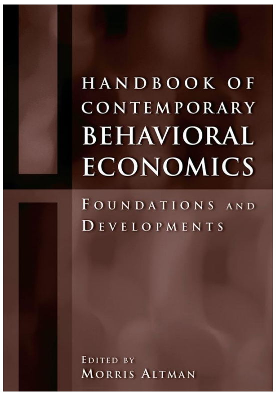

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Morris Altman

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CHAPTER 2

PHYSIOLOGY AND BEHAVIORAL ECONOMICS

The New Findings from Evolutionary Neuroscience

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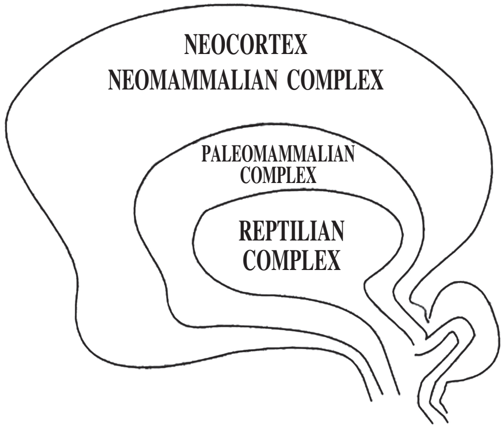
The brain is a physiological organ. That is a fundamental fact of science. The gene-specified neural circuits or architecture constitute that fundamental physiology. And physiologically, the human brain is also a *social* brain. The emergence of the concept of the social brain, emphasizing both the self-preservational (self-interested) and affectional (other-interested) components necessary to social exchange, has been landmarked by the publication of two recent handbooks—*Foundations in Social Neuroscience* (Cacioppo et al. 2002) and *Handbook of Affective Sciences* (Davidson et al. 2003) (see also Cory and Gardner 2002). Earlier but still recent volumes include *Descartes' Error: Emotion, Reason, and the Human Brain* (Damasio 1994), *The Integrative Neurobiology of Affiliation* (Carter, Lederhendler, and Kirkpatrick 1997), and *Affective Neuroscience* (Panksepp 1998). This author's *The Reciprocal Modular Brain in Economics and Politics* (1999) and *The Consilient Brain: The Bioneurological Basis of Economics, Society, and Politics* (2004) represent efforts to tie these new findings graphically, algorithmically, and mathematically to behavioral economics. Recent years have thus brought great advances in detailing the many complex and interrelated pathways of brain's interactive social circuitry.

The social circuitry was forged over millions of years of evolutionary history in small kinship groups which required a cooperative interactive dynamic for survival. These dynamic social circuits motivate human social interaction and social exchange at all levels of our lives today. Like many other physiological processes—for example, blood pressure, body temperature, and glucose level—that mediate between our internal and external environments, these social circuits are homeostatically regulated (see Herbert and Schulkin 2002; Bloom, Nelson, and Lazerson 2001, esp. 167–206; Kandel, Schwartz, and Jessell 2000, 871–997; Nelson 2000, esp. 447–94; Lapeyre and Lledo 1994; Becker, Breedlove, and Crews 1992; Cannon 1932). In fact, the broader term *allostatic*, which means "adaptive," perhaps better describes the social circuitry's rather wide, variable, and modifiable set points and boundaries (see McEwen 2003; McEwen and Seeman 2002; Sterling and Eyer 1981).

THE EVOLUTIONARY BACKGROUND

Leading evolutionary neuroscientist Paul MacLean, longtime head of the Laboratory of Brain Evolution and Behavior of the National Institutes of Health, pioneered the study of the neural circuitry substrating the brain's social architecture. In his 1990 masterwork, *The Triune Brain in Evolution: Role in Paleocerebral Functions,* MacLean tells us that the primary function of the

Figure 2.1 **The Interconnected, Modular Tri-level Brain** (After MacLean)



human brain is the preservation of the individual self and the human species. Although this may be said of the nervous system of any organism that must survive as an individual to reproduce, MacLean leads us to consider not just automatisms or tightly prewired instinctual mechanisms but the evolved social architecture or circuitry of the human brain upon which social choices are made. His concept of brain evolution, appropriately updated, provides the necessary conceptual platform for this undertaking. (For a detailed, documented critique and update of MacLean's concepts see Cory 1999, 2002a, 2004.) As represented here, the three brain divisions do not constitute distinct additions but rather modifications and elaborations of probable preexisting gene-based homologues reflecting phylogenetic continuity.

MacLean documents the human brain as an evolved three-level interconnected, modular structure (Figure 2.1). This structure includes a self-preservational component reflecting gene-based continuity from our ancestral reptiles, which split off from the dinosaur ancestral line during the Permian and Triassic periods about 250 million years ago. This is called the protoreptilian complex. Also included are a later modified and evolved mammalian affectional complex, and a most recently modified and elaborated higher neocortex representing the higher centers of the brain.

As brain evolution continued in the branching vertebrate line ancestral to humans, simple vertebrate or protoreptilian brain structure was not replaced but was modified and elaborated. The protoreptilian structure, then, provided the substructure and gene-based continuities (called homologues) for later brain development 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. Appreciating the qualitative differences of the three interconnected levels is important to understanding the dynamics of human social experience and exchange behavior.

The protoreptilian brain circuits function in humans, much as they did in our ancestral vertebrates, to govern the fundamentals, or the 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 reptiles as well as earlier amphibians and fishes. Located in what are usually called the hindbrain and the midbrain (i.e., the brain stem) as well as in certain structures at the base of the forebrain (i.e., the basal ganglia), this primal and innermost core of the human brain made up almost the entire brain in ancestral fishes, amphibians, and reptiles (although not necessarily their modern representatives, since they too have undergone further evolution).

The next developmental stage of our brain, which comes from rudimentary mammalian life and which MacLean called the paleo- or "old" mammalian brain, is identified with the structures designated collectively as our limbic system. Developing from gene-based continuities preexisting in the protoreptilian brain, these limbic circuits included significant elaboration of such physiological structures as the amygdala, hypothalamus, the hippocampus, the thalamus, the limbic cingulate cortex, and the orbital frontal cortex. Behavioral contributions to life from these modified and elaborated paleo-mammalian structures included, among other things, the mammalian features (absent in our ancestral reptiles) of warm-bloodedness, nursing, infant attachment, and parental care. These circuits became the basis of family life and our capacity for extended social bonding (e.g., Carter and Keverne 2002; Numan and Insel 2003). Without knowledge of neuroscience, such scholars as Bowlby (1969), Harlow and Harlow (1965), and Harlow (1986) earlier identified these behaviors as forming the basis of infant-mother attachment and affectional relations. These new characteristics were then neurally integrated with the life-support functional and behavioral circuitry of the protoreptilian brain circuitry to create the more complex life form of mammals.

