Emotion: The Self-regulatory Sense

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A dynamic systems model broadly redefines and recasts emotion as a primary *sensory system* – perhaps the first sense to have emerged, serving the biological function of "self-regulation". Drawing upon the physical sciences and recent revelations from the field of epigenetics, the model suggests that human emotional perceptions provide an ongoing stream of "self-relevant" sensory information concerning optimally adaptive states between the organism and its immediate environment, along with coupled behavioral corrections that honor a universal self-regulatory logic. With its ancient substrates exemplified by the molecular circuitry in the E. coli bacterium, the model suggests that the hedonic (affective) categories emerge directly from fundamental positive and negative feedback processes, and that their good/bad binary appraisals relate to dual self-regulatory behavioral regimes – evolutionary *purposes,* through which organisms actively participate in natural selection, and through which humans can interpret "right" and "wrong" states of balanced being and optimal becoming. The self-regulatory sensory paradigm transcends anthropomorphism, unites divergent theoretical perspectives and isolated bodies of literature, and challenges some time-honored assumptions. Contrary to the notion that emotion must be suppressively regulated, it suggests that emotions are better understood as *regulating us*, providing a service crucial to all semantic language, learning systems, evaluative decision-making, and optimal physical, mental, and spiritual health. The implications for moral psychology are discussed.

The wisdom of Jeremy Bentham (1948) has oft been quoted: "Man has been placed under the governance of two sovereign masters: pleasure and pain."

Despite this insight, philosophers and psychologists remain haunted by the question: *What is the biological function of emotion?* It has been difficult to disentangle emotion from biological drives and physiological responses (James, 1884), from motivational appetites and defenses (Cannon, 1927), from cognitive appraisals (Schachter & Singer 1962; Scherer, Schorr, & Johnstone, 2001), or moral intuitions (Haidt, 2001); to make sense of the cultural similarities and differences (Mesquita & Frijda, 1992), or to reconcile divergent theories (Keltner & Gross 1999; Frijda, 2008); so difficult, that theorizing about emotion as a functional whole has largely been abandoned.

As emotion theorist James Averill put it: "It is particularly tempting to treat all emotions as though they have a common function. But it is a temptation we should resist, for it almost always leads to false conclusions" (Averill, 1994). Subsequently, philosopher Paul Griffiths (1997) lamented: "My central conclusion is that the *general concept of emotion* is unlikely to be a useful concept in psychological theory" (emphasis mine).

My purpose is to suggest the opposite: That the problem with the traditional approach is that it has been overly *specific*, narrow, and anthropomorphic. While perhaps cliché (Russell, 2003), emotion theory is indeed reminiscent of the Sufi tale of the elephant and the blind men, with each theorist grasping a portion, but unable to see the phenomenon in its entirety. As a result, emotional feelings and behaviors are written off as outdated animal vestiges, "ill-suited to modern exigencies" (Gross, 1998), to be suppressively regulated by one's conscious rational mind.

But with recent revelations from a variety of disciplines, a formerly hidden – yet astoundingly elegant – functional elephant looms large. I propose that the function of emotion is the very sort of "governance" that Bentham suggested, that of *self-regulation.* But in this usage, "self-regulation" refers primarily to the biologically bottom-up autopilot variety of regulatory control processes, and implies that subordination to our hedonic masters is actually a very good thing. I will argue that our limited ability to suppressively regulate our emotions is because *they are actually regulating us*, and from a much deeper, wiser, evolutionary – indeed *moral* – evaluative authority.

To sketch this ancient function, I pan much further back in our phylogenetic history, and delve deeper into the biophysical regulatory processes of living systems, tracing the emergent trajectory of the emotional system from its simplest mechanistic roots to its present state of elaborate multi-tiered complexity.

To linguistically accommodate the entire functional elephant, I must broadly redefine the category of emotion to include "affect" and innate "hedonic" approach/avoid behavior, locating its function in the arena of *regulatory signaling* and *motor control* mechanisms. I will point specifically to *feedback loops,* recursive, cyclic and reciprocally deterministic, stimulus-response relationships; those that give rise to the earliest forms of "computation" – *information processing* – in nature; those that inform what I call "self-regulated" behavioral agency in organisms as simple as a single-celled bacterium, and those still evident in the cell-signaling cascades that convey identity-relevant information across all levels of organization within complex multicellular organisms – including humans.

Indeed, many theorists have pointed out the primary "relevance detection" (Scherer, 1984), "relevance signaling" (Frijda, 1994), and "informational" (Lang, 1995; Schwarz & Clore, 1983; Schwarz, 1990) functions of emotion, as well as those of resource mobilization and conservation (Clark & Watson, 1994), and the organization and facilitation of adaptive behavioral responses (Levenson, 1994). Likewise, many have noted the categorizational (Niedenthal, Halberstadt, & Innes-Ker, 1999), motivational (Lang & Davis, 2006; Solomon & Corbit, 1974), goal relevant nature

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To cite this article: Peil, K. T. (2013). Emotion: The Self-regulatory Sense. EFS International. (Available at: www.emotionalsentience.com)

(Frijda, 1994) and primacy (Barrett & Russell, 1999; Zajonc, 1984) of affect. In fact, the idea of biophysical feedback itself has a rich history in emotion theory (Baumeister, Vohs, DeWall, & Zhang 2007; Buck, 1980; Clore, Wyer, Dienes, Gasper, Gohm, & Isbell, 2001; Frijda, 2000; Heilman, 2000; Hoeksma, Oosterlaan, & Schipper, 2004; James, 1884; Laird, 1974; Larson, 2000; LeDoux 1996; Pribram & McGinniss, 1975; Rosenblatt, 1985;Tomkins, 1962; Zajonc, 1985) in which Carver & Scheier (1990, 2011) specifically noted feedback as a self-regulatory "control process" underlying affect. Recent revelations, however, about bottom-up "self-organization" (Camazine, Deneubourg, Franks, Sneyd, Theraulaz, & Bonabeau, 2001; Kauffman, 1993) and interactive epigenetic mechanisms (Jablonka & Lamb, 2005) in evolution, can finally root these insights in solid biophysical ground, as well as offer significant clarifications and enhancements.

Indeed, building upon these contributions, I propose that emotion can only be envisioned as a unified functional whole when reconceived as an entire *sensory system* – a primary somatosensory system that guides *biologically adaptive self-regulation*. Not a newly evolved or sixth sense (Larson, 2002), but perhaps the *first* sensory system to have emerged on the evolutionary stage, born of the simple molecular stimulus-response networks that regulate metabolic and genetic activity and crude sensorimotor behavioral control in single-celled organisms. Such primal self-regulatory "sensations" are functionally homologous to, and still manifest within, *cell-signaling mechanisms* in multicellular organisms that integrate and maintain "the self" at all levels of complexity – rooted as deeply as those that control the navigation and differentiation of pluripotent stem cells into their various tissue environments during embryonic self-development. In other words, while they may have emerged as sensorimotor regulators in the earliest life forms, the same principle mechanisms still constitute the signaling and communication systems, the *self-organizing language* – the *self-regulatory music*, if you will – of the human body.

In whatever form of "subjective experience" these original sensations may have yielded, in functional terms they would deliver *primal perceptions* of *time*, *space* and *self* – an inaugural glimmer of a body-self moving within its not-self surroundings, at some point constituting the "feeling of being" (Ratcliffe, 2005) or "how it feels to be alive" (Fingerhut & Marienberg, 2012). Hence, in far more complex bodies in motion (mammals, other primates, and humans), each emotional feeling perception still reflects "a wave of bodily disturbance", or the "bodily affections" (James, 1884), or "the feeling of what is happening" (Damasio, 1999, 2010).

Key to our discussion, however, is that from their emergence forward, these informational sensations have contained "*felt evaluations"* (Helm, 2002; Slaby, 2012), the *symbolic binary opposites that we experience as pleasure and pain, the feel good/feel bad hedonic valence of emotion.* These "positive and negative" binary opposites offer real-time computational representations of the ongoing dynamic orchestration of whole-body coherence, with harmonically resonant and dissonant reverberations ringing forth when environmental perturbations require self-regulatory responses. I will argue that the binary hedonic logic within these felt evaluations offers nothing less than a *biological value system*, informing us of universally right and wrong states of balanced being and becoming – a *moral value system* rooted in the biophysical requirements for life itself. (Indeed, by any definition, "morality" depends on "knowledge of right and wrong", as does legal "sanity" in terms of criminal responsibility (Platt & Diamond, 1966); yet without any biologically significant underpinning, such words are of limited utility.)

At a more concrete level of analysis, I equate the positive and negative hedonic categories with "eustress" and "distress" signals respectively (Selye, 1956), and locate the emotional sense as an intimate affiliate of the *immune system* (recently declared a sensory system itself; Blalock, 2005). Adding, however, that its core physiological "*self*" or "*not-self*" distinction is tethered deeper still in genetic and epigenetic regulatory processes, which gives bottom-up biological teeth to the "self-relevant" (LeDoux, 1989) or "motivationally relevant" (Hajcak, Moser, & Simons, 2006) nature of affective stimulus, and underscores the notorious bidirectional connection between emotion and physical health (Kiecolt-Glaser, McGuire, Robles, and Glaser, 2002; Lazarus, 1993; Mayne, 1999; Petrie, Booth, & Pennebaker, 1998; Segerstrom & Miller, 2004; Taylor, Kemeny, Reed, Bower, & Gruenewald, 2000; Xu & Roberts, 2010). As such, these core self-regulatory feedback processes in humans also undergird the requirement for "regulatory fit" (Scholler, & Higgins, 2011) within and between goals, or concordance within the "psychological immune system" (Gilbert, Pinel, Wilson, Blumberg, & Wheatley, 1998) and other self-balancing processes such as "cognitive dissonance" (Festinger, 1959); although, as I will argue, *emotional* dissonance may be more biophysically accurate.

Identifying the self-regulatory functional elephant will also acknowledge emotion as the unsung hero in conditioned learning (LeDoux, 2000; Pavlov, 1927); in subliminal "priming" (Biederman & Cooper, 1991) and embodied (Barsalou, 1999), implicit (Frith & Frith, 2008) or unconscious cognition (Bowers, 1984), implicit bias (Greenwald & Krieger, 2006; Levy & Banaji, 2002) as well as nonconscious, "auto pilot" self-regulation (Papies & Aarts, 2012); in cognitive identity formation (Bosma & Kunnen, 2001; Stryker & Burke, 2000), self-perception (Bem, 1967), self-concept (Markus & Wurf, 1987), self-serving biases (Bernstein, Stephan, & Davis, 1979) and self-enhancement motives (Leary, 2007); in needs for and feelings about self-determinism (Deci & Ryan, 1985), self-efficacy (Bandura & Locke, 2003), self-esteem (Baumeister, 2005; Harber, 2005), self-expansion (Aron & Aron, 1997) and urges toward self-actualization (Maslow, 1970); all of which are elegantly integrated within emotional sensory perceptions and their coupled behavioral responses.

In short, my hope is to sketch a new image for the box of the puzzle of emotion, one where emotion takes its rightful place as a **sense**; one depicting common *feeling tones* on par with colors, tastes, scents and sounds. One in which feeling perceptions, ranging from rudimentary *pleasure* and *pain*, through basic *joy* and *sadness*, to complex *pride, shame, admiration* and *envy*, serve as sensory signals offering an elegant palette of evaluative information about our adaptive fitness in the immediate environment. Indeed, I am not only proposing that emotion should be reframed as a sensory system, I am suggesting that emotion is the biological *grandfather of all the senses*, and that its hedonic self-regulatory logic remains encoded within all other senses – a simple logic, yet one so crucial as to have been conserved throughout our entire evolutionary history. Acknowledging how our presently elaborate, cognitively enriched, emotional perceptions still bubble up from their ancient self-regulatory wellspring, offers quite profound implications for the psychological community, and the social sciences in general. Indeed, it allows the scientific construct of emotion to come full circle, rejoining with the so-called naïve realism of immediate human experience, yet offering direct inroads to bountiful emotional intelligence, social intuition, and moral reasoning.

But however elegant, these *subjective* manifestations cannot be separated from their *objective* counterpart, for each emotional sensory perception includes both an *informational* component and a coupled *behavioral response.* Indeed, in this new view, emotion is ground zero for all sensorimotor stimulus-response relationships, with the *hedonic approach and avoid behavioral pattern* – a pattern observable from the single celled ameba to the complex human (Medicus, 1987) – serving as the primary empirical justification and departure point for our new story. A crucial point is that this crude sentience is contingent upon, and would *follow from,* the deterministic behaviors themselves, or as Marienberg (2012) put it: "the becoming aware of the capacity to act *while acting*". In short, identifying the biological function of emotion requires taking Skinnerian behaviorism to all new reductionist levels – an inquiry into how approach and avoid behaviors emerge from the chemistry of living systems. Yet, when equipped with the lens of feedback control theory, the journey affords a primordial peek into the "black box", offering a clear and detailed functional explanation of how innate ("unconditioned") stimuli evoke "affect" itself – something decidedly lacking in emotion theory (Frijda, 2008). In fact, the bi-directional regulatory pathways (neuroendocrine, immune, and epigenetic) that undergird the self-regulatory emotional sense address the "hard problem" (Chalmers, 1996) of mind-body interactions and answer the "entirely unresolved" question: "How could feelings possibly influence neurons?" (Frijda, 2008).

In this brief introduction I will first redefine emotion within this broadened context, point out its biophysical substrates and underlying feedback dynamics, and identify the source of what I call "the self-regulatory code". I will then offer the hedonic behavior of the Escherichia coli (E. coli) bacterium as an example of the ancient mechanisms and go on to describe the modern neural, perceptual, and behavioral manifestations of the emotional sense, ending with a brief discussion of the moral implications. Indeed, to formally acknowledge emotion as a primal sensory system exposes many scientifically unsupportable assumptions, inviting critical reevaluation of many deeply engrained beliefs and practices.

Emotion: A Broadened Definition

To begin, I broadly redefine "emotion" within the context of digital *stimulus-response behavioral phenomena*, including any biochemical processes and physical mechanisms, laws and forces that determine their cause and effect relationship. By digital, I mean any sort of distinctly *binary values*, symmetrically isomorphic or oppositional qualities, structures, states or transformative actions that exist in nature that can be harnessed as meaningfully symbolic cues further up the evolutionary ladder. In other words, such binary values (i.e. positive/negative electrical charges, north/south magnetic poles, left/right symmetries, cis/trans isomers, etc.) can serve as digital information "bits" for computational processing. In fact, an *if-then* stimulus-response logic is there for the taking at even smaller scales, inherent in the quantum mechanical laws that determine how electrons "choose" between alternate states of spin "up" or spin "down" depending on their local electromagnetic environment. Indeed, the orderly behavior of electrons ultimately drives all higher scale chemical reactions – from the bonding and anti-bonding behaviors of molecules, through the transitional and equilibrium states of metabolic networks, to the signaling cascades and on/off regulatory switching of genetic processes. In short, the sensory informational components of emotion can only be appreciated against the backdrop of the in-forming, trans-forming, stimulus-response dynamics of matter in motion. These binary opposites, deterministic behavioral laws, and self-organizing dynamics underlie the "regulation" part of the self-regulatory function of emotion, as they deliver bottom-up "order for free" (Kauffman, 1996). As we will see, they also deliver an elegant stimulus-response choice-making logic – whether or not any sentient life form has yet emerged to exploit it.

The "self" part of the self-regulatory function, and the emergence of what I define as emotion proper, is rooted in iterative, self-reflexive, *feedback loops.* Indeed, feedback provides the crucial evolutionary link between the deterministic, self-organizing "happening" behavior of non-living matter and the self-regulatory agency – goal driven "doing" behavior – of living systems. As such, feedback also provides the conceptual linchpin between the physically impartial "positive" and "negative" binaries in nature and the warm-fuzzy/cold-prickly evaluative categories of personal experience.

What is Feedback?

Feedback, in terms of general function, refers to *communication and control mechanisms* prevalent in both mechanical and organic systems – those that report upon (inform) and alter (transform) the relationship between a given system and its immediate environment (de Rosnay, 1979). Feedback is cyclic, as it occurs in circular stimulus-response *loops* where the output of a system is fed back into *itself*, serving as a stimulus for a subsequent round of output responses (See Figure 1, two systems with and without feedback). In this primary mechanical context, however, the term "self" is synonymous with the ***system*** in question, whether it be an atom, a molecule, a cell, an organ system, or an organism interacting with its local "not-self" environment. Equating "system" with "self", of course, does not yet imply sentience or consciousness, but is simply a *relative location in space*, as well as a *subjective center in time* serving as both source and sink for energy and information exchange, and therefore, ground zero for both stimulus and response. Nonetheless, as Figure 1 suggests, feedback processes conceptually juxtapose time, space, and self in unadulterated ways, offering a simple elegant springboard for our discussion of emotion as a primal self-regulatory sense.

But the feedback mechanism is also central to the aforementioned "regulatory" side of the self-regulatory emotional elephant – as well as the emergence of sentience itself. For feedback loops are the basic building blocks of *cybernetic* systems (Ashby, 1956; Weiner, 1948; Powers, 1973), also known as "complex adaptive systems" (Holland, 1992), "dissipative structures" Prigogine & Stengers, 1984), and self-making "autopoietic" systems (Varella, Maturana, & Uribe, 1974) – which include all life forms. As the original "science of control and communication", Weiner, 1948), cybernetics united regulatory control theory with physical information theory, investigating how materially embedded systems can make observers and actors possible – how mechanically in-forming and trans-forming processes give rise to subjective information and behavioral control in living systems. (As Nobel laureate Manfred Eigen suggested: "If you ask where does information come from and what its meaning is, the answer is: information generates itself in feedback loops" (Eigen, 1993). In fact, in terms of thermodynamics, feedback is associated with both *entropy* (chaotic disorder) and the "*negentropic*" (Brillouin, 1953*) ordering principles* that underlie the physical definition of information itself. The functional architecture of these ordering and disordering principles – from electromagnetic polar shape shifting transitions to favored-state energetic balances – was elegantly depicted by the founder of both cybernetics and general systems theory Ross Ashby, in his original "homeostat" (1948). His homeostat was a device that provided a concrete example of adaptive control, a crude electronic "thinking" machine (Latil, 1956) that combined both analog and digital information processing in order to maintain stability in the face of highly varied and challenging environmental perturbations (Cariani, 2009). While criticized in its day as a 'learning' device because it relied upon arbitrary parameters and random chance (Dupuy, 2000) and was not particularly brain-like (Pask, 1961), as we will see, both the order and chaos in its informational architecture are born of feedback mechanisms central to our discussion.

