Journal of Behavioral Economics for Policy, Vol. 5, John Tomer Memorial Issue, 7-38, 2021

Dual motive theory as the biological mecca of the economist. Fulfilling the undeveloped insight of Alfred Marshall. Famed synthesizer of neoclassical economics

Gerald A. Cory, Jr.[1, 2]*

Abstract
Alfred Marshall (1842-1924), acclaimed neoclassical synthesizer famously made the prophetic statement that the Mecca of the economist lies in economic biology. Since the supporting biological science did not exist in his day, Marshall went on with the plagiarized model from physics and did the best that he could. *Behavioral* economics is, by implication or definition, organic or biological. Economics is social behavior, not physics. Physics works the same everywhere. Social behavior/exchange varies individually, situationally, and with the scale of inclusiveness. Economics deals with the social exchange behavior of human beings. It is, therefore, clearly biological or organic. Therefore, we must look to biology for a proper theoretical foundation. John Tomer was a pioneering figure in the move toward a behavioral, therefore biological, economics. Tomer was a thinker who did not get trapped into a narrow focus on the so-called cognitive, hedonic, self-interested side of the behavioral movement that clung to the narrow self-interest motive adopted simplistically through the effort to ape the scientific prestige of physics. Tomer sensed that the cognitive, hedonistic, as a carryover from the modeling of physics, was inadequate as an organic paradigm and recognized the significance of DMT which included the empathetic other-interested side of economics and all forms of social exchange. In the last few years he adopted the approach of DMT and made contributions to its development. In his final book review of the author's *Delusions of Economics and the Way Forward* he made a clear call for economics to follow the DMT path. It is fitting that he be acknowledged as participating in the fulfillment of the yet undeveloped insight of the noted neoclassical synthesizer, Alfred Marshall of Cambridge University, as well as contributing to the correction and fulfillment of neoclassical theory.

JEL Classification: A12; B00; D01; N00

Keywords
dual motive theory — evolutionary brain science — conflict systems neurobehavioral (CSN) model — social brain — socio-economic exchange behavior — empathy in economics

[1] *Senior Fellow, Graduate Studies and Research, San Jose State University (Retired)*
[2] *Professor Emeritus, International Technological University*
***Corresponding author**: augustuscory@msn.com

> Gerald Cory has done a great job of explaining the essence of dual motive theory and its importance. It is now up to the rest of us to develop it further and demonstrate its relevance to many aspects of the economy. (Tomer, 2018: 25)

Introduction

Dual Motive Theory (DMT), which I introduced to economics in a series of publications beginning in the mid 1990s, was based upon my Stanford University doctoral thesis completed in 1974. It was kicked into greater prominence by the support and contribution of Gary Lynne, a professor of economics at the University of Nebraska, beginning with a book review in 2002. DMT is now a well-developed theory built upon a recognized and affirmed foundation in the biological sciences of comparative evolutionary neuroscience and the physiological (organic) concept of homeostasis.

Foundations of economics in the biological sciences

The first relevant biological science that standard economics doesn't connect with is evolutionary brain science. Adam Smith (1723–1790), the acknowledged founder of economics, had no access to the findings of evolutionary brain science. The discipline simply didn't exist in his day. The model of science at that time was the physics of Isaac Newton (1643–1727) describing the forces driving the workings of a clocklike mechanical universe. Nor did Smith's followers – throughout the 19th and early 20th centuries – have access to evolutionary brain science as they sought to make economics a true science modeled along the lines of Newtonian mechanics plus later developments in nineteenth century physics in which vectors of invisible law-like forces of nature led to a state of universal equilibrium.

Along came Marshall biology as "Mecca" of economics

British scholar Alfred Marshall (1842–1924) has long been acknowledged as a leading architect of neoclassical economic theory – that theory built mainly upon a mechanical metaphor drawn from Newtonian mechanics and later 19^{th} century physics. Neoclassical theory prevails today and is the foundation of economic theory as presented in standard introductory college textbooks.

Despite his reliance upon the mechanical metaphor in his development of neoclassical theory, Marshall sensed that economics dealt with a more complex reality and required a more complex dynamic. His intuited but undeveloped assertion that economic biology is the "Mecca" of economics (1947: xiv) has nevertheless resonated through the succeeding decades dominated by the mechanical metaphor. Neither he nor his followers, however, ever developed a theory that exploited the full potential of the biological Mecca. As Hodgson (1993) has so thoroughly explicated and discussed this subject, I will not replicate his efforts here.

Metaphors vs. linkages

Marshall's followers in institutional and evolutionary economics drew primarily upon *metaphors* taken from biology in their failed efforts to achieve influential theory. They avoided the task of establishing the *linkages* – not metaphors – that are necessary to the true unification of the sciences anticipated by the ancients as well as Herbert Spencer and E. O. Wilson, who wrote:

> The greatest enterprise of the mind has always been and always will be the attempted linkage of the sciences and humanities. (1998: 8)

In the unification of the natural and social sciences, then, *linkage rules* – not metaphor or analogy.

Marshall as synthesizer not innovator

Marshall was not a great innovator of new thinking but rather a great synthesizer. He pulled together the parts of the emerging neoclassical approach and framed them well. He also intuited the weaknesses of the essentially mechanical metaphor upon which the neoclassical edifice was built. That is, he saw the so-called laws of economics as *tendencies* rather than the precise laws of Newtonian mechanics. He also saw useful metaphors for economics in the organic hierarchy of interrelated parts and their growth, development, and evolution. Although some later scholars, such as Veblen and other institutionalists made use of the biological metaphors of organic growth and evolution, they never succeeded in achieving an integrated body of theory to challenge the dominance of neoclassical economics.

In the paragraphs that follow, I will develop the case for the biological sciences of evolutionary brain science and human physiology as a proper foundation for economics. I do not consider this effort, primarily, a challenge to neoclassical theory, but rather, a fulfillment of Marshall's undeveloped insight.

The three-phase evolutionary transition to humanity

Evolutionary neuroscience, emerged meaningfully on the scene in the last decades of the twentieth century. In accounting for the evolution of the human brain, key comparative neurobiologists have generally followed a three-phase transitional framework. This framework generally begins with the appearance of amniotes, one group among those vertebrates that ventured out of the sea onto land about 350 million years ago.

So, what are amniotes? Amniotes are those four-legged terrestrial vertebrates that evolved a tough membrane cover of the reproductive DNA carried by eggs (and later in placentas internal to the mother) that facilitated the survival of DNA-bearing eggs on land. This was a protective membrane covering called the amnion that was not needed in the home environment of water. The amnion may be thought of as capturing a portion of the watery environment for the safe development of the reproductive DNA into embryos, fetuses, and ultimately living offspring. The watery environment within the amnion is called the amniotic fluid.

So, who are amniotes? Amniotes are the ancestors of mammals, reptiles, and birds. As descendants of ancestral mammals, we humans are also amniotes. The fact that we are all amniotes is important to remember because subsequent terminology often is the source of confusion. As the amniotes evolved differing characteristics along two divergent lines, we gave them different names: the many diverse names given the various species of mammals, reptiles, and birds. Sometimes this re-naming has led to a forgetting or obscuring of our fundamental ancestral amniotic identity.

The point of divergence marks the last common amniote ancestor of the mammalian (synapsid) and reptilian (diapsid) lines. The two divergent amniote lines continued to evolve independently over millions of years, modifying and expanding the neural structure inherited from the ancestral amniotes. In considering human brain evolution the synapsid amniote line leading to mammals and ultimately to primates and humans is of primary interest. The diapsid amniote line went its own way to become reptiles and, later, birds. The diapsid line did not contribute to mammalian or human brain evolution. It is of interest to human evolution chiefly on a comparative basis.

The original point of synapsid amniote divergence marks the end of the first transitional phase leading to human brain evolution and the beginning of the second phase. At the point of divergence, our ancestral amniotes were creatures who were structured neurally for self-survival. They laid eggs and left them to hatch alone, showing little or no capacity for parental care. They were ectothermal or cold-blooded depending on the environment and behavior for the warmth necessary to survival and reproduction. The second phase considers the subsequently evolved synapsid-mammalo-amniote neural structures that brought parental care, social bonding, and endothermy or warmbloodness. The appearance of these mammalian neural structures depended on modification, diversification, and elaboration of rudimentary neural structures inherited from the amniote line before the point of synapsid divergence.

The third phase considers the most recently evolved neural structures of the synapsid line's higher primates and homo sapiens with the appearance of dramatically expanded social and cognitive abilities.

Paul MacLean and Ann Butler

In discussing the positions of scholars articulating the three-phase evolutionary transition of the human brain, I will limit myself to work of pioneer evolutionary neuroscientist, Paul MacLean, and the re-work of his three-phase concept by comparative evolutionary neuroscientist, Ann Butler.

Paul MacLean (1913–2007), long-time head of the Laboratory of Brain Evolution and Behavior of the National Institutes of Health, was one of the first evolutionary neuroscientists to propose a three-phase evolutionary transition to the appearance of the human brain. He was one of the most notable pioneers in the emergent field.

The mismeasure of MacLean's triune brain modular concept

MacLean's well-known triune brain concept is not only one of the earliest efforts to articulate the three-phased evolutionary transitions leading to the human brain, it is also one of the earliest modular concepts of the brain.

Since its initial publication in the mid 1960s, the concept has been well-received in the field of medicine. As recently as 1992, it has been acknowledged to be the single most influential idea in brain science since World War II (e.g., Durant in Harrington 1992: 268). Nevertheless, it has largely been overlooked by academic neuroscience, cognitive psychology, and other social sciences, including economics.

This anomalous situation – in which the pioneering three-phased modular statement of brain organization coming from neuroscience itself and providing a natural match with aspects of the modular cognitive approach – has been brought about, in part, by a couple of seriously flawed reviews of MacLean's (1990) masterwork that appeared in the influential journals *Science* (1990) and *American Scientist* (1992). The effect of these faulty reviews has been to deny the use of MacLean's very significant research and insights to researchers in the psychological as well as the social science community, who relied upon the authority of these prestigious journals.

A resurgence of interest

A considerable, well deserved, and important resurgence of interest in MacLean's work has occurred in very recent years. For example, the reader is referred to Damasio 1999; Lieberman 2000; Cory, 1992, 1999, 2000, 2004; Cory & Gardner, 2002; Panksepp, 2002; Lambert & Gerlai, 2003. The latter scholars edited an entire issue of the journal *Physiology and Behavior* devoted to MacLean in which leading scholars discussed the importance of his work to modern neuroscience and medical physiology; see also, Wilson & Cory, 2008; Newman & Harris, 2009. Sapolsky (2017) also finds MacLean's work helpful as a framework for understanding the brain.

In the more popular science field Michio Kaku, a prominent physics scholar, in his *The Future of the Mind* (2014) acknowledges the importance of MacLean's evolutionary concept of human brain development (see especially pp. 18–21). It is also significant that the development of molecular genetics in recent years has brought new support to MacLean's concepts. Molecular genetics, like MacLean, emphasizes the remarkable conservation of evolved brain architecture from our ancestral vertebrates.

As Tom Insel, Director of the US National Institutes of Mental Health (NIMH) significantly and appropriately stated in a New York Times obituary, MacLean's research opened the door for neuroscience to "ask big questions about consciousness and philosophy, instead of the more tractable questions about vision and movement" (NYT. January 10, 2008). Such overdue and well-deserved acknowledgment of MacLean's pioneering work is indeed welcome.

MacLean's concepts of the limbic system and the tri-level modular brain, when properly represented, are soundly grounded in evolutionary neuroscience, and with some clarifications, are among the most useful concepts for linking neuroscience with the more highly integrated concepts of the social sciences. The presentation that follows here is adjusted to accommodate criticisms that raise valid questions.

The interconnected three-phase human brain

In his thoroughgoing, encyclopedic summary of the previous fifty years of brain research, MacLean (1990) documented the human brain as an evolved three-level, interconnected, modular structure (Figure 1). The well-known graphic was, of course, oversimplified – even though the detailed discussion in his 1990 masterwork was much more comprehensive. Butler referred to this oversimplified graphic as the "mammalian chauvinist" version since it focused primarily on mammalian brain evolution and omitted components also rudimentarily present in what she called the "reptilian chauvinistic" version (2009: 1186, figures 1 & 2). When understood properly, which MacLean attempted to clarify in his 1990 classic, the tri-level structure includes – rather than separate brains – interconnected and elaborated neural circuitry from major periods of human evolution.

The tri-level structure includes a component of self-preservational circuitry reflecting gene-based continuity from our ancestral stem amniotes. We split off from these stem vertebrates, as did the dinosaur ancestral line, during the Permian period some 300+ million years ago. Based on new scientific thinking since MacLean formulated his concept, it is appropriate to call this the early amniote neural complex rather than the reptilian or protoreptilian complex.

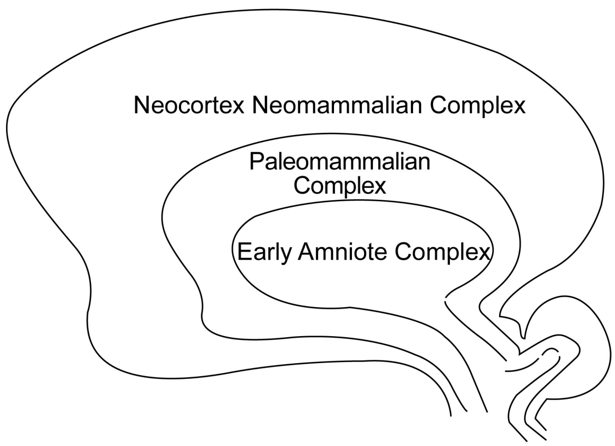

Figure 1. The tri-level brain modified from MacLean (Cory, 2004, 2012; Wood, et al., 2015: 147).

Current thinking on the timing of the point of divergence

It is currently thought that the synapsid-mammalian ancestral line diverged from the ancestral amniote line some 320 mya – about 10 million years prior to the divergence of the diapsid-reptilian line – and before that line produced development of anything like a modern reptile (from which dinosaurs and birds diverged much later) (Butler & Hodos, 2005: 80–81; Evans, 2000: 109–111). A yet perplexing problem among scholars is that there is no definable group of "reptiles" that means anything more than those amniotes that are not mammals or birds and some scholars still speak of reptiles in our synapsid/mammalian ancestry (e.g., see Zimmer, 2014: 84).

MacLean's phases two and three

MacLean's transitional phases two and three were represented in his graphic by the tri-level structure that included a later modified and elaborated mammalian affectional neural complex comprising a greatly elaborated limbic system topped by a most recently modified and elaborated neocortex (isocortex or neopallium) representing the higher centers of the human brain.

As brain evolution continued in the branching synapsid amniote line leading to humans, simple ancestral amniote or early vertebrate brain structure was not replaced. As noted earlier, in keeping with what we have learned recently from gene molecular studies, evolution always builds upon preexisting structures. Genes reflect continuity. They don't just pop out of nowhere to create new structures. They usually experience minor variations that lead to modification and elaboration of existing structures. In control genes, however, which direct the activity of other genes, minor modifications may occasionally lead to significant change – even the appearance of new species (see Gehring, 1998; Pollard, 2009; Hubisz & Pollard, 2014).

Early Amniote structure master routines of life support

The early amniote structure, then, gave us the DNA-directed substructure or gene-based continuities (called homologues) for later brain development. It did this while largely retaining its basic character and function. The mammalian modifications and neocortical elaborations that followed reached the greatest development in the brain of humankind. We must understand the qualitative differences of the three interconnected levels to appreciate the dynamics of human social experience and behavior.

The stem amniote neural circuits in humans mainly do the same job they did in our ancestral vertebrates. They run the fundamentals, or daily master routines, of our life-support operations: blood circulation, heartbeat, respiration, basic food getting, reproduction, and defensive behaviors. These were functions and behaviors also necessary in the ancient ancestral amniotes as well as earlier amphibians and fishes. These earlier vertebrates had to do these things to stay alive, reproduce, and become our ancestors.

Early mammals: Warm-bloodedness, parental care, play and social bonding

The next developmental stage of our brain comes from rudimentary mammalian/amniotic life. This set of circuits is also known collectively as the limbic system. These limbic tissue-clusters developed from gene-based continuities and homologues preexisting in the ancestral amniote neural complex. They included significant elaboration of such physiological structures as the hypothalamus, the amygdala, the insula, the hippocampus, the thalamus, and the probable innovation of the limbic cingulate cortex. Behavioral contributions to life from these modified and elaborated paleo-mammalian structures or limbic system included, among other things, the mammalian features (absent in our ancestral amniotes) of warm-bloodedness, nursing, infant care, socially interactive play, and extended social bonding. These new characteristics were neurally integrated with the life-support functional and behavioral circuitry of the stem amniote circuits to create the more complex form of amniotic mammals. Even basic texts acknowledge the well-established differences that mammals evolved – sometimes without attribution to the pioneers who identified them. Carl Zimmer, in his well-done textbook on evolution, for example states:

> Our relationships with other people – particularly with our family – lead to many of our most intense emotions. These bonds also have an ancient

> history. Among early mammals, strong bonds evolved between mothers and their offspring. Instead of laying eggs and then abandoning them, as reptiles typically do, mammal mothers nurse their offspring. Their young may remain helpless for weeks, months, or even years, during which time they need their mother's protection. (2014: 390)

The neocortex and greater complexity of behavior

The neocortex, which MacLean called the neo- or "new" mammalian brain, is the most recent stage of brain modification and elaboration. This great mass of bi-hemispherical brain matter dominates the skull case of higher primates and humans. It gained its prominence by elaborating the preexisting gene-based continuities present in the brain of earlier ancestral amniote vertebrates. Gradually – perhaps more precipitously in the gap between chimpanzees and humans (see Pollard 2009) – it overgrew and encased the earlier ("paleo") mammalian and ancestral amniote interconnected neural tissues. It did not, however, replace them. As a consequence of this neocortical evolution and growth, these older brain parts evolved greater complexity and extensive interconnected circuitry with these new tissue clusters. In that way, they produced the behavioral adaptations necessary to life's increasingly sophisticated circumstances.