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 hemispherical brain matter that dominates the skull case of higher primates and humans evolved by elaborating the preexisting continuities present in the brains of early vertebrates. The neocortex overgrew and encased the earlier (paleo-) mammalian and protoreptilian neural tissues, but essentially did not replace them. As a consequence of this neocortical evolution and growth, those older brain parts evolved greater complexity and extensive interconnected circuitry with these new tissue structures. In that way, they produced the behavioral adaptations necessary to humankind's increasingly sophisticated circumstances.

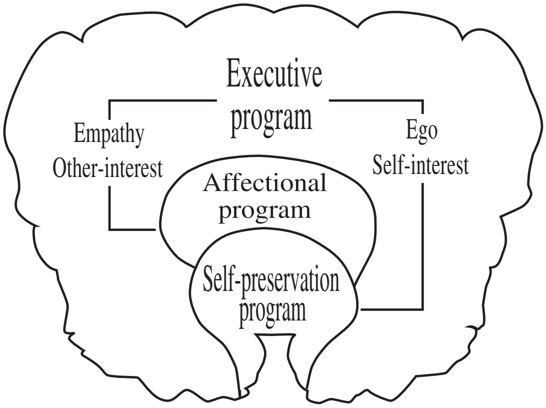
The unique features of our human brain were refined over a period of several million years in a mainly kinship-based foraging society where sharing or reciprocity was necessary to our survival (e.g., see Humphrey 1976; Isaac 1978; Knauft 1994; Erdal and Whiten 1996; Boehm 1999). Such sharing and reciprocity strengthened the adaptive evolution of the now combined mammalian characteristics of self-preservation and affection. Ego and empathy, self-interest and other-interest, are key features of our personal and social behavior deriving from these basic motivational circuits. To relate these to MacLean's concept we need a behavioral rather than neurophysiological vocabulary.

THE CONFLICT SYSTEMS NEUROBEHAVIORAL MODEL

The conflict systems neurobehavioral (CSN) model (Figure 2.2), developed by the author, uses computer-related vocabulary and assigns a dynamic to MacLean's clarified and updated conceptual platform as described above. This simplified cutaway representation of the brain shows the behavioral programs (or circuits) and the derivation of ego/self-interested and empathy/other-interested motives and behaviors. I should note that earlier models, such as Freud's (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 1999, 2000a, 2000b, 2001a, 2001b, 2002a, 2002b, 2003, 2004).

Our self-preservation and affection programs are interconnected and motivated neural network circuits that *subjectively* generate and drive specific and *objectively* observable behaviors. These core motivational (and emotional) circuits are cognitively represented in the frontal regions of our neocortex as ego and empathy, respectively (e.g., see Berridge 2003). They

Figure 2.2 **The Conflict Systems Neurobehavioral (CSN) Model**



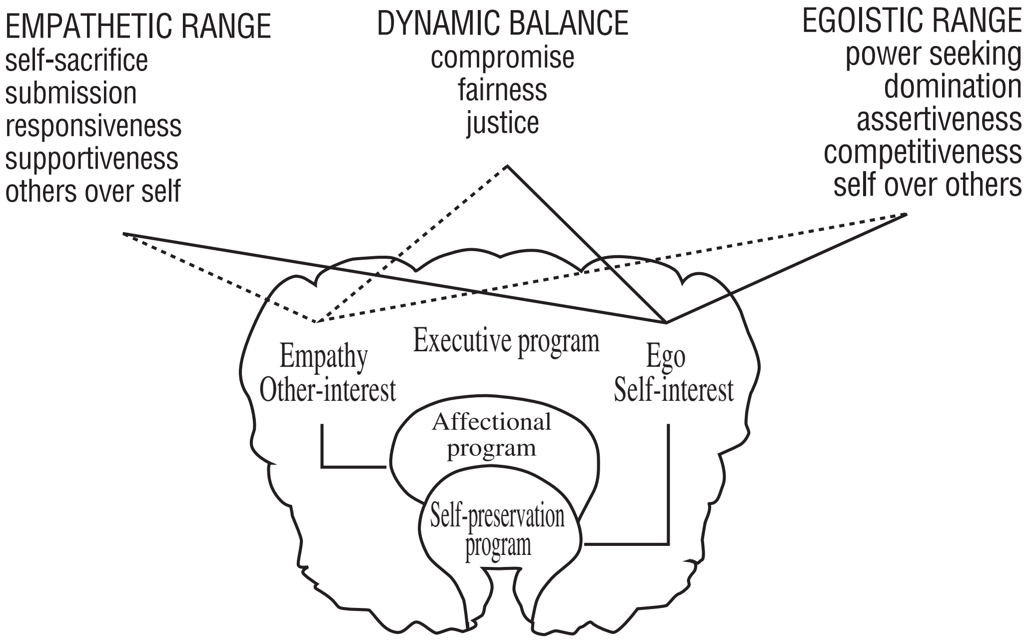
serve as dynamic factors of our behavior. That is, they are dynamically driven by our cellular as well as overall bodily processes of metabolism as mediated by hormonal, neurotransmitter, and neural architecture**.**

Each is an inseparable part of our makeup, because each is coded into our genes by the process of evolution. The degree of genome control seems to vary with the mechanism, however. Brain parts such as the hindbrain and parts of the limbic system, phylogenetically old and necessary for survival, seem to be more closely under gene control. Other, more recent tissues in the neocortex depend also on development and environmental experience. Neuroresearcher Antonio Damasio (1994, 1999) uses the terms *preset* and *preorganized* to avoid the implication of an overly deterministic prewiring or coding in some brain regions.

Behavioral conflict potentially exists, then, simply by virtue of the presence of these two large-scale dynamic modular program sets in our lives—up and running even prior to birth. Behavioral tension, which we may subjectively experience as frustration, anxiety, or anger, occurs whenever one of our two fundamental behavioral programs—self-preservation or affection—is activated but meets with some resistance or difficulty that blocks its satisfactory expression. This subjective tension becomes most paralyzing when both systems 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 thwarted expression of a single impulse or the simultaneous but mutually exclusive urgings of two contending impulses, whenever it remains unresolved or unmanaged it leads to the worsening condition of behavioral stress.

The evolutionary process by which the two opposite promptings of self-preservation and affection were combined in us helped us to survive by binding us in social interaction and social exchange, thereby providing us with the widest range of behavioral responses to our environment. Our inborn conflicting programs are a curse, then, only to the degree that we fail to recognize them as a blessing. Our self-preservation and affection programs allow us a highly advanced sensitivity to our environment, keeping our interactive social exchange behaviors homeostatically within survival limits as well as enabling us to perceive and appreciate the survival requirements of others. Ironically, the accompanying behavioral tension—even the stress—is an integral part of this useful function, for it allows us to more immediately evaluate our behavior and the effect it is having on ourselves and others.

