Evolutionary Neuroscience and Human Motivation in Organizations

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Abstract

Conflicts among and limitations in competing views of human motivation make research on organizations difficult. Mainstream economics assumes self-interest is the dominant motivation although research shows this view is at best incomplete. Other organization sciences sometimes emphasize human social concern and empathy, but fail to provide a view that is comprehensive. As a result, many micro and macro topics are hard to analyze. This paper argues that evolutionary neuroscience provides an empirically grounded understanding of the physiological causes of motivation through which disparate existing approaches can be unified and more complete understanding developed. Evolutionary neuroscience shows that humans are both self-interest-driven and empathy-driven and supports coherent description of and research on these motives and others derived from them. Thus neuroscience-based analysis can show how brain physiology, along with experience and heredity, create motivation that can involve – indeed, even has a natural tendency toward – balance between self-interest and empathy. We offer an approach to using this perspective to strengthen organization theory. We illustrate by applying it to leadership studies where, we suggest, neuroscience insights can enhance and refine theory and theorization.

Evolutionary Neuroscience and Human Motivation in Organizations

Students of organizations differ profoundly on human motivation. On one hand, many economists hold human systems can be understood almost entirely through self-interest-driven analysis. On the other hand, some students of organizational behavior, leadership, and related fields assert that the pursuit of self-interest explains relatively little whereas empathy-based and altruistic forces are important. We lack a well-developed approach to human motivation that can help reconcile these differences and support on-going advances.

The lack of integrated motivation theory creates problems for scholars and practitioners in many fields. For example, Masters of Business Administration curricula typically include economics, strategic management, and finance courses that assume self-interest is the main and perhaps only important motivation. Meanwhile, courses in organizational behavior, leadership, and business-and-society assume that motivations to collaborate and care for others are central. We have neither research programs nor widely accepted frameworks that suggest how these motivations might relate to each other. Meanwhile, analysts call for better thinking on motivation in leadership (Nohria & Khurana, 2010), corporate governance (Ghoshal & Moran, 1996; Lubatkin, 2005), and organizational change (Burke, 2008), as well as micro-level organizational behavior (Diefendorff & Lord, 2008).

This paper argues that neuroscience generally and evolutionary neuroscience in particular can provide a unifying basis for motivation analysis that can help resolve these problems. Neuroscientists have examined how evolution shaped the brain, with neurological elements from different stages of evolution contributing to the basic behavioral template. They have shown the human brain is a product of several distinct stages of vertebrate evolution and that each stage addressed different behavioral issues. As a result, the brain is made up of imperfectly integrated elements, often in conflict with each other. These evolved elements foster behavior that can be either self-interest-driven or empathy-driven or driven by complex but researchable combinations of motives, through mechanisms whose essential nature is understood.

We seek to provide a basic theory of motivation that can help resolve contradictions, support integrated research, and contribute to practice. Evolutionary neuroscience already provides fundamental understanding of motivation in psychiatry (Stevens & Price, 2000). However, its usefulness for motivation analysis in organization science has received little exploration. We address this gap through two specific contributions. First, we summarize what evolutionary neuroscience understands of motivation in human behavior and especially human systems, then develop a unifying, empirically based, high-level model to aid motivation analysis in organizations. We argue this knowledge and framework can unite seemingly contradictory ways of thinking, support lower-level model-building, and allow real differences to be addressed through more sophisticated research paradigms. Second, we illustrate the usefulness of our evolutionary neuroscience-based approach by demonstrating how it might contribute to the specific subfield of leadership theory.

The paper is organized into five sections. First, we summarize organization science literature on motivation. Second, we discuss current motivation research in neuroscience, especially that drawing on evolutionary frameworks. Third, we present our high-level model for understanding motivation in organizations and show how neuroscience knowledge and a model like ours can contribute to motivation analysis in organization studies. Fourth, we discuss our specific example of how evolutionary and neuroscience-based understanding permits more coherent analysis of organization science issues. Finally, we present a concluding summary that discusses limitations and considers needed further research.

I. ORGANIZATION SCIENCE LITERATURE REVIEW

Motivation in Economics

Differences between the dominant approach to motivation in economics and approaches in other fields are central to organization science motivation problems. Most theories in economics present self-interest as the driving human motivation. This idea is frequently but misleadingly traced to Adam Smith, who wrote two major works. Smith's first book, *The Theory of Moral Sentiments* (1759/1982), presented "sympathy" as a central human motivator (in the tradition of other 18th Century philosophers (e.g. Hutcheson, 1725/1971; Hume, 1740/1999)). His second, *Wealth of Nations* (1776/1976) demonstrated how self-interest could have powerful positive effects. *Wealth of Nations* became the founding text of economics whereas *Moral Sentiments* was relatively neglected.

Twentieth Century developments tightened the focus on self-interest, and thus most economic science today is based on the assumption that self-interest motives are preeminent. On one hand, economists sought more "rigorous" models. Specification of motivation as pure self-interest seemed to allow simplicity, clarity, and mathematical tractability (Samuelson, 1947). In addition, the pure self-interest formulation was attractive to economists skeptical about interventionist government. They sought evidence that people who advocated (for example) anti-poverty programs should be assumed to do so because of benefits they themselves would derive. Advocates of interventions were, it was argued, pursuing their self-interests "rather than the social goals (they) find it advantageous to enunciate" (Friedman,1980, front matter p. x).

Economists recognize that humans must cooperate. However, key economic approaches to analysis of cooperation assume it emerges from actors' implicit or explicit calculation of long-term self-interest. Much economic analysis of interpersonal behavior utilizes game theory (von

Neumann & Morgenstern, 1944/2004), which classically assumes self-interest maximization. Transaction cost economics (Williamson, 1985) assumes "contractual man" who may pursue self-interest through "opportunism," that is, a willingness to violate contracts and other understandings unless such behavior is controlled through appropriate approaches to contracting.

No widely accepted alternative has emerged, though some economists have noted limitations in the self-interest model (Arrow, 1972; Sen, 2000) and behavioral economics has introduced dual-motive theory as a more complete analysis (Cory, 2006; Levine, 2006).

Motivation in Other Organization Sciences

Non-economists provide much evidence that motivations other than self-interest are significant. However, unlike economists they have not developed standard approaches to motivation. Among the attempts to develop a comprehensive system outside economics, Maslow's (1954) was probably the most influential. He summarized motivation as a "hierarchy of needs." Drawing on clinical literature, he argued that individuals focus on physiological needs such as hunger until those are satisfied, then in turn on safety needs, "belongingness and love needs," and "esteem needs." If all these are satisfied, people tend to pursue "self-actualization," which Maslow presented as a paradigm of psychological health.

While many analysts have found Maslow's analyses useful, however, his assertions have fared poorly under positivist-style tests. Human needs do not seem to emerge in the hierarchical way proposed (Wahba & Bridwell, 1976). Self-actualization is an important motive, and Wahba and Bridwell support a modified division of human needs into deficiency and growth needs. However, even researchers who believe Maslow made important contributions have had difficulty building additive research streams on his work.

Later motivation researchers achieved many successes, but these did not converge into a comprehensive paradigm. Work motivation studies have created reasonably standardized definitions of motivation. Kanfer, Chen, and Prichard (2008a) summarize: "the psychological processes that determine (or energize) the direction, intensity, and persistence of action within the continuing stream of experiences." Many models analyze aspects of motivation or predict motivation in common situations, and many of these perform better than Maslow's in empirical tests. Kanfer (1990) reviewed more than 300 studies, and many more have been published since.

However, the absence of an empirically supported overall theory has left the relationships among the contributions unclear and limited findings' impact on practice. Kanfer's 1990 review reported several competing "integrative approaches," but none has been widely adopted. Kanfer, Chen & Prichard (2008b) recently stated that work motivation is "one of the more enigmatic topics" in organization science. They argue that the reasons why practitioners fail to use motivation theory to create motivated workforces are "not (as is often suggested) in a basic disconnect between theory and practice but rather in the complexity of the problem." The theories' limitations make it hard to tell what messages they might offer for complex macro-level problems such as leadership or corporate governance. Contemporary organizational behavior texts (e.g., Gordon, 1999; Osland, Kolb, Rubin & Turner, 2007; Schermerhorn, Osborn, Uhl-Bien & Hunt, 2012) offer no comprehensive approaches to motivation. Instead, they describe a variety of motivation theories at best loosely connected to each other (needs theories, equity theories, reinforcement theories, expectancy theory, goal-setting theory, etc.).

Some general models relevant to macro issues have been proposed in recent decades. Lawrence and Nohria (Lawrence & Nohria, 2002; Lawrence, 2010) suggest that four drives are central to human nature: drives to acquire, to bond, to comprehend, and to defend. Lawrence

(2010: 14) argues these are "the criteria by which well-adjusted people lead themselves and by which good leaders lead others." A limitation of the argument is that the authors do not clearly explain why they believe these, rather than others, are the central drives. In any case, neither this nor other comprehensive approaches have achieved wide acceptance.

Thus, motivation theory today fails to provide practitioners with theory that enables them to cope with the complexity of motivation, and it fails to provide scholars with theory that promises further research will dramatically improve understanding.

The apparent limitations of both economists' and non-economists' approaches suggest that to address these problems it should be worthwhile to consider the organ that is thought to generate motivations: the human brain. Fortunately, neuroscience has advanced in recent years through techniques such as noninvasive brain imaging, which supplement animal neuroscience results that have a longer history. Therefore, we next review the neuroscience of motivation.