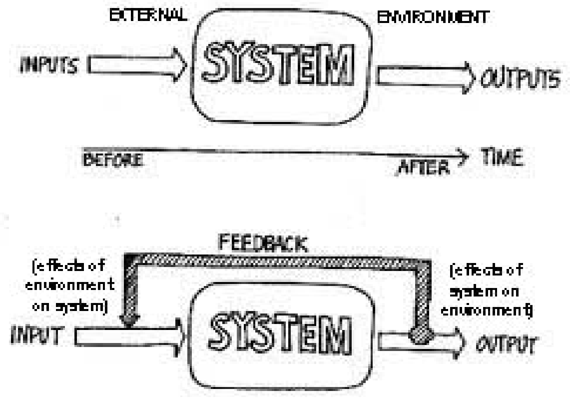

Figure 1: Feedback
(adapted from de Rosnay, 1979)

In fact, recent advances in fields ranging from cosmology to computer science have hinted at a possible deep causal connection between the second law of thermodynamics (entropy maximization) and adaptive intelligence (Wissner-Gross & Freer, 2013) – for feedback is as manifest in the physical territory as it is in our mappings of it. Indeed, feedback is implied in the functions, equations, and infinite series of integral and differential calculus, those that describe the dynamic behavior of complex dynamics systems (Mankiewicz, 2000); in the Fourier transforms that mathematically describe any "periodic", oscillatory, or wavelike phenomena (Devlin, 1994); in the cyclic iterative sequences that drive the transformative branchings and symmetry breaking in chemical reactions (Buhse, Lavabre, Micheau, & Thiemann, 1993), that forge and alter connections between nodes in networks (Farmer, 1990); and that generate "fractal" geometric (Mandlebrot, 1977) structures. Fractals are shapes exhibiting organized networks on both horizontal and vertical dimensions, characterized by level independent "self-similarity" - nested hierarchies of self- repeating part-to-whole relational patterns on multiple scales in both space and time. Indeed, non-Euclidean fractal geometry describes nearly every shape in nature, including the human brain (Briggs, 1992; West, Brown, & Enquist, 1997). So it is ultimately this mathematically precise self-similarity, the biophysically auto-induced, iterative self-reflexive nature, and its ubiquitous role in self-organizing and self-regulatory processes that places feedback center stage for both "self" and "regulation" pieces of the self-regulatory function. In short, feedback is quite literally a key computational in-forming and trans-forming engine in nature. And, in a moment, I will demonstrate how the hedonic valence of emotion – with its definitively "self-relevant" (LeDoux, 1989) stimulus signals – emerges directly from *positive and negative feedback loops*. Indeed, they come in *two types*, providing the binary opposites for digital "choice-making" in what I call the *self-regulatory code*.

For now, suffice it to say that emotion as a self-regulatory sense emerges because feedback "happens" across the great chain of being, the "noise" (Bialek, 2006; Moss, Ward, & Sannita, 2004; Walleczek, 2000; Weaver & Astumian, 1990) of its simple computational dynamics having been harnessed by self-replicating systems, and conserved, honed, and elaborated upon by natural selection. As such, the feedback paradigm can shed light upon the hedonic behavior of simple organisms that emerged on the evolutionary stage long before nerve nets or brains, allowing questions of primitive sentience to be separated from the complex neural processes that are correlated with human consciousness. In fact, it is only within this broadened, less neurocentric depiction that the many facets of the emotional sensory system can come to light.

Sadly however, while commonplace knowledge among physicists, chemists, and biologists that feedback regulation: subserves all biological signaling systems (Thomas, Thieffry, & Kaufman, 1995); underlies biorhythms and biological clocks (Dunlap, 1996; 1999), and molecular and neural circuitry (Grossberg, 1980; Grossberg & Somers, 1991; McNaughton & Coughenour, 1981); is essential to all genetic, epigenetic (Jaenisch & Bird, 2003), immune (Ansel, Lee & Rao, 2003; Coogan & Wyse, 2008; Keller et al 2009) and even sensory mechanisms (Farley & Sampath, 2011), as well as goal-directedness and behavioral control (Heylighen & Joslyn, 2001); the concept of feedback has remained relatively obscure, Ross Ashby's original homeostat languished as incompatible with brain structure, and the "revolution in psychology" promised by cybernetics was largely a failure (Powers,1978; Bandura & Locke, 2003). Indeed, when it comes to applying feedback control theory to human behavior even the best models (Powers, 1973; Carver & Scheier, 1990, 2011), rely upon *only one* of the two types of feedback, confound *feedback* and *feed-forward* processes in time, as well as *internal* and *external* locations in space, and vault to the complex level of human self-regulation with assumptions and conventions that inadvertently *reverse* the logic of the self-regulatory code. As a result, neither the ubiquitous feedback process nor the elegant emotional sense have been given their proper due – and a good deal of wisdom from the behaviorist tradition has been sidelined in the cognitivist fervor.

Nonetheless, this new view honors the *affective revolution* now underway. It allows us to zoom in, conceptually revisiting the earliest emergent sensory mechanisms for detailed clarity in the form and function of self-regulatory feedback. At this micro level, examination of the feedback (and feed-forward) circuitry in the simplest living system offers conceptual precision to descriptive terms for information flow in space and time (i.e. inside, outside, before, after, backward, forward, bottom-up, top-down), precision that can help social scientists transcend the Cartesian ("dual process") mind-body muddle. Likewise, the approach allows us to zoom out to the macro level of analysis, offering a bird's eye vantage from which a complete spectrum of informative emotional feeling tones comes into view, a continuum of meaningful sensory signals ranging from the hardwired and universal, to the learned, socio-cultural and particular life experience of each unique individual.

Indeed, since its initial emergence, the emotional sense has undergone tremendous elaboration by natural selection. Its present structure is an elegant *tri-level informational hierarchy* – from *affect* to *basic* to *complex* feelings – reflecting the generally "triune" structure of the brain (MacLean, 1990), yet with each still playing its own uniquely valuable self-regulatory role. But perhaps most importantly, it shows how affect provides the core "hedonic" (Branscombe, 1985; N'Diaye, Sander, &Vuilleumier, 2009) evaluative message, the fundamental "bad-for-me" or "good-for-me" appraisals that we experience as immediate psychological pain or pleasure. Indeed, identifying emotion as our primal self-regulatory sense, restores our innate tether to biologically determined "right" – perhaps non-negotiable – states of life-giving balance.

In sum, the emotional sense is born of biophysical regulatory feedback signals that come courtesy of lawful stimulus-response behavior, that which still undergirds our hedonic emotional perceptions and their coupled approach or avoid behavioral responses. These affective polar opposites are the highly conserved felt evaluations – saying "no" to this and "yes" to that – those that appear across the various levels of analysis, recognizable in affective "eustress and distress" signals (Selye, 1956); informing us of the immediate environmental "benefits and harms" (Damasio, 1999), or symbolic "challenges and threats" (Blascovich, Mendes, Tomaka, Salomon, & Seery, 2003) and giving rise to our general *positive* and *negative* categories of emotion. Shortly, I will suggest an even more fundamental self-regulatory dichotomy that undergirds them all, one showing how the amazing emotional sense offers universal self-regulatory perceptions for all humans which – when properly understood – also offer a personally tailored *moral compass* to each individual. For now, I define the term "emotion" to include these core hedonic self-regulatory signals as well as the primary or *basic* emotions (Eckman, 1993), and the *complex* (Nunner-Winkler, & Sodian, 1988) feelings (also known as "unnatural" (Lutz, 1988); "secondary" (Kemper, 1987); "intellectual" (Averill, 1996); "social" or "moral" emotions (deSousa, 2001; Haidt, 2003). Indeed, in the Venn diagram depicted in Figure 2, this expanded, multi-tiered, definition of the emotional system also reflects the stair-step evolution of each new level of self-regulatory information as it emerged over our sweeping biological history.

Whether or not the above discussion coheres for academic psychologists who may not stray far from our respective disciplines, please bear with me, for the self-regulatory logic that emerges from the ubiquitous biophysical feedback process speaks for itself. Indeed, once this missing piece of the emotional puzzle – its self-regulatory sensory function – is identified, many other disjointed bodies of empirical evidence fall into place.

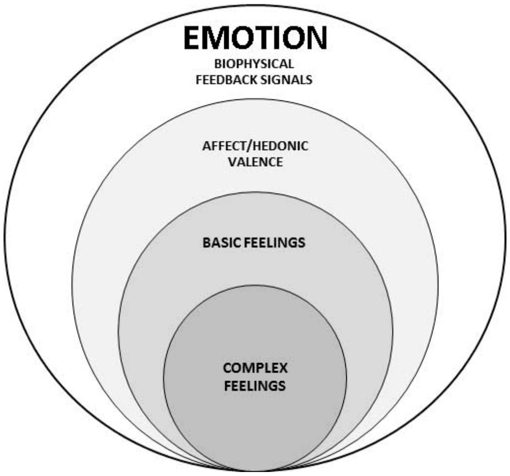

Figure 2: Expanded categorical definition of emotion

Behavior, Feedback, and the Emergence of The Self-regulatory Code

I hope to make clear that such familiar bottom-up phenomena as embodied cognitions, priming effects, subconscious attitudes, unconscious motives, conditioned memories, and instinctive autopilot behaviors are a direct result of the self-regulatory processes we perceive via the emotional sense. In fact, it is only in the context of these primary *bottom-up* aspects of emotion that the more recently evolved *top-down* add-ons begin to make self-regulatory sense.

It is conceivable, however, that I am indulging in naïve realism or am equally guilty of anthropomorphism – pushing the human experience of pleasure and pain back upon less complex species. To avert this critique, I'd like to temporarily decouple the stimulus-response relationship, asking readers to simply bracket the subjective aspects of emotion (depicted in Figure 2) and maintain a strictly behaviorist perspective. In fact, while the sensory information has undergone tremendous elaboration over time, the basic *motor* approach/avoid behavioral responses remain the same – and they embody the self-regulatory logos on offer. Thus, in the spirit of empiricism, I will confine the next portion of the discussion to the objective *approach or avoid* behavioral pattern and let the actions speak for themselves.

To continue, as I've hinted, the secret to cracking the self-regulatory code is *feedback*. This is because feedback is first and foremost a regulatory *control* process – in-forming while trans-forming, ordering, and organizing behavior. In fact, "integral feedback control" is a basic engineering strategy in complex man-made systems such as a jet airplane, with feedback loops found at every level, from transistors and circuits to instruments and actuators, to the autopilot mechanism for the entire vehicle itself (Yi, Huang, Simon, & Doyle, 2000).

With Ashby's homeostat largely lost, this autopilot nature of behavioral control is perhaps what later inspired engineering psychologists to link human behavior with negative or "regulatory" feedback control, as it is associated with *homeostasis* – keeping things at their proper set points in order to keep the airplane or the creature shipshape and on its proper course. Indeed, by the 1970's, on the heels of the behaviorist heyday, feedback control theory (a "quantitative science of purposive systems" (Powers, 1978) was resurrected with the palliative promise of restoring *internal goal states* to psychological theory. In organic systems, however, we've seen that homeostatic goal states rely upon natural physical constants and chemical reaction thresholds and durations, state transitions, and optimal equilibrium balance points – chemically or energetically "favorable" states, in accordance with the laws of thermodynamics. This may be why the classic example of homeostatic feedback control then became the *thermostat* (Carver & Sheier, 1998). The thermostatic regulator functions through a three step process (Powers, 1973): It *compares* the actual state of the system to some preset optimum, *signals* when a mismatch is detected, and *self-corrects* back toward the optimal state (it "effects" an observable behavioral response). In your home heater, for example, the *actual* room temperature is compared to the desired *preset* temperature, and when the house gets too hot or too cold, the thermostat rebalances the system by kicking the heat on or off. While problematic outside its original quantitative context, this thermostatic model offers an excellent inroad into to our detailed examination of the simplest sensory systems, as the three steps (comparison, signaling, and self-correction) are crucial components of the self-regulatory feedback cycle. Yet, as critics of the control model of human behavior suggest, there is far more involved than simply negative feedback (Bandura & Locke, 2003) – even in the simple thermostat.

For key to our discussion, is that feedback comes in *two types*. In fact, the binary code – as well as the thermostatic arrangement itself – emerges from an elegant coupling of these two types of feedback, a stimulus response relationship that creates the necessary bridge between the determined (happening) behavior of matter and the partially free – but logically self-regulatory – (doing) behavior of animate agents. This coupling also delivers the functions that the original cyberneticists suggested could: "at last explain how 'mental' causes could enter into 'physical' effects" (Powers, 1978). Indeed, the coupling of both types of feedback is the missing piece required to vault the gulf to human behavior with the self-regulatory logic intact. However, there has been abundant misunderstanding, misinterpretation, and a series of patterned "blunders" (Powers, 1978) on the road to realizing the early cybernetic vision. In fact, the various interdisciplinary literatures are peppered with a variety of uses for the term "positive" and "negative" feedback (Ramaprasad, 1983), and the language is often confounded with *feed-forward* loops or complex *feedback circuits* built from couplings of multiple positive or negative loops. For reasons I hope will become clear, I've chosen the original cybernetic definitions as the best bare bone descriptors of the mathematical patterns, relationships, and biological processes under discussion. With that said, I now offer a clean slate reintroduction to the two types of feedback.

Positive and Negative Feedback

The first type of feedback is called *positive* feedback. In a positive feedback loop the iterative cycles build upon one another, such that with each new cycle the change to the system proceeds *in the same direction* as that of the former cycle (See Figure 3, left.) Positive feedback is associated with chaotic change, leading to *divergent* behavior, "an indefinite expansion or explosion (a running away toward infinity) or total blocking of activities (a running away toward zero)" (de Rosnay, 1979). Functionally, positive feedback is *amplifying*, associated with rapid, exponential, growth (or decay) and upward or downward spirals of runaway change. Examples include: chain reactions, autocatalysis, signal transduction cascades, economic inflation or deflation, and population explosion or depletion. Please note that there is no evaluative (good or bad) connotation to 'positive', the term speaking only of the direction of change, with positive connoting qualitative change in the same direction as the previous cycle, whether that direction yields a quantitative increase or a decrease in a given energetic or chemical parameter.

The second type, *negative* feedback does just the opposite, *reversing* the direction of the process relative to the previous iteration (See Figure 3, right). Once again, there is no evaluative judgment, 'negative' simply means reversing the direction of the change, regardless of the nature of that change. But since it is a ubiquitous feature of homeostatic circuits, negative feedback is considered *regulatory*, in that it controls the runaway "chaotic" change born of positive feedback loops. As mentioned, negative feedback relies upon natural laws and statistical mechanics, kicking in when upper or lower thresholds of a given parameter are breached,

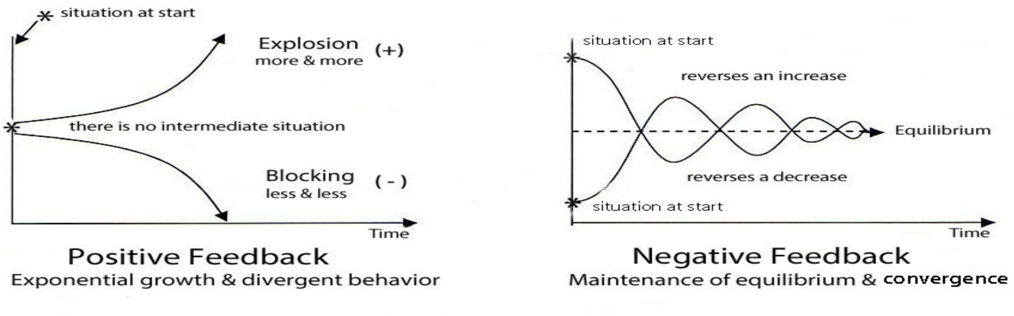

Figure 3: The two types of feedback
(Adapted from de Rosnay, 1979)

providing *convergence* to a preferred, chemically or energetically "favorable" state, in accordance with the laws of thermodynamics and quantum mechanics. (Indeed, even the electron has a preferred energetic "ground" state.) But it is equally important to realize that the wild, runaway behavior of positive feedback also flows from those same physical laws and forces – an electron, an ion, a polarized molecule, a membrane, a neuron, or an organism – can also be in an "excited" or temporarily unbalanced dynamic state. Life certainly could not occur or be sustained without both halves of the in-formative trans-formative whole that is feedback.

In short, both positive and negative feedback are ubiquitous in nature, counterparts to one another, working together in the process of self-organization. While positive feedback yields the instability and divergent processes that constantly create, destroy, and recreate new arrangements of matter, negative feedback provides the stabilizing balance, homeostasis, and preservation of form. As mentioned, feedback loops are among nature's most fundamental building blocks, "the engine of self-organizing dynamical activity" that "leaves its tracks and marks as fractal structures", images of "the way things fold and unfold feeding back into each other and themselves" (Briggs, 1992).

Coupled Feedback Loops and Self-regulation

The failure to account for positive feedback is perhaps the primary reason that control models of human behavior have gone off the rails. Another is that even the simplest behavioral control mechanism in a living system involves many links and *chains of single positive or negative loops*, which changes the entire game. Indeed, when we begin melding the deterministic and the subjective functional definitions of "self", the increases and decreases manifested by positive and negative feedback (the changes and their reversals) connote *state changes* within the identity of a living form, changes driven directly by the reciprocally disturbing interactions between the self-system and its immediate (not-self) environment. In evolutionary terms, such a regulatory process would have emerged along with life itself, an outgrowth of "hypercycles" and "autocatalytic" chemical networks (Eigen, Gardiner, Schuster, & Winkler-Oswatitsch, 1981.) In fact, such a system has been suggested to predate even natural selection, described as "context dependent actualization of potential" Gabora & Aerts, 2005), or "self-other organization" (Gabora, (2006). (See Sherman & Deacon, 2007; for an intriguing theory of a missing link "autocell" that bridges thermodynamics, morphodynamics, and goal-seeking teleodynamics in emergent systems; albeit devoid of the feedback processes discussed here.)

At some serendipitous juncture in our evolutionary history however, *self-replicating* molecular arrangements emerged and natural selection was off and running. But central to our discussion, regardless of how this leap occurred, *regulatory feedback circuits and their dynamic logic* (Thomas, 1998) were *already in place*, utilized by the "branes" – the cellular membranes – of the first single celled creatures. "Regulation" in this context involves changes ("covalent modifications") in the properties of a cell under the influence of external and internal signals in order to adjust the cell's internal biochemistry. This process is considered the evolutionary "origin" of sensory processing (Koshland, Jr., 1981) – and, I argue, is precisely what the cyberneticists were intuiting about feedback control (details to be addressed shortly in our E. coli example).

At present, however, complex organisms at every level on the phylogenetic tree exhibit intricate webworks of coupled feedback loops and circuits with common *functional motifs* born of chains of single positive and/or negative loops. These motifs include such functions as: basal *homeostat*, *threshold limiter*, and *adaption* (born of negative loops); and *amplifier, accelerator, damper, delayer*, or *bistable switching* (of positive loops); or *pulse generators* or *oscillators* (of both); (See Brandman & Meyer, 2008 for details.)

Of particular interest for our new model of emotion, is the positive feedback motif of *bistable, digital switches* between alternative phases or states (Lisman & Fallon, 1999; Rao & Arkin, 2001; Ferrell, 2002; Cinquin & Demongeot, 2002; Brandman, Ferrell Jr., Li, & Meyer, 2005) the aforementioned covalent modifications (Koshland Jr., 1981). As previously hinted, such deterministic binary (either/or) switching is observable at all scales of material organization (i.e. chiral symmetry of amino acids that determine the genetic code; bonding and anti-bonding reactions that govern protein folding; "on/off" switching of genes and all-or-none firings of neurons.) In fact, this bistable pattern emerges consistently even from randomly connected network nodes yielding systems poised critically on the "edge-of-chaos", dynamically balanced between stability and change (Kauffman, 1996). More, it is the *dynamic transitions between these binary states* have been suggested to provide the earliest forms of computation in nature (Langton, 1998). Indeed, even the simple thermostat requires bistable switching – and several other positive feedback motifs, as did Ashby's original homeostat.

Hence, the present proposal is that the winning evolutionary scenario – the one that underpins the self-regulatory behavior of life forms – is a *coupling of both types of feedback* such that the *divergent positive feedback stimulus* triggers *convergent*, *negative feedback regulatory responses* (See Figure 4).

