A R T I C L E S

Leadership and Neuroscience:

Can We Revolutionize the Way That Inspirational Leaders Are Identified and Developed?

by David A. Waldman, Pierre A. Balthazard, and Suzanne J. Peterson

Executive Overview

Recent advances in the field of neuroscience can significantly add to our understanding of leadership and its development. Specifically, we are interested in what neuroscience can tell us about inspirational leadership. Based on our findings, we discuss how future research in leadership can be combined with neuroscience, as well as potential neurofeedback interventions for the purpose of leadership development. We also consider ethical implications and applications to management-related areas beyond leadership.

Leadership development is a multibillion-dollar industry, with in-house as well as external consulting groups offering leadership development techniques and programs for their clients. The efficacy of traditional leadership development methods, however, has recently been called into question (Haines, 2009), with many researchers recognizing the need to go beyond traditional leadership assessment methods, which typically involve evaluating leader behaviors and qualities through some sort of survey process through which followers or peers rate a leader's effectiveness. In particular, recent advances in neuroscience are expanding our understanding of behavior and learning (Boyatzis, Smith, & Blaize, 2006). Specifically, we are interested in what insights the study of the human brain and the field of neuroscience may hold for understanding effective leadership, its assessment, and its development.

While there are many branches of neuroscience, the specific area of social cognitive neuroscience may have the most applicability to the study of leadership. Ochsner and Lieberman (2001) defined social cognitive neuroscience as an emergent, interdisciplinary field that seeks to understand human interactions at the intersection of social, cognitive, and neural spheres of science. Recent advances in this area offer evidence of how the human brain might support leaders in many aspects of cognition and behavior. For instance, Adolphs (2009) proposed a neural basis for the construction of social knowledge, in particular the manner in which social inferences about the feelings, thoughts, and intentions of others are formed. Similarly, Tabibnia, Satpute, and Lieber-

* ***David A. Waldman*** *(waldman@asu.edu) is a Professor in the Department of Management at the W. P. Carey School of Business, Arizona State University.*
Pierre A. Balthazard *(Pierre.Balthazard@asu.edu) is an Associate Professor in the Department of Information Systems at the W. P. Carey School of Business, Arizona State University.*
Suzanne J. Peterson *(Suzanne.Peterson@asu.edu) is an Assistant Professor in the Department of Management at the W. P. Carey School of Business, Arizona State University.*

man (2008) examined brain activity in relation to perceptions of fairness versus unfairness.

Here, we have chosen to focus on the neurological basis of inspirational leadership behavior, a type of behavior that is emphasized in many of today's contemporary leadership theories, such as transformational, charismatic, and visionary paradigms. Our goal is to explore two key questions. First, can we use neuroscientific methodologies to identify those people in leadership positions who are likely to engage in behaviors associated with inspirational leadership? Second, armed with this information, can we consider neurologically based, developmental interventions to enhance behaviors associated with inspirational leadership?

In the remainder of this article, we attempt to address these questions. We begin by defining inspirational leadership. Next, we outline three key challenges (and potential solutions) to the integration of neuroscience with management phenomena such as inspirational leadership. These include (1) problems in attempting to build theory that would conceptually link brain activity to leadership behavior, (2) the use of expedient and effective technologies to pursue basic research that could link neuroscience to leadership, and (3) a lack of knowledge or technology for how to apply neurological findings to leadership development. As we present these challenges, we will also summarize findings from a recent study that we conducted to demonstrate how neuroscience might be used in leadership research.

What Is Inspirational Leadership?

Over the past 30 years, there has been an increasing interest in a genre of leadership theories collectively labeled as neo-charismatic by House and Aditya (1997). Despite a few differences, the various theories share the view that outstanding leaders go beyond simple performance-versus-reward transactions and have a deep impact on their followers and their organizations, including the potential to be a major force in realizing new visions and change. Various labels have been used to describe such leaders, including transformational and visionary. However, inspiration rests at the core of what these theories propose in terms of consummate excellence in the leadership role (see Bass & Bass, 2009, for a review).

Notwithstanding our focus on inspirational leadership, it is important to acknowledge that other, more functional definitions of leadership do exist. For example, in her book *Bad Leadership*, Barbara Kellerman (2004) suggested that "good" leadership is less about the ability of leaders to inspire followers and more about mutual leader and follower responsibility. Specifically, she suggested that effective leaders should emphasize shared power with followers and supportive networks, and should surround themselves with people who tell them the truth. Despite this and other alternative perspectives on leadership, here we focus on inspirational leadership since it rests at the center of the most widely studied forms of effective leadership (Bass & Riggio, 2006).

Inspirational leaders articulate a vision that is based on strongly held ideological values that cause people to become energized and to identify with the vision (e.g., Conger & Kanungo, 1998; Shamir, House, & Arthur, 1993). The ability to inspire is considered fundamental to establishing a high degree of follower confidence, intrinsic motivation, and trust and admiration in the leader (Conger & Kanungo, 1998; Shamir et al., 1993). Moreover, research has consistently found that inspirational leadership is positively related to performance at the individual, group, and organizational levels (Flynn & Staw, 2004, Judge & Piccolo, 2004; Sully de Luque, Washburn, Waldman, & House, 2008).

According to leadership theorists, inspirational leaders are able to have these effects on followers and organizations as a whole primarily because of their visionary communication abilities (e.g., Conger & Kanungo, 1998; Shamir et al., 1993). However, the type of vision put forth by leaders makes a difference in their ability to motivate and connect with followers. More specifically, vision can be delineated in terms of a socialized versus personalized continuum. Socialized vision is characterized by such elements as altruism and social responsibility, the inclusion of empowered followers as a necessary component to organizational success, and a focus on serving the interests and goals of the greater collective (House & Howell, 1992). In short, socialized vision leads to outcomes and processes that benefit followers as well as outside stakeholders such as the larger community or even nation in which a firm resides. Leadership theorists have tended to view socialized vision as prototypical of the type of visionary communication that will inspire followers (e.g., Shamir et al., 1993). In contrast, personalized vision is largely narcissistic in nature (e.g., Chatterjee & Hambrick, 2007) and is characterized by self-interest, an over-emphasis on the leader (rather than others) in achieving organizational outcomes, and an obsession with authority and achieving dominance over competition (House & Howell, 1992). Such vision may be inspiring only to followers with low self-concepts (Howell & Shamir, 2005).

From this review of inspirational leadership, we now turn to the question of whether brain activity can be linked to leadership—and, more specifically, to inspirational leadership.

Can Leadership Be Linked Conceptually to Brain Activity?