II. NEUROSCIENCE OF HUMAN MOTIVATION LITERATURE REVIEW

The 20th Century work of Paul MacLean is fundamental to the neuroscience of human motivation. Based on anatomical-behavioral studies in lizards, monkeys and other animals, MacLean concluded that the human brain contained three evolutionary layers. As early vertebrates evolved into mammals and then humans, he said, new structures in the brain were built on top of earlier structures that survived. (See MacLean (1990) for summary, Cory (2002a) for an analysis of past criticism of MacLean, and Wilson (2008) for an up-to-date review.)

The earliest, most basic layer is what MacLean called the *reptilian brain*, a set of regions in or near the brain stem. This has changed remarkably little since the earliest amniotes, that is, the earliest creatures to produce an egg that could survive on land. In humans, this region is primarily responsible for automatic instinctive behaviors needed for self-preservation and reproduction. The brain and behavioral capacities of early amniotes in our ancestral line (stem reptiles) typically did not support caring for offspring. Therefore they, like most other early vertebrates, were overwhelmingly motivated by self-interest. In reproduction, they simply laid fertilized eggs and then left them to fate. (Crespi & Semeniuk, 2004).

Caring for young, however, is a defining characteristic of mammals. It arose with the brain's second evolutionary layer, which MacLean called the *old mammalian brain*, or the limbic region. An undeveloped limbic region existed in early reptiles (MacLean, 1990: 247, 287; Bruce & Neary, 1995), but it was small and simple. To support parental care, the limbic region had to be well developed in mammals, and it had to support empathy toward others and motivation to care. (See Carter, Harris & Porges, 2009, and Carter, 2014.) In today's mammals it supports parenting motivations, emotion of all kinds, and social bonding in many species.

MacLean called the third and final layer the *new mammalian brain*. Best developed in primates (but also important in elephants, dolphins and whales), it gives us higher cognitive capabilities. This is the cerebral cortex (outer brain layer) that enables language, abstract reasoning, and executive suppression of more basic impulses. It plays the key role in managing conflicting priorities of other brain elements. The "new mammalian brain" permits complex emotions, motivations, and behavior. While mammals without well-developed cerebral cortices demonstrate empathy mainly to mates and offspring, those with sophisticated 'new mammalian brains' show empathy and care toward distant relatives and other members of their social groups.

Since MacLean's time, neural pathways for many human motives, most inherited from ancestral mammals, have been mapped out – many in considerable detail. Panksepp (1998/2005) has provides a unified view of sleep, arousal, curiosity, fear, anger, feeding, sex, love, and bonding. Such analysis, called “affective neuroscience,” has extended MacLean’s results enormously. Research has not supported all MacLean beliefs. He thought the evolutionary layers acted with independence; we now know that they are tightly integrated. Thus we should not speak of three autonomous “brains.” Also, scholars criticized his reference to a “reptilian” brain because it seemed to imply that mammals had fully developed reptiles in their ancestral line when in fact modern reptiles emerged tens of millions of years after the mammalian line diverged. To avoid inaccurate implication, this paper will use the terms “early amniote complex” instead of “reptilian brain,” “paleomammalian complex” instead of “old mammalian brain,” and “neomammalian complex” instead of “new mammalian brain.”

However, the fact remains that the brain has three major assemblages that promote different types of operations (and thus motivated behavior) in a manner consistent with MacLean. These assemblages are the fundamental basis for all our motives and shape all we do.

Thus the motivational elements in our brains come predominantly from one of two evolutionary sources. Motivation driven by concerns already present in the early amniotic complex can be summarized as “self interest” or Ego (written with a capital “E” to denote that this is the sum of motivations derived from self-preservational circuits and not precisely “ego” in ordinary usages). Motivation driven by special contributions of the paleomammalian complex can be summarized as “other interest” or “Empathy” (again capitalized to indicate the sum of motivations derived from specifically mammalian circuitry. Note, however, empathy in the ordinary sense of the term – the ability to understand and share the feelings of another – was central to the emergence of the paleomammalian complex and therefore that such empathy is fundamental to human motivation just as self-interest is.). (Cory, 2002a, 2002b; see also Decety & Ickes, 2009, and especially Carter et al., 2009.)

The capabilities of the neomammalian complex elaborate these two sets of motives in complex ways that give us motivations and behaviors quite different from those of simpler mammals whose outer brain layers are less developed. Working together, the three complexes support the varied social behavior that humans and closely related primates exhibit.

MacLean illustrated his argument with a diagram similar to Figure 1 (MacLean 1990). (We have replaced MacLean's terms with our more contemporary phrases.) The figure is not a literal diagram of the brain, as the brain is almost unimaginably complex. Hence, Panksepp (1998/2005: 42) refers to MacLean's figure as a "conceptual cartoon." But this serious rather than frivolous cartoon helps us understand the layers, the elements within them, their corresponding behavioral repertoires, and the drivers of motivation.

Insert Figure 1 about here

The structures within the layers carry out processes that are part of larger neurological systems. These systems include emotional/motivational circuits, and in them structures from each complex mostly play characteristic roles. The early amniote complex supports basic needs and bodily functions, the paleomammalian plays an emotional role and drives much motivation, and the neomammalian handles cognitive and managerial tasks.

Neural pathways of motivation

Understanding the brain's evolutionary layers and systems helps us understand our most basic motivational mechanisms. However, to understand where specific behaviors come from and address specific motivational questions we have to understand processes and pathways within those layers and systems. A vast number of such processes and pathways exist.

To illustrate, we will here describe the basic neuroscience of a few such processes. As examples, however, let us examine four motivational processes that Lawrence and Nohria (2002: 5) proposed as “drives … central to the nature of all humans.” These are drives to *acquire* and to *defend* (motivations related mainly to self-interest and particularly drawing on the early amniote complex and brain elements related to early vertebrates’ simple limbic system); the drive to *bond* (related mainly to empathy and drawing particularly on the paleomammalian complex); and the drive to *comprehend* (related to both self-interest and empathy as especially influenced by the higher cognitive functioning of the neomammalian complex).

A structure called the hypothalamus and nearby regions at the base of the cerebral hemispheres control many aspects of motivation. These regions drive motivation to acquire (and other seeking) through extensive interactions with both the endocrine system (glands) and the autonomic nervous system (the involuntary nervous system that controls the body largely below the level of consciousness). Motivation to acquire also involves areas of the paleomammalian complex that arouse behaviors connected to feeding and lust (MacLean, 1990; Panksepp, 1998/2005). In addition, the drive involves executive areas of the frontal lobes that form strategies by which goals are fulfilled (part of the neomammalian complex) (Pribram, 1973).

Drives to defend and to bond, on the other hand, seem to be based on programs that often compete with each other (Eisler & Levine, 2002; Levine, 2008). The drive to defend is tied to the so-called *fight-or-flight repertoire* (Cannon, 1929), while the drive to bond is part of a repertoire to *tend-and-befriend* (Taylor et al., 2000).

Fight-or-flight involves many brain elements, principally in the early amniotic and paleomammalian complexes. It also involves the endocrine, immune, and cardiovascular systems. These produce coordinated biochemical changes in response to threatening events

(Koob, 1999; Nestler, Alreja, & Aghajanian, 1999). High coordinated activity (hyperarousal) involving the neurotransmitter norepinephrine and the hormone cortisol prepares the body for fighting the stressful event or withdrawing from it if necessary. All of the endocrine, immune, and cardiovascular systems and most of the brain elements involved have precursors in early vertebrates. Indeed, essentially the same elements that are involved in fight-or-flight in reptiles are involved in humans. However, in mammals fight-or-flight also involves paleomammalian and neomammalian elements. In particular, the emotions attendant on fighting or fleeing in mammals involve a prominent role for the amygdala, part of the paleomammalian complex.

Mammalian caring or *tend-and-befriend* responses, on the other hand, involve elements of the paleomammalian complex that are developed in mammals in ways not seen in early vertebrates. Caring brain activity is even more complex than self-interested brain activity, and neuroscientists once considered social behavior too complex to understand mechanistically. However, recent studies – including work on mammals with relatively simple social lives – have provided important insight. Two biochemically related hormones, *oxytocin* and *vasopressin*, are involved in many empathy and caring processes (Donaldson & Young, 2008). Insel and his colleagues (e.g., Insel, 1992) studied two closely related species of rodents with radically different social organizations: the prairie vole, which is monogamous with strong male-female pair bonding and both parents caring for young, and the montane vole, which is promiscuous with uninvolved fathers. They found that oxytocin attaches to receptor molecules in reward-related brain areas of the pair-bonding species but not the non-bonding species.

In humans, Kosfeld et al. (2005) found that administering oxytocin through the nose to men playing an investment game increased trust in their partners. This trust, however, may be selective toward one’s own group. DeDreu, Greer, Van Kleef, Shalvi, and Handgraaf (2011) found that administering oxytocin to Dutch participants given a choice of whether to sacrifice an individual for the sake of a larger collective made participants less likely to sacrifice if the individual was also Dutch. However, they were no less likely to sacrifice an individual from a different ethnic and religious group. (On the other hand, meta-analysis indicates oxytocin does not produce any actual decrease in trust toward members of out groups. (Van IJzendoorn & Bakermans-Kranenburg, 2012))

Neural pathways for executive control of repertoires. The brain frequently must decide whether to follow the fight-or-flight or tend-and-befriend motivating systems. Other competitions between Ego and Empathy motives are common. When stimuli arouse the organism, the executive system of the brain –elements that make major decisions and coordinate conscious behavior – decides which stored behavioral patterns to activate (Pribram, 1973; Stuss & Knight, 2002). (The executive system is diffuse but concentrated in the frontal lobes – key elements of the neomammalian complex.)