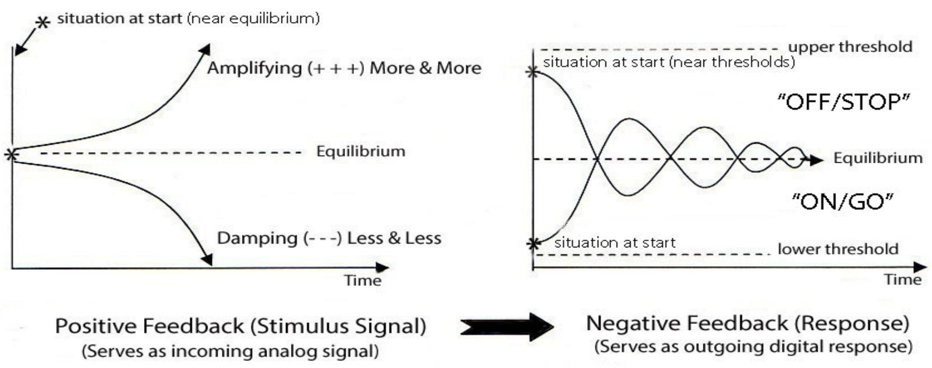

Figure 4: How coupled positive and negative feedback yields stimulus-response behavior
(Adapted from de Rosnay, 1979)

This general arrangement delivers most (if not all) of the functional feedback motifs in one fell swoop, providing nearly every requirement of the regulatory thermostat. For example, as depicted at left in Figure 4, the amplification versus damping, and bistable switching motifs of positive feedback offer a graded *analog* signal which indicates the system is changing in significant ways, that some relevant environmental stimulus is either increasing or decreasing. [Others have termed this the "sense signal" which is then compared to an inner "reference signal", triggering the "error signal" (Powers, 1973) – terms we will return to and clarify shortly. In fact, this *rheostatic,* adjustable, register of resistance and capacitance was inherent in Ashby's homeostat]. These changes are then indeed *compared* to the desired states and reaction thresholds (basal homeostatic and limiter motifs of negative feedback, shown at right); which triggers a *corrective response* that reverses the trend, bringing the system back into balance (like the home furnace). While perhaps neglected in psychological theories, this coupled feedback configuration has been noted elsewhere and deemed a biological *logic gate* or block that can switch from the "and" to the "or" functions (Shinbrot, Grebogi, Ott, & Yorke, 1993; Glass, 2001; Dari, Kia, Bulsara, & Ditto, 2011). (It is also likely what Carver & Scheier (1990, 2010) modeled as two parallel but interacting control systems, one analogous to *distance*, and another to *velocity* in terms of progress toward a high level human goal; and while ultimately problematic, a prescient intuition about core perceptions of space and time in the origins of affect.)

With an elegant simplicity, this general arrangement offers both analog and digital information processing, it's self-similarity across multiple levels of organization forging a pattern of relational causality between faster and slower system dynamics, bridging local and global levels of control – fulfilling all Ashby's original hopes for his homeostatic thinking brain. Like a neural network, it gives rise to *horizontal* cross talk (parallel processing) between local network nodes as well as signaling and control relationships across *vertical* levels in fractal hierarchies. The latter, constitutes an elegant "circular causality" (Hakken, 1984), a patterned bi-directional interaction wherein the faster dynamical behavior of lower-level "local" parts is synchronized and governed by slower, higher level "global" wholes. Such fractal hierarchies can be likened to a set of Russian Nesting Dolls, with the same circular part-to-whole relationship occurring between any two dolls at any given level. The smaller, affecting bottom-up responses to the top-down "environmental" cues from the next largest doll within which it resides. It matters not whether these dolls are atoms, molecules, cells, organs, or an entire organism, the dynamics are the same – with each self at once an autonomous *whole* as well as an indivisible *part* of a larger gestalt.

Most importantly, these reciprocal relationships coordinate functions in complex systems across various time scales, providing communication through signal transduction cascades, guiding intercellular development (Freeman, 2000), and ultimately yielding "perfect adaptation" (Csete & Doyle, 2002) – as the self-regulatory music of the body. In fact, the motifs of coupled positive and negative feedback loops include the oscillatory behavior, pulse generators, and on/off firing behavior of neural networks, and the "tunability" of biological rhythms from cell cycles to heartbeats (Grossman & Paul, 1992; Davis, 2006; Tsai, Choi, AM, Pomereing, Tang, & Ferrel, 2008). Conceptually, this feedback coupling and its three step cyclic flow are likely the facilitators of Spinoza's "dual-aspect monism" (Panksepp, 2008); perhaps the dynamic underpinnings that inspired Hegelian dialectical logic, the identity bridge between quantity and quality (Hegel, 1874), and may well capture the ancient Eastern (Yin/Yang) concept of The Tao (Da, 1987).

Best of all, however, this elegant feedback coupling sets the stage for the first sorts of hedonic approach and avoid behavior – as well as the first sort of enacted, embodied, *mind*. I say "sets the stage", because as we will see, even with the addition of the positive feedback processes we have not yet gone beyond the functionally 'negative' feedback regulation of other control models to arrive at the true binary perception or digital response.

Self-regulatory Behavior in Bacteria & The Tit-for-tat Code

Indeed, this new story strikes at the heart of an ongoing philosophical debate as to the nature and origins of mind. Perhaps related to the original Cartesian mind-body divide, the debate concerns whether mindful "cognition" is an exclusive manifestation of a functional brain or whether it is primarily embodied and embedded in an environmental context (i.e. Dennett, 2003; Blackmore, 2006; Thompson, 2007). The emotional sensory model suggests that it is both, but that as the locus of the feedback control function, "branes"– environmentally embedded cellular *membranes* – came before brains in terms of evolution, and their signaling dynamics delivered the first experience of self in time and space. (In other words, it suggests that emotion *preceded* cognition proper, and that "*sentio ergo sum"* – I *feel*, therefore I am – may have been more biophysically accurate.) As such, the sensory feedback model weds the computational, representational, identity and embodiment approaches to the emergence of mind in the singular concept of *primary self-regulatory perception*. That, which I am arguing, gave rise to the inaugural evaluations within the emotional sense.

In fact, the brilliance of the cybernetic model, was that rather than to control behavior per se, it served to "control perception" (Powers, 1973). It was a theory of how a system controls its *somatosensory experience of being* – its hedonic feeling of what is happening (Damasio, 1999). But this seems just a convoluted way to say that a regulatory control system <u>*delivers*</u> *(ushers or creates)* perception itself. In short, it yields a crude mind. Indeed, founding father of "affective neuroscience" Jaak Panksepp (2008) posits a *core affective consciousness*, or a "visceral nervous system" that yields "primordial affective mentality" – genuine feelings in all neurally endowed creatures, "similar to seeing a color". Psychologist's stop short, however, of declaring emotion to be an actual sense for as pioneering theorist Nico Frijda (2008) puts it: "There is still no detailed hypothesis at the functional level of how innate affective stimuli evoke affect". This is where an examination of the simplest sensory systems can clarify and expose the devilish molecular details within which the primal emotional sense remains shrouded.

Take, for example, the chemosensory system of the Escherichia coli (E. coli) bacterium, perhaps the first identifiable sense to emerge, and one whose molecular circuitry is quite well understood. (With apologies, in advance, for the linguistic switchbacks in terms of "positive" and "negative" that are required). The on/off switching that underlies affect is readily evident in the digital behaviors of coupled protein molecules, those central to genetic regulation as well as sensory perception. (For reviews see Koshland Jr, 1981; Block, Segall, & Berg, 1982; Grebe, & Stock, 1998; Bren & Eisenbach, 2000; Wadhams & Armitage, 2004).

Indeed, in the simple E. coli, there are three levels of binary self-regulatory switching with functional outcomes from *on/off* genetic regulation, through *stop/go* behavior (approach/avoid chemotaxis), to the *yes/no* hedonic evaluations under discussion, and as the details will demonstrate, *each of which exemplifies the self-regulatory feedback arrangement depicted in Figure 4*. In fact, in terms of the brain only view, these three levels offer exact matches to the three criteria required of a legitimate "internal representation" (Haugeland, 1991): 1) to coordinate its behaviors with environmental features not always "reliably present to the system"; 2) to cope with such cases by having "something else" stand in (in place of a direct environmental signal) and guide behavior in its stead; and 3) that "something else" is part of a more general representational scheme – a code – that allows the standing in to occur systematically and allows for a variety of related representational states (Clark, 1997). Likewise, these conditions dovetail cleanly onto Powers' (1973) control model of human behavior, with the *comparison* between Haugland's conditions 1 and 2 (termed the *sense* signal and the *reference* signal), which when discrepant delivers the *error signal*, with a coupled self-correcting *effector* behavioral response, which together I am suggesting manifests as the binary hedonic valence of emotion. In short, the coupling of positive and negative feedback gives rise to all three criteria for a functional mind and an elegant sensorimotor behavioral control system – far before brains emerged on the evolutionary stage.

While some may rightly worry that an E. coli bacterium is hardly analogous to a human being, its simple sensory system provides an elegantly detailed structural example of the "thermostatic" feedback arrangement in action, allowing us to precisely parse what happens *where* and *when* in *space* and *time* that yields self-regulated hedonic behavior. In other words, the E. coli bacterium offers an excellent biological stand-in for the "system" depicted in Figure 1, its membrane physically bounding itself from its not-self environment. The feedback loop is the *embedded* aspect of mind, the transmembrane sensory receptors reporting self-relevant stimulus as the body moves about, with the three steps of feedback control constituting what goes on in the "*black box*" mind proper – a simple loop that yields primal hedonic perception and approach/avoid behavior. I'm suggesting that this simple circuitry reflects the core "molecular universals" of approach and avoid behaviors conserved in a wide range of species (O'Connell & Hofmann, 2010). It is also likely the source of the generally accepted taxonomy of "primary process affects" in emotion theory: *sensory* affects, *bodily homeostatic* affects, and *brain emotional affects* (Panksepp, 2008) – those that loosely capture the three tiers of information encoded in human emotional perceptions.

With that said, the general mechanism works like this: A chemical in the external environment binds to a receptor protein complex on the bug's outer membrane, activating a signal transduction cascade inside the cell that leads to both a short term change in the organism's behavior, and a long-term adaptation of the receptor mechanism itself (Fain, 2003). Each of these changes is driven by the feedback arrangement (depicted in Figure 4), and via their coupling to one another, they typify the circular causality wherein the faster dynamics serve as the bottom-up signals triggering the slower, top-down corrective response. In short, the system utilizes three levels of the thermostatic stimulus-response switching, each facilitated by the feedback coupling.

Specifically, in E. coli, the short-term behavioral response is the switching between a *counterclockwise* (CCW) or *clockwise* (CW) rotation of a given flagellum – one of the four to eight tail-like protein appendages embedded in the cell wall – that allows swimming *toward* or *away* from beneficial or harmful chemical gradients, temperature changes, or other relevant environmental conditions. (With the CCW motion, all the flagella rope together propelling the organism forward, but a switch in any one flagellum to the CW mode, flails them apart causing an abrupt halt and a "tumble" off in another direction.)

From On/Off to Stop/Go.

This basic stop and go behavior is accomplished by a circuit of many positive and negative loops mediating interactions between five receptor proteins (i.e. Trg, sensing ribose and galactose; Tar sensing aspartate; Tsr, serine; Tap, peptides; and Aer, which senses O2) and the protein products of six key genes (CheW, CheA, CheY, CheZ, CheR, CheB). These receptor proteins (numbering in the tens of thousands) cooperatively cluster together in the cellular membrane by a process of stochastic self-assembly (Sourjik, 2004; Park-et-Crane, 2006; Zhang, Khursigara, Hartnell, & Subramaniam, 2007; Greenfield, McEvoy, Shroff, Crooks, Wingreen, Betzig, & Liphardt, 2009), such that they serve as an "information processing organelle" (Baker, Wolanin, & Stock, 2005), likened to a "nose" (Parkinson & Blair, 1993). What is instructive about the "brane", however, is that this nose-like receptor organ spans the depth of the membrane such that it is structurally exposed to both the external and internal environments, it has both *heads* outside and *tails* inside – a general structural feature of most if not all cells that facilitates the feedback comparison and the internal effector response. (Indeed, the transmembrane receptor complexes themselves are the *structural homologues* of Ashby's homeostat, and serve as even more elegant functional analogs! For in physics, chemistry, and evolution, top-down function follows from primary bottom-up form.)

These transmembrane receptor complexes (assisted by adaptor protein CheW and histodine kinase CheA) detect the change in chemical gradients – the environmental stimulus – and regulate behavior accordingly via integral feedback control (Yi, Huang, Simon, & Doyle, 2000). As in Figure 4, they constantly *monitor* the environment, *comparing* the relative concentrations at time one with those at time two (your classic negative feedback homeostat motif), with the increase or decrease in bound receptors serving as a positive feedback *signal* informing the cell that a significant deviation from stable set-points (negative feedback limiter) has occurred. (As the core sensory organ, the outside "heads" of the receptor complexes deliver the "sense signals" (Powers, 1973), and subsequent alterations of the inside "tails" serve as Haugeland's (1991) first criteria for an internal representation - the direct detectors of relevant environmental stimulus that may not always be present.

For from there, a coupled positive feedback exchange between CheA and phophatase CheZ takes place *inside* the cell, which adds or removes phosphorous (respectively) to and from second messenger CheY, which directly initiates the *regulatory* (negative feedback) *motor response*, the switching between CCW and CW flagellum rotational modes that controls the bugs behavior. (This second messenger protein, serves as Haugeland's (1991) second criteria for mindful representation, the "something else" that stands in for the missing stimulus, yet still mediates the stop and go behavior. In the Powers (1973) model, this is an internal extension of the sense signal (and perhaps the simplest example of the evermore complex signal transduction cascades observable in more complex organisms, those that include neurotransmitters and hormones in humans.)

From Stop/Go to Yes/No.

So far, however, this is only half of the story. For these are the bottom-up fast time, activating, dynamics, wherein the binding and unbinding of receptor proteins triggers the *on/off* phosphorylation or dephosphorylation of CheY, which then drives the immediate *stop/go* switching between behavioral regimes. These are the dynamics (driven by the feedback coupling depicted in Figure 4) that operate on timescales of *milliseconds*, with the amplifying (+) signal triggering a (–) reversal switching to the "OFF" (or, in this case, "Stop") mode. Likewise, a decrease (–) in the phosphorylation signal triggers an increase (+), wherein the reversing (negative feedback) response switches to the "ON" (or "Go") mode (See Figure 4, as a picture is indeed worth a thousand words). Do note that these dynamics are regulatory (negative feedback) responses; they are keeping the system within the specific thresholds, preserving the system within its existing conditions. (This is the level where the, homeostatic negative-feedback-only control models still ring true.)

The other half of this regulatory circuit *follows the same feedback pattern*, but unfolds over a longer timescale (minutes), yielding the slower, top-down, deactivating dynamic that gives rise to *adaptation* in the bug's sensory system – a brief, but functional, *"memory"* (Koshland Jr. 1981; Baker, Wolanin, & Stock, 2005). This is a change that increases the range of sensitivity by altering the *sensory mechanism itself*, offering the bacterium a broadened bandwidth of information for subsequent encounters, adding a *feed-forward* step in the cycle (Lagomarsino, Bassetti, & Isambert, 2007).

This is where the rubber meets the road in our new story. For it is this adaptive response that takes the logic of *on/off* switching and *stop/go* behavior to the *yes/no evaluation* that underlies *the feel good/feel bad* hedonic valence of emotion. (As we will see, this feed-forward step is also a missing yet necessary piece for any control model that posits anticipatory or purposeful goal states.)

To continue, this slower top-down adaptation process informs the system of the *rate of change* in the original stimulus, and results in an alteration of the *sensory receptor complex itself*. This occurs through *methylation* of specific units of the receptor complex – the inside "tails" – by a reciprocal on-off relationship between the remaining two proteins: CheR (a methyl transferase that adds a methyl group) to the tail and CheB (a methyl esterase that removes it). This pattern is virtually identical to and directly linked with the faster phosphorylation switching for stop/go behavior (as depicted in Figure 4 at right) and thus provides a record of the specific responses to environmental changes. (Indeed, as phosphorylation of Ch A increases, the methylation activity of Che B correspondingly decreases.)

However, unlike the faster dynamics, this adaptive homeostatic (negative feedback) response occurs *after* existing sensory *thresholds have been breached* (or saturation has occurred), settling the system into a *new normal* rather than simply returning to the original set point. Hence, this modulation-by-methylation allows the system to reset its equilibrium to zero, even while the chemoeffectors are still present, but at a new *higher or lower* equilibrium point – altering receptor sensitivity and adding overall complexity to the system. (This threshold shift can be envisioned by imagining the starting point on Figure 4 at right to have begun either above or below the existing threshold, rather than within as depicted, where the "On" or "Off" response settles the system into a relatively upward or downward new normal. It will also be elaborated upon and depicted soon in Figure 7.) In terms of function, as one molecular biologist put it, this allows the bug to tune the "volume" of its sensory system up or down (Bray, 2009); or as Powers (1978) put it, how the feedback process "controls perception".

In sum, the reciprocal feedback relationship between the phosphorylation and the methylation signaling pathways yield the common circular causality between dolls in our fractal nested set, with its temporal pattern of *fast activation* and *slow deactivation* delivering the best "noise attenuation" (Wang, Zin, & Nie, 2010), bringing us full circle to the vertical tunability that synchronizes cells in multi-cellular organisms. Indeed, this methylation-adaptation process is the *key "stimulus-response" relationship in our new story,* as its corrective action kicks in with threshold-breaching, globally significant stimulus – whenever novel, intense, and deeply "self-relevant" changes are underway.

The Tit-for-Tat Self-Regulatory Code

Best of all, it comes freighted with its own *evaluative logic*. The positive feedback increases or decreases in methylation of the protein receptor complex (the chemical marks on the inside tails) offer an exact reflection of the *stop and go behavior* and its direct correlation with the *harmful or beneficial environmental conditions*. They provide a faithful signal of how previous behavior said "yes" to certain environmental conditions and "no" to others. (They provide Haugeland's (1991) third criterion for a mindful internal representation, a more general representational scheme – a code that can reflect a variety of related stimuli.)

Indeed, the upward going (positive, +) stimulus represents "goodies" that promote metabolic flow and developmental growth, while the downward (negative, –) decreases, signal "baddies" that could threaten structural stability. Together they offer the bacterium a single – yet binary – *evaluative symbol,* one that represents everything of life-giving importance from the presence of food and toxins, to temperature shifts (Salman, & Libchaber, 2007), changes in oxygen levels or ph balance (Rebbapragada –et–Taylor, 1997; Bibikov, Biran, Rudd, & Parkinson, 1997), to the constant energy flux and flows of electromagnetic fields on nanoscales in space and time (Bourret, & Stock, 2002) – which inform the digital approach/avoid behaviors of chemotaxis, thermotaxis, aerotaxis, osmotaxis, and phototaxis, respectively (Baker, Wolanin, & Stock, 2005). In fact, given its origins in electromagnetic forces and thermodynamic laws, it offers a general searching and learning strategy dubbed "infotaxis" for balancing the needs to explore and exploit the immediate environment, a way of zeroing in on information that "accumulates as entropy decreases" (Vergassola, Villermaux, & Shraiman, 2007), not unlike a child's game of

Hot Beans ("you are getting warmer, you are getting colder"). In short, the functional effect of this chemical network is that *a formerly neutral on/off switch can be bootstrapped into holding general good/bad –"for me" – evaluative significance*. Although these elegant feedback control networks are based on simple diffusion and stochastic (statistically random) chemical fluctuations, they set the evolutionary stage for genuine self-regulatory sentience to emerge. Indeed, tremendous selective pressure would be placed upon any mutation allowing the organism to *distinguish between these two binary stimuli and respond in ways that help them along*. In fact, such ability is required in any control model of behavior, as it would constitute both the *comparison* process and *perception of the error signal* itself.

Herein lies the logic of what I call the *Tit-for-Tat self-regulatory code* within the hedonic valence of emotion. All that was required at this historical juncture was an *additional positive feedback loop*, one that could serve as a *feed-forward* enhancement of the existing signaling pathway, one that allowed a *choice-making switch between the yes/no options*, *before* the negative feedback rebalancing had occurred. In fact, this is the missing link required to bridge the gulf to self-regulatory (goal seeking) behavior in humans, as well as the conceptual heart of genuine "cognitive" perception.