Figure 2.3 **The Major Ranges/Modes of Behavior**



Behavioral tension serves as an internal emotional compass that we can use to guide ourselves through the often complicated and treacherous pathways of interpersonal exchange relations.

Behavioral stress tells us that we are exceeding safe limits for ourselves and others, and for our larger social, economic, and political structures.

Our executive programming or circuitry, seated in our frontal cortex (Pribram 1973, 1994; Fuster 1997, 1999; Miller and Cummings 1999; Goldberg 2001; Stuss and Knight 2002), cognitively represents the limbic and protoreptilian subcortical inputs (also see Berridge 2003), making what may be thought of as our *moral* as well as *rational* choices among our conflicting, impulsive, and irrational or nonrational motivations. This capacity to represent, generalize, and choose—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 MAJOR RANGES OF RECIPROCAL SOCIAL BEHAVIOR

The two master, inclusive circuits or programs of self-preservation and affection operate as global state variables (see Panksepp 2002; cf. Schulkin 2002, who refers to central motive states) to shape our social exchange behavior. They operate dynamically according to a set of *subjectively experienced* and *objectively expressed* behavioral rules, procedures, or algorithms.

The major ranges of the CSN model (Figure 2.3) illustrate the features of this ego-empathy dynamic. In the display, social behavior is divided from right to left into three main ranges, called the egoistic range, the dynamic balance range, and the empathetic range. 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 our brain diagram. The broken line stands for empathy and pivots on the word *empathy* in the diagram. To simplify the graph, the three points are intended to mark the center points of each range, with varying mixes of ego and empathy on either side of each point. The graph thus intends to communicate not a zero-sum, either/or set of behavioral options or expressions but a spectrum of the increasing or decreasing (depending on direction of movement) proportions of ego and empathy in behavior. The graph represents only what may be thought of as central tendencies of interactive behavior and is far too simple to represent all the shadings of emotion and motivation.

The Egoistic Range

The egoistic range indicates behavior dominated by self-preservation programming. 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 and 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 and may be described more moderately as controlling, competitive, or assertive. As empathy is gradually increased, the intersection of the two lines of the diagram will be drawn toward the range of dynamic balance. 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 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 backseat. When ego is present to a minimal degree, empathetic behavior may tend to extremes of self-sacrifice and submission. When ego is increased, empathetic behaviors become moderated and may be described 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 and feelings of others ahead of our own.

The Dynamic Balance Range

The range of dynamic balance represents a working balance between ego and empathy. At this point our behavioral programs are operating in roughly equal measure. I speak of "working," "rough," or "dynamic" balance because the tug and pull between the two programs continues ceaselessly. The dynamic nature of the circuitry means that "perfect" balance may be a theoretical point, unattainable in practice. Our more balanced behavior tends to be characterized by 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 Activity Level

The extent to which the programs of self-preservation and affection, ego and empathy, 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. Unmanaged or excessive tension becomes, of course, behavioral stress. But that's not all. Important also is the degree of energy we give to the interaction or the relationship. The amount of energy we put into any activity depends mostly upon how important we think it is or how enthusiastic we feel about it. In competitive sports or contests, qualitative differences in energy are easily observed. In intellectual contests, such as chess, the energy may be intense but less obvious.

THE RECIPROCAL ALGORITHMS OF SOCIAL BEHAVIOR

From the dynamic interplay of ego, empathy, and activity level come the following algorithmic rule statements:

> 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."

We often see the dynamic of such behavior most clearly when children interact. Imagine two children playing on the living room floor. One hits the other, and the second child hits back, responding in kind. Or one child might call the other a bad name, and 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 and have seen it countless times in our own children and grandchildren. We even see similar behavior among adults—in husband-and-wife disputes, bar fights, hockey games, political campaigns, even the process of 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 social exchange relations.

To express 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.

Behavior on the other side of the spectrum is described in the second rule statement:

> 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.

When we do things for others—give them things, make personal sacrifices for them—we can feel quite righteous, affectionate, loving. Nevertheless, we *do* want a payback. That's the tug of self-interest. The tug 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 the tension, the stress, starts to show. We may complain that others are taking advantage of us, taking us for granted, victimizing us. Self-interest cannot be shortchanged for long 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 favor, or kicking them out of the house. Or we may wall up 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. We need only think of the times we received a holiday gift from someone for whom we had failed to buy a gift. Sometimes the sense of obligation prompted by the empathetic acts of others can become a nuisance.

The third rule statement describes the relative balance between the 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.

Most of us find it satisfying to interact with others in equality, with no sense of obligation, superiority, or inferiority. When we work together in common humanity, in common cause, we experience behavioral dynamic balance. Certainly there are many versions of the experience of dynamic balance: the shared pride of parents in helping their children achieve, the joy of athletes in playing well as a team, the satisfaction of co-workers in working together successfully on an important project.

THE RECIPROCAL NATURE OF BEHAVIOR

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 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 social exchange interactions among members of the workplace, society at large, social groups, and entire economic and political systems.

VARIABILITY OF THE RECIPROCAL ALGORITHMS

The algorithmic rules of reciprocal behavior operate as *central tendencies* of behavior. They also show considerable individual variability. They cannot work as precisely as the laws of classical physics or even quantum mechanics because they are achieved through the process of organic evolution, which involves some random processes and natural selection. Gender, developmental, and experiential differences also contribute to variability (Cory 1999, 42–44). This variability and lack of absolute precision is generally true of biological algorithms (e.g., see Maynard Smith 2002).

RECIPROCITY: THE UNIVERSAL NORM

The norm of reciprocity expressing our social neural architecture has long been a major theme in anthropology and sociology (e.g., see Gouldner 1960; Baal 1975) and more recently in economics (e.g., Cory 1999, 2004; Fehr and Gachter 2000; Bowles and Gintis 1998, esp. ch. 17; Gintis 2000; Eckel and Grossman 1997). This universally observed norm, found in all societies, primitive and modern, has been accounted for, or shown to be possible, in evolutionary theory by such concepts as kin selection, inclusive fitness (Hamilton 1964), reciprocal altruism (Trivers 1971, 1981; Alexander 1987), and game theory (Axelrod and Hamilton 1981; Maynard Smith 1982). These efforts draw upon so-called gene-centered perspectives, which see such reciprocity as basically selfish. More recently, extensive reciprocity seen as based not upon selfishness but upon empathy has been reportedly observed in the behavior of rhesus monkeys (de Waal 1996). De Waal's approach is a welcome departure that tries to escape the selfishness of gene-centered approaches and looks to the implied motivational mechanisms. All these approaches, however, including de Waal's, have been based on the external observation of behavior. They have not attempted to identify or even speculate upon the neural mechanisms within the organism that must necessarily have been selected for by the evolutionary process to accomplish the functions of motivating, maintaining, and rewarding such observed reciprocal behavior.

