# Neuroscience in Organizational Behavior

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Annu. Rev. Organ. Psychol. Organ. Behav. 2017. 4:425–44

First published online as a Review in Advance on December 23, 2016

The *Annual Review of Organizational Psychology and Organizational Behavior* is online at orgpsych.annualreviews.org

https://doi.org/10.1146/annurev-orgpsych-032516-113316



## Keywords

neuroscience, management, organizational research, intrinsic activity, reflexive activity

## Abstract

In this review, we consider the advent of neuroscience in management and organizational research. We organize our review around two general themes pertaining to how areas of the brain may be relevant to management and organizational behavior. First, intrinsic, at-rest activity in the brain provides trait-like information that can be used to better understand individuals in terms of cognition, emotions, and behaviors. Second, reflexive activity involves an understanding of the brain in terms of its state-like responses to stimuli. In our review, we identify several research challenges and opportunities, such as the need to consider the theoretical basis of neural concepts and measures and the use of team-based neuroscience technologies. In addition, although research in organizational neuroscience is relatively new, some interesting practical implications are raised here. We conclude with a consideration of key limitations, specifically the possibility of excessive reductionism, as well as ethical and professional issues.

# 1. INTRODUCTION

Have you ever asked the question, "What's going on in this person's head that makes the person think or act the way that he or she does?" Many of us ask that question when we see negative, as well as positive, behavior on the part of others—outside, as well as inside, organizational contexts. Until recently, organizational researchers have had to be content with asking this question in a figurative sense, sometimes resorting to metaphoric representations dealing with cognition. For example, schema represent cognitive structures or lenses through which people process information. However, actual physiological phenomena in the brain, and their relationship to organizational behavior, have remained uncharted territory.

In recent times, that situation has started to change. We see increasing work on brain phenomena that is contributing to our understanding of management and organizational phenomena. As an example, Hannah et al. (2013) used neuroscience-based concepts and methods, specifically quantitative electroencephalogram (qEEG), to inform the concept of leader complexity and the extent to which it predicts adaptive decision making on the part of leaders. Hannah et al. (2013) were able to show how an understanding of leader complexity could be broadened through the incorporation of neuroscience. Moreover, they used a neuroscience-based measure of leader complexity to add unique variance to the prediction of an outcome of leader complexity: adaptive decision making. In sum, this study demonstrates how an understanding of leader complexity, an important way of conceiving leader qualities, could be enlarged by neurological considerations, and in turn, the prediction of outcomes in leadership research could be enhanced.

In this review, we build on recent work that has outlined the value that can be added by neuroscience to conceptualizations and methodologies in organizational behavior research (Ashkanasy et al. 2014, Becker et al. 2011, Senior et al. 2011, Waldman et al. 2016a, Ward et al. 2015). That work has been largely theoretical and has set the stage for recent empirical research in organizational settings, which is the focus of the current review. We organize this article in five sections: (*a*) overview, (*b*) literature review, (*c*) research challenges and emerging directions, (*d*) practical implications, and (*e*) conclusions.

## 1.1. Overview

Organizational neuroscience (ON) represents a natural progression of thinking and research under the larger umbrella of social cognitive neuroscience (Lieberman 2007, Ochsner & Lieberman 2001). The latter deals with broader social psychological issues, such as moral reasoning or judgment (e.g., Greene et al. 2004) and emotions (e.g., Lindquist et al. 2012), whereas the former pertains specifically to how neuroscience can broaden our understanding of people at work and organizing processes (Ward et al. 2015). With that said, there are obvious overlaps between organizational and social cognitive neuroscience. Indeed, given the lack of research in the organizational realm until very recently, ON researchers have had to largely extrapolate from theory and findings in the broader social cognitive neuroscience area. That is, ON researchers (e.g., Dulebohn et al. 2015, Waldman et al. 2011) have based conceptualizations and predictions largely on findings in previous social cognitive neuroscience research. In so doing, ON researchers ground their novel research in existing literature and extend basic neuroscience research to organizational contexts.