Butler and the three-phase transition

Ann Butler, a prominent comparative neurobiologist of George Mason University has recently offered a revised version of MacLean's triune brain concept (2009). This revision is motivated by an acknowledged need to respond to criticisms that I made (1999, 2002a), especially of the *Science* article by Reiner (1990). In her own words:

> As someone thus already involved in the continuing dispute, I will endeavor to be as objective and dispassionate as possible in presenting MacLean's triune brain concept and also the objections to it raised by comparative neuroscientists, recognizing that my own background and knowledge of brain evolution unavoidably influence and inform my perspective. Also, since Cory characterized Reiner's criticisms as 'destructive' rather than 'constructive,' in that Reiner did not offer a 'replacement generalization,' I will do so here. (2009: 1185)

Butler then lists two alternative concepts to characterize her replacement generalization:

1. An objective terminology model for amniote brain evolution.
2. An evolutionarily accurate model of mammalian brain evolution.

She states these will clarify why most comparative neurobiologists view the triune brain concept as they do. Further on, she makes the profoundly important statement from the perspective of consilience (unifying the natural with the social sciences).

> Of great importance for those whose research is focused on human behaviors – including social, psychological, and economic as well as pathological conditions such as those of the basal ganglia – is that the 'replacement generalizations'. . . , the objective-terminology model for amniotes and the evolutionarily-accurate model for mammals, do not contradict or undermine any of their findings or theoretical base. These models simply rectify the conceptual approach with the full range of comparative evolutionary data on brain evolution. (2009: 1185-86)

An objective terminology

Let's consider the first of Butler's alternative concepts to characterize her replacement generalization.

1. The use of term *nonlimbic pallium* to refer to the developing cerebral cortex.
2. The Common Amniote Formation or A-Complex to replace and expand MacLean's Reptilian Brain or complex.
3. The Stem Mammalian Formation to replace and modify MacLean's Paleo-mammalian Brain or complex.
4. The Therian Formation to replace and modify MacLean's Neomammalian Brain or complex.

An evolutionarily accurate model

Butler's replacement generalization, then, as an evolutionarily accurate model of mammalian brain evolution would be graphed from top to bottom as follows beginning with the mammalian subclass of Theria:

Therian formation

Therian mammals: Include the marsupials as well as the eutherians (placental mammals). These mammals have additional association neopallial areas, an expanded prefrontal cortex, and the corpus callosum fiber tract connecting the two hemispheres of the brain

Stem mammalian formation

Stem mammals: These early mammals possibly see the addition of the thalamocingulate component to the limbic system with the neopallial cytoarchitecture of the cingulate gyrus; expanded sensory, motor, and association pallial areas, including prefrontal cortex all with neocortical cytoarchitecture.

Common amniote formation or A-complex

Common amniote ancestor: The neural architecture of the common amniote ancestor included basal ganglia, major limbic system components, primary sensory, motor plus a few association pallial areas.

The higher primates and, of course, we humans have the greatest expanded areas of the neopallial or neocortical areas of the eutherian brain providing for the high level of parental care, social bonding, and cognitive skills that we display.

The main disagreement of comparative evolutionary neurobiologists with MacLean's triune brain graphic is that it did not recognize or include major limbic system and pallial components of our common amniote ancestor in his concept of the Reptilian Brain or complex. I will not attempt here to reconstruct a triune graphic in the style of Butler (2009: 1191) because it also is a simplified representation of a more complex process. If I were to modify the graphic I presented previously in Figure 1, I would have to, as a minimum, significantly increase the area covered by the early amniote complex.

A welcome "replacement generalization"

I welcome this revised version or "replacement generalization" offered by Butler. It corrects perceived difficulties with MacLean's triune brain concept and affirms the three-phase evolutionary transition leading to the evolution of the human brain. As noted previously, she stated that it is of great importance that her alternative representation *does not undermine or contradict the theoretical basis of those scholars who applied MacLean's concept to social and economic behavior*. Her additions and corrections "simply rectify the conceptual approach with the full range of comparative evolutionary data on brain evolution." (2009: 1185–86).

The path is clear, then, to proceed with the theoretical analysis that follows in this paper and that was presented in a number of my previous publications (1992, 1999, 2002, 2004, et al.).

But wait! There are a couple of cautionary pitfalls to acknowledge before going forward with our analysis.

First: There are no ancestral dragons

Unfortunately, stimulated by MacLean's presentation of the Reptilian Brain (or Complex), popularizers like Carl Sagan in his Pulitzer-prize winning *Dragons of Eden* (1977), and followed by some others, the reading public was led to believe erroneously that there were giant reptile-like dragons in our evolutionary ancestral line. Of course, based on more recent findings this is clearly not true.

It is now generally held that our synapsid/mammalian line split off from the ancestral amniote line several million years before the diapsid line that eventually produced what are now defined as reptiles, and later, dinosaurs and birds. By the revised chronology and definitions reptiles (dinosaurs) and birds are not in our ancestral line. Our amniote ancestor was more like a small rather unimpressive four-leg creature. It took about 100 million years or so from the Upper Carboniferous (320 million years ago) appearance of the synapsid line to the appearance of the first mammaliaforms in the upper Triassic Period (237–201.3 million years ago). According to T. S. Kemp such a span of time indicates how long it took to evolve from "a scaly, ectothermic (cold-blooded), sprawling-limbed, small-brained, and simple-toothed amniote to a fur-bearing, endothermic (warm-blooded), parasagittaly-gaited, large-brained, complex-toothed, and behaviourally complex mammal" (parenthetical terms added) (Kemp, 2016: 117).

Emphatically then, there are no reptilian dragons in the Eden of our ancestry! I doubt if one of the recent popular accounts, *Up From Dragons* (2002), would have sold as well if the title had read "Up From non-reptilian lizard-likes". It is notable, however, that some recent texts on evolution still surprisingly refer to reptiles in our ancestral line (e.g., see Zimmer, 2014: 84).

Second: The rise of epigenetics avoiding simple-minded genetic determinism

In broadest terms epigenetics is the study of changes in organisms caused by modification of gene expression without alteration of the DNA sequence of genetic code itself. The "epi" part means "above" or "on top of." Therefore, the word means on top of or above genetics. It is an emerging discipline with a yet fluid definition and set of parameters and accompanied in the popular literature by a lot of hype and exaggeration. For some researchers it includes all changes in the phenotype of the individual brought about by environmental experience (Blumberg, et al., 2010). And that environmental experience can range from hunger, deprivation, learning, education, and socialization (Kolb & Gibb, 2011). Other researchers define it to include only heritable changes that can be passed across generations (Berger, et al., 2008).

At its broadest definition epigenetics, then, is part of the nature/nurture conundrum that has always preoccupied science. It is phrased, however, from the biological perspective rather than the sociological or philosophical perspectives that have sought to avoid strict genetic determinism. If stretched to its definitional limit epigenetics could subsume all of what we think of as *nurture*.

Some special characteristics to keep in mind

Since epigenetic changes by definition do not alter fundamental DNA passed in the genome, for our purposes it can be thought of as concerning superficial or surface changes to fundamental genetically prescribed neural architecture and other human physiology that was laid down over millions of years of evolutionary adaptation. Epigenetic changes may be helpful or harmful. They have been found to underlie certain medical disorders to include some forms of cancer. Some epigenetic changes seem to be heritable; others such as learning are not. Epigenetic changes are also reversible. Fundamental DNA prescribed neural architecture is not – that is, not without serious invasive genetic intervention.

Nevertheless, *expression* of aspects of the fundamental neural architecture can be affected by epigenetic changes – that is what long-term memory or learning is all about. Both require gene expression, the creation of new proteins, to record the long-term memory or learning (e.g., see Kandel, et al., 2013: ch 66; Fioriti, et al., 2015). In the broader definition of epigenetics, education and proper socialization are included. And that is why they are so important! They help to direct our neural architecture into desirable homeostatic balance and social expressions.

A final important thought

As a final important thought, we should not feel overwhelmed by the presently seemingly sweeping definitions and claims of epigenetics. This is a new discipline still searching for its proper parameters. It is essential to keep in mind the fundamental fact that our neural architecture, like other aspects of our physiology, evolved in the environment of evolutionary adaptation – an environment that covered millions of years of evolution. The human species presently occupies practically every terrestrial clime on the planet – some long isolated from others

> – and we still recognize them as one of us!

Epigenetics does not change our fundamental humanity and our fundamental mammalian neural architecture is an essential component of that humanity.

Refining and defining human uniqueness

The unique features of our human brain were refined over a period of several million years in a mainly kinship-based foraging society where sharing or reciprocity was necessary to our survival. Such sharing and reciprocity strengthened the adaptive evolution of the now combined mammalo-amniotic characteristics of self-preservation and affection.

Ego and Empathy, self-interest and other-interest, are key features of our personal and social behavior. To connect these features to MacLean's as well as Butler's modified three-phased concept we need, at this point, a behavioral vocabulary rather than a neurophysiological one. We need a vocabulary that will express what the presence of our ancestral amniote self-preserving mechanisms and our stem mammalian affectional brain structures mean for our day-to-day, subjectively experienced, behavioral initiatives and responses to one another and the world we live in. I will draw the behavioral vocabulary, in part, from analogy with information and computer technology.

Of snakes, geckos, and sharks the self-preserving programmed circuitry

Our early amniote ancestors were ectothermic or cold-blooded and they did not have brain structures for any extended parental caring. Their care of offspring was, in most cases, limited to making a nest or digging a hole to lay eggs in. The eggs were, then, left to hatch on their own. The eggs and hatchlings were easy marks for predators. Further, some stem amniotes, not knowing their own offspring, would cannibalize them. It was not much of a family life. But the early amniotes continued to exist because they produced large numbers of eggs – enough to make sure some offspring survived to reproduce again and continue the species line. From the mainly survival-centered promptings of these ancestral amniote circuits, as elaborated in our human brain, arise the motivational source for egoistic, surviving, self-interested subjective experience and behaviors. Here we have the cold-blooded, seemingly passionless, single-minded, self-serving behaviors that we have generally associated with the present-day lizard, the snake, and that most maligned of fishes, the shark. And intuitively, we call our fellow humans who behave this way such names as snakes, geckos, and sharks. Here is a world revolving almost exclusively around matters of self-preservation. The stem amniote brain structures, then, will be called, following our high tech vocabulary, our self-preservation programming or circuitry.

Of caring and playful mammals the affectional programmed circuitry

But we humans are mammalian amniotes. We not only got the self-preserving circuitry of our early amniote ancestors, we got also the programmed circuitry for infant nursing, warm-blooded, passionate, body-contacting, playful, and social behaviors that we share with the lion, the wolf, the primates. The motivational source for nurturing, empathetic, other-interested experiences and behaviors arises from such circuitry.

> Here is a world in which nearly single-minded self-preservation is simultaneously complemented and counterpoised by the conflicting demands of affection. The early mammalian modifications, then, will be called our affectional programming or circuitry.

Our evolved networked brain and behavioral conflict

These core behavioral programs within us are built up of many contributing subroutines of our neural architecture. Neuroscientist Jaak Panksepp calls such core programs global-state variables since they sum up the effect of many subroutine circuits. He states that a network doctrine is needed to grasp such system-wide emergent dynamics (2002: xiv; see also Schulkin, 2002; cf. Rolls, 2016: 4, 10, 40–71).

These global-state circuits act as dynamic factors of our behavior. They are energy-driven by our cellular as well as overall bodily processes of metabolism, or energy production, as mediated by *hormones, neurotransmitters, and neural architecture*. And each is an inseparable part of our makeup, because each is "wired into" our brain structure by the process of evolution. The degree of gene control, however, does vary. Older brain parts, like the brain stem and parts of the limbic system, long established and necessary for survival, are under tighter gene control. Other more recent tissues, especially the higher centers of the neopallium or neocortex, depend a lot on epigenetic development and experience. We are set up for behavioral conflict simply by the presence of these two global-state energy-driven circuits in our lives – up and running, perhaps, even before birth. Their mere physical presence sets us up for a life of inner and outer struggle, as we are driven by and respond to their contending demands.

Conflict is more than an externally observed, objective ethical, moral, or decision-making dilemma, as much modern science tends to see it. We also feel it very strongly within ourselves. That is, inwardly or *subjectively*, we get feelings of satisfaction when we can express our felt motives. On the other hand, we get feelings of frustration when we cannot express our self-preservation or affectionate impulses in the behavioral initiatives and responses we wish to make.

The rise of behavioral tension

Behavioral tension then arises. We experience such behavioral tension as frustration, anxiety, or anger. And it arises whenever one of our two fundamental behavioral circuitries – self-preservation or affection – is activated but meets with some resistance or difficulty that prevents its satisfactory expression. This subjective tension becomes most paralyzing when both circuits are activated and seek contending or incompatible responses *within a single situation*. Caught between "I want to" and "I can't" – for example, "I want to help him/her, but I can't surrender my needs" – we agonize.

Whether this tension arises through the blocked expression of a single impulse or the simultaneous but mutually exclusive urgings of two competing impulses, whenever it continues unresolved or unmanaged it leads to the worsening condition of behavioral stress. The evolutionary process by which these opposing global-state promptings of self-preservation and affection were combined in us, however, gave us a great survival advantage. Their combined dynamic binds us together in social interaction and provides us with a wide range of behavioral responses to our environment – a range much wider than species lacking our dual motive circuitry.

Conflict: A mitigated curse

Our naturally conflicting programs are a curse, then, only to the extent that we fail to recognize them as a blessing. Our self-preservation and affection circuits allow us a highly advanced sensitivity to our environment. They impel us into social action and serve to keep our interactive social behaviors mostly within survival limits by giving us the ability to understand and appreciate the survival and affectional requirements of others. Ironically, the accompanying behavioral tension – *even the stress!* – is an integral part of this useful function. It allows us to more quickly evaluate our behavior and the effect it is having on ourselves and others.

> Behavioral tension serves as an internal emotional compass that we can use to guide ourselves through the often complicated and treacherous pathways of interpersonal relations. Behavioral stress tells us that we are exceeding safe limits for ourselves and others, and even for our larger social, economic, and political structures.

Our mammalian heritage: A dual motive neurobehavioral model

Evolutionary brain science is an emerging discipline. It, therefore, offers new opportunities for research in the fine detailing of our mammalian neural heritage. A mountain of research, however, some old some very recent, has established beyond doubt a couple of fundamental characteristics of the human brain. First, the brain is a physiological organ. Second, it is an organ evolved for social interaction. I will look at both characteristics in more detail.

The human brain: a physiological organ

Like other organs of the body – hands, feet, heart – the brain developed over many millennia to its present form in *Homo sapiens*. It evolved out of accumulated mutations – including mutations of the highly influential master control genes that can in some instances produce dramatic change by single mutations (Gehring, 1998; Pollard 2009; Hubisz & Pollard, 2014). Such mutations were confirmed by natural selection – that is, they generally helped us survive and reproduce – in the genetic information repository of our DNA. The brain, then, develops in each individual under the prescriptive guidance of DNA that, despite a considerable amount of developmental and experiential plasticity, assures a high degree of fidelity in the replication of fundamental brain architecture. The main features of our brain, like the main features of our human body plan (head, trunk, arms, legs), are expressed in common across our human species.

The social nature of the brain

Physiologically, the human brain is also an organ supporting *social* life. The social brain concept necessarily emphasizes both the self-preservation (self-interested) and affectional (other-interested) mammalian components necessary to social interaction. The *social brain* is an organizing concept heralded in a number of recent publications – *Human Evolution* (Dunbar, 2016), *Consilience, Brains, and Markets* (Cory, 2010), *The Evolutionary Epidemiology of Mania and Depression* (Wilson & Cory, 2008), *Attachment and Bonding: A New Synthesis* (Carter, et al., 2006), *Textbook of Biological Psychiatry* (Panksepp, 2004), *Foundations in Social Neuroscience* (Cacioppo, et al., 2002) and *Handbook of Affective Sciences* (Davidson, et al., 2003; see also, Cory & Gardner, 2002). Slightly earlier but related volumes include *Descartes' Error: Emotion, Reason, and the Human Brain* (Damasio, 1994), *The Integrative Neurobiology of Affiliation* (Carter, et al., 1997) and *Affective Neuroscience* (Panksepp, 1998). Recent years have thus brought great advances in detailing the many complex and interrelated pathways of interactive social circuitry in the brain.

Hunting, gathering, and *sharing*

The genes specifying social circuitry were selected over millions of years of evolutionary history in small kinship groups that required a cooperative interactive dynamic for survival. In fact, our survival strategy as an emerging species was not only hunting and gathering but also essentially *sharing* of the fruits of these activities. These dynamic social circuits motivate human social interaction and social exchange at all levels of our lives today. (e.g., see Humphrey, 1976; Isaac, 1978; Knauft, 1994; Erdal & Whiten, 1996; Boehm, 1999).

Executive circuitry and language

It is in that capacity to reflect, to self-consciously experience, generalize, and decide upon the tug-and-pull of our conflicting urgings, that we come to third stage of brain development in both MacLean's and Butler's models. That is, the "new" mammalian or neopallium brain structures – what I call the executive programming or circuitry. As well, our elaborated neopallium or neocortex provides us with the evolutionarily unique and powerful ability to use verbal and symbolic language. We can, thus, create concepts and ideas by which to interpret our consciousness. We can describe the feelings, motives, and behaviors that arise within us and in response to our social and environmental experiences. It is with this so-called executive circuitry or programming, then, that we acquire the ability to name, to comment upon, to *generalize*, and to *choose* between our contending sets of behavioral impulses.

Higher cognitive integration: Self- and other-interest

Self-preservation is commonly called, at a high level of cognitive integration, "egoistic" or "self-interested" behavior. We call affection, at an equally high level of cognitive integration, "empathetic" or "other-interested" behavior.

> Empathy allows us the critical social capacity to enter into or respond emotionally to another's self-interest as well as other emotional states.