Indeed, a feed-forward control process can act in *anticipation* of stimulus conditions (Shudo, Haccou, & Iwasa, 2003), drawing upon the on-line memory embodied in the ebb and flow of sensory adaptation. This flexible choice-making response would indeed facilitate the optimal sorts of changes that have happened in the past, and could readily be accomplished by a binary switch between the *positive or negative feedback responses* themselves. I am suggesting that something like this must have occurred, giving rise to the binary computational algorithm inherent within the feedback comparator: a straightforward *if-then logical rule* within the self-regulatory sense. Elegant in its simplicity, the rule states: **If positive (+) then positive (+), if negative (–) then negative (–).** In other words, for a positive stimulus signal (more and more), perform a positive feedback (more and more amplifying) response. For a negative stimulus signal (less and less), perform a negative, stabilizing response that reverses the present trend (See Figure 5).

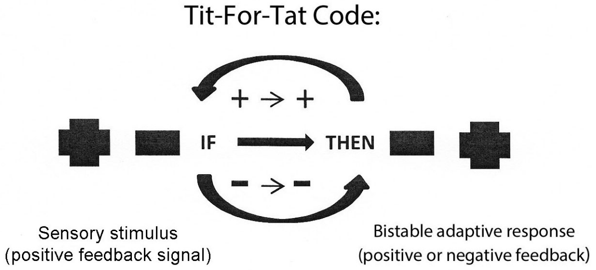

Figure 5: The Tit-For-Tat self- code

Following this simple tit-for-tat self-regulatory logic allows the organism to approach, facilitate, and otherwise *increase* the in-forming conditions that are life-promoting, and to avoid, prevent or otherwise *decrease* harmful, entropic changes. Likewise, with the automatic nature of the adaptive process, this simple code provides the classical semantic symbols, the innately reinforcing – rewarding or punishing – "unconditioned" Pavlovian responses that undergird both classical and operant conditioned learning. Indeed, the fundamental hedonic perception provides the elusive "basement language" that philosophers have long sought, reliable knowledge about the external world rooted in primal sensory experience (Kauffman, 2012). In short, the self-regulatory code unites the stimulus-response phenomena noted within the behaviorist tradition with the cybernetic control models of human behavior. As depicted in Figure 6, the self-regulatory code elucidates the inner workings of the black box (what goes on between the input stimulus and output response); clarifying the relationship between Powers' (1973) "sense", "reference" and "error" signals; and bridging cleanly to Carver & Scheier's (1990, 2011) origins of affect. However, it offers the more intuitive self-relevant logic of hedonism, wherein negative feedback is associated with pain and avoidant behavior rather than with pleasure and approach. In our little E. coli, however, it matters not whether any subjective experience of the positive feedback signal is present, for the adaptation – has already had an important self-regulatory effect (Koshland Jr., 1977). The adaptation has shifted the system to a *higher* or a *lower* equilibrium point (the new normal), rather than returning it to the formerly favorable state, and in perfect accordance with the harmful or beneficial environmental stimulus. In doing so, it has accomplished either an *optimizing, developmental, adaptation* – saying "yes" to beneficial changes – or a *self-preservationary intervention*, saying "no" to potentially self-destructive harms.

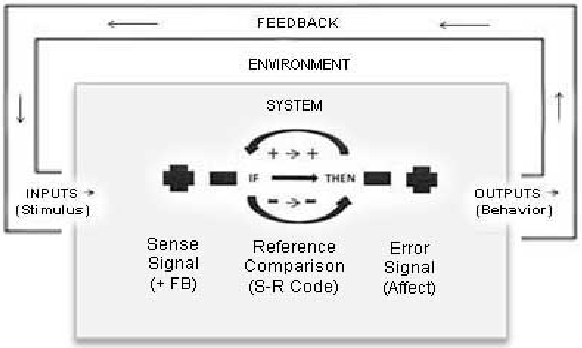

Figure 6: The self-regulatory code in the black control box

Depicted, for example, at left in Figure 7, is essentially the "on/off" response process shown previously (at right in Figure 4), and at right in Figure 7, is that *same response* but one *following a breach of either threshold* yielding the "yes/no" evaluation. (Herein lies the roots of the hedonic treadmill (Brickman & Campbell, 1971), wherein sensory adaptations to good stuff become internalized such that new levels of stimulus are required to trigger positive self-relevance.) But regardless of any possible perceptual accouterments, in even the very earliest forms of life, these simple chemical regulatory feedback networks have cracked the philosophical door between determinism and compatible free will, between hardwired logos and softwired telos, ushering behavioral agency with a few degrees of freedom – allowing the organism an active role in the evolutionary process.

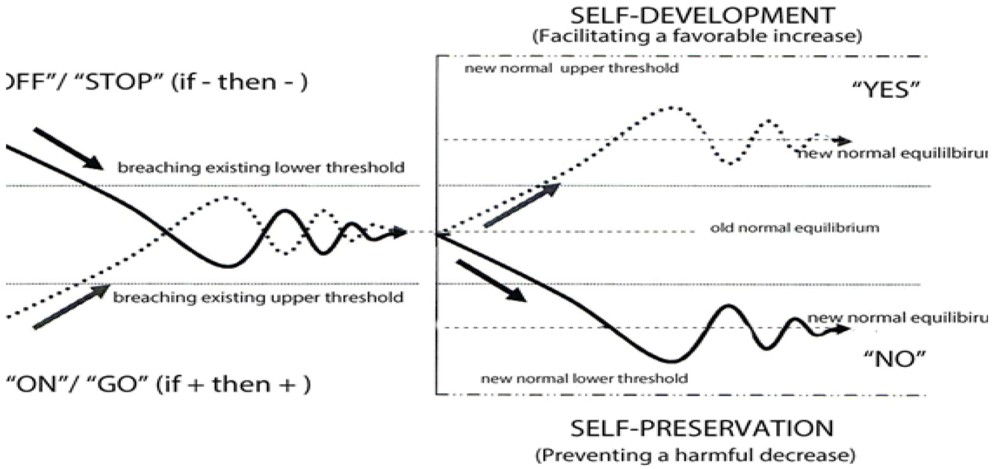

Figure 7: How the Tit-For-Tat code serves dual self-regulatory "purposes":
Self- Development & Self-Preservation

Individual and Social Aspects of Self

In fact, and perhaps even more philosophically intriguing, this simple self-regulatory system also sets the stage to define *individual* and *social* aspects of the self-system. While the cellular membrane initially demarks self from the not-self environment, this simple yes-no rule can also be pressed into service to identify genetically similar and different bacterial species – in perhaps the earliest forms of cooperative communalism and competitive tribalism. For example, the phenomenon of "quorum sensing" where on/off switching between behavioral modes depends upon the concentration of *other citizens* within a specific bacterial species (Bassler, 1999).

Indeed, in addition to pre-existing environmental stimuli, quorum sensing bacteria produce and release self-identifying *autoinducers*, chemical signal molecules that then rise and fall with the local cell-population density. They are used for *communication*, allowing individuals to synchronize particular behaviors so they can function as multi-cellular organisms, marshaling cooperative chemical defenses – or virulent attacks – against other species (Waters & Bassler, 2005.) Likewise, these either/or (me or we, us or them) signals, can be coupled to other sensory stimuli like heat or cold to guide more complex autonomous or communal behavior. For example, an individual E. coli bacterium will normally thermotax toward warm environments where growth conditions are optimal. But should the population become overly dense and therefore resources strained, loner – self-preservationary – mode will kick in and the bug will move toward cooler locations (Salman, & Libchaber, 2007) to "chill out" until conditions for growth improve (Bray, 2009).

The bottom line is that a core, physical, sense of *identity* – both personal and social – is already apparent in the lowly bacterium, founded upon simple protein networks and their integral feedback dynamics. Hence, this first form of self-regulatory sentience also cracks the philosophical door to phenomenal *being* (and *becoming*) in time and space as well as *doing* behavior. In fact, with its lovely combination of self-reflexive dialectic cycles, binary computations, evaluative – qualitative – digital signaling, and its fully-determined-yet-partially- free stimulus-response behavior, the concept of self-regulatory feedback can indeed bridge the gap between conflicting accounts of the origins of "mindful" consciousness (Blackmore, 2006; Thompson, 2007).

Nonetheless, first and foremost, I am suggesting that these ancient self-regulatory mechanisms have been honed by natural selection to yield the chemical – hard-wired (*genetic*) – distinction between self and not-self utilized by the immune system, as well as the chemical language of the endocrine system (van Honk & Schutter, 2005), and to subserve the neuropeptides involved in neural communication in both enteric (Benarroch, 2007) and central nervous systems – those deemed the "molecules of emotion" (Pert, 1998). In fact, they provide the informational "language" (Pagel, 2008) that allows optimal cellular differentiation and space/time migration of the *right* types of cells to the *right* places at the *right* times throughout embryonic development. But in addition to this physiological legacy, in humans, the ongoing development and empathic expansion of one's mindful, social, and cultural sense of identity (Adams & Marshall, 1996; Bosma & Kunnen, 2001) is also crucial to an optimal developmental trajectory, and key to decoding the *universal moral messages* offered by our emotional sensory perceptions.

Purpose in Evolution?

This brings us to the fundamentally significant binary dichotomy I hinted at previously, that which lies at the most primordial core of nature's *value system.* This is the prime self-regulatory directive that has been conserved, kept intact throughout our evolutionary history; the one that allows organisms to actively participate in natural selection; and the one that provides the evaluative meaning within the hedonic valance of emotion.

As already depicted in Figure 7, the yes/no binary evaluations mediate dual *teleological goal states* – ***purposes***, if you will: Those of ***self-development***, the core evaluative appraisal for categorically pleasurable "positive" emotions, and ***self-preservation***, for the painful or "negative" category. These are the binary functional outcomes of the ancient self-regulatory process, those that make hedonic behavior "optimal" or "right" in the moral sense of the word – and those that make emotion central to morality. Indeed, they provide the evaluative universal substrate for any rules to guide consistently "right" behavior.

While I will address the moral implications in a moment, I'll emphasize here that these are *two right and good*, perhaps *non-negotiable* requirements for life itself inherent within the most primordial regulatory processes. These are the underlying goals states, the teleological purposes, glimpsed by the early cyberneticists; later described by pioneering systems psychologists as *preparatory* (preserving the original set point) and *participatory* adaptation to the new (Pribram & Melges, 1969); and are now described as the dual regulatory "focuses" within complex human self-regulation (Scholer & Higgins, 2011). These binary purposes are also what complexity scientist's might call self-organizing "attractors" on "fitness landscapes" (Kauffman, 1993), those that keep creatures poised between chaotic change and rigid stability; and those that are reflected in the digital "growth or protection" programs of cells (Lipton, 1998b, 1999). Best of all, these dual purposes provide a direct biophysical tether between *subjectively good and bad perceptions* and *objectively right and wrong states of living-giving balance.*

This is how acknowledging bottom-up self-regulatory sensory feedback can fill a sizable gap in evolutionary theory – for these dual purposes are simply mirror reflections of the top-down criteria for natural selection: *adaptation* and *survival* (Pollak, 2008). Yet, until recently, these behavioral adaptations were considered irrelevant, and the role of the cell membrane in genetic control had been completely overshadowed by the idea that the nucleus alone – the DNA – called all the shots. In fact, upon the mapping of the genome, the subsequent revelations about *epigenetic* control processes have forever altered the central dogma by elucidating the crucial role of environmental cues, intrinsic signals, and cellular memory in evolution (Jablonka & Lamb, 1998; Jablonka & Lamb, 2005; Jaenisch & Bird, 2003; Levenson & Sweatt, 2005; Jablonka & Raz, 2009). Revelations of how supposedly "junk DNA" and noncoding RNA are actually providing ongoing regulatory switching (Mattick, 2004; Mattick & Mukunin, 2006); with relational if-then rules of engagement that ensure specific gene products are brought into action when and only when appropriate (Baverstock & Ronkko, 2008), and mediating the very developmental morphology of an organism (Newman & Muller, 2000) as well as its behavior. Revelations of how epigenetic switching yields critical modifications during cellular stress responses (Ansel, Lee, & Rao, 2003; Cole, 2009, 2010; Harris & Levine, 2005; Chan, et al., 2010), plays a key role in immune functioning (Fitzpatrick & Wilson, 2003) and serves as modulators of neuronal responses (Khudayberdiev, Fiore, Schratt, 2009) and neuroplasticity (Kemperman, Gast, & Gage, 2002; D'sa & Duman, 2002; Draganski, Gaser, Busch, Schuierer, Bogdahn, & May, 2004; McClung & Nestler, 2008). Revelations of how our old friend the methylation marking process, sets down tracks on the histone cores of DNA, yielding heritable memory systems in non-germline cellular replication (Regev, Lamb, & Jablonka 1998); marks which may even be bidirectional ("poised") switches themselves (Hodges, et al., 2011; Herb, et al, 2010); discoveries that help explain the mysterious phenotypic variations between monozygotic twins (Fraga, et al., 2005) and highlight the importance of individual differences in behavior, cognition, physiology (Zhang & Meaney, 2010) – and emotionality (Holmes, Guisquet, Vogel, Millstein, Leman, & Belzung, 2005; Worthman, 2009).

In sum, the discovery of epigenetic regulatory mechanisms is expanding and reframing the reactive "selfish gene" scenario (Dawkins, 1989), to a more Lamarckian proactive, fluid, and *self-regulating genome*, now recognized to be in constant cyclic interaction with the immediate environment, and adaptively switching specific genes on or off in response to ever-changing ecological circumstances. (Of course, these include *social* environments and the relational components of self-regulation, as evidenced in such emerging fields as "social genomics" (Cole, 2009), "stress genomics" (Cole, 2010) and "social neuroscience" (Norman, Hawkley, Cole, Berntson, & Cacioppo, 2012). Acknowledging these bottom-up dynamics honors the generative, developmental, symbiotic and cooperative underpinnings within and between living systems and partially deflates the purely competitive, random, blind, meaningless, and glacially slow depiction of evolution. Indeed, as Charles Darwin himself once suggested (in a letter to Nathaniel Wallich, 1881), selection might be 'the consequence of a much more general law of nature' (Eigen, 1993) – to which I would add: That of the *binary computational laws* of *self-regulatory feedback*.

From Branes to Brains and the Modern Feedback Cycle

These new micro-biological lenses can liberate social scientists from limited evolutionary narratives that look only to conditions of the ancient ancestral environment to elucidate the genetic components of adaptive behavior. Indeed, the "iterated systems" and "algorithms that govern emotional states" in the here-and-now are anything but "irrelevant" (Tooby & Cosmides, 1990). They serve as the very self-regulatory core of adaptation itself. In fact, the original molecular sensory organs of the emotional sense (receptor clusters on cellular membranes) remain hard at work regulating each cell of every specialization within its immediate intracellular environment. While the second messengers – and third, and fourth… from phosphates and kinases to neuropeptides and hormones – have become ever-more complex, their original binary computational processes generate the electrical, chemical, and cellular "rhythms" (Goldbeter, 2002) – the cyclic feedback at every level of scale that delivers self-regulatory "coherence" (McCraty, Atkinson, Tomasino & Bradley, 2009). Examples include the *G-protein-coupled receptors* (the largest family of proteins in the human genome (Hanson & Stevens, 2009) that mediate responses to hormones and neurotransmitters as well as facilitate vision, olphaction, and taste (Rosenbaum, Rasmussen & Kobilka 2009); *the IP3 receptor* (Inositol Thriphosphate receptor) a calcium release channel that switches between open and closed conformations, generating calcium oscillations that in turn regulate periodic hormone secretions (Dal Santo, Logan, Chisholm & Jorgensen, 1999); the β_{2}-*adrenergic receptor* that regulates cardiovascular and pulmonary function (Rosenbaum et al, 2007); the *Syk* family of *kinase*s that turn immunoreceptors on or off, and the *Src kinases* that can "turn up or turn down immune cell signaling responses" (Lowell, 2004); and T cell antigen receptor complexes that tune immune responses to match the level of the threat (Guy, et al 2013) – in the classic homeostatic arrangement.

Nonetheless, the 'sensory organ' of emotion now has many additional structural components, from the original membrane receptors and networks of molecules to specialized nodes and networks of neurons (sensory, motor, excitatory, inhibitory, interneurons, etc.), and the topological architecture of the human brain.

Dendritic Computations via Feedback

Moreover, the feedback arrangement, with its fractal self-similarity, computational logos and three step cycle (compare, signal, self-correct) is also readily apparent in the structure and function of *individual neurons* as well (Poirazi & Bartlett, 2001; Häusser & Bartlett, 2003). Indeed, the *dendritic spines* of pyramidal nerve cells have been discovered to serve as *computational building blocks* that are fundamental to synaptic plasticity – a discovery with "revolutionary implications for neuroscience" (Barlow, 1996). For contrary to Cajal's (1911) original notion that action potentials only flow one way (dendrites to soma to axons), it has become clear that they also "backpropagate" in the reverse direction (soma to dendrites), such that feedback processes are now evident within and between the myriad branches of the dendritic tree and the cell body within a single neuron (Koch & Segev, 2000). In short, the dendrites are not simply passive receivers or transmitters of incoming information, they are providing active computational services – the fast time dynamics that serve as local bottom-up inputs that trigger slower top-down global action potentials.

These formerly unacknowledged dendritic computations allow the neuron to sum up synaptic inputs, "compare" that sum against a threshold, and "decide" whether to initiate an action potential, to "operate as a device where analog computations are at some decision point transformed into a digital output signal" (London & Häusser, 2005). We see yet again the ubiquitous binary logos, the pattern of yes/no increases and decreases in synaptic weights to positive and negative exemplars (Poirazi, & Mel, 2001); in long term potentiation and damping (Linden, 1999), and in the reciprocally local and global computations. Furthermore, the intriguing fact that dendritic spines are suspiciously homologous in size, structure, and chemosensory function to bacteria – a possible ancient symbiont a la mitochondria – has not gone unnoticed (Bray, 1995).

In fact, in the 1990's neurobiologists discovered discrete structures on neural membranes known as "microdomains", little rafts that perform computations and regulate ion-channel dynamics – if not the action potential itself (Wallace, 2007). These microdomains self-assemble in clusters with haunting similarity to the nose-like membrane receptor clusters on the E. coli, and play a significant role in the assembly of other receptor proteins as well. (Enriched in cholesterol and sphingomyelin, microdomains are likened to larger, fancier 'heads' on the topside of the membrane, those that allow the neuron to function as a *series of switches*, rather than just one.) Whether evolutionarily homologous or not, however, the circular causality and self-similar fractal pattern of signaling are unmistakable, with dendrites to neurons, neurons to neural networks, and neural networks to sensory perceptions analogous to our set of Russian Nesting dolls, each making unique contributions to the ongoing interactive computational process.

The Three Functional Loops in the Tri-level Brain

Even without the added discoveries of microdomains and dendritic computation, even the more conservative ("cognitive") neuroscientists have identified both the top-down (efferent) and bottom-up (afferent) neuroanatomical pathways of emotional sensory perception; converging in the limbic sensorimotor cortices, and complete with frontal-lobe hemispheric lateralization of positive and negative affect in approach and avoid behavior, respectively (Craig, 2008). Even those disputing the natural kind view of emotion (Barrett, 2006), acknowledge that affect is synonymous with somatosensory perception of both external stimulus and internal responses (Barrett, Bliss-Moreau, Duncan, Rauch, & Wright, 2007). And perhaps even the most neurocentric explanations of emotional experience can soften in light of the fact that the very development of nerve cells, particularly *interneurons* of the prelimbic cortices – a hallmark of complex brains of every variety – is contingent upon optimal immune signaling in response to distress and early deprivation (Brenhouse & Anderson, 2011).