A key challenge for researchers is to attempt to make theoretical connections between brain activity and overt leadership behavior and qualities. Without such theory, research endeavors might simply involve searches for relationships between vaguely conceived neurological variables on the one hand (see Vul, Harris, Winkielman, & Pashler, 2009), and traditional, psychometrically based measures of leadership on the other. More than 30 years ago, Henry Mintzberg (1976) addressed this challenge when he suggested that left brain/right brain differences may be relevant to management and leadership. Specifically, he argued that managers may differ in relative strength or dominance with regard to the two hemispheres of the brain. As later summarized by Finkelstein and Hambrick (1996), managers with dominant left hemispheres (i.e., in which the focus is largely logic and rational thinking) may make good planners. In contrast, they suggested that managers with dominant right hemispheres (i.e., in which the focus is largely imagination, creativity, visual imagery, and emotional response) may make good managers or leaders. While some researchers (e.g., Hines, 1987) were critical of what was termed the "left brain/right brain mythology," advancements in neuroscience theories, methodologies, and findings over the last decade have led to a renewed interest in, and exploration of, brain lateralization theories. In particular, a neuroscientific construct known as "coherence" has facilitated the study of the origin of complex behaviors associated with leadership.

Neuronal Coherence and Inspirational Leadership

While a number of indicators exist to interpret brain activity, coherence is one of the more commonly applied metrics in social cognitive neuroscience research. Coherence is a way of measuring the interconnectedness of areas of the brain. More simply, coherence is a way of tracking coordinated activity or communication between various areas of the brain. This makes coherence ideally suited for the examination of complex behavioral concepts such as inspirational leadership behavior, which are likely to require multiple parts of the brain (e.g., emotional and cognitive centers) to act jointly (Cacioppo, Berntson, & Nusbaum, 2008; Nolte, 2002). Coherence is typically reported in the form of a percentage; for example, 90% coherence would indicate relatively high coherence (i.e., a high degree of coordinated activity between two parts of the brain), while 10% coherence would indicate relatively low coherence (i.e., less coordinated activity between two parts of the brain).

Furthermore, coherence levels may indicate different behavioral phenomena for different locations in the brain. For example, the presence of high coherence in the right hemisphere could suggest greater emotional balance and understanding through integration in the processes that manage emotional thought, including an understanding of one's own emotions as well as the emotions of others (Thatcher, Krause, & Hrybyk, 1986; Thatcher, North, & Biver, 2007). It might also reflect a greater cognitive understanding of the larger picture when reasoning and making decisions (Thatcher et al., 2007).[1]

Regarding the former, various authors have stressed the importance of the affective or emotional component of visionary communication, which makes a direct appeal to the personal values, beliefs, and needs of followers and attempts to get them excited and optimistic about the future (e.g., Boal & Hooijberg, 2001; Shamir et al., 1993). As such, the affective component underlies the leader's ability to generate the motivation and commitment necessary for followers to carry out the vision. Indeed, emotions are important in terms of the emotions leaders themselves experience and share, as well as the emotions followers experience toward the leader and his or her vision (Barsade & Gibson, 2007; George, 2000). Effective leadership involves the regulation of one's own emotions—for example, expressing a positive, optimistic mood about the future, while minimizing expressions of anxiety, sadness, or fear that might demotivate followers. Furthermore, it involves an understanding of and an ability to influence the positive emotions of others through hope and inspiration, despite the ambiguity, setbacks, or fears that they might otherwise face (Barsade & Gibson, 2007).

The relationship between specific brain activity and emotions may be found through a better understanding of the nature of emotional balance. Using the terminology of emotional intelligence, balance is achieved by promoting the positive emotions associated with optimism and excitement, while keeping more disruptive negative emotions such as anxiety, selfishness, fear, anger, and sadness in check (Goleman, 1998). As argued further below, leaders who espouse more socialized visions may be better able to regulate feelings and emotions (i.e., they have greater emotional intelligence), which allows them to inspire in others a desire to achieve the goals of the collective (Ashkanasy & Daus, 2002; Humphrey, 2002).

Various authors have proposed a specific neurological basis for emotional intelligence or skills (Ashkanasy, 2003; Goleman, Boyatzis, & McKee, 2001). Goleman et al. (2001) noted that emotional intelligence has a basis in brain circuitry and further suggested that it derives from how cortical regions of the brain interpret and manage neurotransmitter signals from the brain's limbic system. Morse (2006) suggested that a leader's use of emotions and reasoning for the purpose of formulating and espousing a vision has a basis in the limbic system. Naqvi, Shiv, and Bechara (2006) further suggested that parts of the brain, such as the ventromedial prefrontal cortex, may help a person to balance emotions in decision making, especially in situations in which outcomes are ambiguous or uncertain. There is also recent research showing that regions of the cortex may help to assess risk and guide behaviors in anticipation of emotional consequences, including such negative consequences as fear and despair (Paulus, Rogalsky, Simmons, Feinstein, & Stein. 2003; Sanfey et al., 2003).

Beyond emphasizing the different hemispheres of the brain (left and right), it seems logical to focus on the frontal regions of the brain (as opposed to the distal or posterior regions). This is because the front part of the brain may be especially involved in the regulation and expression of emotions, as well as higher cognitive functioning such as goal-directed or visionary behavior (Hagmann, Cammoun, Gigandet, Meuli, & Honey, 2008). For instance, Heisel and Beatty (2006) found the right frontal part of the brain to be essential for effective interpersonal communication and social relationships. Moreover, it has been shown that right frontal dysfunction gives rise to antisocial behavior and an inability to understand relationships with other people (i.e., social skills, mood control, and awareness of self; see Salloway, Malloy, & Duffy, 2001) and difficulties balancing emotions in decision making under conditions of uncertainty (Naqvi et al., 2006). In sum, the social/emotional skills or abilities associated with right frontal activity might also be relevant to behaviors involved in inspirational leadership, especially the espousal of socialized visionary communication. In addition, in line

[1] We should note that the ideal level of EEG coherence varies by the function of the particular brain network or region. Indeed, some brain functions may be improved with integration (i.e., more coherence), while others may be improved with differentiation (i.e., less coherence). In the current research, we posited a region in the brain in which more coherence would be associated with leader behavior.

with the assessment of neuronal coherence, recent work would suggest that emotional regulation involves multiple regions of the brain working in conjunction (Cacioppo et al., 2008). Thus, our primary focus in this research is on right-brain coherence, especially in the frontal regions (Thatcher et al., 1986; 2007).

Visions that are socially based inherently involve the effective working through of potential trade-offs pertaining to a wide range of possible stakeholder groups, including employees, customers, and the greater community in which the organization exists. In line with our above arguments, we posit that individuals with enhanced right frontal coherence may be able to both conceptualize the balancing of concerns of multiple constituent groups in the formation of a more socialized vision and deal with potential emotional strains, moral issues, and uncertainties. They may further recognize that the positive emotions of others can be enhanced through visions that emphasize more socialized, as opposed to personalized, content (Carmeli, Gilat, & Waldman, 2007).