The amygdala, part of the paleomammalian complex, sometimes responds rapidly to perceived threats and triggers fight-or-flight**.** However, where more careful decision-making is possible one frontal lobe region, the *orbitofrontal cortex* (OFC), can turn on and off expressions of many major behavioral programs. The OFC is the main link between the paleomammalian and neomammalian complexes. In one famous case, the OFC was damaged in the 19th Century patient Phineas Gage. After a railroad tamping iron went through his skull, Gage lost ability to plan behaviors and changed from a sober to a radically impulsive personality, even as his purely cognitive abilities remained intact. (Damasio, 1994).

The OFC links neural activity patterns in the sensory cortex (which processes current stimuli) with other neural activity in the amygdala (in the paleomammalian complex) and the hypothalamus. The states in each of these elements reflect not only current situations but also past experience and innate disposition (Öngür & Price, 2000). Neuroscientists believe connections to the OFC from other parts of the cortex are strengthened or weakened with experience. Thus, similar interpersonal contexts evoke tend-and-befriend behavior in some people and fight-or-flight in others. Chronic childhood abuse alters the brain so that the adult brain reacts aggressively to minor slights (Perry, Pollard, Blakley, Baker, & Vigilante, 1995). Conversely, being raised in a caring family tends to produce caring adults (Eisenberg, 1992). Such plasticity occurs primarily in children, yet all through adult life there is still a lesser degree of brain plasticity, primarily in the form of cell-level neurochemical changes (Rakic 2002).

Neuroscience thus tells us that the dual, and often conflicting, motives of self-interest and other-interest operate in people differently depending on experience and heredity. Neuroscience empirically validates claims that balance between Ego and Empathy derives partially, but only partially, from the genes and that social institutions and cultural relationships matter. It points to fundamental human needs both to pursue self-interest and to build relationships.

Neural pathways for a comprehension drive. A drive to comprehend clearly exists. All primates are innately curious. When presented with mechanical puzzles in the absence of food reinforcement, monkeys spend much time trying to solve them. Panksepp (1998/2005) relates the motivation to comprehend to the same emotional/motivational system as the drive to acquire. However, the brain rewards curiosity differently than the pursuit of food or money. Biederman and Vessel (2006) found that both complex scenes and scenes in which the perceiver tries to understand the totality of events activate association areas of the visual cortex rich in opiate receptor molecules. These areas are less activated by repetition of the well-understood scenes.

Biederman and Vessel conjecture that opiates are a mechanism by which pleasure reinforces novel stimuli.

In the drive to comprehend, the neomammalian complex – the higher brain area best developed in primates and especially in humans – plays a primary role as humans seek to comprehend abstractions, operational patterns, and other complex conceptual phenomena.

Summary: Motivation at the Individual Level

Though our understanding remains incomplete, this brief review has summarized how evolutionary neuroscience makes possible a unified analysis of motivation. Humans have self-interested motivations that were already present in rudimentary form in early amniote ancestors. Other-interested motivations draw on neuromental components that we share with all mammals. Our neomammalian elements work with these older elements to create our amazing complexity and capabilities for social life. Our wide variety of motivations can be understood through study of specific systems and motivational processes.

Neuroscience of Motivation in Organizational Processes

Understanding motivation in individuals, however, is not enough for analysis of motivation in organizations. We must also understand how motivation works in groups, particularly in groups organized for shared purposes. The neuroscience of group motivation is at an early stage of development, but promising results have been achieved.

Humans naturally form groups and show loyalty to them. Haidt (2012) summarizes the evidence that evolutionary group selection promotes empathy toward members of one's own group. Moreover, other-interest motivations within groups are well documented. Although the tendency show concern for others is reinforced by the belief that others will reciprocate, neuroscience suggests such belief is as much a matter of empathy as of rational calculation. The same hormones that support caring at the individual level produce trust within groups. (Zak, 2007; Reidel & Javor, 2011)

Managing organizations requires that complex understandings of motivations and interests of others. This need is not new to modern organizations, however. Ethological studies show leadership exists in many primate social groups, and in a variety of species leadership involves intricate, caring behaviors that dominants must learn and practice with care (de Waal, 1982/2007; de Waal & Lanting, 1997; Cory, 2012).

Two distinct patterns seem to play roles in group organization among humans and other great apes (chimpanzees, bonobos, orangutans, and gorillas) (Chance, 1988). “Agonic” and “hedonic” patterns are fundamentally based on different sets of brain elements, involve different constellations of motivations, and support different kinds of functional activity in organizations.

Agonic organizing involves close attention to strict, hierarchical rank differentiations. “Agonistic” competition for rank is well-developed in lower vertebrates such as reptiles and agonic groups exist among many species. Vertebrates’ competitive motivations and sense of need to yield when necessary – built into the early amniotic complex – establish hierarchical relationships central to structuring such groups (Price, 1988). Pierce and White (1999) show agonic structure described by animal behavior researchers closely parallels the “mechanistic” organizational style that Burns and Stalker’s (1961/1966) organizational ethnography described.

Hedonic organizing involves less overt competition. Groups of mutually dependant individuals divide tasks and resources informally. Status differences are important, but group members often care for each other across levels. Hedonic organizing seems to require the neocortex of the great apes. While competition-driven agonic organizing is seen in a wide variety of vertebrates, even primate species such as the Indian Macaque monkey and the Savannah baboon seem incapable of it (Chance, 1988: 4). Pierce and White show that the hedonic mode corresponds to Burns and Stalker's "organic" organizing style.

Primate studies provide helpful indications of how these two constellations of motivations and structure contribute to organizations. Burns & Stalker described dysfunctions of mechanistic processes but did not document strengths they might have. Power (1988), however, showed that a chimpanzee band switched from hedonic/organic to agonic/mechanistic when researchers supplemented its widely dispersed resources with concentrated piles of bananas. (The researchers wanted to attract the band to a site where they would be easier to study.)

Pierce and White (1999) noted important parallels between chimpanzee behavior and behavior in organizations: The chimpanzees used hedonic/organic organization when they pursued widely dispersed resources in unpredictable locations. Similarly, organizations use hedonic/organic organization in research units that pursue dispersed resources (information) whose locations are unpredictable. Moreover, just as chimpanzees used agonic/mechanistic mode where resources were centralized and therefore subject to contests among them, organizations use more agonic/mechanistic structure where they manage centralized, well-defined resources (e.g., in factories). Thus organizations seem to tend toward structures involving competitive, Ego-oriented motivation when managing well-defined sets of resources and organizing driven by more obviously pro-social motivations when resources are more dispersed.

It may often be unhelpful to classify human groups as agonic or hedonic. Managers in all organizations face challenges in achieving Ego/Empathy balance (Wilson & Cory, 2007). However, understanding these tendencies and related neuroscience provides real insight. Goleman, Boyatzis, and McKee (2001) argue that leaders need "emotional intelligence" derived from neomammalian regions that interpret signals from paleomammalian regions. Emotional intelligence will be important in real human organizations regardless of whether their structure is more agonic or more hedonic. (See Salovey, Brackett and Mayer, 2004, for summaries of the psychological research that underlies that of Goleman et al.)

There is evidence that in many situations, performance as measured by strictly economic criteria is enhanced through leadership that communicates a vision that benefits stakeholders and is articulated with emotional strength that affects others' paleomammalian complexes (Judge & Piccolo, 2004). Waldman, Balthazard and Peterson (2011) found coherence (Thatcher, North & Biver, 2008) in the right frontal cortex predicted leaders' ability to articulate a powerful vision. Boyatzis et al. (2012) identified differing elements in followers' brains that responded to "resonant" and "dissonant" leaders.

III. NEUROSCIENCE-INFORMED MODELS FOR THE ORGANIZATION SCIENCES

These neuroscience findings demonstrate that knowledge of the human brain offers the organization sciences a clearer, more unified pathway to understanding motivation in individuals and groups. While neither economics nor other organizational sciences offer a firm foundation for deepening our knowledge, the physiological nature of neuroscience theory provides a solid basis. Self-interest-driven motivations and other-interest-driven motivations power human behavior and each operates continually in organizational participants. Details of the mechanisms are gradually coming to be understood.

Our knowledge enables neuroscience to support at least two important kinds of motivation models that can help resolve motivational issues: 1) a simple, credible high-level model of human motivation, and 2) specialized models suitable for understanding and predicting behavior in particular circumstances. Together, the two kinds of model and our rough understanding of how the models all fit together represent knowledge of motivation that can both help practitioners manage and help scholars achieve further advances over time.

A High-level Model of Motivation for Organization Science

Our high-level model (Figure 2) summarizes how human motivation works and provides basic understanding of fundamental factors in motivation processes. The core is the three complexes created in the stages of evolution. Each makes characteristic contributions to motivation: the early amniote complex supporting basic self-preservation/self-interest functions, the paleomammalian supporting emotions and other-interest, and the neomammalian with executive and cognitive brain elements. These provide the building blocks for motivation.

Insert Figure 2 about here

The most basic motivation processes take place in the many emotional/motivational circuits that run through these three levels, driving the vast range of human behaviors. Figure 2 illustrates these circuits as two-way paths through the three complexes. To understand the motivational workings of any situation we need first to understand what is happening in the relevant circuits. Today virtually no circuits are fully understood. But today's partial understandings still give considerable insight.

The motivations that the circuits produce frequently conflict. We show the executive as a circle in the front part of the neomammalian complex because that is the location of the largest number of its neurons; arrows point toward the emotional-motivational circuits to show its influence. As information from sensory organs is processed throughout the brain, all emotional/motivational systems can react to stimuli. However, the executive system regulates how much of some reactions affect behavior. The executive system tends to establish a homeostasis (that is, a stability - though not necessarily a happy one). Conflicts are especially likely to occur when stimuli arouse the individual. Interactions among systems are not necessarily smooth, and conflict is central to the brain's workings. As discussed above, motivations driven by mammalian elements (that is, social motivations) are generally more complex than those driven predominantly by elements inherited from the early amniotes.