The CSN model as a functional representation of physiological circuits

The CSN Model is a functional neurobehavioral representation of the underlying Conflict Systems Neurobehavioral (CSN) Complex. The CSN Complex refers to the actual physiological structures or circuits of the brain – the brain stem, basal ganglia, limbic system, and the neopalliam or neocortex. The CSN Model, then, is a functional schematic of that underlying physiology. The functional schematic of the CSN Model also represents the now scientifically well-established evolutionary transition from a primarily self-preserving ancestral amniote to a both self-preserving and other-preserving mammalian amniote to the highly social, cognitively powered human amniote species.

The functional approach may avoid future minor technical disagreements

By approaching the all-important three-part evolutionary transition from a functional perspective, the CSN Model attempts to avoid some of the minor rather technical disagreements that may yet arise among comparative evolutionary theorists. As Butler (2009) has so helpfully noted, the three-part evolutionary transition, first represented by MacLean's triune brain theory and more recently modified by herself, is not itself in question.

Although the positioning of Ego and Empathy in Figure 2 (facing the reader) is primarily for illustrative purposes only and is not intended to suggest a definitive lateralization, there is evidence to suggest that the right hemisphere is favored somewhat for emotion and the left for more analytical self-preserving behaviors (e.g., see Damasio, 1994; Tucker, Luu, & Pribram, 1995; Brownell & Martino, 1998; Henry & Wang, 1998; Stuss & Knight, 2002).

However, the total experience of emotion is not lateralized but involves dynamic interactions between forward and posterior regions of both hemispheres as well as subcortical (limbic) structures (Heller, et al., 1998). Therefore, such complex, highly integrated capacities as Ego and Empathy should more safely be thought of as engaging the interaction of both hemispheres (Beauregard & O'Leary, 2007; Decety & Ikes, 2009).

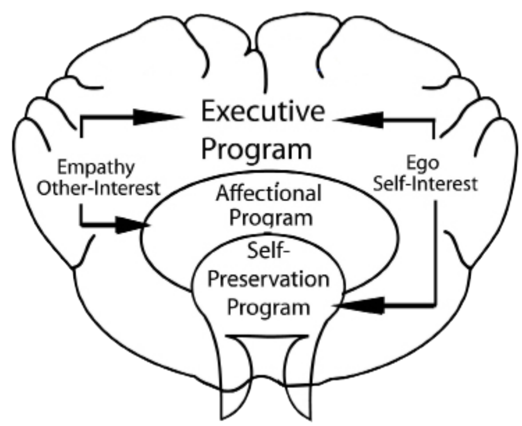

Figure 2. The Conflict Systems Neurobehavioral Model. A simplified cutaway representation of the brain showing the behavioral programs and the derivation of Ego/self-interested and Empathy/other-interested motives and behaviors. I should note that earlier models, e.g., Freud (id, ego, and superego) postulated three-part conflictual models. Freud, however, was unable to tie his model to brain circuitry and it remained ungrounded in neural science because brain research had simply not advanced to that point (Cory after MacLean, see Cory, 1992, 1999, 2000, 2001ab, 2002ab, 2003, 2004, 2006ab, 2009, 2010, 2018).

In other words, our executive programming, especially our frontal cortex, has the capability and the responsibility for cognitively representing these ancestral limbic and stem amniote brain connections and inputs and making what may be thought of as our moral as well as rational choices among our conflicting, impulsive, and irrational or nonrational motivations. This self-conscious, generalizing, choosing capacity accompanied, of course, with language, is what differentiates us from even closely related primate species and makes findings in primate behavior, although highly interesting and unquestionably important, insufficient in themselves to fully understand and account for human behavior.

The frontal neocortex has long been recognized to be involved in executive functions (Pribram & Luria, 1973; Fuster, 1980, 2008; Stuss & Knight, 2002; Leh et al., 2010). However, the more inclusive concept may be that the neural substrate of executive functions is a neural network that includes the synchronized activity of multiple regions, both cortical and subcortical.

Our early vertebrate and limbic circuits are interconnected neural network circuits that *subjectively* generate and drive specific, and *objectively* observable, behaviors. These core motivational (and emotional) circuits are connected largely through the thalamocingulate gateway to the executive frontal circuitry as well as other neocortical regions. In these higher regions, they are respectively represented as self-preserving Ego and species-preserving Empathy cognitions (e.g., see Berridge, 2003; cf. Saarela, et al., 2006; Tankersley, et al., 2007; Ward, 2013).

The neural substrate for self-survival Ego mechanisms likely proceeds from circuits in the brain stem, basal ganglia and rudimentary limbic structures (ancestral amniote complex) through connections with the elaborated amygdaloid and other limbic circuits to include an emergent cingulate cortex (early mammalian amniote complex), and probable other subcortical circuits, such as the insula, which add emotion or passion, ultimately to be gated into the frontal cortex by thalamocortical circuitry (see Jones, 2007; Sherman & Guillery, 2001; Devinsky & Luciano, 1993).

Likewise, the mammalian nurturing (affectional) substrate and its associated motivation, a fundamental component underlying Empathy, may originate in the septal and medial preoptic limbic areas. It may, then, proceed through hippocampal and amygdaloid circuitry, the insula, as well as other limbic structures (Carter, et al., 2006; Morgane, et al., 2005; Numan & Insel, 2003; Carter & Keverne, 2002; Taylor, 2002; cf. Porges, 1998).

Ultimately, and in turn, the affectional circuitry will largely be gated into the orbital, frontal, and other areas of the cortex by neuromodulating thalamocortical circuits (to include the cingulate cortex), where the conflict with egoistic inputs is resolved in the executive or global workspace of conscious self-awareness. Additionally, and more recently the temporoparietal junction (TPJ) of the neocortex has also been shown to be an important node within the social brain. A number of studies indicate that the TPJ may host or control representations of the self and/or other and be a significant player in the neocortical expression of Empathy and other sociocognitive processes (e.g., see Santiestaban, et al., 2012; for more recent research and discussion from an evolutionary perspective of the neural circuitry underlying self-survival and affectional behaviors and their gating into the frontal executive see Loonen & Ivanov, 2016; Rolls, 2016; Sherwood, et al., 2012; Abiotiz & Montiel, 2012).

The gating of dual motives

As noted above, the dual motives of self-survival and affection are largely gated into the neocortical executive by a structure known as the thalamus. The neuromodulating and gating of *affect* as well as cognition by the thalamocortical circuitry is a function well-known to medical neuroscience. The role of the thalamus as the essential gating structure of the myelinated cables passing from the subcortical motivational circuitries, into the higher cortical areas, has long been established (e.g., see Devinsky & Luciano, 1993; Jones, 2007; Ward, 2013).

It was these fiber tracts that were cut in the well-intended, but now notorious psychosurgical procedures of the 1930s–1950s. Lobotomies, leukotomies, and other similar procedures were deliberate efforts to disconnect the frontal cortex from the lower archetypal motivating circuitries. The objective was to reduce anxiety, violence, and other unwanted behaviors.

Psychosurgery as clear evidence for dual motive theory

The psychosurgical procedures were largely effective in achieving their objective. They regularly produced what medical science, euphemistically called "flat affect." That is, reduced or no Ego and Empathy. Some critics to this day complain that the current drugs used in treating such symptoms have the same intention and effect – deactivation of the emotional and motivating circuitries (Breggin, 2008).

The psychosurgical practices of the 1930s through 1950s provide some of the clearest physiological evidence for dual motive theory. The archetypical neural circuitries, their thalamocingulate gating mechanisms, and their frontal connections were known facts of physiology. The work done on humans had previously and since been confirmed by experiments upon other primates (Fulton, 1951; O' Callaghan & Carroll, 1982; Valenstein, 1986, Housepian, 1998; Pressman, 1998).

Recent research has further indicated that Empathy has both emotional and cognitive components activated by different but overlapping areas of neural circuitry (Singer, 2006; Blair, 2003). Perhaps mirror neurons, recently reportedly found in humans (Rizzolatti, 2011) as well as other primates, may serve as switches to activate and access the rather wide-ranging but overlapping areas of neural circuitry. This overlapping is summed in the CSN Model, with its varying mixes of Ego and Empathy across a spectrum of behavior.

The major ranges of social behavior

The two master archetypal programs of self-preservation and affection that have been wired into our brain structure operate dynamically according to a set of behavioral rules or algorithms. We experience the workings of these algorithmic rules internally. We also express them externally in our interpersonal behavior. We need to understand the workings and applications of these algorithms to grasp the role of conflict, tension, and stress in our personal and interactive lives. The major ranges of the CSN Model (Figure 3) show graphically the features of this Ego-Empathy dynamic. In the display, both internally felt as well as overt interpersonal behavior is divided from right to left into three main ranges. From right to left, they are the egoistic range, the dynamic balance range, and the empathetic range.

The source of all motives

Each range represents a varying mix of egoistically and empathetically motivated behaviors. The solid line stands for Ego and pivots on the word "Ego" in the executive program of the brain diagram. The broken line stands for Empathy and pivots on the word "Empathy" in the diagram.

Before going further, I wish to emphasize an important, but not necessarily obvious point. That is, all behavioral motives emerge from and are expressive of our mammalian neural architecture. Ego and Empathy are the most fundamental of motives. All other motives – and an endless proliferation of them appears in the both scientific and popular literature – derive from the Ego/Empathy dynamic. All the expressions of Ego/Empathy included across the spectrum – some of which are listed above each range of the behavioral spectrum in the graph can be viewed as motives. After all, they are energized expressions of behavior derived from our archetypal neural architecture.

The egoistic range

The egoistic range indicates behavior dominated by our self-preserving circuitry. Since the two behavioral programs are locked in inseparable unity, Empathy is present here, but to a lesser degree. Behavior in this range is self-centered or self-interested. It may tend, for example, to be dominating, power-seeking, or even attacking, where Empathy is less. When Empathy is increased, Ego behavior will become less harsh. It may, then, be described more moderately as controlling, competitive, or assertive. As Empathy is gradually increased, the intersection of the two lines of the diagram will move toward the range of dynamic balance. That is, Ego behavior will be softened as Empathy is added. But the defining characteristic of the egoistic, self-interested range is *self-over-others*. Whether we are blatantly power-seeking or more moderately assertive, in this range we are putting ourselves, our own priorities, objectives, and feelings, ahead of others.

The empathetic range

The empathetic range represents behavior weighted in favor of Empathy. Ego is present, but is taking a back seat. When Ego is present minimally, empathetic behavior may tend to extremes of self-sacrifice and submission. When Ego is increased, empathetic behaviors are moderated. We can then describe them as supportive, responsive, or any of a variety of "others first" behaviors. As the influence of Ego is gradually added, empathetic behavior will approach the range of dynamic balance. In the empathetic range, the key phrase to remember is *others-over-self* or others first. Whether we are at the extreme of self-sacrifice or more moderately responsive, we are putting the priorities of others ahead of our own.

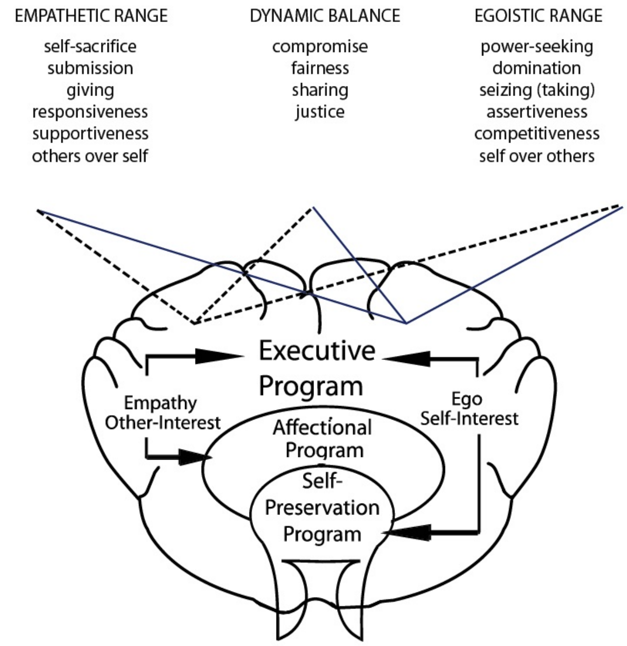

Figure 3. The Major Ranges of Reciprocal, Conflict Behavior (Cory, 1974–2018). The dynamic of the model, the tug-and-pull of Ego and Empathy, allows the expression of the mix of motive and behavior as a range or spectrum. The usual dichotomizing of self-interest and altruism is seen only at the extremes of the spectrum. For a neural network modeling of the dynamic see Levine (2006), Levine & Jani (2002).

The dynamic balance range

The range of dynamic balance represents a working balance between Ego and Empathy. At this point our behavioral circuitries are operating in roughly equal measure. I speak of "working," "rough," or "dynamic" because the tug-and-pull between the two programs continues ceaselessly. The dynamic nature of the neural architecture means that "perfect" balance may be a theoretical point, unattainable in practice. Our more balanced behavior tends to express equality, justice, sharing, and other behaviors that show respect for ourselves and others. In fact, respect for self and others is the keynote of the range of dynamic balance.

Energy or activation level escalation and de-escalation

The extent to which the circuits of self-preservation and affection are out of balance, or pulling against each other is a measure of behavioral tension. We experience this behavioral tension both internally and between ourselves and others in any relationship or interaction.

But that is not all.

Excessive, unmanaged or unresolved tension engenders behavioral stress along a range of behavior. But the amplitude of escalating or de-escalating energy we invest in the interaction or the relationship is an equally important factor affecting behavioral stress and its multiple physiological manifestations. Much of this arousal occurs automatically by activation of the HPA (hypothalamic-pituitary-adrenal) axis. Nevertheless, it is also under cortical control to a significant degree. We can put more energy into activities and responses for which we feel enthusiasm – less into others. In highly competitive sports or contests, qualitative differences in energy are easily observed. In intellectual contests, like chess, the energy may be intense, but less obvious.

Such arousal level – or escalation/de-escalation – is applicable across the Ego-Empathy spectrum, giving us two essential axes of social behavior.

The Ego-Empathy and escalation/de-escalation axes, thus, are two of the most essential axes of social behavior. For an alternative graphic representation of these axes, see Wilson and Cory (2008: ch. 10). From the descriptions of these two axes given above I can put together the reciprocal algorithms of our social behavior.

From Figure 3 representing the major ranges of behavior, we saw the dynamic of our neural architecture displayed graphically. Here, I will supplement that visual reference by a precise verbal description of that global-state, interactive dynamic. From the dynamic interplay of Ego, Empathy, and activity or escalation/de-escalation level come a series of algorithmic rule statements.

The first rule
describes the egoistic range

1. Self-interested, egoistic behavior, because it lacks Empathy to some degree, creates tension within ourselves and between ourselves and others. The tension increases from low to high activity levels. And it increases as we move toward the extremes of Ego.

Within ourselves, the tension created by the tug of neglected Empathy is experienced as a feeling of obligation to others or an expectation that they might wish to "even the score" with us.

Within others, the tension created by our self-interested behavior is experienced as a feeling of imposition or hurt, accompanied by an urge to "even the score."

In the behavior of children

Children often reveal the dynamic of such behavior in a clear, unsophisticated form. Imagine two children playing on the living-room floor. One hits the other. The second child hits back, responding in kind. Or the children may not hit each other at all. One might instead call the other a bad name. The second child reciprocates, kicking off a round of escalating name-calling. One child may eventually feel unable to even the score and will complain to a parent to intervene. Most of us have experienced such give-and-take as children. Surely, we have seen it countless times in our own children and grandchildren.

In the behavior of "grownups"

Similar behavior is embarrassingly observable among adults. It can be seen in husband and wife arguments, bar fights, hockey games, political campaigns, even in sophisticated lawsuits. The rule operates not only in such highly visible conflict situations, but also in very subtle interactions – in the small behavioral exchanges, the ongoing give-and-take of all interpersonal relations. Expressive of the underlying conflictual excitatory/inhibitory dynamic of the neural architecture, we can say that:

The reactions that build in ourselves and others do so potentially in proportion to the behavioral tension created by egoistic, self-interested behavior. That is, the harder I hit you, the harder you hit me in return. Or the fouler a name you call me, the fouler a name I call you in return. Or perhaps with more sophistication, I resolve the tension in me by an act of visible "superiority." I ignore you – although I could call you an even fouler name, if I chose.

The second rule
describes the empathetic range
on the other side of the scale

2. Empathetic behavior, because it denies Ego or self-interest to some degree, also creates tension within ourselves and others. This tension, likewise, increases as activity levels increase and as we move toward extremes of Empathy.

Within ourselves, the tension created by the tug of the neglected self-interest (Ego) is experienced as a feeling that "others owe us one" and a growing need to "collect our due." This tension, especially if it continues over time, may be experienced as resentment at being exploited, taken for granted, not appreciated, or victimized by others.

Within others, the tension created is experienced as a sense of obligation toward us.

The reactions that build in ourselves and others, again, are in proportion to the behavioral tension created. And again, the unmanaged, or excessive tension is experienced as behavioral stress.

"Thank you" as payback there is no free behavioral gift

When we do things for others – give them things, make personal sacrifices for them – it can make us feel righteous, affectionate, loving. But we *do* want a payback. At least a *thank you* or other expression of appreciation. That's the tug of self-interest. It can be very slight, hardly noticeable at first. But let the giving, the self-sacrifice, go on for a while, unacknowledged or unappreciated (that is, without payback to the Ego), and see how we begin to feel.

The tension, the stress, starts to show. We complain that others are taking advantage of us, taking us for granted, victimizing us. Self-interest cannot be long short-changed without demanding its due. We may eventually relieve the stress by blowing up at those we have been serving – accusing them of ingratitude, withdrawing our favors, or kicking them out of the house. Or we may sandbag the stress, letting it eat away at our dispositions, our bodies.

On the other hand, when we do things for others, they often feel obliged to return the favor in some form to avoid being left with an uneasy sense of debt. Gift-giving notoriously stimulates the receiver to feel the need to reciprocate. Think of the times when you have received a holiday gift from someone for whom you had failed to buy a gift. Sometimes the sense of obligation prompted by the empathetic acts of others can become a nuisance.