There are both conceptual and methodological reasons accounting for the rise of neuroscience in organizational research. Conceptually, neuroscience can help to broaden our understanding of constructs, as was the case for leader self-complexity in the Hannah et al. (2013) study summarized previously. For example, neuroscience can inform us as to the neurological basis of leadership qualities and behaviors. Similarly, neuroscience can be utilized more broadly to investigate various facets of organizational behavior and can provide additional evidence for the uniqueness or overlap of related constructs such as in the work of Dulebohn et al. (2009), reviewed in detail below in Section 2.5.

Methodologically, we see several advantages of an increased focus on neuroscience technology in organizational research. First, our traditional research methods in organizational research (e.g., surveys) are somewhat limited in terms of being able to account for variance in important outcomes. As Hannah et al. (2013) show, we may be able to increase the variance that is accounted for in outcomes through the incorporation of neural-based variables. Second, problems associated with surveys, such as rating errors or faking, do not exist with neural-based variables. Simply stated, the brain cannot lie or fake, and its assessment through neurosensing methods (e.g., qEEG) represents a highly ecologically valid approach to measurement (Waldman et al. 2015a).

Third, neurosensing/scanning methods, especially those associated with qEEG, have strong temporal resolution and flexibility. In other words, brain activity can be assessed on a millisecond basis when the brain is either at rest or reacting to stimuli. Such immediate, ongoing assessment may help to deal with challenges posed by traditional measurement methods in organizational research. As an example, consider team processes or emergent states where traditional survey techniques have been used to measure retrospective perceptions of team members with regard to aspects of team processes (e.g., Marks et al. 2001). That is, following a team process, a common practice of researchers is to get team members' impressions of what the team process was about. Aside from recollection challenges on the part of team members, such assessment assumes an overall quality regarding a team process, rather than allowing for fluid or momentary shifts. As Waldman et al. (2015b) have argued and shown, qEEG neurosensing methods allow for more precise, momentary assessment of team processes and emergent states. In contrast, survey methods are not highly practical for assessing shifts in team processes or emergent states because of the interruption that would be caused. Moreover, although observation could be feasible, it is questionable whether observers can accurately assess phenomena such as team arousal or engagement, whereas neurosensing methods may be able to overcome such challenges (Waldman et al. 2015b).

As we describe in more detail in Section 4, neuroscience may also have strong applications in terms of practice, especially for training and development purposes (Stikic et al. 2015). As an example, traditional methods of leader development include such techniques as multisource feedback, executive coaching, motivational speeches, and classroom activities, among others. These methods have questionable return on investment, although neuroscience-based approaches show much promise for improving such returns (Waldman et al. 2011). For example, neural-based measures can identify when and how training methods produce lasting changes in the brain and related behavioral responses. Additionally, neuroscience methods can be used to provide real-time feedback to trainees that has proven to be beneficial for recognizing and managing behavioral triggers in oneself and others.

## 2. LITERATURE REVIEW

In this section, we overview ON research to date. In so doing, we focus on empirical studies dealing with concepts that are directly relevant to the process of organizing, which best captures the organizational aspect of organizational behavior (Heath & Sitkin 2001). Before our review, we consider two issues: (*a*) the nature of neural-based variables and (*b*) predispositional, intrinsic versus reflexive assessment.

### 2.1. Neural Variables

An in-depth overview of neural-based variables that might be used in ON research is beyond the scope of the current article. Descriptions can be found in the work of Waldman et al. (2011)

and Balthazard & Thatcher (2015). Variables should be considered separately from neuroscience technologies, although respective variables tend to be associated with specific technologies.

For example, functional magnetic resonance imaging (fMRI) technology has been used in ON research, and the predominant variable associated with this technology is represented by the blood-oxygenation-level dependent (BOLD) signal. It is commonly used to assess changes in blood flow in the brain in reaction to various stimuli. Through the use of BOLD, areas of the brain associated with cognitive or emotional processing can be isolated. Thus, in a typical fMRI study, participants are presented with visual images or sounds (e.g., images that evoke moral judgment), which then can reveal how brain structures and processes are associated with the stimuli. In a similar fashion, participants can be asked to make judgements or decisions regarding presented stimuli to explore brain processes and networks associated with the decision. In doing so, researchers can ascertain whether decisions and behaviors are the product of conscious deliberation or more visceral emotional response of which the participant may or may not be aware.