According to the CSN model of our neural architecture, reciprocity through conflict is achieved in the range of dynamic balance, where behavioral tension operating freely tends to pull us. In dynamic balance, ego and empathy provide for the emergence of cooperation and fairness, trust and morality in interpersonal, social exchange activities. Taking the dynamic balance range to be approaching or approximating the equilibrium of ego and empathy as driven by behavioral tension, we can derive a formula that expresses this dynamic.

THE EQUATION OF SOCIALITY OR SOCIAL EXCHANGE

The reciprocal algorithms emerging from our social neural architecture have been illustrated graphically by the three major ranges of social behavior (refer back to Figure 2.3). They have also been written in plain English in the section describing their algorithmic interactive dynamic. I can now state them mathematically in the form of the equation of sociality or social exchange approaching equilibrium:

$$BT = \frac{Ego}{Emp} \; or \; \frac{Emp}{Ego} = \pm 1 \left(approx.\ equilibrium,\ unity,\ or\ dynamic\ balance \right)$$

In the above formula *BT* stands for behavioral tension and is a function of the ratio of ego to empathy or vice versa. Because of the physiological homeostatic nature of the dynamic, either ego or empathy can serve as the numerator or denominator as necessary to avoid the inconvenience of fractions and to more accurately reflect the magnitude of divergence or convergence. The degree of convergence or divergence is what is of interest.

This equation gives basic mathematical expression to the social exchange architecture of our evolved brain structure. As the conflicting modules of our social architecture approach equilibrium or dynamic balance—represented by the symbolic approximation to unity or dynamic balance, ± 1—behavioral tension/stress are minimized. On the other hand, as the ratios diverge increasingly toward the extremes of ego or empathy, behavioral tension increases. That is, if we have an empathy magnitude of 8 and an ego magnitude of 4, or vice versa, we have a behavioral tension magnitude of 2. At a minimum the neural dynamic serves generally to keep our social behavior homeostatically within survival limits, which accounts for its Darwinian selection. On the other hand, at the level of optimal functioning, the algorithms, driven by behavioral tension, tend to move us toward dynamic balance of ego and empathy or self and other interest, that is, balanced reciprocity, or equality. The formula, therefore, is very simple, but deceptively so, because it can be quite variable and can ramify in many ways.

THE EVOLUTION OF THE MARKET

To understand the behavior of the modern-day free enterprise market as it is shaped by our inherited brain structure and behavior, it is helpful to go back to early times—to reconstruct as best we can the days before the market appeared. For a discussion and documentation in detail, see Cory 2004, 1999.

The Family or Group Bond

In those times, when people consumed what they produced, the excess that they shared with, gave to, or used to provide 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 a diffuse, not specific, value assigned to it. It also had social effects—the givers or providers gained status in the group. Both the emotional and social effects were directly governed by the reciprocal algorithms of behavior.

Let us look more closely. The provider brought meat from the hunt or berries and fruits from the field, tanned skins, and so on to give to the family or group. The act of providing, giving, created behavioral tension in the giver, who, acting empathetically, denied ego to some degree and required a response of acknowledgment, 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—that created tension requiring 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 of such social exchange, are largely not quantified but are diffuse. They become obligations—bonds—that hold the group together for protection or mutual survival. Nevertheless, they must achieve some approximation of balance or the unresolved tension will build within the group and become disruptive. Expressions for "thank you" and "you're welcome," found in all known human languages, reflect this reciprocity in social exchange activity.

The Gift

From these early, primitive behavioral 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 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. The gift economy of so-called primitive peoples—an important theme in anthropology—operated in this way (see, e.g., Mauss 1925; Bohannon 1963; Cheal 1988; Godelier 1999; Gérard-Varet, Kolm, and Ythier 2000; Davis 2000; Fennell 2002).

From Gift to Transaction

From the gift evolved the transaction—namely, the gift with the reciprocal specified or quantified (e.g., see, Mauss 1925; Polanyi 1957; Sahlins 1972; Gregory 1982; Appadurai 1986; Seymour-Smith 1986, 44; Barfield 1997, 73; Hunt 2002; Osteen 2002). The transaction is the beginning of the contract, perhaps of the 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 market, we may be dealing with strangers not to be seen again. Nevertheless, the transaction retains its essential mammalian characteristics as an act of empathy, of nurturing, which requires a balancing reciprocal act in payment to ego.

When we encounter its equivalent in the impersonalized market economy of today, how often do we feel the subjective experience of the transaction? We take our sick child to the physician, who empathetically and carefully applies the knowledge it took ten years and a fortune to gain. We pay the bill—that is, we make a return gift with money that represents a portion of our accumulated education and labor. The scenario is repeated in transactions with the plumber, the carpenter, the computer maker. The behavioral algorithms still apply, but the feeling, the subjective experience, has to a large degree been lost.

Behavioral Tension Yet Drives the Transaction

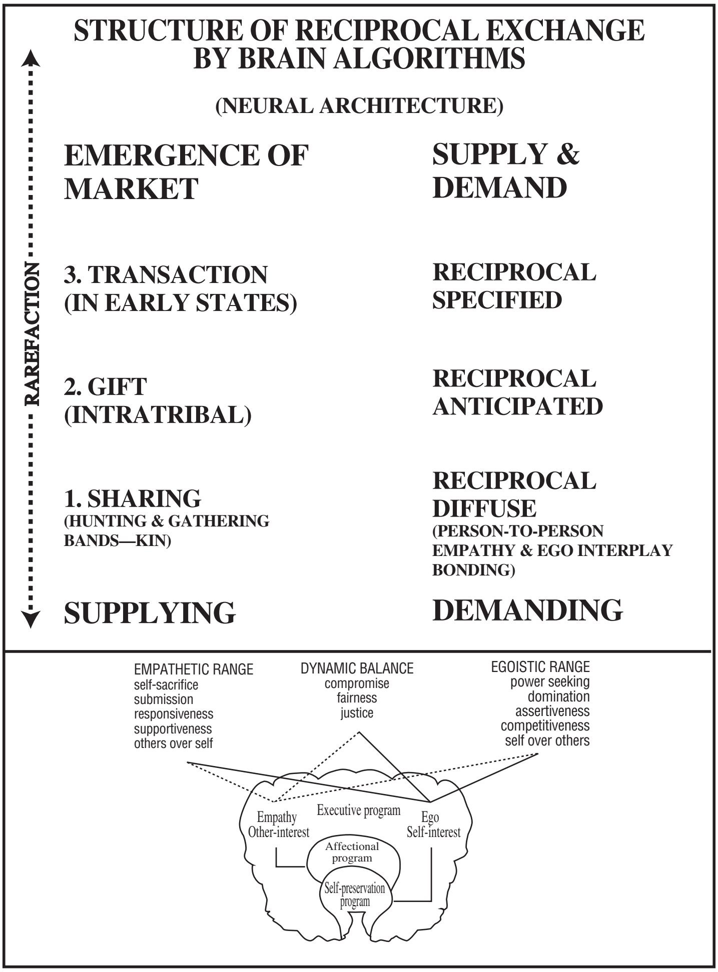
But wait! Let the transaction go wrong, the expected reciprocals not be forthcoming, and the behavioral tension becomes immediately and personally felt. The reality of the transaction—the market—reveals itself with clarity and intensity. No one likes to be cheated or shortchanged. And most will be motivated to take some action to correct the imbalance in expected reciprocity or harbor the behavioral tension indefinitely to be acted upon in the future. The dockets of our small-claims courts are filled with cases reflecting the tension of such unbalanced reciprocity.

