about instinctual behavior unique to humans, Winston (2002)observes:

> Instinct, then, is essentially that part of our behavior which is not learned. Nevertheless, our environment (and hence our learning) may have a powerful effect on the way our instincts are expressed. Instinct is those elements of human action, desire, reason andbehavior that are inherited, and those instincts which are specifically human are thosethat were honed during our time on the savannah. Nowadays we know a great deal more about inherited qualities than Darwin ever did – we know that they are transmittedthrough genes. (p. 6)

It is the result of genetic "hardwiring" that humans perform many actions which occur spontaneously and automatically. The honing of these actions happens at a much earlier evolutionary time and this may be what Darwin meant by the repeated performance of the actions. James agreed with this view. But once they are instinctive, this honing is no longer needed. The information about this "learning" is encoded into the genes.

In the chapter titled *The Emotions,* James (1890/1992) reviewed both what was known and not well understood at the time (pgs. 738 – 766). He made the following points:

> …we see the reason for a few emotional reactions; for others a possible species of reason may be guessed; but others remain for which no plausible reason can even be conceived. These may be reactions which are purely mechanical results of the way in which our nervous centres are framed, reactions which, although permanent in us now, may be called accidental as far as their origin goes. (James, 1890/1992, p. 765).

James thus, could not find reasonable explanations for the existence of some emotions and he doubted that anyone during his time could provide such explanations. He speculated that some emotions occurred

by accident and might be the result of the mechanics of the nervous center which is now become permanent. It is evident that James struggled to determine a meaningful definition for the word emotion in this chapter. For example, he observed that to name every emotion would necessitate probing the introspective vocabulary of an individual and that each race of men has found different shades of feeling (James, 1890/1992, p 766). One sees in this struggle an earnest respect for the imprecision of the truth. There is a clarity in James' recognition that emotions are very often culturally and individually defined. It was a very modern sensibility to which James humbly submitted.

One cannot reasonably understand what shapes present-day views on emotions without an accounting of William James. Some scholars may be quick to credit Sigmund Freud with introducing constructs dealing with consciousness and ego which are used today. But as has been noted, in the late nineteen century James was elaborating on both in great detail, and in many ways, his ideas have withstood the test of time. So much of what James wrote in *The Principles of Psychology* laid the foundation for his later writings and the research of others in psychology who followed him. This is why he is credited with being the father of psychology. As noted by Reevy et. al. (2010), “Psychologists today still praise these books highly. For instance, Peter Gray, who has written an introductory text that has been successful for several decades, called James's text the best introductory text ever written (2002)” (p. 334). Although his James-Lange Theory was attacked severely, new evidence suggests it has some validity. It also helped generate serious research into emotions and their relationship to thought processes. Today, it is also James’s ground-breaking definitions of consciousness which continue to inform psychology.

Behaviorism:

A most profound change occurred in how emotions and mental life were understood and approached with the dawning of behaviorist psychology. The new precedent of behaviorism radically altered psychology and learning theory. It provided powerful testing methodologies for conducting psychological research which were previously unavailable. The four most influential researchers in the development of this approach were B. F. Skinner, John Watson, Ivan Pavlov, and Edward Thorndike. According toReevy et. al. (2010) “Behaviorism is a paradigm in psychology that focuses on studying (considering) behavior, with a deemphasis on mental processes (those psychological aspects that are

experienced internally such as emotions, thoughts, motives, and dreams)" (p. 124). It was argued that behavior can be studied objectively, and this usually means that two or more people can observe behavior and come to an agreement about the nature of what they observe. Mental processes, on the other hand, are experienced by the subject only. Therefore, it cannot be studied objectively and is not an appropriate subject matter for science (Reevy et. al., p. 124).

Put simply then, behavior can be observed, and thinking cannot be observed by anyone other than the thinker. While it may be debatable that research conducted even with the most rigorous use of the scientific methodology is truly objective, behaviorism supplied an essential tool for measuring behavior which permitted reasonable inferences about motivation, feelings, and thoughts. Experiments could be conducted with animals and humans which measured responses to rewards, reinforcements as well as punishments.

One might argue that in theory, behaviorism intentionally separates the mind from the body so that in practice observable behaviors can be studied and speculations about mental processes can be largely ignored. This mind-body parsing is arguably a form of dualism. Importantly then, behaviorism is best understood as a reaction to the heavy reliance on introspection as a research tool in psychology. As asserted by Edward Thorndike (1911/2004) in *Animal Intelligence*:

> On the whole, the psychological work of the last quarter of the nineteenth century emphasized the study of consciousness to the neglect of the total life of intellect and character. There was a tendency to an unwise, if not bigoted, attempt to make the science of human nature synonymous with the science of facts revealed by introspection. (Chap. 1)

Clearly, Thorndike was not impressed with the study of psychology during his lifetime. He thought the preoccupation with introspection had created a distorted view of human nature. He went on in this passage to note how the study of reaction times was only valued as a means to understand reaction-consciousness (Thorndike, 1911/2004, chap. 1). He also observed how it was pretended that the experimental methods were not to aid the experimenter but to benefit the subject in knowing what he experienced (Thorndike, 1911/2004, chap. 1). He set about to change this. Though he did not describe

himself as a behaviorist, he is perhaps the first in line, because he laid the foundation for tools forming the basis of behaviorism.

Thorndyke's research with animals led him to establish the theory of connectionism (Edward, 2017, para. 5). This was the learning theory of stimulus-response (S-R) which laid the foundation for behaviorism. This theory of trial and error learning formed the basis of what B.F. Skinner would later label operant conditioning (Edward, 2017, paras. 1 – 3). The second major theory of conditioning to emerge from behaviorism was classical conditioning, and it was Ivan Pavlov's work with dogs which laid the foundation for it (Cech, 1998, Para. 3). Operant conditioning is a learning process involving long-term behavior modifications which are brought about through either rewards or punishments for behaviors (Charles, 2014, para.5). Charles (2014) also indicates that classical conditioning is a learning process in which at least two biologically potent stimuliare paired, and an individual has developed a response to at least one of the stimuli (para. 11). Reinforcement results from the repeated pairing of the two stimuli and this can mean that when one of the two is presented to the individual, he will respond the same way they did when both were presented together (Charles, 2014, para. 12).

The key to understanding the value of behaviorism is to appreciate how it shedsterms with abstract meanings and replaces them with ones referring to objects or events which are detectable with sensory experience. Hence, one can never find mention of the ego, or the Oedipal complex, in behaviorism since these cannot be detected and are impossible to measure. One may argue strenuously for or against their existence, but without the ability to measure them, there is no scientific conclusion one can reach. Somewhat more controversially, emotion words are often (though not always) discarded by some behaviorists as abstractions not inferable from behaviors. For example, if a child is given a piece of candy and smiles, some behaviorists assert that one cannot infer that smiling means the child is experiencing happiness. On the other hand, if the child completing a task is rewarded with candy and the child seeks the reward each time it completes the task again, then the child is demonstrating its preference as a result of operant conditioning. This implies a kind of hierarchy where action outcomes reign supreme above emotion which can be perceived as a questionable. But perhaps for psychology to graduate into a scientific discipline, it can be argued that this rigidity may comeat a time when it is desperately needed.Indeed, it is hard to see how it could have advanced otherwise.

Of course, it cannot be denied that language is always imprecise, but supplying clear definitions of words such as *reward*, *punishment*, and *reinforcement* which describe observable experiences, means they can be operationalized for measurement and testing. Such measurement and verification are necessary for any true scientific method and even more important, the testing and measurements make it possible to reproduce similar results or reject those hypotheses which cannot be reproduced. This is the only way it is presently known for good science to move forward.

It was John B. Watson (1913/2004) who published the seminal article, titled *Psychology as the Behaviorist Views It,* where he outlined the major features of a new philosophy of psychology and labeled it "behaviorism." (para. 1). Watson (1913/2004) echoed Thorndike's disdain for the application of introspection in the study of psychology, arguing that it held no scientific value (para. 1). He claimed that studying animal response can provide important observable information about human behaviors, insisting that there is no difference between "man and brute." (Watson, 1913/2004, para. 1). Finally, he argued that behavior and not consciousness must constitute the only objective of the psychologist's total investigation (para. 24). He contended that the problem with emotion is determining the number and kind of elementary constituents, their loci, intensity and appearance (Watson, 1913/2004, para. 2). Certainly, at the time this article was published, his assessment of what was known about emotion was accurate. However, with modern advancements in brain scanning technologies, neuroscience has been able to infer much more about the psychophysiological constituents, the location and the intensity of emotion generation (Hamann, 2012). Unfortunately, Watson's eagerness to prove the efficacy and viability of behaviorism led him to conduct the highly controversial and unethical classical conditioning study on a young human baby widely known as the "Little Albert" experiment (Burgemeester, 2018). As a result, Watson's reputation was seriously tarnished. This may account for the reason John B. Watson's work is not held in high esteem today.

After several decades, It was Burrhus Frederic Skinner (better known as B.F. Skinner) who revived behaviorism and it is he who deserves credit for establishing the theoretical underpinnings of the modern-daytheory and practice. Certainly, Skinner was heavily influenced by his predecessors John B. Watson, Ivan Pavlov, and Edward Thorndike, however, he greatly improved upon their work (Reevy et. al., 2010, p. 531). According to Reevy et. al. (2010), "During his career, Skinner published prolifically on

the conditioning of animals, primarily rats and pigeons. He achieved what John Watson, the founder of behaviorism, had not fully achieved: proof that behaviorism can be made into a science that is applicable" (p. 531). They add that Skinner became the primary champion of behaviorism by the 1960s and thus it became the leading American psychological paradigm. However, its popularity waned as other approaches to psychology such as cognitive science and neuroscience rose to the forefront (Reevy et. al., p. 531).It was really Skinner then, who brought legitimacy to behaviorism within the disciples of psychology and education. The research and writings of Skinner made him a prominent public figure, as well.

Skinner (1974) was a proponent of what he coined "radical behaviorism," which he describes in his book *About Behaviorism*. Regarding it, he claimed:

> Radical behaviorism restores some kind of balance. It does not insist upon truth by agreement and can therefore consider events taking place in the private world within the skin. It does not call these events unobservable, and it does not dismiss them as subjective. It simply questions the nature of the object observed and the reliability of the observations. (Skinner, 1974, pgs. 16-17)

Here Skinner argued that his radical behaviorism was different from the behaviorism of Watson and others in that it accepted introspection as valid while continuing to interpret psychology by studying behavioral outcomes (Skinner, 1974, p. 17). It strongly suggests he was arguing for a balanced approach to the study of psychology and *against* a mind-body dualism.

However, Skinner (1974) goes on to claim: "An organism behaves as it does because of its current structure, but most of this is out of reach of introspection" (p. 17) This appears to be a vigorous disclaimer. That Skinner viewed speculation about mental processes as unproductive is difficult not to concludeand as a practical matter, he insisted on parsing mind from body, focusing entirely on the observable (i.e. the behavioral outcomes). There appears to belittleif any evidence to support the idea that he incorporated an evaluation of one's "private world" in his research at any time during his career. Skinner developed the thesis that animals (including humans) are conditioned by anticipating rewards or punishment. This was Skinner's operant conditioning.Of operant conditioning, Skinner (1974) wrote:

> When a bit of behavior has the kind of consequence called reinforcing, it is more likely to

> occur again. A positive reinforcer strengthens any behavior that produces it: a glass of water is positively reinforcing when we are thirsty, and if we then draw and drink a glass of water, we are more likely to do so again on similar occasions. A negative reinforcer strengthens any behavior that reduces or terminates it: when we take off a shoe that is pinching, the reduction in pressure is negatively reinforcing, and we are more likely to do so again when a shoe pinches. (p. 46)

Skinner was thus contending that in operant conditioning, reinforced consequences are anticipated, and this results in predictable behavioral responses. The importance relative to emotions is that operant conditioning can sometimes be used in the treatment for addiction and phobias (Funk, Lo, Coen, Le, 2016; Scemes, Wielenska, Savoia, Bernik, 2009). Of course, it is also still used in educational instructional materials including computer-based instruction (Neiman and Loewenstein, 2014).

Like Watson and Thorndike, Skinner believed the only valid scientific approach to psychology is to study behaviors (Skinner, 1974, p. 251). However, Skinner (1974) did insist that he thought the mind is not separate from the body, and he defined thoughts as private behaviors which can be analyzed and measured by applying the same principle of operant conditioning that he used to understand public (observable) behaviors (p. 104).

As a well-known author, one of Skinner's best-known books was *Walden II.* This was his only novel and it incorporates many of the same ideas included in the original *Walden* written by Henry David Thoreau. In evaluating the book, Rozycki (2011)argues that in *Walden II*, Skinner was writing a parody of Plato's *Republic.* Rozyckiobserves that like the Philosopher- Kings in the *Republic*, an elite rule in *Walden II,* by structuring contingencies of reinforcement, based on their perceptions of the good and the nature of the lower classes (para. 11). Skinner showed this to be *naturally* satisfying to *all* the inhabitants. For Skinner then, being fulfilled and happy was simply a matter of creating an environment structured with the necessary reinforcements (Skinner, 1974, p. 39). He argued:

> The body that behaves in a considerate way most of the time is the same body, that is occasionally callous or cruel; the body that behaves heterosexually most of the time is the same body that is occasionally homosexual. What a person is really like could mean what he would have been like if we could have seen him before his behavior was

> subjected to the actions of an environment. We should then have known his "human nature." But genetic endowment is nothing until it has been exposed to the environment, and the exposure immediately changes it. (Skinner, 1974, p.150)

Human nature is meaningless until biological endowment encounters the environment, according to Skinner. Supplying the proper (healthy) environmental exposure can be predicted to lead to an outcome personally beneficial and socially constructive. For Skinner (1974) this meant operant conditioning using positive reinforcements (p. 46). This book presented a highly idealized society leaving one with many unresolved questions about how its implementation is remotely possible (or even desirable), given the realities of socioeconomic power on this planet. Nonetheless, this book endures as significant primarily because of his reputation as a psychologist and as a social philosopher.

B.F. Skinner's second important book *Beyond Freedom and Dignity*(Skinner, 1971) was a discussion of his general theories. While in general, it supported a behaviorist approach to psychology, learning, and societal ills, once again Skinner (1971) stepped forth as a social philosopher, putting forward in detailed form his thesis in opposition to free will (in favor of determinism). Ashe later contended:

> …the conditions which determine the form of probability of an operant are in a person's history. Since they are not conspicuously represented in the current setting, they are easily overlooked. It is then easy to believe that the will is free and that the person is free to choose. This issue is determinism. The spontaneous generation of behavior has reached a stage as the spontaneous generation of maggots and micro-organisms in Pasteur's day. (Skinner, 1974, pgs. 53 -54)

A person has a history of positive and negative reinforcements. These apparently are "stored" perhaps in memory, and always get remembered when the person confronts a choice. As a result, every choice is simply a conditioned response to a remembered outcome anticipated by the person. Skinner (1974) argued thatalthough the reinforcement is not evident in every setting, it still can be accounted for in this way (p. 54). If this is true, how is learning possible since it involves behavior modification resulting from the acquisition of new information? This is not like maggots which will always appear and spread

spontaneously when certain environmental conditions of decay are met. Maggots do not change but human actions do. Skinner (1971) may have revealed his response in the following:

> An experimental analysis shifts the determination of behavior from autonomous man to the environment—an environment responsible both for the evolution of the species and for the repertoire acquired by each member. Early versions of environmentalism were inadequate because they could not explain how the environment worked, and much seemed to be left for autonomous man to do. But environmental contingencies now take over functions once attributed to autonomous man, and certain questions arise, Is man then "abolished"? Certainly not as a species or as an individual achiever. It is the autonomous inner man who is abolished, and that is a step forward. (Chap. 9)

The emphasis should be placed entirely on the environment and not on man, according to Skinner. Like a pawn on a chessboard, man only moves when he is moved. This means man can only learn when presented with new environmental stimuli creating new forms of conditioning. Therefore, man's choices are always determined by his programming exposure to environmental stimuli. Like in *Walden II*,Skinner (1971) argued that because of this, creating the desirable environment constructed on operant positive reinforcement is the imperative of modern science.

But this seems like an odd assertion coming from someone credited with developing programmed learning (Anglin, 1991). In the most basic trial and error learning, the learner does not sit passively waiting for the correct environmental cue. Instead as first articulated by Edward Thorndike, trial and error learning involves the learner in a process of actively testing the truth or falsehood of a solution (Weibell, 2011, para. 4). This is so basic to the learning process that A. I. robots cannow learn to perform tasks in precisely this manner (Yang, 2015, para. 1).

But as is well known, Skinner's ideas were severely criticized. In the *New York Review of Books*, for example, Noam Chomsky (1971) wrote:

> The dogmatic element in Skinner's thinking is further revealed when he states that "the task of a scientific analysis is to explain how the behavior of a person as a physical system is related to the conditions under which the human species evolved and the conditions under which the individual lives" (p. 14). Surely the task of a scientific analysis is to discover the facts and

> explain them. Suppose that in fact the human brain operates by physical principles (perhaps now unknown) that provide for free choice, appropriate to situations but only marginally affected by environmental contingencies. The task of scientific analysis is not — as Skinner believes — to demonstrate that the conditions to which he restricts his attention fully determine human behavior, but rather to discover whether in fact they do (or whether they are at all significant), a very different matter. (para. 16)

Thus, Chomsky (1971) criticized Skinner for arriving at a conclusion about the human capacity for free choice without scientific evidence and insisting that the only valid science must be constrained to operate with this conclusion as its premise (i. e. human behavior *is* determined therefore the only question is how). Chomsky agreed that science should study and explain the facts but suppose the facts are that the brain operates on physical principles currently unknown, that provide for free choice? He charged Skinner with dogmatism, arguing that he was wrong to assume his job is to demonstrate the validity of operant conditioning.Instead as a scientist, Skinner must ask how it should be understood in the larger scientific understanding of humans, according to Chomsky (1971). Chomsky also rejected the notion put forward by Skinner, that science must never deal with 'internal states' including feelings, impulses or purposes.

Noam Chomsky's book review was published soon after Skinner's book appeared. Thus, to be fair to both he and Skinner, they wrote well before the major advancements in neuroscience which have revolutionized the scientific understanding of the brain-mind connection. Nonetheless, it is very significant that evidence emerging in neuroscience suggests thought processes which are spontaneous, self-organizing, spatiotemporal patterns. These patterns are never quite the same and they emerge from different electrical signal centers at different times. According to J.A. Scott Kelso(1995):

> Like many complex, nonequilibrium systems in nature, at critical values of control parameter, the brain undergoes spontaneous changes in spatiotemporal patterns, measured, for example, in terms of relative phases, spectral properties of spacial modes, and so forth. Remarkably, these quantities exhibit critical slowing down and fluctuation enhancement, predicted signatures of pattern-forming in self-organizing (synergetic) systems. Even more remarkable, coherent states and state transitions in both brain and behavior are often captured by the same collective variable, characterizing the

> spatiotemporal phase relations among obviously very different component processes
> . Similarly, the linkage between materially different entities appears to be governed by a biophysical coupling. The resulting collective dynamics bridges the language of neuronal ensembles and behavioral function. (p. 284)

What Kelso has submitted is vital evidence for the link missing between the behavioral outcomes and the mental processes which are coupled with them. It is this biophysical linkage which governs behaviors. Furthermore, Kelso argues that stochastics plays an important role in self-organizing thought development. He says:

> Chance decides which solution nature adopts. Fluctuations are crucial to understanding how patterns are formed. They are always probing the stability of the system, allowing it to discover new and different ways to solve problems. Of course, fluctuations are intrinsic to all natural systems, not just a source of noise to be damped out. (Kelso, 1995, p. 11)

It is this characteristic which thinking shares with other forms of spontaneous self-organization occurring in nature and *not* deterministic environmental controls, according to Kelso (1995, p. 11). This presents compelling evidence for the basis of free choice within human and animal thought processes, thus suggesting Chomsky was justified in raising the question many years earlier. The importance of this to how emotions emerge within the affective-cognitive processes will be elaborated in Chapter 4.

Perhaps it can be argued that B.F. Skinner's strongest legacy by far is his contribution to learning applications derived from his research into operant conditioning. In his attempt to be a social philosopher, on the other hand, his reductionism and dogmatism offer a constricted and distorted lens through which to interpret human affairs or even to understand the brain-mind connection. Skinner appeared to try to address his criticism, but his insistence that he was viewing behavior and mind in a unified way appears to be little more than a rhetorical disclaimer. Inevitably, his prejudice was a serious impairment, preventing any meaningful understanding of the role of emotions in relation to behaviors. For example, Skinner (1974) claimed:

> Almost all terms descriptive of emotions which do not carry a direct reference to inciting conditions were originally metaphors. Although the verbal community solves the problem of privacy in this way and succeeds in teaching a person to describe many states of the

> body, the descriptions are never completely accurate. (p. 25)

Emotion descriptions are not reliable because they are almost always only metaphoric descriptions taken from common human experiences, according to Skinner. But how different is the etymology of emotion words from other words? It is difficult to see how all language is not symbolism, metaphoric of something else. But Skinner didn't employ emotion descriptors in his research and as a result, his research findings offer validity only for narrowly defined outcomes. Nevertheless, it can hardly be argued that Skinner was wrong in assuming humans and animals are alike and the large, well-documented studies he conducted with animals are a tremendous advancement in the understanding of human behaviors and learning.

Despite the poor ethics displayed by Watson and others, along with the methodological errors of a very young discipline in the early twentieth century, there is little doubt that behaviorism transformed the study of psychology into a science. It was Skinner who recognized these problems and made the methodological corrections necessary to accomplish this. But in accomplishing this, the limits of behaviorism in the study of the mind-brain connection become glaringly recognizable. As observed by Kelso (1995):

> An astonishing fact about behaviorism was that it did not actually deal with behavior or action, but only the results or *outcomes* of individual acts. The central concept of Skinner's behaviorism, the *operant*, captured nothing about how behavioral actions were organized spatially and temporally. Put another way, behaviorism acknowledged that pigeons can press a lever and rats can run a maze, but it didn't care a hoot about how the lever was pressed or the maze run. It treated the organism as a dimensionless point and ignored the form of behavior produced. (p. 30)

The biophysical processes which are given expression as spatiotemporal mental processes from the brain cortex are ignored in behaviorism. This is done quite intentionally based on the premise that this process cannot be measured or understood in any reliably objective sense. (Kelso, 1995)appears to be on the mark to stress that it is only the outcomes of these processes which are observable and measurable to anyone other than the individual affecting the thought leading to the behaviors. This gives little information about the mind-body, brain-mind connections.

To be sure, behaviorism provides many useful psychological insights, especially about how learning occurs in animals, including humans. It is well understood for instance, how rewards, punishments, and reinforcements for behaviors will affect human behaviors. One may attempt to draw inferences about emotional experiences based on these observable behaviors. This has often been done in research and supplemented with other research tools such as survey questionnaires where subjects identify feelings and where research comparisons are made between the responses of a control group and a study group. When this sort of well-designed research can be reproduced with similar results, it provides a compelling argument for recognizing its validity. But the fact remains that the information inferred is derived indirectly, and it says nothing about what people internally experience in a reward, a punishment, a reinforcement or the changes in thought processes. Despite the fact that Skinner claimed to reject mind-body dualism, in practice, his research embraced dualism by reducing all human actions to conditioned rewards and punishments and deliberately ignoring their causal relationship to mental processes and emotions. This created a dichotomy between mind and body, emotional expression and action.

By the late twentieth century, new computed tomography CAT and magnetic resonant imaging MRI scanning technologies launched the dawning of neuroscience. For the first time, it was possible to get an unobtrusive glimpse into the inner processing of the brain. The brainwaves generated by electrical activity can be observed and recorded. This is a new frontier now possible and never imagined during the time of William James, Edward Thorndike or John Watson. Neuroscience is already creating a revolution in what is known concerning the brain and consciousness. It is already offering exciting new insights into emotional experience. This information can only be expected to increase geometrically at a very rapid pace as new data are collected.

Chapter 3 Entropy: The Historical Background

Knowing the historical background of the Second Law of Thermodynamics and entropy is important to an understanding of the theoretical development. The scope of the chapter will extend from the earliest physics and chemistry discoveries as well as the formulation of the law through to the application of the law in information theory and biology. Special attention under biology will be given to self-organization in nonequilibrium entropy because this process will be important to understanding how

entropy can occur in thought processes in Chapter 4. Additionally, this chapter will discuss some of the ways in which the biophysics of entropy points to evidence for psychological entropy as a prelude the more extensive evidence in the following chapter.

The Physical Principle

It was Sadi Nicolas Leonard Carnot's published results of his study on steam engines that first identified the basic principles which underlie any heat engine regardless of the mechanical structure (kafri and Kafri, 2016, p. 16). But Carnot's book did not receive much attention. Carnot did not formulate the Second Law of Thermodynamics, nor was he aware of entropy. However, he had an intuitive grasp of the idea that if any machine transfers energy from a hot space to a cold space, then the maximum amount of mechanical work one can expect is the amount of heat energy removed, less the amount absorbed by the colder space (kafri and Kafri, 2016, p. 19). Carnot's formula stated simply that caloric energy can be transferred from a hotter to a colder body and this can be done repeatedly in a cyclic fashion (Kafri and Kafri, 2016, p. 22). The central finding in the Carnot principle was, "…*it is impossible to build any machine whose efficiency will be greater than the Carnotefficiency*" (Kafri and Kafri, 2016, p. 24). In other words, it is impossible to use heat energy within any system more efficiently than demonstrated by the Carnot principle.

According to Kafri and Kafri (2016), it was the Prussian physicist Rudolph Clausius who gave formal definition to the laws of thermodynamics, recognizing within Carnot's heat efficiency a set of unconsidered properties, and he called it entropy (p. 31). They observe:

> According to thermodynamics, heat *tends* to flow from a hotter object to a colder one; however, entropy neither initiates the process or defines the length of time it takes Rather, it seems to stimulate a propensity that can be compared in some limited ways to human will. (Kafri and Kafri, 2016, p. 32)

Clausius' work was based entirely on Carnot's efficiency, but unlike Carnot, he received immediate recognition due to his scientific reputation (Kafri and Kafri, 2016, p. 32).

In his *Scientific Autobiography*, Max Planck (1949/1992) wrote, "Clausius deduced his proof of the Second Law of Thermodynamics from the hypothesis that '*heat will not pass spontaneously from a colder to a hotter body'"* (p. 78). Clausius focused much of his research on the problems of heat transfer

in a simple heat engine. But for Planck, Clausius' explanation of entropy was far from sufficient. Planck (1949/1992) asserted, "…this hypothesis must be supplemented by a clarifying explanation. For it is meant to express not only that heat will not pass directly from a colder into a warmer body, but also that it is impossible to transmit, by any means, heat from a colder into a hotter body without there remaining in nature some change to serve as compensation" (p.78). He worked at simplifying this because he came to regard the Second Law of Thermodynamics "…as next to energy the most important property of physical systems" (Planck, 1949/1992, p. 78).

But his contribution is quite incomplete without giving much credit to the work of Ludwig Boltzmann. Boltzmann's two most significant contributions to modern physics were his interpretation of entropy as a mathematically well-defined measure of the "disorder" of atoms, and the Boltzmann equation describing the statistical properties of a gas made up of molecules (Cercignani, 2010, p. 1). It is well understood that these properties change over time (i.e. they are dynamic). However, the Boltzmann equation was the first to mathematically represent a law governing dynamic probabilities that occur over time and his theory derived a proof of the irreversibility of macroscopic phenomena (Cergignani, 2010, p. 7). It was the question of reversibility and the "arrow of time" which stymied physicists (Carroll, 2016, Para. 1). Time cannot reverse itself. Yet, physicists could prove symmetry with equations. Nevertheless, most people intuit that if a coffee cup falls from a table to the floor and shatters, it cannot reverse itself by springing back onto the table and reassembling all it pieces in perfect order. The well-known theory postulating the irrepressibility (asymmetry) of time is referred to as the "arrow of time." While it was a theory subscribed to by many physicists at the time, Boltzmann's equation offered a proof that the direction of the colliding microscopic molecules is different only in scale from the observable macroscopic phenomena (Cergignani, 2010, p. 7).

Boltzmann applied his method of probability statistics to his understanding of entropy, but initially, Planck and others rejected it. Ultimately, however, Planck used it to refine his own definition of the Second Law of Thermodynamics. Thus, according to Planck (1949/1992), "*The process of heat conduction cannot be reversed by any means.'* This expresses the same idea as the wording of Clausius, but without requiring an additional clarifying explanation. A process which in no manner can be completely reversed I called a '*natural*' one. (p. 78)The process of entropy could not adequately be

characterized without clarifying that it was not naturally reversible, according to Planck. This is an understanding of entropy which has endured.

Boltzmann's statistical methodologies were influenced by his relationship with the leading scientist James Clerk Maxwell (Cercignani, 2010, p. 88). It was largely his application of these methodologies which guided Boltzmann in the formulation of his foundational equation. Writing of the Boltzmann paper on the equation, Cercignani (2010) observes:

> …as remarked by the author himself, it implied an entirely different approach to the proof of the Second Law, which showed not only the existence of an entropy function for the equilibrium states, but also permitted one to study its increase in irreversible processes. (p. 89)

This was Boltzmann's equation describing the conduct of gas molecules. For example, in a closed room with a space heater operating at one end and an air conditioner at the other, air molecules start out very hot at one end of the room and very cold at the other. The hot molecules have a very high speed and the cold ones have a very slow speed. In Boltzmann's *H-theorem*, H can be understood as equal to Q/T (i. e the ratio of heat is equal to energy divided by temperature) (Kafri and Kafri, 2016, p. 56). In physical terms, this is the minimum speed attainable for any air molecule. Boltzmann argued that any distribution of an air molecule with a speed greater than the minimum would, through collision, transform its speeds in such a way as to slow down H, moving toward the minimum speed. This would have the practical effect of evening out the room temperature gradually so that over time, the air molecules at one end of the room would have nearly the same speed and temperature as at the other. In theory, once all the molecules in the room have the exact same speed and temperature (i. e. reached their minimum), they have reached "equilibrium." It is through the random collision of molecules that an increased disordering of them occurs. The maximum attainable disorder is the state of equilibrium. This is how the equation works.

As Lindley (2001) notes, this is a process of astounding power (p. 76). He states, "In fact, as Boltzmann was eager to believe, his quantity H was by all appearances exactly what he needed as a kinetic definition of the thing Clausius called entropy" (Lindley, 2001, p.76). But Planck (1949/1992) admitted to his initial hostility to this new theory presented by Boltzmann. Writing of his encounters with Boltzmann, Planck (1949/1992) said, "He was especially annoyed by the fact that I was not only indifferent but to a certain extent even hostile to the atomic theory which was the foundation of his entire

research" (p. 81). Regarding the Boltzmann theorem, Planck (1949/1992) noted, "In fact, Boltzmann omitted in his deduction every mention of the indispensable presupposition of the validity of his theorem – namely, the assumption of molecular disorder. He must have simply taken it for granted" (p. 81). In the context of entropy, 'perfect internal disorder' describes the state or condition of "equilibrium", but because it is so different than what is implied in normal speech, it has been a source of confusion. Nevertheless, since Planck was reportedly well acquainted with the works of Clausius, it is somewhat puzzling why he was unable to draw this inference from Boltzmann's theorem. He did, however, finally come around to giving some recognition to Boltzmann (Planck, 1949/1992, p. 82).

It might serve the purposes of this discussion at this juncture to summarize the key points about entropy and provide a simplified definition: 1) Entropy is defined as a measure of the amount of disorder in a dynamic system. In this sense, the entropy of an object is the amount of energy *unavailable* to do work (i. e., a measure of lost work) (Greitzer, Spakovsky, and Waitz, 2006, para. 1). 2) Entropy is also a measure of the number of possible arrangements the atoms in a system can have (i. e., the amount of disorder or disbursement) (Lambert, 2007, para. 13). In this sense, entropy is a measure of uncertainty or randomness. Both of these understandings of entropy will be important to this discourse. Thus far it has been established that if heated molecules exist in a closed space with colder molecules, the temperature of the molecules will even out (tend toward equilibrium) over time. This is because the velocity and temperature of the molecules within the space tend toward the minimum uniform velocity and temperature possible over time. In this chapter, it will be shown how this applies to inanimate matter, information and living organisms.

As noted, entropy occurs in a closed space (isolated system) by using up the energy available to do work. Another name for this is "free energy." Josiah Willard Gibbs deserves mention here. According to the American Physics Society (2018), Gibbs integrated all the variables of a chemical reaction (i.e. temperature, pressure, energy, volume, and entropy) in one simple equation which has come to be called the Phase rule (para. 5). Rukeyser, (1988) notes it was Gibbs who discovered the essential component of "free energy" in thermodynamics and chemistry for which it is often referred to as Gibbs free energy (p. 247).

The concept of a perfectly closed system (isolated system) is hypothetical since no one has yet observed a system that is perfectly closed. However, in practice, some systems nearly achieve this. For example, the cylinder enclosing pistons in a combustion engine can for all practical reasons be called a closed system. In theory, in such an isolated container, entropy must increase to perfect disorder when all the heated expanding gas molecules in the cylinder are burned up, thus the system would attain equilibrium. One term used to describe this is "heat death" because if all the heated gas molecules actually burned up, the system would cool down to a uniform temperature. This would mean there would be no energy to do work and the pressure from the expanding gas would be gone. The cylinder would lose all power as a result. Such a theoretical cylinder would need to be impermeable to any outside energy and not allow any gas to escape.

In reality, on the other hand, all the gas (free energy) is not burned and must escape the cylinder as incomplete combustion (exhaust) through the exhaust system. The closed system is also not truly isolated because energy in the form of gravity and radiation still can affect the system. In a typical combustion engine, it is because the heated, expanding gas molecules are released that the piston in the cylinder moves. Therefore, entropy in such a system measures the energy *lost* which potentially could have been used to do work. Though heated water molecules are not burned, this, in every other respect, is exactly the same principle observed in the steam-driven piston by Carnot.

Theoretically, if the universe is an isolated system, then its entropy must also increase with time. The universe must ultimately experience heat death as its entropy increases toward maximum equilibrium and uniform temperature. Indeed, as scientists observe the expansion of the universe, many speculate on this outcome (Frautschi, 1982, para. 1). The essential point is that this thermodynamic principle applies broadly to all matter and energy. In general, the equilibrium state for an isolated system is equivalent to the alternate definition for entropy as a measure of disorder in a system (Kafri and Kafri, 2016, p. 42). As noted, Boltzmann established that such a completely random molecular dispersion corresponds to the observable heat transfer of Clausius' entropy (Kafri and Kafri, 2016, p. 44). Kafri and Kafri (2016) observe that Boltzmann's equation can also be described as measuring entropy in terms of *uncertainty*(p. 41).

Most entropic systems which have been studied have been open systems in some significant way (Stephanescu, 1996, p. 1).This is really the importance of the Gibbs discovery because, in any open

system, there will always be *free energy* to do work. An open system allows free energy to enter in some form, though the entropic system will still *always* tend toward equilibrium (complete disorder) (Melamede, 2002, p. 2). Free energy acts as an opposing force to entropy (Melamede, 2002, p. 2). It is thus a useful way of understanding how entropy generates work in living things. And there is a natural connection to how entropy operates in the brain and emotions. More will be discussed about this.

Another indispensable contribution to the understanding of entropy came from Claude Shannon. In his ground-breaking paper, *A Mathematical Theory of Communication*, Shannon focused on the problem of how best to encode transmitted information. He used probability theory in his analysis of communication theory to develop the measure of uncertainty in a message, otherwise called information entropy. In their description of how Shannon derived the new theory, Soni and Goodman (2017) observe, "It was there in the work of physicists like Rudolf Clausius and Ludwig Boltzmann, who were pioneering ways to quantify disorder – entropy – little suspecting that information might one day be quantified in the same way" (p. 125). Thus, Shannon was the founder of Information Theory which was rooted in the theory of Clausius and Boltzmann. Shannon's findings proved to fundamentally transform telecommunications, computerization, and electronics (Deb, 2014, paras. 11 – 13). But one cannot fully appreciate the import of his discoveries without recognizing their impact in nearly every field of science, from physics, chemistry, and biology to neuroscience and psychology (Deb, 2014, paras. 4 – 44). The fundamentals of signal transmission discovered by Shannon are applicable to biology, physiology and thus, to the brain-body reciprocity.

To understand Shannon's work, one must first understand what he was attempting to do. Prior to Shannon's work, scientists knew that information was transmitted via telecommunication signals, but if signals were sent over a wire long distances, they would fade (Soni and Goodman, 2017, p. 138). To solve this, Shannon studied the problem of sending certain types of messages (like English text) over a noisy communication channel (Pierce, 2016, p. 101). He analyzed how such a message can be encoded (represented) by means of electrical signals to obtain the fastest possible transmission over the noisy channel without error (Pierce, 2016, p. 146).

In dealing with the transmission of a signal over a wire, Shannon was viewing it something like a pipe through which a signal must pass and he labeled this channel capacity (Pierce, 2016, p. 107). He

had no interest in the content of the messages being sent, only in the probability they could be sent through the wire over long distances. Hence, Shannon was trying to *reduce* uncertainty so as to increase the probability a desirable message could reach the receiver (Soni and Goodman, 2017, p. 311). To address this, Shannon determined the signal to noise ratio (SNR) for the channel (Morikawa, 2015, para. 4). This ratio compares the level of the desired signal to the level of background noise. For example, if the ratio was 50/50, then a desirable message could be received 50% of the time. Shannon used entropy to measure the uncertainty for the receiver of messages. Entropy increases as the freedom of choice (or uncertainty to the recipient) increases (Pierce, 2016, p. 81). It decreases as the freedom of choice and uncertainty are reduced (Pierce, 2016, p. 81). The word choice is being used here to mean alternatives between messages.

Shannon used relay switches representing movable connections that could be flipped back and forth between two fixed contacts (Nahin, 2013, p. 69). This operation can be achieved mechanically, manually or electrically. In its simplest form, this was the foundation for digital technology. As Nahin (2013) writes, “It was Shannon’s insight to see that putting switches in a series or parallel allows one to construct logical *and* or logical *inclusive-or* electrical circuits, respectively. And clever use of the *not* logical operation, too” (p. 69) This is important because it formed the basis for an encoding language for a signal transmission and it was this digital encoding which made it possible to send messages long distances without fading (Soni and Goodman, 2017, p. 159). Nahin (2013) notes, “In ‘Mathematical Theory’ Shannon considers two types of channels: the so-called *continuouschannel* that would carry, for example, a continuous signal like the human voice, and the so-called *discrete channel* that would carry again for example, a keyboard’s output in digital streams of bits” (p. 114).