In sum, it is possible that not only will right frontal activity be heightened for inspirational leaders, but we may also witness greater coherence between areas in this portion of the brain. As described below, we tested this prediction through the use of a direct assessment of socialized visionary communication, as well as a more indirect assessment through followers' ratings of inspirational/charismatic leadership.

The Advancement of Neuroscience Methodologies

A challenge for the examination of neuroscience and leadership is how to technologically examine the topic. The technology associated with neurological assessment and research has advanced greatly in recent years. A number of techniques are now available to investigate brain activity that may be relevant to effective leadership behavior. For research purposes, two of the more popular ones are functional magnetic resonance imaging (fMRI) and quantitative electroencephalogram (qEEG). These techniques vary in terms of their precision and exact capabilities, but nevertheless represent a large improvement over past techniques in their ability to detect and quantify key aspects of brain activity.

For our research program, we have chosen to use qEEG, which employs advanced signal processing techniques to infer data about the brain through the scalp and skull (Niedermeyer & Silva, 1995). The data produced by qEEG can be readily used in conjunction with statistical analysis programs. In addition, qEEG is relatively inexpensive, portable, and non-invasive, and its use involves no health risk. Unlike fMRI and other methods that require people to remain immobilized in an unnatural setting (that is, in a clinical setting within a confined tube), qEEG assessment can be completed while people are comfortably seated and engaged in everyday tasks—including conversations associated with the type of vision communication task described below.

Two basic measurements are commonly used to analyze a qEEG recording: (1) the amplitude, or the size of the electrical waves, and (2) the frequency, or the number of waves per second. Amplitude and frequency of brain waves can be assessed with regard to five bandwidths and range from low arousal (sleeping) to high arousal (extreme alertness). From lowest to highest arousal levels, these bandwidths are known as delta, theta, alpha, beta, and gamma rhythms. In the current research, we were interested in examining brain activity in the beta rhythm because beta waves are the most prevalent in the alert brain. In addition, beta waves are involved with affective and cognitive processes, selective attention, concentration, and anticipation (Classen, Gerloff, Honda, & Hallet, 1998). More will be said below regarding our use of beta waves and coherence in our study of the relationship between neurological functioning and inspirational leadership.

A Study of Business Executives

As an illustration, we now describe a specific research project that we conducted in our attempt to link qEEG assessment with inspirational leadership. We collected qEEG data, coded visionary communication statements, and rated leadership data from a diverse sample of 50 individuals who held leadership positions in a large metropolitan area located in the western United States. While this sample is somewhat small, it is fairly unique in that it provides leadership and neurological data for individuals who are at the upper echelons of their organizations, as opposed to samples that might include students or lower level supervisors or employees. The sample included an eclectic mix of people in business and community leadership roles, such as physicians, lawyers, deans, politicians, developers, company executives, entrepreneurs, and community activists. To illustrate the senior level of these individuals in their respective organizations, the modal salary reported was "$125,001 plus," and 90% of participants self-reported themselves as a senior executive, professional, owner, or self-employed/entrepreneur. The median number of direct and indirect reports was reported as 25 to 99 individuals, although half of our sample led organizations with significantly larger workforces.

qEEG Assessment of Coherence. As mentioned above, coherence is a measure of coordinated activity between multiple parts of the brain and is calculated as a percentage; 0% represents low coordinated activity and 100% represents high levels of coordination. Coherence measures were generated using NeuroGuide™ software.[2] The software examines electrical data collected from 19 electrodes placed on a participant's scalp, and reports (as coherence values) the pairwise comparison of the activity patterns from the 171 possible combinations of the electrode locations. We focused on the three electrodes that are located on the right frontal regions of the brain, known as Fp2, F4, and F8.[3] Thus, our right frontal brain coherence index was derived by averaging the coherence scores obtained from the three electrode combinations in this region. Further, as mentioned earlier, we examined coherence associated with the high-frequency beta rhythm (20–30 Hz) because of its association with an alert/active mental state.

Vision Statements. While participants were undergoing qEEG assessment, we asked them to engage in a vision task—an activity that is common to conceptualizations of inspirational leadership behavior. Participants were asked two questions about the future of their organizations, and responses were recorded and transcribed: (1) "Can you please describe your current plans for your organization, as well as plans for the future?" and (2) "As you look toward the future, can you formulate a vision statement for your firm?"

The vision statements of the participants were coded by two trained coders on a scale of 1 to 3. Vision statements that scored 1 tended to fall into the personalized vision category. This style can be characterized by use of singular pronouns (e.g., *I* and *me*); a focus on dominance, exploiting others, beating the competition, and financial results; and a refusal to acknowledge the roles of the team, employees, or other constituents/stakeholders. Examples of personalized statements were "My vision is to be the number-one supplier of essential office products and services, regardless of what that product line is within the markets that I service" and "I look at my accomplishments or what am I planning . . ."

In contrast, statements that scored a 3 were considered to be examples of a more socialized vision. These visions were focused on the collective *we*, empowerment, values, the necessary role of the team in the organization's future success, a desire for all levels of the organization to benefit from the outcomes, and positive contributions to employees, customers, the community, and the environment. The following excerpts were illustrative of such statements: "To also provide an environment at work that is fun, rewarding, fulfilling, and with opportunities to grow and expand for our associates, and also to be a player in the community" and "We will operate within an umbrella of a vibrant and productive environment that promotes the best possible working conditions for our workforce, and to give them the best possible development opportunities." Statements coded as 2 were somewhat mixed, with both personalized and socialized elements.

Traditional-Rated Leadership Assessment. Perceptions of inspirational leadership were obtained

[2] NeuroGuide™ is a product of Applied Neuroscience, Inc., of Tampa, Florida, and is widely used by therapists in clinical settings.

[3] The 19 scalp locations, including the right frontal areas Fp2, F4, and F8, are based on the International 10/20 system of electrode placement that was originally developed by Jasper (1958).

via surveys from three to six direct reports of each participant in the days or weeks following his or her qEEG assessment. In line with prior work (Avolio, Bass, & Jung, 1999), these perceptions were assessed using the idealized influence and inspirational motivation scales from the short form of the Multifactor Leadership Questionnaire (Bass & Avolio, 1990). While much research has labeled these perceptions simply as charismatic leadership, in line with our earlier definition we believe that they tap heavily into the inspirational component of charisma. Accordingly, we provide the label "inspirational/charismatic leadership." As is commonly the case in prior research (cf. Judge & Piccolo, 2004; Lowe, Kroeck, & Sivasubramaniam, 1996), we summed the scores of these scales across respective followers to form an overall measure of inspirational/charismatic leadership for each study participant ($\alpha = .91$, 8 items).