The evolution of the transactional market (demand and supply) as shaped by neural architecture can be summarized in Figure 2.4.

METAECONOMICS AND THE DUALITY OF MOTIVES

From the transactional perspective, the CSN model also provides underpinning for what is called metaeconomics and the question of multiple motives or utilities (Lynne 1999, 2000;

Figure 2.4 **Evolution of Market Exchange Based on Dynamics of Neural Architecture**



Lutz 1993; Etzioni 1986). The CSN model shows that the tug and pull between ego and empathy goes on constantly within us and between us as we interact socially. To the extent that our economic transactions or choices are social, and they inevitably are, they will involve the tug and pull of ego and empathy to some degree. The very nature of social or market exchange is transactional, give-and-take, or interpersonal. The idea that we make independent choices separate from interpersonal or social concerns is largely illusory. The transactional atom, when opened up, is shown to be composed of ego and empathy, mutual benefit, in a state of negotiated tension (Cory 1999, 77–78). There is therefore some degree of behavioral tension from the tug and pull of ego and empathy, a dual motive (or perhaps utility) on both sides in every social or market choice or transaction. The degree of tug and pull or behavioral tension will depend upon the triviality or significance of the transaction—something neoclassical theory does not distinguish. Adam Smith recognized clearly this essential mutual benefit nature of the market in the line quoted below, which immediately precedes the customarily quoted passage that traditionally has been wrongly taken to justify a sole self-interest motive.

> Give me what I want, and you shall have what you want, is the meaning of every such offer. (Smith 1776, Book I, ch. 2).

In modern times we recognize the above quote on mutual benefit as *win-win.* The equal mutual benefit or balanced reciprocity position of win-win is reflected in the graph of the CSN model as dynamic balance and in the equation of social exchange as ±1.

THE SELF-REFERENCE FALLACY OF NEOCLASSICAL ECONOMICS

The confounding of *self-reference* with *self-interest* is a fundamental fallacy of the neoclassical approach. This logical fallacy allows the subsuming of all motives under the rubric of self-interest and obscures the roughly equal role of empathy. Taking the individual as the starting point, microeconomic theory mistakenly transforms this individual or self-referential *perspective* into an all-inclusive *motive* of self-interest. From this logically unwarranted transformation, any other motive is seen as proceeding from the self-interest motive. Therefore empathy (and its derivatives of cooperation and altruism, even love) can be trivialized as tastes or preferences indistinguishable in significance from coffee, tea, or milk. Nevertheless, the hidden duality of ego and empathy is seen in every demand curve and supply curve, especially when both are combined to show price equilibrium. The dual roles are always present implicitly if not explicitly. The supplier performs the empathetic role; the demander performs the egoistic role. (See Appendix 1 for examples of the hidden duality of ego and empathy within the customary self-referential neoclassical perspective.)

THE INVISIBLE HAND IN THE STRUCTURE AND BEHAVIOR OF THE MARKETPLACE

To understand the function of the invisible hand in the socioeconomic market, it helps to maintain a clear distinction between structure and behavior.

Structure

The invisible hand as the tug and pull of ego and empathy is expressed in the market structure as *demand* and *supply.* The reciprocal dynamic tends to work despite the unidimensional overemphasis on self-interest in classical economics by the fallacy of self-reference. This is because the very structure itself of the market is the institutionalized product of the ego/empathy dynamic of our evolved neural architecture. That is, as Adam Smith saw, when we enter into market exchange, we fundamentally agree to a give-and-take exchange that necessitates mutual benefit, reciprocity, and respect for self and others, or ego and empathy. Our self-survival ego *demand*s are rooted ultimately in our ancestral protoreptilian or vertebrate neural complexes and represented in our higher frontal brain circuits as self-interest or ego. Contrastingly, the act of *providing* or *supplying* is fundamentally an act of mammalian nurturing—likewise represented in our higher frontal brain circuitry as other-interest or empathy. The market exchange system originated from and is sustained by 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 to respond to the needs of others. Dinosaurs and crocodiles, as well as our ancestral vertebrates, never produced markets.

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 unobstructed tendency of the market will be toward a balance of ego and empathy. To survive in the market, individual and collective actors, whether seemingly motivated primarily by self-interest or not, will be compelled by the very evolved and institutionalized market structure itself to perform the structural equivalent of empathy. That is, under pressure of competition among providers, they will be required to provide (supply) a proper service or product to fill the needs (demand) of others. This is especially true of the idealized, purely competitive market envisioned by standard economic theory.

To the degree, however, that empathy is a consciously included and recognized behavioral motivational component within the market structure, the product or service provided may be enhanced in quality and the emergence of trust in market relationships will be facilitated. Conversely, the overemphasis on self-interest in the neoclassical paradigm tends to vitiate the development of quality and the emergence of trust in the market. Aside from the scientifically inaccurate concept of the market in neoclassical economics, this vitiation of quality and trust, adding to transaction costs, is one of its greatest drawbacks in practice.

Reciprocity through conflict is achieved in the range of dynamic balance where behavioral tension operating freely tends to pull us. In dynamic balance, ego and empathy provide for the emergence of cooperation and fairness, trust and morality in interpersonal, social, and economic exchange activities. Taking the dynamic balance range to be approaching or approximating the equilibrium of ego and empathy as driven by behavioral tension, again we call upon the previously derived formula:

$$BT = \frac{Ego}{Emp} \text{ or } \frac{Emp}{Ego} = \frac{Demand}{Supply} \text{ or } \frac{Supply}{Demand} = EP = \pm 1 \left(\begin{array}{l}\text{approx. equilibrium, unity, or} \\ \text{dynamic balance}\end{array}\right)$$

The above equation—with either ego or empathy, demand or supply, as the numerator or denominator to accurately reflect the magnitude of behavioral tension—gives basic mathematical expression to the interaction of ego (demand) and empathy (supply). Appendices 2 and 3 clarify the effect of the above formula on the standard treatment in calculus for demand and supply and demonstrate its application more fully. As the two motives intersect freely in the marketplace, we tend to have equitable exchange. Or, in the case of specific products and services, we tend toward equilibrium price (*EP*) or fair price. Since the evolved algorithmic dynamic works imperfectly, I use the word *tend.*

The formula or equation proceeding from evolved neural network architecture thus provides the unifying linkage between brain physiology (or neuroscience) and economics or social exchange theory. The behavioral tension driving toward the proximate dynamic balance between demand and supply in the marketplace accounts for the motive force for the venerable invisible hand—that elusive dynamic previously accounted for variously by the hand of a deity, Newtonian mechanics, or other inappropriate physical processes (see Cory 2004, 1999, 92–95; Ingrao and Israel 1990).