The source information may be text, a person speaking, a rock band playing, photographs, movies, or live TV images. In information theory, such sources have the properties of ergodic sources (i. e. letters, numbers, characters or electrical signals) (Pierce, 2016, p. 81). The information “bit” in Shannon’s research was a digital encoding for the signal of the source information being transmitted (Pierce, 2016, p. 66). The bit used binary numbers of 1s and 0s to represent a sampling of the source information. This was based on the logical relay switching, as described. The theoretical problem of fading messages over long distances was a problem of the quantity of message lost. To put it concretely,

it was the quantity of 1s and 0s sent over a channel from a source that would be correctly received, *and* the quantity that would be incorrectly received by the receiver because of channel noise (Soni and Goodman, 2017, pgs. 159 – 160). As noted, this is measured by SNR. Pierce (2016) describes entropy in information theory:

> In communication theory we consider a message source, such as a writer or speaker, which may produce on a given occasion any one of many possible messages. The amount of information conveyed by the message increases as the amount of uncertainty as to what the message actually will be produced becomes greater. A message which is one out of ten possible messages conveys a smaller amount of information than a message which is one out of a million possible messages. The entropy of communication theory is a measure of this uncertainty and the uncertainty, or entropy, is taken as a measure of the amount of information conveyed from a source. (p. 23)

As mentioned, a slightly different way to say information *conveyed from a source* is information *a receiver receives from a source*. If the amount of information received is increased, the amount of uncertainty is greater. As explained, this means the information entropy is greater. Conversely, if the amount of information is decreased, the amount of uncertainty (entropy) decreases (Pierce, 2016, p. 81). This can be measured by SNR. The message source randomly chooses among many messages for transmission. In connection with the message source, entropy is a measure of choice exercised by the source (Pierce, 2016, p. 81). Maximum entropy is achieved in an error-free communication channel. (Pierce, 2016) importantly observes:

> This largest possible entropy of message transmitted over an error-free channel is called channel capacity. It can be proved that, if the entropy of a source is less than the channel capacity of the channel, messages from the source can be encoded so that they can be transmitted over the channel. This is Shannon's fundamental theorem for the noiseless channel. (p.106)

This is maximum uncertainty because it is the maximum information (freedom of choices) received by the receiver. Another way to express this is that the largest possible entropy occurs when all the expected (desired) messages have the same probability of reaching the receiver. Taking a simplified example,

when a message is coded as either a 1 or a 0, the messages have an equal probability of occurring. Hence, there would be a 50% likelihood that maximum information would be either a 1 or a 0 and this would be conveyed as 1 bit to the receiver. Shannon proved that if the entropy of a source is less than the channel capacity, messages from the source can be encoded so they can be transmitted over the channel (Pierce, 2016, p. 106). Thus, the noiseless error-free channel is the maximum entropy in information theory and is analogous to equilibrium (perfect disorder) in a physical system (Kafri and Kafri, 2016, p. 136). As mentioned, Shannon based his engineering solution on Boltzmann's equation, but he applied it to determine how to reduce uncertainty (Soni and Goodman, 2017, p. 125).

The fundamentals of signal transmission and information theory have prompted many scientists to theorize on ways the brain and body physiology send information back and forth. Avery (2012) makes the essential point, "In living (and even non-living) systems, signals can be written and read at the molecular level" (p. 103). Hence, information theory is relevant and directly applicable to understanding the discussion that follows. Furthermore, it is from these models of entropy, coupled with the neuroscientific research into brain entropy that the inference of emotional entropy can be made as a psychophysiological phenomenon.

Entropy in Living Things

"Our next task is to study coming-to-be and passing-away. We are to distinguish the causes, and to state the definitions, of these processes considered in general – as changes predictable uniformly of all things that come-to-be and pass away by nature" (Aristotle, trans. 1992, p. 409). Aristotle wrote these words as the opening passage in his treatise *On Generation And Corruption.* With remarkable clarity, his observations appear to intuitively foreshadow an understanding of entropy in nature. It is also Aristotle who introduced the idea of potency and actuality which he defined in *Metaphysics*. By potency, Aristotle (trans. 1992) was referring to the capacity in things for potential change. He said, "And a thing is capable of doing something if there will be nothing impossible in its having the capacity" (Aristotle, trans. 1992, p. 572). For example, the painter potentially paints a picture if she is capable of painting and nothing makes it impossible, like the fact that she has no paint. Aristotle defined "actuality" as the thing completed. He asserted, "…that movement in which an end is present is an action. E. g. at the same time we are seeing

and have seen, are understanding and understood, are thinking and have thought…" (Aristotle, Trans. 1992, p. 574). Hence, in the example of the painter, actuality is the painted picture.

For Aristotle, the actuality always existed waiting to be realized in the potency. The actualized painting awaits completion in the potency. The actualized music awaits a potential performance by the band. The actualized house is a potential awaiting construction. One can see the analogy to biology. The seed of the tree contains the actualized tree. The egg of the bird contains the actualized bird. There is a sense in reading Aristotle that he was attempting to grapple with the issues central to entropy and relevant to a discussion of biology. First, he put forth as a generalized principle, the idea that everything in the physical universe is either coming to be or passing away. Second, he was arguing for an existence of a goal-driven change. When Aristotle discussed potency and actuality, by implication he was asserting that things change to be completed (actualized). Change is driven toward a goal of actualization.

Aristotle applied this thesis further in his study of biology. For example, in *On The Generation of Animals,* Aristotle (trans. 1992) wrote that animals that change their locality by flying, walking or swimming all come into being with two sexes (p. 255). He added, however, "…but all which are not produced by animals, but from decaying matter, generated indeed, but produced another kind, and the offspring neither male nor female; such are some of the insects" (Aristotle, trans.1992, p. 255).

He also declared, "The same holds true for plants, some coming into being from seed and others, as it were, by spontaneous action of Nature, or in some part of the plants…" (Aristotle, trans. 1992, p. 255). Thus, in biology, he acknowledged the cycle of spontaneous generation and decay, and that even in decay there is new energy for living things. While Aristotle's writing was not an accurate science, it was reflective of his deep intuition that the cyclical processes of life and death are directly the result of nutritive energy exchange. In describing gestation prior to birth, he argued:

> When the embryo is once formed, it acts like the seed of a plant. For seeds also contain the first principle of growth in themselves, and when this (which previously exists in them only potentially) has been differentiated, the shoot and the root are sent off from it, and it is by the root that the plant gets nourishment; for it needs growth. So also in the embryo all the parts exist potentially in a way at the same time, but the first principle is furthest on the road to realization. Therefore the heart is first differentiated in actuality.

(Aristotle, trans. 1992, p. 280)

Hence, he clearly was convinced that life changes because it is goal-driven to actualize, and it emerges and decays. Life also uses restorative energy to grow. These concepts are central to understanding entropy as it operates in biology as will be demonstrated in the writing of Erwin Schrodinger (1944/1992). It is often noted that Aristotle's writing on animals had an influence on Charles Darwin. That undoubtedly is true, but the influence on Schrodinger also seems apparent.

In *What Is Life? The Physical Aspects of the Living Cell,* Schrodinger (1944/1992) introduced the world to the revolutionary concept of entropy in living things, which was not widely understood. Until this time, scientists struggled to understand how dynamic systems worked and changed. Biology, in particular, is problematic from the standpoint of physical laws because it involves self-organization and growth through cell reproduction. With the introduction of Schrodinger's theory, an entirely new understanding was articulated of how dynamic living organisms survive, grow and die over time, based on the Second Law of Thermodynamics.

Schrodinger (1944/1992) began by describing how most physical laws on a large scale are due to chaos on a small scale, introducing the concept of "order-from-disorder" (pgs. 497 – 498). He rhetorically posed the question, "Why should an organ like our brain, with the sensorial system attached to it, of necessity consist of an enormous number of atoms, in order that its physically changing state should be in close and intimate correspondence with a highly developed thought?" (Schrodinger, 1944/1992, p. 472). His answer was that thought is an orderly thing which can only be applied to the material with some degree of order (Schrodinger, 1944/1992, p. 472). It is clear from this observation that Schrodinger saw self-organization as being involved in thought and biology. Schrodinger (1944/1992) concluded, "Therefore, the physical interactions between our system and others must, as a rule, themselves possess a certain degree of physical orderliness, that is to say, they too must obey strict physical laws to a certain degree of accuracy" (p. 472). In elaborating on this concept, he added importantly that it is only in the "cooperation" of a very large number of atoms that the statistical laws will function and control the assemblies with accuracy increasing as the number of atoms decreases (Schrodinger, 1944/1992, p. 472). This is how the events take on truly orderly features.

Schrodinger then provided examples of how this process operates in reverse (i. e. how disordering naturally occurs). Clearly harkening back to Clausius and Boltzmann in one example, he described what he called the “diffusion” of molecules due in part to random variations. He asserted:

> Being based on pure chance, its validity is only approximate. If it is, as a rule, a very good approximation, that is only due to the enormous number of molecules that co-operate in the phenomenon. The smaller their number, the larger the quite haphazard deviations we must expect – and they can be observed under favorable circumstances. (Schrodinger, 1944/1992, p.474)

Favorable circumstances appear to be necessary for wider molecular deviation to represent itself in organisms, according to Schrodinger. Another way to state this is, conditions must be right for greater disordering to occur. Schrodinger demonstrated how this is related to the Second Law of Thermodynamics but first, he presented a problem. It is a problem evident in the assumption of self-organization itself.

In his summary of what was known at this time about the hereditary mechanism, Schrodinger(1944/1992) elaboratedon the important role mutationsplay in evolution (pgs. 481 – 486).His conclusion was that the carriersof hereditary information must be both small in size and permanent in time (Schrodinger, 1944/1992, p. 480). This contradicted the physicist's expectation, and the contradiction was not resolvable by classical physics. He theorized that hereditary material has to be a molecule which does not repeat itself. In this respect, it is dissimilar to a crystal (though in other respects it resembles crystal). He called this an "aperiodic" crystal, meaning that its growth is similar to a crystal (Schrodinger, 1944/1992, p. 492). Schrodinger (1944/1992) argued that this aperiodic crystal operates as coding for genes (p. 492 – 493). At the time, the structure of DNA was not yet discovered. Schrodinger's hypothesis appeared to remarkably foreshadow the discovery of DNA science by several decades. Indeed, it also appeared to be suggestive of a theoretical link between the discoveries of Shannon concerning signal coding a few years later, and cell growth in biology.

It is in Chapter 6 that Schrodinger (1944/1992) began to explicitly detail his theory of entropy in living organisms (p. 495). The basic principle involved order from disorder. Based on the Second Law of Thermodynamics there is within all living organisms a natural tendency toward disorder or decay.

Schrodinger (1944/1992) added, “Much more important for us here is there bearing on the statistical concept of order and disorder, a connection that was revealed by the investigations of Boltzmann and Gibbs in statistical physics” (p. 497). As noted previously, Boltzmann’s contributions to understanding entropy were twofold. They included his interpretation of entropy as a mathematically well-defined measure of the “disorder” of atoms, and the Boltzmann equation describing the statistical properties of a gas made up of molecules. It was also previously mentioned that Gibbs’ major contribution was the discovery and validation of “free-energy” (energy available to do work) in an entropic system. Schrodinger synthesized these concepts to develop his thesis on life.

Something is said to be alive when it goes on doing something, moving, exchanging material with its environment and for a much longer time than would be expected of an inanimate piece of matter under similar circumstances. Inanimate matter can be contrasted by example (Schrodinger, 1944/1992, p. 496). Schrodinger provides the following example:

> …if a glass filled with pure water and a second one filled with sugared water are placed together in a hermetically closed case at constant temperature, it appears at first that nothing happens, and the impression of complete equilibrium is created. But after a day or so it is noticed that the pure water, owing to its higher vapour pressure, slowly evaporates and condenses on the solution. The latter overflows. Only after the pure water has totally evaporated has the sugar reached its aim of being equally distributed among all the liquid water available. (Schrodinger, 1944/1992, p. 496)

Schrodinger (1944/1992) observed that these slow exchanges of matter (reactions) could never be mistaken for life (p. 496). Hence, by presenting a hypothetical example of an entropic system which demonstrates the natural tendency toward equilibrium in inanimate matter, he then contrasted these processes of change to what happens in living matter.

According to Schrodinger (1944/1992), it is the ability to avoid rapid decay into an inert state of equilibrium that is strikingly different about living organisms (p 496). But how is this possible? According to Schrodinger (1944/1992), “The obvious answer is: By eating, drinking, breathing and (in the case of plants) assimilating. The technical term is *metabolism*” (p. 496). Nutrition is thus converted to extend life. Metabolism is understood to mean exchange. But he thought it is very misleading to describe it as

"feeding upon energy," although he thought this idea had become a popular misconception (Schrodinger, 1944/1992, p. 496). Instead, Schrodinger (1944/1992) said, "What an organism feeds upon is negative entropy. Or to put it less paradoxically, the essential thing in metabolism is that the organism succeeds in freeing itself from all the entropy it cannot help produce while alive" (p.497). The complexity of this idea deserves a fuller explanation.

The first thing that should be noted is that Schrodinger's use of the term "negative entropy" (sometimes shortened to negentropy) is often misunderstood. To be clear, he was not creating a new concept associated with entropy. His use of the term negative entropy meant the same thing Gibbs meant when he discussed "free energy" (Schrodinger, 1944/1992, p. 498). That is, Schrodinger was stating that living organisms take in or consume free energy as a way of avoiding entropy (death). Second, Schrodinger's reference to "freeing its self" is not accidental. It was related to the first point. Schrodinger was referring to the statistical "degrees of freedom" or the number of different ways the dynamic system of life can move without violating the constraints imposed on it. This is associated with the energy free to do work. Third, Schrodinger (1944/1992) made it clear that equilibrium for any living system is naturally reached at death (p. 497). It is hardly worth mentioning that all living things eventually die, and the goal of life is to delay this inevitability as long as possible. Therefore Schrodinger (1944/1992) argued that the purpose of negentropy through metabolism is to slow the process of decay leading to death (p. 496).

There is a paradox inherent to this process and it is one that he fully recognized (Schrodinger, 1944/1992, p. 497). By metabolizing to avoid death, a living organism does work which expends energy. When living things expend energy, they promote decay which must ultimately lead to death. Thus, an organism can delay death by taking in more food, but it cannot avoid it because its work in delaying death also is energy expended increasing entropy. Schrodinger (1944/1992) demonstrated how Boltzmann represented this as a mathematical formula. He noted:

> If *D* is a measure of disorder, its reciprocal, 1/*D*, can be regarded as a direct measure of order. Since the logarithm of 1/*D* is just minus the logarithm of *D*, we can write Boltzmann's equation thus:
>
> $$-(\text{entropy}) = k\log(1/D).$$
>
> Hence the awkward expression "negative entropy" can be replaced by a better one:

entropy, taken with a negative sign, is itself a measure of order. (Schrodinger, 1944/1992, p. 498)

A living organism will maintain a high level of orderliness by continually "sucking" orderliness from its surrounding environment (Schrodinger, 1944/1992, p. 498). It may appear evident in higher animals, but the process occurs just as much in organic compounds which serve as food for the higher animals (Schrodinger, 1944/1992, p. 498). Schrodinger (1944/1992) continued, "After utilizing it they return it in a very degraded form – not entirely degraded, however, for plants can still make use of it. (These, of course, have their most powerful supply of "negative entropy" in the sunlight)" (p. 498). Thus, according to Schrodinger (1944/1992), there is a natural process of negative entropy (orderliness) based on metabolism which struggles against the natural tendency toward decay, and death (p. 498). There is a hereditary coding within the cell directing it toward order. One must pause to remember the intuition of Aristotle. He recognized the coming-to-be and a passing-away and described the potency and actualization in nature (Aristotle, trans. 1992, p. 255).

However, the important point Schrodinger was trying to get across was that a new law of physics is necessary to explain the behavior of living matter. This is a law involving self-organization and at the time of his writing clear evidence for it in biology had yet to be discovered (Schrodinger, 1944/1992, p. 500). The Second Law of Thermodynamics can account for the process of disordering and decay in living organisms which is consistent with the behavior observed in all matter, but it cannot account for the process of ordering within a dynamic animated life form. As Schrodinger (1944/1992) asserted, "The unfolding of events in the life cycle of an organism exhibits an admirable regularity and orderliness, unrivalled by anything we meet with in inanimate matter" (p. 499). But he also emphasized that the new principle represented by this description was not alien to physics. He argued instead that it was the principle of quantum theory. As quantum theory is understood to deal with the nature of small scales and low energy levels of atomic and subatomic particles, one can infer that Schrodinger was contending that low energy at the atomic and subatomic level is involved in the ordering principle present in living organisms.

Schrodinger (1944/1992) prefaced his idea by first observing how the motion of the solar system and constellations operates with a mathematical precision that makes them very predictable (p. 501). He

observed that there is a mechanistic quality to this which is not statistical (Schrodinger, 1944/1992, p. 501). He added:

> Nor does the regular motion of a clock or any similar mechanism appear to have anything to do with statistics. In short, all purely mechanical events seem to follow distinctly and directly the “order-from-order” principle. And if we say “mechanical,” the term must be taken in the wide sense. (Schrodinger, 1944/1992, p. 501)

He then introduced an extremely important concept in this passage. The "order-from-order" principle is not alien to entropy in living organisms (Schrodinger, 1944/1992, p. 501). It is an opposing principle to entropy but does not overrule it. This paradoxical principle was studied by many researchers following Schrodinger's lead. It should also be noted that Schrodinger (1944/1992) was careful to make it clear that his comparison of the self-organizing principle to a clock should not be misunderstood. He argued that the organism has some aperiodic forming hereditary substance obtained largely from disorder and heat motion (Schrodinger, 1944/1992, p. 501). But he did not want his description to be thought of as cogs of a kind of organic machine (Schrodinger, 1944/1982, p. 502). Thus, Schrodinger's foundational work introduced enduring concepts in biology which may have helped lead to the discovery of the structure of DNA a few years later, as well as open a whole new line of research into self-organizing biology. Additionally, it appeared to strongly hint at the operation of information theory at the cellular level in living organisms.

Using a tree as an example of how entropy occurs in living organisms, one can observe that it is an open system where water and soil nutrition are metabolized (converted) to energy available to do work (free energy). This free energy is used by the tree in growing new cells in the process of self-organization. But while the self-organization continues, an opposing process leading to entropy occurs as the tree ages, shedding dead leaves, branches, and bark. This is a process leading to death. Thus, by the tree self-organizing through the meticulous assembly of millions of cells, it delays its inevitable death in a process paradoxically using up all the free energy and ultimately leading to the tree's death.

Certainly, it is apparent that there are no exceptions to the law of entropy. It presents itself as a governing principle in matter, energy, and biology with elegant beauty. In nature, there are no flowers or dogs exempted from thermodynamics, either in whole or in part. It is hardly in dispute that humans are

living organisms as well, and their existence also conforms to the Second Law of Thermodynamics. The human body and physiology are regulated by entropy. Thus, it must follow that the human brain is also regulated by entropy. The central nervous system (CNS) and the autonomic nervous system (ANS) integrate with the body and its organs. As asserted by Morowitz (1987), “It is therefore impossible to dissociate the mind's information from the body's entropy. Knowledge of that state of the system without an energetically significant measurement would lead to a violation of the second law of thermodynamics" (p. 271). Hence, it appears only to be the result of the perennial mind-body dualistic affliction in Western thought that the problem of whether the human brain is somehow uniquely exempted from thermodynamics presents itself. To those for whom mind-body dualism is dogma, this author proposes that the time to disabuse one's self from this distortion is long overdue. Much more discussion of the brain-body connection and its relationship to the mental, emotional process will follow in Chapter 4 as part of a detailed examination of the evidence for emotional entropy.

However, two initial evidentiary pieces for psychological entropy are elaborated here as a prequel to the next chapter. As previously mentioned, the “arrow of time” is an important concept in understanding entropy irreversibility. The theory of the Arrow of Time first postulated by Arthur Eddington, is defined as the one-way direction (or asymmetry) of time (Price, 2010, p. 115). As mentioned, it was Boltzmann who produced the first equation to prove this and it most importantly applies to entropy.

It is accepted by scientists that the psychological arrow of time conforms with the physical arrow (Henrich, Knopp and Pas, 2016, p. 229). That is, memories and thoughts are irreversible like physical occurrences. But suppose the psychological arrow of time did not conform with the physical arrow of time? A reversible (two-way) arrow in psychology would mean psychological entropy would be impossible. Some researchers decided to test this hypothesis. In an article published in *Physical Review E*, Mlodinow and Brun (2014) examine whether the psychological arrow of time aligns with the thermodynamic arrow where the arrow is well defined. The researchers argue that if the thermodynamic arrow and psychological arrow of time are to align, then there must be an increase in entropy when a record of events (memory) is erased(Mlodinow and Brun, 2014, p. 1).Hence, a memory or record of events must dissipate energy and be an irreversible system. In their model, they create a container with gas molecules in two separate chambers. Between the two chambers, is a valve that acts like a turnstile

allowing gas molecules from one chamber selectively into the other. As entropy is increased in one chamber, the valve records the number of molecules that pass from this side to the other (much like one's memory records events). In theory, if the system was reversible, the entropy would decrease in the chamber where it occurs, if and when a record of the molecule being counted is erased from the valve (Mlodinow and Brun, 2014, p. 5). The model showed, however, the tendency toward entropy was in no way decreased even when the memory (record of the molecular count) was erased (Mlodinow and Brun, 2014, p. 7).

The researchers show in their paper that the alignment of the psychological arrow of time with the physical can be proven with their model, and generalized beyond it for all systems that follow classical physics with a well-defined thermodynamic arrow of time (Mlodinow and Brun, 2014, p. 7). Put another way, their research provides evidence that memories and thought processes move one-way because to create a reverse psychological arrow of time would mean a reversal or decrease of entropy which violates this principle of physic, proven by Boltzmann's equation. However, in fact, when a memory of an event is erased, there is an *increase* in entropy and the record of events is dissipated (Mlodinow and Brun, 2014, p. 7). Most importantly, therefore, psychological entropy must exist because the psychological arrow of time corresponds to the physical.

In the second example, Duncan, Hayes, Wiebking, Tiret, Pietruska, Chen, Rainville, Marjanska, Ayad, Doyon, Hodaie and Northoff (2015) conducted brain research to examine to how childhood trauma affects the adult brain (p. 4622). To do the research, the researchers selected a group of psychologically healthy college students. Along with the Childhood Trauma Questionnaire (CTQ), the researchers used extensive Functional Magnetic Resonance Imaging (fMRI) imaging to measure the variability of entropy. In the study, entropy was defined as the statistically-based degree of complexity (or disorder) of the signal (as measured in fMRI) across time (and space) within the brain.Specifically, it was defined as how much the signal at one point in time (and space) was different from the signal obtained at the subsequent and later points in time. Therefore, the researchers defined entropy as a statistically-based measure of the temporal structure of the brain's resting state activity (Duncan et al., 2015, p. 4623).The researchers evaluated how the entropy of subjects reporting negative childhood trauma (NCT) was affected in the temporal structure of the brain's intrinsic activity in the specific brain region called the perigenual anterior

cingulate (PACC). Previous studies show this region is important in processing personal relevance.The subjects who scored high for early childhood trauma also showed higher degrees of entropy in their PACC intrinsic activity in early adulthood (Duncan et al., 2015, p. 4627). That is, a significant correlation between PACC entropy and their questionnaire score was observed. Hence, the higher the degree of early childhood trauma, the higher the degree of PACC entropy in the brain's intrinsic activity in adulthood was indicated (Duncan et al., 2015, p. 4627). This result suggests that higher degrees of early childhood trauma may have become encoded into the temporal structure, i.e. entropy of the brain's intrinsic activity at the time and persisted until early adulthood. There were other important measurements in this study(Duncan et al., p. 4633).

By linking a history of childhood trauma to fMRI brain pattern measurements of electrical activity, this study may offer additional evidence of psychological entropy and its relationship to physiology. Emotional trauma appears to be measurably encoded in the brain, lending support for the idea of emotional entropy as well as to its neural-biological connection. There will be more discussion of this study as well as others in the next chapter.

As has been mentioned, one signature characteristic of living organisms appears to be their ability to self-organize to stay apart from equilibrium. This represents an opposing force to entropy and as has been shown, it may generate spontaneously by using negative entropy (free energy). The definition of self-organization was provided in the Introduction, but it will be repeated here for purposes of this discussion. Self-organizationrefers to a process by which systems that are in general composed of many parts spontaneously acquire their structure or function without specific interference from an agent that is not part of the system (Haken, 2013, para. 2). In the discussion that follows, the research of two important scientists is explored. Their insights about how spontaneous self-organization works in biology propose a meaningful grounding on which inferences can be drawn about how self-organization occurs in thoughts and emotions.

Expanding on Schrodinger's work is John Scales Avery whose book *Information Theory and Evolution*builds on the long history of research into entropy as well as the works of Darwin and the discovery of DNA structure. Avery (2012) presents an argument for how self-organization in biology operates. Key to Avery's thesis is the concept of biological coding. He observes that the DNA code was

found to be the same for all species studied, no matter how widely separated they were in form, confirming Darwin's theory (Avery, 2012, p. 48). This confirmation was far-reaching in its impact. It is RNA (ribonucleic acid) which is a nucleic acid present in all living cells. Its principal role is to act as a messenger carrying instructions from DNA for controlling the synthesis of proteins, although, in some viruses, RNA rather than DNA carries the genetic information (Avery, 2012, p. 46).

Building on his discussion of the scientific history, Avery then includes Schrodinger's hypothesis into his construct. He states:

> All living organisms draw a supply of thermodynamic information from their environment, and they use it to "keep aloof" from the disorder which constantly threatens them. In the case of animals, the information-containing free energy comes from food. In the case of plants, it comes primarily from sunlight. The thermodynamic information thus gained by living organisms is used by them to create configurations of matter which are so complex and orderly that the chance they could have arisen in a random way is infinitesimally small (Avery, 2012, p. 95).

Certainly he, like Schrodinger, recognizes that all living organisms conform to the Second Law of Thermodynamics and entropy exists in biology just as it does in inanimate material. He also embraces Schrodinger's concept of negative entropy. Just as Schrodinger, he describes the process of negative entropy (delaying death) based on metabolism in living things. Organisms take in food and sunlight. But Avery (2012) adds to this by characterizing this nourishment as "thermodynamic information" (p. 97). Avery's use of the term is as a descriptive property of the distribution of matter and energy (p. 95). He also makes the essential observation that the negative response to disordering entropy is one of ordering and it is so complex that the likelihood that this is done by pure chance is extremely small (Avery, 2012, p. 95).

Avery (2012) makes a distinction between what he calls cybernetic information and thermodynamic information. He contends:

> …despite the close relationships, there are important differences between Shannon's quantities and those of Boltzmann. Cybernetic information (also called semiotic information) is an abstract quantity related to messages, regardless of the physical form

> through which the messages are expressed, whether it is throughelectrical impulses, words written on paper, or a sequence of amino acids. Thermodynamic information, by contrast, is a temperature- dependent and size-dependent physical quantity. Doubling the size of the system changes its thermodynamic information content; but neither doubling the size of a message written on paper, nor warming the message will change its cybernetic content. (p. 90)

Avery, therefore, is observing that any system can be studied like a machine (cybernetically) and all systems viewed in this way deliver messaging. The form of that messaging can vary, and this information varies cybernetically as a result. In other words, these different messages provide information about the characteristics of the system as a whole. This can be understood to be information as expressed by Shannon. However, thermodynamic information (expressed by Boltzmann as a statistical disordering), which is represented as a molecule, will change depending on temperature and the size of the system (Avery, 2012, p. 90). Copies of the information do not provide cybernetic information. That is, they provide no information about the whole system because one is not like another. The evolutionary process consists of making many copies of a molecule of a larger system. The multiple copies undergo random mutations and natural selection preserves those which are favorable (Avery, 2012, p. 90). Avery (2012) asserts that in the evolutionary process, copies of molecules are made of a larger system (p. 90). Over time the molecules undergo mutations and after making further copies, natural selection preserves those mutations which are favorable to survival. According to Avery:

> It is thermodynamic information that drives the copying process, which the selected favorable mutations may be said to contain cybernetic information. The cybernetic information distilled in this process is always smaller than the quantity of thermodynamic information required to create it (both measured in bits) since all information must have a source. (p. 90)

From this, it is clear Avery is arguing for two primary sources of information as central in the creation and functioning of life. He argues that genetic mutations are done in response to the thermodynamic properties of systems and this is conveyed as molecular information which settles out through randomized mutation in the evolutionary process (Avery, 2012, p. 90). Once a random mutation is "favorable," it is copied, and cybernetic information is "distilled." The cybernetic information is always a

smaller quantity of information relative to the thermodynamic information and it is evident that Avery is expressing that both kinds can be encoded into bits (Avery, 2012, p. 90).

Based on his application of cybernetics, Avery (2012) argues that the line between what is, and is not life, is very murky. He asserts there are many borderline cases (p. 97). For example, certain bacteria form spores which do not metabolize but which exist without nourishment for millions of years. Avery asks if these bacteria are alive. He says:

> …Aristotle seems to have it right when he said, 'Nature proceeds little by little from lifeless things to animal life, so that it is impossible to determine either the exact line of demarcation, or on which side of the line an intermediate form should lie.' However, one theme seems to characterize life: It is able to convert the thermodynamic information contained in food or sunlight into complex statistically unlikely configurations of matter. A flood of information-containing free energy reaches the earth's biosphere in the form of sunlight. Passing through the metabolic pathways of living organisms, this information keeps the organisms far away from thermodynamic equilibrium ("which is death"). (Avery, 2012, p. 97)

The ability of life to convert the information of sunlight and food contained within Gibbs free energy to avoid thermodynamic death is what separates it from nonliving matter, according to Avery (2012, p. 97). Thus, the notion of the amount of information attaches itself very naturally to entropy.

But it is also Avery's main thesis that there is a merging of information technology with biotechnology. He notes that the development in both fields has accelerated rapidly, citing the advancements in computer technology, the Internet and the exponential growth of information available (Avery, 2012, p. 173). Avery (2012) also observes how this has accelerated scientific discovery in nearly every field. In evolutionary biology, biologists, biochemists, and crystallographers have now obtained much information about amino acid sequences and the structures of proteins (p. 179).

Armed with this information, he describes the "self-assembly" of "supramolecular structures." In other words, he addresses the construction system of molecules done without guidance (other than a suitable environment). A supramolecular structure is a supermolecule or a larger, more complex molecule. Avery (2012) observes that molecules have physical shapes which recognize other molecules

(p. 174). They will fit together like a lock and key (Avery, 2012, p. 174). As an example of spontaneous auto-assembly, he cites the behavior of the tobacco mosaic virus in as observed in a well-known study,

> The mechanism for this spontaneous auto-assembly is a random motion of the molecules through the solvent until they approach each other in such a way that a fit is formed. When two molecules fit closely together, with their physical contours matching, and with complementary patterns of excess charge also matching, the Gibbs free energy of the total system is minimized. (Avery, 2012, p. 174)

Here he presents just how life is formed through spontaneous self-assembly (synergetics) within a system of thermodynamic entropy. The results of this study are very consistent with Schrodinger's concept of negative entropy based on the concept of free energy. As the system tends toward increased entropy, free energy is minimized as the self-assembly occurs, to remain aloof from equilibrium (Avery, 2012, p. 174). While he does not say this explicitly, it appears he means that the process of self-assembly occurs in a nonequilibrium state induced in the order-from-order process discussed by Schrodinger (1944/1992, p. 501). Avery (2012) goes on to say:

> The mechanism of self-organization of supramolecular structures is one of the most important universal mechanisms in biology. Chemical reactions take place spontaneously when the change in Gibbs free energy produced by the reaction is negative, i. e., chemical reactions take place in such a direction that the entropy of the universe increases. When spontaneous chemical reactions take place, the universe moves from a less probable configuration to a more probable one. (p. 175)

Spontaneous self-organization is the way life emerges and grows. This essential information about life tangibly supports Schrodinger's idea of negative entropy and it deepens the understanding of how it operates. This self-ordering is life's powerful survival defense against entropy and death and the same principle controls the motion of larger systems. Biological structures of all kinds are formed spontaneously from their components because assembly information is written onto their adjoining surfaces. These complimentary surface contours (lock and key) join together, according to Avery (2012, p.175).

Avery (2012) devotes the remainder of his book to comparing how information coding, storage, and processing in computer technology has attempted to replicate these same things in biology. He

describes the molecular "switches" of bacteriorhodopsin and their role in self-assembly (Avery, 2012, p. 177). It is clearly information theory which has made it possible for biologists like Avery to study this. He speculates on both biological and artificial neural networks and he considers the feasibility of artificial life. According to Avery (2012), "We come nearer to what most people might call ‘artificial life' when we take parts of existing organisms and recombine them in novel ways, using the techniques of biotechnology" (p. 186). He then provides examples of how the genes of different species have been successfully combined and noted that this is being done as a routine part of farming (Avery, pgs. 186 – 188).

Thus, Avery builds on Schrodinger by showing how incoming thermodynamic information keeps the living organism far away from thermodynamic equilibrium while attaining a statistically complex system. He stresses the essential role of spontaneous self-organization in this, showing that the information content of living things is a measure of how unlikely it is it would arise by chance. Life, according to Avery, maintains itself and evolves by feeding on free energy. This is, of course, is what Schrodinger contended. Importantly, he emphasizes the role of information coding in biological spontaneous self-organization.

Theoretical biologist Stuart A. Kauffman, like Avery, is a strong proponent for the role of self-organization in biology, but he takes a somewhat different theoretical approach from Avery. In his book *The Origins of Order*, Kauffman (1993) uses random Boolean networks to query genetic self-organization properties of the gene regulatory networks. He argues that cell types are dynamical attractors in gene regulatory networks and that cell differentiation can be understood as transitions between attractors (Kauffman, 1993, p. 442). He begins his book by stating its purpose. The central theme he explains, is that powerful spontaneous ordering occurs in simple and complex biological systems (Kauffman, 1993, p. vii). It interfaces with the process of natural selection to produce well-adapted environmental designs or it chances upon a historic accident (Kauffman, 1993, p. xiv). Random drift (or stochastic drift) describes the change in the average value in a stochastic process. Thus, Kauffman (1993) is asserting that self-organization is available to the random changes trending in biology (p. 645).

He initially discusses what he calls "Fitness Landscapes," which can be applied in two ways. For the evolutionary biologist, fitness refers primarily to the whole organism (Kauffman, 1993, p. 33). To evaluate fitness, components of fecundity, fertility and additional variables of successful reproduction are

considered. This determination includes more complex elements such as the frequency and density of each genotype in a region or an entire ecosystem (Kauffman, 1993, pgs. 33 – 67). Understanding fitness in this broader context makes it difficult to assign a fitness to a specific gene or genotype because of their interdependence with other organisms in the population. Secondly, therefore, Kauffman (1993) defines the fitness landscape in a more restricted sense to a well-specified property and its distribution across a group (p. 33). As an example, he uses the property of catalyzation of protein in protein space, showing how the distribution of velocities would be the fitness landscape for that function.

Using three-dimensional mathematical modeling, Kauffman (1993) describes the structure of these fitness landscapes and argues that they must regulate the adaptive evolution at the molecular and morphological levels (p. 66). He also addresses the biological implications of fitness landscapes noting:

> Adaptive evolution is a search process – driven by mutation, recombination, and selection – on fixed or deforming fitness landscapes. An adapting population flows over the landscape under these forces. The structure of such landscapes, smooth or rugged, governs both the evolvability of populations and the sustained fitness of their members. (Kauffman, 1993, p. 118)

He is asserting that it is these fitness landscapes of organisms which determine how evolution occurs. Mutation, recombination and natural selection are shaped on fixed or deforming organismic fitness landscapes and an adapting population flows over the landscape under these forces. The structure of a fitness landscape governs evolution in populations and the sustained fitness (survivability) of each member. Significantly, Kauffman (1993) also presents a similar assertion for fitness landscapes on the molecular level, based on his mathematical modeling (p. 118).

Furthermore, Kauffman (1993) contends that these fitness landscapes are structures within the broader context of random Boolean networks (p. 174). According to Kauffman (1993), “Random Boolean networks are a vast family of disordered systems. Yet we shall find that they exhibit three broad regimes of behavior: order, complex, and chaos” (p. 174). Thus, it appears that Kauffman is arguing that it is these random Boolean networks which effectuate self-organization through fitness landscapes. Avery (2012) observes that Stuart Kauffman has constructed computer models for the way in which components of complex systems of reflexive catalysts may have been linked (p. 61). He notes that Kauffman’s models

exhibit a surprising tendency to produce orderly behavior when randomly programmed (Avery, 2012, p. 61).

In a review of Kauffman's book, Fox (1993) notesthat Kauffman's implicit message is, "Biological order obeys the first and second laws of thermodynamics and it is molecular in character. Its conceptualization rests firmly in physics and chemistry" (p. 2699) Thus, Kauffman follows in the tradition of Schrodinger and clearly accepts the concept of entropy in dynamical living organisms. He is contending that the complexity of biological systems and organisms results as much from self-organization as from natural selection and it occurs far from equilibrium dynamics. He says:

> …I seek the adaptation principles of such complex and beautiful ordered systems. I explore two components of those principles: self-organization and selection. First of all, contrary to our deepest intuitions, massively disordered systems can spontaneously 'crystallize' a very high degree of order. Much of the order we see in organisms may be the direct result not of natural selection but of the natural order selection was privileged to act on. Second, selection *achieves* complex systems capable of adaptation. Moreover, I shall suggest that there are general principles characterizing complex systems able to adapt: They achieve a 'poised' state near the boundary between order and chaos, a state which optimizes the complexity of tasks the system can perform and simultaneously optimizes evolvability. (Kauffman, 1993, p. 173)

Massively disordered systems spontaneously crystalize to become highly ordered. Much of this is the direct result of natural selection acting on the system, but only that within the system on which natural selection was capable of acting. Selection also makes complex systems capable of adaptation. Finally, Kauffman theorizes that these complex systems achieve a poised state near the boundary between order and chaos, making it possible to optimize the complexity of tasks and to optimize evolvability (Kauffman, 1993, p. 173). Thus, complex systems respond (crystalize) to natural selection by spontaneously self-organizing and this makes complex systems capable of adaptation to their environment Kauffman, 1993, p. 173). Kauffman's description of a poised state near the boundary of order and chaos references The Second Law of Thermodynamics. Such a stable state would be far from equilibrium.

Kauffman (1993) also claims that much of the order seen in living organisms is the same spontaneous order out which living things emerged (Kauffman, 1993, p. 644). This is the result of a complex evolutionary process involving different ecosystems and different fitness landscapes (Kauffman, 1993, p. 644). He contends that each organism has a structure of biological limits and constraints within which the organism can survive and evolve, which he calls a fitness landscape (Kauffman, 1993, p. 644). When organisms evolve to become more complex, the optima (or the most favorable point) attainable falls toward the average features of the class of organisms (Kauffman, 1993, p. 644). A mutation-selection balance is struck, beyond some level of complexity. Selection cannot hold an adapting population at the high peaks (the optima) of the landscape, and the population falls toward the average properties of the underlying class of organismic systems (Kauffman, 1993, p. 644). It is this pattern within organisms according to Kauffman (1993) that is evidence of spontaneous self-organization (pgs. 644 – 645).