Summary of Study Findings

The values for coherence varied from 3% to 71%, with a sample average of 23.7%. These values represent differences across the participants in this study in terms of the degree of neural connectivity in the right frontal portions of their brains. More specifically, we found three key results relevant to coherence in the right frontal portion of the brain. First, as predicted, right frontal coherence was associated with participants who were coded as high on socialized visionary communication ($r = .36$, $p < .05$).[4] Second, socialized vision was correlated with follower perceptions of inspirational/charismatic leadership ($r = .39$, $p < .01$). Third, right frontal coherence was only marginally associated with follower perceptions of inspirational/charismatic leadership ($r = .26$, $p < .10$). In short, these findings suggest that right frontal coherence may help to form the basis of socialized visionary communication, which in turn helps to build follower perceptions of the leader in inspirational or charismatic terms. That is, right frontal coherence (i.e., our neurological indicator) was more strongly related to our direct coding of socialized visionary behavior, rather than the more indirect or generalized behavioral measure involving perceptions of inspirational/charismatic leadership on the part of followers. To further illustrate our findings, we identified two illustrative case examples from our participant sample.

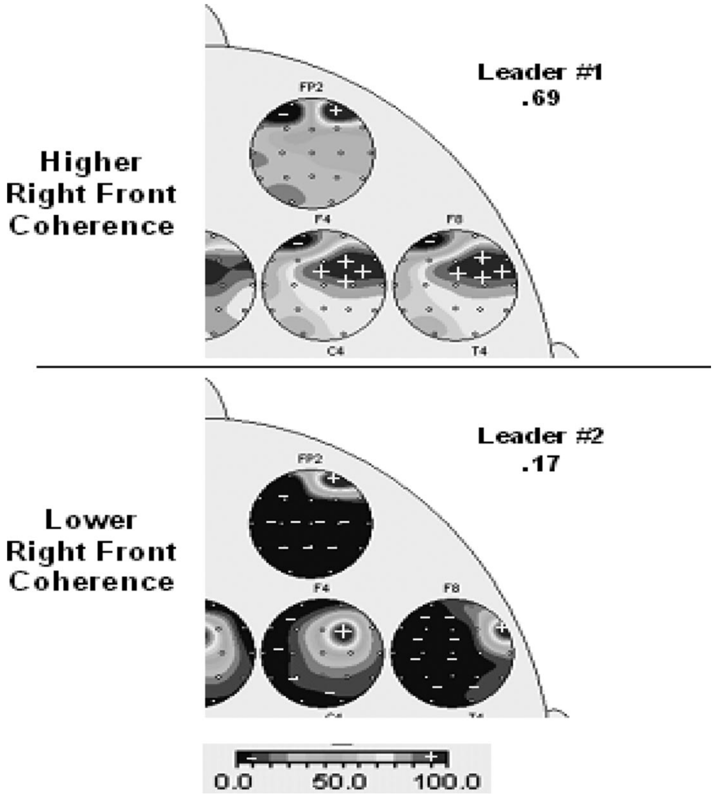
Case Examples

Figure 1 shows a grayscale translation of a colored spectral analysis associated with more versus less coherence in the right frontal region, specifically for the three areas mentioned earlier: Fp2, F4, and F8. Dark regions with plus (+) signs represent areas with high degrees of coherence (75% or higher), while dark regions with minus (-) signs represent areas with low coherence (25% or lower). In general, as described further below, Leader #1 displays more coherence emanating from each of the three right frontal regions. Coherence is especially concentrated within those three regions for this individual, as compared to Leader #2.

Leader #1 is a 52-year-old leader of a private non-profit, community-based corporation that provides health and human services to Hispanic communities. This individual earned a master's degree in educational leadership. Based on evaluations by followers, Leader #1 rated very high on inspirational/charismatic leadership. In addition, in response to the vision task, this individual demonstrated a highly socialized vision, as illustrated by the following statements: "Our goal is to create a good environment for this community and to give back to the community, which has been nurturing our company all these years, to make it a profit-sharing endeavor," "we hope that the community can benefit more from our products," and "we hope to be able to add more workers so that we will reduce the amount of unemployment in this area." Thus, this leader seemed to display a vision that was both positive and socially responsible. Furthermore, this individual tended to have a great deal of thought and reasoning behind the ideas put forth. In short, leader #1 appeared to display a socialized vision and, in turn, was viewed largely as inspirational/charismatic by

[4] To explore the robustness of our findings we examined the relationship between socialized vision communication and coherence in several other regions in the brain (e.g., left frontal coherence). The purpose of these analyses was to eliminate the possibility that coherence in general (i.e., in any region of the brain) might be related to socialized vision communication. In none of these instances did we find a significant relationship between coherence and socialized vision communication.

Figure 1
Case Examples of the Right Front Coherence of Leaders



Note: Grayscale translation of a color spectral analysis of right front coherence. The gradient shows the levels of beta coherence from the perspective of the three right frontal electrode locations, including areas at 0% (indicated by the minus signs), areas at 100% (indicated by plus signs), and areas in between. Dark regions with plus (+) signs represent areas with high degrees of coherence (75% or higher) while dark regions with minus (-) signs represent areas with low coherence (25% or lower). The numerical values of .69 and .17 represent the summed and averaged coherence scores for the Fp2, F4, and F8 regions for respective leaders.

followers. Concomitantly, the qEEG analysis revealed high frontal right hemisphere coherence (69%) for this individual.

Leader #2 is a 48-year-old senior executive in an engineering/construction firm. In the housing boom of the early 2000s, leader #2 changed employers several times while simultaneously gaining higher-level management positions. Despite this person's personal success at navigating the corporate ladder, in response to the vision task, this individual offered only a non-socialized or generic view of the future: "to produce good products." Leader #2 then became frustrated and apologized for the (self-perceived) less-than-adequate responses. Overall, crafting the vision seemed to be difficult and somewhat frustrating, with the coded socialized vision score ranking very low. Leader #2 also produced one of the lowest scores recorded in our research in terms of follower ratings of inspirational/charismatic leadership. Moreover, this person's brain activity presented only limited coherence (17%) in the right frontal regions, a marked contrast to the patterns seen in leader #1.

Implications for Research and Leadership Development

The above discussion demonstrates that neuroscience may provide information relevant to underlying brain patterns associated with inspirational leadership. But what exactly can be done with such data to further the goals of leadership research and leadership development? As mentioned earlier in the article, leadership research over the past several decades has centered around constructs that are measured largely through psychometric methods (e.g., surveys), and are then correlated with other phenomena (e.g., performance outcomes). Despite honing leadership constructs and theory, researchers have typically not been able to account for more than 10% of the variance in outcomes (Bass & Bass, 2009).

Neuroscience techniques and theories present the potential for important breakthroughs. Thus, we agree with Lieberman (2007, p. 279), who suggested that social cognitive neuroscience "can contribute to the development of new theories and the enrichment of existing theories within the social sciences, demonstrating that social cognitive neuroscience can be both a science of new techniques and a science of new ideas." Furthermore, in line with our work, Cacioppo et al. (2003, p. 653) stated that an understanding of "where and how activity in the brain covaries with a social process, construct, or representations . . . has the potential to inform theory."