The marketplace is thus clearly a product of the dynamic of our evolved neural architecture. The same dynamic formula can be shown to underlie not only market and social exchange but also power relationships, social stratification, and other relations of inequality

(Cory 2004). Kept free (by appropriate institutions) of the skewing effects of excessive wealth accumulation and the pressure of powerful special interests, both a democratic free enterprise economic system and a democratic political system will, in accord with the neural architecture, tend toward a dynamic equilibrium that minimizes economic and political inequalities.

On the other hand, the behavioral tension or inequality within a market system or a political system may be indexed by the same dynamic formula to the extent that it departs from dynamic equilibrium and the ratio begins to diverge increasingly.

CONCLUSION

In conclusion, the neural algorithms of our social brain function as competing or conflicting neural networks, both excitatory and mutually inhibitory, interacting with each other homeostatically within prescribed limits. Neural network models have been developed to express this ego/empathy dynamic (Levine and Jani 2002; cf. Leven 1994). They are thus a physiologically (homeostatically) regulated social mechanism like numerous other bodily functions—for example, blood pressure, blood sugar, and body temperature. Their interactive dynamic generally ensures that our social behavior stays within survival limits. At its optimum the dynamic tends toward equilibrium or dynamic balance, which promotes social harmony and cooperation. Over history, despite the emphasis on violence and war, the dynamic has worked successfully to achieve a human population of over six billion—creating, of course, new problems to be dealt with. In fact, one author has questioned whether the human species is not a suicidal success (Tickell 1993).

The interactive dynamic can be mapped onto mathematical operations or formulas identifiable with social stratification and inequality as well as the invisible hand of economic supply and demand. It is the convergence or divergence of the ratio that is of interest. As the ratio diverges from approximation to ±1 or unity, it serves to index the behavioral tension and stresses among ourselves and within our economic, social, and political structures. The equations expressing their dynamic interactions approaching equilibrium or unity as reflected in exchange and political economy are as follows.

Neuroscience:

$$\textit{Behavioral Tension (BT)} = \frac{\textit{Ego}}{\textit{Empathy}} \text{ or } \frac{\textit{Empathy}}{\textit{Ego}} = \pm 1 \left(\begin{array}{l} \text{approx. equilibrium, unity, or} \\ \text{dynamic balance} \end{array} \right)$$

Economics:

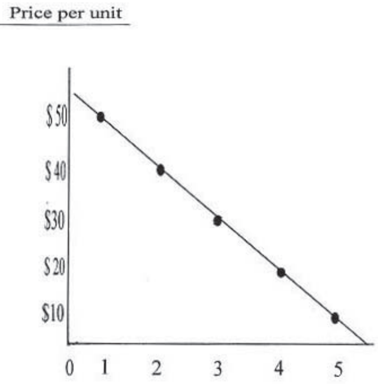
$$\textit{BT} = \textit{Equilibrium Price} = \frac{\textit{Demand}}{\textit{Supply}} \text{ or } \frac{\textit{Supply}}{\textit{Demand}} = \pm 1 \left(\begin{array}{l} \text{approx. equilibrium, unity, or} \\ \text{dynamic balance} \end{array} \right)$$

Political Economy:

$$\textit{BT} = \textit{Political Tension} = \frac{\textit{Domination}}{\textit{Subordination}} = \pm 1 \left(\begin{array}{l} \text{approx. equilibrium, unity, or} \\ \text{dynamic balance} \end{array} \right)$$

Figure 2.5 **The Demand Curve**

Price	Quantity
$50	1 unit
$30	3 units
$10	5 units



Invisible Hand
of Economics:
of Politics:

$$BT = \frac{Ego}{Emp} \text{ or } \frac{Emp}{Ego} = \pm 1 \begin{pmatrix} \text{approx. equilibrium, unity, or} \\ \text{dynamic balance} \end{pmatrix}$$

The CSN model, emerging from evolved neural architecture, anchors behavioral economics, equilibrium theory, and market and free enterprise theory firmly in the physiology of neuroscience and supports the introduction of the moral component of empathy into the rational calculus of economics, free enterprise theory, and other social sciences. The model supports ongoing efforts to introduce cooperation and fairness, trust and morality into the neoclassical calculus and definitively counters the long-prevailing, inaccurate, and troubling self-interested bias of received microeconomic and traditional business theory. The CSN model provides the basis for a new research program to develop and test the hypotheses proceeding therefrom and to explore the potential implications for rethinking aspects of contemporary economic, business, and political policy. It is particularly applicable to the challenges of global trade and business, which must be based on respect for self and others—the dynamic interplay of ego and empathy—if trade is to be conducted peacefully without the threat of military conflict.

APPENDIX 1: NEURAL ARCHITECTURE AND THE DUALITY OF THE MARKET

The demand, supply, and equilibrium curves that follow are presented in very simplified form. They nevertheless illustrate the essential features of all such curves.

I. The Demand Curve

The demand curve slopes downward because as price increases on the y-axis, the quantity people are willing and able to buy generally decreases (x-axis) (see Figure 2.5). Even the single-actor perspective of the demand curve shows the duality of exchange expressive of our neural architecture: Price = give = empathy; Quantity = take = ego. In other words, price is what we give, quantity is what we take. The demand curve, therefore, illustrates the reciprocal, give-and-take, empathy-ego social exchange relationship.

Figure 2.6 **The Supply Curve**

Price	Quantity
$50	5 units
$30	3 units
$10	1 unit

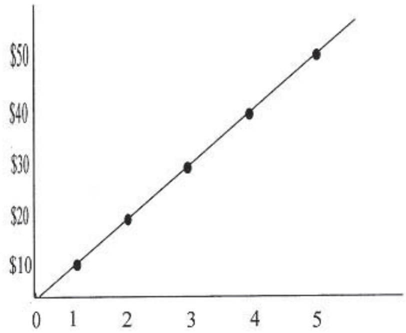
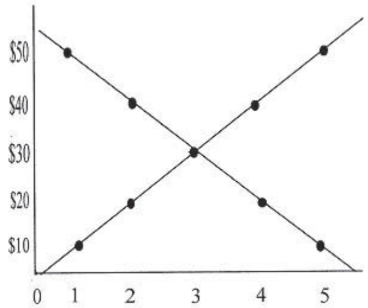


Figure 2.7 **Equilibrium in the Market**

Price	Quantity Supply	Quantity Demand
$50	5 units	1 unit
$30	3 units	3 units
$10	1 unit	5 units



II. The Supply Curve

The supply curve slopes upward because as price increases (y-axis) suppliers are willing and able to provide more units. (see Figure 2.6) The supply curve, like the demand curve, shows the duality of exchange expressive of our neural architecture. From this perspective: Quantity provided = give = empathy; Price = take = ego. Again, the supply curve illustrates a reciprocal, give-and-take, empathy-ego social exchange relationship.