As mentioned, central to his thesis on spontaneous self-organizing is the idea that cell types are dynamical attractors in gene regulatory networks (Kauffman, 1993, pgs. 467 – 469). He demonstrates that cell differentiation can be understood as transitions between attractors. Recentscientific evidence suggests that cells are dynamical attractors in gene networks. Li, Wennborg, Aurell, Dekel, Zou, Xu, Huang and Emberg (2016) assert, “It has been proposed, based on the theory of complex gene regulatory networks, that cell types, including cancer cells, represent attractor states of the network dynamics. Here, we characterize for the first time, to our knowledge, the detailed dynamics of a cancer cell attractor at single-cell resolution” (para.1). The researchers note they are able to map observable cells of different kinds within a clonal population as dynamical states clustering together around attractor points resulting from random fluctuations (Li et al. 2016, p. 2672). This seems to validate Kauffman’s hypothesis including his idea that cell attraction results from stochastic fluctuations.

If cell types are dynamic attractors, then perhaps they operate within the brain as much as anywhere else in the body. Indeed, this might include the limbic system. Therefore, this might account for neuronal stochastic fluctuations which result in the spontaneous self-organization of spatiotemporal patterns of thought and emotion as studied by Kelso (1995) and others.

There is little doubt that Stewart Kauffman's theory breaks new ground in biophysics, and it leads to a rethinking of how Darwin's natural selection occurs in nature. Biological entropy informs his views in the tradition of Schrodinger and though his theory approaches self-organization in a slightly different way, he shares this understanding of the Second Law of Thermodynamics with John Scales Avery.

Presently research on self-organization includes the brain, with new neuroscientific studies generated nearly every week. An example is Fingelkurts and Fingelkurts (2017). The goal of the study was to analyze information flow in the brain based on Shannon's information theory.Additionally, they examined theinterplay of dynamics inclusive of self-organization, stability/instability, the timing of sequential processing, coordination of multiple sequential streams, circular causality, and information creation (Fingelkurts and Fingelkurts, 2017, para.1). All of these processes are dynamic, hierarchically nested, and they correspond to a continuous brain state change.

Because the brain functioning is metastable, their results were that information was continuously created. It was preserved for some time and then dissipated through the formation of dynamical, nested, spatiotemporal coalitions of simple neuronal assemblies as well as largercoupledconglomerates of operational modules (Fingelkurts and Fingelkurts, 2017, para. 15). This study may provide evidence linking the self-organization of the biophysical with the spatiotemporal self-organization occurring dynamically in the brain, bridging with the research discussed in the next chapter.

Chapter 4

The Entropy Theory of Emotion

The historical understanding of emotions and the scientific developments in entropy theory were examined in the previous two chapters. Important ways in which the Second Law of Thermodynamics applies to physiology and the brain were also discussed. Neuroscientific studies showing how entropy can be measured in mental processes and psychology were also referenced. A discussion of how entropy may impact emotions will follow in this chapter. What appears to be lacking in the psychological research is a hypothesis which broadly describes how entropy impacts emotional brain activity and behavioral outcomes. It is argued that this is essential to understand the immediate and lifelong implications, integrating behavior, physiology, and the brain. First, a hypothesis will be elaborated which includes three

major parts: 1) emotional dysregulation, 2) self-organization and 3) cognitive appraisals. This will be followed by a section devoted entirely to evidence, including inferential statistics.

Based on a review of a variety of studies, it is maintained that emotional entropy exists in mental activity. Some examples of this research will be discussed under the *Evidence for Emotional Entropy*section of this chapter. Though this research presents significant correlations between measures of entropy and emotions which suggest that further research is warranted, the results demonstrate inconclusive evidence. Nevertheless, it is thought that a new construct will greatly facilitate the conduct of further research by offering guideposts for interpreting and evaluating entropy within emotional states. Therefore, the following paradigm is submitted here for consideration. *It is hypothesized thatEmotional entropy is a measure of emotional dysregulation as experienced in thought patterns and expressed in behaviors. Emotions and moods have a natural tendency toward complete dysregulation. Completely unregulated emotion (equilibrium) is a state or condition of unpredictable impulsivity or disorder culminating in death.* It will also be advanced that emotions spontaneously self-organize into emotion schemas (Izard, 2007, p. 265). Because this latter supposition is closely linked to the first, it is referenced now, but it will be detailed later in the discussion.

However, the point is, it is proposed that these self-organized emotion schemas are susceptible to dysregulation. For example, in a review of studies on schema therapy for emotional dysregulation in personality disorder (PD), Dadomo, Panzeri, Caponcello, Carmelita and Grecucci (2018) claim that, "Although the treatment of emotional dysregulation is not the core of schema therapy, it is certainly important inside this theoretical framework. The mode model helps clinicians address their work toward the reduction of dysfunctional modes, whereas fostering functional modes" (para. 1) In other research, Powell, Simpson, and Overton (2015) observe that modern theories of disgust portray an emotional construct diverse in character (p. 1). This schema is elicited in multiple ways across the sociocultural environment generating qualitatively different patterns. Thus, Powell et. al. (2015) assert that self-disgust may form an emotion schema (p. 1). As proposed here, dysregulation presents itself as maladaptive emotion schemas which are manifested in psychopathology and behavior (Izard, 2007, p. 266). They may be the result of early childhood neglect or cumulative trauma (Waldrip, 2018, para. 2). It may be through socialization and learning that the new-born infant acquires skills in

self-regulation derived from schemas (Izard, 2007, p. 265; Waldrip, 2018, para. 2). The range of emotional experience may broaden and may be better articulated in development (Izard, 2007, pgs. 265 – 266). The earliest forms of this learning may be acquired through the mother-infant bond (Izard, p. 266). If these skills are not or cannot be acquired, the infant may begin to demonstrate signs of emotional dysregulation. Data suggests that early signs of this can create problems for individuals later in life (Dvir, Ford, Hill & Frazier, 2014, para. 1). Evidence suggests that it is also possible that one can acquire emotional dysregulation problems later in life, such as occurs from PTSD (Tripp and Murphy, 2015, para. 1). Additional evidence suggests that it may be very possible for one to move toward increasingly unregulated emotional disorder later in their life (Orgeta, 2011, para. 1).

It is advanced that the most obvious ways that dysregulation should be measured are through scanning of the general or targeted electrical activity of the brain, behavioral observation and statistically valid self-reporting instruments (Duncan, et al., 2015, para. 1). If increased stochasticity in neural signals is correlated with changes in behavior and physiology, then inferences about levels of dysregulation can be made. Put another way, different levels of emotional entropy can be calculated and inferred from evidence of increasingly random neural signals associated with observed behavioral and physiological changes. Brain scanning techniques such as functional magnetic resonance imaging (fMRI) can be targeted at local areas of the brain or they can be applied globally to the entire brain (Garcia-Martinez, Martinez-Rodrigo, Cantabrana, Garcia and Alcaraz, 2016; Fingelkurts and Fingelkurts, 2017). At this writing, the question of whether local targeted or global measures provide the best results remains unresolved. It seems appropriate therefore that both approaches should be explored. Indeed, answers may not be adequately obtained from an either/or approach (Kelso and Engstrom, 2006, p. 143). Settling on a specific metric which meaningfully measures entropy from brain scan modalities is also experimental at present (Garcia-Martinez, Martinez-Rodrigo, Cantabrana, Garcia and Alcaraz, 2016, para. 1). A review of research suggests a variety of different metrics may have utility. It is hoped that this can be refined with further research correlated with an operationalized definition of emotional dysregulation (Korner, 2012, p. 4). In this discussion, it will also be postulated that shorter life expectancies may correlate with mental disorders and this may suggest that prolonged high levels of emotional dysregulation are associated with accelerated entropy (death). In Chapter 3 it was observed that entropy is a measure of the energy

unavailable to do work (Greitzer et al., 2006, para. 1). In other words, it is a measure of energy lost. It has also been mentioned that entropy is a measure of disorder (i. e., dispersion or randomness) (Kafri and Kafri, 2016, p. 56). There may be a significant energy loss associated with dysregulated emotions (i. e., maladaptive emotion schemas or disordering in which self-regulation is lost). This point is elaborated under the section *Sleep*.

It is proposed that emotional episodes occur dynamically as spatiotemporal patterns resulting from the excitement of brain neurotransmitters in response to the arousal from stimuli. Describing pattern formation in the brain, Kelso (1995) asserts, “Pattern formation and switching, in other words, take the form of a dynamic instability. Notably, the coherence of both brain and behavioral signals is captured by the same collective variable, relative phase” (p. 276). These patterns may be associated with dynamical cognitive brain patterns. According to Izard (2007) for example, emotion schemas form with the affective-cognitive processes (p. 265). That these emotional patterns present themselves as indistinct subsets of dynamical spatiotemporal mental patterns as described by Kelso (1995) seems probable (pgs. 270-271). It is conjectured that within the mind, the two exist on a kind of continuum, with raw sensory impulse at one extreme and high-level cognition at the other extreme. This continuum may be consistent with the evolution of the brain.

As noted, the second major supposition is closely linked to the first. *It is hypothesized that emotional episodes spontaneously self-organize and that this operates much like the self-organization occurring in all living organisms.* The spontaneous self-organization of emotions is presumed to likely be an extension of this process. As argued by Izard (2007, p. 265), it is suggested that emotions self-organize into *emotion schemas* or arrangements of emotional responses based largely on learning and socialization. It is advanced that self-organization uses the energy available to do work (free energy) to generate emotional episodes and emotion schemas. Hence, it opposes the tendency toward entropy to remain aloof from equilibrium.

It is postulated that emotion schemas interpret the environment and as has been mentioned, they can be maladaptive (emotional dysregulation). It may be the learning of these schemas which gets encoded and stored as emotional memories. As discussed in Chapter 3, Avery (2012, p. 174) describes how self-organization involves cell information in biological growth. It is suggested that a similar assembly

of emotional signals may grow schemas forming emotional patterns in the brain. But on what basis can it be contended that emotional self-organization occurs within affective-cognitive processes? Based on his extensive neuroscientific scanning research, Kelso (1995) claims the brain contains specific neural circuits that he labels central pattern generators (CPGs) (p. 239). Referring to thought patterns, Kelso (1995) asks what form such self-organization takes (p. 242). He asserts, “A crucial point is that of all the possible neuronal patterns that a circuit, in principle, could generate, only a few temporal orderings are actually produced” (Kelso, 1995, p. 242). Thus, he implicates CPGs as possible brain network generators of self-organizing spatiotemporal patterns, and he observes that the of the variety of patterns theoretically possible, the number of different patterns generated is relatively few. It is argued that it does not matter if this emotion information coding is always the same because it doesn’t need to be, to create an emotional episode. It is Izard’s (2007, p. 265) theory of emotion schemas which in part forms the basis of what is submitted here. The important perceptual connection between environmental conditions and the potential for emotional dysregulation (entropy) must not get lost on the reader. It is proposed that schemas are interpretations of the environment (Izard, 2007, p. 265). More discussion of Izard and Kelso will be elaborated under *Evidence for Emotional Entropy*.

The contention is that emotional episodesare coarse grain because they are thought patterns which uses energy. But it is unclear how much energy is lost (unused) during emotion creation (i.e. how much information is lost). Consistent with how Schrodinger (1944/1992) describes entropy in living organisms, it is this loss which is entropic, while the self-organization of an emotion schema is negative entropy (p. 496). It is posited that emotional episodes occur within a dynamical universe of thought (i. e., a universe where change occurs but one which is stable) and this might be called the “affective-cognitive process” as coined by Izard (2007, p. 264). As conceived of in this discourse, it should be understood as a nonlinear dynamical spatiotemporal universe and it is postulated that emotional episodic patterns spontaneously self-organize when the conditions described here occur.

It is theorized that since the dynamical mental universe is an open system, free energy continuously becomes available to create emotions which through adaptation form into schemas. It seems probable that if free energy is seriously impaired or restricted, emotional dysregulation leading to unregulated emotion will occur. This scenario is conceived of as an increase in the number of

maladaptive emotion schemas and it may ultimately lead to death. Therefore, it is postulated that emotions are dynamical processes requiring energy to exist. For this to be possible means some natural mechanism must be in place to convert the sources of free energy into energy available for emotions. Emotional life is an apt term because emotions may be understood as alive like an organ of the body. That they require energy to sustain their ability to perform work normally seems probable because that is how entropy occurs in the natural world.

Schrodinger (1944/1992) argued that it is the process of metabolism in living organisms which converts natural sources into free energy used to keep living things aloof from equilibrium and death (496). He described this as a process of "exchange" in which energy was used and waste was created (Schrodinger, 1944/1992, p. 496). While it is important to recognize the essential role this process plays in emotions, it is argued that it does not fully describe the process of exchange acting on emotional states. It is submitted that in order to complete the picture, one must incorporate the concept of environmental exchange or the way emotional experience is impacted by interactions with the environment. It is proposed that environmental exchange is the process by which one incorporates the meaning of his environment in relation to survival goals, which may result in an attitudinal change and which increases brain entropy. Schrodinger was quick to point out that the word exchange must not be taken literally as an exchange of some material for some other (Schrodinger, 1944/1992, pgs. 496 – 497). Instead, he describes exchange as the metabolizing of food and nutrition which promotes life and yet by using energy, a living organism will paradoxically increase its entropy (Schrodinger, 1944/1992, p. 497).

Similarly, it is put forward in this discussion that environmental exchange should not be viewed in literal terms as an exchange of material. As stated, it is proposed that environmental exchange involves interactions that form interpretations of one's environment generating emotion which increases entropy. It is posited that when emotions interpret the environment, they perform an exchange in which information is appropriated, which can lead to emotional/attitudinal shifts. Thus, a self-organizing emotional reaction is produced to stay aloof from equilibrium while paradoxically increasing entropy and tending toward equilibrium. Viewing interaction as an environmental exchange to study psychological entropy is not entirely without precedent. Vetromille-Castro (2013) published the results of a study on social interactive

entropy (pgs. 625 – 641). Within the study, he analyzes the importance of interaction to the unpredictability (randomness) of behaviors (Vetromille-Castro, 2013, pgs. 639 – 640). For this discourse, it is suggested that this exchange mechanism is unique to the affective-cognitive processes and can dramatically alter emotional states in ways that are dysregulating. It is maintained that it is based on cognitive appraisals which will be discussed in greater detail.

Of course, emotions would be impossible without the sources of free energy described by Schrodinger (1944/1992, p. 496). They are essential for generating emotional self-organization and the energy for sustaining life is "metabolized" into the affective-cognitive process. It also seems to follow from this that the emergence of emotions into the assembly (self-organization) of schemas requires life sustenance (energy available to do work). Without sufficient amounts of it, emotional dysregulation would appear to be a threat. The system of schemas may break down. Evidence suggests that memories stored in the hippocampus may be closely associated with emotion (Mandal, 2018, para. 1). Perhaps it becomes an antecedent constituent for emotion. In this way, spontaneous self-organization of emotional episodes and the subsequent emotion schematic patterns may occur through interactions internal to the brain, without intervention by externally directed influences.

Free Energy

The way in which Schrodinger (1944/1992) presents free energy and its relevance to emotional entropy has been discussed (p. 496). In *Scientific American*, Jabr (2013) observes that neuroscientists have discovered that the human brain is an energy glutton, constantly demanding 20% of the energy of the body and yet only requiring about 5% more when dealing with a difficult mental challenge (para. 8). Similarly, University World News (2013) notes, "Representing only 2% of the weight of an adult, the brain consumes 20% of the energy produced by the body" (para. 1). It appears to be the case that the brain demands much more than it uses to produce an emotion. It seems reasonable to conjecture that it is this unused energy which tends toward entropy while the emerging emotion spontaneously self-organizes in negative entropy. This is because entropy is a tendency occurring with energy loss. As previously stated, entropy is a measure of the energy *unavailable* to do work (Greitzer, Spakovsky, and Waitz, 2006). Hence, if one argues that emotional entropy exists, it must conform to the Second Law of Thermodynamics. By definition, emotional entropy *must be* a measure of the energy unavailable to do

work. But assuming this is so, what happens to all this unused energy? It may be that most of it is converted to heat. Of course, the brain does not come equipped with its own tailpipe. Living cells and many animals recycle their waste, and brain energy may have a special way of recycling (restoring) most of the energy (Nortley & Attwell, 2017). It is proposed that sleep (or downtime) may be a crucial mechanism in the management of unused energy. More will be said on this under *Sleep.*

Memory and Emotion

As noted, memories are stored in the lower portion of the cerebral cortex known as the hippocampus (Mandal, 2018, para. 1). This represents a major portion of the brain in humans and all vertebrates. In humans, there are two and they are considered to be a part of the limbic system which regulates emotions in the brain. The hippocampus is particularly important in long-term memory. According to Mandal (2018):

> Damage to the hippocampus can lead to loss of memory and difficulty in establishing new memories. In Alzheimer's disease, the hippocampus is one of the first regions of the brain to be affected, leading to the confusion and loss of memory so commonly seen in the early stages of the disease. (para. 2)

Evidence suggests, that the hippocampus is a data storage organ which is so essential to normal functioning that the brain cannot organize thoughts effectively without it. Hence, its close linkage to emotional regulation is essential to the understanding of how emotional dysregulations works.

For example, Johnston and Olson (2015) detail some of the important research which has been conducted concerning the hippocampus relative to emotion and stress (pgs. 202 – 204). They observe:

> …one function of the hippocampus is to regulate the stress by inhibiting amygdala output. In addition, the hippocampus responds to increases in glucocorticoids by inhibiting the HPA axis, which in turn down-regulates the amygdala (see Box 4.1 for more details). Thus, damage to the hippocampus may result in hyperactivity of the amygdala, amplifying the stress response. (Johnston and Olson, 2015, p. 202)

Thus, it may be that the hippocampus interfaces with the amygdala and it seems probable that it regulates emotion and stress. One might infer from this that it may be the hippocampus which participates directly in emotional self-organization and self-regulation and that damage to this area of the brain may result in emotional dysregulation.

The hippocampus and the amygdala are considered to be part of the limbic system in the brain. The functions of the limbic system serve the purposes of self-preservation and species preservation (Swenson, 2006, para. 1). The functions of the limbic system are interconnected, and they regulate autonomic and endocrine function, especially in response to emotional stimuli (Swenson, 2006, para. 1). They establish the level of arousal and they are involved in motivation as well as behaviors (Swenson, 2006, para. 1). They are also important to particular types of memory (Swenson, 2006, para. 1). In addition to the hippocampus and the amygdala, the limbic system includes the hypothalamus and Swenson (2006) observes that it is the primary output node for the limbic system (para. 4). Swenson (2006) notes that the hypothalamus serves many functions, including sexual function, behavioral function and autonomic control (para. 4). The limbic system also includes the limbic cortex (Swenson, 2006, para. 21). This is also known as the prefrontal cortex and it is anterior to the premotor cortex, according to Swenson (2006, para. 21). In humans, this portion of the cortex is extremely well developed, and it is critical to judgments, insights, motivation, and mood (Swenson, 2006, para. 21).

It appears that it is the limbic system where emotions and cognition are conjoined. Memory must always have some emotional connection. It is not known how exactly this occurs. Some scientists implicate the amygdala in the generation of emotions such as fear, anxiety, and aggression. Indeed, it may be responsible for the full range of emotions. In a study of the amygdala, Joseph LeDoux (2003) finds:

> …working memoryreceivesagreaternumberofinputs,andreceivesinputs of agreatervariety, inthepresenceofanemotionalstimulusthaninthepresenceofotherstimuli.These extrainputs mayjustbewhatisrequiredtoaddaffectivechargetoworkingmemory representations,and thustoturnsubjectiveexperiencesintoemotionalexperiences. (p. 733)

The amygdala may influence memory and conversely, memory originating in the hippocampus appears to regulate cortical arousal from emotion as well as the control of bodily responses. These responses

(behavioral, autonomic, endocrine) may provide feedback that influences cortical processing directly. Working memory receives a great number and variety of inputs when an emotional stimulus is present compared to nonemotion producing stimulus. This then, may be exactly what is needed to turn a subjective experience (an experimental subjects report of experience) into an emotional experience, according to LeDoux (2003, p. 734).

This suggests that the limbic system could be implicated in the encoding of emotion and memory together. The Cognitive Appraisal theory of Lazarus and Folkman (1984) will be described under *Emotional Content*, but it is relevant here. It is submitted that appraisal information may be stored in the hippocampus and applied to stimulus to elicit an emotional response leading to behavior or reaction. This is conceived of as the emotional *work* expended, drawing on the energy available to do work.

The LeDoux (2003) study brings together observations of lab rats who are tested for their fear responses. One of his essential observations concerning the fear reaction of rats is, “Theresponsesarenot learned and are not voluntary. They are innate, species-typical responses to threats and are expressed automatically in the presence of appropriate stimuli” (p. 728). It can be inferred that animals innately experience the emotion of fear. Rats know no language and this experience does not require learning. What other emotions might they innately experience? This follows the classical view first asserted by Darwin (1872/1992) that all animals experience and express emotions (p. 150).

It would be wrong to characterize emotional episodes as anything other than perceptual experiences, though certainly, they are registered and measurable in physiology and as behaviors. As noted, there is a reciprocal effect in which emotions influence perceptions and memory, and generate new emotions. But it is argued that while the spatiotemporal patterns of emotions are a subset of thought patterns, emotional patterns have their own unique encoding "signature" as self-organization within the self-organization of thought patterns. While it may be true that emotions lack a precise pattern fingerprint which is reproducible the exact same way across all humans and/or animals, they may fall within a predictable range of patterns. This might be similar to how every person has different handwriting yet from the shapes presented on a page, it is possible to generalize the pattern well enough to decipher the meaning.

Sleep

It is estimated that roughly a third of one's life is devoted to the sleeping state (University of Minnesota, 2016, para. 1). What is the purpose of all this sleep? In this section, the role of emotional entropy in sleep and rest will be examined. According to Jabr (2013):

> By the mid-1990s, however, Marcus Raichle of Washington University in Saint Louis and his colleagues had demonstrated that the human brain is in fact a glutton, constantly demanding 20 percent of all the energy the body produces and requiring only 5 to 10 percent more energy than usual when someone solves calculus problems or reads a book. Psychologists have just begun to unravel the heretofore mysterious causes and impacts of sleep on the brain and body. (para. 8)

As mentioned, this discovery was confirmed in observations of other neuroscientists as well. This clearly suggests there may be significant brain energy which is unused during waking thought processes. Far from being idle, evidence indicates the brain is highly active during periods of sleep (Jabr, 2013, para. 9; Northoff, 2018, p. 19). In addition to sleep, daydreaming, which Jabr (2013, para. 9) calls the default mode network (DMN), serves much the same purpose. It is posited that DMN may provide the brain an interlude during which recovery is spontaneously initiated. If the brain is active during periods of rest, then energy is expended. Could it be that the brain uses resting periods as a kind of recycling interval for unused energy? Dworak, McCarley, Kim, Kailinchuk, and Basheer (2010) conducted an animal study suggesting the brain's energy is "restored" during sleep. The study indicated that during the initial stages of sleep, energy levels increase dramatically in brain regions found to be active during waking hours. Using electroencephalogram (EEG) to examine adenosine-triphosphate (ATP) which they call "the currency of cellular brain energy", the neuroscientists found a statistically significant positive correlation between a surge in ATP and EEG nonrapid eye movement during spontaneous sleep. The results suggest that the surge in cellular energy may replenish the brain processes necessary to function normally while one is awake. Perhaps then, this process uses some portion of energy unused during waking periods. If true, the tendency toward entropy in the brain would mean there must still be some loss of energy.

Jabr (2013) also contends that the DMN is anything but purposeless and unproductive but instead is essential to mental processes affirming one's identity, developing an understanding of human behavior and instilling an internal code of ethics (para. 9). According to Jabr, it also helps the brain make sense of what it has learned, bringing to the surface fundamental unresolved tension and turning one's reflection inward (Jabr, 2013, para. 9).

Viewing this through the lens of emotional entropy then, sleep and periods of rest may be times of mental self-regulation and spontaneous spatiotemporal self-organization (Northoff, 2018, p. 19). They may occur as negative entropy in a state far from equilibrium and draw on the unused free energy. Some (but not all) the unused energy may get recycled in this manner. The energy which remains unused would be lost as the tendency toward increasing entropy would continue. It is postulated that if sleep is deprived and the amount of recycled energy is low, emotional dysregulation will increase. Because of the restorative properties evidenced by the energy expended during resting states, it is posited that the greater the sleep deprivation, the higher the level of emotional dysregulation (entropy) and this may ultimately lead to death. For example, the Committee on Sleep Medicine and Research (2006) reports:

> Sleep disturbances are so commonly seen as symptoms of certain psychiatric disorders that they are listed as diagnostic criteria under DSM-IV (APA, 1994). For example, insomnia is a symptom used with others to diagnose major depression. The comorbidity, or coexistence, of a full-blown sleep disorder (particularly insomnia and hypersomnia) with a psychiatric disorder is also common. Forty percent of those diagnosed with insomnia, in a population-based study, also have a psychiatric disorder (Ford and Kamerow, 1989). Among those diagnosed with hypersomnia, the prevalence of psychiatric disorder is somewhat higher – 46.5 percent. (p.79)

These data appear to suggest a high correlation between unhealthy sleep patterns and mental illness. A study conducted by Yoo, Gujar, Hu, Jolesz, and Walker (2007) also found a significant correlation between sleep deprivation and a range of emotional disturbances (para. 5). Other studies yield similar results. It seems reasonable to infer that without normal sleep; emotional dysregulation occurs with greater frequency.

The Division of Sleep Medicine at Harvard Medical School (2008) notes that one's body regulates sleep in much the same way it regulates eating, drinking and breathing (para. 3). It, therefore, may serve a similarly critical role in health and well-being and have a physiological basis, though it also may greatly influence one's perceptions. Other theories concerning sleep lend credence to Jabr's contentions while also providing evidence for the deleterious effects of sleep deprivation. For example, the Division on Sleep Medicine, Harvard Medical School (2008) asserts:

> Another explanation for why we sleep is based on the long-held belief that sleep in some way serves to 'restore' what is lost in the body while we are awake. Sleep provides an opportunity for the body to repair and rejuvenate itself. In recent years, these ideas have gained support from empirical evidence collected in human and animal studies. The most striking of these is that animals deprived entirely of sleep lose all immune function and die in just a matter of weeks. This is further supported by findings that many of the major restorative functions in the body like muscle growth, tissue repair, protein synthesis, and growth hormone release occur mostly, or in some cases only, during sleep. (para. 12)

Thus, like the Dworak et. al., 2010), other theorists suggest that perhaps the sleeping state creates a metabolic condition where free energy may restore and repair, and the absence of restoration may result in death. This is consistent with the entropy theory of emotion. The importance of sleep to normal emotional and cognitive functioning is also underscored by Kate Duff (2014), "Sleep researchers now state with confidence that sleep is not just a simple pleasure of guilty indulgence, it is necessary for our cognitive, physical and emotional well-being" (p. 116). She notes this is particularly evident in cognitive and memory performance. Common sense seems to suggest that sleep must be restorative but based on this science, it is conjectured that sleep plays a crucial role in emotional self-regulation and self-organization both during sleep and during waking periods.

Emotional Content

In this section, the third major supposition will be described in detail. Cognitive Appraisal Theory (sometimes called appraisal theory) refers to how emotions are extracted from one's evaluations (appraisals or estimates) of events and cause specific reactions in different people. Essentially, one's

appraisal of a situation causes an emotional or affective response that is based on that appraisal. First hypothesized in the 1940s by Magda Arnold, it was later developed by Richard S. Lazarus. According to Lazarus (1991), "The appraisal process involves a set of decision-making components, as it were, which create evaluative patterns that differentiate among each of the emotions; and three secondary appraisals, which have to do with the options for coping and expectations" (p. 39). According to appraisal theory, there is operating within an emotional episode an appraisal process of "harm," "threat," needs" and "wants." Lazarus (1991) contends that the primary appraisal components involve "goal relevance." Thus, cognitive appraisals are goal-driven (p. 222). The secondary appraisal components deal with "goal congruence" (i.e. blame, credit, and coping) (Lazarus, 1991, pgs. 222 – 223). He also argues that coping also plays an important role in the personal significance of the person-environment relationship and this influences the appraisal process (Lazarus, 1991, p. 222). As a direct result, it affects emotion through feedback.

Therefore, it is hypothesized that within emotional content, there is an appraisal of threat, harm, and coping. This involves likes and dislikes, wants and needs. Appraisals may be preconscious or subconscious, but they are goal-driven. It is proposed that this appraisal mechanism is a tool for survival,and it includes iterative assessments based on new information obtained through perceptions. As noted by Lazarus and Folkman (1984), some appraisals conclude stimuli are irrelevant (p. 32). Thus, they generate no stress (anxiety). Furthermore, evidence suggests that cognitive appraisals are not confined to humans, but routinely appear in the emotional behaviors of other social animals as observed by Faustino, Oliveira, and Oliveira, (2015, para.1).

To expand upon the research about appraisals, Lazarus & Folkman (1984) refined the concept as a new way of understanding how people cope with stress. Since then, the theory has been accepted by a much wider community of psychologists and as a result, a large body of research on appraisal theory has been generated. As Lazarus (1999) observes, “One bit of foolishness in the way people in Western society, including many scholars, think about emotions is that they are irrational” (p. 86). What he appears to mean is that emotions are evaluative, goal-driven, and purposeful. There is an abundance of evidence in support of this contention, some examples of which will follow under *Evidence for Emotional Entropy*.

What follows is a description of the basic cognitive appraisal construct, which is important to an understanding of the emotional entropy paradigm. As (Lazarus & Folkman, 1984) explain:

> Primary appraisal consists of judgement that an encounter is irrelevant, benign-positive, or stressful. Stressful appraisals can take three forms: harm/loss, threat, and challenge. Harm/loss refers to damage the person has already sustained, threat refers to anticipated harms or losses, and challenge refers to events that hold the possibility of mastery or gain. Threat and challenge are not poles of a single continuum; they can occur simultaneously and must be considered as separate, although related constructs.
>
> Secondary appraisal is judgement concerning what might and can be done. It includes an evaluation about whether a given coping option will accomplish what it is supposed to, that one can apply a particular strategy or set of strategies effectively, and an evaluation of the consequences of using a particular strategy in the context of other internal and/or external demands or constraints.
>
> Reappraisal refers to a changed appraisal based on new information from the environment and/or person. A reappraisal differs from an appraisal only in that it follows an earlier appraisal. (p. 53)

Lazarus and Folkman (1984) point out that this cognitive appraisal process is not necessarily conscious (p. 54). But they argue it is phenomenological in that it is the meaning of the event to the person which shapes the emotional and behavioral response. This is a departure from the view of many that emotions are produced solely in response to reinforcements, drives, and arousal. It is asserted instead that emotions *interpret* meaning and are reality-based. The reappraisal is iterative based on new information and this may lead to new emotions and behaviors. It is submitted, therefore, that they must necessarily engage both emotional episodes and emotion schemas. Izard (2007) argues that cognitive appraisals are the method by which schemas interpret and adapt to the world (pgs. 264 – 265). It is contended that such appraisals may be accurate or inaccurate, successful or failing, rewarding or punishing, depending on many variables.

As mentioned, cognitive appraisals are goal-driven (Lazarus, 1991, p. 222). Another way to state this is to say they cause emotions to *work*toward a goal. It is proposed that this work expends free

energy. It may be that if they work to meet survival goals satisfactorily within self-organization, then emotional self-regulation can occur or be reinforced. Thus, cognitive appraisals may be the drivers of self-regulation (adaptive emotion schemas). If they are not effective in meeting these goals, it is argued that this may lead to emotional dysregulation (maladaptive emotion schemas). It is postulated that a key feature in emotional response is its effectiveness in accessing the cognitive control necessary to self-regulate. Self-regulation may occur with simple emotion as argued by Izard (2007), and perhaps it occurs with emotion schemas (pgs. 264 -265). Central to this paradigm is the proposal that with self-regulation weakened or absent, the emotional episodes become more incoherent and increasingly stochastic. Psychopathological schemas (disorders) may emerge which ultimately move one closer to equilibrium. Perhaps memories stored in the hippocampus as stimulated by emotions derived from the amygdala or other limbic system areas play an essential role in determining well-regulated emotional reactions. If so, these memories would likely record all past appraisals including the full range of emotive judgments such as perceived dangers, pleasures, dislikes, likes, etc. It is postulated that this acts as a database of memories from which the cognitive appraisal is drawn in the present moment. It is suggested that memories may be a kind of logical "premise" from which a "conclusive" appraisal of the moment is derived. This could lead to an emotional reaction.

The environmental exchange process was detailed, and it deserves mention here. As referenced, it is submitted that this is a kind of interchange with the environmental conditions which expends energy increasing entropy. It is contended that this may initiate an immediate emotional reaction accompanying an appraisal. Thus, it may reinforce the appraisal process. It is further argued that it likely forms the basis of many emotion schemas which can determine how successful one is in adapting to the world for long periods of time. Therefore, it is maintained that in this sense, it can shape one's attitudes and belief systems by acting as a kind of template for an appraisal.

As noted, it is argued that appraisals may be associated with simple emotions and more complex emotion schemas. The evidence on animal appraisals suggests that appraisals associated with simple emotions may not require representation and occur absent symbolic language (Faustino, Oliveira, and Oliveira, 2015). This may account for the reason that many animals appear to display emotional instinctive reactions based on appraisals. While there can be a danger in anthropomorphizing animal

behaviors, cognitive appraisal studies provide a tool for evaluating animal behaviors and avoiding this as evidenced in, Boissy, Aubert, Desire, Greiveldinger, Delval, and Veissier (2011, para.1). Also, evidence that emotions are recognized when symbolic language is not present is quite apparent with cognitively impaired persons, as indicated in Channell, Conners, and Barth (2014, para.1), and in stroke victims, as suggested by Wu, Lee, Su and Pai (2015, para.1). In each case, these people appear to engage in the evaluation of likes and dislikes, threats, safety and coping with their environment using their database of memories to appraise their condition. On the other hand, complex appraisals appear to be associated with emotion schemas and are associated with higher-order thinking. This may necessitate ideation and symbolic language.

Emotional Entropy, Addiction, and Substance Abuse

It will be argued under *Inferential Statistics* that drug addiction and alcoholism may correlate strongly with high levels of emotional dysregulation and entropy. Studies suggest that emotional dysregulation early in life may also be a strong predictor for substance abuse, drug addiction and alcohol dependence later in life as indicated in Morioka, Howard, Caldeira, Wang and Arria (2018, para.1) and Murphy, Taylor, and Elliot (2012, para. 94). The American Addiction Center (2018) reports there are roughly twenty-one million people age fourteen and older who experience some form addiction in the U.S (para.1). Addiction is increasingly being understood as a disease. In fact, in the U.S. approximately 50% (10.2 million adults) are mentally ill and co-abusing substances, according to the National Alliance on Mental Illness (NAMI) (2018, para. 1). The reasons why people start using appear to be extremely complicated and not well understood. Statistical evidence indicates that like mental illness, addiction and substance abuse shortens the lifespan of the dependent person. Studies also provide evidence that increasing brain entropy is correlated with age (Yao, Lu, Xu, Li, Lin, Waxman, and Feng, 2013).

Evidence for Emotional Entropy

In *Inference and Entropy*, Kelley Wells (2014) claims that philosophic reasoning and argumentation are governed by the entropic process. He asserts that conceptually the premise moves to a conclusion in a logical argument like work toward equilibrium within an entropic system. He says:

> Thus inductive arguments as dissipative structures decrease entropy. But their uncertainty is an increase in entropy. Hence, they have the notion of a change in entropy

> built into them. Conversely, deductive arguments are idealizations and hide their entropy generation under a cloak. They appear to be logical "perpetual motion machines" but logical "perpetual motion" or certainty is impossible. Entropy is generated just the same. (p. 35)

Wells' argument on how reasoning works suggests that it replicates the organic entropy present throughout the physical world and by implication in biology. His argument is an analogy based on the abundance of evidence for entropy in the natural world (i. e. the universality of thermodynamics). If reasoning is a psychophysical process connected to emotion and belief (interpretations), then this theory of argumentation may be grounded in what is known about neurological brain function. Antonio Damasio (2005) observes:

> …there appears to be a collection of systems in the human brain consistently dedicated to the goal-oriented thinking process we call reasoning, and to the response selection we call decision making, with a special emphasis on the personal and social domain. This same collection of systems is also involved in emotion and feeling, and is partly dedicated to processing body signals. (p. 70)

It seems probable that memory, the hippocampus and different parts of the limbic system are implicated in this, as has been discussed. This strongly suggests an intersection between emotion and cognition. If these Mind-Brain processes are "orchestrated" together, then entropy occurring in cognition may also occur in the emotion as goal-driven work.

Wells (2014) continues his line of reasoning to present a new logical paradigm for philosophical inquiry based on uncertainty and probability statistics. He argues that because logic in philosophy employs words to construct arguments, philosophical reasoning is necessarily imprecise (Wells, 2014, p. 85). It cannot do the work of arithmetic computation and thus it is not "omniscient." He notes that philosophers fully concede this. But he emphasizes that words have contextual meaning not conveyed by arithmetic. He argues that the task of philosophers ought to be to cull this meaning while admitting to uncertainty (Wells, 2014, p. 85). Therefore, the best mathematical model offered to philosophical logic is provided in probability statistics, according to Wells (2014, p. 85). That is, the certainty of conclusions can only be predicted within a frequency distribution (or range) of possible conclusions.

Surely in human emotion, word symbols must play an important role as the secondary and tertiary processes to interpret and assign labels to emotions. But it is proposed that they are not necessary for humans or animals to experience emotion. Human beings may search for emotional meaning in a quest to find a purpose for what they do. In this sense, they seek to reduce emotional uncertainty. This is a high-level cognitive function which appears to be uniquely human, and it seems to be this same process which is employed by the philosophers discussed by Wells. It is advanced in this discourse that cognitive uncertainty and emotional uncertainty have very deep mind connections and efforts to resolve cognitive uncertainty bare a strong resemblance to cognitive appraisals.

It is asserted that this resemblance is not coincidental. Instead, even in its highest forms, what is commonly identified as cognition (i. e. the ability to reason logically) may be an extension of the cognitive appraisal process occurring in emotions. It is submitted that the complex mathematical equations created by astrophysicists and astronomers are symbolic forms which may be rooted in the primitive survival mechanisms of cognitive appraisals requiring no symbols or vocabulary. The evolution of the brain as part of the CNS may account for this connection. The idea of "premise to conclusion" thinking at its core involves an emotional assessment and a decision to act (or react) toward a specific goal. This appraisal work appears to apply to both inductive and deductive reasoning. In evolutionary terms, one can view this either from the top down or the bottom up. Viewing from the bottom up, perhaps emotion-based cognitive appraisals were the first form of estimation made by the earliest prehistoric humans and these survival defenses gradually evolved into higher level forms of thinking. Conceptually, therefore, it is maintained that emotions do *work* toward a goal just as is the case in higher level inference because they participate in the same process operating within thinking at all levels, and it is that work which tends toward entropy. As noted, Izard (2007, p. 265) observes importantly that this cognitive appraisal process occurs within emotion schemas which are the self-organized structures of emotions. This will be explained in greater detail.