Motivational signals ultimately give impetus to somatic elements (elements dedicated to managing action in our bodies) in each complex. Brain signals then drive actions of our muscles and other body elements, which produce our behavior.

High-Level Motivation Analysis and Human Performance. This high-level analysis provides reason to believe that mental functioning and performance are likely to suffer when human systems promote over-use of either self-interested or other-interested elements. Ego-driven and Empathy-driven brain elements differ significantly. States of dynamic balance that allow appropriate expression for both – successful cooperative activities, for instance – are likely to produce less behavioral tension. Behaviors that can induce more tension include behavior in a highly self-interest-driven range – power-seeking, domination, and competitiveness, for example – or behavior in a highly Empathetic range such as giving, ingratiating, and self-sacrifice (Cory, 2002b; Wilson & Cory, 2008). (When behavior in one range is necessary, tension is likely to be less if it is soon balanced by behavior in the other range. For example, when a group must unite in self-interested struggle, the quality of empathetic behavior that members can show before and after and during the struggle will determine dynamic balance.)

The High-Level Model and Specialized Models

Specialized neuroscience models for particular kinds of situations may be even more important than the high-level model. The high-level model tells us far less than we want to know, and creating more complete overall motivation models is profoundly difficult (as traditional motivation researchers have known (Kanfer, Chen & Prichard, 2008a)). Traditional motivation research has produced dozens of models for specific situations – for example, models of motivation of workers based on job design or motivation of team members based on how the team is managed. But these predict motivation based on constructs relevant to the specific situation. Often relationships between constructs in different models are difficult to determine. For instance, individual-level work motivation models can be used in job design. They traditionally address job characteristics including skill variety, task identity, task significance, autonomy, and feedback (Hackman & Oldham, 1976; Parker & Ohly, 2008). They successfully predict motivation, but causal mechanisms have not been thoroughly analyzed. Models of work team motivation use different constructs – for example, leadership climate, team-performance feedback, and leader-member exchange (Chen & Kanfer, 2006; Chen & Gogus, 2008). It has proved difficult to tell how work motivation and work team models relate to each other. Few models have been studied neurologically. However, research suggests that neuroscience explanations of many can be created. Table 1 summarizes examples of motivational processes whose neuroscience is at least partially understood. It includes the neuroscience behind the four drives highlighted by Lawrence, the transformational leadership neuroscience developed by Waldman et al. (2011), neuroscience of emotional contagion and neuroscience of the goal pursuit. The table illustrates the diversity of organization science-relevant neurological motivational processes that have been (and can be) studied empirically. Because the brain locations of at least part of each process is known, relationships among them may be clearer than relationships among many established motivational theories.

Insert Table 1 about here

Berkman and Lieberman's study of goal pursuit is particularly interesting. They found relatively few empirical studies of goal pursuit. However, they were able to assemble a credible initial picture of the neuroscience of goal pursuit from data mostly gathered for other purposes. (For example, studies where volunteers follow procedures prescribed by experimenters provided data on where extrinsic goals are stored and processed in the brain.)

The high-level model can give a sense of how special-purpose models relate to each other, indicate limitations of some specialized models, guide development of more reliable specialized models, and support further research to resolve contradictions (apparent and real) about motivational theory among different subfields.

Neuroscience and the Strengths and Limitations of Specialized Models. The context that the high-level model and underlying neuroscience provide can also indicate limitations of specialized models – including some that are sometimes wrongly presented as universal.

As discussed above, neuroscience supports the legitimacy of models that are not universal. A good example of the appropriateness of specialized models is seen in how self-interest-oriented models are used in economics and many disciplines within organizations such as compensation analysis, finance, and accounting. Neuroscience suggests that some self-interest-driven brain systems, while highly complex, are simpler than processes that depend more on the paleomammalian complex. Consequently, self-interest-driven processes are generally easier to model. Self-interest-based profit-maximization-oriented models may thus be quite appropriate in management of organizational resource allocation, compensation, and finance.

A key intuition from our high-level model, however, is that successes of self-interest-based models should not lead to their over-emphasis. Some economists have held that analysis of rational utility maximization can explain all human behavior. (See Nelson, 2001: 166-176.) Neuroscience shows this is not true. Ultimately, human systems must draw on both self-interest and other-interest motivations, and comprehensive insight can only be gained addressing both.

Lawrence and Nohria's four-drive theory (Lawrence & Nohria, 2002; Lawrence, 2010) is probably best understood as a specialized model of motivation relevant to management and leadership. The four drives they posit as central – to acquire, to bond, to comprehend, and to defend – are significant in the brain and have strong relevance to the management and leadership. Theirs is not a comprehensive theory of motivation. (It includes no sexuality or reproduction drives, for example.) However, it clearly identifies both self-interested and empathy-driven motivations. Drawing on Darwin's Descent of Man (1871/2004), Lawrence (2010) proposes that relying on our drives to bond and to comprehend is central to leadership.

Since many other important motivational processes exist, further empirical work is needed before we can say that a reliable specialized theory for management and leadership definitely exists. We need to consider whether motivations like self-actualization, for instance, need to be included and examine the effects of narratives on motivation (Kitayama and Park, 2010). We need further study of how management and leadership processes work neurologically. Further work, however, could result in specialized models of motivation in management and leadership with highly credible empirical foundations.

IV. DISCUSSION: EVOLUTIONARY NEUROSCIENCE' POTENTIAL ROLE IN ESTABLISHED ORGANIZATION STUDIES SUB-FIELDS

As we have shown, evolutionary neuroscience' understanding of the human brain's emergence forms a solid basis for addressing the challenges of analyzing motivation in organizations. Knowledge of the interplay of self-intrest driven and other-interest driven motivation and the mechanisms of specific motivational processes can improve our thinking about motivation in important ways.

A unified, neuroscience-based understanding should permit better analysis of many issues. It can help disciplines talk to each other. For example, relationships between self-interest-based economics theories and transformational leadership research (Judge & Piccolo, 2004) may be understood through analysis of self-interest and organizational ethos in the brain.

Evolutionary neuroscience can also help subfields understand their own issues. In the past, self-interest-based analysis has sometimes seemed more scientific than other social science. This caused disagreements between scholars who sought rigor in self-interest-based analysis and others who felt alternative approaches more significant. Neuroscience shows self-interest works everywhere but that other-interest is also overwhelmingly powerful – part of all human life.

An Example: How Evolutionary Neuroscience Might Contribute to Leadership Theory

We can see neuroscience' potential contributions best through specific subfields. Strategic management, leadership, corporate governance, organizational change, micro-level organizational behavior, and management education could all be candidates. Here we will discuss the leadership subfield. We will not attempt fully developed theory. However, we will illustrate how neuroscience can put leadership theories on a more unified, researchable basis.

Problem: Research with Limited Contribution for Practice. Weaknesses in leadership theory are a problem. Nohria and Khurana (2010: 4) note that educating leaders is central to missions of business, law, education, public health, and public policy schools. Yet, they say, research has not produced reliable answers to major leadership questions. One business school dean (Zupan, 2010) recently quoted a 1959 Warren Bennis paper that said: "Of all the hazy and confounding areas in social psychology, leadership undoubtedly contends for the top nomination." Zupan added that this "seems to ring even truer today."

Yet leadership study is ancient, pre-dating emergence of *homo sapiens*. As noted above, leadership exists in a variety of social primate species. deWaal (1982/2007) documented how a strong young male won nominal leadership of a chimpanzee band but failed to gain full benefits because he lacked the right skills. Older primates who lose "alpha male" struggles can keep a good deal of power if their experience gives them understanding of how power is exercised.

Approaches to Leadership Theory. Leadership is a matter of influencing or directing others (Yukl, 2006: 5), so it involves motivating. Yet texts lack coherent motivation discussion (Daft, 2002; Yukl, 2006; Northouse, 2010). Neuroscience-based analysis offers needed elements.

Table 2 summarizes three approaches to leadership. The first is from a standard text (Yukl, 2006), clearly documenting scientific leadership studies. The conclusions in Yukl's final chapter include: Leaders face relentless, conflicting demands. They must develop suitable short-term and long-term agendas. Effective leaders exert power in a subtle, easy fashion. Yukl cites rigorous research supporting these points. However, while useful, they do not really tell how to lead. Moreover, the text offers no indication that further research would enable tell how to lead.

Insert Table 2 about here

The second column summarizes "a new theory of leadership" that Bennis developed with Nanus (1985/2007). Examining "transformative leadership" (Burns, 1978), Bennis and Nanus interviewed 90 leaders. Practitioners find their theory helpful; the book has sold over 500,000 copies. Its conclusions are actionable. In authors' summary, transformative leadership requires: 1) Attention to outcome driven by a vision; 2) creation of meaning through communication; 3) creation of trust through predictability and clear statement of positions; 4) Positive self-regard and ability to pour oneself into pursuit of positive goals. Numerous stories illustrate.

Much of the book, however, is art rather than science. Obvious theory-development elements get little attention. Bennis and Nanus say they selected leaders who achieved "fortunate mastery over present confusion," but provide no details. Many assertions have not been tested and would be difficult to test. It can be said that much represents good art. When Bennis and Nanus argue importance of "Attention through Vision," they illustrate with comments by Ray Kroc, founder of McDonald's, on why he created a "Hamburger University" where employees obrain a "Bachelor of Hamburgerology with a minor in French fries." (1985/2007: 27). The reader does not have to like McDonald's to feel vividness. This is not science, though.

The third column summarizes a new approach by the economist Zupan (2010), who – unlike mainstream theorists – follows economists' self-interest motivational assumption. Mainstream authors believe leadership includes emotional caring. (Yukl, for instance, discusses controversy among mainstream scholars over what counts as "leadership." Some hold a person is not "leading" unless he or she achieves "enthusiastic commitment." Others hold real leaders may sometimes use power to require compliance. Both sides seem to agree that creating "enthusiastic commitment" [apparently for reasons that go beyond expected profit] is preferred.)