Indeed, since this ancient regulatory pattern is so fundamental, the three main steps in the feedback cycle are reflected in globally complex nested loops of the triune brain, each integrating particular emotion and appraisal processes (Lewis, 2005). These include a "*motivated monitoring loop*" (linking the dorso-lateral prefrontal cortex (DLPFC), the anterior cingulate cortex (ACC), hippocampus (HPC), amygdala (AM), orbitofrontal cortex (OFC) and the brain stem/basal forebrain (BS/BFB); the "*motivated object evaluation loop*" (linking the OFC, AM, and BS/BFB with the sensory cortices); and the "*motivated action loop*" (between the OFC, AM, nucleus accumbens (NAS), ventral pallidum (VP), the ventral tegmental area (VTA) and the thalamus; where, respectively, the ongoing *comparisons, signaling* and the *corrective actions* occur.

In fact, if defining an emotional "sensory organ" in terms of neural structures, the *amygdala* is present in all three loops (Hamann, Ely, Hoffman, & Kilts, 2002; Heberlein & Adolphs, 2004; Heberlein & Atkinson, 2009; Oya, Kawasaki, Howard, & Adolphs, 2002; Ruby & Decety, 2004), and is instrumental in signaling the novelty (Schwartz et al, 2003) and uncertainty (Bornhövd et al, al, 2002) of self-relevant (LeDoux, 1989) environmental stimulus. Likewise, would be the ACC, "the receptive organ of the experience of emotion" (Papez, 1937), with special clusters of P-type (positive) and N-type (negative) neurons in the primate pregenual (pACC) that are respectively "sensitive to positive and negative motivational states" (Kennerly, 2012). Together, the AM and pACC serve as exact functional analogs to the on/off (occupied 'heads') and yes/no (methylated 'tails') of the sensory receptor clusters in the E. coli bacterium. Of course, as we have seen, the self-regulatory sensory network begins in the 'branes' of all cells, including the skin cells that still bound and contain the human system – hence the classic GSR measure of emotional arousal as well as the emotive component of social touch (Gazzola, et al., 2012).

Likewise, the coupling between positive and negative feedback is evident in the reciprocal, bi-directional, interactions between the right and left hemispheres of the brain (Royet, Plailly, Delon-Martin, Kareken, & Segebarth, 2003), between the brain and heart (McCraty, 2003) and between the sympathetic and parasympathetic branches of the autonomic nervous system. Indeed, the vagal nerve mediates bottom-up emotional sensitivity (high stress "reactivity") as well as top-down emotion regulation (faster recovery), both of which are associated with high vagal tone (Campos, Campos, & Barrett, 1989; Gottman & Katz, 2002; Lewis, Hitchcok, & Sullivan, 2004; Rottenberg, Salomon, Gross, & Gotlib, 2005;

Movius & Allen, 2005). In fact, the polyvagal theory (Porges, 1995), picks up the story of the evolution of emotion, setting forth the phylogenic shift in regulatory mechanisms through three global stages that gave rise to the "primary" emotions of our "social nervous system" (Porges, 2001). As mentioned, Jaak Panksepp (2008) has mapped "the affective brain" across species, and the bottom up emotional regulatory path characterizes the "default mode network" in humans (medial parietal / posterior cingulate, medial prefrontal, lateral inferior parietal and superior temporal cortices), specific to empathy and "social tasks" versus those that manipulate inanimate objects (Jack, et al, 2012).

The Modern Human Feedback Cycle

All told, over our evolutionary history, natural selection has expanded the self-regulatory feedback cycle from its original two-step stimulus response loop to a *five step interactive process* between mind and body and world (See Figure 8). At present, the cycle contains three cognitive *feed-forward* (top-down) add-ons cobbled upon, yet constantly interacting with the ancient (bottom-up) subconscious autopilot system. Loosely, the first three steps can be described as conscious intentional *motives*, volitional *actions,* and perceived *outcomes* – all of which inevitably contain perceptual filters, and cognitive biases (Tversky & Kahneman, 1974; Campbell & Sedikides, 1999; Conlin, O'Donoghue, & Vogelsang, 2005) unique to one's individual socio-cultural developmental history. Fortunately, they are kept in check by steps four and five, the original yes/no *evaluative perception* and the approach/avoid *behavioral correction* from whence they emerged. This general five step temporal sequence was aptly captured in James Gross' (2001) process model of emotion regulation, with his "antecedent focused" coping capturing the first three feed-forward steps of the modern cycle, and his "response focused" regulation capturing the last two – the original here and now body-in-world sensory-motor feedback loop.

However, I would emphasize the crucial link between steps *three* and *four,* wherein the salient self-relevant *comparison* now takes place – a vital comparison between how the mind *perceives* an unfolding event against the body's *actual* outcome. This might well be accomplished by Lewis' (2005) "motivated monitoring loop", which then triggers the *primordial affective feedback signal* in order to *keep things biophysically real* – hence, my call to rethink the value of suppressive forms of emotion regulation. Indeed, in this new view, our binary feel-good/feel-bad hedonic feelings remain the conscious mind's *only* valid informational tether to the biophysically right/wrong conditions required for life itself, and an innate safeguard against its more volitional – yet potentially dishonest (Greene & Paxton, 2009) – rationalizations and hypocrisies (Valdesolo & DeSteno, 2008). Instantly, they offer both a reality check and a behavioral fix – concordant with the ancient self-regulatory imperatives. Their elegant stimulus-response mechanics moves us to actively avoid self-destruction and create evolutionary self-development, and their simple tit-for-tat logic constantly reminds us of these dual universal purposes.

Moreover, suppression does not work. Suppressive emotion regulation actually increases bottom-up activation of the error signal (McRae, Ochsner, & Gross, 2011). Likewise, whether or not the informational component of the emotional message is deliberatively and rationally factored into the cognitive schemata (building conscious, reasoned motives), the coupled corrective response will simply forge them into the mindscape via Pavlovian conditioning (perhaps through Lewis' "motivated action loop"), yielding the subconscious variety of motives propounded by Freud – those instinctive libidinous drivers that run roughshod over our higher rational intentions.

The key point is that this five-step cycle depicts a fundamental *temporal* sequence that is prerequisite for the many facets of the self-regulatory emotional elephant to come into view. It conceptually reunites "the self" as a functional whole, bridging the gap left by the Cartesian severance of mind from body and the many illusory divides, judgments and assumptions that would follow. Particularly those that privileged reason over emotion, and conscious and intentional processes over intuitive, embodied cognitions and "naïve" sensory perceptions. Indeed, the sensory feedback model resolves many time honored controversies in emotion theory: Reconciling William James' original insights about the bottom-up causal components with Cannon's top down; Lazarus' subsequent emphasis on cognitive appraisal despite Zajonc's primacy of affect. It unites the dimensional (Barrett & Russell, 1999) with the discrete models of emotion, and the feedback dynamics offers the bridging rules (Nagel, 1961) that reconcile the materialist, behaviorist, identity and functional approaches to subjective emotional experience (Barrett, Mesquita, Ochsner, & Gross, 2007). It honors Joseph LeDoux's (1989) distinction between cognitive computations and affective – *self-relevant* – computations, and his low road/high road dual but interactive emotional processing paths in the brain, those that validate Bernard Weiner's (1985) "attributional" linking of motivation and emotion.

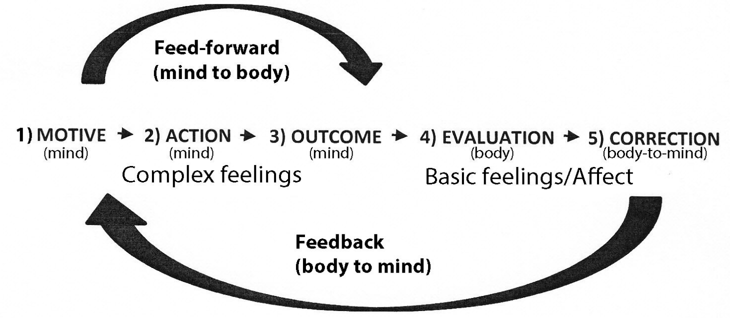

Figure 8: Modern feedback cycle with feed-forward cognitive elaborations and complex feelings

Perhaps most importantly, it elucidates how core affect (Russell, 2003), basic emotions (Ekman, 1993), and complex (socially constructed) feeling perceptions (Harré & Parrott, 1996) all dovetail together in exquisite functional elegance of within the modern day emotional sensory system (as previously depicted in Figure 2).

Decoding Human Emotional Messages

In this section I will set forth more detail about the three levels of information encoded in emotional perceptions, how they unite the various components of the self, and how they relate to the temporal sequence of the modern-day five step feedback cycle (depicted in Figure 8). Doing so will clarify muddy linguistic conventions with more precise terminology.

Hedonic Valence (Affective Evaluation)

The first of which concerns the term *affect*, which I will henceforth subsume within, after distinguishing from, the *hedonic valence of emotion*. Indeed, in the literature, "affect" concerns only valence and arousal intensity (Barrett & Russell, 1999) and omits the motivational behavioral dimension. The key insight of this model, of course, is that the binary valence is *born* of behavioral regulation and rooted in positive and negative feedback processes. In fact, the evaluative message it bears is not only meaningful for optimal self-regulation (maintaining "emotional equilibrium" (Stechler, 2003) and "regulatory fit" (Scholer & Higgins, 2011), but one fundamental to the process of evolution itself. The valance provides subjectively positive or negative "qualia" as an informational lynchpin between an organism's biophysical well-being and the criteria of natural selection. In short, valence speaks of natural – universal and nonnegotiable - *values.*

Indeed, in terms of epigenetics and immune functioning, core affect relies upon the ancient evaluative yes-no logic of cellular signaling, synthesizing the myriad voices of the cells, organs, and organ systems, into the symphonic "interoceptive" (Craig, 2008) wisdom of the entire organism. From the human perspective, the bottom-up primary evaluation encoded within affect (Zajonc, 1984) is the perceptual error signal, directing attention toward self-relevant events and placing them in the context of the dual self-regulatory purposes, with "goodies" signaling opportunities for adaptive self-development and "baddies" for corrective self-preservation. While this deeper relational and functional significance of pleasure and pain has gone largely unrecognized, natural selection has conserved the original hedonic stimulus-response pairing, and forged the basic emotions and their complex blends and shades upon their ever-present base.

As such, affect – with its ancient dialectic dynamic – remains hard at work providing immediate *feedback* about the state of the *body in present time and space*, the original right-here-right-now signaling of good or bad events as they are unfolding, the somatic (Damasio, 1991) and visceral (Panksepp, 2008) perceptions, "attentional attitudes" (Frijda, 2008), and "gut feelings" (Katkin, Wiens, & Öhman, 2001). These are also the time-urgent "hot nodes" of emotional perception (Bower & Cohen, 1982; Mischel & Ayduck, 2011), those that signal the dissonance long thought to be "cognitive" (Egan, Santos, & Bloom, 2007).

Likewise, whether or not we are aware of any sensations of pleasure and pain, primal affect also delivers the subconscious, automatic, aspects of emotional perception, regulating purposeful approach/avoid behavior even if the mind remains out of the loop. This includes, of course, all the nonconscious aspects of motivation and self-regulation: implicit volition (Moskowitz, Li, & Kirk, 2004), implicit intention (Wood, Quinn, & Kashy, 2002) or automated will (Bargh, Gollwitzer, Chai, Barndollar, & Troetschel, 2001). Hence, the ubiquity, primacy, immediacy, and classical conditioning power of affect (Olson & Fazio, 2001; Panksepp, 2005), and such mysterious manifestations as the "present bias preferences" (O'Donoghue & Rabin, 1999), the anchoring and availability heuristics (Teversky & Kahneman, 1974), the projection bias (Conlin, O'Donoghue, & Vogelsang, 2007); the confirmatory bias, (Rabin, 1998), and a host of other "wild" Akerlof (2001), "irrational" (Aumann & Sorin 1989; Cohen & Blum, 2002), influences that have long bedeviled the rationalist model of economic decision making (Camerer, 2005; Sent, 2004). Of course, they also reflect the ancient embodied wisdom, and manifest as the automatic, subconscious aspects of decision making that are intuitively advantageous (Bechara, Damasio, Tranel, & Damasio, 1997) – for they faithfully reflect the ancient self-regulatory code.

Basic Emotions

Likewise, the "natural kinds" (Izard, 2007) basic or primary (Izard, 1977; Plutchik, 1984; Eckman, 1993; Clark, 2010) emotions also deliver in-the-moment, bottom-up, *feedback signals* with universal symbolic meanings – yet with an added layer of specificity within their common *appraisal themes* (Arnold, 1945; Scherer, Schorr, & Johnstone, 2001). Here I make an important distinction between the efferent, top-down, *cognitive appraisal* (Lazarus (1984) and the afferent, bottom-up *affective evaluation* (Zajonc,1985), the former involving more complex prefrontal and linguistic processing; yet I emphasize that both serve important functional roles in the emotional system.

While there remains controversy over which emotions are basic (Ortony & Turner, 1990), based upon their temporal (feedback) significance, this model suggests *joy, sadness, disgust, fear* and *anger* to be the best contenders for the mantle of universal self-regulatory perceptions. These basic emotions are relatively more hardwired, unfolding over the first 6 months of infant development (Stenberg, Campos, & Emde, 1983; Lewis, 1993), with their common appraisal themes delivering more specific information (Han, Lerner, & Keltner, 2007) about basic life-giving requirements – "hedonic needs" (Koole, Van Dillen, & Sheppes, 2011) – and how to fulfill them in the immediate environment. The "how to" part is the additional informational component, involving conditioned or conscious cognitive schemata forged through the feedback cycle over time, yet the hedonic requirements and behaviors remain the same.

Indeed, like primary colors, their common appraisal themes carry specific information about innate *physiological* as well as *psychosocial needs* (Maslow, 1970; Deci & Ryan, 2000). ('Needs' in this context reflect any biologically hardwired values or "specialized modes of organismic operation that match evolutionarily recurrent situations" (Tooby & Cosmides, 1990). Although research on needs is scant, this model suggests the "hierarchical" nature of needs relates directly to *the dual self-regulatory purposes,* with the top priority negative emotions (self-preserving: sadness, disgust, fear, and anger) largely honoring the non-negotiable thermodynamic and metabolic needs – with the autonomous agency, the *freedom* and *empowerment* as well as the physical and social *safety* required to fulfill them; and basic joy driving optimal developmental adaptations and fostering novel need-meeting approaches to these same basement needs. In short, basic emotions offer universal meaning in the present moment and under the specific conditions of the immediate environment, information about the health and well-being of the *body* – any body and everybody.

Complex Feelings

In contrast, as secondary blends and shades of the primary emotions, the *complex* feeling perceptions enfold the remembered past and the imagined or expected future, bearing self-regulatory messages about the *mind.* Complex feelings include *trust, mistrust, courage, anxiety, pride, shame, gratitude, contempt, compassion, guilt, admiration, envy, hope, worry, devotion, rage, love, hate, curiosity, honor, faith,* etc., and have a clear developmental trajectory (emerging between ages two and eight (Nunner-Winkler & Sodian, 1988), if not fully complete by age 3 (Lewis, 1993). They largely serve the *self-developmental imperative*, and are goal-relevant to the "higher" human needs – needs for enduring *social bonds*, for *self-esteem*, for *creativity*, and *meaning*. They are the result of many self-constructing (Ford & Lerner, 1992) repetitions through the feedback cycle, the basic themes having been elaborated upon by language, individual learning experiences, self-identifying concepts, and socio-cultural schemata (cognitive structures – knowledge, beliefs, rules, rituals, traditions and in-group norms, obtained from one's foster environment).

With the notable exception of rage (a perfect storm of belief driven blame, positive feedback amplification, and basic anger) the complex emotions are the less time urgent, "cold nodes" of emotion (Bower & Cohen, 1984; Mischel & Ayduk, 2011), yet still carry the ancient hedonic logos within them. Indeed, as depicted in Figure 8, these complex feeling perceptions are the more long-term *feed-forward* causal components of behavior (Bandura & Locke, 2003), reflecting both conscious and habitual motives, judgments, and appraisals that still carry their original emotional valence as "emotion schemas" (Izard, 2007) in attitudes (Edwards, 1990; Cacioppo, Gardner, & Berntson, 1999; DeSteno, Petty, Rucker & Wegener, 2000); moods (Morris & Reilly, 1987; Thayer, Newman & McClain, 1994), and even personality traits (Izard, Libero, Putnam, & Haynes, 1993). In short, the complex feeling perceptions deliver self-regulatory information about the *mind*, feeding forward an ongoing stream of evaluative commentary about its optimal or dysfunctional holdings, habits, and the uses and abuses of the rational intellect.

In sum, the self-regulatory feedback model proposes that there are *three levels of self-regulatory information* encoded within each human feeling perception – information that subserves the self-regulatory purposes of all living systems, as well as a suite of universal human needs, and the individually unique ways of meeting them that evolve over time. The model highlights the ongoing, cyclic, trial and error nature of learning and human development, with the confluence between the three levels coming into focus with the recognition that primordial affect serves as the "error" signals – both good and bad deviations from homodynamic states of balance. Balance within and between body and world, within and between mind and body, and within and between individuals comprising social bodies.

This key insight refines and builds upon the rich tradition of "consistency theories" (Swanson, Rudman, & Greenwald, 2001) wherein some stimulus event creates a deviation from a balanced cognitive state and affect plays a role in signaling or restoring that balance. Some examples include congruity theory (Osgood & Tannenbaum, 1955), cognitive dissonance theory (Festinger, 1957), balance theory (Heider, 1958), psycho-cybernetics (Maltz, 1960), neuropsychological theory (Pribram, 1967), self-discrepancy theory (Higgins, 1987), homeostatic synaptic signaling (Turrigiano, 2007), affect-balance mediation (Sanjuán, 2011), regulatory focus theory (Scholer & Higgins, 2011), the original "logical calculus" in nervous activity (McCullough & Pitts, 1943), and even the "equilibrating" nature of development itself (Piaget, 1952). As mentioned, all such models suggest a sort of *psychological immune system* (Vaillant, 1993; Gilbert, et al 1998) that operates unconsciously, wherein intense hedonic states trigger a variety of processes designed to attenuate them (Gilbert, et al 2003). These range from the homeostatic processes that diminish their physiological impact (Solomon, 1980; Diener, Sandvick, & Larson, 1985) to the defensive processes (i.e. rationalization, self-serving bias, positive delusions, self-deception, etc.) that diminish their *psychological* impact (Freud, 1937; Lazarus & Alfert, 1964; Mazar, Amir, & Ariely, 2008; Vaillant, 1977; Gross, 1998) – in order to "protect the individual from an overdose of gloom" (Gilbert, et al 1998). To which I would add, "gloom" which when misunderstood and left unanswered, can spell "doom" – threatening the very physical integrity of the individual.

Fight, Flight, and 'Right' Responses

Of course, these models emphasize the negative sorts of discrepancies – the painful distress signals, and their urgent "No!–Stop!–Bad-for-me" self-preservationary message. Indeed, bad is stronger than good (Baumeister, Bratslavsky, Finkenauer,, & Vohs, 2001; Larson, 2009), for the ratio of basic emotional feedback signals is skewed nearly *four to one* toward the negative – perhaps the reason why evolutionary theory acknowledged only the self-preservationary imperative, and why psychology has historically emphasized the dysfunctional aspects of the human condition (Seligman, 2002). But through this new lens of emotional sensory perception, this is because nature gifts us with nearly four times as much specific, universal, information about how to *correctively preserve the body in the world.*

For instance, the appraisal themes of the four basic negative emotions – *loss* (sadness), *imminent danger* (fear), *contamination* (disgust), and disempowering *obstacles to agency or social violations* (anger) – move us to either change the immediate environmental circumstances or alter our location, to "fight or take flight". To which I would add: ***to make right,*** a catchall term I offer to categorize any sort of adaptive, creative problem-solving response to emotional distress, born of the *self-developmental* imperative and the *approach* mode of behavior. (My hope is for the phrase "to right, fight, or take flight" to enter the psychological lexicon, in emphasis of the adaptive, cooperative – indeed moral – alternative.)