E. O. Wilson plus Sapolsky vs Ghiselin

The no-free-behavioral-gift, described by the interactive dynamic of Ego and Empathy circuits, has been sensed by some leading scholars but without a full grasp or articulation of the neural dynamic. Famed sociobiologist and student of ant behavior, E. O. Wilson, for instance, cites the evolution of cooperative behaviors in humans that contain elements of both selfishness and altruism (2012: 17, 248)

Robert Sapolsky, a prominent primatologist, for another example, asks about the self-interested reputational rewards of being altruistic, and further, questions if the element of self-interest is ever truly absent? In closing his discussion, he refers (without attribution) to Michael Ghiselin's much quoted comment about scratching an altruist to see a hypocrite bleed. And he asks us to ease up a bit on the application of that observation. He justifies the easing up by asserting that the bleeding altruist is merely the product of altruism and reciprocity being evolutionarily inseparable in human behavior (2017: 545-552).

Michael Ghiselin, a prominent biologist, made his widely quoted altruist/hypocrite comment near the conclusion of his work on the economy of nature (1974: 247). In the last paragraph of the same work, however, he modified the earlier statement by suggesting that self-interest and common welfare are not fundamentally beyond reconciliation (p. 263). In a later work he refers to the altruist as a bleeding hypocrite statement as piece of widely quoted hyperbole that he really didn't mean (1989: 83).

As I have shown in the tug-and-pull of the Ego-Empathy neural dynamic, Ego and Empathy (self- and other-interest) are always present together to some degree, mutually affirming, restraining, or modifying each other, except at the extremes of behavior which are out of survival range.

The third rule statement
the range of dynamic balance
between our contending motives

3. Behavior in the range of dynamic balance expresses the approximate balance of Ego and Empathy. It is the position of least behavioral tension. Within ourselves and others, it creates feelings of mutuality and shared respect.

For most of us it is an especially satisfying experience to interact with others in equality, with no sense of obligation, superiority or inferiority. To work together in common humanity, in common cause, is to experience behavioral dynamic balance. Of course, there are many versions of the experience of dynamic balance: the shared pride of parents in helping their child achieve, the joy of athletes in playing well as a team, the satisfaction of coworkers in working together successfully on an important project. We may also include the feeling that "we are all in this together" that became pervasive during the coronavirus pandemic.

Reciprocity through conflict

These algorithms of behavior operate in the smallest interactions of everyday personal life. The dynamic of behavioral tension provides that for every interpersonal act, there is a balancing reciprocal. A self-interested act requires an empathetic reciprocal for balance. An empathetic act, likewise, requires a balancing self-interested reciprocal. This reciprocity goes back and forth many times even in a short conversation. Without the reciprocal, tension builds, stress accumulates, and either confrontation or withdrawal results. If not, and the relationship continues, it becomes a tense and stressful one of inequality or domination/submission, waiting and pressing for the opportunity for adjustment.

These, then, are the basic interpersonal algorithms of our three-level brain. These algorithms show how we get to reciprocity through conflict. They shape the conflict and reciprocity, the give-and-take, at all levels of our interactive, social lives. Overemphasis on either self-interest or Empathy, exercise of one program to the exclusion of the other, creates tension and stress in any social configuration – from simple dyadic person-to-person encounters up to and including interactions among members of the workplace, society at large, social groups, and entire economic and political systems.

The scale of inclusiveness

The reciprocal algorithms of our neural architecture, the tug-and-pull of Ego and Empathy, apply at all levels of social exchange. However, the intensity of empathetic bonding tends to vary with kinship, proximity, and related factors creating a varying scale of inclusiveness. The scale of inclusiveness is an important factor in fully understanding the nature of human bonding created by the Ego/Empathy dynamic.

The family connection

A basic feature of our evolutionary development is that we evolved to full humanity in small family kinship groups. Our neural architecture is, therefore, designed primarily to work most effectively in such small face-to-face, closely knit groups. Empathy bonds us most tightly and securely in the family, Ego is reined in by love and care for parents, children, mates, cousins. And we feel the depth of love and passion most keenly to those in close physical proximity – those we live and work with on a daily basis. With distance the intensity of Empathy tends to become increasingly rarefied.

In Africa, our brain developed over millions of years in such small group circumstances. Dynamically-balanced, essentially egalitarian, social behavior characterized such groups. A leader, or Alpha, did not dominate through brute Ego force, as some traditional lore would have it. The leader emerged as the one who could engage alliances and provide the most in wisdom, survival skills, and affection. Providing such is the essence of mammalian Empathy. Our survival strategy as a species, thus, was *sharing, reciprocity* – not *domination and submission*. All this, and the neural circuitry supporting it, was essentially cast in DNA/protein concrete – hard-wired – long before we entered into larger social groupings. Long before we developed agriculture and settled down. Long before we grouped into early cities and kingdoms, creating civilization. And long before the barely five to ten thousand years ago (a very short and recent time in our human development), when we created writing and made recorded history possible.

Present-day mismatch in the scale of inclusiveness and the importance of socialization and education

Our evolution of Ego and Empathy in small family groups means that this architecture is in somewhat of a state of mismatch with our current mass impersonal environment. Empathy for others weakens, as they are more distant from us – creating the scale of inclusiveness. We feel Empathy most strongly for family and those most close to us, less to those more distant. This scale of inclusiveness is a consistent and perennial problem for larger societies. It is only resolved by socialization or education which extends and universalizes the archetypal motivational circuitries.

Historically, we have sensed this mismatch and attempted intuitively to overcome it by appeals to kinship terms. Secularly, we have used such terms as: the family of man, brotherhoods, sisterhoods, mother- or fatherlands. Without the basic architecture, such appeals would be groundless. They are clearly intuitive efforts to extend and universalize the fundamental Ego and Empathy dynamic.

Physiology and social behavior

In physiology, this ability to regulate, to keep all parts working together within set limits, was first described by Claude Bernard, a French physiologist of the 19th century. However, it was Walter B. Cannon, an American physiologist, who gave these regulating processes the name "homeostasis." The year was 1929 and the name stuck. The word Cannon chose comes from two Greek words. *Homeo* means similar and *stasis* means standing. As used by Cannon, and other scientists who followed him, homeostasis does not mean something rigidly set in concrete, unshakable, or immovable.

Homeostasis as the foundation of all modern physiology

Homeostasis, then, describes a condition that varies yet at the same time is relatively constant. For the organism it describes a condition that is kept within survival limits. When the homeostatic limits are exceeded the mechanism either self-corrects or the organism gets dysfunctional. That is; it either gets out of whack, sick, or dies. Like all other creatures, our human vital processes are homeostatic. Built-in controls keep them generally within healthy and, ultimately, within survival limits. As a recent edition of a well-known college text on anatomy and physiology states:

> The principle of homeostasis is the central theme of this text and the foundation of all modern physiology. (Martini, et al., 2015: 7)

Homeostasis of the social architecture

The word homeostasis usually refers to the regulation of the internal environment of living organisms. Can we legitimately apply the concept to the workings of our social neural architecture? **Absolutely, We Can!**

As stated above, homeostasis is the foundation of all modern physiology. The brain is, of course, a physiological organ. Therefore, it should not come as a surprise that the social behavior of our neural architecture is also homeostatically regulated. All the elements for homeostatic regulation are present – standards, the ability to monitor and evaluate, sensors and effectors, feedback. In fact, our autonomic nervous system through its connections with the hypothalamus has primary involvement in behavioral homeostasis. The hypothalamus is closely linked with neural structures in the both the affectional and self-preservation circuitry located in the limbic system and the brain stem (e.g., see Herbert & Shulkin, 2002; Kandel, et. al., 2000: 871–997; Nelson, 2000, esp. pp. 447–494).

Like other bodily processes, our social neural architecture is regulated within limits. All the sensory systems of our body feed information into the monitoring neural centers. Many cues – from happy, sad, angry facial expressions to vocalizations of tenderness, frustration, surprise, and anger – are genetically wired and fine-tuned epigenetically through development and experience. The muscles of our body act to carry out adjustments to our social as well as physical environment.

Behavioral tension generic regulator of our social architecture

What we experience as behavioral tension is the generic regulator. Behavioral tension tells us when we are deviating from balance. Behavioral stress warns us that we're exceeding safe limits for ourselves and others (e.g., see Przewlocki, 2002). The behavioral spectrum set out in Figure 3 illustrates the necessary behavioral range and limits. The algorithmic rules of reciprocity describe the social regulatory process. The social equation to be formulated further on represents the process mathematically.

Homeostatic variability, neural plasticity and learning

Homeostatic regulations, as noted, can vary quite a bit in the ranges permitted. Some are tighter, some are looser. Our social architecture is one of the looser kind. This is to be expected. The brain, in its higher centers, is the most plastic of our organs. It is designed for learning – to respond to new experience. Learning plays an important role in the development and variability among individuals of the neural dynamic. This was discussed previously under the topic of the emerging science of epigenetics.

My friend and colleague John Tomer, to whom this essay is dedicated felt that I did not emphasize enough the importance of learning and experience in some earlier works and thoughtfully sought to correct that perceived deficit in a recent article in the *World Economic Review* (2012). I have sought to remedy this by the earlier discussion on epigenetics. The reader may also wish to consult the following scholars on neural plasticity: Chalupa, et al., 2011; Kolb & Gibb, 2011; Kolb, et al., 2003; Shaw & McEachern, 2001; Kolb, 1995; Greenough & Chang, 1989.

Executive brain centers considerable control, but not absolute

In addition, the higher executive centers of the brain can also assert considerable control. Such control can never be absolute, but it can be strengthened or weakened by learning or experience. If this were not so, there would be no point in writing this essay. By self-consciously exercising our executive neural architecture we can vary the expression of our behavior across the spectrum of Ego and Empathy quite widely. As long, that is, as we can handle the behavioral tension we create in the process. That is to say, to a considerable extent, we can control the heat in our own kitchen.

Despite the variability our social architecture is, nevertheless, set within clear outer limits. When we act too egoistically. When we nearly totally suppress Empathy. For instance, when we engage in attacking behavior, we approach the outer limits. And clearly somebody can get hurt or killed. Perhaps we even get hurt or killed ourselves.

Behavior at the extremes of either Ego or Empathy can be life threatening. We see examples of the egoistic extreme in street crime, gang wars, bar fights, and even in domestic violence. We see the relentless and deadly reciprocity of extremes at a societal level – in war, in the conflict between Israel and the Palestinians, between Pakistan and India over Kashmir. The examples are countless.

On the other hand, we see the empathetic extreme when parents sacrifice themselves for their children. We also see it when firefighters rush into blazing, collapsing buildings to rescue trapped citizens. In the summer of 2002 Empathy was demonstrated on television for all to see as extraordinary efforts were made to save trapped miners in Somerset, Pennsylvania. Also, the world rejoiced in Empathy when in the summer of 2010 a group of 33 Chilean miners were rescued after being trapped underground for 69 days.

In the face of so much violence reported daily in the news, we may seem mostly inclined to exceed homeostatic limits and create mainly death and destruction in our social world. This, however, is a distortion – perhaps based on our natural tendency to see the disturbing exception, rather than the comforting rule. It is an illusion encouraged by mass media reporting in a global society.

In spite of media emphasis on violence we mostly cooperate

Much more often the controls of behavioral tension and stress keep us well within survival limits. Mostly we cooperate, help each other out, obey the law. Mostly we live together in reasonable harmony or dynamic balance. Over history, despite the emphasis on violence in the written record, cooperation has prevailed overwhelmingly. In truth, we seldom exceed homeostatic limits. The historical evidence speaks to us loudly in confirmation. Our homeostatic neural social architecture is an undeniable success. It has brought us to a population success or explosion of over six billion.

Is the human species a suicidal success?

Crispin Tickell, a longtime advisor to British prime ministers and former president of the Royal Geographical Society, deals with this point in a well-read article titled *The Human Species: A Suicidal Success?* Of course, this collaborative success of our social brain has created other challenges to the maintenance of social homeostasis that we must yet confront adequately – like overpopulation, exhaustion of resources, pollution, climate change. Nevertheless, there is no denying the evidence of success so far.

The third form of the neural dynamic

Here, I will introduce a third form – the mathematical expression or equation that represents the homeostatically-regulated dynamic. If math is not your favorite subject, don't let the math I use intimidate you. I will keep it simple. I won't use a lot of the usual confusing math symbols or Greek letters. Instead I will use abbreviations of the actual English words. You won't have to hold a bunch of numerical abstractions in the higher part of your neural architecture while you try to follow the reasoning.

Keep in mind something that is easy to forget. The math is *not* the dynamic. Nor is it the reality. Math *represents* the dynamic and the reality. Math is a tool we invented that helps us clarify and simplify. Symbols are used because they are easier to manipulate than word descriptions. They also help us to see relationships more sharply. In the equation, I will *represent* the previous graph of the major ranges of behavior as well as the written description of the algorithms. I will try to capture very simply the dynamic of our social neural architecture. Here goes:

$$\mathrm{BT} = \frac{\mathrm{Ego}}{\mathrm{Empathy}} \quad \text{or} \quad \frac{\mathrm{Empathy}}{\mathrm{Ego}} = \pm 1$$

(dynamic balance, approx. equilibrium, or unity)

There it stands: the dynamic homeostatic equation of our social brain expressed as a dynamically-balanced equation, an equation approaching equilibrium, or an equation expressing optimal homeostasis. Pretty straight forward really.

BT as a function of magnitude

In the equation, BT stands for behavioral tension and is a function of the ratio of Ego to Empathy or vice versa. It represents our self-preservation and affection circuitry tugging and pulling against each other. Because of the self-correcting homeostatic nature of the dynamic – the varying tug-and-pull of forces against each other – we can make either Ego or Empathy the numerator or denominator as needed. We can do this because it is the *magnitude* of divergence or convergence between the two self-correcting forces that we are interested in expressing by the equation.

This short equation gives basic mathematical expression to the social architecture of our evolved brain structure. As the conflicting circuits of our social brain approach equilibrium, dynamic balance, or optimal homeostasis, behavioral tension/stress are minimized.

I use the symbolic notation, ± 1 (plus or minus one) to represent dynamic balance for two reasons: First, the plus or minus notation represents approximate, but not perfect unity, equilibrium, or dynamic balance. Perfect unity, equilibrium, or balance, would be 1 or unity without the plus or minus. Perfect unity is a theoretical point probably impossible to attain because of the ongoing tug-and-pull of the dynamic circuitry. Second, the notation represents the minimal range for behavioral tension. Since the dynamic tug-and-pull goes on ceaselessly, there is never zero tension. Also, there is never zero Ego or Empathy because they are locked together in inseparable unity in our neural architecture.

An organic equation: Zero equals death

Zero is impossible as a value in the numerator or denominator because that would indicate organic death. At death the organic homeostatic equation would decompose into a Newtonian or non-organic equation. Physics nobelist Ilya Prigogine and others have identified this quality of organic systems, which are called dissipative systems or far from equilibrium systems as opposed to inorganic systems (e.g. see Prigogine & Stengers, 1984). Equilibrium, as used in the latter work, refers to thermodynamic equilibrium not homeostatic (organic) equilibrium. As Harry Teitelbaum, a medical doctor and PhD, earlier observed in an article "Homeostasis and Personality" in the *Archives of Neurology and Psychiatry* (1956):

> When homeostatic failure occurs, then the organism goes into thermodynamic equilibrium with its environment: or, to put it more simply, it dies. The organism becomes an inorganic system and reacts like other inorganic systems. (1956: 317)

On the other hand, as the ratios diverge more and more toward the extremes of Ego or Empathy, behavioral tension increases. In proximity to either extreme, our behavior becomes life-threatening, we may kill or self-sacrifice. Behavioral tension gives us due warning.

Optimal function a measure of health and happiness

On the other hand, at the level of optimal functioning, the contending algorithms, driven by behavioral tension, tend to move us toward dynamic balance of Ego and Empathy or self- and other-interest – that is, toward balanced reciprocity, or equality. The equation, therefore, is very simple, but deceptively so, because it can be quite variable and can ramify in many ways. For instance, we can experience, even control or direct, by effort of our frontal executive, a different mix of Ego and Empathy in every one of our relationships and interactions. Some of our relationships may be quite dynamically-balanced or harmonious. Some may be tension-filled. Some may be quite unbalanced and stressful.

In one day – even in one hour of an exciting day – we may be jerked reactively back and forth all over the Ego-Empathy spectrum. Or we may move back and forth more self-consciously. Perhaps the average of all our relationships and interactions is a measure of our personal social health or happiness.

The neural social equation: Some differences

The neural social equation is not a simple reciprocal. Don't let this confuse you. Simple reciprocals, which we see a lot of in math, merely show a proportional relationship. They compare the amount of something to the amount of something else. Or they compare a part to a whole. Simple reciprocals have no dynamic similar to the social equation. There is no behavioral tension. On the contrary, the social equation is dynamic. It is driven by tension. The numerator and denominator tug-and-pull against each other, straining toward dynamic balance or equilibrium.

Don't confuse the equation with the resultant or outcome of a simple intersection of forces like you see often in the physical sciences. Such forces impact each other but they do not varyingly tug and pull against each other dynamically. The organic equation is different. It represents a homeostatic, dynamic, living process. And that difference makes all the difference in the world.

The equation and complexity theory

At this point it may be clarifying to say a few words about the equation from the perspective of physics and complexity theory. The equation is repeated here for ready reference.

The equation:

$$\mathrm{BT} = \frac{\mathrm{Ego}}{\mathrm{Empathy}} \quad \text{or} \quad \frac{\mathrm{Empathy}}{\mathrm{Ego}} = \pm 1$$

In thermodynamic terms of chaos/complexity theory, an organic, homeostatic equation such as the above can never be 0 at the point of force equilibrium. This is because, in keeping with complexity theory and the theory of dissipative systems, organic processes or algorithms are kept at a state far from thermodynamic equilibrium.

Thermodynamic equilibrium as organic death

Therefore, as long as the self-correcting dynamic of homeostasis is doing its job, there will never be zero in either numerator or denominator. Thermodynamic equilibrium for living things is death. This would occur only when homeostatic forces fail or exceed survival limits. The self-correcting forces while organically alive, or at a state far from thermodynamic equilibrium, will always have a ratio of 1:1 at perfect force equilibrium, representing their dynamic presence in balance.