A growing body of research suggests compelling correlative evidence for emotional or psychological entropy. The way entropy is measured will vary depending on the research. The fact that different metrics are applied to differing research designs means that the studies offer findings which are inconclusive and often raise more questions than they answer. Nevertheless, it is hoped they put forward

new understandings which can form the basis of emotional entropy research and a deeper perspective on psychology. Some of this research has also studied the effects of self-organization in thought patterns. In addition, psychological studies applying cognitive appraisal theory suggest validation for the theory. Descriptive examples of these studies are provided in what follows.

A study published in *Frontiers in Neuroscience* byCarhart-Harris, Leech, Hellyer, and Nutt (2014, para. 1) finds that human consciousness has two fundamentally different modes of cognition, based on their research model. The two modes of consciousness are distinguished by different degrees of entropy they exhibit, according to Carhart-Harris et. al., (2014, para. 1). The "primary consciousness" is characterized by a higher level of entropy and the "secondary consciousness" a lower level. Secondary consciousness is associated with the normal waking state in adults. The mind in this state is organized to represent the external world as precisely as possible. It scans the environment for predictable, stable patterns that presumably coincide with reality. In the higher entropy of primary consciousness, however, the mind is far less assiduous and accuratein its handling of the external world. It represents reality in a manner which is easily biased by emotions (Carhart-Harris et. al. 2014, para. 1).

Carhart-Harris et. al. (2014) collected data using psilocybin to induce the primary consciousness and increased levels of entropy (para. 1). They obtained data from two types of brain scans: magnetoencephalography (MEG), Magnetic Resonance Imaging (MRI) and functional magnetic resonance Imaging (fMRI). The researchers propose thatentropysuppression correlates with normalwaking (secondary) consciousness (i. e., aconstrainedquality). This includes the associatedmetacognitivefunctions,reality-testing, andself-awareness. Entropy disorder correlated with the primary consciousness during periods of rest and sleep. Still more interesting is the fact that these researchers include the important idea of self-organizing spatiotemporal patterns of thought. They state, “System entropy, as it is applied to the brain, is related to another current hot-topic incognitive neuroscience, namely ‘self-organized criticality’ (Chialvo et. al., 2007)” (Carhart-Harris et. al., 2014, p. 2). By self-organizing criticality, they are describing the way complicated systems (ones with multiple individual parts) driven from equilibrium as a result of repeated input of energy, start to show interesting characteristics at a critical point in the small area separating the two extremes of system order and

disorder. Thus, these researchers identify self-organization as a central principle to thought formation which opposes equilibrium in the brain (Carhart-Harris et. al. 2014, para. 2).

Clearly the Carhart-Harris et. al. (2014) model represents the two opposing forces that appear in biological entropy. On the one hand, there is the drift toward disorder and increased entropy, and on the other, there is the drive toward order occurring in negative entropy; the spontaneous self-organization. Based on their brain scans, these researchers may provide further evidence for psychological entropy which is grounded in understandings of biology. Based on the model, one might infer that increased levels of entropy (disordered thoughts) are associated with more emotion. The writer has some questions about the way the study rigidly compartmentalizes two modes of consciousness, however. A distinction between adaptive and maladaptive emotion schemas made by Izard (2007, p. 265) is not made here, and the study suggests that any emotional episode must challenge ordered cognition. In this study, disordered thoughts appear to result from excessive emotion rather than emotional disorder (dysregulation).

However, another study Duncan et. al. (2015) was described in the previous chapter. As mentioned, the researchers conducted brain research to examine how childhood trauma affects the adult brain (para.1). To do the research, researchers selected a group of psychologically healthy college students. Along with the Childhood Trauma Questionnaire (CTQ), researchers used extensive fMRI imaging to measure the variability of entropy. The findings of the study suggest that the higher the degree of early childhood trauma, the higher the degree of perigenual anterior cingulate (PACC) entropy in the brain's intrinsic activity later in early adulthood (Duncan et. al. 2015, para. 1). This result appears to suggest that higher degrees of early childhood trauma became encoded into the temporal structure (i.e. entropy of the brain's intrinsic activity at the time and persisted until early adulthood). It is proposed that these findings may be important in several ways. First, they may establish a linkage between emotions and memory, suggesting that emotional memory is encoded and retrieved during ones' life. Second, by indicating specific evidence of how remembered experiences are correlated with disturbing feelings in subjects, they suggest that the opposite may also be true (i. e. memories may be correlated with pleasant or stable feelings). In other words, normally, emotions may self-organize far from equilibrium in a healthy way. This last point is an inference not evident from the previously cited study. The Carhart-Harris et. al. (2014) study appears to create a false dichotomy between emotion and

cognition reminiscent of the dualism discussed in Chapter 2. However, this study does not appear to do this. In this case, it is a memory of emotional trauma which is correlated with increased entropy, not modes of consciousness in which emotions are in greater control. Hence, the Duncan et. al. (2015) study appears to lend support to the theory of emotional entropy based increased levels dysregulation whereas Carhart-Harris et. al. (2014) appears to implicate the role of all emotions in cognitive entropy.

An important additional piece of evidence is suggested in the research of Garcia-Martinez, Martinez-Rodrigo, Cantabrana, Garcia, and Alcaraz (2016). The purpose of their study was to apply entropy-based metrics to reliably identify emotional distress (para.1). In this nonlinear analysis of physiological signals, there were three metrics applied to discern (correlate) the states of calm and negative stress (distress). The major problem in measuring emotions is the lack of a standard model for their definition. For this study, emotions were defined using the widely accepted model of valence. First developed by Russell (2003), the valence scale is a two-dimensional emotion measure of "pleasantness or unpleasantness" (positive or negative) as well as emotional intensity. The metrics used were: sample entropy (SE), quadratic sample entropy (QSE), and distribution entropy (DE). Electroencephalographic (EEG) recordings from 32 subjects were analyzed. Significantly, the researchers found that QSE has the ability to correlate with negative stress with a discriminant ability of about 70% (Garcia-Martinez et. al. 2016, para. 1). This makes QSE the first single metric known to have this ability. Garcia-Martinez et. al. (2016) also report that QSE provides significant differences between brain regions in the triggering of neural activation by the two considered emotions (calm and distress) (Para. 11). The other two metrics of SE and DE did not produce this result. The study has introduced a new metric based on valence which may have application in measuring emotional dysregulation. By applying QSE to measure emotional distress, it appears to demonstrate how increases in dysregulation translate into measurable increases in entropy. Long-term application of QSE and other similar measures may vastly improve scientific understanding of how entropic emotional states emerge.

A similar study was conducted by Candra, Yuwono, Handojoseno, Chai, Su and Nguyen (2015) who explored how the EEG could be used to identify four emotions of happiness, sadness, anger, and relaxation (para. 1) by extracting wavelet energy and wavelet entropy. They also applied a measure of valence as emotional differentiation which established that they came from wavelet features of alpha,

beta and gamma bands. They then were able to extract information describing each emotion. Based on analysis using the Data for Emotional Analysis using EEG, Physiological and Video Signals (DEAP), a high rate of specificity was indicated (Candra et. al., 2015, p.4).

Chu, Huang, Jian and Cheng (2017) conducted a study of individuals diagnosed with schizophrenia in which they used EEG entropy to identify normal, moderate and markedly ill schizophrenic patients (p. 1). The aim of the researchers was to assess the effectiveness of this methodology using different approaches to calculating entropy (Chu et. al. 2017, p. 1). To conduct the research, they employed the international affective picture system (IAPS) to evoke emotions and the corresponding signals were collected using EEG (Chu et al. 2017, p. 1). The record of different brainwave points, frequency and entropy were used to identify the different groups of patients. The result was that in applying their entropy equations to the data collected, one equation, Approximate Entropy (ApEn), stood out as having a high success rate in discerning the severity of illness among this population of schizophrenics (Chu et. al. 2017, p. 1).

Coupled with the use of IAPS to evoke emotional responses, the identification result using the ApEn equation was as high as 81.5% with the markedly ill group. When Chu et. al. (2017) applied it to moderately ill patients, the identification correlation was as high as 79.5% (p. 1). Also noteworthy was that the researchers observed a significant difference in the brainwaves of normal patients when compared to the other groups. The pertinence of the Chu et. al. (2017) study to this argument is that it both suggests that schizophrenia of different degrees of severity may be correlated with varying levels of entropy and it provides a possible means for measuring this. Is it possible then that increasing levels of entropy are associated with all other mental disorders? That of course, is exactly what is postulated in the entropy theory of emotions.

Finally, in a study of major depression using measures of entropy in heartbeat, Valenza, Garcia, Citi, Scilingo, Tomaz and Barbieri (2015) measured heartbeats recorded on an electrocardiogram (ECG) from a sample of 48 Hispanic outpatients diagnosed with major depression (MD) (para.1). The goal of the research was to determine if using the nonlinear measures of inhomogeneous point-process approximate entropy (ipApEn) and inhomogeneous point-process sample entropy (ipSampEn) could effectively describe the unique characteristics of MD patients experiencing emotional stimuli (Valenza et.al. 2015,

para.1). The use of the ECG allowed for continuous monitoring and the subjects were intermittently exposed to audiovisual stimuli. Measures of ipApEn and ipSampEn were thus calculated at continuous instantaneous intervals for the full monitoring duration (Valenza et al. 2015, para. 1).

According to Valenza et. al. (2015), the results of the study suggested they were consistent with similar findings applying entropy measures to the rate of heartbeats of MD subjects and they validated the measures as a possible means of effectively identifying persons with MD (para. 37). The heartbeat rates of MD patients during stimuli and arousal were slower and not consistent with normal heartbeat patterns (Valenza et. al. 2015, para. 38). Thus, it can be inferred that people experiencing MD may represent a statistical outlier in terms of emotional reactions and this may be interpreted as increased emotional dysregulation. Using ECG in this manner to predict MD or other mental disorders may have utility.

In addition to the neurological research focusing on psychological functioning, there have been many studies which focus on how entropy occurs the brain. These studies tend to view the brain more as a neurological system connected to the CNS. Since such studies also lend support to entropy in emotions, an example is provided in what follows.

Previously mentioned was a study conducted by Yao, et. al. (2013). The researchers studied entropy to measure the aging properties of the brain (Yao, et. al. 2013, p.1). Using fMRI data from a large dataset of people and measuring resting state blood oxygen level dependent (BOLD) signals, Yao et. al. (2013) determined that increased brain entropy is correlated with increases in age (p. 1). During an average lifespan, BOLD signals occurred with greater frequency and were distributed throughout the brain while the number of excitatory neurons and conductance decreased over time (p. 2). Their dataset included both males and females. Surprisingly, the data showed that males at birth had lower entropy than females. But at about age 50, there was an intersection between the genders and after this age entropy for males was greater than for females (Yao et.al., 2013, p. 4). This research appears to be compatible with the assumptions underlying the theory of emotional entropy. It is submitted that as people grow older, they are more susceptible to a range of mental disorders which represent emotional dysregulation. Dementia, Alzheimer's, depression and Parkinson's may present a threat to gradually disintegrate one's personality. It is asserted that what opposes this is the growth of cognitive and self-regulating emotional engagement as self-organization in the brain.

Emotional entropy can also be inferred through an analysis of the ANS and arousal. For example, there is more neuroscientific evidence for emotional entropy presented in the research of Donald Pfaff (2006). In his extensive study of brain arousal, Pfaff (2006) notes that beneath one's mental functions and emotional episodes there is a primitive arousal system (p. 1). Through his application of information theory, Pfaff presents a new transformative scientific approach to understand the structure of brain arousal and how it interacts with thoughts and behaviors. It is within his application of Shannon's information theory that Pfaff shows how arousal mechanisms may be connected to brain entropy and changing emotional states. In essence, what Pfaff presents is a construct of physiological arousal entropy which may be the foundation for brain and emotional entropy. He contends for example, that fluctuations in brain entropy may allow a person to raise excitement and then reduce it in the form of rewards (Pfaff, 2006, p. 64).

Pfaff (2006) uses an example to illustrate the information flow associated with the neurobiology of arousal and measuring uncertainty (p. 13). For the sake of simplicity, he uses a span of time in which two possible events can occur, the waving of a blue flag or the waving of a red flag. He observes:

> If the red flag is waved all the time and the blue flag not at all, no information is transmitted by either flag. And vice versa. However, if the flag selection is random, with a 50:50 chance of either flag being selected, as much information is being transmitted by those flags as can be. When all the events are equally probable, information is at its top value (see the following example for taste nerves). Disorder maximizes information flow. At the opposite extreme, perfect order minimizes information flow. Coming from thermodynamics, the technical term for disorder in Shannon's equation is entropy. (Pfaff, 2006, pgs. 13-14)

What Pfaff is explaining here is well understood, as has been described previously in Chapter 3. However, based on neuroscience, Pfaff (2006) is arguing for the centrality of this law of entropy in the functioning of arousal mechanisms (p. 64). He goes on to describe how Shannon's information theory formula is applied by scientists to the Central Nervous System (CNS). He explains:

> First, consider the trains of action potentials, or 'spikes', exhibited by nerve cells. If time is split up into bins and spikes are counted as either occurring or not within each bin, the amount of

> information in the spike train is calculated by a formula deriving from Shannon's equation. Similarly, the amount of information inherent in the response to a novel stimulus can be compared to the (smaller) entropy calculated from the repeated stimuli. (Pfaff, 2006, p.14)

A basic methodology employed in neuroscience is being described by Pfaff. Its significance is twofold. He is illustrating the power of applying Shannon's equation to calculate entropy (uncertainty) in understanding how arousal influences thoughts and he is claiming that there can be no argument that the Shannon equation measuring disorder in information is fundamentally operational in arousal, thoughts, emotions, and behaviors (Pfaff, 2006, p.25).

Hence, Pfaff (2006) asserts that if there is change, there must be some uncertainty about the environment (p. 25). He contends that information theory provides a universal quantitative approach to understanding neuronal, emotional and behavioral responses to a wide variety of human situations (Pfaff, 2006, p. 25). He argues, "High-information stimuli produce responses that range from stark fear to belly-shaking laughter. Information theory can reveal similarities and differences in behavioral data for which conventional mathematical statistics come up empty" (Pfaff, 2006, p. 20). The cited evidentiary studies demonstrate how this may be possible, in this analysis. Yet presently these sorts of neuroimaging applications are still quite new. It is important to be reminded that the way Pfaff (2006) is describing the uses of information technology is based on measuring physiological responses (neuron firings) which are connected to behaviors. It is, therefore, an extension of behaviorism and while this very often correlates to mental experiences, it is not the same as an emotional episode. As noted in the previous chapter, the other point which should be considered is that in living systems, thermodynamic information behaves differently than semiotic information, as observed by Avery (2012, p. 95).

It can be inferred that Pfaff understands this. He cites data and research extensively showing how patterns of ANS response emerge in the body and demonstrates how generalized arousal is connected to sexual behavior, fear, hunger, thirst and more (Pfaff, 2006, p. 26 – 51). In one schematic, he provides a simplified visual representation of the five major neurochemically distinct systems of arousal which are associated with the ANS. These are norepinephrine (NE), dopamine (DA), serotonin (5HT), acetylcholine (Ach) and histamine (HA). He indicates, it is the 5HT serotonin which perhaps plays the most significant role in emotions (Pfaff, 2006, p. 27). Through its influences on the limbic cortex and hypothalamus, it is

the stimulus-response for emotion creation, and it is this area of the cortex which humans share with other animals. This is the primitive basis for mental experience and it strongly suggests that arousal centers are most often localized to areas of the brain (Pfaff, 2006, p. 27). It is also the DA which is typically attributed to a powerful response to pleasure arousal. DA is implicated in addiction and substance abuse for this reason (Pfaff, 2006, p. 34). As noted, there is good evidence that the amygdala may play a significant role in producing emotion responses. Pfaff (2006) mentions that the amygdala has a direct connection with the lower brain stem and argues that it clearly manages autonomic responses to "emotionally laden stimuli" (p. 76). However, he also argues that the hypothalamus plays a central role in sexual arousal and that this is closely associated with the amygdala (Pfaff, 2006, p. 33).

The studies and research described thus far offer interesting and exciting neuroscientific evidence for emotional entropy. Numerous other research examples could have also been included. New research moving neuroscience closer to how entropy occurs in psychology is being published nearly every month.

A review of evidence for the second hypothesis will follow. As noted, the hypothesis is that emerging emotions spontaneously self-organize and that emotional episodes combine into emotion schemas. But how exactly does this process occur? Izard, Brian, Ackerman, Schoff, and Fine (2000) provide important insights. They argue:

> Although person-environment transactions play a role in the development of healthy emotions, the potential for each component of each discrete emotion self-organized in phylogeny and emerged as evolutionary adaptation. Individual emotions also coassemble with other emotions to form contingent emotion patterns that stabilize over repetitions and time. (Izard et. al. 2000, p.15)

In this way, it is proposed that individual emotions are both the product and material of system organization. The systems are self-organizing because repeated interactions among component processes generate emergent properties. Izard et. al. (2000) call their model differential emotion theory (DET). They argue that a core principle is that emotions operate as complex systems and that they emerge as a result of interactions of neurohormonal, motoric and experiential processes (Ackerman, Abe, and Izard, 1998, p. 86). Hence, from a systems perspective, DET fits well within the theories of dynamic systems (DS).

DET describes each individual emotion as a system and more complex systems are created by sets of patterns of co-occurring emotions (Ackerman, et al., 1998, p. 85). All individual and emotional patterns operate in a more inclusive emotional system. According to Izard et. al. (2000), "…the emotions system functions as the primary motivational system within the superordinate self-system or personality. Personality development emerges through interactions of emotions and cognition and their linkage in affective-cognitive structures" (p. 16). This interaction between emotions and cognition involves a cognitive appraisal according to Izard (2007, p. 265). The theory thus brings together two presupposed elements of the entropy theory of emotion.

It is these co-occurring patterns of emotions which Izard (2007) labels emotion schemas and it is within these systems that appraisal happens (p. 265). He says, "Emotion schemas, the most common emotion experiences in older children and adults, involve higher order cognition and may involve complex appraisals…" (p. 265). Because this is described in synergetic terms of DS, it can be inferred that the theory is grounded in an understanding of entropy and the Second Law of Thermodynamics. Though Izard does not appear to consider the implications of this in her model, it nevertheless has tremendous relevance here.

Izard (2007) emphasizes that there are both adaptive and maladaptive emotion schemas and these are based on appraisals (p. 265). He observes that a set of coherent emotion schemas may be similar to an affective style or to a form of psychopathologies such as anxiety or depressive disorders (Izard, p. 265). She argues, "Maladaptive connections between emotion feeling, cognition, and action can lead to behavior problems and psychopathology (Izard et. al. in press; Izard, Youngstrom, Fine, Mostow, & Trentacosta, 2006)" (Izard, 2007, p. 266). It is submitted that her insight based on psychological research is foundational in describing how emotional dysregulation should be understood because it is argued that this represents increased levels of entropy in emotional systems.

While this emotional self-organization paradigm lends strong support for the arguments presented in this analysis, there is a point of departure which is necessary to address. The DET model is based on the premise that there are a set of "basic" or natural emotions out of which emotion schemas will get assembled (Izard, 2007, p. 261). Izard (2007) is the first to admit that defining such a set is very difficult and therefore there is confusion and disagreement among experts about how those emotions are defined

(pgs. 261 – 264). But he defends her theory based on evolutionary characteristics which she asserts are universal. She says:

> Basic emotions may be categorized as natural kinds on the basis of a common set of characteristic properties. These properties include emotion-specific universal capacities to regulate and motivate cognition and action independent of the cycle processes that characterize homeostasis and physiological drive states like hunger and thirst (Izard, 1971; Tomkins, 1962). (Izard, 2007, p. 261)

Thus, he claims a basic emotion can be distinguished from an emotion schema by possessing the properties of regulating and motivating thoughts and actions independent of the cyclical processes of homeostasis or physiological drive states. On this basis, he argues for the five basic emotions of joy/happiness, sadness, anger, disgust and fear (Izard, 2007, p. 261).

A major difficulty with this contention is that there is no evidence that emotion episodes ever present themselves *independent* of the cyclical processes of homeostasis and physiology. As has been shown in Pfaff (2006) for example, there is an inseparable connection to arousal, the ANS and the CNS (pgs. 26 – 34). It presently is impossible to demonstrate an independent causal connection of an emotional episode to motivate and regulate cognition and action. It is proposed that emotions emerge far from equilibrium in a relatively stable state. For emotions to operate independently of homeostasis and physiology would appear to violate the Second Law of Thermodynamics.

Yet, creating a set of "basic" emotions is problematic in other ways as well. For example, for psychologists to reach a consensus on how many there should be and criteria for them, has proven to be an impossible task. It is argued that too much importance is often placed on the set of labels (emotion words) used to describe the emotional experience. Cultural differences factor significantly into how one sets up this list and how one categorizes their emotional experience. Izard (2007) does an excellent job of outlining how emotional development works to create emotion schemas and he also is keenly aware that emotions developed through human evolution. Nevertheless, characterizing pre-language emotion experience with a set of labels seems questionable when there are so many different interpretations of emotional experience. To be sure, based on observations of both animal and human behaviors as well as the evidence derived from neuroscience, there appears to be little doubt that emotional experience is

omnipresent and that much of it is unlearned (Izard 2007, p. 261; Darwin 1872/1992, p. 150; Bekoff, 2011). It also seems probable that through development from infancy to adulthood, emotions become better articulated and refined and this forms the basis for the creation of emotion schemas as asserted by Izard, (2000, p. 16) as well as Lewis and Granic (2000, p. 2). Izard (2007, p.265) also acknowledges the utility of the valence (pleasant and unpleasant) positive and negative emotion scale of James Russell (2003). The scale avoids ambiguously labeling emotion, as noted. But unfortunately, he insists on claiming the existence of knowable basic emotions which somehow operate independently of physiology and homeostasis.

While it may be possible at some future date to ascertain a kind of "periodic table" of discrete basic emotions, no such evidence presents itself at this writing. Even if they become clearly measurable and understood, it seems very unlikely they will operate separately from physiology. Therefore, for purposes of this discussion, there will be no determination made concerning a basic set of emotions and no references to such a set. Instead, the valence scale of Russell (2003) will be used as a more reliably measurable gauge of emotional responses. As for emotion episodes which are not a part of emotion schemas, it is proposed that they are simple emotion events (episodes) decoupled from schemas. In the writer's opinion, It is not necessary to see them within any hierarchy of basic to co-emotional patterns. It is postulated that simple emotion is usually characterized by being brief in duration and inclusive of a simple appraisal (such as threat or safety, approach/avoidance). It is argued that it can play a powerful role in regulating emotion behaviors, but this latter characteristic is one which it has in common with emotion schemas. Thus, it is contended that lower level animals are capable of simple emotion and simple appraisals (Faustino, et. al. 2015; Boissy, Aubert, Desire', Greiveldinger, Deval and Veissier, 2011). On the other hand, it is posited that emotion schemas spontaneously self-organize from simple emotions, they tend to be longer in duration, and they tend to involve high-level (complex) cognitive appraisals. Schemas are thought to also play a powerful role in regulating emotion response as well as behavior primarily because they are interpretations of the environment. When they break down, it is contended that the psychopathologic tendency toward dysregulation (entropic disorder) is increased. This does not diminish the brilliant paradigm supplied by Izard (2007) which as noted, may be a strong defense for self-organizing emotions.

More support for spontaneously self-organizing emotions can be found from Mark Lewis (1970). He argues from a DS perspective that there are five principles of self-organization involved in emotion-cognition feedback (para. 1). These principles may explain the individual differences in personality and social behavior. It is their interaction which may be the source of fundamental stability, diversity, and change in individual development, according to Lewis (1970, para. 1). The five principles of self-organization are feedback, order through fluctuation, stability, change and disequilibrium (Lewis, 1970, para. 1). He claims the principles apply to cognition-emotion relations at the microdevelopmental level of seconds, minutes and hours, and the macrodevelopmental level (Lewis, 1970, para. 1). This implies that the organization of behavior microcosmically reflects the organization of the whole personality.

Research conducted by Fogel, Nwokah, Dedo, Messinger, Dickson, Matusov and Holt (1992) presented the hypothesis that emotions are not states but self-organizing dynamic processes connected to the flow of individual activity and context. In their study, they review data on the relationship between emotional actions and social context, in particular, smiling and laughter (p. 122). The researchers constructed a model to show how emotional processes in early infancy become embedded into sociocultural systems and to propose new avenues for research. The researchers claim their dynamic self-organizing processes construct better explains the data they reviewed. Noteworthy is the fact that Fogel et. al. (1992) argue there is insufficient empirical evidence for a set of core or "basic" discrete emotions at birth. They assert that data on the first two weeks of infancy suggests wide-ranging contextual modulation and expressive variability (Fogel et. al. 1992, p. 128). The model the researchers propose is one involving self-organization from the interaction between the acculturation of emotions and the infant's detection of invariants in emotional gradients that are embedded in social routines. In other words, they argue emotions are learned through cultural exposure and the early awareness of predictable repetitious behaviors (Fogel et. al., p. 129).

Hence, Fogel et. al. (1992) appear to make a strong case for the existence of self-organization in emotional experience. Nonetheless, they depart from Izard (2007), Panksepp and Bevin (2012), Lewis and Granic (2000), as well as Darwin (1872/1992) by concluding that innate emotion cannot exist because it cannot be adequately measured in early infancy (p. 128). Given the inconclusiveness of this evidence and evolutionary data which contradicts their conclusion, this appears to be spurious reasoning.

While as has been noted, one must be cautious in interpretations of emotion experience, it does not follow that all emotion is due to acculturation and learned interactions. Secondly, the heavy emphasis placed on the role of socialization in emotional organization appears to completely ignore the possibility of interplay in affective-cognitive processes that is arguably inherent to simple emotions and emotion schemas. The researchers appear to have entirely abandoned the DS model in their approach. However, the researchers stress the importance of much more study of their construct and its presentation of a variant of emotional self-organization provides new insights about the importance of social interaction and context (Fogel et. al. 1992, p 129).

In another article, Lewis (2004) asserts that using the DS principles provide a connection between the psychology and neurobiology of emotion (p. 2). He contends psychology coupled with neural processes can be explained in terms of bidirectional causation and emergent part-whole relations (Lewis, p.2). This is grounded in a model of self-organizing states in explicit correspondence between psychological and neural events. Thus, he argues that cognitive appraisals influence emotions and emotions influence cognitive appraisals, and therefore, cognition. Much like Izard (2007), he recognizes that dynamic emotions theory allows for a reconceptualization of emotion-appraisal states as self-organizing wholes (Lewis, p. 2). They emerge resulting from bidirectional causal interactions among perceptual, cognitive and emotional constituents creating a circular causality (or reciprocity). Central to his premise then, is the theory of cognitive appraisals. According to Lewis (2004):

> A variety of studies have shown that pre-attentive appraisals are sufficient to elicit an emotion such as anxiety, fear (Ohman, 1988; Ohman & Soares, 1994; Robinson, 1998), and possibly anger (Berkowitz, 1989). Interestingly, this corresponds well with evidence that coarse perceptual processing by the amygdala is sufficient to activate emotion (LeDoux, 1987; see also Lazarus, 1999; Scherer, 1993) and that animals without cortical controls have intact emotional responses (LeDoux 1995a; Panksepp, 1998). (p. 12)

But Lewis (2004) points out that most psychological researchers are concerned with "higher-cognitive" levels of appraisal as has been represented in the writing of Izard, for example (p. 12). Evidence shows, however, that these appraisals often occur very rapidly and do not require ideation (Lewis, 2004, p. 12). He also observes that the major flaw with most appraisal theory models is they are one-way (linear),

presenting the effect of cognition on emotion and not the reverse and may require consciousness (Lewis, 2004, pgs. 13 – 14).

Lewis (2004) argues that the DS analysis of the neurobiology and emotion demonstrates concretely that emotions and cognition were never distinct (p. 14). They are not distinct at the level of interacting parts or at the level of the wholes to which the interacting of the parts give rise (Lewis, 2004, p. 14). He says, “While it remains useful to differentiate cognition and emotion for many research agendas, a neuroscientific analysis finds them to be different aspects of a unitary phenomenon in which interpretation and relevance merge together” (p. 91). Clearly, this argues for a fundamentally new way of understanding thought processes and emotional events. It is advanced that Lewis’ research offers a compelling defense for the concept of self-organizing emotions based on cognitive appraisals. But also noteworthy is that he contends that emotions emerge in a nonlinear DS wherein simple visceral appraisal (often observed in animals) and cognitive appraisal (associated with high-level cognition in humans) work in a bidirectional fashion (Lewis, 2004, p. 29). His concept of interactive dynamic emotions forming into “wholes” is analogous to emotion attraction into schemas of Izard (2007, p. 265).

It is submitted that this is a compelling basis on which to predicate this discussion and it can be expanded to observe that appraisal-based emotions are goal-driven (Lazarus, 1991, p. 222). Thus, it is maintained that they do work toward a goal. Both conceptually and thermodynamically, it is inferred that they expend energy far from equilibrium in a stable zone close to chaos. As has been presented, the tendency toward entropy is always to increase, though this tendency is opposed (and thus delayed) with self-organization. Secondly, as has been argued, higher-order cognition and emotion-based appraisals exist in a seamless evolutionary continuum from simple to complex appraisals as the basis for (and evidence of) emotion in all animals.

, There is evidence that there is a close association between emotion and memory stored in the hippocampus. Adding to the previous defenses is the evaluation made by Teuvo Kohonen (1989) of the research into memory processes. In his book *Self-Organization and Associative Memory*, he discusses the mapping of the brain neural networks and his analysis of both long-term and short-term memory function. He says:

Although a part of such ordering in the brain were determined genetically, it will be intriguing to

> learn that an almost optimal order, in relation to signal statistics, can completely be determined in simple self-organizing processes under the control of received information. (Kohonen, 1989, p. 119)

Most remarkably then, Kohonen (1989) is stating that there now exists evidence for self-organization in memory processes. It is an ordering process which usually does not involve the movement of cells or units. Instead, it is an optimal ordering in relation to signaling statistics determined by simple self-organizing processes under the control of the received information, and he contends that it is this spatial order which is necessary for the effective mental representation of information models (Kohonen, 1989, p. 119).

These “maps” formed in self-organization use one and two-dimensional representations to describe topological relations of input signals and they are fundamental in the formation of abstractions as well, according to Kohonen (1989, pgs. 120 – 121). He also discusses the role of the hippocampus in memory storage and retrieval (Kohonen, 1989, p. 121). If he is correct concerning how memories are dynamically processed in self-organization, he makes a convincing case for a close linkage to emerging emotional processes in the limbic system (Kohonen, 1989, p. 121). Indeed, the self-organization of emotion and memory signals may be the same process so that the maps which are formed comprise information and emotionality.

J. A. Scott Kelso (1995) has conducted research over several decades focused on extending the physical concepts of self-organization to the nonlinear dynamics of the brain.Noteworthy in his research is his use of superconducting quantum interference devices (SQUIDs) which are highly sensitive detection devices usually employed with magnetoencephalographies (MEGs). Based on his research, Kelso (1995) makes the following assertion:

> Like many nonequilibrium systems in nature, at critical values of a control parameter, the brain undergoes spontaneous changes in spatiotemporal patterns, measured, for example, in terms of relative phases, spectral properties of spatial modes, and so forth. Remarkably, these quantities exhibit critical slowing down and fluctuation enhancement, predicted signatures of pattern-forming instabilities in self-organizing (synergetic) systems. (p. 284)

Hence, Kelso (1995) is detailing important evidence for spatiotemporal spontaneously self-organizing thought patterns (pgs. 260 – 284). He is describing its occurrence in an entropic brain with no equilibrium, or a brain in which negative entropy occurs. By inference, this must exactly be the process which would occur when an emotional episode emerges. This is the same process which Avery (2012) and Kauffmann (1993) describe as occurring in biology. It also is the same process described by Pfaff (2006) within the ANS, and by Kohonen (1989) within associative memory of stored in the hippocampus.

Spontaneous self-organization of spatiotemporal patterns derives from stochastic or determined origins within the brain, according to Kelso (1995, p. 284). Kelso (1995) asserts that these patterns emerge, and new patterns are created when the environment, tasks or internal conditions demand it (p. 284) They are patterns occurring as nonequilibrium transitions and they are a mechanism involving the collective action of neurons (Kelso, 1995, p. 284). He observes that this rapid brain switching mechanism enters various coherent states (of consciousness) and provides the brain tremendous flexibility (Kelso, 1995, p. 284). This may suggest a conjoining of emergent affective-cognitive, spatiotemporal patterns in the brain. By implication, therefore, Kelso (1995) appears to acknowledge the existence of emotional spontaneous self-organization within the entropic system of the brain. Indeed, his research is cited by Lewis (2004).

But Kelso and Engstrom (2006) observe that over the centuries of neurological and psychiatric research there has been a controversy about how the brain works. (p. 143) The debate has been between those who argue in favor of localization and segregation of brain function, and those who insist it is a highly integrated organ that works by a kind of “mass-action” (Kelso and Engstrom, 2006, p. 143). However, they propose that the two models of brain function are not mutually exclusive (Kelso and Engstrom, 2006, p. 143). They ask, “Might such a subtle blend of integration and segregation hold the key to understanding the brain ~ mind, as well as complementary pairs *and* the complementary nature" (Kelso and Engstrom 2006, pgs. 143-144)? Their answer is that this is exactly how the brain works and they elaborate on this model to describe self-organization of spatiotemporal patterns in the brain (Kelso and Engstrom, 2006, p. 144).

Thus far, evidence and supporting arguments have been put forward suggesting the validity of emotional entropy and the spontaneous self-organization of emotions. Similar evidence for cognitive

appraisals will be reviewed in the examples of studies that apply appraisal theory in what follows. Though they are not bidirectional as critiqued by Lewis (2004), it is proposed that they demonstrate effectiveness in capturing emotional outcomes resulting from one-way goal-directed estimations (work). Within a nonlinear DS, it is argued that this same goal-directedness exists in simple emotion experience and does not require conscious awareness or ideation. These primitive visceral appraisals can very often have a great impact on high-level cognition. Hence, it is claimed that this affective-cognitive process is bidirectional.

The first example is a study conducted by Meade, Wang, Lin, Wu, and Poppen (2009) using cognitive appraisal coping measures on Chinese villagers infected with HIV/AIDs (para. 1). The study analyzed stressors on a population of rural villagers in China who were exposed to HIV/AIDs as a result of being former commercial plasma blood donors (FPDs) during the 1990s (Meade et. al., para.1). For the study, 207 participants were selected representing multiple villages and they completed a battery of questionnaires assessing HIV-related stress, HIV symptoms, cognitive appraisal, coping behaviors and psychological distress (Meade et. al. 2009, para. 1).

The results of the study according to Meade et. al. (2009), were that participants reported high levels of HIV-related stress, depression, and anxiety (para. 27). Based on a structural equation model, the greater HIV-related stress, symptoms of HIV, and threatappraisal were directly associated with psychological distress. HIV-related stress wasalso indirectly associated with psychological distress through the threat appraisal. In asecond model, coping was found to mediate the relationship between the challengeappraisal and psychological distress (Meade et.al. Para. 28). The researchers maintain that the results support the utility of cognitive appraisaltheory and its specific application tostress management interventions and they argue that it has direct application in targeting HIV-positive FPDs in China (Meade et. al. Para.36). This study may also lend validity to the model as a cross-cultural application.

Another longitudinal study involving a sample of 407 older adults conducted by Hermsen, Van der Wouden, Leone, Smalburgge, Van der Horst and Dekker (2016) used cognitive appraisal to correlate physical function (PF) with perceptions of joint pain in connection with comorbidity (para. 2). There is substantial variation in how patients with comparable pain severity will cope with pain and Hemsen et. al. (2016) point out that the extent to which determinants effect PF remains unclear (para.1). The purpose of

their study was to apply longitudinal quantitative measures of cognitive appraisal to evaluate the statistical significance of psychological attitudes in influencing the improvement or the deterioration of PF (Hemsen et al., paras.1-2).

Hemsen et. al. (2016) used five measures of cognitive appraisal strategy and four measures of coping strategy (para. 6). The cognitive appraisal strategies measured were: 1) consequences 2) concerns 3) emotional representations 4) self-efficacy and 5) catastrophizing (para. 6). The coping strategies measured were: 1) ignoring pain 2) positive self-statement 3) increasing activity levels and 4) activity avoidance (Hemsen et. al., Para. 6). The findings of the study were that increases in negative thoughts about the consequences of pain were correlated with increased catastrophizing and increased activity avoidance appeared to contribute significantly to the deterioration of PF (Hemsen et. al. 2016, para. 3). By contrast, higher perceived self-efficacy appeared to aid improvements in PF (Hemsen et. al., 2016, Para.3). Hence, the saliency to this discussion is that understanding cognitive appraisal may unlock hidden goal-driven emotion strategies.

In a different study, Ritland and Rodriguez (2014) evaluated whether exposure and attention to anti-obesity media content increases people's appraisals of threat and their ability to cope with it (para. 1). It also assessed whether these cognitive processes, in turn, affect people's intention to abide by the practices recommended to prevent obesity (Ritland and Rodriguez, 2014, para.1).To arrive at the sample, an online questionnaire was emailed to a random sample of sixteen thousandcollege student residents of Iowa. The sampling frame was secured from the Office of the Registrar of Midwestern University (Ritland and Rodriguez, 2014, para. 23). Data gathering was conducted over a seven-week period and a total of six hundred and thirty-three students returned their completed questionnaires for a response rate of 4%. To diversify the sample, a link to the online survey was posted on the social networking site Facebook, asking the participation of adult Iowa residents (Ritland and Rodriguez, 2014, para. 23). Following this online solicitation, eighty-nine completed questionnaires were received (N = 722) (Ritland and Rodriguez, 2014, para. 24). They performed two multiple regression tests to determine the effect of threat appraisal and coping appraisal (exercise) on intention to exercise and the influence of threat appraisal and coping appraisal (diet) on intention to maintain a healthy diet (Ritland and Rodriguez, 2014, para. 45).

The results suggested that only coping appraisal (exercise) is a significant predictor of intention to exercise. However, both variables appeared to be significant predictors of intention to maintain a healthy diet, according to Ritland and Rodriguez (2014, para.46). These results suggest that people associate the coping mechanism of maintaining a healthy diet more highly (compared to that of exercising) with combatting obesity (Ritland and Rodriguez, 2014, para. 53). The researchers interpreted the absence of threat appraisal influence on intention to exercise as suggesting people think of exercise as an activity that offsets health threats besides obesity (Ritland and Rodriguez, 2014, para. 53). Thus, the study suggests that people still intend to exercise despite having a low perceived obesity threat, according to Ritland & Rodriguez (2014, para. 53).