III. Equilibrium in the Market

The duality of exchange expressive of our neural architecture is most clearly seen in the graph of demand and supply curves combined to show their equilibrium point (see Figure 2.7). The supplier performs the empathetic structural or institutional role; the demander performs the egoistic structural or institutional role. In standard economics the demand and supply curves are related only at the point of equilibrium.

The formula derived from our neural architecture provides a significant insight:

$$BT = (Equilibrium\ Price) = \frac{Demand}{Supply} \text{ or } \frac{Supply}{Demand} = \pm 1 \quad \left(\begin{array}{l}\text{approx. equilibrium, unity, or}\\ \text{dynamic balance}\end{array}\right)$$

In economics price is customarily treated as an exogenous, independent variable. That is, demand and supply curves are related only at the equilibrium price. Price as an exogenous, independent variable draws them together but remains essentially unexplained. The formula from neural architecture demonstrates the continuing relationship between demand and supply and the source of motivation for change that brings demand and supply into equilibrium—behavioral tension that motivates buyers and sellers to change their behavior. Thus, all points on the demand and supply curves that do not match the equilibrium point are indicators of behavioral tension. This effectively unifies the dynamics of neural architecture with economics.

The Problems with Empathy as a Preference or Taste

Currently economics proceeding from the self-reference perspective treats self-interest as the only primary motive. Empathy is treated as a taste or preference. The problems with such treatment are:

1. Empathy becomes optional. You may have such a taste or preference or not. This is distorting because empathy is not optional but a fundamental motive of our neural architecture roughly equal with self-interest or ego.
2. It trivializes empathy. Empathy as a preference or taste is indistinguishable from a taste or preference for Fords or Mercedes or for tennis shoes or sandals.
3. It distortingly forces a rational self-interested perspective.
4. It misconstrues the real nature of the market.
5. It obscures the dynamic shaping effect of the ego/empathy interplay in all social exchange.
6. It is not consilient with evolutionary neuroscience—a more fundamental science.

APPENDIX 2: CALCULUS IN PRICE THEORY

As represented in standard texts (e.g., Landsburg 1992; Lindsay 1984) on price theory, demand and supply are functions that convert prices to quantities.

$$D(P) = \text{ Quantity demanded at price } P$$

$$S(P) = \text{Quantity supplied at price } P$$

Derivatives are expressed as follows:

The fact that the demand curve slopes downward is expressed by the inequality

$$D'(P) < 0 \text{ or } \frac{dQd}{dP} < 0$$

The fact that the supply curve slopes upward is expressed by the inequality

$$S'(P) > 0 \text{ or } \frac{dQs}{dP} > 0$$

Equilibrium price is the price at which

$$D(P) = S(P)$$

Equilibrium quantity is the common value.

Again, in this case as well as in the illustrations of the demand, supply, and equilibrium curves, when treated in the standard manner demand and supply are related *only* at the point of equilibrium—the equilibrium price. Price, again, is an exogenous, independent variable that brings them together but remains essentially unexplained. Demand and supply are treated separately prior to the equilibrium point. The calculus model used in economics as reflected above does not represent the relationship of behavioral tension that *exists at all other points.* The formula from neural architecture does this:

$$BT = EP = \frac{Demand}{Supply} \text{ or } \frac{Supply}{Demand} = \pm 1 \begin{pmatrix} \text{unity, approx. equilibrium, or} \\ \text{dynamic balance} \end{pmatrix}$$

This reinforces or confirms the previous insight that all other points on the demand and supply curves are indicators of behavioral tension. Behavioral tension in equilibrium, then, equals price in equilibrium, and price or behavioral tension not in equilibrium is what motivates demanders and suppliers to alter prices or respond to them. Such is the essence of any negotiating process in the market, no matter how formalized. It is seen clearly in domestic flea markets and in many similar institutions (e.g., bazaars) around the world. Price thus becomes an endogenous variable, that is, one that we can explain or account for (Cory 2004, 2002a, 2002b; 2001a, 2001b).

APPENDIX 3: DEMONSTRATION OF APPLICATION OF THE BASIC HOMEOSTATIC EQUATION TO ECONOMICS

In applying the organic equation, units of change or the first order derivative must be used, rather than the actual numerical value. Solving for $EP \pm 1$, we go above or below the *EP* by an increment of 1. *Demand* and *Supply* as used in this demonstration, of course, refer to quantities demanded and supplied. Thus

$$BT \text{ @ } EP + 1 = \$40. \text{ At } P \ \$40 \ \frac{Supply}{Demand} = \frac{4}{2} \text{ numerically or } \frac{2}{1} \text{ units of magnitude}$$

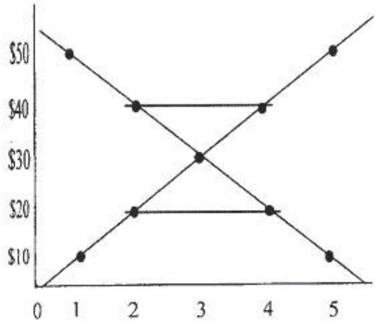
$$BT \text{ @ } EP - 1 = \$20. \text{ At } P \ \$20 \ \frac{Demand}{Supply} = \frac{4}{2} \text{ numerically or } \frac{2}{1} \text{ units of magnitude}$$

Since we are representing an organic homeostatic algorithm (in contrast to a point reduction force vector of Newtonian mechanics) in which the opposing forces (circuits) constantly tug and pull against each other in countering deviations from homeostatic equilibrium, a decrement in one is counterbalanced by an increment in the other. Therefore, there is no change in magnitude of divergence or behavioral tension at equal increments above or below *EP* (see Figure 2.8).

Figure 2.8 **Demonstration of Application of the Basic Homeostatic Equation to Economics**

Price	Quantity	
	Supply	Demand
\$50	5 units	1 unit
\$30	3 units	3 units
\$10	1 unit	5 units

Price per unit



The Constant Case

The previous example represents a special case chosen to demonstrate the application of the equation in easily understandable fashion. In this simple case both the unit of magnitude and numerical value have the same ratio. More complex applications require additional recourse to calculus and rely upon the units of magnitude of divergence. For example, in all cases where price and quantity increments or units are constant and the rate of change is constant, as represented by straight-line curves of demand and supply, the unit change between demand and supply will likewise remain constant. For each unit price change above or below *EP*, the unit change between demand and supply will be 2. Like two cars driving away from the same place in opposite directions at the same speed bound by an elastic counterforce, for each unit of time the distance increases by two units of distance.