In the CSN model death or zero at or below extremes of Ego or Empathy

In the behavioral spectrum of the CSN Model, death or 0 is represented at or below the extremes of Ego and Empathy, which are out of survival limits. Anywhere in between, represents degrees of behavioral tension motivating homeostatic self-correction in the direction of dynamic equilibrium or balance – at 1 in the unlikely case of perfect equilibrium, or $\pm$ 1 representing dynamic homeostasis.

Any equation representing the organic, homeostatic process must be consistent with the premises of chaos/complexity and dissipative systems. It must also recognize and maintain the distinction between thermodynamic equilibrium which is total entropy or chaos and organic, homeostatic equilibrium which reflects the equilibrium of processes/forces far from thermodynamic equilibrium (see Gribbin, 2004; Prigogine & Stengers, 1984).

For a consistency proof of the equation through the calculus process of differentiation and integration, you may wish to consult several of my previous works (e.g., Cory 2006ab, 2010, 2018). Of course, a proof of consistency does not mean that the equation exactly matches the reality it purports to represent. That is a separate question that math itself cannot address.

Indeed, the equation is simple. But it does what has not been done before. It captures in simple form the central dynamic of our social neural architecture. It captures a vitally important living, organic algorithm in very simple terms. The equation allows us to see and express relationships in many areas of our lives. Relationships we have seen only dimly and, perhaps, as fragmented up to now.

Sources of probability and the CSN model

The CSN model, then, because of its organic, homeostatically, variable nature, depends on probabilities for a great deal of its predictability. The idealized, or rather statistically generalized, tug-and-pull of Ego and Empathy may be further probabilized in actuality by other contributing factors.

Among such factors are: genetic variation, gender and developmental differences, individual experience and learning, as well as other environmental shaping and reinforcing influences that have been noted in the discussion on epigenetics. In other words, *genetically speaking*, given the individual differences in genetic inheritance that we see in such obvious things as in hair, skin, or eye color, some individuals *behaviorally* may be more or less as strongly wired for self-preservation and affection as others.

Nevertheless, granting *gender, developmental, experiential, and learning* differences, every human being is similarly wired with the fundamental brain architecture unless he/she has very serious genetic defects indeed.

We take our compatibility for granted

We generally take the commonality of our human brain architecture for granted. We interact with each other socially without questioning our general compatibility. Indeed, without a common architecture our social life would be impossible. A good deal of early childhood research backs this up.

Influential developmental psychologists like Jean Piaget of Switzerland (1932, 1965) and Lawrence Kohlberg of Harvard (1984), operating from a behavioral perspective, have built and tested theories of childhood moral development. In the theories of both scholars, moral stages of development emerge much the same in all cultures when the child experiences anything approaching a normal family life. Such generalized moral stages could not be found across cultures if they were not genetically based on the species-wide brain structure and its associated behavioral potentialities.

Development and learning interact with our genes

From the standpoint of *individual learning, socialization,* and other *environmental* factors, modifications in gene activity and expression occur in early development and throughout life (see Tomer, 2012 and the earlier discussion of epigenetics). The higher brain centers, especially, develop in an interactive social context producing some variation in gene expression. Our *individual* life experiences may epigenetically facilitate, suppress, strengthen, or otherwise modify the expression of these DNA based neural circuits.

Other environmental factors, to include the physical conditions under which we live, as well as our socially and scientifically accepted institutions and paradigms, may also epigenetically shape and reinforce the expression of the evolved algorithmic dynamic. As noted previously recent research has revealed considerable plasticity in our neural development.

Individual learning, experience, or environmental factors of our individual lives *cannot*, however, *eliminate* the fundamental gene-based structure and programming of the brain. That is, not without radical injury, surgical, or genetic intervention. And the behavioral tension of our dynamic architecture will be there to both resist the changes and to shape the experience, even shape the environment itself, in a dynamic manner. That is, we resist radical manipulation of the human genome and we work assiduously to support and create physical and social environments for our healthy gene expression.

Physics, genes, and behavior: precision vs. statistical probability

Because of these factors, the behavioral algorithms are *statistical – much in* the same way as are the second law of thermodynamics and quantum theory of physics. That is, they *generally do not allow precise* prediction of specific behavior at the basic unit of analysis – the individual, molecular, or subatomic levels respectively – but only on the aggregated basis of statistical probability.

Evolution: Family, gift, and market

This section begins the process of demonstrating that the reciprocal architecture of the social brain founded in evolutionary neuroscience is the proper model for economics, not the model of Newtonian mechanics and later nineteenth century physics. Our social brain is structured for give and take – for social exchange. The graphic of the CSN model, its descriptive algorithms, and the equation of our social brain represent a dynamically reciprocal neural architecture. In this section I show how the market evolved from this dynamic. Reciprocity is in fact a ubiquitous norm which anthropology and sociology have long studied. Economists have picked up the theme more recently.

The prevalence of reciprocity means that in society, everywhere we look, we find social relations of give and take. The relations are sometimes informal, sometimes formal. But spoken or unspoken, written or not, they tell each member that what is received must be returned in some form, at some time. The tension binding these give-and-take relations produces the web work of obligation that holds the society together.

In evolutionary theory, scholars account for reciprocity by such concepts as kin selection, inclusive fitness (Hamilton 1964), reciprocal altruism (Trivers, 1971, 1981; Alexander, 1987) and game theory (Maynard Smith, 1982; Axelrod & Hamilton, 1981; Bendor & Swistak, 1997). These accounts draw upon so-called selfish gene perspectives, which see such reciprocity as basically selfish. More recently, however, researchers have reported widespread reciprocity in the behavior of rhesus monkeys and chimpanzees based not upon selfishness, but Empathy. Two excellent books that present the extensive evidence for Empathy among primates are de Waal (1996) and Boehm (1999). The observation of Empathy in our primate cousins is a welcome approach that tries to escape the selfishness of traditional approaches. All these approaches, however, are based on the outside observation of behavior. They have not tried to identify or even speculate about the neural circuitry within the animal that must necessarily have been chosen by the evolutionary process to accomplish the work of motivating, maintaining, and rewarding such observed reciprocal behavior.

The CSN Model, building upon evolutionary neuroscience goes to the heart of the question of brain circuitry substrating reciprocity. The social brain, driven by the tug-and-pull of Ego and Empathy, is the motive source of human reciprocity. The circuitry lies within the self-preservation and affection structures of our evolved neural architecture. From these insights, we can easily understand the evolution of market exchange.

As the market evolves

To understand the behavior of the modern-day free enterprise market as it is shaped by the circuits of our social brain, it helps to go back to early times – to reconstruct as best we can the days before the market appeared. In those times, when our ancestors consumed what they produced, the excess that they shared with, gave to, or provided for the needs or demands of the family or community was in the nature of natural affection or Empathy. The reward for the empathetic, supplying act was emotional – there was not a specific, but a diffuse value assigned to it. It also had social effects. The givers, providers gained status in the group. The emotional and the social effects were both directly governed by the reciprocal algorithms of behavior.

Let us look more closely. The provider, say the warrior, brought meat from the hunt or the mate brought berries and fruits from the field, tanned skins, and so on, to give to the family or group. The act of providing created behavioral tension in the giver, who acting with Empathy denied Ego to some degree. This Ego denial required a response of acknowledgment – an expression of gratitude, respect, affection, or some other reaffirmation of Ego.

This providing or giving also created behavioral tension in the receivers. It was a service to their Ego, their needs or demands – to their own preservation. The tension created required an offsetting empathetic response, a thank-you, an expression of appreciation or respect. In any family or close group, even now, this dynamic flows constantly, even in the smallest activities. In the small group, the rewards, the reciprocations, are mostly not quantified, but are diffuse. They become obligations – bonds – that hold the group together for protection or mutual survival. Nevertheless, they must reach some approximation of balance or the unresolved tension will build within the group and become disruptive.

Thank you and you're welcome courtesy mitigates behavioral tension

Expressions for *thank you* and *you're welcome*, found in all known human languages, reflect this reciprocity and the behavior needed to sustain it. We call it courtesy. It greases the social skids. Without courtesy daily life would be almost unbearable. We would have to swallow all that tension or be at each other's throats.

The gift

From these primitive, familial exchanges, emerged the gift: an empathetic act of providing or serving that followed the same algorithmic behavioral rules that governed provision for survival. It created tension in the giver – an expectation of reciprocity – and tension in the receiver, who was bound to reciprocate. The rewards associated with the gift were at first diffuse, unspecified, unquantified – except by some subjective measure of feeling, emotion, or behavioral tension. A gift to a warrior or chief might vaguely obligate his protection. A gift to a prospective mate might vaguely obligate his or her attentions.

French anthropologist Marcel Mauss's, path-breaking earlier study about exchange practices in primitive and ancient societies is called *Essai sur le Don* (1950). It was most recently translated into English by W. D. Halls (1990) and given the title, *The Gift*. Mauss was the nephew of Emile Durkheim, an influential figure in establishing the academic discipline of sociology. Mauss was not a neuroscientist, and from all indications had no interest in brain function. And considering the state of neuroscience at the time of his study nearly a century ago, knowledge of the discipline would probably have been of little or no help. Mauss's findings of pervasive reciprocity in gift-giving in all of its varied forms throughout these seemingly primitive societies powerfully confirm the algorithmic dynamic tug-and-pull of Ego and Empathy of our neural architecture. There were serious social, economic, and political consequences attending the exchange of gifts. Generous giving brought honor and prestige. Failure to return an approximately equal gift brought a loss of status. Among the peoples he studied the failure or refusal to engage in exchange of gifts was tantamount to a declaration of war (1990: 13).

The anthropological literature on gift-giving has expanded greatly since Mauss's work. It continues to the present day. Such literature overlaps with the literature on reciprocity. The total volume of work is too extensive to deal with here but I have tried to deal with it further in an earlier work (e.g., most recently Cory, 2018).

Derrida: The impossibility of the pure gift confirms essence of our social brain

Jacques Derrida (1992), the French philosopher of deconstruction tries to separate the gift from reciprocity to examine its pure form. He concludes the pure gift is not only impossible but is *the impossible*, because any acknowledgement or even knowledge of it – even subjectively – by giver or receiver, constitutes a reciprocal that annuls the gift by his own definition by revealing it as a matter of reciprocal economic exchange. Derrida, without apparent knowledge of evolutionary neuroscience, has, in pursuit of deconstructive logic, run up against the homeostatic algorithms of behavior. There is no separating Ego and Empathy, as they are bound together in our homeostatic neural architecture. There is no such thing as a pure gift without reciprocal. Said another way: *there is no free gift*. Such is the essence of our social brain, now so widely recognized in psychology and psychiatry.

From gift to transaction

From the gift in all its varied expressions evolved the transaction – namely, the gift with the reciprocal specified or quantified. The evolution of the transaction from the gift is widely supported by the anthropological literature (e.g., Polanyi, 1957; Gregory, 1982; Mauss, 1990). The *Dictionary of Anthropology* in distinguishing the commodity from gift states that a commodity exchange creates a relationship between things (that is, it is impersonal) as opposed to gift exchange which creates a relationship between people (Seymour-Smith, 1986: 44). Gregory (1982) holds that commodity exchange is an exchange of alienable objects between persons who are in a state of reciprocal independence which establishes a quantitative (i.e., specified) relationship. Gift exchange, on the other hand, is an exchange of inalienable objects between persons who are in a state of reciprocal dependence that establishes a qualitative relationship between the persons involved in the exchange (see also Barfield, 1997: 73; Osteen, 2002: 229–247). Bohannan defines market exchange or the market transaction as the exchange of goods at prices governed by Supply and Demand under a free and casual contract. On the other hand, reciprocity or gift exchange is seen most clearly in kinship relations (1963: 231–232). Since kinship reciprocity precedes market transactional relations in human affairs, the latter clearly evolved from the former.

Universalization of the scale of inclusiveness and moral ambivalence: Gifts that corrupt

Because of its bonding function at the familial or small community level – its contribution to social solidarity (see esp. Komter, 2005) – the gift has become somewhat idealized in comparison with impersonal, non-binding market or commodity exchange. In our larger mass societies of today, in which the scale of inclusiveness has become universalized or extended to include all, the one-to-one bonding effect of the gift can produce morally ambivalent if not downright pernicious or illegal effects.

That is, individual gifts may become bribes to be reciprocated on a one-to-one basis when given to political leaders, CEOs of large corporations, public servants, and others whose obligations of equal treatment extend to a large number of stakeholders or even to an entire nation (universalized) rather than to an individual gift-giver. That is why such gift-giving is often prohibited by law.

Every nation is confronted with such immoral or illegal "gift-giving" under the rubric of corruption. At the time of this writing, China is launching a national campaign against such corruption. Also, in the recent past, the woman president of South Korea faced impeachment charges on the same basis. Under the term "pay for play" it was an issue of considerable concern in our most recent national elections.

Back to the gift and transaction

A large body of evidence, then, clearly establishes the case that the transaction evolved from the gift. The transaction probably evolved in groups larger than family or extended kinship units. It is here that we begin to deal with strangers. The transaction is the beginning of the contract, perhaps of the commercial market itself. The transaction operates, however, by the same algorithms of behavior as the gift – except that it attempts to head off the residual, unresolved behavioral tension that creates a condition of obligation or bonding.

After all, in the commercial market, we may be dealing with complete strangers. We may wish to avoid any future obligation to them from our exchanges. We have not seen these strangers before and we may never see them again. Further, we are naturally suspicious of them. They are not family or close neighbors. We feel it wise to avoid the leftover tension that might oblige us to invite them home for dinner – to share the feast as our ancestors did.

Reciprocal specified/quantified in the transaction

In such market transactions, then, both the gift object transferred and the reciprocal are specified to the satisfaction of giver and receiver. The exchange deal is done in equal or balanced return. There is no behavioral tension binding us socially and economically in a cycle of mutual obligation. Nevertheless, despite these considerations, the transaction itself retains its essential mammalian characteristics. It is an act of Empathy, of nurturing, which requires a balancing reciprocal act in payment to Ego.

Adam Smith and the market

Previously, I presented the evolution of the market in terms of the tug-and-pull of Ego and Empathy. The market was created by the human social brain – by like brains interacting with like brains. There is simply no other possible source.

No market based on laws of physics

If markets were established and run on the basis of Newtonian mechanics or nineteenth century physics, as once thought by most economists in the 19th century and some in the 20th century, we should expect to find them ready and waiting for us on the moon and Mars. After all, such principles apply there also. All we would have to do is move in and start using them. The thought is, of course, absurd. Markets are the expression of human social exchange activity. And they don't exist independently of that activity.

For the last two hundred plus years the orthodox theory of free enterprise and economics has similarly inaccurately claimed that self-interest is the *sole primary motive* of the market.

How did we get it so wrong?

We falsely blamed Adam Smith. Open almost any basic economic textbook and you will find that we blame Adam Smith (1723–1790). Smith was a moral philosopher. He taught at the University of Glasgow, Scotland back in the 18th century. Smith earned the reputation as founder of economics and the capitalist free enterprise system by publishing the *Wealth of Nations* in 1776 – the same year the American colonies declared independence from Britain over economic issues.

The misinterpretation of Smith's motives

The source for the venerated self-interest motive was a quote from Book I, Chapter 2 of that volume. It goes as follows:

> It is not from the benevolence of the butcher, the brewer, or the baker, that we expect our dinner, but from their care for their own interest. We appeal not to their humanity but to their self-interest, and never talk to them of our own necessities, but of their advantages.

This often-cited quote, however, is taken completely out of context. On the same page and on either side of the famous quote, yet never included, are two clear references to the importance of benevolence or Empathy. Just two short paragraphs above the famed quote Smith reminds us that:

> . . . man has almost constant need for the help of his brethren.

And, immediately following the famous quote he tells us:

> Thus, nobody but a beggar chooses to depend chiefly upon the benevolence of his fellow-citizens. . .

When properly understood, then, Smith, in the celebrated quote, is not saying that there is only self-interest, but that there is both self-interest and Empathy and that we should show an empathetic concern for the self-interest of the butcher, the baker, and the brewer, in requesting their products and services – inducing them to engage in a transaction. That is, being competent players in the market, we should not seize their products and services unjustly, or do so beggarly. Rather we should expect to compensate their labors.

With Smith everyone wins

In fact, Smith makes the above absolutely clear – again on the same page – when he says in the line directly above the celebrated quote:

> Give me what I want, and you shall have what you want, is the meaning of every such offer.

In the above phrasing, Adam Smith has virtually stated the algorithms of reciprocity, the dynamic tug-and-pull of Ego and Empathy, self- and other-interest. Both you and I get what we need from the exchange. Nobody gets ripped off. In everyday parlance in our modern times, we call this intuitively – win-win. All parties get what they want and everyone is satisfied. The exchange process, as Smith saw it, then, was more accurately aimed at a balance of self- and other-interest. And Smith didn't know anything about brain science or neural architecture. He was operating intuitively from common sense. After all he had the same neural architecture we have – although he had no concept of it as such.

The evidence goes even further. Smith wrote another book – a magnum opus called *The Theory of Moral Sentiments*, which he first published in 1759, well before the *Wealth of Nations*. The second book, almost entirely ignored for two centuries, was for Smith the more important of the two. It emphasized morality, sympathy, and fellow-feeling. By the term sympathy Smith meant essentially what we define as Empathy in present day usage. He wrote that sympathy "... arises from bringing your case home to myself, from putting myself in your situation..." (Smith 1790, part VII, sec. iii, ch. I, 317). We might note that putting oneself in another's situation – or walking in their moccasins – is the very definition of Empathy. Smith considered this book so important he revised it six times – the last time shortly before his death in 1790. Smith's two volumes capture the tug-and-pull of Ego and Empathy, the algorithms of reciprocity.

How did such an historical oversight or misinterpretation occur? I think there is a reasonable explanation. It goes, in part, along the following lines. The businessmen and entrepreneurs of that day were chafing under the excessive and invasive restrictions of the British mercantile system. The crown's bureaucracy was micro-managing everything, stifling especially free flowing international trade. The businessmen saw what they needed to break the restrictive bonds of mercantilism in the self-interest motive and in the hands off (laissez-faire) approach advocated by Smith. They pounced on the two like a fumbled football and off they went. After all, they were practical men interested in making money, not in theory. The Empathy – the moral concerns – of Smith got lost in the shuffle.