A strength of fMRI is its superior spatial resolution. Early on, this facilitated the attention-grabbing images that were featured in many articles. However, "it should only be considered an indirect measure of neuronal activity because the time it takes for dynamic changes to occur in blood flow is much longer than that for neurons to fire off their electrochemical messages. As such, fMRI is said to have poor temporal resolution" (Balthazard & Thatcher 2015, pp. 94–95). With that said, as the technology has matured, advanced techniques such as region of interest analysis have moved fMRI beyond whole-brain analysis and what might be seen as pretty images. Nonetheless, the practicality of fMRI is somewhat limited in ON research due to prohibitive costs, artificial research contexts, and some degree of discomfort or anxiety on the part of research participants (Waldman et al. 2011). The latter is especially relevant to the recruitment of actual organizational members, as opposed to student-based subject pools. Despite these difficulties, fMRI represents a tool that already has and will certainly continue to contribute to OB research (Poldrack 2012).

A second popular technology associated with ON research is qEEG, which measures the electrical activity of the brain. As compared to fMRI, qEEG has more precise temporal resolution (i.e., immediate assessment of brain activity). That is, fMRI is based on relatively slow changes in blood oxygenation. With the capability to locally assess brain activity to within 5–7 mm, the spatial resolution of qEEG is significantly less than that of fMRI (2–3 mm). However, such spatial resolution has proven to be adequate to investigate organizational phenomena (e.g., Hannah et al. 2013; Waldman et al. 2011, 2016b). Moreover, qEEG is relatively inexpensive; its use involves no health risks; and as compared to fMRI, it can be used in a more natural environment for research participants.

qEEG data are collected in terms of electromagnetic frequency bandwidths, specifically delta (1–4 Hz), theta (4–8 Hz), alpha (8–12 Hz), beta (12–30 Hz), and gamma (30–100 Hz) frequency bands. At the various bandwidths, two general categories of continuous variables can be examined: (*a*) power spectral density and (*b*) network connection measures such as coherence. Power spectral density reflects the sheer amount of electrical energy in various regions of the brain. Coherence involves the strength of connectedness between various regions of the brain (Balthazard & Thatcher 2015). Whereas density gives a measure of how strong the response is in a single brain region, coherence provides a measure of connectedness between two regions of the brain.

The relative value of density versus coherence measures in organizational research is beyond the scope of this review, although it is becoming apparent that research has favored network connection measures, such as coherence (see Balthazard & Thatcher 2015). Although coherence sounds like universally a good thing, Hannah et al. (2013) showed that lower coherence in the alpha bandwidth of frontal lobes was associated with greater leader self-complexity.

Conversely, other research has shown the relevance of greater coherence, especially in right frontal areas, in relation to phenomena such as leader vision (Waldman et al. 2011) and ethicality (Waldman et al. 2016b). Furthermore, coherence is a measure that is not particular to qEEG technology. It is possible to attain such a measure with fMRI, although BOLD has been more commonly used in fMRI research. As with the BOLD measure, qEEG variables can be readily used in conjunction with psychometric measures for the purpose of enriching ON research.

Lastly, we briefly introduce diffusion tensor imaging (DTI), an emerging MRI method that is becoming widely used in basic neuroscience but has yet to be employed in ON. DTI is able to map out neuronal organization and connectivity by analyzing the movement (diffusion) of water molecules within the brain (Mori & Zhang 2006). The resulting data can be used to create three-dimensional maps of major axonal connections between specific brain regions. This method is primarily intrinsic in nature, meaning that it measures relatively stable characteristics of the brain that can vary between individuals, and provides a means of investigating how individual differences in brain connectivity and networks can influence reflexive processing and resulting behavior. In a recent study, researchers used DTI to show that psychopaths demonstrated impaired frontal lobe connectively and then used fMRI to show that this was also associated with a decoupling of activity in the amygdala and prefrontal cortex (Motzkin et al. 2011). Although it may be some time before this method is accessible to organizational researchers, we include it here because of its great promise for supplementing fMRI and qEEG findings.