This can be represented by the following elaboration of the basic equation to calculate divergence from balance and to derive values to be substituted into the original equation:

$$BT = \frac{d(D \leftarrow \rightarrow S)\ @\ EP \pm X}{r(D \leftarrow \rightarrow S)\ @\ EP} = ?$$

where *d* refers to the difference, differential, unit difference, or rate of change; $D \leftarrow \rightarrow S$ indicate that demand and supply are interconnected and the magnitude of their divergence is a fundamental measure of the homeostatic, self-correcting function of *BT* (behavioral tension) as one circuit acts to counter the other in deviations from homeostatic equilibrium. Thus, a value decrement in one is countered by a value increment in the other. No loss in magnitude of *BT* occurs. The unit magnitude of divergence between them is what is of interest as a measure of *BT*.

X represents the specific value of *EP* plus or minus; and
r denotes the ratio between demand and supply at *EP,* which by definition is unity or 1.

In simple terms, then, *BT* equals the unit differential between demand and supply or vice versa at values of *EP* ±1 or more, divided by the ratio between demand and supply or vice versa at *EP*, which is, by definition of equilibrium, unity or 1.

The constant rate of change can be expressed as a function. That is, *BT* = *f(x)* @ *EP* ± ?; *f(x)* is the unit differential between *D* and *S*, or *S* and *D*, or *f(x)* is *d(D* ← → *S)*, which represents an increment of 2 at every unit of price above or below *EP* as *D* and *S* increasingly diverge.

The following table results as divergence begins:

$$f(x) \text{ at } EP \pm 1 = 2$$

$$f(x) \text{ at } EP \pm 2 = 4$$

$$f(x) \text{ at } EP \pm 3 = 6$$

$$f(x) \text{ at } EP \pm 4 = 8$$

$$f(x) \text{ at } EP \pm 5 = 10$$

Substituting the values of the table into the elaborated equation:

$$BT @ EP = \frac{1}{1} = 1$$

$$BT @ EP \pm 1 = \frac{2}{1} = 2$$

$$BT @ EP \pm 2 = \frac{4}{1} = 4$$

$$BT @ EP \pm 3 = \frac{6}{1} = 6$$

$$BT @ EP \pm 4 = \frac{8}{1} = 8$$

$$BT @ EP \pm 5 = \frac{10}{1} = 10$$

Inserting values into the original basic equation approaching equilibrium:

$$BT = \frac{Demand}{Supply} \text{ or } \frac{Supply}{Demand} @ EP \pm 1$$

At equilibrium with no divergence:

$$BT @ EP = \frac{D}{S} \text{ or } \frac{S}{D} = \frac{1}{1} = 1$$

For positive values of *EP* above equilibrium, supply is the numerator.

To adequately represent the ratio, demand, then, is held constant at 1 as the units diverge between demand and supply

$$BT\ @\ EP + 1 = \frac{S}{D} = \frac{2}{1} = 2$$

$$BT\ @\ EP + 2 = \frac{S}{D} = \frac{4}{1} = 4$$

$$BT\ @\ EP + 3 = \frac{S}{D} = \frac{6}{1} = 6$$

$$BT\ @\ EP + 4 = \frac{S}{D} = \frac{8}{1} = 8$$

$$BT\ @\ EP + 5 = \frac{S}{D} = \frac{10}{1} = 10$$

For negative values of *EP* below equilibrium, demand is the numerator.

To adequately represent the ratio, in the negative case, supply, then, is held constant at 1 as the units diverge between demand and supply.

$$BT\ @\ EP - 1 = \frac{D}{S} = \frac{2}{1} = 2$$

$$BT\ @\ EP - 2 = \frac{D}{S} = \frac{4}{1} = 4$$

$$BT\ @\ EP - 3 = \frac{D}{S} = \frac{6}{1} = 6$$

$$BT\ @\ EP - 4 = \frac{D}{S} = \frac{8}{1} = 8$$

$$BT\ @\ EP - 5 = \frac{D}{S} = \frac{10}{1} = 10$$

The Nonconstant Case

When the conditions of constancy do not hold—rates of change are not constant—the determination of *BT* and the unit differences of demand and supply will require more complex mathematical operations, to include averaging processes. This, however, does not affect the validity of the organic equation's application to economics.

Interim Summary

Based upon the integration of the neural dynamic with demand and supply, we can conclude that all points on the demand and supply curves *not* at equilibrium represent points of behavioral tension. And it is this behavioral tension that *motivates* demanders and suppliers to change their behavior toward the equilibrium price.

Without such an organic motivating, self-correcting force the market could never come to equilibrium on its own except by accident or randomly.

At all prices, as long as the first order derivative, or rate of change is constant, or the slope is a straight line, and the units are of equal increments, the ratio between the unit differentials or demand and supply at *EP* ± 1 will be 2:1 or a magnitude of divergence of 2. The ratio of divergence from *EP* will increase by an increment of 2 for each unit change of price. At *EP* ± 5, for example, the unit differential between supply and demand, or vice versa, will be a magnitude of 10. This is the fundamental measure of behavioral tension.

When the rate of change is *not* constant, the determination of differential magnitudes will become more complex and will require an averaging process.

Price adds *significance* and acts as an amplifier of *BT*. As a general proposition, as price increments rise or fall, the magnitude of *BT* also rises or falls. That is: generally, buying a house or car carries more significance than a loaf of bread. Of course, this can vary subjectively with the situation of each party to the exchange.

Differences in Representing the Organic, Homeostatic Equation

Representing an organic, homeostatic algorithm, such as that of our social neural architecture, with a constant counterbalancing tug and pull of two forces or circuits requires some modification in mathematical representation. The magnitude of convergence or divergence from equilibrium is what is of interest, not the numerical value. Equal increments above or below the equilibrium point represent the *same* magnitude of behavioral tension because one force makes up for the other. That is why demand and supply may be inverted in the equation to represent the magnitude of divergence more accurately. This magnitude is the fundamental calculus of behavioral tension, amplified or diminished by *price* as an indicator of significance.

Extended Application of Organic Equation

Up to this point economics has lacked the conceptual apparatus to meaningfully and mathematically ask the question of sociobehavioral tension in the market. The very question of motivation for change toward equilibrium has been largely begged, brushed over simplistically, or left as an implicit assumption. The degree of sociobehavioral tension or stress in the market is, of course, of great importance to behavioral economics and socioeconomics as well as to sociology and political science in general. The organic social exchange equation provides a framework for addressing this important issue.

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