Ritland and Rodriguez (2014) concluded, based on their results, however, that coping appraisal significantly contribute to the intention to exercise and maintain a healthy diet (para. 55). Together, they argued these factors are significant predictors of intention to diet (para.55). But coping appraisal appeared to be the only significant factor of the two in predicting intention to exercise and because of the importance of coping appraisals, the researchers also concluded that self-efficacy and response efficacy are stronger predictors of behavioral intention than perceived vulnerability or severity (Ritland and Rodriguez, para. 56). Thus, they contended that coping appraisal strongly predicts the intention to exercise while weakly predicting the intention to eat a healthy diet (para. 57).

Therefore, Ritland & Rodriguez (2014) argued that although threat appraisal influences behavioral intent in connection with diet and exercise, coping appraisals play a larger role (para. 57). Hence, both their application and analysis of people's responses to obesity-related media may lend support to the cognitive appraisal theory in understanding motivation and emotion.

Finally, Bigatti, Steiner & Miller (2012) provide another example in their study conducted to evaluate cognitive appraisals, coping and depression in breast cancer patients (p. 378). Guided by the Transactional Theory of Stress developed by Lazarus & Folkman (1984), the researchers examined the relationship between cognitive appraisals, strategies for coping and depressive symptoms among a sample of sixty-five women scoring in the normal range of depressive symptoms (Bigatti et.al., 2012, p. 378). The researchers used path analysis (statistical measures of directed dependency) in combination

with Cognitive Appraisal of Illness (CAI) scale, the Ways of Coping Questionnaire (WCQ) and the Center for Epidemiological Studies Depression scale (CESD) (Bigatti et.al., 2012, p. 380).

According to Bigatti et. al. (2012), 11.9% of the subjects reported having, “ever been diagnosed with a mood disorder” and 39% reported that they suffered from what they described as “depression anxiety” (pgs. 381 – 382). Their mean score on the CESD fell within the normal range of mood, but they scored highest on challenge appraisals and lowest on benign appraisals (Bigatti et. al., 2012, pgs. 381 – 382). In the end, the path analysis showed that higher appraisals of harm/loss and greater use of escape-avoidance coping predicted higher depressive symptoms (Bigatti et. al., 2012, p. 382). The findings appear to improve upon the prediction of depression among breast cancer patients. They, therefore, may suggest the need to examine cognitive appraisals when attempting to understand depressive symptoms (Bigatti et. al., 2012, p. 382).

Inferential Statistics

Comparisons of inferential statistics and statistical analysis may suggest meaningful evidence of emotional entropy. Emotional dysregulation is conceived of as a process leading to death because it consumes more energy at a faster rate and thus wastes more energy. Schrodinger (1944/1992) argued that living organisms continually increase in entropy by paradoxically using the energy available to do work derived from the natural world (p. 497). It is submitted that if it assumed that entropy occurs in emotional states, it must be viewed as a subprocess of a dynamic living system. It is reasoned, therefore, that emotional entropy must not be viewed as an autonomous process acting on a living brain. Instead, paralleling Schrodinger's understanding of entropy in living organisms, it is proposed that emotional entropy is a tendency largely influenced by natural environmental conditions. As noted, in addition to the natural process of exchange (metabolism) described by Schrodinger, it is postulated that a process of environmental exchange exists in emotional entropy. It is asserted that this environmental exchange may be a direct interchange with emotion schemas effectuating interpretations of the environment. Certainly, there is evidence to suggest that abusive and/or neglectful environments, as well as heredity, are correlated with emotional dysregulation (Dvir, Ford, and Frazier, 2014; Hervas 2017). If then emotional entropy is expressed as dysregulation, is it possible that persons identified with higher levels of emotional dysregulation might die sooner than those with lower levels?

It was also mentioned that Yao et. al. (2013) conducted a study suggesting a correlation exists between aging and increasing levels of entropy in the brain. In a separate study, Erra, Mateos, Wennberg, and Velazquez (2017) found evidence suggesting that consciousness may be a byproduct of entropy (p. 1). Describing the research, Philip Perry (2017) says, "Scientists recently found parts of the brain which may form a circuit that provides consciousness. But how did it come about? A group of scientists from France and Canada believe that consciousness may have arisen in response to entropy. Our brains just like any other system, are hurtling toward the end" (para. 3). Erra et. al (2017) applied probability theory to evaluate statistical models of neural networks to determine the thermodynamic properties (Perry, 2017, para. 4). Based on a small sample of participants, the researchers studied the synchronization of neuronal firing patterns. The researchers found that during waking states, the participants exhibited the greatest number of configurations of interactions between brain networks, representing the highest entropy values (Perry, 2017, para 6). The researchers contend that due to the high entropy, in order to maximize the exchange of information between neurons, consciousness arose as an “emergent property”, helping to improve survival while leading to increased entropy as a consequence, according to Perry (2017, para. 6). Primarily because of the small sample used, the study has drawbacks, but based on the findings, a much larger study may be in order. Nevertheless, if it is theoretically possible that aging is correlated with brain entropy and that consciousness itself is a byproduct of entropy, could there be a strong correlation between lifespan and emotional entropy?

It is on this basis that, the theory being interrogated by the statistical test in this section is whether high levels of emotional dysregulation as evidenced in both mental disorder and addiction, may statistically validate the use of shortened lifespans as an indicator and predictor of increased emotional entropy when such diagnoses are determined. That mental disorders can lead to shorter lifespans is nearly universally accepted by psychological researchers. Psychological researchers also point out that there are many environmental factors independent of the disorder which can decrease the lifespan of an individual with mental illness or substance dependence. There is strong evidence to support this claim and it may be accurate in many situations. But as stated, it is proposed by this author that emotional entropy must not be viewed as a process autonomous of environmental conditions, but instead, as a tendency influenced by such conditions, most prominently through an environmental exchange. On the

other hand, this is not meant to dismiss any consideration of independent environmental factors which may be important to research designs. The correlations made in this section can in no way be construed as conclusive proof. However, they are offered as suggestions for possible new research.

Certainly, most individuals in the general population confront serious crises and losses in their life. These occurrences usually cannot be controlled or predicted. But these factors do not express themselves as major mental disorders or addiction for most individuals in the general population. In the case of some individuals, however, evidence suggests these events may trigger mental illness or substance abuse (Dvir, Ford, Hill and Frazier, 2014; Hansen, Flores, Coverdale and Burnett, 2016). In the case of others, the mental disorder may trigger disordered (maladaptive) behaviors resulting in a disordered life (Banasik, Gierowski, and Nowakowski, 2017; Moller, 2016). It is reasoned, therefore, that if certain individuals are subjected to mental disorder or addiction because they may be more predisposed to it than the general population, then they may also be more likely to experience the conditions which lead to a shorter life when compared to the general population. It should be noted that the data on reduced lifespans used in this analysis is taken from research conducted on populations diagnosed with mental disorders. It is on this basis that using lifespan as an indicator of emotional entropy will be explored. The statistical analysis that follows does not adjust for independent environmental factors. It merely exams data in the aggregate to identify the strength of possible correlations. Though the results are inconclusive, it is hoped the analysis can be a starting place for a much more in-depth inquiry into the impact of emotional entropy on lifespan.

Before lifespan can be considered as an indicator of emotional entropy, it is argued that three criteria should be met. These are: 1) the definition of emotional entropy should be operationalized, 2) the definition of mental disorder should be operationalized and 3) the correlation between reduced lifespan is shown to be very strong. In what follows, therefore, a case will be proposed for using the data on shortened lifespans of persons with mental disorders as a possible indicator and predictor of increased entropy because such data may represent evidence for the existence of emotional entropy.

The mortality statistics for persons diagnosed with a range of mental disorders (psychopathologies) were compared to those with mortality statistics for the general population. Correlation coefficients between expected lifespan and reduced life expectancy resulting from mental

disorder were also generated. Standard deviations and a 95% confidence interval were applied to sample data to establish correlations. It was assumed that some correlation must exist. The question being interrogated was *to what degree* it exists since anything less than a very close correlation would probably deem it unreliable as a measure of increased levels of emotional entropy. A similar evaluation comparing substance addicted persons and those diagnosed with autism spectrum disorder to the general population was also conducted. Experts generally agree that addiction is a disease. Many list addiction as a form of mental illness and of the 44 million adults diagnosed with some form of mental disorder, slightly more than one in five (23%) are co-addicted to a substance (National Alliance on Mental Illness, 2013). As noted previously, it is proposed that emotional dysregulation may frequently have hereditary or physiological causes. There are about 3.5 million people with autism spectrum disorder in the U.S. (Autism Society, 2014). These data are therefore included. All these data and findings are described in narrative form in what follows, and in many instances, tables will summarize the findings.

Finally, since increased emotional dysregulation may lead to a shorter life, it can be inferred that the opposite might also be true and that there is an inverse relationship between life expectancy and levels of emotional dysregulation. If true, then perhaps measuring greater *self-regulation* (emotional regulation) will show evidence for *longer* life. Hence, studies in longevity will be cited and described in this determination.

According to the National Alliance on Mental Illness (NAMI), approximately 18.5% of the population annually has some form of mental disorder. This represents approximately 43.8 million persons. Of this group, approximately 9.8 million suffer from severe mental disorders or about 4% of the U.S. population. But these statistics may undercount persons experiencing some form of mental disorder at some point during their lifetime, whether it is depression, anxiety, addiction or other age-related mental deterioration. The *Psychological Dictionary,* Nugent (2013) defines mental disorder as:

> …an umbrella term used to describe any psychological symptoms, abnormal behaviours, impaired functioning or any combination of the prior. There is a wide range of explanations available for these mental disorders some more credible than the others including-genetics, social, organic, chemical and psychological explanations. (Par. 1)

Therefore, perhaps mostly for convenience, the term mental disorder is intended to bring together a wide range of emotional dysfunctions under a single label. In reality, these often-disparate emotional problems are manifested in many different ways. These mental disorders are also often alternately labeled psychopathologies. Izard (2007) refers to maladaptive emotion schemas as well (p. 265). It is this latter construct which may provide a useful way of operationalizing the term mental disorder which will be applied broadly here because it refers to the way emotion schemas can fail to adapt to environmental cues and the resulting tendency toward longer term or permanent psychopathologies. It is submitted that this may be a measurable way of understanding emotional entropy. Hence, for purposes of this discussion, the term mental disorder will refer to maladaptive emotion schemas and the tendency toward them will define emotional entropy.

The National Institute of Mental Health (NIMH) reports that the median average number of years lost in one's lifespan resulting from mental disorders is 10.1 years (Insel, 2015, para. 2). This is based on an analysis of 203 studies conducted in twenty-nine countries. The analysis also suggests that the minimum number of years lost is 1.4 and the maximum loss is thirty-two years. The National Vital Statistics Report (NVSR) indicates that normal life expectancy in the United States is 78.9 years. Thus, it seems apparent that with a mental disorder, one's age on average could be reduced to 77.5 (-1.4) or to as low as 46.9 (-32), with a median reduction to age 68.8 (-10.1). Hence, this suggests that those with mental disorders may be dying, on average, 10.1 years earlier than the general population.

Since historic lifespan statistics show variability in life expectancy in different racial groups, for this research, life expectancy data was collected for three major racial groups in the general population. The racial groups selected were: Black non-Hispanic, Hispanic, and White- non-Hispanics. These demographic groups were selected in part to avoid overlap (double counting) between Hispanic and non-Hispanic people in the general population. Somewhat surprisingly, it was discovered that Hispanics appear to have the longest life expectancy at 82.1 years. Hispanic female life expectancy is 84.5 while male Hispanic life expectancy is 79.4 years. The reasons for this long life remain unclear. The second group is the White non-Hispanics with an average life expectancy of 78.8 years. Female White non-Hispanic life expectancy stands at 81.2 years and males average 76.5 years. Unfortunately, Black non-Hispanic life expectancy is substantially below all other racial groups. The average life expectancy for this

group currently stands at 75.3 years. For females, the life expectancy is 78.2 years while for males in the group it is only 72.2 (National Vital Statistics Reports, 2017). Poverty for a segment of this group, as well as inadequate access to healthcare, may be factors influencing life expectancy.

As noted, to establish shortened lifespans resulting from mental disorders as a meaningful indicator and predictor of increased emotional entropy, it is contended that such a correlation must not merely exist, but it must be statistically significant. Therefore, using these data for the general population, the question was asked: Is the correlation between reductions in life expectancy and mental disorders statistically significant? For mental disorders overall, the standard deviation of 15.77 suggests a wide variation in reduced life expectancies. The mean reduction is 14.5 years with a 95% confidence interval. However, 68% of these life expectancies can be expected to fall within one standard deviation of the mean in a normal distribution. On this basis, a correlation coefficient was calculated of a random sample comparing average life expectancies for each racial group with the reduction in ages that could be expected. This calculation yielded a very strong positive correlation of $r = 0.911$. Thus, if these shortened lifespans result from high levels of emotional dysregulation, they may represent an important piece of correlative evidence for a possible emotional entropy indicator. Based on this, it is postulated that in the U.S., at least 43.8 million people may have their lives shortened from between 1.4 to 32 years because they experience high levels of emotional dysregulation. Table I below summarizes the findings.

TABLE I

REDUCTION IN LIFE EXPECTANCY DUE TO MENTAL ILLNESS

	Normal Life Expect.	AVG.	MIN.	MAX.	AVG AGE	MAX AGE	MIN AGE
All	78.9	-14.5	-1.4	-32	64.4	77.5	46.9
Males	76.5	-14.5	-1.4	-32	62	75.1	44.5
Females	81.3	-14.5	-1.4	-32	66.8	79.9	49.3
Whites-non-Hispanic							
All	78.8	-14.5	-1.4	-32	64.3	77.4	46.8
Males	76.5	-14.5	-1.4	-32	62	75.1	44.5
Females	81.2	-14.5	-1.4	-32	66.7	79.8	49.2
Black-non-Hispanic							
All	75.3	-14.5	-1.4	-32	60.8	73.9	43.3
Males	72.2	-14.5	-1.4	-32	57.7	70.8	40.2
Females	78.2	-14.5	-1.4	-32	63.7	76.8	46.2
Hispanic							
All	82.1	-14.5	-1.4	-32	67.6	80.7	50.1
Males	79.4	-14.5	-1.4	-32	64.9	78	47.4
Females	84.5	-14.5	-1.4	-32	70	83.1	52.5

Note. Numbers shown under Normal Life Expectancy (column two) are from National Vital Statistics Reports (2017). 66(4); the numbers shown under Minimum and Maximum years lost (columns four & five) are from Insel (2015).

Thus, the minimum years lost in column four yield the maximum age in column seven and the maximum years lost in column five yield the minimum age in column eight. But these results by themselves are insufficient to draw any reasonable inferences. To test the correlative strength further, the data was broken down into specific mental disorders (maladaptive emotion schemas). The life expectancy for certain mental disorders was compared to average life expectancy for the general population. Data on life expectancy for seven different common mental disorders were collected and evaluated. Data for schizophrenia, depression, bipolar disorder, Post Traumatic Stress Disorder (PTSD), Personality Disorders (PD), Borderline Personality Disorder (BPD) and schizoaffective disorder were all collected and analyzed. The decision to select these particular disorders was guided largely by the availability of good data. Had data been available for general anxiety disorder (GAD) for example, it would have been included but determining life expectancy for this group is difficult (Goodman,.2012, para. 5).

For every mental disorder surveyed, the data collected indicated significant declines in life expectancy. For each mental disorder, the average decline in life expectancies was identified to be the following: bipolar disorder (-14.5), BPD (-14.5), depression (8), PD (-17.7), PTSD (-12.3), schizoaffective disorder (-12.8) and schizophrenia (-13.5). These numbers were derived from recent studies as reported in science journals and publications.

Of the disorders, the data suggests it is Post Traumatic Stress Disorder (PTSD) which effects the largest percentage of the adult population (18.1%) annually, according to the NAMI website (https://www.nami.org/Learn-More/Mental-Health-By-the-Numbers). Based on the 2017 population estimates reported on the QuickFacts United States Census website (https://www.census.gov/quickfacts/fact/table/US/PST045217), there are approximately 251 million persons over the age of eighteen in the United States. Thus, the number of adults suffering from PTSD is estimated at 45.4 million, or approximately one in five adults! Though PTSD is often associated with men returning from war, the data suggests that women are more often victims resulting from rape, sexual violence and childhood traumas (Hosier, 2013). The reduction in life expectancy resulting from PTSD ranges from a minimum of 5.5 years to a maximum of nineteen years lost. As noted, the mean is 12.3 years with a confidence interval of 95%. The standard deviation (SD) is 6.75, with 68% of the life expectancies falling within one SD of the mean. As with mental disorders overall, PTSD appears to be strongly correlated with reductions in lifespan, yielding a positive correlation coefficient of $r = 0.967$, based on this analysis. The data summarized in Table II indicates outcomes similar to mental disorders overall.

TABLE II

REDUCTION IN LIFE EXPECTANCY DUE TO PTSD

	Normal Life Expect.	AVG.	MIN.	MAX.	AVG AGE	MAX AGE	MIN AGE
All	78.9	-12.3	-5.5	-19	66.6	73.4	59.9
Males	76.5	-12.3	-5.5	-19	64.2	71	57.5
Females	81.3	-12.3	-5.5	-19	69	75.8	62.3
Whites-non-Hispanic							
All	78.8	-12.3	-5.5	-19	66.5	73.3	59.8
Males	76.5	-12.3	-5.5	-19	64.2	71	57.5
Females	81.2	-12.3	-5.5	-19	68.9	75.7	62.2
Black-non-Hispanic							
All	75.3	-12.3	-5.5	-19	63	69.8	56.3
Males	72.2	-12.3	-5.5	-19	59.9	66.7	53.2
Females	78.2	-12.3	-5.5	-19	65.9	72.7	59.2
Hispanic							
All	82.1	-12.3	-5.5	-19	69.8	76.6	63.1
Males	79.4	-12.3	-5.5	-19	67.1	73.9	60.4
Females	84.5	-12.3	-5.5	-19	72.2	79	65.5

Note. Numbers shown under Normal Life Expectancy (column two) are from National Vital Statistics Reports (2017). 66(4); the numbers shown under Minimum and Maximum years lost (columns four & five) are from Hosier (2013).

Personality disorders (PD) are a group of mental illnesses involving long-term unhealthy patterns of thought and behavior (Nugent, 2013, para. 1). These disorders can cause serious problems in job performance and in relationships. PD affects approximately 9.1% of the adult population or about 2.7 million adults in the U.S., according to the National Institute of Mental Health website (https://www.nih.gov/health/statistics/personality-disorders.shtml). Persons diagnosed with PD are predicted to have reductions in life expectancy ranging from 17.4 years to 18 years, based studies of this group with the mean at 17.7 years (Fok, Hayes, Chang, Stewart, Callard and Moran, 2012). The SD is less than one. Hence, there appears to be very little variation in the number of years of expected loss. It is not known what accounts for this, but perhaps this can be explained by the fact that most sufferers of PD experience a similar lifelong pattern of illnesses. One might speculate that when compared to each other,

individuals with PD maladaptive emotion schemas use energy to move toward equilibrium in a fairly similar manner. As indicated from the data on different mental disorders, other maladaptive schemas very often appear to lack this uniformity. Since the range of nearly all the predicted years lost for PD fall within a single SD at the 95% confidence interval, a very strong positive correlation coefficient of r = 0.999 results. This may be suggestive of increasing levels of emotional entropy in mental processes. These data are summarized in Table III.

TABLE III

REDUCTION IN LIFE EXPECTANCY DUE TO PERSONALITY DISORDERS (PD)

	Normal Life Expect.	AVG.	MIN.	MAX.	AVG AGE	MAX AGE	MIN AGE
All	78.9	-17.7	-17.4	-18	61.2	61.5	60.9
Males	76.5	-17.7	-17.4	-18	58.8	59.1	58.5
Females	81.3	-17.7	-17.4	-18	63.6	63.9	63.3
Whites-non-Hispanic							
All	78.8	-17.7	-17.4	-18	61.1	61.4	60.8
Males	76.5	-17.7	-17.4	-18	58.8	59.1	58.5
Females	81.2	-17.7	-17.4	-18	63.5	63.8	63.2
Black-non-Hispanic							
All	75.3	-17.7	-17.4	-18	57.6	57.9	57.3
Males	72.2	-17.7	-17.4	-18	54.5	54.8	54.2
Females	78.2	-17.7	-17.4	-18	60.5	60.8	60.2
Hispanic							
All	82.1	-17.7	-17.4	-18	64.4	64.7	64.1
Males	79.4	-17.7	-17.4	-18	61.7	62	61.4
Females	84.5	-17.7	-17.4	-18	66.8	67.1	66.5

Note. Numbers shown under Normal Life Expectancy (column two) are from National Vital Statistics Reports (2017). 66(4); the numbers shown under Minimum and Maximum years lost (columns four & five) are from Fok, Hayes, Chang, Stewart, Callard and Moran, (2012).

In the case of bipolar disorder, the reduction in life expectancy ranged from a minimum of 9 years lost to a maximum of twenty years lost. As mentioned, the mean is a loss of 14.5 years. The SD is calculated at 5.5 with a 95% confidence interval. Again, 68% of the numbers will cluster within one SD. This yields a very strong positive correlation of r = 0.982. It turns out borderline personality disorder (BPD), has nearly identical mortality statistics to bipolar disorder. This may be explained by the fact that

symptoms of the two illness closely resemble each other, though the illnesses are entirely separate. One might also infer that because symptoms are very similar, the use of energy expended in the dysregulation of emotion schemas directed and accelerated toward entropy may be nearly comparable. With depression, the minimum years of life lost is five and the maximum is eleven. As noted, the mean is eight lost years. Major depression affects about 3.4% of the adult population in the U.S., according to the Center for Disease Control (CDC). At the 95% confidence interval, the SD is three, again suggesting little variation from the mean, and it produces a very strong positive correlation of r = 0.988. Data on schizophrenia indicates that it may reduce lifespan from twelve to fifteen years with the mean average reduction at 13.5, as noted. For schizoaffective disorders, the range is between eight and 17.5 years lost with a mean average of 12.8 years. Together, these two illness affect approximately 3.5 million adults in the United States, based on data from the NAMI website (https://www.nami.org/). For schizophrenia, nearly 100% of the population falls within only two SD of the mean with a score of 1.5. The reduction of life is strongly correlated with this illness: r = 0.991. Schizoaffective disorder has a SD of 4.75 with 68% of lifespans falling within one standard deviation. Like all the other disorders in this evaluation, its positive correlation coefficient of r = 0.974 relative to shortened life appears to be very strong.

Data collected from the 2014 National Survey on Drug Use and Health (NSDUH) indicates there are an estimated 21.5 million persons aged twelve and older suffering from Substance Use Disorder (SUD) in the United States. NSDUH also found that one out of eight who suffer from some substance abuse disorder also struggle with alcoholism. The NSDUH website reported results of a different survey conducted by CDC estimating there were more than 72,000 drug overdose deaths in 2017 (https://www.drugabuse.gov/related-topics/trends-statistics/overdose-death-rates). While in 2015, the National Institute of Alcohol Abuse and Alcoholism (NAAA) website (https://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/alcohol-facts-and-statistics) reported that there were about 16 million persons aged twelve and older who suffered from Alcohol Use Disorder (AUD) with 88,000 alcohol-related deaths occurring annually. Thus, it may be inferred from these facts together that there may be roughly 38 million people in the United States suffering from some form of addiction, representing a major pandemic.

Recalling how emotion schemas are defined as maladaptive if they fail to effectively react to environmental cues, it is suggested that in the instances of addiction, the abuse of substances may be a maladaptation in reaction to environmental cues which can form progressively into dependence. This may involve the environmental exchange. It may also be that maladaptive emotion schemas act the same way with alcoholism. As noted, reduced lifespans resulting from substance abuse and addiction will be evaluated to determine the statistical significance of their correlation with the addiction. As with other mental disorders, it is proposed that a strong correlation with shortened life expectancy may lend support to the application of the data as an indicator and predictor of emotional entropy. However, as with other mental disorders, if the correlation is weak or not statistically significant, this would diminish the claim that an emotion entropy indicator could be derived.

For this research, reduced life expectancy was calculated using the Addiction Calculator available on Northpoint Recovery Program website (https://www.northpointrecovery.com/blog/limited-time-life-expectancy-data-worst-addictions/). Using the calculator, one can input data simulating typical drug and alcohol abuse and the calculator will output the estimated reduction in lives lost. The online calculator was created by Omni Calculator and its assumptions are based on data from the CDC, U.S. Census and the Substance Abuse Mental Health Administration (SAMHA). Thus, the calculator provided an ideal simulator based on statistically valid data.

Using the calculator, simulations of drug and alcohol abuse were created for six different substance categories - cigarettes, alcohol, heroin, cocaine, methamphetamine and methadone pills(Omni Calculator website,https://www.omnicalculator.com/health/addiction). These were selected primarily because simulation was possible using them in the model, though this represents a good cross section of substance abuse. To do these simulations, certain assumptions were made about typical abuse patterns for each substance. An investigation of substance abuse patterns was conducted for each category. The calculator permitted one to input the number of times a substance was used during a day, week or month as well as the age at which a simulated user began using the substance. These are important factors creating variability in lifespan.

Because of these factors can be highly variable, this writer decided to create a range of lifespans by simulating an early user and a late user. In all cases except one, the simulated early substance abuser

started using at age fourteen while the simulated late user started using at thirty-five. The only exception to this was for methadone pill abuse. Data suggests this is a substance which is abused by mature adults or the elderly (Goodheart, 2017). For methadone pills usage simulation, therefore, the early usage starting age was thirty and the late usage starting age was sixty. Variability in daily usage was also simulated because one drink of alcohol does not equate to a hit of methamphetamine or a shot of heroin, for example. The second reason is, of course, there are wide differences in the amount of a given substance consumed by abusers of that substance. Alcoholic X may drink six to eightdrinks a day while alcoholic Y can go for nearly a month but then binge drink for 48 hours. For purposes of simulation, therefore, a "heavy" and "light" consumer was created to compare differences in lifespan reductions.

Assuming that alcohol consumption begins at age fourteen and the drinker consumes only two drinks a day, they would lose 23.2 years from their life expectancy, based on the simulation. On the other hand, if they start at age thirty-five and consume only two drinks a day, the amount they would lose in life expectancy drops to 15.9 years. The mean is 19.6 years lost. This would appear to belie the widely held view that moderate drinking is good for one's health. If the previous detailed racial demographic life expectancy data is used, a correlation between alcohol consumption and reduced life expectancy can be determined. The SD is estimated at 3.65 with 68% of the reduced lifespans within one SD. Calculation of the correlation coefficient yields a very strong $r = 0.996$.

However, the picture only gets worse the more one drinks. In the extreme case where an alcohol abuser consumes ten drinks a day and begins drinking at age fourteen, the person would lose an astonishing forty-eight years from their normal lifespan! But there is still a great reduction in lifespan if they wait. If they start at age thirty-five, they still lose 32.6 years from their normal lifespan. The mean reduction is 40.3 years. The SD is estimated at 7.7, suggesting a fairly wide variation in lifespan reduction resulting from alcoholism. However, 68% of these are expected to fall within one SD of the mean in a normal distribution. Similar to the other correlations in this evaluation, this indicates a very strong positive correlation of $r = 0.983$. Tables IV and V below summarize the simulation results when applied to the general population.

TABLE IV

REDUCTION IN LIFE EXPECTANCY DUE TO ALCOHOL(2 DRINKS PER DAY)

	Normal Life Expect.	AVG.	Start Age 35	Start Age 14	AVG AGE	MAX AGE	MIN AGE
All	78.9	-19.6	-15.9	-23.2	59.3	63	55.7
Males	76.5	-19.6	-15.9	-23.2	56.9	60.6	53.3
Females	81.3	-19.6	-15.9	-23.2	61.7	65.4	58.1
Whites-non-Hispanic							
All	78.8	-19.6	-15.9	-23.2	59.2	62.9	55.6
Males	76.5	-19.6	-15.9	-23.2	56.9	60.6	53.3
Females	81.2	-19.6	-15.9	-23.2	61.6	65.3	58
Black-non-Hispanic							
All	75.3	-19.6	-15.9	-23.2	55.7	59.4	52.1
Males	72.2	-19.6	-15.9	-23.2	52.6	56.3	49
Females	78.2	-19.6	-15.9	-23.2	58.6	62.3	55
Hispanic							
All	82.1	-19.6	-15.9	-23.2	62.5	66.2	58.9
Males	79.4	-19.6	-15.9	-23.2	59.8	63.5	56.2
Females	84.5	-19.6	-15.9	-23.2	64.9	68.6	61.3

Note. Numbers shown under Normal Life Expectancy (column two) are from National Vital Statistics Reports (2017). 66(4); the numbers shown under Minimum and Maximum years lost (columns four & five) are estimated from the Omni Calculator website,https://www.omnicalculator.com/health/ addiction.

TABLE V

REDUCTION IN LIFE EXPECTANCY DUE TO ALCOHOL(10 DRINKS PER DAY)

	Normal Life Expect.	AVG.	Start Age 35	Start Age 14	AVG AGE	MAX AGE	MIN AGE
All	78.9	-40.3	-32.6	-48	38.6	46.3	30.9
Males	76.5	-40.3	-32.6	-48	36.2	43.9	28.5
Females	81.3	-40.3	-32.6	-48	41	48.7	33.3
Whites-non-Hispanic							
All	78.8	-40.3	-32.6	-48	38.5	46.2	30.8
Males	76.5	-40.3	-32.6	-48	36.2	43.9	28.5
Females	81.2	-40.3	-32.6	-48	40.9	48.6	33.2
Black-non-Hispanic							
All	75.3	-40.3	-32.6	-48	35	42.7	27.3
Males	72.2	-40.3	-32.6	-48	31.9	39.6	24.2
Females	78.2	-40.3	-32.6	-48	37.9	45.6	30.2
Hispanic				-48			
All	82.1	-40.3	-32.6	-48	41.8	49.5	34.1
Males	79.4	-40.3	-32.6	-48	39.1	46.8	31.4
Females	84.5	-40.3	-32.6	-48	44.2	51.9	36.5

Note. Numbers shown under Normal Life Expectancy (column two) are from National Vital Statistics Reports (2017). 66(4); the numbers shown under Minimum and Maximum years lost (columns four & five) are estimated from the Omni Calculator website,https://www.omnicalculator.com/health/ addiction.

All the remaining reduced life expectancy numbers for substance abuse suggest strong correlations. In the case of heroin addiction, for example, research suggested that the typical addict consumed three shots per day. Using this as the baseline simulation, lifespan reduction for a user starting at age fourteen was contrasted to a user starting at age thirty-five. Thus, if the heroin user starts using at age thirty-five, their loss of expected life is thirty-three years based on simulation. If they start at age fourteen, their life expectancy is shortened by 48.5 years. The mean reduction in life expectancy is 40.8 years. The SD is 7.75 suggesting wide variation in life reduction with heroin addiction. However, 68% of

the reductions occur within one SD of the mean in a normal distribution and calculation of the correlation coefficient yields r = 0.973. Similarly, with cocaine addiction, typical usage was determined to be three lines per day. On this basis, a simulation of reduced lifespan for someone starting at age thirty-five was 17.3 years and for someone starting at age fourteen, it was 25.4 years. The mean was 21.4 years and the SD was four. Based on this sample simulation, heroin addiction has a strong positive correlation with a reduced life expectancy of r = 0.989. Addiction, therefore, may correlate strongly with shortened lifespan in much the same way as other mental disorders and it may be that the psychological and physiological damage accelerates the process of entropy in a very similar manner. It should be underscored that while suggestive of evidence, this analysis is inconclusive. However, perhaps it can put forward guideposts for further research.

Until recently, little life expectancy data was collected for persons with autism spectrum disorder (ASD). However, a recent study provides a sample from which statistics can be used (University of Utah Health, 2018). ASD is classified as a developmental disorder and refers to a range of conditions characterized by challenges to social skills, repetitive behaviors, some unique strengths and differences in speech as well as nonverbal communication (Heydt, 2017, pgs. 20 – 24). Its causes are thought to be both genetic and environmental and it affects approximately 3.5 million people in the U.S. Its importance to this discussion is to illustrate how emotional entropy may have a connection to a disorder which is largely hereditary in origin and to link it to the evaluation of other maladaptive emotion schemas. Because of genetic factors not fully understood, persons living with ASD interpret environmental cues in ways that fail to successfully adapt. At its core then, ASD may be an example of a disorder of developmental maladaptive emotion schemas which accelerate emotional entropy. Persons with this lifelong disorder can have a shortened lifespan when compared to the general population, by as much as thirty years or as little as sixteen years, when compared to the general population, with the mean average being twenty-three years. Comparing these data to life expectancy for the general population, the SD for ASD is seven and there is a strong positive correlation of r = 0.969.

A positive correlation coefficient of better than r = 0.9 was thus determined for every category analyzed. The mean correlation for all the categories combined was 0.981. Accounting for environmental exchange and using emotion schemas as a framework for understanding how all these categories

connect may suggest that emotional dysregulation is a common factor to them all. To prove this, further research is necessary.

Up to this point, it has been suggested that entropy may occur universally in the emotional process based on many indicators of dysregulation in emotion schemas. However, if this process of entropy is by nature dysregulation, then the reverse must also be true (i.e. greater emotional regulation must be associated with much lower entropy). It is argued that this opposing process of self-organization which must evidence itself as greater self-regulation. One might infer that if the tendency toward maladaptive emotion schemas lead to equilibrium, that *adaptive* emotion schemas (successfully ordered schemas) should, therefore, prolong life. Many studies have been done on the topic of longevity. A few examples will be discussed which may have relevance to emotional entropy.

In a landmark longitudinal study spanning eight decades known as *The Longevity Project*, Friedman and Martin (2011) evaluated the determinants for long life. Though data collection started on the subjects of the study eight decades earlier by Lewis Terman, the researchers applied modern scientific methods to study the 1500 subjects across the eight decades of their lives (Friedman and Martin, 2011, pgs. IX – XVIII). Many of the findings contradict consensus views held within the fields of medicine and psychology. For example, they found that working long hours does not necessarily lead to death and they claim, based on their data, that many who work the hardest, live longer if their work is challenging (Friedman and Martin, p. 147). They also found that getting and staying married is not a guarantee of a long life, particularly for women (Friedman and Martin, 2011, pgs. 127 – 128).

As discussed, there are many variables which get factored into how long a person lives and the researchers address many of these in their findings. However, perhaps most noteworthy is their findings of what childhood characteristic is the best predictor of a long life. According to Friedman & Martin (2011), "…the best childhood personality predictor of longevity was conscientiousness – the qualities of a prudent, persistent, well-organized person, like a scientist-professor – somewhat obsessive and not carefree" (p. 9). Several important inferences can be made about this finding. First, this study did not set out to explicitly study self-regulation. Instead, in their aim to determine important factors in longevity, the researchers experienced surprise at this finding. This suggests the study may not have been biased concerning this finding. Secondly, the finding suggests compelling evidence that long life may be

correlated with effective self-regulating emotion schemas that translate into adaptive interactions with the environment. Thirdly, these strategies for self-regulation may be a part of spontaneous emotional self-organization (schemas) in stable states far removed from equilibrium. It seems probable that they are goal-driven and thus may also actively engage cognitive appraisals. By implication, they may also point to the importance of appropriate environmental exchange in rewarding and reinforcing self-regulating behavior. The fact that this research was conducted longitudinally over eight generations makes it one of a kind and this should not be overlooked.

A different study conducted by Bogg and Roberts (2013) provides a similar assessment. Using a modified health process model, the researchers evaluated evidence linking conscientiousness to the health and disease processes (Bogg and Roberts, para. 2). They examined, longevity, diseases, morbidity-related risk factors, health-related psychophysiological mechanisms, health-related behavior and social environmental factors related to health and they conclude that the accumulated evidence supports greater integration of conscientiousness into the public health, epidemiological and medical research with the aim of understanding how facilitating more optimal trait standing can foster improved health (Bogg and Roberts, para. 3). Very similar findings are to be found in Kern & Friedman (2008) and Hill, Turiano, Hurd, Mroczek & Roberts (2011). It is postulated that a pattern of behaviors labeled conscientiousness may be a self-regulatory process applying cognitive appraisals in emotion schemas to effectively adapt in environmental exchange. In achieving this ordering, the tendency toward entropy may be delayed as one remains aloof from the threat of emotional dysregulation. Thus, it is possible that greater longevity results from ordered conscientiousness.

Chapter 5: Refutations

The previous chapters have addressed history, theory and the core arguments of this discussion. Evidence in defense of the thesis was also provided. But theories on emotion, psychology and brain entropy vary widely, as has been discussed. This chapter will focus on some theories and studies which differ significantly from what has been argued. To each presentation, counter-arguments will be proposed which are consistent with this entropy theory of emotion.

Psychological Entropy

In a major article published in the *Psychological Review*, Hirsh, Mar, and Peterson (2012) describe their model of uncertainty related anxiety. Resolving uncertainty is a fundamental biological necessity, according to the researchers (Hirsch, et. al. 2012, p. 1). They state, "We propose the entropy model of uncertainty (EMU), an integrative theoretical framework that applies the idea of entropy to the human information system to understand uncertainty related anxiety" (Hirsh, et. al., p. 1). The researchers assert EMU is based on four basic tenets: 1) Uncertainty poses a critical adaptive challenge for any organism, so individuals are motivated to keep it at a manageable level; 2) uncertainty emerges as a function of the conflict between competing perceptual and behavioral affordances; 3) adopting clear goals and belief structures helps to constrain the experience of uncertainty by reducing the spread of competing affordances; 4) uncertainty is experienced subjectively as anxiety and is associated with activity in the anterior cingulate cortex and with heightened noradrenaline release (Hirsh, et. al., 2012, p. 1). Furthermore, the researchers argue that the EMU operates within the framework of both information theory and self-organization (Hirsh, et. al., 2012, p. 1). They specifically observe that within thermodynamics and information theory, the concept of entropy describes the amount of uncertainty and disorder in a system and that self-organizing systems must engage in a continual dialogue with the environment to keep uncertainty at a minimum (Hirsch, et. al., 2012, p. 1). Hence, the researchers have presented a new model of psychological (or emotional) entropy.

In defending the EMU model, Hirsch et. al. (2012) argue that psychological entropy appears to be inversely related to the integrity of the individual's existence in the world as demonstrated in one's ability to successfully perform work and obtain rewards through goal-directed perception and action (p. 12). They also contend that much of one's life is directed toward trying to reduce and manage uncertainty. In many respects, the EMU model appears to capture important elements of the entropy theory of emotion as has been articulated in this analysis. But while the researchers mention self-organization, they do not elaborate on their meaning and it remains unclear exactly how the EMU model would directly relate to self-organization.