Zupan builds on a different keystone. He holds that members of an inadequately led organization are essentially participants in a “prisoner’s dilemma”-like game. Good leaders play roles analogous to creators of organized crime syndicates who prevent criminals from confessing to police by ensuring that any who do will be punished. This surprising analogy provides new and significant insight – but with limitations inherent in self-interest-based analysis.

In the “prisoner’s dilemma,” two criminals are arrested. Police lack evidence, so if both stay silent, they will get no more than 2-year sentences (on a minor charge). But if one confesses and not the other, the police will favor him/her with a mere one year sentence. If both confess, though, they’ll both get 10-year sentences. A “payoff matrix” shows that if prisoners believe they will only play this “game” once, they both have incentive to confess. But if players will “play” multiple times, they can construct incentives (e.g., by creating a syndicate) to encourage silence.

Zupan says people in poorly led organizations suffer from the same kind of unhelpful incentives as prisoners captured by the police. Everyone may know that life would be better if all behaved differently. But until someone gets the whole collectivity to change, no one has incentive to act differently.

Zupan’s theory emphasizes leader vision. By creating an attractive target and a sense that each individual can benefit by investing to move the organization toward it, leaders shift the organization out of its “inferior equilibrium.” Drawing on Bennis and Nanus (1985/2007), Zupan says leaders need to enroll people in the vision through infectious hope, demonstrate real commitment, and achieve integrity, effective communication, and authenticity. Zupan argues largely deductively, with more concern for scientific rigor than Bennis and Nanus. His self-interest-oriented analysis provides substantial, carefully drawn reason to believe that leaders with vision and willingness to risk commitment can appeal to others' personal desires, create incentives for them to commit and take risks, and get a new vision to work.

However, though most Zupan arguments meet scientific norms, some appear not to. Zupan seeks comprehensive theory, and his examples include Martin Luther King, Mother Teresa, and Abraham Lincoln – leaders whose work does not seem to fit his model. Yet the closest he comes to showing how these leaders' motivations belong is a brief discussion of "authenticity." He does not tell what authenticity is, where it comes from, or how it works.

Thus, though Zupan makes a real contribution, he delivers a model with serious limitations. He credibly shows how a leader with a vision may sometimes be able to drive change using overwhelmingly self-interest-oriented incentives – a contribution that seems to apply to leadership among non-human primates as well as humans. (See de Waal, 1982/2007: 46-49.) However, he seems to fail in his effort to address the whole phenomenon of leadership.

Thus, no approach seems to take leadership out of the realm of the "hazy." Nohria and Khurana's concerns are supported. The most useful leadership theory (Bennis & Nanus, 1985/2007) is unscientific and apparently cannot be made scientific. Leadership literature fails to produce comprehensive, scientifically grounded, consistently helpful advice.

How Motivation Theory May Unify and Clarify Leadership Studies

Neuroscience of motivation can help us leverage the strengths of each approach and clarify relationships among them. It can help us analyze what can be analyzed and provide scientific basis for identifying elements that may always have to be "art more than science."

Three ideas derived from evolutionary neuroscience may help leadership theory overcome some of its problems:

1. *The universality of both self-interested and empathy-based motives*. Researchers such as Cory and Gardner (2002) and Lawrence (2010) demonstrate the biological importance of both the kind of positive motives often addressed in leadership literature and self-interest motives. So analysis focused on either self-interest alone or caring behavior alone will be at best partial. Moreover, while the two are deeply intertwined, the brain mechanisms that support each differ enough that it may often be worthwhile to analyze them separately.
2. *The relative straight-forwardness of self-interest circuits*. The small brains of flies and minnows do effective self-interest-oriented thinking. Leadership analysis may sometimes succeed better if it considers simpler self-interest-oriented issues first, simply because they are simpler. This does not imply self-interest analysis is more important. Examining self-interest first is simply reasonable for creating scientific theory.
3. *The incredible complexity of social brain processes*. The complexity of paleomammalian complex-intensive processes and thus other-interested behavior may make it difficult for neuroscience to fully understand all aspects, particularly the range of empathic capacities. It leaves the arts and humanities with important roles. Indeed, it may be that the intersection of neuroscience and organization sciences will be one of the places where science most clearly documents the importance of art.

These points suggest a straightforward way to establish unified, non-hazy leadership thinking is to start with self-interest-related aspects. Table 3 presents one approach, starting with self-interest-oriented analysis and then building on that with analysis of more complex processes that draw on empathetic motivations. We are not now arguing that this is necessarily the right approach. We are just noting that this represents one way to use the above observations to clarify leadership. Significant self-interest-based aspects of leadership seem able to be summarized simply, as Zupan demonstrates. With this as context, analysts can then study more complex, more emotional processes. This would unify three ways of approaching leadership: first, standard theory as articulated in leadership texts, second, self-interest-driven economic analysis like Zupan's, and finally artistic leadership discourse that serves practitioners so well.

Insert Table 3 about here

Advances in cognitive and behavioral neuroscience and sophisticated neural network modeling (Grossberg, 2000; Levine, 2000) promise more insights over time. We achieve best understanding today, however, with an intelligent combination of modes of analysis and art.

Such neuroscience supports 18th century moral philosophers' argument that humans are naturally driven by two basic motives: self-interest and "sympathy" (Hume, 1740/1999; Smith 1759/1982, 1776/1976. See Gazzaniga, 2005, and Cory, 2010 for the neuroscience supporting Smith's understanding of sympathy, which seems identical to what we would today call "empathy.") Neuroscience thus gives reason to believe that leadership based on both meeting self-interest needs and addressing caring passions is universal in human and related primate societies. Leaders of chimpanzee bands, businesspeople, and scientists all have goals pursued out of self-interest and goals pursued due to empathetic motivations. They want to succeed in ways that greatly benefit themselves and greatly benefit other collectivity members. Those who do succeed this way – be they people or chimpanzees – win peers' admiration.

As discussed above, we present these elements of a possible unifying approach as illustrative. Much further debate is needed before evolutionary neuroscience can make its full contribution. But with neuroscience-informed approaches, leadership need not be “hazy and confounding.”

Evolutionary Neuroscience and Other Subfields of the Organization Sciences

There is reason to hope evolutionary neuroscience can also sharpen discussion in other organization studies subfields (while perhaps also demonstrating the need to leave some aspects to art). For example, the strategic management field is structured around the assumption that actors are driven by self-interest (Porter, 1985; Hill & Jones, 2008). However, studies of firms that actually achieve sustained competitive advantage repeatedly find motives other than wealth maximization drive their creators and builders (Kanter, 1983; Collins, 2001). Comprehensive analysis of motivation could well produce a more credible strategic management discipline.

The study of corporate governance, on the other hand, suffers from polarization between those who build self-interest-based theories (Schleifer & Vishny, 1997) and others who argue the apparently rigorous pursuit of such approaches leads to companies that fail to sustain long-term profitability (Paine, 2002). Clearer understanding of how human motivation actually works can aid understanding of the nature of the problem and possibly viable approaches.

Diefendorff and Lord (2008) note a different kind of opportunity in micro-level study of motivation. While traditional motivation research emphasized goal setting and intensity of effort, recent research recognizes that examining the whole process of human self-regulation is more credible. Diefendorff and Lord note that neuropsychology represents a unifying perspective that allows a comprehensive approach to self-regulation.

As these examples make clear, further development of the evolutionary neuroscience of motivation offers considerable opportunities.

V. CONCLUSION

The research presented in this paper indicates that evolutionary neuroscience provides a credible fundamental theory of human motivation and a unified foundation for the scientific study of motivation in organizations. It is a solid framework for addressing the complexity of motivation and, combined with other neurological data and theories, it provides a basis for further research that will improve understanding.

This should not lead us either to overstate the extent of scientific knowledge of neuroscience today or to exaggerate the extent to which it can improve understanding of organizational questions. The complexity both of the brain and of motivated behavior in organizations means that motivation remains poorly understood. Mystery will always remain.

Nonetheless, important additional progress is possible. Further research into brain processes is needed. Recent progress using techniques such as functional magnetic resonance imaging and qEEG suggests that such study can make real contributions to understanding many organizational issues. Likewise, exploration of the implications of evolutionary neuroscience for many subfields in organization science is required.

Despite the need for further research, however, with today's knowledge we can say that the evolutionary and neuroscientific heuristics of brain activities for self-interest and other-interest are of fundamental importance. Research in neuroscience and related disciplines increasingly makes their significance clear for organizational analysis.