The Right Response.

Instead of suppression or behavioral avoidance, a Right Response (RR) is one that involves an active, adaptive, rebalancing of the ecologically optimal (biophysically favorable) relational state between the organism and the environment. The RR has been captured in the stress literature as problem-focused coping (Folkman, Lazarus, Gruen, & DeLongis, 1986; Pearlin & Schooler, 1978) or transformational coping (Chen, 2006), as perhaps the most adaptive way of reducing the psychophysiological arousal tension (Haines, & Williams, 1997). This happens in one of two ways: It can involve an active adaptation of the *immediate external environment*, which is essentially creative action or "work", the way we build social and economic capital (DeSteno, 2009) and the way we accomplish cultural evolution.

For example, when *sad,* finding or creating replacements for what has just been lost; when *disgusted,* finding more wholesome comestibles or creating hygienic conditions; when *afraid,* finding protective shelter, connectivity and community; or when *angry* removing the obstacles to one's requisite self-regulatory agency, ensuring balanced interactions, and repairing social connections. Indeed, in terms of interpersonal conflict, all acts of nonverbal and linguistic communication are RRs, reducing basic pain with an outside change without running away or resorting to fisticuffs. In fact, "doing good", helping to resolve the distress of others, is in and of itself a buffer against "feeling bad" (Grant & Sonnentag, 2010).

The second kind of RR is affected to the *internal environment*, the personal mindscape, in conscious knowledge acquisition, in an act of deliberate learning , personal growth, or mindful self-regulation – offering a personally accountable answer to the distress call (oftentimes despite the external circumstances). This internal variety of RR also includes invoking optimal belief structures to reappraise (Lazarus, 1991; McRae, Ochsner, & Gross, 2011) or temporarily endure a challenging or uncontrollable situation; or to bear an injustice or misfortune with relative grace and "resilience" (Seery, 2011). This internal RR is also known as "self-control" (Tabibnia, Satpute, & Lieberman, 2008; "self-discipline" (Duckworth & Seligman, 2005), or when habitual, "grit" (Duckworth, Kirby, Tsukayama, Berstein, & Ericsson, 2011); all of which describe the ability to endure short-term pain in order to cultivate long-term complex pleasure (captured by the body builder's lament "no pain no gain".) They also capture any legitimate value in "suffering" (Davies, 2012), although I reserve that term for more dysfunctional, complex emotional pain. For there is a vast difference between a RR and suppressive emotion regulation, as by definition the corrective action itself is informed by the specific emotional message, is consciously undertaken, and it self-preserves through open, approach behavior, adaptive development and social cooperation.

In short, the RR is a self-developmental response more indicative of the neurally well-endowed, culturally creative human being, if not all social primates. In fact, the developmental benefits of the internal RR also concern the perceived boundary between self and other, delivering what philosopher Peter Singer (1983) deems "the expanding circle" of concern for non-kin social others. This occurs when the empathic understanding of universal distress allows the broadening of one's identity boundary such that the concerns, well-being and interests of unfamiliar others (or "outgroups") become "self-relevant" as well. In fact, this empathic expansion is apparent even in the lowly behavior of rats (Bartal, Decety, & Mason, 2011) – and may be prerequisite for cooperative social behavior (the external RRs).

In fact, as mentioned, both the self-other distinction and social behavior are evident in the simplest life forms (including our little E. coli), and clearly many species have co-opted the first person *intrapersonal* language of emotional sensory feedback to mediate dyadic ***inter****personal* relationships, readily apparent in the nonverbal behavioral expressions involved in reciprocal social exchanges whether they be competitive or cooperative. Furthermore, comparisons between the dominance hierarchies of Chimpanzees and the more equalitarian networks of Bonobos (perhaps our closest primate relatives), offer elegant depictions of the self-regulatory affective dynamics, the fight, flight and right interpersonal strategies, and the social structures predicted by the sensory feedback model. Actually, "dominance" was noted as one of the original dimensions of affect, which signified a continuous scale between being powerful and in control versus relatively helpless or impotent (Fontaine, Scherer, Roesch, & Ellsworth, 2007). Or, in other words, the continuum between possessing the social freedom and power to utilize one's full range of behavioral agency, or the subordination and submission to those who do (Shapiro & Biggers, 1987).

Likewise, evolutionary theorists pondering the emergence of altruism have noted both the negative emotional dynamics, the selfishness (Rachlin, 2005), and competitive within and between-group "tug-of-war" conflicts (Reeve & Hölldobler, 2007), and the positive compassionate, caring and sharing of cooperative breeding and parenting (Desmond & Laule, 1994; Hrdy, 2009), as well as the motivational glue of empathy itself (Bateson, 1991; Levenson & Ruef, 1992; Preston & de Waal, 2002; Eklund, 2006; Danziger, Prkachin, & Willer, 2006). Indeed, game theorists have even noted the *tit-for-tat logic* within the reciprocally competitive (sum-zero, win-lose, interactions) or cooperative (non-zero, win-win) interpersonal strategies (Axelrod & Hamilton, 1981); albeit without acknowledging the fundamental self-regulatory role of emotional feedback processes in hedonic behavior, conditioned learning, and in the motivated actions of individuals, or in the reciprocal delivery of social punishment or reward.

In short, in the context of the feedback cycle, despite the primacy of pain, the modern behavioral toolkit includes a creative *approach* response as well as avoidant reactions to emotional distress. When feeling out of balance, we can take flight or fight in defense, or we can capitalize upon our neural endowments, stay in approach mode, and correctively "right" the problematic event. In fact, it has recently been demonstrated that the RR of reappraisal can exert top-down self-regulatory influence on even the bottom-up non-conscious affective evaluations, likely through the amygdala processing path (McRae, Ochsner, & Gross, 2011). Indeed, the RR should be the first choice reaction and constitute the greatest percentage of all corrective responses. But if, despite such efforts, unacceptable environmental conditions persist over time, then more assertive and aggressive (yet non-hostile) confrontational "fight" responses become appropriate, until finally a "flight" to more habitable and just environments becomes the only viable option. But whether the situation dictates a Right, Fight, or Flight response, the primary objective is to immediately identify and reduce the internal or external *environmental conditions* that are triggering the distress in order to self-preserve.

As we have seen, raw affect and the *basic* emotional cues are specifically asking us to actively alter the here-and-now *external conditions,* the physical or socio-cultural *landscape* in order to both self-preserve and adaptively self-develop. In contrast, the *complex* feelings call for *internal* environmental corrections – *righting* one's personal *mindscape* as a captain would right his sailboat in response to winds of change. Indeed, when it comes to the mindscape, fight and flight defenses are tantamount to denying the wind itself, they are maladaptive; they are *wrong*.

In sum, RRs are the mechanism for conscious, intentional, and ultimately "reasoned" learning. Such optimal self-regulatory responses promote good health (Bandura, 2005), spur both individual and social self-development, and create neural structures that deliver optimal feed-forward control, including empathic understandings that afford others the egalitarian respect, compassion and forgiveness required by the trial and error nature of emotional sensory self-regulation. Indeed, given that the boundary between self and other is rooted in the biophysical self/not-self distinction of the immune system as well as our most fundamental regulatory feedback processes, it should be no surprise that unresolved emotional distress is unhealthy – if not self-destructive – as an abundance of literature suggests (Sternberg, 2001; Segerstrom & Miller, 2004).

Eustress and the Right Response

The good news however, is that suppressive approaches to emotion regulation often overlook the *positive eustress signals* and their "Yes!–Go!–Good-for-me!" messages, the natural rewards for optimal self-regulation. For while self-preservationary pain may be more urgent, the sheer *joy* of novelty, exploration, discovery, creative flow, and of the wondrous multisensory delights of nature offer both feedback rewards and feed-forward enticements for mindful self-development. Likewise, the intrinsic rewards of play, pair bonding, the attachment between parents and children, and the curious attraction to exotic others drives social and empathic self-development, ultimately to the acknowledgement of our humanitarian unity as a species. Furthermore, although the various appraisal themes of the complex eustress signals also reflect the universal purposes and psychosocial developmental needs, they are far less biologically constrained and more personally suited to each individual's unique socio-cultural milieu, and innate genetic potentials, interests, and talents. Indeed, positive emotions are associated with the functions of the prefrontal cortex (Frith & Dolan, 1996) – consciousness, linguistic categories, volitional action, our relational identity, and optimal cognitive schemata (Fuster, 2008). They "broaden and build" (Fredrickson, 1998) and "inspire and rewire" (Haidt, 2003) the mindscape and social landscape, moving us to bond with others, to "mend, tend, and befriend" (Taylor, Klein, Lewis, Gruenewald, Gurung, & Updegraff, 2000), expanding our empathic boundaries, and to "shift and persist" (Chen, 2012) during formidable challenges. They even promote vibrant health (Fredrickson, 2000; Richman, Kubzansky, Maselko, Kawachi, Choo, & Bauer, 2005), longevity (Carstensen & Mikels, 2012; Xu & Roberts, 2010), and may perhaps underlie the placebo effect (Lidstone, de la Fuente-Fernandez, & Stoessl, 2005; Michael, Garry, & Kirsch, 2012).

Indeed, the positive emotions pull us onto an optimal – *right track* – of life, a richly meaningful (Peterson, 2007), morally virtuous (Aristotle, 1985), spiritually integrated and evolved (Wilber, 2006; Vaillant, 2008), creatively engaged, and socially connected state of flourishing (Seligman, 2011), all by simply "following our bliss" (Campbell, 2004). In fact, the fourfold over-representation of basic negative emotions is counterbalanced by a "positivity ratio", where nearly three times as many positive as negative interactions are required to prevent group fragmentation and individual languishing (Losada & Fredrickson, 2005); which I would argue, occurs naturally if we are responding 'rightly' to our painful emotional messages.

In sum, three decades ago, an "affective revolution" (Haidt, 2007) began, in which the primary role of emotion in identity formation, implicit motives, decision-making, embodied cognition, social intelligence, morality, and optimal health has become evermore apparent (Salovey & Mayer, 1990; Blum, 1991; Watts, 1997; Pizarro, 2000; Nussbaum, 2001; Karstedt, 2002; Koons, 2003; Casebeer & Churchland, 2003; Looy, 2004; Harenski & Hamann, 2005; Hardy, 2006; Crisp, 2006: Young & Koenigs, 2007; Carlo, Mestre, Samper, Tur, & Armenta, 2010; Phelps, 2010). In noting its ancient biophysical roots, the sensory feedback model amplifies this trend suggesting that nature has endowed living systems with an innate self-regulatory – indeed moral – compass that, thus far, has been opaque to science. While we've struggled to suppressively regulate our "irrational" feelings, our emotions have actually been regulating us, with a far more elegant evolutionary rationale, and from a deterministic physical substrate that predated free will itself. And it pulls us unfailingly – magnetically – toward the Truth North of optimal physical, mental, and social wellbeing with the self-evident rewards of authentic happiness (Seligman, 2002).

Moral Implications of Emotion As a Self-regulatory Sense

Despite the recent affective revolution, however, the Cartesian tradition of privileging mind over body endures, "cognitive" dual-process models rule the day, and the emotional sense remains unacknowledged. As such, ethical theory in general – and moral psychology in particular – remain mired in postmodern relativism (Haque, 2011). Ethical principles are held as "human inventions" (Wilson, 1999), and morality itself a "consensual hallucination" (Haidt, 2010), with no true biological universals ever to be found. In fact, scientists have long steered clear of the "naturalistic fallacy" (Moore, 1903; Hume, 1975; Voorzanger, 1987), honoring the idea that one cannot derive an *ought* from an *is* – that *values* lie beyond the realm of science. The emotional sensory view suggests just the opposite: That the positive and negative hedonic valence of emotion provides the *only* biophysically legitimate foundation for any evaluative words such as "good", "bad", "right" and "wrong" — whatsoever, and that to be meaningfully coherent any moral or ethical system must be grounded upon the 'natural' values they embody. Indeed, this new view inverts the traditional subordination of emotion to reason and turns much of what we think we know about morality on its head – a controversial, if not heretical, proposal to be sure.

Nonetheless, in its day, Darwin's theory of evolution prompted outrage by offering blind selection as causal, flipping the prevailing notion of a divine watchmaker on its head in a similarly "strange inversion of reasoning" (Dennett, 2003; Dennett, 2009). While this new view of emotion may well offend, I hope – eventually – it can serve in similarly productive and positive ways. Although the implications are manifold, in this brief introduction I will gesture toward several key areas where the idea of innate self-regulatory sensory guidance challenges our standard assumptions, yet may also help unify some traditional philosophical approaches.

Good and Evil

First, and perhaps most importantly, it calls into question the central dichotomy of morality, that of *good* and *evil*. As we have seen, subjectively good or bad feelings provide information about objectively right and wrong states of life-giving balance. In fact, the emotional sensory model offers perhaps the first biophysical justification for the descriptively "positive" and "negative" categories of emotion – as serving two right and good evolutionary masters. Moreover, functionally, they are neither separate nor truly oppositional, but instead work together regulating systemic balance between imperatives for: *self-development* (largely mediated by basic joy and the complex positive emotions), and *self-preservation* (mediated by the automaticity of core affect and the negative emotions). But through this lens, it becomes clear that "evil" is a superfluous notion born of the political and religious imagination; one that infuses the biological concept of wrongness with a supernatural essentialist cache, yet is paradoxically reliant upon all-too-natural emotional dysfunction as evidence of its ontological validity. Indeed, while perhaps linguistically symbolic of man's own inhumanity, the concept of evil provides justification of exclusionary ideologies that demonize "otherness" (Pagels, 1995) – ideologies that scuttle optimally empathic identity development.

Furthermore, this new story asks us to reexamine such notions as *sin* and *virtue* as fixed character traits and the traditional moral wisdom that hedonistic 'selfishness is bad' and that martyred 'selflessness is good' – both of which are imbalanced (wrong) self-regulatory states, each serving only one purpose at the expense of the other. It allows us to see that both sin and virtue represent the deficits and optimums of emotional self-regulation, if not direct conceptual stand-ins for the emotions themselves. Indeed, from Eastern traditions such as Buddhism, all suffering is rooted in human *craving* and *aversion* – the hedonic valence of emotion – and the righteous path involves transcending the reactions, attachments, and delusions of the self (Chen, 2006). Likewise, from Western traditions, five of the Seven Deadly Sins (Bloomfield, 1967) are emotions (greed, envy, wrath/anger, lust, pride/arrogance), as are many of their counterpart Divine Virtues – love, faith, hope, courage (Jones, 2006), compassion (Cochran, 2008), gratitude (Hemingway, 2010), and happiness (McMahon, 2004).

Rethinking "hedonism" within this new context, however, demonstrates how minimizing sin and maximizing virtue (in self or others) are really about *preserving the body* and the physical environmental conditions required to sustain it, while *developing the mind* and the optimal sociocultural structures that enhance and build upon those physical resources. Most importantly, these goals are two sides of the same coin and accomplished in the same ways, by simply reducing the internal and external conditions that elicit basic pains, and fostering those that elicit complex pleasures. In fact, this insight can also help ease political gridlock as the political left versus the political right traditionally advocate only one side of the two-pronged approach, "the left rolling with the good and the right confronting the bad" (Dodd et al, 2012); (Albeit with the moral "righteousness" (Haidt, 2012) of exclusive religious values and economic priorities (De La O, 2008; Graham, Haidt, & Nosek, 2009; Rock & Janoff-Bulman, 2010) obscuring these otherwise centrist humanitarian optimums.)

The Self: Both Part and Whole

Second, the emotional sensory model allows us to acknowledge the fluid and multidimensional nature of *the self;* to see the human entity as a fractal gestalt, with ever-shifting boundary conditions reflecting the ongoing self-regulatory processes. We are each individual agents interacting within our local environment, autonomous *wholes;* yet we are also *parts* of greater wholes. We are at once the largest doll in the set, looking out on the world perceptually entangled within it (and with the others that comprise it); yet also beholden to the bottom-up sensory signals of all the smaller dolls within us. We are both physical *beings* and mindful social *becomings*, our autonomy and community indivisible, both reciprocally co-creating, aspects of our identity.

In practical terms, the model allows us to transcend linguistic descriptions of the self as merely body or mind, and honors a "between" aspect of self, the *bodymind-in-world*. This aspect of human identity has been captured in such concepts as the relational self, collective self, or interdependent self (Cross, Hardin, & Gercek-Swing, 2011), the communitarian self (Friedman, 1989), the social self (Brewer, 1991), and the moral self (Maclean, Walker, & Matsuba, (2004) all of which fundamentally acknowledge the role of *social relationships* and *human community* in constituting both self-identity and the nature and meaning of the particulars of individual lives. This is the aspect of the mind-self that is "enacted" (Thompson, 2007) as it looks out upon the world, providing the top-down (feed forward) stream of self-regulatory information to be embraced within the body's immune distinction, then becoming a predictor of the range of self-relevant events and bottom-up (feedback) emotional responses – which in turn constantly and cyclically *reenact* the evolving mind.

The model offers further utility in grounding time honored, more ethereal, identity components captured by such words as *spirit* or *soul*. In fact, with its roots in the motor control and information functions of integral feedback, the emotional sense yields both the animation and instinctive guidance once deemed by animists (Bird-David, 1999) and vitalists to be the essential life-giving force in living systems – the "elán vital" (Bergson, 1907) – which constituted both spirit and soul. For example, the Oxford English dictionary defines spirit as: "the non-physical part of a person which is the seat of emotions and character"; and it defines the soul as: "the spiritual or immaterial part of a human being or animal, regarded as immortal; a person's moral or emotional nature or sense of identity".

Indeed, while in a Cartesian world both spirit and soul were subsumed into the "higher" realm of mind, in this new context, both are *embodied manifestations of the emotional sense,* working together to honor and optimally actualize the unique value potentials of each individual (by both preserving the body and developing the mind.) Still, they are distinguishable in two ways. First, the spirit is *immanent*, as intimately present in everyday experience as each self-regulatory breath; sustaining and inspiring us even in dreams while the mind-self sleeps, ceasing (or perhaps departing) only upon death. Likewise, the spirit is an *ever changing process*, the *becoming* impetus of our highest nature. As such, the ongoing *emotional processes* themselves offer a serviceable grounding for the concept of *spirit*, including all "subliminal" (Alvarado, 2002) automatic, or subconscious motivational and behavioral manifestations. In our Russian doll metaphor, the spirit would be the bidirectional flow of cyclic feedback, the ongoing stream of self-regulatory information itself, perhaps the motion of mind as it feeds back and forth, into the world and back into the embodied soul. In fact, the word "emotion" itself is rooted in the Latin *emovere* ("to move out"), or perhaps better *to move from within*.

For in contrast, the soul is considered to be something both *transcendent* and more *essential*, enduring if not permanent – *the being* essence of identity, perhaps in its most optimal, perfected, or Divine Platonic form. Indeed, any mathematically precise in-forming deterministic laws, informed order, or divine design (if not the concept of *information* itself) would be rooted in this ultimate foundation. Hence, these durable, essential, aspects of identity, the core in-forming essence to which the spirit is tethered, could honor and biologically distinguish the traditional concept of *soul*. These include the *self-regulatory optimums*, essential spiritual *needs* (Koole, Greenberg, & Pyszezynski, 2006), all genetic and/or quantum *value potentials*, and potentially infinite *"possible"* (Markus & Nurius 1986) or *"future" selves* (Kerpelman & Lamke, 1997; Leondari, Syngollitou, & Kiosseoglou, 1998; Pronin, Olivola, & Kennedy, 2008), or any such essential "implicate" (Bohm, 2005) seed enfolded within the unfolding developmental process. It matters not whether the spiritual roots to the soul remain limited within nature's lawful ordering principles, potentials of the "adjacent possible" (Kauffman, 2008, 2012), and "serendipitous creativity" (Kaufman, 1993) of our physical universe, or if they extend into any supernatural, or immortal dimensions. It simply signifies an essential Ultimate Self that provides an ideal "not-yet-self" element in the self/not-self feedback comparison, that is – in and of *Itself* – the ultimate True North meaning of divine goodness and love. And, as most religions suggest, this ultimate kingdom, with its evaluative authority for "spiritual judgment" *exists within* (James, 1957); to which I would add, and *speaks from the bottom up*.