The misinterpretation of Smith's motives and the overemphasis on self-interest that followed, however, had its negative side effects. It skewed business behavior toward egoism by its denial of Empathy. It often led to excess and greed – as in the 1890s, 1920s, the 1980s, and the greed epidemic of the late 1990s, the early 2000s, and most recently the sub-prime economic crisis brought on in large measure by flagrant greed. The excesses periodically give the free enterprise system a bad press and lead to public reaction and regulation in the public interest to counter the negative tendencies. Adam Smith, when properly understood, got it right. The free market, as an expression of our neural architecture, depends upon the interplay of Ego and Empathy, self- and other-interest. Not just self-interest alone. A look at the everyday presentation of the business marketplace bears this out further.

Empathy in the marketplace

The overemphasis on self-interest and the lack of an adequate behavioral model have prevented us from seeing how the marketplace derives from brain structure, and how Empathy or altruism plays an equal role with Ego or self- preservation. But the role of Empathy is clearly present in the language, if not the practice, of the marketplace.

The everyday language of marketing *is* the language of Empathy. Advertisements, almost without fail, emphasize service or benefit to the customer. Customer service is, in fact, the keynote of most businesses. Every retail store of any size has a customer "service" department in a prominent location. Never once have I seen a company "self-interest" department so proudly and prominently displayed. Almost nowhere else are we treated with more exaggerated Empathy, even obsequiousness, than in some retail businesses. In marketing, as any good salesperson can tell you, Empathy works. People respond to it.

Rational fools: The trick or deception of self-interest

The trick or deception of assigning a self-interest motive to everything – even to the most empathetic or altruistic acts – is made plausible by the fact that the reciprocal is always there. There is always an egoistic reciprocal to any empathetic act; and, likewise, there is always an empathetic reciprocal to any egoistic act. The dynamic of our social brain supports the protesting observation by nobelist Amartyr Sen in his well-known article "Rational Fools." Sen writes that one can "define a person's interests in such a way that no matter what he does he can be seen to be furthering his own interests in every isolated act of choice" (1979).

The invisible hand as a neural algorithm

This section takes on that icon of economic lore – the Invisible Hand. As a staple of economic theory, the Invisible Hand appears in every economics textbook.

The fabled Hand also appears in many books on free enterprise and business. Television talk shows even take note of it. Libertarians, conservative Republicans, and even Democrats invoke it – sometimes reverently and mysteriously. It is generally traced to Adam Smith. Actually, it goes back a little further. No one knows exactly who first thought it up, but the principle is probably first clearly anticipated by the Englishman, Bernard de Mandeville (1670–1733). In 1714 Mandeville published the *Fable of the Bees* in which he argued that individuals in pursuit of their own purely selfish goals, nevertheless, unintentionally produced benefits for society. This is known as the doctrine of "unintended consequences." It is the forerunner of the Invisible Hand.

Smith follows Locke seeking a better balance

Seemingly repelled by Mandeville's excessive emphasis on human selfishness in the already famous Fable, Adam Smith sought a more balanced interpretation. Smith's teacher and predecessor at the University of Glasgow, Scotland, Francis Hutcheson, as well as his friend, the famed British philosopher David Hume and others of his circle, followed more in the footsteps of philosopher John Locke (1632–1704). They believed that mankind had an innate concern or sympathy for others – a concern that led to a moral sense. Smith states his position in the ongoing debate in his *Theory of Moral Sentiments* (1759). Section 1 Chapter 1 of his moral masterwork, opens with the following paragraph:

> How selfish soever, man may be supposed, there are evidently some principles in his nature, which interest him in the fortune of others, and render their happiness necessary to him, though he derives nothing from it, except the pleasure of

> seeing it. . . like all the other original passions of human nature, [it] is by no means confined to the virtuous and humane, though they perhaps may feel it with the most exquisite sensibility. The greatest ruffian, the most hardened violator of the laws of society, is not altogether without it.

Thus, Smith described fellow-feeling or sympathy as he called it. And such is Empathy as I call it.

As noted previously, Smith, our economic forefather, then, saw not one but two great natural motives somehow rooted in human nature – self-interest, the desire to accumulate wealth and better one's personal circumstances, and sympathy or fellow-feeling, the source of benevolence and morality. Smith, we know, had no access to the findings of modern neuroscience. He knew nothing about brains or neural architecture. He sensed these two motives as somehow built into the nature of human beings by the invisible hand of Deity.

Smith's dual motive hand greater wealth and a better distribution

Smith felt that given freedom from government restriction, which was very extensive and invasive at that time, the dynamics of human nature in pursuit of wealth would produce more wealth and a better distribution of it than any deliberate system statesmen could devise. But unlike Mandeville, he saw the benefits proceeding from both self-interest and sympathy. In Moral Sentiments he writes further on:

> [the rich] are led by an invisible hand to make nearly the same distribution of the necessaries of life, which would have been made, had the earth been divided into equal portions among all its inhabitants, and thus without knowing it, advance the interests of society.

Here we have the idea of unintended consequences clearly expressed by Smith as the Invisible Hand. In other words, left to operate freely, the dynamics of human nature, driven by the principle motives of self-interest and fellow-feeling, will somehow work to create an approximate equality of distribution, at least at the level of the necessities of life. Smith could see how fellow-feeling may work effectively to provide moral stability and provisioning among neighbors, but he was troubled when he tried to visualize its working at the higher level of nations and among nations. To fill this gap, then, and following the thinking of some of his predecessors and contemporaries, he drew further upon the aforementioned deus ex machina, or miracle machine, of the Invisible Hand. It was essentially an undefined, semi-mystical concept taken more on intuition or faith than any empirical evidence or observation. Among nations as among individuals, Smith saw it as a Deity-given natural law like the celestial mechanics of Newton.

Smith went on from there to develop his famous economic principles of supply (or provisioning) and demand as the dynamic forces that drive the marketplace. These principles, now inappropriately elevated to the status of laws, have served as the foundation of economics up to the present day. In fact, the Invisible Hand is even now taken to be the natural outcome of the workings of the so-called laws of Supply and Demand. Even Alan Greenspan, former head of the Fed, and longtime economic psychologist in residence for the nation, can be heard to invoke the laws of Supply and Demand and by implication, the Invisible Hand.

Demand and supply as expressions of the social brain

Let's go back for a moment. From the evolution of the market traced above, we can easily see that Demand and Supply are expressions of our dynamic neural architecture. Ego demands. Empathy provides or supplies. Without Empathy there could be no market. We wouldn't know what to offer or how to offer it to respond to the demands or needs of others. We probably wouldn't even care to be bothered. When Ego and Empathy meet in dynamic balance, fairness and cooperation tend to emerge in exchange activity. When Ego (demand) and Empathy (supply) intersect freely in the marketplace, we tend to have equitable exchange. Since the evolved algorithmic dynamic works imperfectly, I use the word *tend*.

The evolutionary sequence from gift to exchange

The evolutionary sequence summarized here roughly conforms to the standard anthropological literature and follows the previous presentation. Economic historian Karl Polanyi in his landmark work, *The Great Transformation* (1944) advanced the argument of a transformation from a gift economy to a market economy. Noted French historian, Fernand Braudel, in his sweeping three-volume work *Civilization and Capitalism* (1982) can be thought of as picking up where Mauss and others concerned with the gift economy left off.

Braudel's bottom-up approach to the development of the market beginning with the exigencies of material existence and the need for exchange evolving ultimately into capitalism built upon what Adam Smith saw as the natural or inborn propensity of humans to truck, barter, and exchange (Braudel V.2, p 71, 73; also, Smith 1986: 117). While focusing primarily on the development of capitalism in the West from the 15th through 18th century, Braudel presents historical examples of market exchange activity from societies in many centuries and differing cultures across the globe. Although he does not deal with gift economies, he seems to equate civilization – the appearance of towns and cities – with the beginning of transactional markets.

From gift to exchange as a continuum

Anthropologist Marshall Sahlins most fully developed this theory in his *Stone Age Economics* (1972). Sahlins made the important point that the difference between gift exchange and commodity exchange should be viewed as a continuum not as a bipolar opposition. As Parry and Bloch note "one may evolve rather easily into the other" (1989: 8). Gift exchange and the supporting presentation, tends to be between people who are kin. As the kinship or social distance lengthens – in keeping with the scale of inclusiveness – into towns and cities the transactors become strangers, and commodity exchange emerges (see Sahlins, 1972: 185–276). Commodity exchange is characterized by impersonal relationships, no desire for social bonding characteristic of kinship exchange, and specified or quantified reciprocals. For a critique of several theoretical treatments of the gift/commodity distinction see Osteen (2002: 229–247).

From gift economy to transaction economy changes in the manner of social exchange

Notable changes in the manner of social exchange mark this transition and justify our calling them differently. But what are some differences that distinguish the two? There are at least three.

First, in the gift economy you get the gift whether or not you can reciprocate equally. The relationship is much more personal, bonded, and inclusive. You are not left to starve or die of exposure because you cannot return an equal amount of valued goods. Of course, you make payback in loss of status and residual obligation to your benefactor. There is no free gift. As we move to the transaction, however, the relationships become more impersonal, probably deliberately so.

This brings us to the second difference. In the transaction economy the reciprocal is specified or quantified. You don't get the gift or object of exchange in the first place, if you can't produce the specified reciprocal. The exchange just doesn't take place.

The third difference follows from the second. That is, the transaction involves no gain or loss of social prestige. It carries no residual obligation or behavioral tension. It's a clean deal with minimal social effects. Gift economies and market economies to a great extent existed side by side over much of human history. The patron-client relations of the great feudal systems were primarily an extension of a gift-exchange economy. They were bound by residual obligations between patrons and clients underpinned by the behavioral tension of unequal exchange.

In such a system when the patron could no longer provide, he/she lost the support and loyalty of the clients. Sometimes the breakdown of the social exchange relationship was marked by violence and bloodshed. In the Middle Ages the emergence of the towns, merchant class, and the transactional market economy challenged the feudal patron-client power structure. And there were considerable tensions between the two. By the modern age the transactional, market economy had prevailed. Of course, the gift economy never went away. It still functions on a less visible scale among isolated social groupings, as well as among families and groups even in the most highly developed commercial economies.

The invisible hand in the structure and behavior of the marketplace

In the transactional or commercial market, the dynamic tug-and-pull of Ego and Empathy becomes expressed structurally as Demand and Supply. The previous organic homeostatic formula:

$$\text{BT} = \frac{\text{Ego}}{\text{Empathy}} \quad \text{or} \quad \frac{\text{Empathy}}{\text{Ego}} = \pm 1$$

Becomes the structural, organic formula for the working of the market (or the Invisible Hand).

$$\text{BT} = \text{EP (equilibrium price)} = \frac{\text{Demand}}{\text{Supply}} \quad \text{or} \quad \frac{\text{Supply}}{\text{Demand}} = \pm 1 \text{(approx. equilibrium, or dynamic balance)}$$

Like the homeostatic social brain dynamic from which it is derived, the behavioral tension driving toward a proper reciprocal balance between Demand and Supply in the marketplace accounts for the basic motive force for the Invisible Hand. Scholars have previously accounted for the Hand's illusive dynamic in various ways. Early thinkers, beginning with Smith saw in it the prescriptions of Deity or natural law. Later scholars, with somewhat more sophistication, appealed to Newtonian mechanics or other inappropriate physical processes. Some just gave up on the question, but still quoted it on faith.

Such variables as history, culture, and institutions, of course, play their part. And they do so importantly. They give the market its unique expression in any social context. The Hand can't do it all by itself. To grasp the functioning of the Invisible Hand in the marketplace, it helps to keep a clear distinction between structure and behavior.

Structure

The Invisible Hand, as driven by our neural algorithms, tends to work, though somewhat precariously, despite the one-dimensional overemphasis on self-interest in classical economics. This is because the *very structure* of the market itself is the *institutionalized product* of the Ego/Empathy dynamic of our evolved brain structure. Our basic self-survival Ego demands are rooted ultimately in our ancestral amniote neural complexes. Contrastingly, the act of providing or supplying, is fundamentally an act of mammalian nurturing. The market exchange system originated from this dynamic. The market could never have evolved or been maintained on the basis of Ego or self-interest alone. Without Empathy we would not know how or what to do to respond to the needs of others.

Behavior

Behavior, in individual choices and transactions within the above institutionalized structure, may vary considerably in the mix of Ego and Empathy motives on both the Demand and Supply sides. Nevertheless, even in the most Ego-skewed (or self-interested) market behavior the overall tendency of the market will be toward a dynamic balance of Ego and Empathy. Individual and collective actors, whether seemingly motivated primarily by self-interest or not, will be compelled by the very market structure itself – to survive in the market – to perform the *structural equivalent* of *Empathy*. That is, they will be required to provide (supply) a proper service or product to fill the needs (demand) of others or be driven out of business by competitors willing and able to do so. This is the source of the unintended consequences aspect of the Invisible Hand – referred to by Adam Smith himself as well as modern economists. Nobelist Milton Friedman, without knowledge of our mammalian neural architecture, makes essentially the same point in different terms:

> So long as effective freedom of exchange is maintained, the central feature of the market organization of economic activity is that it prevents one person from interfering with another in respect of most of his activities. The consumer is protected from coercion by the seller because of the presence of other sellers with whom he can deal… (1962: 14)

Friedman also equates the voluntary cooperation of individuals in the free market as the source of the Invisible Hand (1962: 14 & 200). On a level playing field, then, left to its own dynamic, the Invisible Hand, stripped of its ghostly demeanor, will tend to come forth. The architecture of our social brain drives it. The dynamic equation of our social brain represents it.

From egalitarian gift to hierarchical exchange

The Invisible Hand largely expressed itself more fully in the small social units of primitive humankind. The interplay of Ego and Empathy in face-to-face groups led to a generally egalitarian sharing of resources and power. Primatologist Christopher Boehm in his study of the origins of egalitarian behavior notes that all known foraging societies were egalitarian. He comments that one of the great mysteries of social evolution is the change from egalitarian to hierarchical society (1999: 88). Anthropologist, Mary Douglas (1990), writing in the foreword to Marcel Mauss's *The Gift*, makes the same point. She observes that the mandatory reciprocal nature of giving, present in pre-market societies, functioned as the equivalent to an Invisible Hand.

As the size of social units expanded, however, and the division of labor grew increasingly defined, the natural tendency could be obstructed in many ways. The very complexity and distances of the emerging market could block the natural tendency at many points. Such obstructions permit inequalities that would be unheard of in the small, largely kinship group environment of our evolutionary adaptation.

The extension of the scale of inclusiveness and the universalization of dual-motive values

The evolution of the market economy over the centuries of human politico-economic history has been shaped by the motivating dynamic of our dual-motive neural architecture. This evolution has led progressively in modern times to the gradual extension of the scale of inclusiveness to all and the ultimate universalization of the values inherent in the dynamic-balancing of our homeostatic neural architecture.

This dynamic is expressed in the seemingly conflicting values of freedom (Ego) and caring for others or equality for all (Empathy). With universalization, of course, the caring that bound the small kinship group has been emotionally thinned out and depersonalized. The Empathy that motivated fair play and rough equality in kinship groups had been codified into laws and principles of equity in market and social behavior. It has now become *structured Empathy*.

The universalization of the scale of inclusiveness driven by our evolved neural architecture underpins the concept of unintended consequences or the action of the Invisible Hand in early social exchange and in the evolved structure of the modern market. The idea comes to us intuitively and naturally based on the dynamic of our social brain – the Ego/Empathy dynamic playing out within each of our skulls as well as between us in social interaction. The intuitive doctrine of unintended consequences or the Invisible Hand launched a determined research program to *scientize* it. This program called general equilibrium theory has been the core of modern economic theorizing from Adam Smith to the present day. The publication of Adam Smith's *Wealth of Nations* (1776), spurred a movement to further refine his concepts. Additionally, scholars sought to move economics from the status of a moral science to that of a positive or objective science.

The unsuccessful effort to find physical laws

The effort to find the universal physical laws driving the market to equilibrium occupied economists and mathematicians over the next 200 years. Almost every conceivable approach was tried without producing satisfactory results. The efforts continue to this date with at best some limited success but with mostly discouraging outcomes. The model initially chosen was, of course, physics. The monumental work of Isaac Newton (1642–1727), with his laws of gravity and the motion of heavenly bodies, was the natural inspiration. Economists sought to discover the natural clock-like laws of the universe that drove the market to equilibrium – like the forces of physical nature and the dramatically precise mathematical calculus that had been developed to describe them.

The main challenge, then, was to account for the anticipated market equilibrium in terms of the equilibrium of natural force vectors. The Invisible Hand was, ambitiously, to be moved from the vague status of a divine intervention or intuited but ill-defined force of human nature or natural law into the status of a mathematically definable set of natural force vectors comparable to those of physics.

During the proximal decades before and after the pivotal decade of 1870s, the so-called "neoclassical" economics – still dominant today – emerged. The emergence marked greatly increased synergy between physics and economics. In tracing the historical relationships, Mirowski (1989) wrote:

> Once one starts down that road, one rapidly discovers that the resemblances of the theories are uncanny, and one reason they are uncanny is because the progenitors of neoclassical economic theory boldly copied the reigning physical theories in the 1870s. The further one digs, the greater the realization that those neoclassicals did not imitate physics in a desultory or superficial manner; no, they copied their models mostly term for term and symbol for symbol, and said so. (1989: 3; for a detailed presentation and discussion of this copying see chapter 5 of the cited work).

The "borrowing" from physics in the search for the underlying regularities of the Invisible Hand became known as general equilibrium theory or GET. For the most comprehensive historical analysis of the invisible hand and general equilibrium theory consult Ingrao and Israel (1990).

GET: Off on the wrong foot

Thus, GET got off on the wrong foot. Neuroscience was not yet developed at this time. Therefore, the appropriated models of physics seemed the only way forward from the prevailing philosophical speculation about human nature, natural law, or the mystical attributes of the Deity.