In short, traditional attempts to observe leader behavior, clinically or through survey methodology, can go only so far in terms of our understanding of leadership processes and their outcomes. Neuroscience and its associated methodologies hold the potential for a much broader understanding of the source of such behavior. For example, a common theme of theories of effective leadership is that both cognitive and affective (or emotional) elements come into play. As noted by Phelps (2006), the neural circuitries of cognition and affect/emotion are intertwined in decision making and reasoning processes. Through neuroscience methodology, cognition and emotion can be theorized and examined simultaneously in order to fully understand the neurological basis of effective leadership. That said, however, we also recognize that effective leadership is a broad concept. Thus, theoretical and empirical attempts to link neurological phenomena to leadership might best be limited to somewhat focused or narrow qualities and behaviors. In the research summarized here, we have attempted to link neuronal coherence to socialized vision, rather than pursuing broader linkages to more general characterizations of "effective leadership."

In sum, we suggest that neuroscience has the potential to greatly inform theory and assessment pertaining to leadership and other managerial phenomena (e.g., decision making) described below. By exploring the neurological bases of leader behavior, more informed theory may be produced to model leadership processes. Moreover, new techniques or measures may be developed to more precisely assess leadership potential.

Can We Apply Neurological Findings to Leadership Development?

The explanation of leadership processes is an area worthy of research, and as argued above, neuroscience can provide new insights and techniques to further such goals. But can such brain activity research be used to identify and develop leaders? If the brain is relatively static in terms of its electrical wiring, then our line of research could at most have implications for leader assessment and perhaps selection. For example, traditional methods of assessing leaders (interviews, assessment centers, and so forth) could be potentially augmented by an examination of neurological profiles. On the other hand, if the neural pathways in the brain are malleable, there could be some interesting implications for leadership development. In short, these issues could shed new light on the age-old question of whether leaders are born versus made, and the efficacy of leadership development versus natural ability.

Current thinking in neuroscience would suggest that the brain is indeed relatively "plastic" in terms of the capability to change the nature of electrical brain activity—and thus behavior. For example, people with maladies such as attention deficit disorder (ADD), depression, sleep disorders, anger management issues, and anxiety associated with phobias now routinely engage in neurofeedback therapy activities for the purpose of correcting such problems (Hanslmayer, Sauseng, Doppelmayr, Schabus, & Klimesch, 2005; Monastra, 2003; Sterman & Egner, 2006). These therapies are based in qEEG research that has identified discriminant functions that delineate neural patterns in the normal population (e.g., individuals without ADD) versus individuals with the malady (e.g., those with ADD). Based on these discriminant functions, neurofeedback training protocols can be developed that are analogous to playing video games with one's brain instead of one's hands. The video game in this instance is designed to provide feedback by rewarding targeted performance (e.g., providing a soothing sound) and penalizing undesired brain patterns (e.g., providing an unpleasant sound). Accordingly, neurofeedback represents a form of operant conditioning. Thus, the brain (unconsciously) learns to adapt to the desired patterns of performance. By repeating the process multiple times, the brain learns the desired pattern in response to a given stimulus, leading toward optimal functioning.

The concept of brain plasticity coupled with emerging techniques associated with neurofeedback would suggest the third challenge that we address in this article: to try to apply findings, such as the ones described here, to leadership development. As outlined below, we see two specific possibilities pertaining to leadership development, one of which can be applied immediately; the other could see applications in the near future. In terms of immediate application, the implication for leadership development is relatively clear. In our work, we have found a small subgroup of managers to have one or more brain profile deficiencies. Unfortunately, such conditions can limit an individual from reaching his or her leadership potential—including being seen as inspiring in the eyes of followers.

As a case example, one of our participants was a manager who reported anger management problems. Obviously, someone with such issues might be challenged when assuming a leadership role, as emotional equanimity is an important quality. It is hard to imagine that anyone in a leadership position who "flies off the handle" could be seen as inspirational. With the help of a neurotherapist, we were able to pinpoint the root cause of the behavior, which as it turns out could be traced to a childhood baseball injury. This injury had affected a portion of the brain particularly relevant to an individual's emotional stability, especially with regard to anger issues. Based on knowledge gained through prior qEEG research dealing with the neurological basis of anger management problems (Fava, 1997; Lubar, Congedo, & Askew, 2003; Martens, 2001), with a series of neurofeedback sessions, the individual was able to rearrange neuropathways in the affected area, create new pathways with healthy neighboring neurons, and largely correct the problem. Accordingly, he was able to set the stage to become a more effective leader.

By dealing with the neuronal deficiencies, we are addressing the issue of leadership development—but only indirectly. That is, we are "cleaning up" problems that might prevent an individual from realizing his or her potential in life, but we are not using neurofeedback to directly develop leadership capabilities. To this end, the ultimate goal is to be able to assess leadership potential via neuroscience technology, and then use neurofeedback to more directly develop the neurological wiring associated with effective leadership behaviors. For example, it may be possible to "rewire" right frontal pathways to achieve greater coherence. In turn, individuals' potential for effective leadership may be enhanced.

Thus, by understanding the neurological bases for inspirational behavior, we may be better positioned to develop inspirational leaders in a more realistic and systematic manner. For instance, instead of simply putting people through a one-size-fits-all leadership development program, the brain may give us some insight as to how and why specific individuals in leadership roles feel, think, and ultimately learn new behaviors. Armed with this knowledge, leadership development could be better customized to fit the unique neurological blueprint of each individual leader. In short, the overall goal of the type of research described here could be to identify specific neurological underpinnings of behaviors associated with inspirational leadership, and to then use such knowledge for development purposes.

While at first glance this may seem far-fetched or even science fiction, there is some precedent for using neurofeedback in the workplace. Specifically, neurofeedback has been used to help with "peak performance."[5] Business executives as well as top athletes are using neurofeedback as a "coach" for their minds. It works by helping the brain to focus and be present in the moment with

[5] Refer to Vernon (2005) and Gruzelier, Egner, & Vernon (2006) for evidence of the efficacy of neurofeedback for optimizing performance.

employees, customers, and teammates. Training the brain, much as one might train the body with physical exercise, allows it to learn to regulate itself and function better. For example, neurofeedback can help improve one's ability to regulate certain bodily reactions, such as responding to stress with less reactivity and intensity. As such, neurofeedback may be useful for those who want to function to the best of their capabilities.