The soul, then, also has a unifying aspect wherein the "not-yet-self" ideal dovetails with the self-other distinction – the core of *empathy* as well as *compassion.* Not only in the ability to stand in the shoes of "the other" and look out at the world from their subjective center, but also to objectively perceive and honor their common value potentials as deeply as we perceive and desire to discover, develop and express our own. In fact, biology is now melding with spirituality in that the neural systems of midline structures and mirror neurons in the human brain suggest that self and other are "two sides of the same coin" (Uddin, Icoboni, Lange, & Keenan, 2007). Indeed, theologian Martin Buber (1970) noted the spiritual importance of the I/Thou "relational encounter", which aptly describes the empathic expansion of one's identity boundary to sufficiently enfold the social other within one's self-relevant sphere. This self-other overlap yields the feeling of oneness with others, a meaningful connection with something greater than oneself, and offers the natural spiritual rewards of the positive emotions (Waugh & Fredrickson, 2006; Vaillant, 2008). In fact, it is likely the developmental process suggested in the Western religious goal to "love thy neighbors as thyself" (Holy Bible, Galatians 5:14), and in the Kantian requirement to honor others as ends themselves rather than means to those ends (Kant, 1959). Furthermore, the default predominance of social empathy in complex task processing (Jack, et al., 2012) suggests we are hardwired to do just that.

In sum, the emotional sensory view suggests that the human identity is an elegant self-regulating fractal gestalt. Yet the boundary between *self* and *other* is far more biophysically determined, chemically adjudicated (Spinella, 2002) and empathically fluid than other models might suppose – and that we have long had the capacity to transcend both our in-group biases and out-group prejudices (Leyens, Paladino, Rodriguez-Torres, Vaes, Demoulin, Rodriguez-Perez, & Gaunt, 2000). Indeed, the self-regulatory dynamics at the identity boundary offer a universal "spiritual" meaning system, with negative emotion contracting the identity boundary when self-preservation is required, and positive emotion otherwise expanding it in psychosocial self-development – adapting us to our local environment, forging empathic bonds, merging our interests with those of others, and co-creatively actualizing our embodied soul potentials in the world at large.

Morality: A First-person Experience

Third, given our self-regulatory nature, morality is a *first person experiential* phenomenon, a relatively personal and private affair, with corrective messages *from* the environmentally embedded body-self (aka spirit), *to* the mind-self, *about* the whole Self (aka body-mind plus soul). They come to us directly, via our innate "moral sentiments" as posited by the great Scottish enlightenment philosophers – David Hume, Frances Hutcheson, Adam Smith (Tronto, 1993) – our ancient "felt evaluations" now offering three levels of self-regulatory information in each emotional perception (as set forth in Figure 2).

But acknowledging emotion as our self-regulatory sense also unites the moral sentiment view with the rationalist, rule and reason-driven, approaches of the Kantian tradition. For they come freighted with the ancient tit-for-tat logos. In fact, the temporal feedback and feed-forward aspects of the emotional sense incorporate both utilitarian and deontological aspects of moral cognition as set forth in "dual-process" models (Cannon, Schnall, & White 2011; Greene, 2007; Greene, Morelli, Lowenberg, Nystrom, & Cohen, 2008). These models acknowledge the "automaticity" (Kihlstrom, 2008) of emotion, yet often neglect the neural overlap (Pessoa, 2008; Shackman, Salomons, Slagter, Fox, Winter & Davidson, 2011), assuming them to be competing or separate systems, loosely associated with reason and emotion. In the sensory feedback model, however, the utilitarian approach (which weighs costs and benefits (Berns et al 2012) is mediated by the top down pathway and feed-forward complex emotions, while the deontological (which emphasizes rights and wrongs), serves from the bottom-up – via raw affect and basic emotion. This may be why the outcome-based mindset facilitates "moral balancing", yet the rule-based approach facilitates "moral consistency" (Cornelissen, Bashshur, Rode, & Le Menestrel, 2013).

Indeed, the simple digital hedonic code yields a singular and universal moral commandment, worthy of the Kantian categorical imperative: To simply ***reduce*** *the external environmental conditions that elicit basic pains* (the ***negative*** emotions)*, and* ***increase*** *those – in both the local landscape and personal mindscape – that foster the complex pleasures* (the **positive** emotions). Better still, this personal prime directive extends via empathy to a biologically universal interpersonal moral code – the negative version of the familiar Golden Rule: ***"Hurt not others with that which pains***

thyself". (This negative version is recommended due to the primacy and universality of pain contrasted against the subjective diversity of the complex pleasures. Indeed, the positive version is not advisable, as it negates the autonomy of the self-regulatory process.) Best of all, this simple biophysical commandment is evident as the common moral strand woven across the great religious traditions (Armstrong, 2004) and is stated explicitly in Hinduism, Buddhism, Jainism, and Confucianism (Rune, 1972).

In sum, the first-person "self-regulatory" nature of emotional messages honors the subjective relativity of morality, yet inverts the standard idea that moral guidance is only to be found *externally* or *from above,* located in socio-cultural rules, doctrinal prescriptions, laws, or transcendent supernatural authorities that are "independent of human experience" (Wilson, 1999). Hence, any social, legal, or otherwise interpersonal forms of moral mediation (such as third party punishments or rewards for good or bad behavior), must work in concert with these more fundamental first person messages and hedonic motivations. In other words, external control mechanisms will only succeed to the degree that they tap into the direct experiences of the person feeling the emotion, and to the degree that they honor the bottom-up universal moral code. As such, they must be forged largely upon the *positive* emotional experiences and empathic self-development (Zak, 2011), lest they run afoul of our primary self-preservationary imperative.

Cooperation is Innate

Fourth, the emotional sensory view suggests that human nature is far more *cooperative* than the competitive "selfish gene" (Dawkins, 1989), 'nature is red and tooth and claw', story proposes. It suggests that cooperative foraging (Tomasello, 2008), feeding (Desmond, Laule, & McNary, 1987), breeding (Desmond & Laule, 1994), and allo-parenting (Hrdy, 2009) – as well as the kin recognition and social cooperation apparent in the simple bacterium – have been underappreciated in evolutionary theory. It bolsters the informative contrasts between the social structures and motivational strategies of our closest primate relatives the Chimpanzees (where competition, dominance hierarchies and negative emotion largely run the show) and the Bonobos whose egalitarian network structure, cooperative coalitions, and make-love-not-war use of sexual capital, has harnessed the positive emotions (DeWaal, 1997; 2006).

Indeed, the moral logos of the emotional sense suggests that win-win cooperation motivated by positive emotion is the long-term rule, and that win-lose fight-and-flight competition driven by self-preservationary pain is the short-term exception. Or, in other words, that reward is a more successful strategy than punishment (Rand, Dreber, Ellingsen, Fudenberg & Nowak, 2009). Likewise, it suggests that the role of emotions such as basic anger, sadness, disgust, and complex trust, gratitude, love, and compassion have largely gone unnoticed in rationalist models of economics, game theory, and interpersonal decision making (Lerner, Small, & Lowenstein, 2004; Han, Lerner, & Keltner, 2007). In sum, it suggests that *nature is green with grace and embrace*, that we enjoy a self-developmental impetus for creative adaptation, that evolution is constructive because of cooperation (Nowak, 2006), and that as Dacher Keltner (2009) put it, we are "born to be good".

However, this model also addresses the time honored debate between Rousseau and Hobbes on the nature of the *social contract* (e.g. Morris, 1999). For functionally, social cooperation is a qualitative condition of the *external environment* (Drea, 2006; Twenge, Gentile, DeWall, Ma, Lacefield, & Schurtz, 2010), a beneficial environmental "affordance" (Gibson, 1954, Greeno, 1994), just like other life-giving resources such as food, optimal temperature, sufficient light, water, and/or oxygen – a list that includes sufficient parental nurturing (Mlot, 1998; Lipton, 1998a). Indeed, given our aforementioned "social nervous system" (Porges, 2005), the interpersonal climate is a genuinely physical "context" to which humans are "biologically sensitive" (Hertzman & Boyce, 2010), causing very real corporeal manifestations if the biophysically 'right' (life-giving) conditions are present or absent (Eisenberger, Taylor, Gable, Hilmert, & Lieberman, 2007). This includes an ecology of caring others through which individuals conserve costly resources through the social level regulation of emotion (Beckes & Coan, 2011). As such, social contextual constraints can trigger the suite of neuropeptides and hormones – the molecules of emotion (Pert, 1998) – that coordinate regulatory activity, from immune responses to epigenetic regulation (Cole, 2009; Jaenisch & Bird, 2003; Weaver, et. al 2004).

Recall, for example, the phenomenon of quorum sensing in bacteria (Brassler, 1999), wherein individuals emit autoinducers, self-identifying molecules for which they also have unique protein receptors that detect when plenty of social self exists in the local world. Like other chemoeffectors, if present in sufficient quantity, it triggers "go" mode cooperation between members of the species, if absent it triggers "stop" and singular self-interest kicks back in. The homolog in humans for these autoinducers would be the products of the *major histocompatibility* (MHC) genes (Klein, Satta, & O'hUigin, 1993), the "self" signals of the adaptive immune system and their epigenetically internalized manifestations (Borghans, Borghans, & ter Weel, 2005). Higher level homologues include pheromones, stress hormones such as cortisol, the cuddle and trust hormones oxytocin and vassopresin, the endorphins, and most importantly the neurotransmitters such as serotonin, dopamine and their metabolizing enzymes that play roles in depression, resilience, and in reward, as well as one's individual and social sense of identity (Panksepp, 1986). In fact, in terms of mate preference, we can both smell and see MHC compatibility or dissimilarity (Wedekind, Seebeck, Bettens, & Paepke, 1995; Havlicek & Roberts, 2009), we can smell empathy (Spinella, 2002) and even personality (Sorokowska, Sorokowski, & Szmajke, 2011). Indeed, "emotional contagion" itself is mediated by the olfactory system. Quite literally, whether we are consciously aware of it or not, we can smell the emotions of others (Prehn-Kristensen, Wiesner, Bergmann, Wolff, Jansen, Mehdorn, Ferstl, & Pause, 2009), and deficits in this sensory modality have been linked with psychopathy (Mahmut & Stevenson, 2012). Of course, I would root this deeper still in the grandparent of them all, the primordial emotional sense; and in fact, psychopaths exhibit a diminished capacity in the affective component of memory, they know the "words" of emotion but not the "music" Johns & Quay, 1962; Patrick, Cuthbert, & Lang, 1994).

In short, the social contract for cooperative behavior – if not optimal human development itself – is contingent upon the structure of the *external environment,* where factors like social safety, empathic nurturance, honest feedback, equitable opportunity, and the individual liberty to self-regulate are prerequisites for attachment (Bowlby, 1969; Ainsworth, 1978; Cassidy, 1994; Lieberman, 2004; Kay & Friesen, 2011), cooperation, social engagement, and the empathic expansion of self-identity, as well as optimal interpersonal emotion regulation and physical health (Eisenberger & Cole, 2012). Without them, a more Hobbesian, every man for himself, self-preservationary state is predictable, one driven by reciprocal expressions of negative emotion that trigger the alarm system, and drive fight/flight defensive behaviors. Indeed, given the power of this primal self-regulatory sense, the ideological structures with which we self-identify are key players in both cultural conflict (Berns & Atran, 2012) and "sociosomatic" disorders (Becker, 1989; Ware, 1989; Ranjith & Mohan, 2006).

The Right Track

Fifth, with its emphasis upon these physical manifestations, the sensory feedback model allows us to see optimal "right track" developmental trajectories applicable for all homo sapiens, as well as "wrong track" deficiencies. In short, when informed by self-regulatory emotional perceptions, morality becomes a simple matter of public health – as the same ancient value system applies to all members of the species. Indeed, these various states of self-regulatory health are loosely reflected in the emotional milestones of Erickson's (1968) stage model of psychosocial development, within Kohlberg's (1967) stages of moral reasoning (Maclean, Walker, & Matsuba, 2004), and within the development of humanitarian empathy and "emotional intelligence" Salovey & Mayer, 1990; Goleman 1995).

In fact, the evolutionary emergence of the three levels of information within emotional sensory perceptions (Figure 2) is also echoed in their pattern of developmental emergence in human infants; with primal affect deeply hardwired, and the basic emotions unfolding in the first six months of life (Izard, 1971). Then, context and experience dependent (Greenough, 1986), entangled with semantic associations (Bower, 1981), assisted by the "deliberate persuasion" of others (Bloom, 2010), and with countless rounds through the feedback cycle, these primary emotions take on personally tailored blends and shades forging and honing the complex emotions over the first decade of life (Campos & Campos, & Barrett, 1989). These milestones reflect the original developmental structuring and pruning of the neural circuitry, the emergence of primary self-regulatory agency, as well as the formation of fundamental complex human capabilities (Heckman, 2007) and personalized psychological capacities. Furthermore, with the revelations about epigenetic regulatory processes, there may also be critical opportunistic windows in the process, which, if stymied, can yield compromised or detrimental developmental outcomes (Nelson, Furtado, Fox, & Zeanah, 2009). In fact, longitudinal evidence suggests a gradient of childhood "self-control" predicts health, wealth and public safety (Moffitt, et al, 2011).

Through this lens, the right track course of human development will be reflected in the early engagement of emotional sensory self-regulation, as well as the expedient emergence of the suite of *complex positive emotions* and the optimal feed-forward adaptive learning, creative actions, and cooperative social interactions – the right responses – they engender. Indeed, although bad may be stronger in terms of sensory urgency, *good is stronger in terms of behavior* (Batson, Batson, Slingsby, Harrell, Peekna, & Todd, 1991; Pizzaro, Uhlmann, & Salovey, 2003; Wang, Galinsky, & Murnighan, 2009), including even good intentions (Gray, 2012). For example, in Erickson's stage model, the first stage is marked by either *trust* versus *mistrust* in the first year of life; the second by "autonomy" (to which I would add: *confidence* in one's self-regulatory agency, *curiosity, delight, zeal,* and *hope* for life) versus *shame* or *doubt* (*anxiety*, *worry*); and the third stage by "initiative" (*courage* to tackle challenges, *faith* in oneself, *mirth, affection* for peers, and *admiration* of inspiring others, *gratitude* for caring support and mentorship, and *compassion* for suffering) versus *guilt* (to which I would add *boredom*, *envy, greed, contempt* and *rage*). Successful development of the right-track positive emotions all contribute to an integrated and meaningful sense of identity and a passionate humanitarian conscience by adolescence, as well as loving intimacy, generosity, and compassion in adulthood (Leary, Tate, Adams, Allen, & Hancock, 2007). Indeed, while the aforementioned 3/1 positivity ratio is required to prevent languishing, once the entire palette of complex positive emotions is in place, I suspect that the right-track ratio for flourishing will be closer to 8/1 positive over negative experience. Overall, the positive feedback dynamic creates an "upward spiral" (Fredrickson, 2009) of personal development, social cooperation, and self-perpetuating positivity.

In sum, the universal right track of human development delivers an optimal suite of complex emotional perceptions and a fully functional moral compass, perhaps even at surprisingly young ages. Furthermore, the moral wisdom delivered by this optimal trajectory is also echoed in common religious mores, the virtues and values identified by the Institute of Global Ethics (Loges & Kidder, 1996), the positive psychology Values-in-Action taxonomy of human strengths (Peterson & Seligman, 2004), and it resonates from within well-being advice across the mental and physical health sciences. But in terms of evolutionary theory, emotion has never been given its rightful due, and the tremendous adaptive value of positive emotion has remained obscured by the notion that all pleasure is simply the handmaiden of sexual reproduction.

The Abuse of Negative Emotion: The Wrong Track

Sixth, and finally, is that despite ever-mounting scientific evidence, given the aversive power of the negative emotions, there remains tacit agreement that emotion is *bad stuff,* a vestigial hindrance (Barrett, 2011), detrimental to ethical judgment (Lurie, 2004), if not spiritually "destructive" (Goleman, 2004). For example, these rather paradoxical headlines from the cover of Discover Magazine: "Primitive brain *senses* emotion" …. "Neuroscientists explore ways to keep emotions from *hijacking the mind*" (Johnson, 2003; emphasis mine). Such slander about our visual, auditory, olfactory, or gustatory sensory processes would be unlikely ('scientists explore ways to keep color – sound, (etc.) – from hijacking the mind'), and we consider ourselves disabled unless all senses are intact; yet this attitude prevails. Clearly, we have *blamed the messenger while missing its primal self-regulatory message*. We have chosen to suppressively regulate our emotions instead of allowing them to regulate us. Indeed, while suppression is little more than self-deception, our cultural traditions encourage us to deny our feeling signals with strategies ranging from religious taboos and admonishments, to socially refined and politically correct manners, and even to powerful psychotropic drugs. But in doing so, we've run off our biologically optimal moral rails onto the *wrong track*.

In fact, the most shocking revelation from this new story is that *the complex negative emotions are largely maladaptive human constructions*. In other words, while basic pain will always exist as a short term biophysical feedback signal, ongoing "suffering" is a feed-forward manifestation created by our own hand – the wrong kind. For this model suggests that the optimal emotional palette for a fully functional moral compass requires *only the four basic negative emotions*, along with joy and the suite of complex positive emotions mentioned above. Indeed, complex feelings such as mistrust, shame, anxiety, worry, envy, contempt, rage and hate *need never emerge* in the developmental trajectory if we understand and employ the optimal corrections requested by the four *basic* negative emotions – corrections effected both as individuals and as cultural creators en masse. Yet when sadness, fear, disgust, and anger are not allowed to their job, the causal environmental factors remain the same, and the unanswered distress signals will simply be conditioned into the mindscape as maladaptive schemata – feeding-forward in negative attitudes and limited beliefs and narrow identity boundaries that skew perception, and that drive habitually avoidant behaviors, and all the predictable intrapersonal dissonance and interpersonal conflict that results. But the self-destructive problem is this *maladaptive schemata* preserved within the mindscape, rather than the complex negative emotional messages they elicit. The latter are the messengers, informing us of their existence so we can respond correctively, while the former are the actual targets of therapeutic interventions such as rational-emotive or cognitive behavioral therapy (Beck, Rush, Shaw, & Emery, 1979; Ellis, 1970). Indeed, the red-flag emotional perceptions point the spotlight in precisely the right directions to expose schemata, their negative valence nominating them as maladaptive candidates for revision or elimination.

Likewise, maladaptive beliefs can harness and redirect the basic emotions to preserve *ideologies* rather than the body itself. Take, for example, the emotion of disgust, with its appraisal theme of *contamination* which is rooted in disease, bacterial overgrowth, and the avoidance of infectious threat (Curtis, 2001, 2007). (In fact, this same response is evidenced in the ancient "stress-sensing" surveillance systems in the C. elegans nematode worm (Kleino & Silverman, 2012; Melo & Ruvkin, 2012) as well as in plants (Jones & Dangl, 2006). Yet, with beliefs and judgments about physical or spiritual "impurity" it can be massaged into either contempt or shame (Danovitch & Bloom, 2009; Rozin, Haidt, & McCauley, 2000), promoting self-destructive behaviors if internalized (Milligan & Andrews, 2005), or if externalized, inspiring prejudice (Inbar, Pizzaro, Knobe, & Bloom, 2009) if not dehumanizing contempt for "others" outside the belief community (Inbar & Pizarro, 2009). In short, conserving maladaptive beliefs can complexify and "disregulate" our emotions (Baumeister, 1997; Peterson & Flanders, 2002; Dias-Ferreira, Sousa, Melo, Morgado, Mesquita, Cerqueira, Costa, & Sousa 2009), and ultimately help manifest the host of psychiatric "affective disorders" described by the DSM. In sum, by choosing the suppressive strategy humanity has not only violated the simple directive to *reduce* the physical and sociocultural *conditions* that elicit painful emotions, but we have *compounded* them by adding an entirely new man-made layer of social distress to the external environment – the complex negative emotions.