Furthermore, the Newtonian system and methodology of physics were overwhelmingly venerated as the standard of true science in the intellectual circles of the day. This veneration held in England and also on the continent of Europe. It was impossible to know at that time that the foundation of the market was in the organic algorithms of our social brain – like brains interacting with like brains – not in the mechanical laws of physics. GET, thus, took the wrong path to a long and tortuous history. But perhaps it couldn't be helped. There was no equivalent or acceptable alternative available. The largely vain search has led some theorists to suggest that a new approach or paradigm may be needed. The proper model, the CSN model, based in neural architecture did not become available until the full emergence of evolutionary neuroscience in the closing years of the 20th century.

I will briefly trace the main developmental features of GET up to the present. In doing so I will omit much historical detail but hopefully still provide an appreciation of where GET came from and where it stands today.

Léon Walras and the full establishment of GET

Equilibrium thinking had long occupied the minds of many European scholars. The effort to Newtonize the concept of the invisible hand, therefore, shortly shifted from Adam Smith's Scotland to continental France. Montesquieu (1689–1755), historically associated with the doctrine of the separation of powers so fully expressed in the American constitution, was early concerned with exploring the equilibrium of social forces in analogical keeping with the Newtonian paradigm.

The French economist Léon Walras (1834–1910), however, is the one credited with putting GET effectively on the economic landscape. Drawing upon the partial work of a number of important predecessors and more recent developments in nineteenth century physics, he put together a set of equations for all the markets of an economy. These equations were to be solved simultaneously to achieve an economy-wide equilibrium.

Distortions of physics and Plato

It was an ambitious project motivated by the belief that there were God-given or natural laws of economics, like the laws of physics, and that these laws could discovered and expressed precisely in mathematical form. Walras not only followed the model of physics, but also Plato's concept of universals. Citing Plato, Walras held that the purpose of science is the study of universals; the only difference among the sciences is with the facts their practitioners select for their study (Walras 1954: 61). The Platonic approach created a further distortion. Universals, of course, do not hold in evolved systems, because of their inherent variability. Walras, as well as his followers in GET, was putting too great of a demand for precision upon a variable organic dynamic that they imagined to be not only a Platonic universal of the cosmos but analogous to the laws of physics.

Utility theory of value

However, especially important in Walras's system was his development of the utility theory of value. Previous scholars like Ricardo and Karl Marx believed that the amount of labor put into a product determined the value. Walras held that not the labor but the utility or satisfaction that the product yielded to buyers in the market was the proper measure of value. The prices, then, that people were willing to pay, marked the level of utility for buyers and these prices changed continuously as they groped for a stable equilibrium between sellers and buyers in the market guided by natural underlying law-like market forces. A stable equilibrium of price vectors became the aim of GET.

Axiomatization: From the top down

The bottom-up approach of Walras and his followers, attempting to match the success of physics, failed to produce the desired results. The mechanical model, then, later gave way to the top-down modeling of mathematician John von Neumann and mathematical economist Oskar Morgenstern. In 1944, they published their jointly authored *Theory of Games and Economic Behavior*. This work launched a new impulse toward axiomatization. This was matched by a somewhat parallel effort by economist Paul Samuelson of Harvard in his *Foundations of Economic Analysis* (1947). Axiomatization involved the building up of a system or model economy by proposing, without necessity of proof, a set of principles that dictated the direction of movement within the model system. Such a system, then, may or may not have any connection with reality. It was primarily an effort to determine under what conditions a system *could* work.

Quantum uncertainty becomes economic uncertainty

The new approach was inspired in large part by developments of uncertainty in modern quantum physics. The uncertainty principle, articulated by German physicist, Werner Heisenberg, revealed at the quantum level the particle-wave duality plus the fact that both the momentum and the position of a particle could not be determined simultaneously. The precise measurement of momentum and position was a process fundamental to the Newtonian system. The findings of quantum physics shook the previously unshakable foundations of straightforward Newtonian mechanics. With uncertainty produced at the foundations of physical science, it was plausible and justifiable to move to a top-down posture of formal modeling in economics. Formal modeling was an attempt to impose some certainty on what had now become an uncertain reality.

Arrow and Debreu existence but no uniqueness or stability

The new approach, in turn, led to the top-down axiomatic approach of French economist Gerard Debreu and American economist Kenneth Arrow. What the bottom-up approach failed to achieve, the top-down approach tried anew. The modeling and axiomatic approaches made little attempt to connect with real economic systems. Their purpose was to try to capture the illusive pattern of the intuited law-like market forces from the top-down by rigorously structured highly simplified models of possible economies.

The pursuit of the question of a market equilibrium produced by the intuited invisible hand became formally divided into the three categories of *existence, uniqueness*, and *stability*. *Existence* required a general equilibrium of sorts. Uniqueness required that the equilibrium settle at one overall set of prices. *Stability* required that the market forces themselves drive inevitably toward equilibrium – and not away from it into disequilibrium. All three aspects were considered to be essential to the proof of GET.

The axiomatic formalization of Arrow and Debreu, published jointly in the journal *Econometrica* in 1954, applied the new methodology to the earlier but recently updated GET theory of John Hicks. Hicks, who spent time at both the London School of Economics and Cambridge, published his *Value and Capital* in 1939. These efforts, and some follow-on ones using the same approach, did achieve demonstration of the *existence* of GET under very general assumptions inherently fundamental to the basic Walrasian theory. On the additional problems of *uniqueness* and *stability*, however, the results have been disappointingly unsuccessful. Nevertheless, failure did not deter the committed. Formalization continued apace. In the continuing formalization process, however, form has taken precedent over content. Models have become more and more divorced from reality and equally from empirical verification.

GET to the future: The assisted free enterprise

The over-formalization of GET and the limited success at the end of the past century led Michio Morishima, a theorist at the London School of Economics, to judge the world of GET to be in fact a dream world not workable in the context of actual society (1992: 70–71).

Of dreams, faith, utopia, and Alice in Wonderland

I should note that previous scholars had also noted the "dreaminess" of GET. For example, George Stigler, near the end of his clearly stated and popular work on the basics of price theory made the following statement about GET:

> Perhaps this brief and highly incomplete sketch is sufficient to illustrate the basis for the economist's faith, for such it is, in the general interdependence of economic phenomena. (1952: 289)

Morishima went on to say that GET economists, including specialists in von Neumann mathematical modeling, had sunk into excessive mental estheticism. He predicted a poor future for GET in the 21st century unless economists could forgo the delights of mathematical display and proceed to build models based on reality. The disillusionment with GET has continued. Frank Ackerman, of Tufts University has bluntly declared it dead (1999). He sees "the roots of the problem in the early history of general equilibrium theory: a mathematical framework transplanted from nineteenth-century physics was far less fruitful in economics, due to fundamental differences between the two fields" (1999: 2).

Alan Kirman, University of Aix-Marseille III, France, in his pessimistic report on GET writes: "The extent to which the analogy between physics and economics has ensnared economics in a position that could have been avoided had it found its source of inspiration elsewhere – for example in biology, as Marshall suggested – is well documented. . . ." (2006: 254; also see Marshall, 1920, xiv also bk I, ch. IV). Jonathan Schlefer, a former editor of MIT's *Technology Review* and author of *The Assumptions Economists Make* (2012) reports that Thomas Palley, a Financial Times contributor and liberal economist, has called GET a paradigm "drawn from Alice in Wonderland" (Schlefer, 2012: 97). Schlefer himself, has called it "utopian" because of its lack of connection to reality (2012: 72–92).

The absentee God's model vs. intelligent design

Nobelist Thomas Sargent, of New York University and Hoover Institution at Stanford has referred to the assumed but yet to be discovered "correct" underlying model of GET as "God's model." (Reported in an interview by George Evans and Seppo Honkapohja, 2005, esp., pp. 566, 570, 575). Of course, there is none – that is, there is no correct or God's model. As previously noted, the vain search for such a model was first motivated by mystical intuition and then by the desire to ape the success of Newtonian and later nineteenth century physics. When the latter effort failed, economists shifted to the top-down modeling of von Neumann mathematics. That, too, has now come to a dead end.

I repeat: there is no underlying God's model to be found. The neural architecture of our mammalian ancestry, with its dual motives of Ego and Empathy, self-and other-interest, is the foundation of all social exchange. It motivates us to look for balance, fairness, or equilibrium in personal relationships, gift-giving, and market exchange. Owing to the constraints and complexities of social organization it has never historically been generalizable or aggregate-able on its own at the society level. Thus, any model developed at the macro level will necessarily be situational: as Sargent suggests – intelligently designed – to achieve the desired equilibrium under existing situational constraints (2008).

In the final analysis pragmatism and intelligent assist

The so-called God model or natural law model analogous to physics does not exist in economics. It is a chimera chased in vain for some two centuries by some of the best minds in economic theory. My own evaluation, based on the recent findings of the foundation of the market in the dynamics of evolved brain structure, is that the further pursuit of *uniqueness* and *stability* are exercises in futility. They were parts of the God model. The neural algorithms, although likely providing an intuitive motivational basis for the search for laws and patterns, are too weak and variable – too subject to blockage and frustration in the complexities and distances of the greater market – to ever assure us of getting to an unassisted equilibrium that is unique or stable.

Our challenge is, therefore, to pragmatically assist the market to reach these goals of meeting the needs of society with a minimum of inequalities and the accompanying social (behavioral) tensions. We will achieve the sought after dynamic equilibrium in the society-wide market of the future only by an Empathy/Ego-motivated intentional, pragmatic (in Sargent's words "intelligently designed") assist to the market forces which themselves emerge from our neural architecture. Such assistance to the market will surely require wisely limited regulation to avoid stifling the incentives that challenge us to produce the societal wealth for the benefit of us all. The assisted free enterprise market can lead us into the future and serve the purpose of a global democratic society.

Conclusion

I like to think of DMT, not only as fulfillment of the Mecca insight of Alfred Marshall, but also perhaps the correction and fulfillment of neoclassical theory rather than a challenge to replace it. I feel that if Marshall had access to the biological sciences of today he would almost certainly have incorporated them into his synthesis.

A full grasp of the biological perspective allows economics to come nearly full circle from the days of Adam Smith. From its origins as a moral or normative science, through its failed transition to a purely positive science, the revised theory emerges as a mixed positive-normative science. It is a positive science because it is anchored firmly in the fundamental biological sciences. It is a normative science because what we have come to cognitively call our moral choices, expressed so forcefully in the present-day social demands for equality and justice, emerge from and are mandated by our physiology – the homeostatic, dynamically-balanced function of our evolved dual motive mammalian neural architecture. Therefore, from the positive emerges the normative. There is no separation of the two. Equality and justice in economics and the other social sciences can no longer be considered as solely ethical, philosophical, religious, cultural or even "learned" considerations. They are, scientifically: inborn – genetically evolved neuro-physiological imperatives.

John Tomer understood these things and saw the importance of accurately understanding economics, not as a purely positive science promoting selfishness and greed under the no longer defensible posture of scientific objectivity, but as a mixed positive-normative, moral science (as did Adam Smith and others). Let us honor his contributions and memory by following his last advice to us quoted at the beginning of this memorial essay.

References

Abiotiz, F. & Montiel, J. (2012). From tetrapods to primates. *Progress in Brain Research, 195*: 3–24.

Ackerman, F. (1999). Still Dead After All These Years: Interpreting the Failure of General Equilibrium Theory. *Global Development and Environment Institute, 1*.

Alexander, R. (1987). *The Biology of Moral Systems*. Aldine de Gruyter.

Arrow, K. & Debreu, G. (1954). Existence of an Equilibrium for a Competitive Economy. *Econometrica, 22*: 265–290.

Arrow, K. & Hahn, F. (1971). *General Competitive Analysis*. North-Holland Publishing.

Avsar, R. (2020). *The Evolutionary Origins of Markets*. Routledge.

Axelrod, R. & Hamilton, W. (1981). The Evolution of Cooperation. *Science, 211*: 1390.

Barfield, T, ed. (1997). *The Dictionary of Anthropology*. Blackwell.

Beauregard, M. & O'Leary, D. (2007). *The Spiritual Brain*. Harper One.

Bendor, J. & Swistak, P. (1997). The Evolutionary Stability of Cooperation. *American Political Science Review, 91*(2): 290–303.

Berger, S., Kouzarides, T., et al. (2009). An operational definition of epigenetics. *Genes & Dev, 23*: 781–783.

Berridge, K. (2003). Comparing the Emotional Brains of Humans and Other Animals. *Handbook of Affective Sciences*: 25–51. Ed. by R. Davidson, et al. Oxford.

Blair R. (2003). Facial expressions, their communicatory functions and neurocognitive substrates. *Philos Trans R Soc Lond B Biol Sci, 358*: 561–572.

Blumberg, M., Freeman, J. & Robinson, S. (2010). *Oxford Handbook of Developmental Behavioral Neuroscience: Introduction*.

Boehm, C. (1999). *Hierarchy in the Forest: The Evolution of Egalitarian Behavior*. Harvard.

Bohannon, P. (1963). *Social Anthropology*. Holt. Rinehart and Winston.

Braudel, F. (1982). *Civilization and Capitalism 15^{th}-18^{th} Century*. Trans. By S. Reynolds. Harper & Row.

Breggin, P. (2008). *Brain-disabling Treatments in Psychiatry*. Springer.

Brownell, H. & Martino, G. (1998). Deficits in Inference and Social Cognition: The Effects of Right Hemisphere Brain Damage on Discourse. *Right Hemisphere Language Comprehension: Perspectives from Cognitive Neuroscience*: 309–328. Ed. by M. Beeman and C. Chiarello. Lawrence Erlbaum.

Butler, A. (2009). Triune Brain Concept: A Comparative Evolutionary Perspective. *Encyclopedia of Neuroscience*: 1185–1193. Elsevier.

Butler, A. & Hodos, W. (2005). *Comparative Vertebrate Neuroanatomy*. 2nd Ed. Wiley.

Cacioppo, J., Berntson, G., Adolphs; R., Carter, C., Davidson, R., et al., eds. (2002). *Foundations in Social Neuroscience*. MIT.

Cannon, W. (1929). *Bodily Changes in Pain, Hunger, Fear, and Rage*. D. Appleton & Co.

Carter, C., et al. (2006). *Attachment and Bonding: A New Synthesis*. MIT.

Carter, C. & Keverne, E. (2002). The neurobiology of social affiliation and pair bonding. *Hormones, Brain, and Behavior*: 299–337. Pfaff, D., et al. (Eds.). Academic Press.

Carter, C., Lederhendler, I., & Kirkpatrick, B. eds. (1997). *The Integrative Neurobiology of Affiliation, 807*. NY Academy of Sciences.

Chalupa, L., et al. (2011). *Cerebral Plasticity: New Perspectives*. MIT.

Cory, G. (2018). *Delusions of Economics and the Way Forward*. Behavioral Ecology Press.

Cory, G. (2012). *Consilience, Brains, and Leadership*. International Technological University.

Cory, G. (2010). *Consilience, Brains, and Markets*. International Technological University.

Cory, G. (2009). Let's Stop Teaching Greed. Dual Motive Theory as a New Paradigm for Global Economics. Paper presented at the *combined meeting of the International Association for Research in Economic Psychology (IAREP) and the Society for the Advancement of Behavioral Economics (SABE)* held at Saint Mary's University, Halifax, Nova Scotia, July 7–10.

Cory, G. (2006a). Physiology and Behavioral Economics: The New Findings from Evolutionary Neuroscience. *Handbook of Contemporary Behavioral Economics: Foundations and Developments*: 24–49. Ed. by Altman, M., ME Sharpe.

Cory, G. (2006b). A behavioral model of the dual motive approach to behavioral economics and social exchange. *The Journal of Socio-Economics, 35*(4): 592–612.

Cory, G. (2004). *The Consilient Brain: The Bioneurological Basis of Economics, Society, and Politics*. Kluwer Academic/Plenum.

Cory, G. (2003). MacLean's Evolutionary Neuroscience and the CSN Model: Some Clinical and Social Policy Implications. *Human Nature and Public Policy*: 161–180. Ed. by Somit, A. and Peterson, S. Palgrave MacMillan.

Cory, G. (2002a). Reappraising MacLean's Triune Brain Concept. *The Evolutionary Neuroethology of Paul MacLean: Convergences and Frontiers*: 9–27. Ed. by G. Cory & R. Gardner. Greenwood/Praeger.

Cory, G. (2002b). Algorithms of Neural Architecture, Hamilton's Rule, and the Invisible Hand of Economics. *The Evolutionary Neuroethology of Paul MacLean: Convergences and Frontiers*. Ed. by G. Cory & R. Gardner. Greenwood/Praeger.

Cory, G. (2000). From MacLean's Triune Brain Concept to the Conflict Systems Neurobehavioral Model: The Subjective Basis of Moral and Spiritual Consciousness. *Zygon: Journal of Religion & Science, 35*(2): 385–414.

Cory, G. (1999). *The Reciprocal Modular Brain in Economics and Politics: Shaping the Rational and Moral Basis of Organization, Exchange, and Choice*. Plenum.

Cory, G. (1992). *Rescuing Capitalist Free Enterprise for the Twenty First Century*. Center for Behavioral Ecology.

Cory, G. (1974). *The Biopsychological Basis of Political Socialization and Political Culture*. Ph.D. thesis. Stanford.

Cory, G. & Gardner, R., eds. (2002). *The Evolutionary Neuroethology of Paul MacLean.Convergences and Frontiers*. Greenwood/ Praeger.

Damasio, A. (1999). *The Feeling of What Happens*. Harcourt.

Damasio, A. (1994). *Descartes Error*. Grosset/Putnam.

Davidson, R.; Scherer, K.; & Goldsmith. H. eds. (2003). *Handbook of Affective Sciences*. Oxford.

Decety, J., & Ickes, W. (2009). *The Social Neuroscience of Empathy*. MIT.

Derrida, J., (1992). *Given Time: I. Counterfeit Money*. Trans. Peggy Kamuf. University of Chicago Press.