Table 1
Examples of Motivational Processes and How They are Studied in the Brain

Motivation Process	**Academic discussion of relevant neuroscience**	**Sources of insight**	**Some brain and/or related endocrine elements involved**
Seeking resources (and other positive stimuli) - a core motivational process sometimes called "approach motivation." (Encompasses much of Lawrence' *acquire.*)	Panksepp, 1998/2005: pp. 144-163; Panksepp & Biven, 2012: pp.76-144	Animals were found to work intensely to obtain electrical stimulation of these areas; the same areas were later implicated in most motivation. (Most motivation is linked to this seeking program.)	System is centered in the medial forebrain bundle-lateral hypothalamic area in the lower (ventral) part of the paleomammalian complex.
Fight or flight repertoire - system for recognizing and responding to threats. (Encompasses much of Lawrence' *defend*.)	Cannon, 1929; Koob, 1999; Nestler, Alreja, & Aghajanian, 1999	Early research in animals examined bodily changes caused by fear-inducing events.	Core of process involves early amniotic elements parallel to those that performed parallel roles in early vertebrates. Human process also involves emotions processed by amygdala, neomammalian complex decision-making, and other elements
Need for and concern for others (Often called "affiliation;" Lawrence' *bond*).	Insel, 1992; Panksepp, Nelson & Bekkedal, 1997; Eisler & Levine, 2002	Comparison of neural processes in species with caring vs. uninvolved fathers	Neurotransmitter oxytocin plays key role in stimulating paleomammalian elements
Search for richly interpretable, novel experience (Lawrence' *comprehend*).	See academic discussions of "Seeking resources" above and Biederman & Vessel (2006)	fMRI scans show increased flow of blood to visual cortex areas with opiate receptors when interesting new pictures are shown but not when pictures are repeated.	Drive to seek resources creates curiosity; novel experience is especially rewarded through activation of areas of visual cortex rich in opiate receptor molecules.
Emotional contagion (tendency to automatically mimic others and thus converge emotionally)	Rizzolati & Craighero, 2004; Hatfield, Rapson & Le, 2009	Observations on monkeys' brains as they both move and observe others move.	Mirror neurons' in the neocortex (in the premotor cortex and nearby regions)
Pursuit of goals (intrinsic and extrinsic).	Berkman & Lieberman, 2009	Wide-ranging review of neuroscience studies on humans, most conducted for purposes other than understanding of goal pursuit.	Different parts of the neomammalian complex (the neocortex) contribute to different aspects of goal pursuit. For instance, extrinsic goals are represented largely in the lateral prefrontal cortex while intrinsic goals appear to be represented largely in the medial prefrontal cortex
Inspirational (or transformational) leadership - visions based on strong ideological values that energize followers and cause them to identify with the visions.	Waldman, Balthazard & Peterson, 2011	Coherence in right frontal brain regions of executives correlated with articulation of socially based vision that would energize followers.	Right frontal cortex, associated in previous research with imagination, creativity, and emotional response.

Table 2
Three Approaches to Leadership Theory

	Yukl (2006)	Bennis & Nanus (1985/2007)	Zupan (2010)
Source	Comprehensive review of leadership literature	Intellectually informed series of 90 interviews with leaders	Self-interest-driven theoretical analysis using a standard economics concept.
Key elements	**Situation:** Leaders face relentless, conflicting demands. **Behavior:** Leaders develop short-term and long-term agendas and strategies, which guide behavior and must suit their situation. **Power and influence:** Effective leaders exert power in a subtle, easy fashion. **Traits and skills:** Technical, conceptual, and interpersonal skills are more important than personality traits, but traits such as ability to tolerate stress are also important.	Excellent transforma-tional leadership involves: 1) Attention to outcome driven by a vision; 2) creation of meaning through communication; 3) creation of trust through consistent predictability and clear statement of positions; 4) Positive self-regard and ability to pour oneself into the pursuit of positive goals.	Leaders matter because organizations are like criminal gangs in game theory's 'prisoner's dilemma' – they tend to fall into 'inferior equilibrium.' They need vision-driven leadership to point a way to productive, cooperative work. To appeal to employee self-interest, leaders must give hope, demonstrate commitment, show integrity, and communicate to call forth followers' investment in their vision.
Relationship to science	Careful analysis of methodologically credible studies.	Model produced through theory development without testing. No grounding in any disciplinary perspective.	Analysis is carefully built on credible economics concepts. Statements about authenticity and ideals lack clear scientific provenance.
Limitations	Diffuseness and lack of connection to any foundational paradigm make usefulness to practitioners limited and cause the theory to get less respect than disciplines such as economics.	Lack of connection to academic disciplines makes it difficult to build on this work. Assumption that leaders with positive self-regard will make positive contributions to society is not actually argued.	No treatment of emotions. No explanation of basis for choosing which non-economic situations will be discussed.
Missing elements		No description of sampling process; no scientific tests.	No connection to other disciplines that could address limitations.

Table 3
An Approach to Using Neuroscience for Stronger Leadership Theory

Sources	Standard literature, self-interest-driven analysis, and scientifically informed artistic works (such as Bennis')
Key elements	Unification and clarification of the study of leadership using knowledge of brain's self-interest- and empathetic processes to explicate relationships between potentially complementary ideas and identify areas where art is likely to achieve more than science. - Because of the relative simplicity of self-interest-driven processes, self-interest-based analyses can create a foundation for overall analysis of leadership, clearly describing self-interest-based aspects of leadership and processes that address them effectively. - Leveraging the self-interest-based analysis, scientific analysis of (more complex) empathetic and other emotional processes permits scientific understanding of many such aspects of leadership. - Recognition of the complexity of empathetic activity demonstrates the need to address leadership through art as well as science. - Neuroscience can play a role in in helping scholars recognize where art will be more important than science and develop appropriate arts such as interview-based storytelling.
Relationship to science	Neuroscience provides mechanisms for clarifying the significance of elements developed in research and for recognizing aspects of leadership that will always be art.
Limitations	Much more work required for full development. Line between what should be art and what should be science will always be unclear.
Missing elements	Many processes and connections unclear. However, use of neuroscience to clarify the relatively straightforward and the very difficult aspects of Leadership Studies can lead to more comprehensive, unified science and appropriate appreciation for art.

Figure 1. Conceptual Diagram of the Evolutionary Layers of the Brain

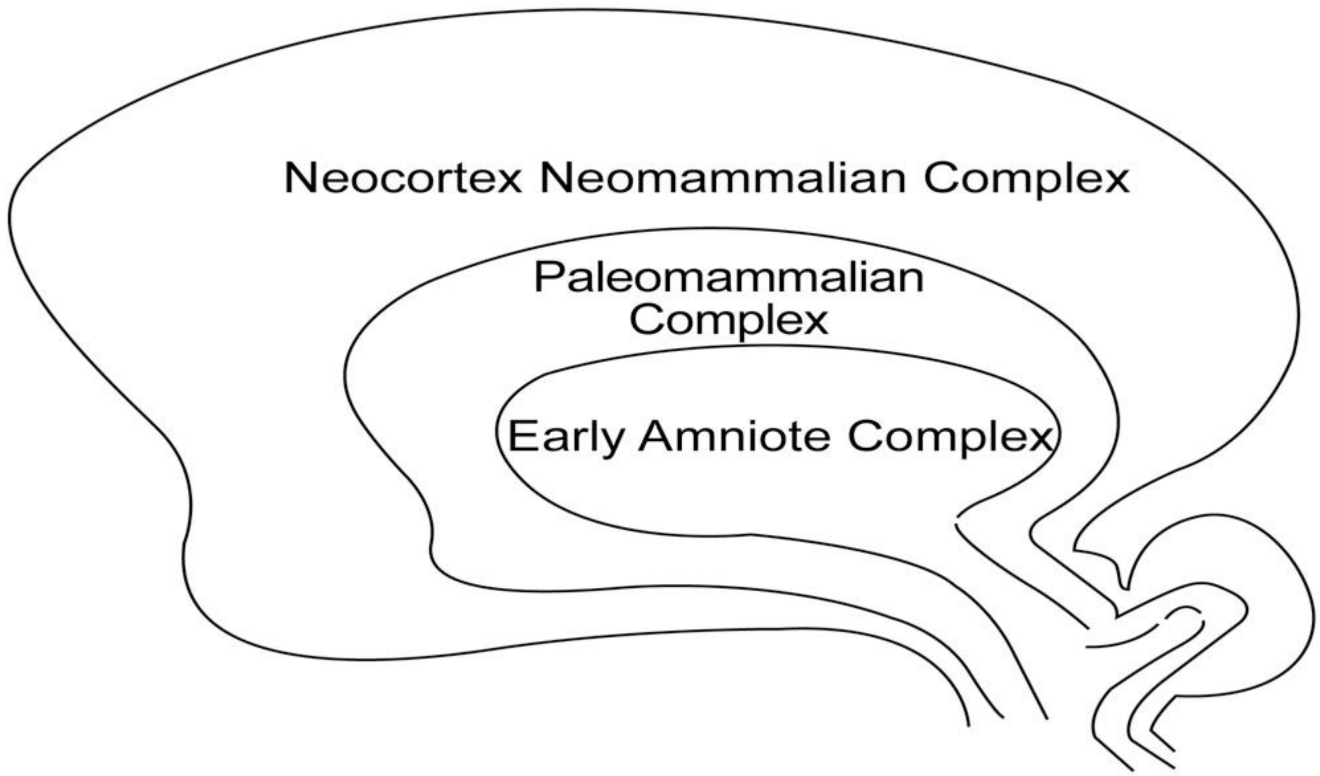
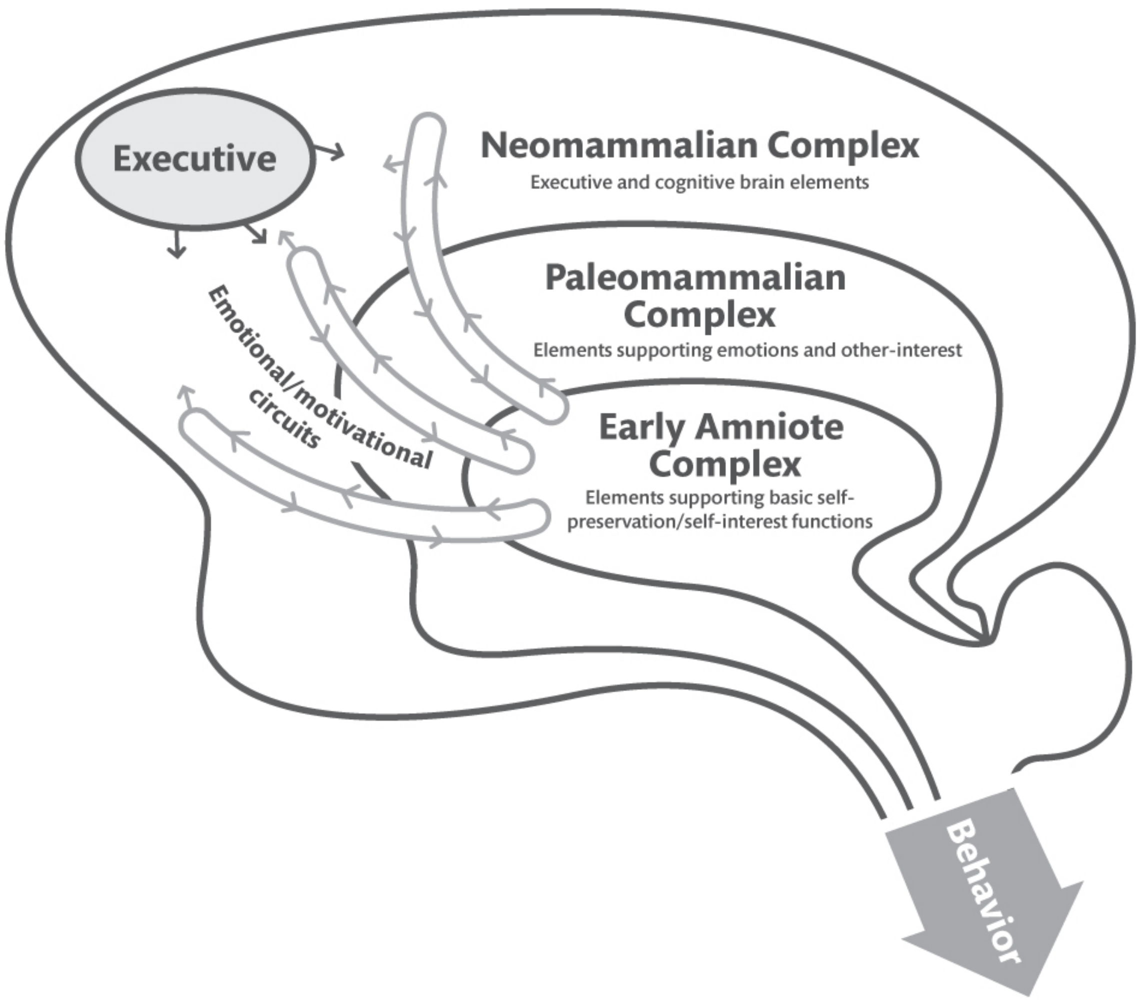