There are, of course, a number of different commonly accepted definitions of uncertainty. But as noted, Hirsch et. al. (2012) operationalize uncertainty as anxiety (p. 1). However, *Merriam Webster*

Dictionary defines the word uncertain as 1) not known beyond doubt: dubious, 2) not constant: variable, fitful, 3) indefinite or indeterminate, 4) not certain to occur: problematical and 5) not reliable: Untrustworthy. But since the authors operationally define uncertainty as anxiety, one must then ask what they mean by anxiety. In a footnote, they make the point that they do not mean fear. Instead, they cite Gray and McNaughton (2000) for their definition of anxiety which presents a construct where conflicting goals produce anxiety, and this results in uncertainty. This dilemma between goals can be characterized as the approach-avoidance conflict where a perceived threat is involved, and one attempts to try and get more information about the environment. This conflict (anxiety) can quickly lead to fear, where an animal will fight or run from a situation.

Thus, Hirsch et. al. (2012) are defining anxiety as a perceived conflict between choices. They have not operationalized anxiety in descriptive emotional terms beyond this observable conflict. This means they are assuming that whenever such a perceived conflict arises, anxiety is produced. The results of the Gray and McNaughton (2000) study which concluded that anxiety was separate from fear, were based on administering specialized drugs to rats. But the clear distinction between fear and anxiety has not always been supported by other research (Dymond, Dunsmoor Vervliet, Roche and Hermans, 2015; Perusini and Fanselow, 2015). Thus, the evidence for drawing a distinction between fear and anxiety appears to be questionable. The researcher's first tenet is that uncertainty poses a critical adaptive challenge for all organisms. EMU assumes that uncertainty is experienced as anxiety, but the researchers never explain how it is possible for all organisms to experience anxiety. Even if one limits their use of the word organism to mean only animals, there may be a danger of anthropomorphizing by characterizing all interactions with the environment as anxiety producing.

These definitional problems are reinforced in their description of EMU. For example, Hirsch et. al. (2012) state, "We contend that the amount of uncertainty associated with a given perceptual or behavioral experience can be quantified in terms of Claude Shannon's entropy formula…" (p. 3) Thus, based on their operationalization of uncertainty as anxiety, the researchers are claiming levels of anxiety can be quantified using Shannon's entropy formula. This might be true only if one has an effective means of collecting data from individuals experiencing anxiety. Hirsch et. al. (2012) mention the behavioral inhibition system (BIS). Presumably, they would use the self-reporting checklist to survey individuals and

then the EMU would be applied to the data collected. But this is particularly problematic if it is the only means of data collection. For example, there is strong evidence that BIS is not a reliable predictor for individuals diagnosed with psychopathy because they have extremely low anxiety levels (Baskin-Sommers, Wallace, MacCoon, Curtin and Newman 2010; Newman and Malterer, 2009; Newman, MacCoon and Sadeh 2005).

More troubling however is that throughout the article they use the word uncertainty to mean different things. For example, according to Hirsch et. al. (2012), “Uncertainty arises when plans are unexpectedly disrupted (e.g. by the emergence of unforeseen obstacles) and the appropriate perceptual frame and behavioral response are not made immediately clear” (p. 6). But the researcher’s original tenet that uncertainty poses a critical adaptive challenge for any organism appears to assert that uncertainty must exist for every organism in *every* situation. This tenet appears to be consistent with Gray and McNaughton (2000), as indicated. However, as described here, uncertainty is more conceptual and situational. Uncertainty, as applied here, might mean not knowing beyond doubt, not constant or variable as described by the *Merriam Webster Dictionary.* Viewed this way, it is unclear whether perceptions of obstacles cause anxiety or the reverse. This confusion means it is impossible to know what is being measured. ButIt can be inferred from this conceptual and situational requirement that Hirsch et. al. (2012) take for granted that higher-order thinking is necessary to experience uncertainty. Nevertheless, this contradicts their first tenet in the model.

As detailed in Chapter 3, in Shannon's information theory, statistical probability and Boltzmann's equation are used to describe the physical properties of an information channel. Shannon used entropy as a measure of the amount of information received by a recipient of telecommunication signals. It is proposed that he had no interest in the message content, only in finding a way that desired messages would not get lost in a noisy channel over long distances. It has been posited that within the spatiotemporal universe (or affective-cognitive processes), emerging emotion episodes spontaneously self-organize into emotion schemas far from equilibrium (Izard, 2007; Lewis, 2004; Kelso, 1995; Kohonen, 1989). To their credit, Hirsch et. al. (2012) argue a similar case for anxiety. But because their definition for uncertainty is ambiguous and they do not describe how self-organization relates to anxiety, their EMU model appears to be poorly defined. Shannon's measurement of entropy was very precise, based on

observable physical properties in signal transmission. By contrast, their EMU model appears to rely upon self-reported BIS data with questionable validity and precision. Because the authors make no reference to any supplemental data collection or observations, their application of the Shannon equation is equally questionable to this data. Therefore, it is argued that equating EMU to Shannon's research is highly misleading. It appears to be little more than an interesting metaphor.

Though they don't specify exactly how, Hirsch et. al. (2012) argue that anxiety is managed and goal-directed, as mentioned. This is generally consistent with an affective-cognitive processes view of anxiety. But assuming they have operationalized uncertainty to mean anxiety, applying the definition to understand emotional entropy presents other problems as well. If the authors are applying it broadly to every choice confronted by individuals, there is clearly an abundance of evidence to show not all situations involve conflicts between anxiety producing goals. As has been noted, psychopaths do not generally show significant levels of anxiety in their choices between goals.

But there is additional evidence within other individuals as well. For example, Doumit, Afifi, and Devon (2015) conducted a study of young college students in war-torn Lebanon, finding that resilience, social support, a sense of wellbeing, and gender were the most significant factors in coping with uncertainty. Similarly, Chiraag Mittal and Vladas Griskevicius (2014)conducted five experiments followed by a case study to determine people's sense of control under conditions of uncertainty. Their meta-analysis findings were that the childhood experiences of people from different socioeconomic backgrounds significantly influence their ability to develop strategies for coping with uncertainty (p. 634). It has also been noted by Lazarus and Folkman (1984) that some cognitive appraisals are irrelevant (p. 32). Hence, it would appear that uncertainty-related anxiety cannot be universally predicted with any precision in every situation and that there is a substantial degree of individual variation in the response to being confronted with conflicting goals. Applying the Shannon equation as a prediction of the degree of uncertainty-related anxiety would therefore not always be informative.

But if it is assumed that EMU does operate effectively to predict increased uncertainty by tracking variable levels of anxiety, is the model sufficient for capturing emotional entropy? To answer this, one must first determine what is important to know about how emotions operate within thought processes. Hirsch et. al. (2012) have made anxiety the centerpiece of EMU, defining it narrowly to mean a conflict

between goals. This eliminates any significant consideration of other emotions or emotion schemas. This may be intentional since the researchers argue that organisms engage in a continual dialogue with the environment where they must manage anxiety (p. 1). It is submitted that as a consequence, the model cannot capture the broad global spectrum of emotional possibility in human and animal experience. It is submitted that any model for measuring emotional entropy must attempt to view the emotional experience as a whole. For it to do less could not be expected to provide adequate information about how the spontaneous self-organization of emotions and schemas operate relative to entropy. It is maintained that it could not be expected to provide adequate explanations for a range of human or animal behaviors.

As envisioned in this analysis, defining emotional entropy either as anxiety, conceptual uncertainty or both is inadequate. The contention is that there are numerous causes of emotional entropy which have no apparent connection to either. Examples of birth defects (genetic disorders) and brain injury have already been cited as possible sources of increased emotional entropy. Certain mental disorders (maladaptive emotion schemas) may provide little or no measurable correlation with either anxiety or uncertainty. It is argued, therefore, that anxiety-producing uncertainty *may* or *may not* be involved in emotional dysregulation. Anxiety is one possible reaction to goal-driven cognitive appraisals. Conversely, there are some highly successful emotion schemas which entail no conflict between goals and no significant anxiety. The self-regulating behaviors associated with conscientiousness may be one example of this, as discussed in Chapter 4. It is therefore argued that a more meaningful measure of emotional entropy can be derived from an evaluation of emotional dysregulation in all its permutations, relative to emotion schemas. To the extent that such schemas fail to successfully adapt to the environment, they can be regarded as dysregulating. If such maladaptive schemas occur with greater frequency and/or greater intensity, they can be understood to be increased entropy. To the extent that they are successful in adapting, the schemas can be understood to be self-regulating. Instead of an EMU model, what may be needed is an entropy model of dysregulation (EMD) because it is contended that the greatest emotional survival threat to animals and humans is emotional dysregulation.

As mentioned, Hirsch et. al. (2012) argue that psychological entropy appears to be inversely related to the integrity of the individual existence in the world. This assertion is very consistent with the entropy theory of emotion argued in this discussion. It is, therefore, a significant point of agreement.

In a study conducted by Wicentowski and Sydes (2012), the researchers sought to identify emotion content expressed in suicide notes using maximum entropy classification (p.51). They incorporated lexical and syntactic features extracted from a training set of externally annotated suicide notes and they trained separate classifiers for each of fifteen pre-specified emotions. The researchers claim they accurately detected and identified sentiments expressed in suicide notes (Wicentowski and Sydes, 2012, p. 60). A maximum entropy classifier is a probabilistic classifier based on multinomial logistic regression classification. To obtain data for the research, an external team began by collating notes and subsequently anonymizing so that no personal information remained. Then, volunteers who had a strong emotional connection to someone who had committed suicide provided a sentence level annotation of the suicide notes so that each sentence was assigned one or more emotions, or was left unlabeled which happened more frequently (Wicentowski and Sydes, 2012, p. 52). Sentences were labeled with a particular emotion only when a sufficient number of annotators agreed on an annotation. Participants in the shared task were also supplied 600 annotated notes as training data. In the next task, the participants classified each sentence in a suicide note as exhibiting zero or more emotions annotated from the pre-defined set of 15 emotions (Wicentowski and Sydes, 2012, p. 52). The set also included non-emotion categories such as “information” and “instructions.” In addition to labels, the researchers employed the use of natural language processing (NLP) to address potential questions of disambiguation, spelling etc. NLP is a form of artificial intelligence concerned with interactions between computers and human (natural) language (Wicentowski and Sydes, 2012, p. 52). As applied in this research, NLP is often used to program computers to process and analyze natural language data.

After the sentences from the notes were processed in this way, the classifiers performed binary labeling for each emotion, estimating it as either present or absent (Wicentowski and Sydes, 2012, p. 53). When the analysis was completed, some sentences were left unlabeled and were classified as the null set. For each emotion, they trained a maximum entropy classifier applying only the trained data. For the maximum entropy classifier, Wicentowski and Sydes (2012) employed the Stanford Classifier (p. 53). This classifier is an off-the-shelf free software learning tool capable of taking a data set and placing them into probabilistic classes (The Stanford Natural Language Processing Group, 2017, para. 1). Maximum entropy in this context is operationalized to mean that the probability distribution best representing the

current state of knowledge is the one with the largest entropy when precisely stated prior data expresses testable information. Using their data, the Stanford Classifier classified sentences labeled with emotions on a range between 0.0 (very strong probability sentence is unlabeled) and 1.0 (very strong probability sentence is labeled). The researchers also experimented using a wide variety of additional classifier options. Two important classifiers used were Sigma (specifies the strength of the prior) and Word Shape (associating similar looking words algorithmically) (Wicentowski and Sydes, 2012, p. 53).

From this, the researchers describe a number of findings. Their tables indicate that the scoring of their emotion labels attributed to sentences in suicide notes varied widely from strongly positive to strongly negative. The best system score obtained from the Stanford Classifier was 0.534. Hence, Wicentowski and Sydes (2012) contend that they have presented a classifier performing with a high degree of precision and propose it might be a useful tool for suicide intervention (para. 32).

Based on the description of the study written by Wicentowski and Sydes (2012), there appear to be serious methodological errors in their research. The first problem seems to be one of sampling error. The article provides no explanation for how the suicide notes used in the research were obtained, or in the sample size used. Can it be assumed that the selected suicide notes are truly representative of the total population of suicide notes? It cannot be assumed because the answer is unknown. Since determining maximum entropy using the Stanford Classifier must be based on precisely stated prior data expressing testable information, this problem would appear to invalidate the statistical outcomes of the classifier. Yet, even if the computed results applying the classifiers are valid for the data, the method may yield entirely different results for the general population. Therefore, the results of the method are completely unreliable.

In addition to the sample of suicide notes, participants in the study were supplied with 600 annotated “training data” notes. Wicentowski and Sydes (2012) do not explain how these training data notes were derived. One is unsure whether the training data notes were additional suicide notes from another anonymous sample or whether they were a creation of the research team for training purposes. If they were the former, they might have some utility for training. If they were the latter, they might unintentionally be conveying the biases of the researchers to the trainees.

Wicentowski and Sydes (2012) make another methodological error in the selection of volunteers who participate in the research. These participants are characterized as having a strong emotional connection to someone who had committed suicide (para. 3). Again, it is not known how many participants are selected or how the researchers determine they can be characterized in this way. But assuming they used such a group, they should also have used a control group of people who did not have such an emotional connection, to compare the results. There is no evidence they did this. This oversight suggests confirmation bias on the part of the researchers and possibly sponsor bias on the part of participants.

The study also included fifteen words used as emotion labels. But Wicentowski and Sydes (2012) offer no explanation for why these particular set of labels were selected or how they were derived. These labels were applied by the participants to describe sentences in suicided notes. Without trying out other descriptors or knowing these descriptors have been tested, it is impossible to determine whether the best (strongest) interpretations were made of sentences. A related problem is that one is unsure in what medium these suicide notes are first recorded as well as in what medium they are viewed by the participants. Is it accurate to say that all suicide notes are handwritten? This seems highly unlikely given the numerous other options available electronically. Hence, the usefulness of detecting handwritten letter shapes and sizes seems questionable.

Perhaps most troubling is that the research creates the impression that it is measuring the entropy of emotional experience of suicidal individuals when in fact it is only supplying a measurement of encoded symbols from notes. Both the emotion labels used, and the codes assigned were interpretations of people who did not write the suicide notes. Therefore, the claim of Wicentowski and Sydes (2012) that their method identifies emotions expressed in suicide notes appears to be false.

In a different study conducted at Stockholm University, Lebedev, Kaelen, Lovden, Nilsson, Feilding, Nutt and Carhart-Harris (2016) researched the effects of an LSD-induced entropic brain on subsequent personality changes (p. 1). The aim of the study was to demonstrate the safety and efficacy of lysergic diethylamide in the treatment psychiatric conditions (Lebedev et. al., p. 2). Nineteen healthy adults submitted to functional MRI scans during resting states with a 75 ug IV (intravenous) insert and placebo (saline) IV. The researchers note that they began the study with twenty subjects, but one

requested the MRI sessions be stopped due to transient anxiety. All the subjects selected were prescreened to confirm no history of mental illness or pregnancy. The age range of the subjects was 31 to 37 and fifteen of the subjects were male. According to the Lebedev et. al. (2016), every subject selected had previously used LSD (p. 3).

To conduct the study, the researchers held two scanning sessions using either 75 ug of LSD or placebo, each applied intravenously over a two-minute period to every subject. This was followed by a two-week interval during which no LSD was administered, and fMRI scanning was done. To assess personality changes, Lebedev et. al. (2016) had each subject complete the Neuroticism Extraversion Openness Revised Personality Inventory (NEO- PI-R) both at initial screening and two weeks after the LSD/placebo sessions (p. 3). The NEO-PI-R is a standard 240-item five-factor revised questionnaire and it includes a visual analogue scale assessing the intensity of ego dissolution. It relies on respondent self-reporting of the degree to which they experienced disintegration of a sense of self (Ashton, 2013, para. 1).

Scanning sessions occurred during 7.5-minute eye-closed resting states which included one where music was played. Sample entropy (SE) was collected during these periods using fMRI. The researchers claim that LSD had a pronounced global effect on brain entropy, increasing it in both sensory and hierarchically higher networks across multiple scales. They contend these shifts predict enduring increases in trait openness Lebedev, et. al., 2016, p. 1) Secondly, Lebedev et. al. (2016) argue that the predictive power of entropy was greatest during periods when subjects were listening to music (p. 1). As mentioned, the researchers attribute this to "ego-dissolution" which was reported during the acute experience (Lebedev, et. al., 2016, p. 9). In the view of the researchers, their study sheds new light on how LSD-induced shifts in brain dynamics and associated subjective experience can be predictive of enduring changes in personality (Lebedev, et. al., 2016, p. 1).

The fact that increased levels of entropy were globally evidenced within the brain during periods when the subjects were receiving doses of LSD does not seem surprising. That this result was markedly different than when the subjects received the placebo could be predicted. However, there appear to be basic design problems with the Lebedev et. al. (2016) study. The first obvious problem is that its findings are based on an insufficient sample. Only nineteen subjects completed the study process and thus, it is

impossible to make reasonable inferences about how the results apply to the general population. The researchers couch their study as a “small-scale pilot” but this does not resolve the fundamental problem because the researchers appear to try and overstate the interpretation of their results. Secondly, the study was designed so that every subject received identical doses of LSD alternating with doses of placebo. But to state that the LSD had an effect of increasing entropy to levels which do not normally occur with people in resting states and to conclude that long-term changes in personality occurred as a consequence, the researchers needed to have a control group who received only placebos. This was not done.

Another potential problem was that every subject indicated previous use of LSD. The question then arises as to what extent this previous usage may have influenced current results? Would the results have been different with a sample of people who had never used LSD before? It is also very unclear what is meant by the self-reported experiences of “ego-dissolution.” More than offering some insights about the value of LSD in therapy, these reports by the subjects may be the result of respondent bias and sponsor bias. Finally, Lebedev et. al. (2016) conducted a follow up using the NEO-PI-R after only two weeks and arrive at the remarkable conclusion that LSD-induced shifts in brain dynamics and the attendant subjective experience can predict lasting changes in personality (p. 9). To lend any validity to this bold claim, it would be necessary to administer the NEO-PI-R to the subjects years later. But this was not done and there is no indication the researchers have such intentions.

Beyond the heightened sense of self-awareness reported by the subjects, Lebedev et. al. (2016) provided no discussion of the long-term psychophysical effects of increased brain entropy. The way drugs present themselves varies widely but it has been shown that drug use resembles mental disorders in how it increases psychological entropy and uses energy to work toward emotional goals. To the extent this entropy increases over time, this may actually increase the aging process (Yao, et. al., 2013, para. 1). However, it is very troubling that Lebedev, et. al. (2016) appear to imply that administering doses of LSD to subjects may permanently alter their personalities by making them "more open". Their study does not support this inference. This poorly designed study is highly misleading which may cause some to conclude it provides meaningful insights about psychological entropy. It cannot make such claims until its outcomes are testable.

Wheel of Emotion

Robert Plutchik (2000) has been perhaps one of the most influential modern emotion theorists. His conception of the psychoevolutionary theory of emotion has formed the basis of many current psychological studies into emotion and provides a method of classification for emotional responses. Plutchik's theory makes no mention of entropy, self-organization, thermodynamics or information theory. Hence, his psychoevolutionary theory departs significantly from what has been argued here. However, similar to Izard et. al (2000), he concludes there are eight basic or "primary" emotions which include anger, fear, sadness, disgust, surprise, anticipation, trust, and joy (Plutchik, 2000, p. 63). These basic emotions he regards to be biologically rooted in evolution and behaviorally adaptive (Plutchik, 2000, p. 79). The psychoevolutionary theory is intended to extend and refine the theory of emotion presented by Darwin (1872/2015).

Plutchik (2000) incorporates three models within the psychoevolutionary theory: 1) the structural model, 2) the sequential model and 3) the derivatives model (p. 59). Of the structural model, Plutchik (2000) says, "The *structural* model assumes that there are eight primary emotion dimensions (like primary colors) that vary in intensity, similarity and polarity" (p. 59). Indeed, it is with color blending and variations that Plutchik creates a three-dimensional analog, the cross-section of which is a circumplex called the wheel of emotion. By mixing emotions, he produces terms which have been associated with personality traits. The sequential model represents the major parts of an emotional reaction. This includes cognitions, feelings, neural changes, impulses to act, goal-directed behavior, defenses, and coping styles (Plutchik, 2000, p.59). In the derivatives model, there are several conceptual domains, such as personality, personality disorders and ego defenses which are systematically derived from emotion (Plutchik, 2000, p. 72).

According to Plutchik (2000), there are three essential characteristics which define an emotion (pgs. 61 – 62). Within the structural model, the language of emotions must first include an implicit intensity dimension (Plutchik, 2000, p. 61). For most words used in the emotion lexicon, it is usually possible to find other words that suggest greater or lesser intensity, according to Plutchik (2000, p. 61). He uses *anger*, *rage*, and *fury* as examples (Plutchik, 2000, p. 61). Secondly, he contends that emotions will vary in how similar they are to each other (Plutchik, 2000, p. 61). The word *fear* varies from *fright,* for

example. This may only describe degrees of intensity or it may represent separate experiences. For example, anger is similar to disgust, dislike, and loathing (Plutchik, p. 61). The third essential characteristic is what he calls their bipolar nature (Plutchik, 2000, p. 62). By this, he is suggesting that emotions present themselves in opposition to other emotions (Plutchik, 2000, p. 62). For example, love versus hate, happiness versus sadness, and fear versus anger in his view would be considered polar opposites. Thus, Plutchik constructs a three-dimensional model that blends the primary colors of basic emotions into various shades which are intended to be representative of a variety of emotional experiences of differing intensities. This model forms a cone shape and as noted, viewing a cross section presents one with a wheel of emotion (circumplex) (Plutchik, 2000, p. 63).

According to Plutchik (2000), often the same adjectives are used to describe both emotion states and personality traits (p. 64). He observes, “Thus, according to this theory, emotions and personality traits are intimately connected, and in fact, personality traits may be considered to be derived from mixtures of emotions” (Plutchik, 2000, p. 64). However, unlike personality traits, emotions seem to be brief in duration and involve feedback loops (i. e. they have a circular process) directed at restoring an individual to equilibrium (Plutchik, 2000, p. 66). By equilibrium, Plutchik means stability or homeostasis. Thus, Plutchik’s equilibrium has nearly the opposite meaning referenced throughout this discussion (i.e. perfect disorder). He argues that during an emotional reaction, once the goal has been achieved, the individual’s relation to the environment changes and thus the emotional response declines. For example, if the goal of aggression is attained, the emotion diminishes (Plutchik, 2000, p. 66).

Plutchik (2000) defines his use of the word derivatives as concepts derived from other more primitive events or concepts (p. 70). As noted, he sees emotions and personality traits having often overlapping descriptions. He says, “An individual can feel depressed or be a depressed person, can feel nervous or be a nervous person, or can be joyful or be a joyful person” (Plutchik, 2000, p. 70). In addition to domains of emotion and personality, Plutchik represents this in a circumplex structure. The psychoevolutionary theory assumes that because of their adaptive role in all organisms, emotions are the precursors of personality traits. Thus, personality traits are derivatives of more fundamental emotional states (Plutchik, 2000, pgs. 71 – 72). Plutchik (2000) likens this to how colors in nature are derived from more primary ones (p. 72). He observes that when personality traits persist in fairly extreme form over

time, they are described using the language of disorders (Plutchik, 2000, p. 72). He theorizes that ego-defense language and coping style language are used as ways to deal with particular emotions and that these defenses are for the most part unconscious (Plutchik, 2000, p. 72). He also largely accepts the Freudian conception of the unconscious and is a strong proponent of psychotherapy (Plutchik, 2000, pgs. 45 – 46). Hence, Plutchik's intended application for the circumplex and his psychoevolutionary theory appears to be in psychotherapy.

Plulchik (2000) contends that all emotions are basic adaptive patterns that can be identified at the phylogenetic levels (p. 74). That is, they are patterns of agonistic behavior, sexual behavior and investigative behavior which are a part of evolutionary history. According to Plutchik (2000), "Emotions are *universal*(in the sense of being part of the repertoire of all living things)" (p. 79). This means that all emotions are tools for survival consistent with Darwin (1872/2015). Emotions, therefore, are innate and present in all organisms, according to Plutchik (2000, p. 79). The subjective feelings of emotions are a relatively new evolutionary development and must not be used as the sole criterion for the presence of an emotional state (Plutchik, 2000, p.79). Thus, he argues that a small number of basic human emotions can be understood as prototype emotions and all others are mixtures, compounds or blends of the primary emotions (Plutchik, 2000, pgs. 78 – 79). As a consequence, there is a basic interrelationship between emotions and personality traits. Plutchik (2000) sees these personality traits as "compromise formations" based on conflicts as well as the repeated mixture of basic emotions (p. 78).

The psychoevolutionary theory of Plutchik (2000) appears to be well grounded in classic Darwinism. Plutchik deserves credit for recognizing emotions are adaptation used by living organisms in order to survive. There is good evidence that animals other than humans experience emotions (Ferdowsian, Durham and Brune, 2013; Panksepp and Biven, 2012; LeDoux, 2003). While this understanding is important to acknowledge, clearly defined emotional states do not necessarily follow from it. It is assumed for this discussion that a range of instinctual emotions exists. These emotions are likely to be comparable to other higher animals in particular.

Unfortunately, however, Plutchik (2000) follows the pattern of supplying inadequate empirical evidence for a basic set of emotions (Ortony and Turner, 1990). His descriptors of emotions are also sometimes highly ambiguous, which present impossible challenges in terms of measurement. To

effectively measure emotions, one must be able to distinguish them from other mental states. But this has been a problem for Plutchik (Richins, 1997). By using these basic emotions as placeholders, Plutchik creates the false impression of being scientific when he applies them to make a three-dimensional model and a circumplex which mix colors representing emotions. This appears to be a major weakness in Plutchik's research model. In this discussion as mentioned, it has been argued that no determination about basic emotions is yet possible. Therefore, no reference to a basic set of emotions will be made. Instead, the two-dimensional emotion valence model of Russel (2003) which avoids ambiguity, is used to understand the range and intensity of emotional experience. It is postulated that both scaling of emotional range (positive to negative) and intensity (high to low), are informative when determining the tendency toward emotional dysregulation.

It is submitted that a second major weakness is that Plutchik appears to be unaware of the fundamental influence of entropy in emotions, thought and brain processes. If one excepts his theory, one cannot reasonably claim that there is a tendency toward increasing entropy in emotional states. The theory he puts forward suggests he does not recognize such a tendency. Evidence correlating emotion states and psychology with increased entropy has been cited in Chapter 4. Clearly, his omission means his model does not account for the tendency toward emotional dysregulation or how spontaneous self-organization of emotions schemas occur far removed from complete dysregulation (death), as has been proposed in this evaluation. Plutchik (2000) describes personality traits which can lead to disorders, but only as a result of the degrees of intensity with which they are experienced (p. 72).

Because the scope of Plutchik's model appears to focus entirely psychotherapeutic solutions, it is contended that it cannot adequately address the global dimensions of entropy-related emotional problems. Plutchik's model appears to be designed so that therapists can work with patients to identify troubling emotions and fix them through talk therapy. However, evidence suggests that traditional psychotherapy used alone may have questionable long-term value (Laws, Darlington, Kondel, McKenna and Jauhar, 2018). Therefore, because his basic emotions are unsupported by empirical evidence, it is argued that they can only be understood as arbitrary placeholders. Because of the well-recognized placebo effect of psychotherapy (Sliwinski and Elkins, 2013), psychotherapy patients may "feel better"

when applying the wheel of emotion of Plutchik (2000). But it is proposed that the long-term benefits of this experience have not been verified.

Emotional Constructionism

Emotional (psychological) constructionism is a very new paradigm for understanding emotions and perhaps its best-known proponent is Lisa Feldman Barrett (2017). The theory of emotional constructionism argues that there exists a paradox between human reported experiences of discrete emotions such as “fear”, “anger,” “happiness” and the inability of science to empirically detect the presence of discrete emotion states by observing the brain and psychophysiology (Barrett and Russell, 2015, pgs. 4 – 5). For this reason, emotional constructionism points to evidence of the existence of affect in the brain and body and that emotions are constructed by multiple brain networks working together, arguing that emotional episodes are the result. Core affect in psychological constructionism is used to refer to processes underlying emotional episodes which are not unique to emotional episodes. They are made up of feelings which correspond to changing bodily physiological states (Barrett, 2017, p. 22). Barrett (2017) argues that individual emotions have no “fingerprint” in the brain (p. 22). She uses the word fingerprint to describe a consistent pattern of neurological activity in the brain or a localized area of the brain which is predictably the source of a discrete emotion (Barrett, 2017, p. 22). Furthermore, she contends there is so much differentiation between individual experiences of emotions that it is impossible to assign labels like “anger”, “fear”, “happiness” with any consistency or reliability (Barrett, 2017, p. 23).

Barrett also observes that fingerprints are absent even if one considers multiple connected regions at once (a brain network), or in the observation of individual neurons stimulated with electricity (Barrett, 2017, p.22). She notes however that there have been recent technological advances in A.I. which permit neuroscientists to perform pattern classification of emotions such as fear or anger (Barrett, 2017, p. 23). By analyzing many brain scans, the program computes statistical pattern summaries of emotional states. Based on the summaries, the program is then capable of analyzing new scans to determine if they are closer to the summary pattern of fear or anger. Though Barrett does not cite a source for this, one good example is Kragel and LaBar (2014). But while she makes this point, Barrett is quick to point out that these statistical summaries do not represent true fingerprints for emotion states. She argues that the scientists who claim this are mistaking the mathematical average for the emotional

norm (Barrett, 2017, p. 23). Thus, she contends that if one should apply emotion words at all, they can only meaningfully be applied as broad categories of highly variable experience (Barrett, 2017, p. 21). She says:

> The summary is an abstraction that does not exist in nature – it does not describe any individual member of the species. Where emotions are concerned, on different occasions and in different people, different combinations of neurons can create instances of an emotion category like anger. Even when two experiences of anger feel the same to you, they can have different brain patterns via degeneracy. (Barrett, 2017, p. 24)

By degeneracy, Barrett means a process of many to one. Hence, a diverse set of emotional instances may merge into a single emotional episode. She is also analogizing emotion categories to be similar to trees or dogs. The words tree and dog apply broadly to categories, but trees vary widely in terms of biology and appearance. The same applies to dogs and individual dogs will not be identical even within the same species. Thus, emotion instances within categories will always be different (Barrett, 2017, p. 24).

Barrett and other emotional constructionists generally recognize the role of human evolution in shaping emotional expression, but they depart from Darwin and the classical view of emotions in fundamental ways. For example, Barrett (2017) rejects the Darwinian idea that emotions can be reliably interpreted from facial expression or body language (p. 35). This, she contends, is partly because how a person is feeling will not always correspond to how facial muscles are shaped and because a person's body position or movements do not always predict their actual emotional experience (Barrett, 2017 pgs. 35 – 36). There can be wide individual differences and some of them can be attributed to cultural and social variation. Secondly, emotional constructionists do not accept that there are certain emotions which are inborn or instinctual (Barrett, 2017, p.38). If emotions are universal, they argue it is due to shared cross-cultural concepts. According to Barrett (2017), "What's universal is the ability to form concepts that make our physical sensations meaningful, from the Western concept 'sadness' to the Dutch concept *Gezellig* (a specific experience of comfort with friends), which has no exact English translation" (p. 38). Thus, she argues that all emotions are learned and require conceptualization.

It is this last point which represents the central hypothesis of emotional constructionism. That is, emotions are formed conceptually like all other concepts. The sensations of feeling derived from affective experience are meaningless until they are conceptualized. Barrett and Russell (2015) argue, “A more modern hypothesis, typical of the psychological construction program of research, is that an emotion word such as ‘fear’ corresponds to a conceptual category. An emotion category is not a physical type with a physical essence…” (p. 47). As mentioned, it is viewed as a collection of instances or a statistical summary. Thus, the instances are not random but functionally linked to the immediate situation.

By asserting that emotions have no meaning until they are conceptualized, emotional constructionism fits into the tradition of linguistic relativity. Adherents of this philosophy usually fall into one of two different schools of thought. Hard linguistic relativists argue that language *determines* thought while soft linguistic relativists assert that linguistic categories and usage only *influence* thought. Therefore, since emotional episodes are a part of thought, the hard-linguistic relativist must argue that emotion is only possible when language exists (i. e. language determines emotion). Soft linguistic relatives argue that language influences emotion. Barrett and Russell (2015) make the following assertion:

> …emotional episodes, no matter the category, are created with at least two domains of core systems: a system (or systems) for representing sensations related to the body (which is usually referred to as “affective”), and a system (or systems) for conceptually making sense of these sensations and/or feelings in relation to the situation (including the language network). (p. 99)

It is this last parenthetical which is a key piece. Barrett and Russell (2015) argue that to create an emotion, use of the language network to make sense of the sensory input is necessary. They describe this process as the conceptual act theory (Barrett and Russell, 2015, p. 84). According to the theory, the architecture of the brain can be understood as a situated conceptualization generator that produces the sequences of brain states corresponding to the mental features that one experiences. It is because of this, that emotion categories lack a physical essence (Barrett and Russell, 2015, p. 98).

It is because the human brain is so good at generating concepts that symbolic renderings (such as through the development of language) are made possible. Other animals display little, if any ability to

create or manipulate symbols and for this reason, it is highly unlikely most species of animal's experience emotions, according to Barrett (2017, p. 276). This then, is another major departure from classic Darwinism in emotional constructionism.

Barrett is stating that emotion is conceptual knowledge when she argues for the conceptual act theory. Stated differently, emotions are constructed because concepts of emotions are formed. The affective domain is composed only of sensory ingredients which do not constitute emotion in themselves. If one views the ingredients for a cake of flour, sugar, and egg separately, one would not describe them as a cake. It is this analogy Barrett (2017) uses to illustrate her point concerning how emotions are made (p. 37). Barrett and Russell (2015) state: "… when developing a concept of anger, for example, the child's brain encodes instances in which the word 'anger' or 'angry' is used" (p. 96) By implication then, Barrett and Russell are asserting that the infant does not create anger until it conceptualizes it with words. Thus, at least as presented by Barrett and Russell, psychological constructionism appears to embrace hard-linguistic relativism (i.e. emotions are determined by language).

For Barrett and Russell (2015), this means they dismiss cognitive appraisal theories because they entail emotional essentialism and are premised on emotional reaction instead of the conceptual act theory. They claim:

> Appraisal theories hypothesize top-down processes in emotive generation, but these are usually thought to react to and modulate incoming, bottom-up stimulation. The conceptual act theory of emotion, by contrast, implicitly uses ideas that are similar to logic or predictive coding in its hypothesis about how the brain creates situated conceptualizations (which are the content of emotional episodes). (Barrett and Russell, 2015, p. 50)

Thus, their central objection to cognitive appraisal is that it does not involve clearly defined logic, that it describes emotions as reactive, and that the appraisals influence affect. Instead, they argue the brain becomes bodily aware "interoceptive" and makes a prediction, conceptualizing an emotional instance based on memories of past experiences (Barrett and Russell, 2015, p. 50). This is an iterative process where instances of emotions change with new information.

Aside from denying the physicality of emotional categories, it is difficult to see how different their argument really is from cognitive appraisal. It appears to be one largely based on semantics. If one

accepts that appraisals are goal-driven estimates of perceived events, it follows that they involve predictive logic and memory. If one holds that bodily awareness must get conceptualized, then is must get modified or controlled. Indeed, other constructionists (Ortony and Clore, 2015, p. 310) defend the application of appraisal theory. Secondly, many appraisal theories are top-down but as discussed in Chapter 4, because this linear, one-way approach to appraisals is incomplete, a bidirectional nonlinear. model is proposed by Lewis (2004).

The entropy theory of emotion posits that while conscious high-level cognitive appraisal can influence emotional episodes, unconscious or preconscious appraisals arising from more primitive innate survival presentations happen, involving their own premise-to-conclusion assessments. Both from an evolutionary and a developmental standpoint, appraisals are understood to occur from the bottom up, beginning with instinctual agency in a continuum to high-level cognition as the brain grows and adapts with built-in plasticity.

It is exactly the linear top-down feature of linguistic relativism on which the conceptual act theory of psychological constructivism is based that is problematic. Asserting that conceptual categorization is required for emotion experience is another way of stating that emotions happen only when some discrete higher-order function within the brain for symbolic language and cognition operates. Thus, when emotional constructionists charge those who argue for discrete basic emotions as lacking evidence, they are guilty of doing the reverse. Their reverence for higher-order cognition has led them to insist that categorizing statistical summaries of emotion instances (conceptual categories) or "read-out" of affective input is the only way possible to experience emotion. But if one argues that there is no fingerprint for discrete emotions and argues that emotions are experienced as categories, where are the fingerprints for different categories? There is no evidence that the brain generates fingerprints for concepts like "chair" or "apple." Of course, there is no evidence indicating discrete "basic" set of concepts which are contained within the brain. Emotional constructionists theorize however that it is the process of concept-making which is innate. But they have not shown where the fingerprint for concept-making exists in the brain. As Kohonen (1989) observes:

> There exists now one very fundamental possible source of confusion which, unless we are aware of it, may severely misguide our thoughts and theoretical approaches in brain theory.

> Because the human beings have the capabilities of solving, e.g., mathematical problems, carrying out high-level verbal communication, and creating art, one may easily tend to think that there must exist corresponding mechanisms or specific functions in the brain itself. The fact to be realized is that most of these tasks belong to the *socialbehaviour* of man; the corresponding skills have been acquired over a very long time in closed cultures by trial and error, resorting to instrumental aids such as writing, and the individuals only have to *learn* them during their own lifetime. (pgs. 246
>
> – 247)

Kohonen (1989) points out that learning may be represented in the brain more or less as collective, distributed, and diffuse state changes drawing from neural networks in some kind of high-level (hierarchical) classical conditioning (Kohonen, 1989, p. 247). He observes that to continue with this line of reasoning leads one to conclude that the existence of any genetically determined, developed linguistic functions identified with brain anatomical structures is not plausible (Kohonen, 1989, p. 247). It is much more likely that these skills are acquired entirely after birth due to enormous brain plasticity and trial-and-error learning. In this way, the very process of concept-making is learned (Kohonen, 1989, p. 247).

Therefore, Kohonen appears to be turning the theory of the linguistic relativists almost literally on its head. Instead of arguing that emotions do not get experienced until there is a cognitive “readout” or labeling of them, Kohonen (1989) is arguing that cognition, linguistics and problem-solving skills do not exist anywhere as a function in the brain and must get created usually through trial-and-error learning (p. 247). If one agrees with Darwin’s theory of evolution, Kohonen’s thesis seems more coherent. One can conceive of cognition itself as a read-out of emotional and sensory experience, and not the reverse. Viewed through the understanding of the cognitive appraisal theory of Lazarus and Folkman (1984), one can easily see that cognition must have evolved from emotional appraisals dealing with survival (p. 24). This may partly explain why appraisals are bidirectional (Lewis, 2004). It is conjectured that the power of primal appraisals is that they are founded in urgent instinctual survival needs and this is why they can force their way up to overwhelm higher-order thinking. Structurally, such appraisals in animals and humans may have acquired more skills through learning derived from new lessons of adaptation. But it is contended that even the highest-level reasoning in humans is connected to the neural network of a brain

designed for survival needs and this is why cognition and emotion are inseparable (perhaps as patterns, indistinguishable).