On the basis of such developments in neurofeedback technology, we may be able to directly address the neural pathways associated with inspirational leadership behaviors. At this point, it is still too early to predict our potential ability to successfully use this knowledge to develop more effective leaders. First, the current research focused on one variable, coherence, in one portion of the brain. It could be that other neurological variables in additional portions of the brain may be relevant to the display of effective leader behaviors. That is, using broader data collection efforts, it may be possible to expand our current focus on coherence to a number of other variables identified through qEEG analyses. If a normative pattern can be identified in these variables that delineates the neurological basis of visionary or inspirational behaviors from less effective behaviors, there is the possibility of applying neurological feedback strategies for the purpose of self-development (i.e., training the brain for better leadership performance). Such techniques could be cost-effective and even pursued in the privacy of a leader's office or home.

Second, we may perhaps find that to achieve maximum results, we will need to join neurofeedback techniques with other, more traditional, leadership development approaches, such as 360-degree feedback and executive coaching. In other words, we do not expect that neurofeedback will replace these more traditional approaches. Rather, through neurofeedback, a leader may have a stronger basis for pursuing the type of behavioral change suggested through 360-degree feedback and coaching.

It should be clear that both the research and practice implications described above require more than just lip service with regard to interdisciplinary efforts. Indeed, such efforts are absolutely critical. For example, neuroscience, behavioral, and management expertise would need to be fused to achieve the type of broadened approach to leadership development suggested here. We suggest that the key to going down this road is not for single individuals to develop all of the necessary expertise. Rather, the practical solution is to form research or application teams containing that expertise. Obviously, efforts of this nature can run counter to traditions, norms, and even organizational structures that may have been focused on the development and application of knowledge within particular specialties (e.g., organizational behavior, human resource management, and so forth).

As we move forward, it is also important to recognize the moral and ethical implications of work directed toward linking neuroscience and leadership. The forms of leadership investigated here represent positive, constructive approaches toward influencing individuals and groups. However, we acknowledge that a darker side exists with regard to leadership in the form of manipulation and personalized vision (House & Howell, 1992). It is imperative that future efforts to use neurofeedback for the purpose of leadership development be cognizant of such distinctions, and that attempts be made to promote only positive uses of such technologies.

Future Research Directions

We envision additional research directions beyond what has been described here. For example, in line with the vast majority of existing leadership theory and research, we have focused on individual leaders who occupy formal hierarchical roles. A broader perspective depicts leadership as a process of positive influence in which formal leaders are only a part (Day, 2000). Day, Gronn, and Salas (2004) suggested that the overall leadership capacity of an entity is a form of social capital that involves the sharedness, distributedness, and connectivity of members of the entity. Along related lines, Pearce and Conger (2003) defined shared leadership in terms of a dynamic process of mutual influence among peers or individuals at differing hierarchical levels in an organization. Accordingly, to fully understand leadership effectiveness, neuroscience assessment may need to be applied to multiple members of groups or entities.

We also foresee research that goes beyond leadership phenomena per se. Three areas pertaining specifically to decision-making processes are evident. First, neuroeconomics is an emerging transdisciplinary field that utilizes the measurement techniques of neuroscience to understand how people make economic decisions (Camerer, Loewenstein, & Prelec, 2005; Zak, 2007). One particular area of interest to neuroeconomists is how people make decisions around trust (e.g., Zak, 2007). Despite the large literature that exists on the importance of trust in organizations (e.g., Lewicki, McAllister, & Bies, 1998; McAllister, 1995), we know very little about why some people choose to trust, or how they become trustworthy. However, because decisions involving trust have been deemed to be largely an unconscious process, neurophysiological measurement during trust experiments has allowed researchers to gain insights into how people make decisions around trust, even when they themselves are unaware of how they make such decisions. Organizational trust researchers may benefit from these findings and methodologies.

Second, there may be implications in terms of the upper echelons perspective (Hambrick & Mason, 1984), which views strategic choice as a function of the demographic and psychological composition of an organization's top management team. Research might address potential neurological differences between executives who tend to pursue bolder or more risky alternatives and those who are more conservative or risk-averse in their decision making. Relatedly, Ashkanasy (2003, p. 15) discussed the neurological basis of the "freezing response" or the tendency to "freeze with fear." Referring to the work of Le Doux (1995), Ashkanasy (2003) described how the fear response appears to involve linkages between the cortex or thalamus and the limbic areas, specifically the amygdala. For a review of such findings, see Phelps (2006). The point here is that it is possible that specific aspects of brain activity may identify strategic decision makers who are risk-averse, in that such individuals are more prone to the freezing response described by Ashkanasy (2003) when considering potentially bold or risky decisions.

Third, moral judgment is also relevant to decision making. Neuroimaging has established that locations in the frontal cortex are involved in moral judgment and evaluations of fairness, as well as morally based emotions such as compassion, indignation, and guilt (Knabb, Welsh, Ziebell, & Reimer, 2009). Dysfunction in these locations can result in a variety of moral deficiencies relevant to decision making, including apathy, impulsiveness, lack of consideration, and inability to maintain goal-directed behavior. Greene and colleagues found that when an individual reasons through a variety of moral dilemmas, a network of prefrontal areas is activated (Greene, Sommerville, Nystrom, Darley, & Cohen, 2001). The activation is greater when the moral decision involves potential negative consequences for other people. What is not clear at this point is whether patterns of brain activity can be identified for those who tend to make more ethical or moral judgments and decisions, versus those who do not.

We also believe that it is important to recognize the potential contributions of additional synergistic research intersections to illuminate leadership and organizational theory. Of particular promise may be the future integration of neuroscience, genetics, evolutionary psychology, and leadership research. For instance, there is early evidence (Lee & Chamberlain, 2007) that genetics may influence brain processes, such as the efficiency of the prefrontal cortex and sensitivity of the amygdala, which in turn may affect leadership behaviors. Similarly, recent empirical work integrating behavioral genetics and leadership research has concluded, based on samples of twins, that about 30% of the individual differences in leadership role occupancy can be attributed to latent genetic factors (Arvey, Rotundo, Johnson, Zhang, & McGue, 2006; Arvey, Zhang, Avolio, & Kruger, 2007). However, the impact of genetic factors can be lessened by the leader's social environment (Zhang, Ilies, & Arvey, 2009).

Further, evolutionary psychology (Pinker, 2002) is a field predicated on the notion that the human brain has evolved and changed due to environmental and social circumstances—and will continue to do so. It suggests that although much of the human brain remains fixed by genetic factors, certain portions may be enhanced or modified over time. For example, the enlargement of the human brain over time has allowed for increased capacity in learning and memory. This, in turn, has led to the development of more sophisticated skill sets such as the ability to be flexible and adaptable to new situations (Pinker, 2002), a competency often associated with effective leadership. Additional leadership implications of evolutionary psychology rest on the idea that some leadership behaviors may be hardwired, rendering them difficult to change, while others may be developable (Nicholson, 1998). A recognition of both the limitations and possibilities of the brain's malleability and potential for adaptability is important to future investigations of leadership phenomena through the use of neuroscience methodologies.