Worse, we have pressed this superfluous suffering into service in a warped 3rd party form of morality, one where we *suppressively regulate one another* by deliberately inflicting emotional pain. For example, as moral psychologist Paul Rozin has noted, ethical codes are routinely enforced by third party expressions of the negative emotions (Rozin, Lowery, Imada, & Haidt, 1999). They noted how *disgust* mediates codes of *divinity* (religious mores), how *contempt* enforces codes of *community* (local sociocultural mores) and how *anger* upholds codes of *autonomy* (equal justice, human rights, etc.) This new story suggests, however, that these third party expressions likely operate by instilling *first person* emotions such as shame, embarrassment, guilt, sadness, or fear, and succeed only to the degree that they harness the "flight", submissive, mode of hardwired emotional response (Tangney, Stuewig, & Mashek, 2007).

But this strategy can backfire. For it also predicts competitive conflicts between the various ethical codes should they prompt first person disgust or anger instead, and its naturally aggressive "fight" mode of self-preservationary avoidance (Mullen & Nadler, 2008) – or elicit such hostile complex emotions as contempt, rage, or hate and "getting even" (the negative feedback rebalancing) via revenge (DiGiuseppe & Froh, 2002). In fact, punitive authoritarian parenting that relies upon shame and humiliation negates the self, invites anger, promotes rage (Scheff, Retzinger, & Suzanne, 1991) and self-destructive activity (Milligan & Andrews, 2005); and it can lead directly to violent criminal behavior (Athens, 1992; Gilligan, 1996).

All in all, these reciprocal cycles of negative emotional behaviors drive ongoing social conflict (Berns & Atran, 2012), also creating a runaway self-perpetuating positive feedback loop. But in this case, it is a *downward, self-destructive*, *spiral* of interpersonal negativity. In short, when it comes to 3rd party morality, given the crucial distinction between the universal hedonic evaluation and the more fluid, personalized, cognitive appraisal, the religious admonishment to "judge not" resonates all the more. While social punishment may indeed be at the root of our modern justice system (Buckholtz & Marois, 2012), in this view it is biologically unsound. In fact, we humans appear to be uniquely self-destructive in this way, for even our more violent primate relatives do not employ the tactic of third party punishment (Riedl, Jenson, Call, & Tomasello, 2012).

Furthermore, given the emotional system's ancient roots in self-regulatory signaling, such tactics are a recipe for personal disaster. As noted above, sociocultural structures that exploit negative emotion in this manner create a lingering state of distress (Dickerson & Kemeny, 2004) that sets the epigenetic stage for compromised immune function, ill health, maladaptive development and psychiatric disorder (Meyer-Lindenberg & Tost, 2012; Tsankova, Renthal, Kumar, & Nestler, 2007). Indeed, through epigenetic pathways, stressful events become biologically embedded – they get "under the skin"– during developmental windows crucial to the forging of neural circuitry (Hertzman & Boyce 2010), and is implicated in the DNA damage that accelerates degenerative aging (Hara, et. al., 2011). It is now well documented that environmental factors such as maltreatment, family adversity, marital conflict, maternal depression, and even financial distress are been linked with cognitive deficits and socio-emotional behavioral problems in children (Kahnsari, Murgo, & Faith, 1990; Burchinal, Roberts, Hooper, & Zeisel, 2000; Boyce et al., 2001; Tsigos & Chrousos, 2002; Caspi et al, 2002; Cummings & Davies, 2002; Essex, Klein, Cho, & Kalin, 2002; Patel & Kleinman, 2003; Masten & Shaffer, 2006; Van Ijzendoorn & Bakermans-Kranenburg, 2006; Taylor, Way, Welch, Hilmert, Lehman, & Eisenberger, 2006; Bakermans-Kranenburg &Van Ijzendoorn, 2007; Boyce, 2007; Kleinman, 2010). The mechanism of such biological embedding has been called "time dependent sensitization" (Bell, 1994), "neural sensitization" (Bell, Schwartz, Baldwin, & Hardin 1996), "sensory hyper-arousal" (Baron-Cohen & Belmonte, 2005), "central sensitization" (Yunus, 2007), "central nervous system sensitization" (Sorg, 1999), and "sensitivity to context" (Obradović, Bush, Stamperdahl, Adler, & Boyce, 2010); but by any name, they reflect the self-regulatory feedback dynamics – and epigenetic and immune manifestations – of *the emotional sense*.

Additionally, humans continue to evolve, and we may be becoming increasingly sensitive to the biophysical cues that elicit emotional perceptions, implying that epigenetic processes are becoming more and more influential in all aspects of our health and well-being. Or, in other words, that psychosomatic and sociosomatic effects of the mind and the world have an increasingly potent effect on our genetic processes. In fact, one's very stress response can be epigenetically programmed by the environmental exposures of one's immediate ancestors – one's grandparents (Crews, et al., 2012). Indeed, "increasing evidence suggests that most, if not all, diseases of the central nervous system are associated with either primary or secondary perturbations of the epigenome" (Qureshi & Mehler, 2010), which of course include "psychosomatic" syndromes, affective disorders (Panksepp, 1988; Pittenger & Duman, 2008) and psychiatric diseases (Mehler, 2010) – not to mention the profound developmental deficits from extreme contextual deprivation (Nelson, Furtado, Fox, & Zeanah, 2009). Furthermore, disruptions in these chemical signaling systems and their neural circuitry can give rise to the empathy deficits in autism (Baron-Cohen & Belmonte, 2005), to psychopathy (Blair, 1997; 2007), and the dissociative (Scaer, 2001) and identity pathologies in schizophrenia (Radulesca, 2008; Garay & McAllister, 2010).Yet their underlying feedback dynamics can also explain the marginal efficacy, adaptive tolerance, and long-term deficits that can accompany pharmacological therapies (Carlat, 2010; Whitaker, 2010; Kirsch, 2011).

Nonetheless, our ever-evolving emotional sensitivity is a good thing. For while increased sensitivity to context in children raised in adverse, stressful, environments is particularly harmful; extra sensitivity in those with enriched and nurturing environments fosters even better developmental outcomes than their less sensitive peers (Obradović, Bush, Stamperdahl, Adler, & Boyce, 2010). Likewise, with the development of emotional literacy and emotional intelligence, extra sensitivity means earlier warning, more detailed information, and timely opportunities for swift and effective RRs.

All in all, the moral implications of this new view of emotion are manifold and perhaps unsettling. The model challenges us to revisit such common moral terms as good, bad, right and wrong, and to reframe them all through a more biophysically informed lens – if not restructuring the concept of morality itself. It asks us to rethink traditional dichotomies such as good and evil, virtue and sin, cooperation and competition, in-groups and out-groups, and the very notion of *positive* and *negative* emotions. And it does require some rather startling inversions of our former reasoning and traditional beliefs about human nature. For, as Western religions have suggested, we have indeed eaten the forbidden fruit from the tree of knowledge and all hell has broken loose. But the error, our 'fall from Divine Grace', was not one of disobedience for which we deserve punitive suffering; it was in creating a *false value system* – the false dichotomy of good and evil – that supplanted our innate authoritative guidance, *our emotional awareness of biologically right and wrong states*. If there has been any legitimate *sin* beyond ignorance, it has been self-deception (Peterson, DeYoung, Driver-Linn, Séguin, Higgins, Arseneault, &Tremblay, 2003; Ariely, 2012), that of suppressing and abusing perhaps one of our most precious natural gifts: our innate guidance system – our emotional self-regulatory sense.

Fortunately, however, it also offers a much more becoming and optimistic portrait of human nature. It invites science to speak of value and purpose, to understand our moral sense and its role in the spiritual experience. It also invites science and religion to unite on the grounds of evolutionary theory – an approach already formally embraced by the Pope (Arber & Duve, 2008), and ultimately, to forge "an inclusive cosmopolitan ethic" (Wright, 2009) for our global community.

Conclusion

I have argued that a broadened interdisciplinary perspective, an updated evolutionary theory, and an expanded definition are required to elucidate the biophysical function of human emotion – to envision the entire emotional elephant both beyond and within the wide variety of theoretical viewpoints. Indeed, despite all effort, emotion remains undefinable in psychology (Larsen & Fredrickson, 1999), and theorists continue "dissecting" (Russell & Barrett, 1999) rather than integrating the elephant. The result is a continuum of independent and often mutually incompatible theories ranging from the position that emotions are biologically hardwired, to the view that they are largely sociocultural constructions, suggesting that "emotion generation" and "emotion regulation" are "either one or two, depending on your point of view" (Gross & Barrett, 2011) – a situation that has reduced the science of emotion to a matter of opinion.

This new story, however, suggests that emotion generation IS emotion regulation, because it is best understood as a biologically ancient *self-regulatory sensory system.* Yet, despite many theorists noting the bigger picture of both the sensory and self-regulatory nature of emotion (not to mention the fact that synesthesia, the odd overlapping of sensory modalities, includes an "emotionally mediated" variety (Milán, et al., 2012), there seems little inclination to officially acknowledge emotion as a sense. My point has been that there is an abundance of empirical evidence to make that declaration – solid evidence from physics, chemistry, and systems biology, as well as from the descriptive and experimental offerings of the social sciences. There is evidence ranging from the patterned molecular activity that drives hedonic stimulus-response behavior and yields inaugural perception in the simplest organisms, to the functional connections between cell signaling networks and epigenetic, immune, and neural processes in more complex organisms. Evidence of how these mechanical regulators manifest as multi-tiered feeling perceptions, sensitivity to context phenomena, patterns of development, motivation, decision-making, moral reasoning and emotion regulation in humans. Evidence that compatibly dovetails with – as well as enhances, extends, and provides biological foundations for – "the laws of emotion" (Frijda, 1988), that melds with evolutionary theory in both its early and contemporary forms, and that is comfortably compatible with nearly every major ideological tenet within psychology. So my friendly challenge is to ask: *Why not?* If it walks like a duck, talks like a duck, and acts like a duck (or functional elephant in this case) perhaps it's time to call it just that.

For indeed, this new story has come from a broader evolutionary vantage, noting that affective feelings and their coupled behavioral responses are rooted in the most primal forms of sensory-motor control – readily apparent in the molecular structures and feedback circuitry of "branes" (membranes) of the simplest living systems, circuitry that is homologous to the stimulus-response cell signaling networks in complex organisms. It suggests that this ancient self-regulatory system emerged first from the bottom-up (body-to-mind) – with fundamental chemical feedback regulation giving rise to primary ***intra***personal self-regulatory signals and behavioral responses, as well as secondary *inter*personal cues and social signals; and ultimately, to multi-tiered brain circuitry, complex informative feeling perceptions, and the top-down (mind-to-body) dimension of self-regulation. It suggests a cyclic, bidirectional, flow of self-regulatory information between any given 'self' and its immediate 'not-self' environment, as well as within and across various fractal levels of self-organization. This self-regulatory configuration manifests not only in the generally tri-level structure of the human brain and its dual processing paths (LeDoux, 1989; Phillips, Drevets, Rauch, & Lane 2003; Craig, 2008), but also in the overlap between the epigenetic, immune, endocrine, respiratory and central nervous systems in the generation of 'self-relevant' emotional sensory perceptions. With empathic self-development, it extends the boundary of self-relevance to include the interests and concerns of others, elegantly balancing the individualistic and social aspects of human identity.

This new view suggests that pleasurable and painful categories of feeling relate directly to the criteria for natural selection (self-preservation and adaptive self-development); fashioned via a serendipitous coupling of positive (amplifying) and negative (regulating) feedback processes and harnessed – very early on – as cues for beneficial or harmful environmental conditions to govern hedonic approach and avoid behavioral motivation. It suggests that subjective 'goodness' and 'positivity' concern optimal balances between the organism and its immediate environment, and that 'rightness' equates with optimal biophysical conditions for living systems as well as adaptive responses to immediate environmental challenges – those that both preserve the body-self (by creatively enhancing the external environment) and that enact and develop the mind-self (creatively "righting" the internal environment). This view maps the confluence of the self-regulatory computational dynamics across the fully determined genetic and epigenetic landscape with its dynamic on-off switching, to stop/go appetitive behavioral control, to yes/no hedonic approach/avoid responses – binaries that we experience as desirable or aversive feelings, those that inform our free will choices as well as forge the subconscious automaticity in accordance with its simple – yet universal – tit-for-tat self-regulatory code. This new model is also fully testable, and as I hope to have shown, many of its predictions are already well-established as facts across the social as well as physical sciences.

On the other hand, the model is not without its vices. *Accessibility* is of primary concern, due to its departure from traditional assumptions and approaches, if not *antipathy*, given that its inversions of reasoning upset several paradigmatic apple-carts. Investigations will require healthy doses of curiosity, humility, and courage, and transcendence of predictably painful self-preservationary signals. But mostly it will require a broader scientific lens – an interdisciplinary inquiry and a *synthesis* of biophysical facts – perhaps particularly challenging in an academic landscape that privileges reductionism (Kauffman, 2007), trends toward ever more detailed analysis and career specialization, and thereby engendering the very blind-men/elephant conundrum that plagues emotion theory.

It will also necessitate a revised vocabulary for the feeling signals themselves. Indeed, words fail; and even exploring the model's implications will require building a new lexicon, one with terms that more accurately depict the biophysical origins, temporal significance, and elegant complexity of emotional feeling perceptions. For example, when based upon the ancient approach/avoid behavioral dimension (aka "emotivational goals" (Roseman, Wiest, & Swartz, 1994) as well as the dual self-regulatory purposes, both the basic emotion of *anger* (Lerner & Tiedens, 2006; Harmon-Jones, Schmeichel, Mennitt, & Harmon-Jones 2011) and the complex emotion of *guilt* (Tangney, Wagner, Hill-Barlow, Marschall, & Gramzow, 1996; Sheikh & Janoff-Bulman, 2010) might better be categorized as *positive emotions*. Likewise, positive emotion labels such as *determination, faith,* or *honor* added to the complex category might be better still in describing the moral nuances of anger and guilt. In short, we will need to build a new vocabulary; one that is functionally tethered to the biophysical underpinnings; one that rightly privileges our hedonic evaluations, one that links appraisal information with universal human needs, one that is not freighted with mind-body dualism or the good/evil dichotomy, and one that has been laundered of the pejorative connotations that suppressive emotion regulation presupposes.

The model may also challenge the ecological validity of some standard empirical approaches, ranging from laboratory emotion induction and self-reports (such as PANAS), to statistical analysis (wherein a more Bayesian paradigm would honor the feedback dynamics, the self-relevant nature of emotion, the subjectivity of the investigator, and the observable real-world behavioral patterns. See: Berger & Berry, 1988; Raferty, 1995; Körding & Wolpert, 2004). In short, the model poses some heady challenges for social scientists.

The virtues of this model, however, suggest surmounting such hurdles to be a worthy pursuit. For, to my knowledge, it is the first model of emotion to be devoid of neurocentricity and rooted in the fundamental hard-science biophysical principles beyond the conventional interpretation of Darwinian evolution. In fact, while he wondered whether or not emotional facial expressions may be vestigial (Barrett, 2011), Darwin himself recognized the bottom up behavioral automaticity and positive feedback in his "principle of direct action", the negative feedback dynamic in his "principle of antithesis", and anticipated the self-developmental Pavlovian conditioning and its feed-forward manifestations in his "principle of serviceable associated habits" (Darwin, 2005). He also endorsed Alexander Bain's "fundamental law of pleasure and pain", which states that pleasure is connected with an increase and pain a decrease in vital power (the tit-for-tat self-regulatory code), a law founded upon "the principle of self-conservation, the *self-regulating, self-acting impulse* of the animal system" (Bain, 1874; emphasis mine). Had Darwin been privy to modern understandings of the chemical networks, computational, and regulatory dynamics involved in genetics, epigenetic inheritance (Jablonka & Lamb, 1999, 2005), social genomics (Cole, 2009) and neuroplasticity (e.g. van Praag, Kempermann, & Gage, 2000), it seems likely he would have noted the importance of here-and-now environmental interactions and behavioral responses, and perhaps more pointedly given emotion its functional due. Still, despite his laudable parsimony, Darwin concluded that "the 'language of emotion' is certainly of importance for the welfare of mankind" (Darwin, 2005).

Indeed, in addition to unifying many seemingly separate and unrelated bodies of literature, this model affords science a pioneering inroad into the territory of *values* – the "spiritual judgments" according to the great William James (1958). It allows us to reexamine and transcend the naturalistic fallacy, providing a language of embodied bio-values against which to contrast, inform, and assess our standard philosophical and religious assumptions. To the moral and ethical theorist, it shifts morality into the realm of public health with 'right' and 'wrong' states concerning biophysically universal requirements, conditions and optimal balances for all life forms. To the psychologist it offers a hard-science bedrock for the 'positive' in "positive emotions" (Fredrickson, 1998) and "positive psychology" (Seligman & Csikszentmehalyi, 2000) as well as the 'positive' adaptive functions of the 'negative' emotions and insight into why they are so insistent.

Better, the model places *purpose* in an evolutionary context, with both positive and negative relating to universal self-regulatory purposes to which the biovalues of all living systems are tethered. Indeed, to recognize our teleological end-directed purposes is to fill a "gaping hole" in our understanding of our world and our place within it – "the intrinsic value in humankind" (Deacon, 2011). In fact, given the emerging global village, science is clearly needed to weigh in on the issue of values lest we retreat into conflicting religious fundamentalisms (Kauffman, 2008; Harris, 2010).

Finally, this model offers a much more optimistic portrait of human nature – if not of nature itself. It suggests that cohesion, cooperation and adaptive creativity are as deeply rooted in our evolutionary history as red-in-tooth-and-claw competition and random mutation. It suggests that nature is green with grace and embrace, balancing self-preservationary necessities with self-developmental synergy, and that it is our feeling sense that defines us – and defines us as good: ('Sentio ergo sum…..bonum'!) It allows us to imagine and progress toward a future wherein our existing 3rd party morality (regulating one another via negative emotion; Rosen, et al, 1999) is transcended by our natural 1st party moral impulses that are driven predominantly by the complex positive emotions, yet still steered – realistically course-corrected – by the basic pains. For example, rather than exploiting contempt, Ethics of Community could be mediated by reciprocal expressions of *compassion*, *curiosity*, *respect, mirth,* and cooperative public *trust*; the Ethics of Divinity, by humanitarian *devotion*, *gratitude, love, forgiveness*, and *awe/humility*, *wonder, inspiration,* and *faith* in the integrity, ordered beauty, symmetry and mystery of nature; the Ethics of Autonomy – our primary self-regulatory imperative – by honoring the universal messages of basic *anger, sadness*, *disgust,* and *fear*, bolstered by complex *authenticity, admiration, zeal, self-respect*, *integrity, honor, pride*, and *happiness*.

Still, aside from a better scientific foundation, this isn't really a new story. It has been with us since time untold, for even the ancients – Plato, Aristotle – recognized moral virtue as rooted in the judicious use of pleasure and pain. But reframing emotion as a self-regulatory sense, offers a more judicious appreciation of the biological fact that first and foremost, emotion is actually – and rightly – *regulating us*. Indeed, as Jeremy Bentham suggested, our "sovereign masters" of pleasure and pain "point out what we ought to do as well as determine what we shall do". And, that their perceptual persistence is not only devoid of vestigial or original "sin", but may offer our only salvation from it.

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