In higher forms of life, the CNS has evolved to facilitate the survival of the species, as noted by Kohonen (1989, p. 245). It is maintained that approaching the brain and CNS as mechanisms of biology directed at survival is the only way to understand their actual function. It is unreasonable to attempt comparisons between computers and the biological neural networks for this reason, according to Kohonen (1989, p. 245). Yet, this sort of research proliferates. While psychological constructionism does not make explicit comparisons to computers, the idea that concepts determine emotions operates from a premise which is similar. The assumption underlying it is that the goal to survive has nothing to do with how emotions are made. What Kohonen does not say (though undoubtedly, he must see) is that the endless search for the "reasoning" neurons in the brain, and the attempts at defining all mental activity as cognition are the latest distorted formulation of mind-body dualism. They resurrect the dichotomy between thinking and emotion and insist that no sensory experience exists in the central nervous system unless there is a concept of it in awareness. One wonders how living organisms ever survived over millions of years absent the ability to form concepts of their experiences! This, of course, is a profound absurdity. Therefore, central to understanding the entropy theory of emotion, it is submitted that the neural network of the brain is a product of biological evolution and is a result of trial and error experiments in self-organizational survival.

As discussed, Barrett and Russell (2015) argue that emotions are not created and do not emerge until one can consciously conceptualize them. This means a readout of affective input is necessary for emotion to occur. In many ways, their linking the affective to conceptual categories appears to be little more than a semantical swap which removes the word emotion from being assigned to the affective and reassigns it to ideation. Affect is reduced to bodily sensation or sensory stimulation which they deny as having essence (Barrett and Russell, 2015, p. 47).

There is little evidence that most other animals experience consciousness exactly as humans do and this is why Barrett (2017) seriously doubts that most other animals are capable of emotion (p. 277). She contends that there are no circuits dedicated to emotions in the animal brain, therefore in the vast majority of animals there is no evidence for emotion (Barrett, 2017, p. 277). But the misleading

assumptions and bias of Barrett's arguments are apparent, and this is another reason the constructionist model for emotion creation is flawed. As noted by Panksepp and Biven (2012):

> The affective neuroscience approach does not envision emotional feelings being 'read out' by higher cognitive brain functions, although there are persuasive interactions with those regions of BrainMind. Affective states are part and parcel of each emotional operating system. However, this does not mean that higher cognitive mechanisms do not interact with or reflect on these ancient powers. (p. 75)

Thus, the basic problem with the constructionist's model is its heavy reliance on conscious conceptualization. Panksepp and Biven coin the term "BrainMind" to describe the conjoined CNS with thought processes. Conscious awareness represents the tip of the mental iceberg and so much of mental experience is not represented in formal concept. It is because it represents a relatively new development in the evolution of the brain cortex. Emotional survival mechanisms have been in existence for animals much longer.

Panksepp and Biven (2012) describe emotion as an unreflective, unthinking primary-process of consciousness that precedes one's cognitive understanding of the world (p. 75). They refer to it as "anoetic" (without external knowledge) (Panksepp and Biven, 2012, p. 14). The primary-process emotions are raw affects that automatically make important decisions in one's situation. They point out, however, that virtually no one in the field of psychology would dispute that the higher mind can dramatically influence the lower affective landscape (Panksepp and Biven, 2012, pgs. 76-77). But the problem which comes up, creating often bitter disagreement between scientists is the result of different theorists discussing different levels of analysis in a highly complex hierarchical set of affective-cognitive systems. The constructionists like Barrett make a fatal error. As Panksepp and Biven (2012) observe:

> There has been a temptation among many theorists (who spend much of their own mental lives in the higher conceptual reaches of BrainMind processing) to put all psychological experiences within those highest realms of mind. This leads to the unjustified assumption that the lower brain functions are strictly unconscious. But that conclusion is simply not justified by the evidence (Merker, 2007; Panksepp, 1998a; Shewmon et. al. 1999). (p. 77)

Panksepp and Biven have unearthed another underlying constructionist bias in this observation. If the only way emotion is possible is through cognitive conceptualization, then this effectively shuts off any potential preconscious (or subconscious) awareness of feeling states and moods, creating a kind of binary concept/no concept construct for emotional experience. But surely emotions do not always turn on and off like light switches. A dimmer switch for emotion experience might be a more apropos analogy. Emotions vary in intensity as well as in feeling positive or negative. Constructionists maintain that emotions have no pre-concept *essence*. While they insist that this should not be interpreted to mean that pre-concept feeling states are illusory, it is impossible to draw any other conclusion based on their arguments. Barrett (2017) insists that because no fingerprint can be found, no signature pattern for emotions can exist and all affective awareness can be reduced to sensory input (Barrett, 2017, pgs. 35 – 38). Therefore, she concludes, there can be no psychophysiological essence until an abstraction, or generalizations of affective instances occurs which is derived from repeated exposure.

However, Panksepp and Bevin (2012) contend emotions are not abstractions and therefore they can be experienced without the symbolic concepts of language (p. 79). They compare the knowledge of them to how one learns colors. Once someone discovers red for the first time, all their subsequent experiences of red will be the same. Research on primates indicates that different species perceive a different spectrum of colors based on the evolutionary development of the retina and the importance of objects to the survival of the species (Kawamura, 2016). This would appear to be consistent with this with the analogy to emotions made by Panksepp and Bevin (2012). Once a color is recognized, there will be no variation in that experience, so that no abstraction is required to understand red. They state:

> But the raw phenomenal experience of seeing red does not require intelligence. So words like *chair* represent intelligent concepts, while other words like *red* represent primary experiences that require no intelligence except, of course, if you wished to label the experience. (p. 79)

Language is merely a label that represents these experiences, but no conceptual intelligence is necessary to experience emotions (Panksepp and Bevin, p. 79). It should be made clear that this does not mean Panksepp and Bevin have defined a clear set of basic or discrete emotions. They are merely describing the essence of affective physiology as a primary experience.

This might be compared to how one experiences different flavors on the pallet. One can discriminate between sweet and bitter tastes without having concepts for them, for example. With learning, one can develop a very refined sense of flavor with a broadly articulated range. But flavor can be experienced by animals as well as humans. Panksepp and Bevin add:

> Thus, our use of words does not necessarily mean that other animals need to be competent with verbal concepts in order to experience affects. Primal affects are surely *prelinguistic* experiences – experiences common to all mammals and perhaps to other animals as well (Huber et al., 2011). (p. 79)

It is obvious Panksepp and Bevin (2012) have no difficulty recognizing the capacity to experience emotion in animals which, as has been shown, is quite consistent with the evolutionary theories of Charles Darwin (1872/2015). But the assumption of constructionists like Barrett (2017) that symbolic language is a requirement for experiencing emotion seems to sever humans from all other species of the animal population as well as deny most other animals any potential for an emotional range of experience. As has been cited, there is a considerable body of evidence to contradict this. However, additional examples of evidence are supplied in the research of King, Smith, Grandin and Borchelt, 2016; Moore MJ, der Hoop, Costidis, Gulland, Jepson, Moore KT, Raverty and McLellan, 2013; Bekoff, 2011; Dreschel, 2010.

It has been mentioned that a central premise within constructionist theory is emotional episodes have no neurological fingerprint and there are no localized areas of the brain which are dedicated to emotions. Barrett (2017) argues, for example, that each instance of emotion is unique and there is no consistent pattern which can be detected for what is colloquially called emotions (p. 23). But simply because she and her colleagues have not been able to identify such localized areas and patterns, should one assume they do not exist? In fact, other scientists have conducted important research identifying local areas where one can infer emotions are generated. For example, despite Barrett's claim that there is no evidence for a dedicated connection between the amygdala and emotion, several studies reveal just such a possible connection. According to Johnston and Olson (2015):

> One piece of evidence that the amygdala plays a central role in facilitating the processing of emotionally salient stimuli is the finding that the attenuation of the attentional blink by emotionally salient stimuli does not occur in patients with amygdala lesions (Anderson &

Phelps, 2001). (p. 257)

This suggests that the lesion of the amygdala creates an impairment which prevents the patient from reacting emotionally to a stimulus which would cause a “defensive” blink in someone without the lesion. Thus, it suggests the amygdala may have a role in emotion (Johnston and Olson, 2015, p. 257). They also note two other significant pieces of evidence concerning the amygdala. They observe that recent neuroimaging studies (Pessoa, Garcia-Pereira and Oliveira, 2010) indicate that the amygdala mediates temporal lobes when object recognition of the visual cortex is enhanced by emotional stimulus activation (Johnston and Olson, 2015, p. 257). Additional evidence comes from studies of humans with damage to the right frontoparietal attentional network, suggesting such patients are oblivious to information in the contralateral left hemispace, an attentional disorder known as hemispatial neglect (Johnston and Olson, 2015, p. 257).

These are some examples of compelling evidence that the amygdala may play an import role in emotional attention. As discussed in Chapter 4, other research has implicated the hypothalamus as well. Other parts of the limbic system, such as the hippocampus, are undoubtedly important. While this question is not definitively resolved, it is the view of this writer that dismissing this research would be a serious mistake at this time. Indeed, it may be that large-scale brain networks should be studied as a whole. But these unresolved questions do not negate the psychophysiology of emotions. Making the psychological constructionists claim that there is no fingerprint for emotion more questionable is the simple fact that statistical summaries of instances can be produced using A. I. based on fMRI scanning. As noted, Barrett (2017) concedes this point but hastily dismisses them, contending that the scientists are “…mistaking a mathematical average for the norm” (p. 23). Barrett and Russell (2015) also concede that they are not random (pgs. 47 – 48).

As previously cited, Kragel and LaBar (2014) are a good example of this. Krager and LaBar (2016) followed up with a second study conducted along similar lines. Their approach is to apply a multivariate statistical method in analyzing brain scans employing A.I. to identify emotion classifications. The statistical summaries provide instance variable ranges of emotions from which the A. I. computer model can predict an emotion pattern from a scan. The researchers claim that functional neuroimaging data can be accurately classified along affective dimensions and discrete emotion categories (Krager

and LaBar, 2016, para. 1). To be sure, this is not definitive evidence that discrete basic emotion states exist. However, it would be a mistake to reject their findings as meaningless. Barrett (2017) argues they are deeply flawed because they rely on statistical norms (bell curves) to predict emotion states. One wonders if she and her colleagues would also dismiss the predictive models used in meteorology? They are after all, based on very similar statistical summaries of past weather events, though they are not a description of any specific weather event. Certainly, such forecasting can be inaccurate. Yet, they offer sufficient reliability in predicting future weather events so that they are incorporated into major policy decisions such as when to issue weather warnings, evacuations, when it is safe to fly a jet or when to keep a highway open to travel. The reason these mathematical averages are important is they are predictive of a range of what is most likely to exist. Their predictive value will improve with more sampling.

Finally, a critique of emotional constructionism would be incomplete without an examination of how entropy is viewed. Barrett (2017) makes no reference to it. This suggests that she does not regard it as a significant influence in emotional construction. Certainly, she must be aware of the large body of research into brain entropy. It is not known why she does not discuss it.

However, her constructionists' colleagues Cunningham, Dunfield, and Stillman (2015) describe entropy as a component of constructionism. They argue, "…entropy may be thought of as the number of possible arrangements of the neuronal network that can produce that representation. In other words, entropy is the number of possible inputs (microstates) that can create the observed representation (macrostate)" (p. 174). Using Barrett's terminology, Cunningham et. al. (2015) assert that it is the ratio of affective instances to summary emotion concepts. They contend that a stimulus which has just been encountered and has not settled into a "stable" representation creates the highest entropy and it is reduced by engaging in pattern extraction (p. 174). They stress that this is an iterative process where concepts are constantly being revised with new information. This information comes from affect. The goal in this information entropy is always to reduce uncertainty and entropy in the dynamic system (Cunningham, et. al., 2015, p. 174).

The hypothesis of Cunningham et. al. (2015) is clearly linked to Shannon's information formulation. To their credit, they appear to place higher importance than Barrett (2017) on affect in *creating* and *revising* emotion concepts. But their entropy hypothesis still relies *exclusively* on top-down

conceptualization as emotion regulators. Of course, it is put forward in the entropy theory of emotions, that emotions need not be conceptualized to exist, and every episode is goal-driven. The Cunningham et. al. (2015) conception of entropy nevertheless is quite different. Their entropy model would mean that pre-language infants who sense danger and scream, might experience high levels of entropy but they could not be fearful in the least, because they lack concepts and labels for affect. The Cunningham et. al. (2015) model also emphasizes uncertainty, suggesting that its focus is on reducing anxiety rather than the more global idea of reducing dysregulation (p. 174). Therefore, their application of entropy in emotional constructionism appears to present theoretical dilemmas.

Conclusions

Since ancient times, Western thinkers have grappled with the meaning of emotions. The writings of Hippocrates demonstrated a clear understanding of how emotions are connected to both the body and mind. Plato's ontology separated a realm of pure form from the experienced realm. Within this, Plato established a dualism of mind and body. Plato regarded emotions as a threat to wisdom and civilization. By contrast, Aristotle viewed some emotions as good, arguing that being habituated to emotions leading to acts of bravery or promoting justice are good. He also asserted that some men are emotionally habituated to be irascible or self-indulgent. Ancient Stoicism and Epicureanism were also early attempts at emotional self-regulation. Stoics practiced a discipline of calm detachment from the passions and while the Epicureans sought happiness, they also believed in delayed gratification. As discussed, recent studies suggest individuals who are conscientious, may live longer (Friedman and Martin, 2011; Kern and Friedman, 2008). It appears, therefore, that these ancient schools of thought may embody fundamental principles essential for delaying entropy and prolonging one's life.

The early Stoic teachings of Zeno, Cleanthes and Chrysippus identified a set of eight bad thoughts which were adopted by early Christianity and formed the basis of the Christian seven deadly sins. In the Middle Ages Aristotle and the Stoics were given further legitimacy in the teachings of Thomas Aquinas. Aquinas contended that "passions" were a hindrance to reason if they were consented to deliberately. But he thought they could be virtuous if they were kept subordinate to reason. This hierarchy

placing reason above emotion proved to be a significant idea which presented a dichotomous force between reason and emotion in Western thought.

Niccolò Machiavelli and Thomas Hobbes during the Renaissance regarded emotional expression in cynical terms. Much like Plato, they both thought the passions of the masses were a danger to social order and control and therefore, the subjugation of the general populous under state control was necessary. On the other hand, fear used in the hands of rulers to suppress unruly mass emotion was both acceptable and necessary. Also carrying forth the mind-body dualism of Plato was René Descartes who viewed any emotional experience as a distraction impeding his ability to understand the truth with pure reason. Thus, the dichotomy between emotions and reason was of primary importance to Descartes' thesis. Indeed, Descartes attempted to find truth by severing all reasoning from bodily sensations. He also believed geometry represented the purest form of logic. It was Benedict de Spinoza who presented arguments in striking opposition to Descartes. Instead of dualism, Spinoza's ontology falls into the tradition of monism. He argued that there cannot be a substance which is not God and thus, nothing else is conceivable. It is largely on this basis that Spinoza maintained that the mind and body are united and that there is a reciprocity of effect between body and mind. Also, because the "affects" are of God, Spinoza argued they are natural properties about which it is justified to learn more. He then attempted to provide his evaluation of the affects in ways which seem to foreshadow modern psychological understandings of emotions.

The theories of Charles Darwin demarcate the modern era in understanding emotions. Darwin integrated emotion within the context of biological evolution. He asserted that living organisms have evolved over millions of years through natural selection and adaptation to the changing environment. He contended that emotions are closely linked to human and animal instincts, meaning they are largely unlearned and that all animals experience emotions. Darwin advanced that emotional expressions are universal and observable in both humans and other animals. This he contended, was evidenced in facial expressions and body language. Darwin's theories about emotions represented the dawning of evolutionary psychology in addition to revolutionizing the study of biology and nature.

Following in Darwin's footsteps were many psychologists who endeavored to expand upon his theory of evolutionary psychology. William James stands out as providing important understandings of the

conscious and unconscious mind and in providing descriptions of the stream of thought which are still meaningful today. James accepted Darwin's thesis regarding instincts and emotions. However, somewhat more controversially, James contended that emotions were all a reaction to physiology as presented in the James-Lange Theory of Emotion. Most psychologists now reject this. Nevertheless, a growing body of neuroscientific evidence suggests that it may be true at least part of the time. James also presented a theory for how attention is selective which seems to be borne out by present-day neuroscientific research. Hence, James appears to have foreshadowed many modern-day understandings of psychology.

As a reaction to applying introspection to the new field of psychology, the school of behaviorism emerged. Because behaviorists focused entirely on observable behavioral outcomes, they established a means for measuring psychological experience which heretofore had not existed. The early animal research of Edward Thorndike and Ivan Pavlov into Stimulus-Response (S-R) and classical conditioning provided the framework for John Watson and B. F. Skinner who are credited with formalizing behaviorism. Although Watson was a strong proponent and was the first to coin the word behaviorism, his "Little Albert Experiment" raised serious ethical concerns which set back developments in the discipline for several decades. Skinner effectively revived behaviorism using rigorously structured animal experiments. He developed the theory of operant conditioning which described how reinforcements in rewards or punishments influence behavior. Skinner created considerable controversy by claiming that all behavior was determined by environmental stimuli. Evidence that this reductionism is inaccurate has been more recently presented in neuro brain scan research revealing stochastic spatiotemporal patterns. These random patterns of brain activity suggest that affective-cognitive processes work autonomous of environmental cues, though they may be influenced by them. However, Skinner's most enduring contribution was to the understanding of learning theory. By its very nature, behaviorism was premised on parsing the observable body from the unobserved mind. Thus, it must be regarded as dualistic. While this supplied a means of measurement, the trade-off was that it offered little ability to connect outcomes to psychophysical experience and that emotions were reduced to a set of rewards and punishments.

The Second Law of Thermodynamics is perhaps one of the single most important physical principles presently understood about the nature of the universe. As first discovered and articulated by Rudolf Clausius, heat will transfer from a warmer body to a colder body but not the reverse. Clausius

called this phenomenon entropy. Since heat exists everywhere, the law is universally applicable. It was Ludwig Boltzmann who first developed an equation based on statistical probability showing that entropy was a process of order to disorder involving random changes in atoms. Erwin Schrodinger was the first to conceive of how this process occurred in living organisms while Claude Shannon applied Boltzmann's equation to determine how to send signals by reducing uncertainty. Schrodinger was the first to speculate on the unique quality of self-organization in living things. It was Shannon who established the fundamentals of information theory. It was the theory of Shannon combined with Schrodinger's conception of entropy in living organisms which led subsequent scientists to examine how information was encoded in DNA/RNA and physiology. Other researchers such as Stewart Kauffman and John Scales Avery theorized on how self-organization could occur far removed from equilibrium within living systems. With the development of neuroscience brain scanning technologies, new formulas for measuring brain entropy were developed and this has led research into psychological entropy. It is argued therefore that thermodynamics is the mind-body unifying principle which is impossible to ignore.

This wealth of research is foundational to what is maintained in this discussion. The evidence presented indicates that measurable psychophysiological entropy may be correlated with emotional episodes and emotion schemas. It is submitted that entropy is manifested as increasing levels of dysregulation in emotions andit is expressed in thought patterns and behaviors. Evidence suggests Emotions and moods may have a natural tendency toward complete dysregulation and that this may represent a threat to humans and animals. Completely unregulated emotion (equilibrium) is conceived of as a state or condition of unpredictable impulsivity or maladaptive disorder culminating in death. While a review of neuroscientific studies points to possible evidence for psychological and brain entropy. It is contended that additional evidence may be presented in the apparent thermodynamic connection between mind, brain and body and the universality of the Second Law of Thermodynamics. It is also possible that mental disorders and substance addiction, in which increased levels of brain entropy are measurably evident, are strongly correlated with reduced life expectancy. This may suggest that when maladaptive emotion schemas occur with greater frequency and intensity, increasing dysregulation toward equilibrium (death) is accelerated. It is conjectured that this may occur because as more emotive energy is expended there is a paradoxical increase in entropy. Providing more evidence may be

longitudinal studies suggesting that conscientiousness may be inversely related to dysregulation because it appears to be strongly correlated with longevity. In other words, the inverse of emotional dysregulation may prolong one's life.

Evidence suggesting that emotional episodes spontaneously self-organize much like the self-organization which occurs in the growth and development of all living organisms was presented. It is postulated that it is an extension of this biological process. It is asserted that emotions may emerge and assemble into emotion schemas, or arrangements of emotional reaction based largely on learning and socialization. The spontaneous self-organization of emotion is understood to occur as negative entropy in an order from order process. In other words, it appears to be a process opposing the tendency toward equilibrium, but paradoxically using the free energy to do emotive work which increases entropy. It is proposed that the signal information coding for emotion experience in the brain is being used within the spatiotemporal pattern-making, which is connected to the ANS. It is submitted that it does not matter if this emotion information coding is always the same (i. e. has a brain fingerprint) because it doesn't need to be in order to create an emotional episode. Individual emotion episodes are conceived of as both the product and material of system organization. This emotional spontaneous self-organization may occur as a subset of thought processes and may be inseparable (perhaps indistinguishable) from the spatiotemporal cognitive pattern-making within the affective-cognitive process. Thus, the systems (schemas) may be self-organizing because repeated interactions among component processes generate emergent properties. Research conducted by Izard (2007); Lewis (2004); Izard, Brian, Ackerman, Schoff, and Fine (2000); Lewis and Granic (2000) offer evidence suggesting the existence of spontaneous self-organizing emotions. Kelso (1995) also provides compelling evidence indicating dynamic self-organizing pattern-making in mental processes. Kohonen (1989) presents evidence for how self-organization may be involved in associative memory. It is argued that memory function in the hippocampus is closely linked to emotion expression within the limbic system.

It is further advanced that within emotional content, there is an appraisal of threat, harm, and coping. It is envisioned to involve likes and dislikes, wants and needs. Appraisals may be unconscious, preconscious or conscious, but is contended that they are goal-driven. The appraisal mechanism appears to be a tool for survival, and it includes iterative assessments based on new information obtained through

emotional exchange. Though not original to them, Lazarus and Folkman (1984) refined cognitive appraisal theory and since then, it has been widely accepted by other psychological researchers. Because appraisals involve estimates of choices, it is suggested that they necessarily entail a premise to conclusion logical format about which an individual is usually unaware, and which can occur very rapidly with an emotional episode. That some but not all cognitive appraisals involve the management of anxiety, is also contended. Indeed, it is asserted that some appraisal choices are deemed irrelevant and produce no stress. Thus, important elements of cognitive appraisals appear to be goal relevance and goal congruence. Therefore, because appraisals are goal-driven, it is argued they are the work of emotions. In this way, they are understood to expend emotive energy. There also is evidence suggesting that appraisals are not confined to humans. Other animals appear to perform them as well (Faustino, Oliveira, and Oliveira, 2015). In its highest forms, what is commonly identified as cognition (i. e. the ability to reason logically) appears to be an extension of the cognitive appraisal process occurring in emotions. For example, the complex mathematical equations created by astrophysicists and astronomers may be the symbolic forms rooted in the primitive survival mechanisms of cognitive appraisals requiring no symbols or vocabulary. The evolution of the brain as part of the CNS may account for this connection. It is proposed that the idea of "premise to conclusion" thinking at its core may involve an emotional assessment and a decision to act (or react) in response to specific goals. This would appear to apply to both inductive and deductive reasoning. In evolutionary terms, one can view this either from the top down or the bottom up. It is posited that appraisals must be understood as bidirectional and nonlinear (Lewis, 2004). In this sense, goal-driven emotions may be part of an evolutionary and developmental continuum beginning with sensory experience and ending with higher-order cognition. At every level, goal-driven survival appears to function. In this paradigm, it is assumed that cognitive appraisals occur both within complex emotion schemas and within simple brief emotion episodes. Evidence for cognitive appraisal was presented. Examples of recent psychological studies applying the theory to measure the emotional reactivity of research participants dealing with a variety of stress and coping experiences suggest validity for appraisal theory.

It is suggested that understanding emotional processes is not possible unless the thermodynamic forces which act on the psychophysiological information processing are fully considered.

This discussion has presented evidence suggesting that a tendency toward emotional dysregulation may register as elevated measures of brain entropy. This may be correlated with mental disorders and substance abuse. It may be operative in genetic disorders and personality disorders associated with aging. The findings of this analysis are incomplete and inconclusive. However, they are presented as a possible starting place for further research. It is hoped the paradigm can facilitate psychological research by applying the concept of emotional entropy dysregulation and presenting new pathways for neuroscience. Perhaps it can aid in determining standardized metrics for measuring emotional entropy and open new doors for the treatment of a broad range of mental disorders. Therefore, this new construct is proposed to better understand emotions.

References

Ackerman, B., Abe, J. A. A., Izard, C. (1998). Differential Emotions Theory and Emotional Development. .In M. F. Mascolo & S. Griffin (Eds.), *What Develops in Emotional Development?* New York: Plenum Press.

American Addiction Centers. (2018). *Statistics on Drug Addiction.* Retrieved from American Addiction website: https://americanaddictioncenters.org/rehab-guide/addiction-statistics/

American Physics Society. (2018). *J. Willard Gibbs.* Retrieved from American Physics Society website: https://www.aps.org/programs/outreach/history/historicsites/gibbs.cfm

Anglin, G. (1991). The 1950s:Programmed Instruction and Task Analysis – B. F. Skinner. *Instructional Technology*: *Past, Present, and Future*, Retrieved from A Hypertext History of Instructional Design website: http://faculty.coe.uh.edu/smcneil/cuin6373/idhistory/skinner.html.

Aquinas, T. (1992). Summa Theologica. In *The Great Books of the Western World.* (Vol. 18, pp. 1-1085). Chicago, IL: Encyclopaedia Britannica.

Aristotle. (1992). On Generation And Corruption. In *The Great Books of the Western World.* (Vol. 7, pp. 409 - 441). Chicago, IL: Encyclopaedia Britannica.

Aristotle. (1992). Metaphysics. In *The Great Books of the Western World.* (Vol. 7, pp. 499 - 626). Chicago, IL: Encyclopaedia Britannica.

Aristotle. (1992). Nicomachean Ethics. In *The Great Books of the Western World.* (Vol. 8, pp. 339 - 436). Chicago, IL: Encyclopaedia Britannica.

Associationism. (2013). In *Psychology Dictionary*. P. Nugent (Ed.) Retrieved from Psychology Dictionary website: https://psychologydictionary.org/associationism/

AshtonM. C. (2013). Individual Differences and Personality (Second Edition). In*ScienceDirect, Revised NEO Personality Inventory*,Retrieved from ScieneDirect.com website: https://www.sciencedirect.com/topics/neuroscience/revised-neo-personality-inventory

Autism Society. (2016). *Facts and Statistics.* Retrieved from Autism Society website: https://www.autism-society.org/what-is/facts-and-statistics/

Avery, J. S. (2012). *Information Theory and Evolution*. Hackensack, N.J.: World Scientific.

Baltzly, D. (2018). Stoicism. In*Stanford Encyclopedia of Philosophy* (Summer 2018 Edition), E. N. Zalta (Ed.) Retrieved from Stanford Encyclopedia of Philosophy website: https://plato.stanford.edu/entries/stoicism/#toc

Banasik, M., Gierowski, K., Nowakowski, K. (2017). Aggressiveness and the Intensity of Psychopathic Symptoms – Gender Differences. In *Psychiatria Polska*, 51(4). 751 – 762. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/28987062

Barrett, L. F. (2017). *How Emotions Are Made*. Boston: Houghton Mifflin Harcourt.

Barrett, L. F. (2015). Ten Common Misconceptions about Psychological Construction Theory. In L. Barrett et al. (Eds.), *The Psychological Construction of Emotion*. New York: The Guilford Press.

Baskin-Sommers, A. R., Wallace, J. F., MacCoon, D. G., Curtin, J. J., Newman, J. P. (2010). Clarifying the Factors that Undermine Behavioral Inhibition System Functioning in Psychopathy. In *Personality Disorders*, 1(4). 203 – 217. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2992384/

Bekoff, M. (2011). Empathic Chickens and Cooperative Elephants: Emotional Intelligence Expands its Range Again. In*Psychology Today*, Retrieved from Psychology Today website: https://www.psychologytoday.com/us/blog/animal-emotions/201103/empathic-chickens-and-cooperative-elephants-emotional-intelligence

Bigatti, S. M., Steiner, J. L., Miller, K. D. (2012). Cognitive Appraisals, Coping and Depressive Symptoms in Breast Cancer Patients. In *Stress Health*, 28(5). 355 – 361. Retrieved from IUPUI ScholarsWorks Repository website:https://scholarworks.iupui.edu/bitstream/handle/1805/4903/bigatti-2012-cognitive.pdf?sequence=1&isAllowed=y

Boccardi, V., Comanducci, C., Baroni, M., Mecocci, P. (2017). Of Energy and Entropy: The Ineluctable Impact of Aging in Old Age Dementia. In *International Journal of Molecular Sciences*, 18(12). 1 – 11. Retrieved from ResearchGate website: https://www.researchgate.net/publication/321705708_Of_Energy_and_Entropy_The_Ineluctable_Impact_of_Aging_in_Old_Age_Dementia

Boissy, A., Aubert, A., Desire`, L., Greiveldinger, L., Deval, E., Veissier, I. (2011). Cognitive Sciences to Relate Ear Postures to Emotions in Sheep. In *Animal Welfare* (South Mimms, England). 20. 47 – 56 Retrieved from ReasearchGate website: https://www.researchgate.net/publication/230851716_Cognitive_sciences_to_relate_ear_postures_to_emotions_in_sheep

Brookes, M. J., Hall, E. L., Robson, S. E.., Price, D., Palaniyappan, L., Liddle, E. B., Liddle, P. F., Robinson, S. E., Morris, P. G. (2015). Complexity Measures in Magnetoencephalography:

Measuring “Disorder” in Schizophrenia. In *PLOS ONE*, 10(4).Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4401778/

Burgemeester, A. (2018). The Little Albert Experiment. In *Psychologized*. Retrieved from Psychologized website: https://www.psychologized.org/the-little-albert-experiment/

Burnette, J. L., O`Boyle, E. H., VanEpps, E. M., Pollack, J.M., Finkel, E.J. (2013). Mind-Sets Matter: A Meta-Analytic Review of Implicit Theories and Self-Regulation. In *Psychological Bulletin*, 139(3) 655 – 701. Retrieved from Northwestern Univ. website: http://faculty.wcas.northwestern.edu/eli-finkel/documents/2013_BurnetteOBoyleVanEppsPollackFinkel_PsychBull.pdf

Candra, H., Yuwono, M., Handojoseno, A., Chai, R., Su, S., Nguyen, H. T, (2015).Recognizing Emotions from EEG Subbands Using Wavelet Analysis. In *Conference Proceedings: 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/26737666

Carhart-Harris, R. L., Leech, R., Hellyer, P. J., Shanahan, M., Feilding, A., Tagliazucchi, E., Chialvo, D. R., Nutt, D. (2014).The Entropic Brain: A Theory of Conscious States Informed by Neuroimaging Research with Psychedelic Drugs. In *Frontiers in Human Neuroscience*, Vol. 8(20). Retrieved from Frontiers in Human Neuroscience website: https://www.frontiersin.org/articles/10.3389/fnhum.2014.00020/full

Carroll, S. (2016). The Origins of the Universe and the Arrow of Time. In*Georgia Tech Physics*, Retrieved from www.physics.gatech website: https://www.physics.gatech.edu/event/origin-universe-and-arrow-time

Cech, C. G. (1998). Chapter 2: The Basic Findings In Classical Conditioning. In*UCS Louisiana*, Retrieved from University of Louisiana at Lafayette website: http://www.ucs.louisiana.edu/~cgc2646/LRN/Chap2.html

Cerginani, C. (2010). *Ludwig Boltzmann*. Oxford: Oxford University Press.

Channell, M. M., Conners, F. A., Barth, J. M. (2014).Emotion Knowledge in Children and Adolescents with Down Syndrome: A New Methodological Approach. In *American Journal on Intellectual and Developmental Disabilities*, 119(5). 405 – 421. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/25148055

Charles, E. (2014). Explaining Behaviorism: Operant and Classical Conditioning. In*Psychology Today*, Retrieved from Psychology Today website: https://www.psychologytoday.com/us/blog/fixing-psychology/201402/explaining-behaviorism-operant-classical-conditioning

Chomsky, N. (1971). The Case Against B. F. Skinner. In *The New York Review of Books*, Dec. Retrieved from Chomsky.Info website: https://chomsky.info/19711230/

Chu, W., Huang, M., Jian, B., Cheng, K. (2017).Analysis of EEG Entropy During Visual Evocation of Emotion in Schizophrenia. In *Annals of General Psychiatry*, 16(34).1 – 9. Retrieved from Annals of General Psychiatry, BioMed Central website: https://annals-general-psychiatry.biomedcentral.com/track/pdf/10.1186/s12991-017-0157-z?site=annals-general-psychiatry.biomedcentral.com

CohenM. (2015). Theory of Forms. In*University of Washington*, Retrievedfrom faculty.washington.edu website: https://faculty.washington.edu/smcohen/320/thforms.htm

Coleman, A., &Snarey, J. (2011). James-Lange Theory of Emotion. In*Encyclopedia of Childhood Behavior and Development*, Vol. 2, 844-846. Retrieved from ResearchGate website:

https://www.researchgate.net/publication/302966834_James-Lange_Theory_of_Emotion

Colten, H., & Alteyogt, B. (Eds.) (2006). *Sleep Disorders and Sleep Deprivation.* Washington D.C. The National Academies Press.

Connolly, P.,& van Deventer, V. (2017). Hierarchical Recursive Organization and the Free Energy Principle: From Biological Self-Organization to the Psychoanalytic Mind. In *Frontiers in Psychology*, Vol.8. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5623195/

Cunningham, W. A., Dunfield, K., Stillman, P.E. (2015). Affective Dynamics: Iterative Reprocessing in the Production of Emotional Responses. In L. Barret et al. (Eds.), *The Psychological Construction of Emotion*. New York: The Guilford Press.

Dadomo, H., Panzari, M., Caponcello, D., Carmalita, A., Grecucci, A. (2018).Schema Therapy for Emotional Dysregulation in Personality Disorders: A Review. In *Current Opinion in Psychiatry*, Vol.31(1). 43 – 49. Retrieved from Current Opinion in Psychiatry website: https://journals.lww.com/copsychiatry/Abstract/2018/01000/Schema_therapy_for_emotional_dysregulation_in.9.aspx

Damasio, A. (2005) *Descartes' Error.* New York: Penguin Books.

Darwin, C. (2015) *The Expression of the Emotions in Man and Animals.* Wallachia: Wallachia Publishers.

Darwin, C. (1992). The Descent of Man. In *The Great Books of the Western World.* (Vol. 49, pp. 253 – 600). Chicago, IL: Encyclopaedia Britannica.

Deb, S. (2014). Information Technology, Its Impact on Society and Its Future. In *Advances in Computing*, 4(1). 25 – 29. Retrieved from Scientific & Academic Publishing website: http://article.sapub.org/10.5923.j.ac.20140401.07.html

Descartes, R. (1992). Rules for the Direction of the Mind. In *The Great Books of the Western World.* (Vol. 28, pp. 223 - 262). Chicago, IL: Encyclopaedia Britannica.

Doumit, R., Afifi, R. A., Devon, H. A. (2015). Serenity in Political Uncertainty. In *Holistic Nursing Practice*, 29(2). 78 – 86. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/25658930

Division of Sleep Medicine at Harvard Medical School & WGBH Educational Foundation. (2008). *Why Do We Sleep, Anyway?* Retrieved from Division of Sleep Medicine website: http://healthysleep.med.harvard.edu/healthy/matters/benefits-of-sleep/why-do-we-sleep

Drake, G. W. F. (2018). Entropy. In*Encyclopaedia Britannica*, Retrieved from Encyclopaedia Britannica website: https://www.britannica.com/science/entropy-physics

Dreschel, N.A. (2010). The Effects of Fear and Anxiety on Health and Lifespan in Pet Dogs. In*Applied Animal Behaviour Science*, 125(3). 157 – 162. Retrieved from ResearchGate website: https://www.researchgate.net/publication/223596811_The_effects_of_fear_and_anxiety_on_health_and_lifespan_in_pet_dogs

Duff, K. (2014). *The Secret Life of Sleep.* New York: Atria Books.