Conclusion

In this article, we have identified three key challenges in the pursuit of applications of neuroscience to leadership assessment and development. Based on the early findings summarized here, we believe that research may now have the potential to advance our understanding of the brain's role in producing effective leadership behavior and to explore how the brain itself might be used to better develop exemplary leadership potential. This knowledge could be useful to organizations that undertake extensive efforts to identify and improve leadership skills and behaviors.

References

Adolphs, R. (2009). The social brain: Neural basis of social knowledge. *Annual Review of Psychology*, *60*, 693–716.

Arvey, R. D., Rotundo, M., Johnson, W., Zhang, Z., & McGue, M. (2006). The determinants of leadership role occupancy: Genetic and personality factors. *The Leadership Quarterly*, *17*, 1–20.

Arvey, R. D., Zhang, Z., Avolio, B. J., & Kruger, R. F. (2007). Developmental and genetic determinants of leadership role occupancy among women. *Journal of Applied Psychology*, *92*, 693–706.

Ashkanasy, N. M. (2003). Emotions in organizations: A multi-level perspective. *Research in Multi-Level Issues*, *2*, 9–54.

Ashkanasy, N. M., & Daus, C. S. (2002). Emotion in the workplace: The new challenge for managers. *Academy of Management Executive*, *16*, 76–86.

Avolio, B. J., Bass, B. M., & Jung, D. I. (1999). Reexamining the components of transformational and transactional leadership using the Multifactor Leadership Questionnaire. *Journal of Occupational and Organizational Psychology*, *72*, 441–462.

Barsade, S. G., & Gibson, D. E. (2007). Why does affect matter in organizations? *Academy of Management Perspectives*, *21*, 36–59.

Bass, B. M., & Avolio, B. J. (1990). *Transformational leadership development: Manual for the Multifactor Leadership Questionnaire*. Menlo Park, CA: Mind Garden.

Bass, B. M., & Bass, R. (2009). *Bass handbook of leadership: Theory, research, and managerial applications* (4th ed.). New York: Free Press.

Bass, B. M., & Riggio, R. E. (2006). *Transformational leadership*. Mahwah, NJ: Lawrence Erlbaum Associates.

Boal, K. B., & Hooijberg, R. (2001). Strategic leadership research: Moving on. *The Leadership Quarterly*, *11*, 515–549.

Boyatzis, R. E., Smith, M. L., & Blaize, N. (2006). Developing sustainable leaders through coaching and compassion. *Academy of Management Learning & Education*, *5*, 8–24.

Buckingham, M., & Coffman, C. (1999). *First, break all the rules: What the world's greatest managers do differently*. New York: Simon & Shuster.

Cacioppo, J. T., Berntson, G. G., Lorig, T. S., Norris, C. J., Rickett, E., & Nusbaum, H. (2003). Just because you're imaging the brain doesn't mean you can stop using your head: A primer and set of first principles. *Journal of Personality and Social Psychology*, *85*, 650–661.

Cacioppo, J. T., Berntson, G. G., & Nusbaum, H. C. (2008). Neuroimaging as a new tool in the toolbox of psychological science. *Current Directions in Psychological Science*, *17(2)*, 62–67.

Camerer, C., Loewenstein, G., & Prelec, D. (2005). Neuroeconomics: How neuroscience can inform economics. *Journal of Economics Literature*, *43*, 9–64.

Carmeli, A., Gilat, A., & Waldman, D. A. (2007). The role of perceived organizational performance in organizational identification, adjustment and job performance. *Journal of Management Studies*, *44*, 972–992.

Chatterjee, A., & Hambrick, D. C. (2007). It's all about me: Narcissistic CEOs and their effects on company strategy and performance. *Administrative Science Quarterly*, *52*, 351–386.

Classen, J., Gerloff, C., Honda, M., & Hallett, M. (1998). Integrative visuomotor behavior is associated with interregionally coherent oscillations in the human brain. *The American Physiological Society*, *79*, 1567–1573.

Conger, J. A., & Kanungo, R. N. (1998). *Charismatic leadership in organizations*. Thousand Oaks, CA: Sage.

Day, D. V. (2000). Leadership development: A review in context. *The Leadership Quarterly*, *11*, 581–613.

Day, D. V., Gronn, P., & Salas, E. (2004). Leadership capacity in teams. *The Leadership Quarterly*, *15*, 857–880.

Fava, M. (1997). Psychopharmacologic treatment of pathologic aggression. *Psychiatric Clinics of North America, 20*, 427–51.

Finkelstein, S., & Hambrick, D. (1996). *Strategic leadership: Top executives and their effects on organizations*. St. Paul, MN: West Publishing.

Flynn, F. J., & Staw, B. M. (2004). Lend me your wallets: The effect of charismatic leadership on external support for an organization. *Strategic Management Journal, 25*, 309–330.

George, J. M. (2000). Emotions and leadership: The role of emotional intelligence. *Human Relations*, *53,* 1027–1055.

Goleman, D. (1998). What makes a leader? *Harvard Business Review*, *76,* 93–102.

Goleman, D., Boyatzis, R., & McKee, A. (2001). *Primal leadership*. Boston, MA: Harvard Business School Press.

Greene, J. D., Sommerville, R. B., Nystrom, L. E., Darley, J. M., & Cohen, J. D. (2001). An fMRI investigation of emotional engagement in moral judgment. *Science, 293*, 2105–2108.

Gruzelier, J., Egner, T., & Vernon, D. (2006). Validating the efficacy of neurofeedback for optimising performance. *Progress in Brain Research*, *159*, 421–431.

Hagmann, P., Cammoun, L., Gigandet, X., Meuli, R., & Honey, C. J. (2008). Mapping the structural core of human cerebral cortex. *PLoS Biology*, 6, 1–15.

Haines, S. (2009). Bankrupt leadership development? *Training, 46*, 64.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top managers. *Academy of Management Review, 9*, 193–206.

Hanslmayer, S., Sauseng, P., Doppelmayr, M., Schabus, M., & Klimesch, W. (2005). Increasing individual upper alpha by neurofeedback improves cognitive performance in human subjects. *Applied Psychophysiology & Biofeedback 30(1)*, 1–10.

Heisel, A. D., & Beatty, M. J. (2006). Are cognitive representations of friends' request refusals implemented in the orbitofrontal and dorsolateral prefrontal cortices? A cognitive neuroscience approach to 'theory of mind' in relationships. *Journal of Social and Personal Relationships, 23*, 249–265.

Hines, T. (1987). Left brain/right brain mythology and implications for management and training. *Academy of Management Review*, *12*, 600–606.

House, R. J., & Aditya, R. (1997). The social scientific study of leadership: Quo vadis? *Journal of Management, 23*, 409–474.