Figure 2. A High-Level Model of Human Motivation



References

Arrow, K. J. (1972, Summer). Gifts and exchanges. *Philosophy & Public Affairs, 1*(4), 343-362.

Bennis, W., & Nanus, B. (2007). *Leaders: Strategies for taking charge.* New York: Collins Business Essentials. (Original work published 1985)

Berkman, E. T., & Lieberman, M. D. (2009). The neuroscience of goal pursuit: Bridging gaps between theory and data. In G. B. Moscowitz & H. Grant (eds), The psychology of goals. New York: Guilford Press.

Biederman, I., & Vessel, E. A. (2006). Perceptual pleasure and the brain. *American Scientist, 94* (May-June), 249-255.

Boyatzis, R. E., Passarelli, A. M., Koenig, K., Lowe, M., Mathew, B., Stoller, J. K., et al. (2012). Examination of the neural substrates activated in memories of experiences with resonant and dissonant leaders. *Leadership Quarterly, 23,* 259–272.

Bruce, L. L., & Neary, T. J. (1995). The limbic system of tetrapods: A comparative analysis of cortical and amygdalar populations. *Brain, Behavior, and Evolution, 46,* 224-234.

Burke, W. W. (2008). *Organization change: Theory and practice.* (2nd ed.) Thousand Oaks, CA.: Sage.

Burns, T., & Stalker, G. (1966). *The Management of Innovation.* London: Social Science Paperbacks. (Original work published 1961)

Cannon, W. B. (1929). *Bodily changes in pain, hunger, fear, and rage*. New York: Appleton-Century-Crofts.

Carter, C. S., Harris, J., & Porges, S. W. (2009). Neural and evolutionary perspectives on empathy. In J. Decety & W. Ickes (eds), *The social neuroscience of empathy* (pp. 169–182). Cambridge, MA.: MIT Press.

Carter, C. S. (2014). Oxytocin pathways and the evolution of human behavior. *Annual Review of Psychology, 65,* 17–39.

Chance, M. R. (Ed.), Omark, D. R. (Asst.). (1988). *Social fabrics of the mind.* Hove, England: Lawrence Erlbaum.

Chen, G., & Gogus, C. I. (2008). Motivation in and of work teams: A multilevel perspective. In R. Kanfer, G. Chen & R. D. Prichard (eds), *Work motivation: Past, present, and future* (pp. 285–317). New York: Routledge.

Chen, G., & Kanfer, R. (2006). Toward a systems theory of motivated behavior in work teams. *Research in Organizational Behavior, 27,* 223–267.

Collins, J. C. (2001). *Good to Great.* New York: HarperBusiness.

Cory, G. A., Jr. (2002a). Reappraising MacLean's triune brain concept. In G. A. Cory, Jr. & R. Gardner, Jr., *Evolutionary neuroethology of Paul MacLean* (pp. 9–30). Westport, CT: Praeger.

Cory, G. A., Jr. (2002b). Algorithms of neural architecture, Hamilton's rule, and the invisible hand of economics. In G. A. Cory, Jr. & R. Gardner, Jr., *Evolutionary neuroethology of Paul MacLean* (pp.345–382). Westport, CT: Praeger

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

Cory, G. A., Jr. (2010). *Consilience, brains, and markets: Saving the free enterprise market for a global society.* Sunnyvale, CA: ITUgreen.

Cory, G.A., Jr. (2012) *Consillience, brains, and leadership.* San Jose, CA: ITU Green Press.

Cory, G. A., Jr., & Gardner, R., Jr. (Eds.). (2002). *Evolutionary neuroethology of Paul MacLean.* Westport, CT: Praeger.

Crespi, A. & Semeniuk, C (2004) Parent-offspring conflict in the evolution of vertebrate reproductive mode. The American Naturalist, 163:5, 635-653.

Daft, R. L. (2002). *The leadership experience.* Mason, OH: Thomson South-western.

Damasio, A. (1994). *Descartes' error: Emotion, reason, and the human brain*. New York: Putnam.

Decety, J., & Ickes, W. (eds). (2009). *The social neuroscience of empathy.* Cambridge, MA: MIT Press.

De Dreu, C. K. W., Greer, L. L., Van Kleef, G. A., Shalvi, S., & Handgraaf, M. J. J. (2011). Oxytocin promotes human ethnocentrism. *Proceedings of the National Academy of Sciences*, *108*, 1262-66.

De Waal, F. (2007). *Chimpanzee politics: Power and sex among apes.* Baltimore: Johns Hopkins University Press. (Original work published 1982)

De Waal, F., & Lanting, F. (1997). *Bonobo: The forgotten ape.* Berkeley: University of California Press.

Diefendorff, J. M., & Lord, R. G. (2008). Goal-striving and self-regulation processes. In R. Kanfer, G. Chen & R. D. Prichard (eds), *Work motivation: Past, present, and future* (pp. 151–196). SIOP Organizational Frontiers Series. New York: Routledge.

Donaldson, Z. R., & Young, L. J. (2008, 7 November). Oxytocin, vasopressin, and the neurogenetics of sociality. *Science, 322,* 900-904.

Eisenberg, N. (1992). *The caring child*. Cambridge, MA: Harvard University Press.

Eisler, R., & Levine, D. S. (2002). Nurture, nature, and caring: We are not prisoners of our genes. *Brain and Mind, 3*, 9-52.

Friedman, M. (1980). *Free to choose.* New York: Avon.

Gazzaniga, M. S. (2005). *The ethical brain.* New York: Dana.

Ghoshal, S., & Moran, P. (1996, January). Bad for practice: A critique of the transaction cost theory. *Academy of Management Review, 21*(1), 13–47.

Goleman, D., Boyatzis, R. E., & McKee, A. (2001). *Primal leadership: Learning to lead with emotional intelligence.* Boston: Harvard Business School Press.

Gordon, J.R. (1999). *Organizational behavior: A diagnostic approach.* (6th ed.) Upper Saddle River, NJ: Prentice-Hall.

Grossberg, S. (2000). The complementary brain: Unifying brain dynamics and modularity. *Trends in Cognitive Sciences*, *4***,** 233-246.

Hackman, J. R., & Oldham, G. R. (1976). Motivation through the design of work: Test of a theory. *Organizational Behavior & Human Performance*, *16*, 250–279.

Haidt, J. (2012). *The righteous mind: Why good people are divided by politics and religion*. New York: Pantheon.

Hatfield, E., Rapson, R. & Le, Y.C.L. (2009). Emotional contagion and empathy. In J. Decety & W. Ickes, eds., *The social neuroscience of empathy* (pp. 19-30). Cambridge, MA: MIT Press.

Hill, C. W., & Jones, G. R. (2008). *Strategic Management.* Boston: Houghton Mifflin.

Hume, D. (1999). *A treatise of human nature: Being an attempt to introduce the experimental method of reasoning into moral subjects.* Kitchner, Ontario: Batoche. (Original work published 1740)

Hutcheson, F. (1971). *Illustrations on the moral sense* (B. Peach, Ed.). Cambridge, MA: Harvard University Press. (Original work published 1728)

Insel, T. R. (1992). Oxytocin: A neuropeptide for affiliation - Evidence from behavioral, receptor autoradiographic, and comparative studies. *Psychoneuroendocrinology*, *17*, 3-33.