Duncan, N. W., Hayes, D. J., Wiebking, C., Tiret, B., Pietruska, K., Chen, D. Q., Rainville, P., Marjanska, M., Ayad, O., Doyon, J., Hodaie M., Northoff, G. (2015).Negative Childhood Experiences Alter a Prefrontal-Insular-Motor Cortical Network in Healthy Adults: a Preliminary

Multimodal rsfMRI-fMRI-MRS-dMRI Study. In *Human Brain Mapping*, 36,4622 – 4637. Retrieved from Human Brain Mapping website: https://static1.squarespace.com/static/528facb6e4b0a18b7e9cde91/t/584af7011b631b40738f396d/1481307906613/Duncan_et_al-2015-Human_Brain_Mapping.pdf

Dutton, B. D. (n. d.). Benedict De Spinoza (1632 – 1677). In*Internet Encyclopedia of Philosophy*, J . Fieser & B. Dowden (Eds.) Retrieved from Internet Encyclopedia of Philosophy website: https://www.iep.utm.edu/spinoza/

Dvir, Y., Ford, J. D., Frazier, J. A. (2014).Childhood Maltreatment, Emotional Dysregulation, and Psychiatric Comorbidities. In *Harvard Review of Psychiatry*, May – June. 149 – 161. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4091823/

Dworak, M., McCarley, R. W., Kim, T., Kalinchuk, A. V., Basheer, R. (2010). Sleep and Brain Energy Levels: ATP Changes During Sleep. In *The Journal of Neuroscience*, 30(26).Retrieved from The Journal of Neuroscience website: http://www.jneurosci.org/content/30/26/9007

Dymond, S., Dunsmoor, J. E., Vervliet, B., Roche, B., Hermans, D. (2015).Fear Generalization in Humans: Systematic Review and Implications for Anxiety Disorder. In *Behavior Therapy*, 46(5).561 – 582. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/26459838

Edward, D. (2017). An Introduction to Operant Conditioning (Instrument Conditioning). In*Psychology Unlocked*, Retrieved from Psychology Unlocked website: http://www.psychologyunlocked.com/operant-conditioning/

Emotional Regulation. (2013). In *Psychology Dictionary*. P. Nugent (Ed.) Retrieved from Psychology Dictionary website: https://psychologydictionary.org/emotional-regulation/

Erra, R. G, Mateos, D. M., Wennberg, R., Velazquez, P. (2017).Towards a Statistical Mechanics of Consciousness: Maximization of Number of Connections is Associated with Conscious Awareness. In *arxiv.org*, Retrieved from arxiv.org website: https://arxiv.org/pdf/1606.00821.pdf

Faustino, A. I., Oliveira, G. A., Oliveira, R. F. (2015). Linking Appraisal to Behavioral Flexibility in Animals: Implications for Stress Research. In *Frontiers in Behavioral Neuroscience*, Vol.9. Retrieved from oliveiralab.files.wordpress.com website: https://oliveiralab.files.wordpress.com/2015/04/2015_faustino_etal.pdf

Ferdowsian, H., Durham, D., Brune, M. (2013). Mood and Anxiety Disorders in Chimpanzees (Pan Troglodytes): A Response to Rosati et al. (2012). In *Journal of Comparative Psychology*,127(3). 337 – 340. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/?term=Ferdowsian%2C+Durham+and+Brune%2C+2013+mood+anxiety

Fingelkurts, A. A., &Fingelkurts, A. A. (2017). Information Flow in the Brain: Order sequences of Metastable States. In*MDPI Journal*, 8(1), 1 – 9. Retrieved from MDPI website: https://www.mdpi.com/2078- 2489/8/1/22

Fiske, S.T. (2015). Grolar Bears, Social Class and Policy Relevance: Extraordinary Agendas for the Emerging 21st Century. In*European Journal of Social Psychology*, 45(5). 551 – 559. Retrieved from PubMed Central website:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4936535/

Fogel, A., Nwokah, E., Dedo, J. Y., Messinger, D., Dickson, K. L., Matusov, E., Holt, S. A. (1992). Authors' response The Social Process Theory of Emotion: A Radical Contextualist Perspective. In *Social Development*, 1 (2). Retrieved from Eugene Matusov Univ. of Delaware website:

http://ematusov.soe.udel.edu/vita/Articles/Fogel,%20Nwokah,%20Dedo,%20Messinger,%20Dickson,%20Matusov,%20Holt,%20The%20social%20process%20theory%20of%20emotion%20-%20A%20radical%20contextualist%20perspective,%20SD,%201992.pdf

Fok, M. L., Hayes, R. D., Chang, C., Stewart, R., Callard, F. J, Moran, P. (2012).Life Expectancy at Birth and All-cause Mortality Among People with Personality Disorder. In *Journal of Psychosomatic Research*, 73. Retrieved from Isi Articles.com website: http://isiarticles.com/bundles/Article/pre/pdf/37836.pdf

Fox, R. F. (1993). The Origins of Order: Self-Organization and Selection in Evolution by Stuart Kauffman. In *Biophysical Journal*, Vol. 65. 2698 – 2699. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1226010/pdf/biophysj00081-0432.pdf

Frautschi, S. (1982). Entropy in an Expanding Universe. In*Science Magazine*, Vol. 217(4560), 593 – 599. Retrieved from Science Magazine website: http://science.sciencemag.org/content/217/4560/593

Friedman, H. S., &Martin, L. R. (2011). *The Longevity Project*. New York:Hudson Street Press.

Funk, D., Lo, S., Coen, K., Le, A. D. (2016).Effects of Varenicline on Operant Self-administration of Alcohol and/or Nicotine in a rat Model of Co-abuse. In *Behaviourial Brain Reseach*, Vol. 296. 157 – 162. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4659739/

Garcia-Martinez, B., Martinez-Rodrigo, A., Cantabrana, R. Z., Garcia, J. M. P., Alcaraz, R. (2016). Application of Entropy-Metrics to Identify Emotional Distress from Electroencephalographic Recordings. In *Entropy*, Vol.18(6). Retrieved from MDPI website: https://www.mdpi.com/1099-4300/18/6/221/htm

Gazzaniga, M. S. (2018). What William James Got Right About Consciousness. In*Nautilus: Science Connected*, 065. Retrieved from Nautilus website: http://nautil.us/blog/what-william-james-got-right-about-_consciousness

Goodheart, B. (2017). Older Adults with Opioid Use Disorders. In *Addiction Treatment Forum*. Retrieved from Addiction Treatment Forum website: http://atforum.com/2017/12/older-adults-opioid-use-disorders-forgotten-generation/

Goodman, B. (2012). Even Mild Anxiety May Shorten a Person's Life. In *WebMD*. Retrieved from WebMD website:https://www.webmd.com/mental-health/news/20120731/mild-anxiety-may-shorten-persons-life#1

Goodman, R. (2017). William James. In*Stanford Encyclopedia of Philosophy* (Summer 2017 Edition), E. N. Zalta (Ed.) Retrieved from Stanford Encyclopedia of Philosophy website: https://plato.stanford.edu/archives/sum2017/entries/james/

Graff, H. (2015). Questions for Plato's Dialogues. In*Oakton Community College Humanities and Philosophy Dept.*,Retrieved from Oakton.edu website: https://www.oakton.edu/user/2/hgraff/QuestionsForPlatosDialogues.htm

Grandy, T. H., Garrett, D. D., Schmiedek, F., Werkle-Bergner, M. (2016). On the Estimation of Brain Signal Entropy from Sparse Neuroimaging. In *Scientific Reports*, Vol. 6. 1 – 16. Retrieved from ResearchGate website: https://www.researchgate.net/publication/299502168_On_the_estimation_of_brain_signal_entropy_from_sparse_neuroimaging_data

Gray, J. A., &McNaughton, N. (2000). Anxiolytic Action on the Behavioral Inhibition System Implies Multiple Types of Arousal Contribute to Anxiety. In *Journal of Affective Disorders*, 61(3), 161 – 176. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/11163419

Greitzer, E. M., Spakovsky, Z. S., Waitz, I. A. (2006). 16. Unified: Thermodynamics in Propulsion Pro. Z. S. Spakovsky. (2006). In *Thermodynamics and Propulsion*, Retrieved from web.mit.edu website: http://web.mit.edu/16.unified/www/FALL/thermodynamics/notes/node49.html

Griffiths, P. E. (n. d.). Ethology, Sociobiology, and Evolutionary Biology. In*Blackwell's Companion to Philosophy of Biology*, Sakar, Sakar & Plutynski (Eds.) Retrieved from Philosophy of Science Archive, University of Pittsburg website: http://philsci-archive.pitt.edu/2643/1/Ethology%2C_Sociobiology%2C_EP.PDF

Haken, H. (2013). Self-organization of Brain Function. In*Scholarpedia*, Retrieved from Scholarpedia website:http://www.scholarpedia.org/article/Self-organization_of_brain_function

Hamann, S. (2012). Mapping Discrete and Dimensional Emotions onto the Brain: Controversies and Consensus. In*Trends in Cognitive Sciences*,Retrieved from hamann.weebly.com website: http://hamann.weebly.com/uploads/4/9/3/4/4934597/tics-hamann-emotion-2012.pdf

Heinrich, T., Knopp, B., Pas, H. (2016). Entropy, Biological Evolution and the Psychological Arrow of Time. In *Journal of Modern Physics*, Vol. 7. 228 – 236. Retrieved from Scientific Research Publishing website: http://file.scirp.org/pdf/JMP_2016012914360267.pdf

Hemsen, L. A. H., van der Wouden, J. C., Leone, S. S., Smalbrugge, M., van der Horst, H.E., Dekker, J. (2016).The Longitudinal Association of Cognitive Appraisals and Coping Strategies with Physical Functioning in Older Adults with Joint Pain and Comorbidity: A Cohort Study. In *BMC Geriatrics*, 16(29). Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4730621/

Hervas, A. (2017). Emotional Dysregulation and Autism Spectrum Disorders. In *Revista Neurologica*, 64(s01). S17 – S25. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/28256682

Heydt, S. (2017). *A Parents' ABC of the Autism Spectrum*. London: Jessica Kingsley Publishers.

Hippocrates. (1992). Hippocratic Writings. In *The Great Books of the Western World.* (Vol. 9, pp. 1 - 339). Chicago, IL: Encyclopaedia Britannica.

Hirsh, J. B.., Mar, R. A., &Peterson, J. B. (2012). Psychological Entropy: A Framework for Understanding Uncertainty-Related Anxiety. *Psychological Review*, 119, 304 - 320.

Hobbes, T. (1992). Leviathan. In *The Great Books of the Western World.* (Vol. 21, pp. 39 - 283). Chicago, IL: Encyclopaedia Britannica.

Hosier, D. (2013). How Childhood Trauma Can Reduce Life Expectancy By 19 Years. In*Childhood Trauma Recovery*. Retrieved from Childhood Trauma Recovery website: https://childhoodtraumarecovery.com/all-articles/a-discussion-of-research-suggesting-that-childhood-trauma-may-reduce-life-expectancy-by-19-years-but-why-not-to-panic/

Insel, T. (2015). Post by Former NIMH Director Thomas Insel: Mortality and Mental Disorders. In*National Institute of Mental Health*. Retrieved from National Institute of Mental Health website:

https://www.nimh.nih.gov/about/directors/thomas-insel/blog/2015/mortality-and-mental-disorders.shtml

Institute of Medicine, Committee on Sleep Medicine, Board on Health Science Policy. (2006). *Sleep Disorders and Sleep Deprivation.* H. R.Colton & B. M. Altevogt (Eds.) Washington D.C.: The National Academies Press.

Izard, C. E., Ackerman, B., Schoff, K. M., Fine, S. E. (2000).Self-Organization of Discrete Emotions, Emotion Patterns and Emotion-Cognition Relations. In *Emotion, Development, and Self-organization: Dynamic Systems Approaches to Emotional Development* (Cambridge Studies in Social and Emotional Development), M. D. Lewis & I. Granic (Eds.) 15 – 36. Retrieved from Cambridge Core website: https://www.cambridge.org/core/books/emotion-development-and-selforganization/selforganization-of-discrete-emotions-emotion-patterns-and-emotioncognition-relations/EA5FA1B87478F1503FC0BBD084297F71

Izard, C. E. (2007). Basic Emotions, Natural Kinds, Emotion Schemas, and a New Paradigm. In *Perspectives on Psychological Science*, Vol. 2(3), 260 – 280. Retrieved from www.scribd.com website:https://www.scribd.com/document/344181516/Izard-2007-Basic-Emotions-Natural-Kinds-Emotion-Schemas-and-a-New-Paradigm

Jabr, F. (2013). Why Your Brain Needs More Downtime. In*Scientific American*, Retrieved from Scientific American website: https://www.scientificamerican.com/article/mental-downtime/

James, W., &Lange, K. G. (1922). *The Emotions – Primary Source Edition*. Baltimore: Williams & Wilkin.

James, W. (1992). The Principles of Psychology. In *The Great Books of the Western World.* (Vol. 53, pp. 1 – 897).Chicago, IL: Encyclopaedia Britannica.

Johnston, E., &Olson, L. (2015). *The Feeling Brain*. New York:W.W. Norton.

Jouhari, Z., Haghani, F., Changiz, T. (2015). Factors Affecting Self-Regulated Learning in Medical Students: A Qualitative Study. In *Medical Education Online*, Vol.20. Retrieved from PubMed Central website:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4637332/

Jung, M., Hwang, J., Tani, J. (2015).Self-Organization of Spatio-Temporal Hierarchy via Learning of Dynamic Visual Image Patterns on Action Sequences. In *PLOS ONE*, 10(7). Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4492609/

Kafri, O., &Kafri, H. (2016). *Entropy: God's Dice Game*. San Bernardino, Ca.:Kafri Nihul Ve'Hashkaot.

Kassam, K. S.,& Mendes, W. B. (2013). The Effects of Measuring Emotion: Physiological Reactions to Emotional Situations Depend on Whether Someone is Asking. In *PLOS ONE*. Retrieved from plos.org website: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0064959

Kauffman, S. A. (1993). *The Origins of Order.* New York: Oxford University Press.

Kawamura, S. (2016). Color Vision Diversity and Significance in Primates Inferred from Genetic and Field Studies. In*Genes and Genomics*, Vol. 38. 779 – 791. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4987397/

Konstan, D. (2018). Epicurus. In*Stanford Encyclopedia of Philosophy* (Summer 2018 Edition), E. N. Zalta (Ed.) Retrieved from Stanford Encyclopedia of Philosophy website: https://plato.stanford.edu/entries/epicurus/

Kelley, W. M., Wagner, D. D., Heatherton, T. F. (2015).In Search of a Human Self-Regulation System. In *Annual Review of Neuroscience*, Vol. 38. 389 – 411. Retrieved from Dartmouth Univ. website: http://www.dartmouth.edu/~bil/pubs/kelley_2015_annurev-neuro.pdf

Kelso, J. A. S., &Engstrom, D. A. (2006). *The Complementary Nature*. Cambridge, Ma.: MIT Press.

Kelso, J. A. S. (1995). *Dynamic Patterns.* Cambridge, Ma.: MIT Press.

Kelso, J. A. S. (2016). On the Self-Organizing of Agency. In*Trends in Cognitive Sciences*, Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4912857/

King, C., Smith, T. J., Grandin, T., Borchelt, P. (2016). Anxiety and Impulsivity: Factors Associated with Premature Graying in Young Dogs. In *Applied Animal Behaviour Science*, Vol. 185. 78 – 85. Retrieved from deepdyve.com website: https://www.deepdyve.com/lp/elsevier/anxiety-and-impulsivity-factors-associated-with-premature-graying-in-KutgnqC0Qt

Klonek, F. E., Guntner, A. V., Lehmann-Willenbrock, N., Kauffeld, S. (2015). Using Motivational Interviewing to Reduce Threats in Conversations about Environmental Behavior. In *Frontiers in Psychology*, Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4508486/

Koerner, K. (2012). *Doing Dialectical Behavioral Therapy.* New York.: The Guilford Press.

Kohonen, T. (1989). *Self-Organization and Associative Memory.* Berlin: Springer-Verlag.

Konstan, D. (2018). Epicurus. In*Stanford Encyclopedia of Philosophy* (Summer 2018 Edition), E. N. Zalta (Ed.) Retrieved from Stanford Encyclopedia of Philosophy website: https://plato.stanford.edu/entries/epicurus/

Kragel, P. A.,& LaBar, K. S. (2014). Advancing Emotion Theory Multivariate Pattern Classification. In *Emotion Review*, 6(2). 160 – 174. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4955568/

Kragel, P. A.,& LaBar, K. S. (2016). Decoding the Nature of Emotion in the Brain. In *Trends in Cognitive Sciences*, 20(6). 444 – 455. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4875847/

Lambert, F. L. (2007). 'Disorder' in Thermodynamic Entropy. In*Entropysite.oxy.edu*, Retrieved from Occidental College website: http://entropysite.oxy.edu/boltzmann.html

Larre, C., Root, C, De La Valle, E.R. (1996). *The Seven Emotions: Psychology and Health in Ancient China*.Taos NM.:Redwing Book Co.

Laws, K. R., Darlington, N., Kondel, T. K., McKenna, P. J., Jauhar, S. (2018). Cognitive Behavioral Therapy for Schizophrenia – Outcomes for Functioning, Distress and Quality of Life: A Meta-Analysis. In *BioMed Central, Psychology*, 6(32).1 – 10. Retrieved from BMC Psychology website: https://bmcpsychology.biomedcentral.com/track/pdf/10.1186/s40359-018-0243-2

Lazarus, R. S. (1991). *Emotion & Adaptation.* New York: Oxford University Press.

Lazarus, R. S. (1999). *Stress and Emotion.* New York: Springer Publishing Co.

Lazarus, R. S., &Folkman, S. (1984). *Stress, Appraisal, and Coping*. New York: Springer Publishing Co.

Lebedev, A. V., Kaelen, M, Lovden, M., Nilsson, J., Feilding, A., Nutt, D.J., Carhart-Harris, R. L. (2016). LSD-Induced Entropic Brain Activity Predicts Subsequent Personality Change. In *Human Brain Mapping*, 5 (97). Retrieved from ourmagazineworld.org website: https://www.ouramazingworld.org/uploads/4/3/8/6/43860587/lebedev_hbm-2016.pdf

LeDoux, J. (2003). The Emotional Brain, Fear, and the Amygdala. *Cellular and Molecular Neurobiology.* 23, 4/5, 727 – 734.

Lewis, M. (2004). Bridging Emotion Theory and Neurobiology Through Dynamic Systems Modeling. In *Behavioral and Brain Sciences*, Retrieved from The Emotional Intelligence Training Co. website: http://www.eitrainingcompany.com/wp-content/uploads/2012/02/Neurobiology-and-Pscyhology-of-Emotion.pdf

Lewis, M. (1970). Cognition-Emotion Feedback and the Self-Organization of Developmental Paths. In *Human Development*, 38(2). 71 – 102. Retrieved from ResearchGate. website: https://www.researchgate.net/publication/232453202_CognitionEmotion_Feedback_and_the_Self-Organization_of_Developmental_Paths

Lewis, M., &Granic, I. (2000). *Emotional Development and Self-Organization*. Cambridge, U.K.: Cambridge University Press.

Li, Q., Wennborg, A., Aurell, E., Dekel, E., Zou, J., Xu, Y., Huang, S., Emberg, I. (2016).Dynamics Inside the Cancer Cell Attractor Reveal Cell Heterogeneity, Limits of Stability, and Escape. In *PNAS*, Vol.113 (10). Retrieved from Proceedings of the National Academy of Sciences website: http://www.pnas.org/content/pnas/113/10/2672.full.pdf

Lindley, D. (2001). *Boltzmann's Atom*. New York: The Free Press.

Machiavelli, N. (1992). The Prince. In *The Great Books of the Western World.* (Vol. 21, pp. 1 – 37). Chicago,IL: Encyclopaedia Britannica.

Mandal, A. (2018). Hippocampus Functions. In*News-Medical-net*, Retrieved from News-Medical-net website: https://www.news-medical.net/health/Hippocampus-Functions.aspx

McCormick, M. (n. d.). Immanuel Kant: Metaphysics. In*Internet Encyclopedia of Philosophy*, J. Fieser & Bradley Dowden (Eds.) Retrieved from Internet Encyclopedia of Philosophy website: https://www.iep.utm.edu/kantmeta/#H4

Meade, C. S., Wang, J., Lin, X., Wu, H., Poppen, P.J. (2009).Stress and Coping in HIV-positive Former Plasma/Blood Donors in China: A Test of Cognitive Appraisal Theory. In *Aids and Behavior*, Vol. 14(2). Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3629837/

Melamede, R. (2002). Dissipative Structures and the Origins of Life. In*New England Complex Systems Institute*, Retrieved from necsi.edu website: http://necsi.edu/events/iccs/2002/Mo09_Melamede.pdf

Mental Disorder. (2013). In *Psychology Dictionary*. P. Nugent (Ed.) Retrieved from Psychology Dictionary website: https://psychologydictionary.org/mental-disorder/

Mitchell, J.P. (2009). Social Psychology as a Natural Kind. In*Trends in Cognitive Sciences*, 13(6). 246 – 251. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2935896/

Mittal, C., &Griskevicius, V. (2014). Sense of Control Under Uncertainty Depends on People's Childhood Environment: A Life History Theory Approach. In *Journal of Personality and Social Psychology*,

107(4), 621 – 637. Retrieved from American Psychological Association website: https://www.apa.org/pubs/journals/releases/psp-a0037398.pdf

Mlodinow, L., &Brun, T. A. (2014).Relation Between the Psychological and Thermodynamic Arrows of Time. In *Physical Review E*, 89(052102), 1 – 8. Retrieved from Authors Library, California Technical University website: https://authors.library.caltech.edu/46399/5/PhysRevE.89.052102.pdf

Moller, H. J. (2016). The Relevance of Negative Symptoms in Schizophrenia and How to Treat Them with Psychopharmaceuticals? In*Psychiatria Danubina*, 28(4). 435 – 440. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/27855437

Moore, M. J., der Hoop, J. V., Barco, S. G., Costidis, A. M., Raverty, S., McLellan, W. A. (2013). Criteria and Case Definitions for Serious Injury and Death of Pinnipeds and Cetaceans Caused by Anthropogenic Trauma. In *Diseases of Aquatic Organisms*, 103(3). 229 – 264. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/23574708

Morikawa, R. (2015). What is SNR? In *George Mason University*,Retrieved from mason.gmu.edu website: http://mason.gmu.edu/~rmorika2/What_is_SNR_.htm

Morioka, C. K., Howard, D. E., Caldeira, K. M. Wang, M. Q., Arria, A. M. (2018).Affective Dysregulation Predicts Incident Nonmedical Prescription Analgesic Use Among College Students. In *Addictive Behaviors*, 76. 328 – 334. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/?term=Morioka%2C+Howard%2C+Caldeira%2C+Wang+and+Arria+2018

Morowitz, H. J. (1987). The Mind Body Problem and The Second Law of Thermodynamics. In*Biology and Philosophy*, 2, 271 – 275. Retrieved from www.newdualism.org website: http://newdualism.org/papers/H.Morowitz/Morowitz-BandP-1987.pdf

Morsella, E. (2015). Control of the Stream of Consciousness? In*Psychology Today*, Retrieved from Psychology Today website: https://www.psychologytoday.com/us/blog/consciousness-and-the-brain/201502/control-the-stream-consciousness

Murphy, A., Taylor, E., Elliott, R. (2012). The Detrimental Effects of Emotional Process Dysregulation on Decision-making. In Substance Dependence. In *Frontiers in Integrative Neuroscience*, Vol.6. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3491319/

Nahin, P. J. (2013). *The Logician and the Engineer.* Princeton, N.J.: Princeton University Press.

Nastase, S. A., Lacovella, V., Davis, B., Hasson, U. (2015). Connectivity in the Human Brain Dissociates Entropy and Complexity of Auditory Inputs. In *Neuroimage*, Vol.108. 292 – 300. Retrieved from PubMed Central website:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4334666/

National Alliance on Mental Illness. (2018). *Mental Health by the Numbers.* Retrieved from NAMI website: https://www.nami.org/Learn-More/Mental-Health-By-the-Numbers

National Alliance on Mental Illness. (2013). *Mental Health Illness Fact Sheet.* Retrieved from NAMI website: http://www.namimass.org/wp-content/uploads/Mental-Illness-Fact-Sheet-National-1.pdf

National Center for Health Statistics, National Vital Statistics System. (2017). *National Vital Statistics Reports.* 66(4)Retrieved from www.CDC.gov website: https://www.cdc.gov/nchs/data/nvsr/nvsr66/nvsr66_04.pdf

Neiman, T., &Loewenstein, Y. (2014). Spacial Generalization in Operant Learning: Lessons from Professional Basketball. In *PLOS Computational Biology*, 10(5). Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4031046/

Newman, J. P., MacCoon, D. G., Vaughn, L. J. Sadeh, N. (2005).Validating a Distinction Between Primary and Secondary Psychopathy with Measures of Gray's BIS and BAS Constructs. In *Journal of Abnormal Psychology*, 114 (2). 319 – 323. Retrieved from ResearchGate website: https://www.researchgate.net/publication/7869775_Validating_a_Distinction_Between_Primary_and_Secondary_Psychopathy_With_Measures_of_Gray's_BIS_and_BAS_Constructs

Newman, J. P., &Malterer, M. B. (2009).Problems with BIS/BAS Scales or Lykken's Model of Primary Psychopathy? A Reply to Poythress et. al. (2008). In *Personality and Individual Differences*, 46(7), 673 – 677. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2679499/

Northoff, G. (2018). *The Spontaneous Brain.*Cambridge, Ma: MIT Press.

Nortley, R., &Attwell, D. (2017). Control of Brain Energy Supply by Astrocytes. In *Current Opinion in Neurobiology*, Vol. 47. 80 – 85. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/29054039

Oatley, K. (2004). *Emotions: A Brief History.* Malden, Ma.: Blackwell Publishing.

Oginska-Bulik, N.,& Kobylarczyyk, M. (2016).Association Between Resiliency and Posttraumatic Growth in Firefighters: The Role of Stress Appraisal. In *International Journal of Occupational Safety and Ergonomics*, 22(1). 40 – 48. Retrieved from PubMed Central website https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4784514/

Orgeta, V. (2011). Emotion dysregulation and Anxiety in Late Adulthood. In*Journal of Anxiety Disorders*, 25(8), 1019 – 1023. Retrieved from ResearchGate website: https://www.researchgate.net/publication/51544155_Emotion_dysregulation_and_anxiety_in_late_adulthood

Ortony, A., & Clore G. (2015). Can an Appraisal Model be Compatible with Psychological Constructionism? In L. Barrett et al. (Eds.), *The Psychological Construction of Emotion*. New York: The Guilford Press.

Ortony, A., &Turner, T. J. (1990).What's Basic about Basic Emotions? In *Psychological Review*, 97(3), 315 – 331. Retrieved from Northwestern Univ. website: http://www.cs.northwestern.edu/~ortony/Andrew_Ortony_files/1990%20-%20Basic%20emotions.pdf

Panksepp, J., &Biven, L. (2012). *The Archaeology of Mind*. New York:W.W. Norton.

Pavlov, H. (2004). Condition Reflexes: An Investigation of the Physiological Activity of the Cerebral Cortex. In*Classics in The History of Psychology*, C. D. Green (Ed.) Retrieved from Classics in The History of Psychology website: http://psychclassics.yorku.ca/Pavlov/lecture2.htm

Perry, P. (2017). New Theory Suggests that Consciousness is a Byproduct of Entropy. In*Big Think*, Retrieved from Big Think website: https://bigthink.com/philip-perry/new-theory-suggests-that-consciousness-is-nothing-more-than-a-byproduct-of-entropy

Perusini, J. N., &Fanselow, M. S. (2015). Neurobehavioral Perspectives on the Distinction Between Fear and Anxiety. In *Learning Memory*, 22(9), 417 – 425. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4561408/

Pessoa, L., Garcia-Pereira, M., Oliveira, L. (2010).Attention and Emotion. In *Scholarpedia*, 5(2). Retrieved from Scholarpedia website: http://www.scholarpedia.org/article/Attention_and_emotion

Peters, A., McEwen, B. S., Friston, K. (2017). Uncertainty and Stress: Why it Causes Diseases and how it is Mastered by the Brain. In *Progress in Neurobiology*, Vol.156. 164 – 188. Retrieved from ScienceDirect website: https://www.sciencedirect.com/science/article/pii/S0301008217300369?via%3Dihub

Pfaff, D. (2006). *Brain Arousal and Information Theory.* Cambridge Ma.: Harvard University Press.

Physics, Ohio-State. (2004). *Chapter 6: Entropy and the Law of Thermodynamics.* Retrieved from Physics.Ohio-State.edu website: https://www.physics.ohio-state.edu/p670/textbook/Chap_6.pdf

Physics Stack Exchange. (2019). *Is thermodynamic free energy and potential energy the same thing?* Retrieved from physics.stackexchange.com website: https://physics.stackexchange.com/questions/127268/is-thermodynamic-free-energy-and-potential-energy-the-same-thing

Pierce, J. R. (2016). *An Introduction to Information Theory.* New York: Dover Publications.

Pigliucci, M. (n. d.). Stoicism. In*Internet Encyclopedia of Philosophy*, J. Fieser, B. Dowden (Eds.) Retrieved from Internet Encyclopedia of Philosophy website: https://www.iep.utm.edu/stoicism/

Planck, M. (1992). Scientific Autobiography and Other Papers. In *The Great Books of the Western World.* (Vol. 56, pp. 77 – 117).Chicago, IL: Encyclopaedia Britannica.

Plato. (1992). The Republic. In *The Great Books of the Western World.* (Vol. 6, pp. 295 – 441). Chicago, IL: Encyclopaedia Britannica.

Plutchik, R. (2000). *Emotions in the Practice of Psychotherapy.* Washington D.C..: American Psychological Association.

Popkin, R. H. (2018). Benedict de Spinoza. In*Encyclopaedia Britannica*, Retrieved from Encyclopaedia Britannica website: https://www.britannica.com/biography/Benedict-de-Spinoza

Porath, C. L.,& Pearson, C. M. (2012). Emotional and Behavioral Responses to Workplace Incivility and the Impact of Hierarchical Status. In *Journal of Applied Social,* Vol. 42, E326 – E357. *Psychology*. Retrieved from South Eastern Oklahoma State University website: http://homepages.se.edu/cvonbergen/files/2013/01/Emotional-and-Behavioral-Responses-to-Workplace-Incivility-and-the-Impact-of-Hierarchical-Status.pdf

Powell, P. A., Simpson, J., Overton, P. G. (2015).An Introduction to the Revolting Self: Self-disgust as an Emotion Schema. In *ResearchGate*, Retrieved from ResearchGate website: https://www.researchgate.net/publication/282857307_An_introduction_to_the_revolting_self_Self-disgust_as_an_emotion_schema

Price, H. (2010). Time's Arrow and Eddington's Challenge. In*Seminaire Poincare'*, Vol. 15. 115 – 140. Retrieved from The bourbaphy.fr website: http://www.bourbaphy.fr/price.pdf

Quammen, D. (2004). Was Darwin Wrong? In*National Geographic*, Retrieved from University of

Maryland website: http://www.uvm.edu/~pbierman/classes/gradsem/2005fall/DarwinWrong.pdf

Reevy, G. M., Ozer Y. M., &Ito, Y. (2010). *Encyclopedia of Emotion* (Vols. 1 – 2). Santa Barbara, Ca.: Greenwood.

Renner, M., Lancaster, M. A., Bian, S., Choi, H., Ku, T., Peer, A., Chung, K., Knoblich, J. A. (2017). Self-Organized Developmental Patterning and Differentiation in Cerebral Organoids. In *The EMBO Journal*, 36(10). 1316 – 1329. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5430225/

Robinson, H. (2017). Dualism. In*Stanford Encyclopedia of Philosophy* (Fall 2017 Edition), E. N. Zalta (Ed.) Retrieved from Stanford Encyclopedia of Philosophy website: https://plato.stanford.edu/entries/dualism/

Rozycki, E.G. (2011). A Critical Review of B.F. Skinner's Philosophy. In*New Foundations*, Retrieved from New Foundations website: http://newfoundations.com/EGR/Walden.html

Richins, M. L. (1997). Measuring Emotions in Consumption Experience. In*Journal of Consumer Research*, Vol. 24. 127 – 145. Retrieved from The Customer Connection website: http://thecustomerconnection.nl/docs/Measuring%20Consumption%20Emotions%20(Richins).pdf

Rittland, R., &Rodriguez, L. (2014). The Influence of Antiobesity Media Content on Intention to Eat Healthy and Exercise: A Test of the Order Protection Motivation Theory. In *Journal of Obesity,* 2014(954784), Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4253704

Rukeyser, M. (1988). *Willard Gibbs.* Woodbridge Ct.: Ox Bow Press.

Russell, J. A. (2003). Core Affect and the Psychological Construction of Emotion. In*Psychological Review*, Vol. 110(1). 145 – 172. Retrieved from Simon Fraser University website: http://ivizlab.sfu.ca/arya/Papers/Others/Emotions/Core_Affect.pdf

Scemes, S., Wielenska, R. C., Savoia, M. G., Bernik, M. (2009).Choking Phobia: Full Remission Following Behavior Therapy. In *Revista Brasileira de Psiquiatria*, Sept. 31(3). 257 – 260. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/19787155

Schrodinger, E. (1992). What Is Life? The Physical Aspect of a Living Cell. In *The Great Books of the Western World.* (Vol. 56, pp. 469 – 504).Chicago, IL: Encyclopaedia Britannica.

Schore, A. N. (2003). *Affect Dysregulation & Disorders of Self*. New York: W. W. Norton & Co.

Skinner, B.F. (1971). Beyond Freedom and Dignity. In*Faculty York Pa. College*, Retrieved from York College of Pa. website: http://faculty.ycp.edu/~dweiss/phl224_human_nature/skinner.htm

Skinner, B. F. (1974). *About Behaviorism.*New York: Albert Knopf.

Sliwinski, J., &Elkin, G. R. (2013). Enhancing Placebo Effects: Insights from Social Psychology. In *American Journal of Clinical Hypnosis*, 55(3), 236 – 248. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3602922/

Sokunbi, M. O. (2014). Sample Entropy Reveals High Discriminative Power Between Young and Elderly Adults in Short fMRI Data Sets. In*Frontiers in Neuroinformatics*, 8(69). Retrieved from PubMed Central website:https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4107942/

Soni, J., &Goodman, R. (2017). *A Mind at Play*. New York: Simon & Schuster.

Spinoza, B. D. (1992). Ethics. In *The Great Books of the Western World.* (Vol. 28, pp. 589 - 695). Chicago, IL: Encyclopaedia Britannica.

Stephanescu, A. (1996). *Energy Conversion and Entropy Production in Open Systems*(Doctoral dissertation). Available from Iowa State University Digital Repository. (11492)

Swenson, R. (2006). Chapter 9 – Limbic System. In*Review of Clinical and Functional Neuroscience - Swenson*,Retrieved from Dartmouth College website: http://www.dartmouth.edu/~rswenson/NeuroSci/chapter_9.html

Sznycer, D., Tooby, J., Cosmides, L. J. Porat, R., Shalvi, S., Halperin, E. (2016).Shame Closely Tracks the Threat of Devaluation by Others, even Across Cultures. In *PNAS*, 113 (10). 2625 – 2630. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4790975/

The Stanford Natural Language Processing Group. (2017). *Software>Stanford Classifier.* Retrieved from Stanford.edu website: https://nlp.stanford.edu/software/classifier.shtml

Thoman, E. B., &Browder, S. (1987). *Born Dancing*. New York: Harper & Row.

Thorndike, E. (2004). Animal Intelligence. In*Classics in The History of Psychology*, C. D. Green (Ed.) Retrieved from Classics in The History of Psychology website: http://psychclassics.yorku.ca/Thorndike/Animal/chap1.htm

Tohmiya, N., Tadaka, E., Arimoto, A. (2018). Cross-sectional Study of Cognitive Stress Appraisal and Related Factors Among Workers in Metropolitan Areas of Japan. In *BMJ Open*, 8(6). Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6020948/

Torrey, E. F. (1992). *Freudian Fraud.*New York: HarperCollins.

Tripp, J., &McDevitt-Murphy, M. (2015). Emotion Dysregulation Facets as Mediators of the Relationship between PTSD and Alcohol Misuse. In *Addictive Behaviors,* 47, 55 – 60. Retrieved from ResearchGate website: https://www.researchgate.net/publication/274837921_Emotion_Dysregulation_Facets_as_Mediators_of_the_Relationship_between_PTSD_and_Alcohol_Misuse

Uncertain. (2018). In *Merriam-Webster Dictionary*. Retrieved from Merriam-Webster website: https://www.merriam-webster.com/dictionary/uncertain

University of Minnesota Taking Charge of your Health and Wellbeing. (2016). *Sleep.* Retrieved from Taking Charge website: https://www.takingcharge.csh.umn.edu/sleep

University of Utah Health. (2018). *Autism, Health Care and Life Expectancy.* Retrieved from University of Utah Health website: https://healthcare.utah.edu/the-scope/shows.php?shows=0_c7gew5g5

University World News. (2013, May 11). *The brain – Our most energy - consuming organ.*Retrieved from http://www.universityworldnews.com/article.php?story=20130509171737492

Waitz, I. A. (2000). Thermodynamics Course Introduction. In*Unified Lectures Online*,Retrieved from web.mit.edu website: http://web.mit.edu/16.unified/www/FALL/thermodynamics/thermo.pdf

Waldrip, K. M. (2018). Emotional Schemas. In*TherapySites*, Retrieved from Kaitlin M. Waldrip, LCSW-C website: http://www.kwaldriptherapy.com/EmotionalSchemas.en.html

Valenza, G., Garcia, R. G., Citi, L., Scilingo, E. P., Tomaz, C. A., Barbieri, R. (2015).Nonlinear Digital Signal Processing in Mental Health: Characterization of Major Depression Using Instantaneous Entropy Measures of Heartbeat Dynamics. In *Frontiers in Physiology*, 16(34).1 – 9. Retrieved from Frontiers in Physiology website: https://www.frontiersin.org/articles/10.3389/fphys.2015.00074/full

Vetromille-Castro, R. (2013). Social Interactive Entropy. In *RBLA, Belo Horizonte*. 13(2). 625 – 641. Retrievedfrom Scientific Electronic Library website: http://www.scielo.br/pdf/rbla/v13n2/12.pdf

Wang, Z., Yin, L., Childress, A. R., Detre, J. A. (2014). Brain Entropy Mapping. In *PLOS ONE*,Retrieved from plos.org website: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0089948

Watson, J. B. (2004). Psychology as the Behaviorist Views it, C. D. Green Ed.) Retrieved from Classics in The History of Psychology website:http://psychclassics.yorku.ca/Watson/views.htm

Webb, T. W., &Graziano, S. A. (2015). The Attention Schema Theory: A Mechanistic Account of Subject Awareness. In *Frontiers in Psychology,* 6(500). Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4407481/pdf/fpsyg-06-00500.pdf

Weibell, C. J. (2011). Connectionism (Edward Thorndike – 1898). In*Principles of Learning: 7 principles to guide personalized, student-centered learning in the technology-enhanced, blended learning environment*,Retrieved from Principles of Learning Wordpress website: https://principlesoflearning.wordpress.com/dissertation/chapter-3-literature-review-2/the-behavioral-perspective/connectionism-edward-l-thorndike-–-1898/

Wells, K. J. (2014). *Inference Entropy*(Unpublished book). Evergreen Valley College.

Wicentowski, R., &Sydes, M. R. (2012). Emotion Detection in Suicide Notes Using Maximum Entropy Classification. In*Biomedical Informatics Insights*, Vol. 5, 51 – 60. Retrieved from Swarthmore College Computer Science Dept. website: https://works.swarthmore.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1000&context=fac-comp-sci

Winston, R. (2002). *Human Instinct.*London: Bantam Press.

Wu, M. H., Lee, S., Su, H. Y., Pai, H. C. (2015).The Effect of Cognitive Appraisal in Middle-aged Women Stroke Survivors and the Psychological Health of Their Caregivers. In *Journal of Clinical Nursing*, November 24, 21 – 22. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pubmed/?term=The+effect+of+cognitive+appraisal+in+middle%E2%80%90aged+women+stroke+survivors+and+the+psychological+health+of+their+caregivers%3A+a+follow%E2%80%90up+study

Yang, S. (2015). New 'Deep Learning' Technique Enables Robot Mastery of Skills. In*Berkeley News*, Retrieved from UC Berkeley website: ` https://news.berkeley.edu/2015/05/21/deep-learning-robot-masters-skills-via-trial-and-error/

Yao, Y., Lu, W.L., Xu, B., Li, C. B., Lin, C. P., Waxman, D., Feng, J. F. (2013).The Increase of Functional Entropy of the Human Brain with Age. In *Scientific Reports*, Vol. 3(2853). 1 – 8. Retrieved from PubMed Central website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3793229/

Yoo, S., Gujar, N., Hu, P., Ferenc, A. J., Walker, M.P. (2007).The Human Emotional Brain Without Sleep – A Prefrontal Amygdala Disconnect. In *Current Biology*, Vol.17(20). Retrieved from Walkerlab berkeley.edu. website: https://walkerlab.berkeley.edu/reprints/Yoo-Walker_CurrBiol_2007.pdf