House, R. J., & Howell, J. M. (1992). Personality and charismatic leadership. *The Leadership Quarterly*, *3*, 81–108.

Howell, J. M., & Shamir, B. (2005). The role of followers in the charismatic leadership process: Relationships and their consequences. *Academy of Management Review*, *30*, 96–112.

Humphrey, R. H. (2002). The many faces of emotional leadership. *The Leadership Quarterly, 13*, 493–504.

Jasper, H. H. (1958). Recent advances in our understanding of ascending activities of the reticular system. In H. Y. Jasper, L. D. Proctor, R. S. Knighton, W. C. Noshay, and R. T. Costello (Eds), *Reticular formation of the brain* (pp. 319–332). Boston: Little, Brown and Co.

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

Kellerman, B. (2004). *Bad leadership*: *What it is, how it happens, why it matters*. Boston: Harvard Business School Press.

Knabb, J. J., Welsh, R. K., Ziebell, J. G., & Reimer, K. S. (2009). Neuroscience, moral reasoning, and the law. *Behavioral Sciences & the Law, 27*, 219–236.

Le Doux, J. E. (1995). Emotion: Clues from the brain. *Annual Review of Psychology, 46*, 209–235.

Lee, N., & Chamberlain, L. (2007). Neuroimaging and psychophysiological measurement in organizational research: An agenda for research in organizational cognitive neuroscience. *Annals of the New York Academy of Sciences, 1118*, 18–42.

Lewicki, R. J., McAllister, D. J., & Bies, R. J. (1998). Trust and distrust: New relationships and realities. *Academy of Management Review*, *23*, 438–458.

Lieberman, M. D. (2007). Social cognitive neuroscience: A review of core processes. *Annual Review of Psychology*, *58*, 259–289.

Lowe, K. B., Kroeck, K. G., & Sivasubramaniam, N. (1996). Effectiveness correlates of transformational and transactional leadership: A meta-analytic review of the MLQ literature. *The Leadership Quarterly, 7*, 385–425.

Lubar, J. F., Congedo, M., & Askew, J. H. (2003). Low-resolution electromagnetic tomography (LORETA) of cerebral activity in chronic depressive disorder. *International Journal of Psychophysiology, 49*, 175–185.

Martens, W. H. (2001). Agitation therapy for antisocial and psychopathic personalities: An outline. *American Journal of Psychotherapy, 55*, 234–250.

McAllister, D. J. (1995). Affect- and cognition-based trust as foundations for interpersonal cooperation in organizations. *Academy of Management Journal*, *38*, 24–59.

Mintzberg H. (1976). Planning on the left side and managing on the right side. *Harvard Business Review*, 54, 49–58.

Monastra, V. J. (2003). Clinical applications of electroencephalographic biofeedback. In M. Schwartz and F. Andraskik (Eds), *Biofeedback: A practitioner's guide* (3rd ed.), pp. 438–463. New York: Guilford.

Morse, G. (2006). Decisions and desire. *The Harvard Business Review*, *84*, 42–51.

Naqvi, N., Shiv, B., & Bechara, A. (2006). The role of emotion in decision making: A cognitive neuroscience perspective. *Current Directions in Psychological Science, 15*, 260–264.

Nicholson, N. (1998). How hardwired is human behavior? *Harvard Business Review*, *July–August*, 135–147.

Niedermeyer, E., & Silva, F. L. (1995). *Electroencephalography: Basic principles, clinical applications and related fields*. Baltimore: Williams & Wilkins.

Nolte, J. (2002). *The human brain: An introduction to its functional anatomy*. St. Louis: Mosby.

Ochsner, K. N., & Lieberman, M. D. (2001). The emergence of social cognitive neuroscience. *American Psychologist, 56*, 717–734.

Paulus, M. P., Rogalsky, C., Simmons, A., Feinstein, J. S., & Stein, M. B. (2003). Increased activation in the right insula during risk-taking decision making is related to harm avoidance and neuroticism. *NeuroImage, 19*, 1439–1448.

Pearce, C. L., & Conger, J. A. (2003). All those years ago: The historical underpinnings of shared leadership. In C. L. Pearce and J. A. Conger (Eds.), *Shared leadership: Reframing the hows and whys of leadership*, pp. 1–18. Thousand Oaks, CA: Sage.

Phelps, E. A. (2006). Emotion and cognition: Insights from studies of the human amygdala. *Annual Review of Psychology 57*, 27–53.

Pinker, S. (2002). *The blank slate: Modern denial of human nature*. New York: Penguin Books.

Salloway, S. P., Malloy, P. F., & Duffy, J. D. (2001). *The frontal lobes and neuropsychiatric illnesses*. Washington, DC: American Psychiatric Publishing.

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E., & Cohen, J. D. (2003). The neural basis of economic decision-making in the ultimatum game. *Science*, *300*, 1755–1758.

Shamir, B., House, R. J., & Arthur, M. B. (1993). The motivational effects of charismatic leadership: A self-concept based theory. *Organization Science, 4*, 577–594.

Sterman, M. B., & Egner, T. (2006). Foundation and practice of neurofeedback for the treatment of epilepsy. *Applied Psychophysiology & Biofeedback*, *31*, 21–36.

Sully de Luque, M., Washburn, N., Waldman, D. A., & House, R. J. (2008). Unrequited profit: How stakeholder and economic values relate to subordinates' perceptions of leadership and firm performance. *Administrative Science Quarterly*, *53*, 626–654.

Tabibnia, G., Satpute, A. B., & Lieberman, M. D. (2008). The sunny side of fairness: Preference for fairness activates reward circuitry (and disregarding unfairness activates self-control circuitry). *Psychological Science, 19*, 339–347.

Thatcher, R. W., Krause, P., & Hrybyk, M. (1986). Corticocortical association fibers and EEG coherence: A two compartmental model. *Electroencephalography and Clinical Neurophysiology*, *64*, 123–143.

Thatcher, R. W., North, D., & Biver, C. (2007). Development of cortical connections as measured by EEG coherence and phase delays. *Human Brain Mapping*, *29*, 1400–1415.

Vernon, D. J. (2005). Can neurofeedback training enhance performance? An evaluation of the evidence with implications for future research. *Applied Psychophysiology & Biofeedback*, *30*, 347–364.

Vul, E., Harris, C., Winkielman, P., & Pashler, H. (2009). Puzzlingly high correlations in fMRI studies of emotion, personality, and social cognition. *Perspectives on Psychological Science*, *4*, 274–290.

Zak, P. J. (2007). The neuroeconomics of trust. In R. Franz (Ed.), *Renaissance in behavioral economics* (chapter 2). New York: Routledge.

Zhang, Z., Ilies, R., & Arvey, R. D. (2009). Beyond genetic explanations for leadership: The moderating role of the social environment. *Organizational Behavior and Human Decision Processes*, *110*, 118–128.