Insel, T. R., & Winslow, J. T. (1998). Serotonin and neuropeptides in affiliative behaviors, *Biological Psychiatry*, *44*, 207-219.

Judge, T., & Piccolo, R. (2004). Transformational and transactional leadership: A meta-analytic test of their relative validity. *Journal of Applied Psychology, 89*(5), 755-768.

Kanfer, R. (1990). Motivation theory and industrial and organizational psychology. In M. D. Dunnette & L. M. Hough (eds), *Handbook of industrial and organizational psychology* (pp. 75–170). Palo Alto, Calif.: Consulting Psychologists Press.

Kanfer, R., Chen, G., & Prichard, R. D. (2008a). The three C's of work motivation: Content, context, and change. In R. Kanfer, G. Chen & R. D. Prichard (eds), *Work motivation: Past, present, and future.* (pp. 1-16). New York: Routledge.

Kanfer, R., Chen, G., & Prichard, R. D. (2008b). Work motivation: Forging new perspectives and directions in the post-millenium. In R. Kanfer, G. Chen & R. D. Prichard (eds), *Work motivation: Past, present, and future* (pp. 601–632). New York: Routledge.

Kanter, R. M. (1983). *The change masters: Innovation and entrepreneurship in the American corporation.* New York: Simon & Schuster

Kitayama, S., & Park, J. (2010). Cultural neuroscience of the self: Understanding the social grounding of the brain. *Social, Cognitive, and Affective Neuroscience, 5*(2–3), 111–129.

Koob, G. F. (1999). Corticotrophin-releasing factor, norepinephrine, and stress. *Biological Psychiatry*, *46*, 1167-1180.

Kosfeld, M., Heinrichs, M., Zak, P. J., Fischbacher, U., & Fehr, E. (2005). Oxytocin increases trust in humans. *Nature*, *435*, 673-676.

Lawrence, P.R.. (2010). *Driven to lead: Good, bad, and misguided leadership.* San Francisco: Jossey-Bass.

Lawrence, P.R. & Nohria, N. (2002). Driven: how human nature shapes our choices. San Francisco: Jossey-Bass.

Levine, D. S. (2000). *Introduction to neural and cognitive modeling* (2nd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Levine, D. S. (2006). Neural modeling of the dual motive theory of economics. *Journal of Socio-Economics*, 35, 613-625.

Levine, D. S. (2008). Neural networks of human nature and nurture. *Advances in Latin American Psychology*, *26*, 82-98.

Lubatkin, M. H., (2005). A theory of the firm only a microeconomist could love. *Journal of Management Inquiry*, 14. 213-216.

MacLean, P. D. (1990). *The triune brain in evolution: Role in paleocerebral functions*. New York: Plenum.

Maslow, A. H. (1954). *Motivation and personality.* New York: Harper & Bros.

Maslow, A. H. (1968). *Toward a psychology of being*. New York: Van Nostrand.

Nelson, R.H. (2001). *Economics as religion.* University Park, PA: Pennsylvania State University Press.

Nestler, E. J., Alreja, M., & Aghajanian, G. K. (1999). Molecular control of locus coeruleus neurotransmission. *Biological Psychiatry*, *46*, 1131-1139.

Nohria, N., & Khurana, R. (2010). Advancing Leadership Theory and Practice. In N. Nohria & R. Khurana (eds), *Handbook of Leadership Theory and Practice* [An HBS Centennial Colloquium on Advancing Leadership]. Boston, Mass.: Harvard Business Press.

Northouse, P. G. (2010). *Leadership: Theory and practice.* Thousand Oaks, Calif.: Sage.

Öngür, D., & Price, J. L. (2000). The organization of networks within the orbital and medial prefrontal cortex of rats, monkeys, and humans. *Cerebral Cortex*, *10*, 206-219.

Osland, J. S., Kolb, D. A., Rubin, I.M., & Turner, M.A. (2007).*Organizational behavior: An experiential approach.*. Upper Saddle River, NJ: Pearson Prentice Hall.

Paine, L. S. (2002). *Value shift: Why companies must merge social and financial imperatives to achieve superior performance.* New York: McGraw-Hill.

Panksepp, J. (2005). *Affective neuroscience*. New York: Oxford University Press. (Original work published 1998)

Panksepp, J. (2012). *The archaeology of mind: Neuroevolutionary origins of human emotions.* New York: W.W. Norton.

Panksepp, J., Nelson, E., & Bekkedal, M. (1997). Brain Systems for the Mediation of Social Separation-Distress and Social- Reward Evolutionary Antecedents and Neuropeptide Intermediariesa. Annals of the New York Academy of Sciences, 807(1), 78-100.

Parker, S. K., & Ohly, S. (2008). Designing motivating jobs: An extended framework for linking work characteristics and motivation. In R. Kanfer, G. Chen & R. D. Prichard (eds), *Work motivation: Past, present, and future,* pp. 233-284. New York: Routledge

Perry, B. D., Pollard, R. A., Blakley, T. L., Baker, W. L., & Vigilante, D. (1995). Childhood trauma, the neurobiology of adaptation, and "use-dependent" development of the brain: How "states" become "traits." *Infant Mental Health Journal*, *16*, 271-291.

Pezzulo, G., & Castelfranchi, C. (2009). Thinking as control of imagination: a conceptual framework for goal-directed systems. *Psychological Research*, *73*, 559-577.

Pierce, B. D., & White, R. (1999). The evolution of social structure: Why biology matters. *Academy of Management Review, 24*(4), 843–853.

Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance.* New York: Free Press.

Pribram, K. H. (1973). The primate frontal cortex: Executive of the brain. In K. H. Pribram & A. R. Luria (Eds.), *Psychophysiology of the frontal lobes* (pp. 293-314). Oxford, UK: Academic Press.

Price, J. (1988). Alternative channels for negotiating asymetry in social relationships. In M. R. Chance (Ed.), D. R. Omark (Asst.), *Social fabrics of the mind* (pp. 157–196). Hove, England: Lawrence Erlbaum.

Rakic, P. (2002). Neurogenesis in adult primate neocortex: an evaluation of the evidence. *Nature Reviews Neuroscience* 3 (1): 65–71.

Riedl, R., & Javor, A. (2011). The biology of trust: Integrating evidence from genetics, endocrinology, and functional brain imaging. *Journal of Neuroscience, Psychology, and Economics, 5*(2), 63–91.

Rizzolati, G. & Craighero, L. (2004). The mirror neuron system, *Annual reviews of neuroscience*, *27*. pp 169-192; C1-4.

Salovey, P., Brackett, M. A., & Mayer, J. D. (eds). (2004). *Emotional intelligence: Key readings in the Mayer and Salovey model.* Port Chester, N.Y.: Dude.

Samuelson, P.A. (1947). *Foundations of economic analysis.* Cambridge, MA.: Harvard University Press.

Schermerhorn, J.R., Jr, Osborn, R.N., Uhl-Bien, M., & Hunt, J.G. (2012). *Organizational Behavior*. Hoboken, NJ: John Wiley & Sons.

Schleifer, A., & Vishny, R. W. (1997, June). A survey of corporate governance. *Journal of Finance*, *52*(2), 737–783.

Sen, A. (2000). *Development as freedom.* New York: Anchor.

Smith, A. (1982). *The theory of moral sentiments.* Indianapolis: Liberty Fund. (Original work published 1759).

Smith, A. (1976). *An inquiry into the nature and causes of the wealth of nations* (Edwin Cannan, Ed.). Chicago: University of Chicago Press. (Original work published 1776).

Stevens, A., & Price, J. (2000). *Evolutionary psychiatry: A new beginning, 2nd. ed.*. London: Routledge.

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

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A. R., & Updegraff, J. A. (2000). Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *Psychological Review*, *107*, 411-429.

Thatcher, R. W., North, D. M., & Biver, C. J. (2008). Development of Cortical Connections as Measured by EEG Coherence and Phase Delays. *Human Brain Mapping, 29,* 1400–1415.

Van IJzendoorn, M. H., & Bakermans-Kranenbury, M. J. (2012). A sniff of trust: Meta-analysis of the effects of intranasal oxytocin administration on face recognition, trust to in-group, and trust to out-group. *Psychoneuroendocrinology, 37,* 438–443.

von Neumann, J., & Morgenstern, O. (2004). *Theory of games and economic behavior.* [Princeton Classic Editions]. Princeton, NJ: Princeton University Press. (Original work published 1944).

Wahba, M. A., & Bridwell, L. G. (1976, April). Maslow reconsidered: A review of research on the need hierarchy theory. *Organizational Behavior and Human Performance, 15*(2), 212–240.

Waldman, D.A., P.A. Balthazard & S.J. Peterson. (2011). "Leadership and neuroscience: can we revolutionize the way that inspirational leaders are identified and developed?" *Academy of Management Perspectives.*

Wilson, D. R., & Cory, G. (2008). *The evolutionary epidemiology of mania and depresssion*. Lewiston, ME: Edwin Mellen.

Wilson, D. R. (2008). *A brief history of neural evolution*. In D. Charney & E. Nestler (Eds), *Neurobiology of mental illness*. (3rd ed.). New York: Oxford University Press.

Young, L. J., & Wang, Z. (2004). The neurobiology of pair bonding. *Nature Neuroscience*, *7*, 1048-1054.

Yukl, G. A. (2006). *Leadership in Organizations.* Upper Saddle River, NJ: Prentice Hall.

Zak, P. J. (2007). The neuroeconomics of trust. In R. Franz (Ed.), *Renaissance in behavioral economics.* New York: Routledge.

Zupan, M. A. (2010). An economic perspective on leadership. In N. Nohria & R. Khurana (eds), *Handbook of Leadership Theory and Practice*. Boston: Harvard Business Press.

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