Devinsky, O. & Luciano, D. (1993). The Contributions of Cingulate Cortex to Human Behavior. *Neurobiology of Cingulate Cortex and Limbic Thalamus: A Comprehensive Handbook*: 527–556. Ed. by Vogt, B. and Gabriel, M. Boston: Birkhauser.

de Waal, F. (1996). *Good Natured: The Origins of Right and Wrong in Humans and Other Animals*. Harvard.

Douglas, M. (1990). Foreword: No Free Gifts. *M. Mauss, The Gift*. Trans. By W. Halls. Norton.

Dunbar, R. (2016). *Human Evolution*. Oxford.

Eisenberg, N. (1994). Empathy. *Encyclopedia of Human Behavior*: 247–253. Ed. by V. S. Ramachandran. Academic Press.

Erdal, D. & Whiten, A. (1996). Egalitarianism and Machiavellian Intelligence in Human Evolution. *Modelling the Early Human Mind*: 139–150. Ed. by P. Mellars & K. Gibson. The Mc Donald Institute, Cambridge.

Evans, G. & Honkapohja, S. (2005). An interview with Thomas J. Sargent. *Macroeconomic Dynamics, 9*: 561–583.

Evans, S. (2000). General Discussion II. *Evolutionary Developmental Biology of the Cerebral Cortex*. Ed, by G. Bock & G. Cardew. Wiley.

Fioriti, L., et al. (2015). The Persistence of Hippocampal-Based Memory Requires Protein Synthesis Mediated by the Prion-like Protein CPEB3. *Neuron, 86*(6): 1433–1448, 17 June 2015.

Friedman, M. (1962). *Capitalism and Freedom*. University of Chicago Press.

Fulton, J. (1951). *Frontal Lobotomy and Affective Behavior*. Norton.

Fuster, J. (2008). *The Prefrontal Cortex*, Fourth Edition, Academic Press.

Fuster, J. (1980). *The Prefrontal Cortex: Anatomy, Physiology, and Neuropsychology of the Frontal Lobe*. Raven Press.

Gehring, W. (1998). *Master Control Genes in Development and Evolution*. Yale.

Ghiselin, M. (1989). *Intellectual Compromise*. Paragon.

Ghiselin, M. (1974). *The Economy of Nature and the Evolution of Sex*. University of California.

Gloor, P. (1997). *The Temporal Lobe and the Limbic System*. Oxford.

Greenough, W. & Chang, F. (1989). Plasticity of synapse structure and pattern in the cerebral cortex. In A. Peters & E. Jones (Eds.), *Cerebral cortex, 7*: 391–440. Plenum.

Gregory, C. (1982). *Gifts and Commodities*. Academic Press.

Gribbin, J. (2004). *Deep Simplicity: Bringing Order to Chaos and Complexity*. Random House.

Hamilton, W. (1964). The Genetical Evolution of Social Behavior, I & II. *Journal of Theoretical Biology, 7*: 1–16 & 17–52.

Harrington, A. ed. (1992). *So Human a Brain*. Boston: Birkhauser.

Heller, W., Nitschke, J & Miller, G. (1998). Lateralization in Emotion and Emotional Disorders. *Current Directions in Psychological Science, 7*(1): 26–32.

Henry, J. & Wang, S. (1998). Affects of Early Stress on Adult Affiliative Behavior. *Psychoneuro-endocrinology, 23*(8): 863–875.

Herbert, J. & Schulkin, J. (2002). Neurochemical Coding of Adaptive Responses in the Limbic System. *Hormones, Brain and Behavior*: 659–697. Ed. By D. Pfaff, et al. Academic Press.

Hicks, J. (1939). *Value and Capital*. Oxford.

Hodgson, G. (1993). *Economics and Evolution*. Polity Press.

Hoffman, M. (2000). *Empathy and Moral Development*. Cambridge.

Housepian, E. (1998). Bilateral Frontal Resection for Psychoses Revisited. *Medical Review. Fall, 5*(2).

Hubisz, M. & Pollard, K. (2014). Exploring the genesis and functions of Human Accelerated Regions sheds light on their role in human evolution. *Current Opinion in Genetics & Development, 29*: 15–21.

Humphrey, N. (1976). The Function of the Intellect. *Growing Points in Ethology*: 303–317. Ed. by P. Bateson & R. Hinde. Cambridge.

Ingrao, B. & Israel, G. (1990). *The Invisible Hand: Economic Equilibrium in the History of Science*. Trans. by Ian McGilvray. MIT.

Isaac, G. (1978). The Food-sharing Behavior of Protohuman Hominids. *Scientific American, 238*: 90–108.

Jaffe, W. (1983). *William Jaffe's Essays on Walras*. Ed. D. Walker. Cambridge.

Jones, E. (2007). *The Thalamus*. 2nd Ed. Cambridge.

Kaku, M. (2014). *The Future of the Mind*. Doubleday.

Kandel, E. et al. (2013). *Principles of Neural Science*. 5th Edition. McGraw-Hill.

Kandel, E., Schwartz, J. & Jessell, T. (2000). *Essentials of Neural Science and Behavior*. Appleton & Lange.

Kemp, T. (2016). *The Origin of Higher Taxa*. Oxford & Chicago.

Kirman, A. (2006). Demand Theory and General Equilibrium: From Explanation to Introspection, a Journey down the Wrong Road. *History of Political Economy, 38* (annual suppl): 246–280.

Knauft, B. (1994). Culture and Cooperation in Human Evolution. L. Sponsel & T. Gregor, eds. *The Anthropology of Peace and Nonviolence*: 37–67. Lynne Rienner.

Kohlberg, L. (1984). *The Psychology of Moral Development, 2*. Harper & Row.

Kolb, B. (1995). *Brain Plasticity and Behavior*. Erlbaum.

Kolb, B., Gibb, R. & Robinson, T. (2003). Brain Plasticity and Behavior. *Current Directions in Psychological Science, 12*(1): 1–5, Feb.

Kolb, B. & Gibb, R. (2011). Brain Plasticity and Behaviour in the Developing Brain. *Journal of the Canadian Academy of Child and Adolescent Psychiatry Nov, 20*(4): 265–276.

Komter, A. (2005). *Social Solidarity and the Gift*. Cambridge.

Lambert, K. & Gerlai, R. eds. (2003). A Tribute to Paul MacLean: The Neurobiological Relevance of Social Behavior. *Physiology and Behavior, 79*(3).

Leh, S. et al. (2010). The Neural Circuitry of Executive Functions in Healthy Subjects and Parkinson's Disease. *Neuropsycho-pharmacology, 35*(1): 70–85, Jan.

Levine, D. (2006). Neural modeling of the dual motive theory of economics. *Journal of Socio-Economics, 35*(4). August.

Levine, D. & Yani, N. (2002). Toward a Neural Network Theory of the Triune Brain. *The Evolutionary Neuroethology of Paul MacLean*. Cory, G. & Gardner, R., (eds). Convergences and Frontiers. Praeger.

Lieberman, P. (2000). *Human Language and Our Reptilian Brain*. Harvard.

Loonen, A. & Ivanov, S. (2016). Circuits Regulating Pleasure and Happiness: the evolution of the amygdalar-hippocampal-habenular connectivity in vertebrates. *Front Neurosci, 10*: 539.

Lynne, G. (2006). Toward a Dual Motive Economic Theory. *Journal of Socio-Economics, 35*(4). August.

Lynne, G. (2002). The Reciprocal Modular Brain in Economics and Politics (Book Review). *Journal of Socio-Economics, 31*: 581–586.

MacLean, P. (1990). *The Triune Brain in Evolution: Role in Paleocerebral Functions*. Plenum.

Mandeville, B. de. (1714). *Fable of the Bees*.

Marshall, A. (1947). *Principles of Economics*. Eight Edition. Routledge.

Marshall, A. (1949 [1920]). *Principles of Economics*. Eighth Edition. MacMillan.

Marshall, A. (2003 [1892]). *Elements of Economics of Industry*. Simon Publications.

Martini, F., et al. (2015). *Fundamentals of Anatomy & Physiology*. Tenth Edition. Pearson Education.

Mauss, Marcel. (1990). *The Gift*. Trans. By W. Halls. NY: Norton

Mauss, Marcel. (1954). *The Gift*. Trans. by Ian Cunnison. Norton.

Maynard Smith, J. (2002). Equations of Life. *It Must be Beautiful: Great Equations of Modern Science*: 193–211. Ed. by G. Farmelo. Granta Books.

Maynard Smith, J. (1982). The Evolution of Social Behavior–a Classification of Models. *Current Problems in Sociobiology*: 28–44. Ed by. King's College Sociobiology Group. Cambridge.

Mirowski, P. (1989). *More Heat than Light*. Cambridge.

Morgane, P., Galler, J., Mokler, D. (2005). A review of systems and networks of the limbic forebrain/limbic midbrain. *Progress in Neurobiology, 75*: 143–160.

Morishima, M. (1992). General Equilibrium Theory in the Twenty-First Century. *The Future of Economics*. Ed. By John D. Hey. Oxford: Blackwell.

Nelson, R., (2000). *An Introduction to Behavioral Endocrinology*. 2nd Ed. Sinauer.

Neumann, J. von & Morgenstern, O. (1944). *Theory of Games and Economic Behavior*. Second ed. Princeton.

Newman, J. & Harris, J. (2009). The Scientific Contributions of Paul D. MacLean 1913–2007. *Journal of Mental and Nervous Disease, 197*(1).

Numan, M. & Insel, T. (2003). *The Neurobiology of Parental Behavior*. Springer.

O'Callaghan, M. & Carroll, D. (1982). *Psychosurgery: A Scientific Analysis*. MTP Press.

Osteen, M. (2002). Gift or Commodity. *The Question of the Gift*: 229–247. Ed. by M. Osteen. Routledge.

Panksepp, Jaak. (2004). *Textbook of Biological Psychiatry*. Wiley.

Panksepp, Jaak. (2002). Foreword. *The Evolutionary Neuroethology of Paul MacLean: Convergences and Frontiers*. Ed. by G. Cory & R. Gardner. Praeger.

Panksepp, Jaak. (1998). *Affective Neuroscience*. NY: Oxford.

Parry, J. and Bloch, M. (eds.).(1989). *Money and the Morality of Exchange*. Cambridge.

Perlman, M. & McCann, C. (1999, 2000). *The Pillars of Economic Understanding, 1&2*. Michigan.

Piaget, Jean. (1965 [1932]). *The Moral Judgement of the Child*. Free Press.

Plato. (1982 [c 380 B.C.]). *The Republic*. Trans. by G. Grube Indianapolis, IN: Hackett.

Polanyi, K. (1944). *The Great Transformation*. Farrar & Rineheart.

Pollard, K. (2009). What Makes Us Human? *Scientific American, 300*(5): 44–49.

Porges, S. (1998). Love: An emergent property of the mammalian autonomic nervous system. *Psycho-neuroendocrinology, 23*: 837–861.

Pressman, J. (1998). *Last Resort: Psychosurgery and the Limits of Medicine*. Cambridge.

Pribram, K. & Luria, A. (eds.) (1973). *Psychophysiology of the Frontal Lobes*. Academic Press.

Prigogine, I. & Stengers, E. (1984). *Order out of Chaos: Man's New Dialogue with Nature*. New Science Library.

Przewlocki, R. (2002). Stress, Opiod Peptides, and their Receptors. *Hormones, Brain, and Behavior*: 691–733. Ed. by D. Pfaff, et al. Academic Press.

Reiner, A. (1990). Review of MacLean's The Triune Brain in Evolution. *Science, 250*: 303–305, (Oct 12).

Rizzolati, G. (2011). The Mirror Mechanism: New Findings. Keynote Address: *Annual Conference American Psychological Society*: 26–29, May. Washington, D.C.

Rolls, E. (2016). *Cerebral Cortex: Principles of Operation*. Oxford.

Saarela, M., et. al. (2006). The Compassionate Brain: Humans Detect Intensity of Pain from Another's Face. *Cerebral Cortex*. doi: 10. 1093/cercor/bhj 141.

Sagan, C. (1977). *Dragons of Eden*. Ballantine Books.

Sahlins, M. (1976). *Culture and Practical Reason*. Chicago.

Sahlins, M. (1972). *Stone Age Economics*. Aldine-Atherton.

Sahlins, M. (1963). On the sociology of primitive exchange. *The Relevance of Models for Social Anthropology*: 139–236. Ed. by M. Banton. Tavistock.

Samuelson, P. (1947). *Foundations of Economic Analysis*. Harvard.

Santiesteban, I., et al. (2012). Enhancing Social Ability by Stimulating Right Temporoparietal Junction. *Current Biology, 22*(23): 2274–2277, 4 Dec 2012.

Sapolsky, R. (2017). *Behave: The Biology of Humans*. Penguin.

Sargent, T. (2008). Evolution and Intelligent Design. *American Economic Review, 98(1)*: 5–37.

Schlefer, J. (2012). *The Assumptions Economists Make*. Belknap Press of Harvard.

Schulkin, J. (2002). Hormonal Modulation of Central Motivational States. *Hormones, Brain, and Behavior*: 633–657. Ed. by D. Paff. V.1. Academic.

Sen, A. (1979). Rational Fools: A Critique of the Behavioral Foundations of Economic Theory. *Philosophy and Economic Theory*. Eds F. Hahn and M. Hollis. Oxford.

Seymour-Smith, C. (1986). *Dictionary of Anthropology*. Boston: G. K. Hall & Co.

Shaw, C. & McEachern, J. (2001). *Toward a Theory of Neuroplasticity*. Psychology Press.

Sherman, S. & Guillery, R. (2001). *Exploring the Thalamus*. Academic Press.

Sherwood, C.; Bauernfeind, A, Bianchi, S. & Raghanti M. (2012). Human brain evolution writ large and small. *Prog Brain Res, 195*: 237–254.

Singer, T. (2006). The Neuronal Basis and Ontogeny of Empathy and Mind Reading. *Neuroscience and Biobehavioral Reviews, 30*: 855–863.

Skoyles, J. & Sagan, D. (2002). *Up from Dragons: The Evolution of Human Intelligence*. McGraw-Hill.

Smith, Adam (1977 [1740-90]). The Correspondence of Adam Smith,(1740-90), Mossner, E. & Ross, T. Eds. *The Glasgow Edition of the Works and Correspondence of Adam Smith, 6*. General editing by D. Raphael and A. Skinner. Oxford: Clarendon Press.

Smith, Adam (1982 [1790]). *The Theory of Moral Sentiments*. 6th edition. Ed. by D. Raphael & A. Macfie. Liberty Press.

Smith, Adam (1937 [1776]). *The Wealth of Nations*. Ed. by E. Cannan. Modern Library.

Smith, Adam (1986 [1776]). *The Wealth of Nations*, Books I-III. Penguin Classics.

Stigler, G. (1976). The Successes and Failures of Professor Smith. *Selected Papers, 50, Graduate School of Business*. University of Chicago.

Stigler, G. (1971). Smith's Travels on the Ship of State. *History of Political Economy*: 265.

Stigler, G. (1952). *The Theory of Price*. MacMillan.

Stuss, D. & Knight, R. (2002). *Principles of Frontal Lobe Function*. Oxford.

Tankersley, D., Stowe, C., Huettel, S. (2007). Altruism is Associated with an Increased Neural Response to Agency. *Nature Neurosciencem 10*(2): 150–151, Feb.

Taylor, S. (2002). *The Tending Instinct*. Time Books.

Taylor, T. (2012). *The Instant Economist*. Plume (Penguin).

Teitelbaum, H. (1956). Homeostasis and Personality, *Archives of Neurology and Psychiatry*: 317–324.

Tickell, C. (1993). The Human Species: A Suicidal Success. *Geographical Journal, 159*: 219–226.

Tomer, J. (2018). Book Review: Delusions of Economics and the Way Forward. *Journal of Behavioral and Experimental Economics*: 24–25, August.

Tomer, J. (2012). Brain Physiology, Egoistic and Empathetic Motivation, and Brain Plasticity: Toward a More Human Economics. *World Economic Review, 1*.

Trivers, R. (1981). Sociobiology and Politics. *Sociobiology and Human Politics*: 1–44. Ed. by E. White. Heath & Company.

Trivers, R. (1971). The Evolution of Reciprocal Altruism. *The Quarterly Review of Biology, 46*: 35–57.

Tucker, D., Luu, P., Phan, P. & Pribram, K. (1995). Social and Emotional Self-Regulation. *Annals of the New York Academy of Sciences, 769*: 213–239.

Valenstein, E. (1986). *Great and Desperate Cures: The Rise and Decline of Psychosurgery and Other Medical Treatments for Mental Disorders*. Basic Books.

Vinogradova, OS. (2001). Hippocampus as comparator: role of the two input and two output systems of the hippocampus in selection and registration of information. *Hippocampus, 11*(5): 578–98.

Walker, D. (Ed.) (1983). *William Jaffe's Essays on Walras*. Cambridge.

Walras, Léon. (2010 [1936]). *Studies in Social Economics*. Trs. J. van Daal & D. A. Walker. Routledge.

Walras, Léon. (1954). *Elements of Pure Economics*. 4th Edition. Trans. by W. Jaffe. Richard D. Irwin, Inc.

Ward, L. (2013). The thalamus: gateway to the mind. *WIREs Cogn Sci*. doi: 10.1002/wcs.1256.

Wilson, D. & Cory, G. (2008). *The Evolutionary Epidemiology of Mania and Depression*. Mellen Press.

Wilson, E. (2012). *The Social Conquest of Earth*. Liveright.

Wilson, E. (1998). *Consilience: The Unity of Knowledge*. Knopf.

Witter, M. & Groenewegen, H. (1992). Organizational Principles of Hippocampal Connections. *The Temporal Lobes and the Limbic System*: 37–60. Ed. by Trimble, M. et al. Wrightson Bio-medical Publishing.

Wood, R., et al. (2015). Evolutionary Neuroscience and Motivation in Organizations. *Organizational Neuroscience*: 143–167. Ed. by D. Waldman and P. Balthazard. Emerald.

Zimmer, C. (2014). *The Tangled Bank: An Introduction to Evolution*. Second Edition. Roberts and Company.