## 2.2. Reflexive versus Intrinsic Assessment

To a large extent, organizational research involves examining individual or team reactions to events or actions (e.g., leader directives or vision, job redesign, customer problems). It also involves a better understanding of ongoing qualities or traits associated with individuals within an organizational context (e.g., personality, cognition, emotions, values, behavioral styles). Similarly, in ON research, it is possible to assess neurological activity in reaction to stimuli, while also focusing on relatively enduring structures of the brain that exhibit activity during times of rest, rather than active engagement in a specific task. The former has been referred to as reflexive, whereas the latter reflects intrinsic brain activity (Fox et al. 2005, Raichle 2010, Raichle & Snyder 2007).

The reflexive conceptualization of brain activity fits “well with the view of the brain as driven by the momentary environmental demands” (Raichle & Snyder 2007, p. 1084). As noted in prior work (Waldman et al. 2011, 2016a,b), it approximates the notion of individual states (as opposed to traits) in personality research. The assumption is that to better understand how regions of the brain, or connections between regions, are relevant to cognition and emotional processing, the brain may temporarily change in function or activity in response to various stimuli. By observing this reflexive activity, cognitive and emotional processing can be isolated and linked to specific behavioral responses. This helps us to better understand and explain the neurological basis of organizational behavior, especially in terms of reactions to stimuli on the part of individuals. For example, Dulebohn et al. (2015) showed differences in reactions to justice-based stimuli, and how such differences were due in part to gender differences.

Recently, neuroscientific research, including ON applications, would also suggest that individuals' relatively stable and enduring differences in brain activity play a role in explaining cognitive, emotional, and behavioral qualities (Buckner & Vincent 2007, Lindquist et al. 2012, Raichle 2010). Thus, relatively enduring patterns of brain functioning may vary between individuals, reflecting trait-like differences in the neurological activity that people may “draw upon or harness” in their cognition and behavior (Healey & Hodgkinson 2014, p. 774). This relatively stable activity of the brain has been referred to as the intrinsic brain, and it is measured when an individual is in a resting state, rather than while he or she is engaged in a specific task (Balthazard & Thatcher 2015). As Waldman et al. (2016a,b) note, the brain in a resting mode is not the same as an inactive brain. Indeed, in a paradoxical sense, the sheer amount of electrical energy in the resting brain is typically higher than when the brain is actively involved in a task (Waldman et al. 2011). Once a significant stimulus is presented, the brain activates the appropriate task-positive network to respond to the stimuli (Friedman et al. 2015). In short, the distinction between reflexive and intrinsic methods and variables in ON research is important to understand because each involves different types of theoretical approaches and research questions. Reflexive methods are appropriate for determining similarities in response to stimuli, and intrinsic methods are appropriate for identification of individual neural-based differences that might be predictive of cognition, emotions, and behavior. Thus, conclusions that can be drawn depend on the type of method used.

### 2.3. Review of Empirical Organizational Neuroscience Studies

As mentioned above, the growing interest in ON has led to several conceptual or thought pieces. In our own review here, we use multiple criteria to evaluate potential studies to review. Specifically, we included only empirical studies that (*a*) used neuroscanning or neurosensing technologies, and (*b*) addressed variables that are central to the process of organizing (Heath & Sitkin 2001). For example, these criteria excluded studies that investigated genetic links with organizational behavior (e.g., Li et al. 2012) and studies that looked at topics such as advertising (e.g., Mostafa 2012). Additionally, we excluded research that examined what has been termed neuromodulating chemicals (e.g., synthetic oxytocin) that may enhance or inhibit cognitive functioning and improve mood and mental alertness (Barraza et al. 2011, Fuchs 2006, Zak 2011). We organize our discussion according to the predominant type of approach that was taken in a given study—either intrinsic or reflexive in nature.

### 2.4. Intrinsic-Based Neural Research

In the domain of ON research, several empirical publications have looked at intrinsic variables, which involve stable brain characteristics and individual differences. Many of these studies were in the context of leadership. In an early study, Peterson et al. (2008) investigated the neurological underpinnings of psychological capital, which is a positive predictor of leader performance. The authors used psychometric self-report measures to assess hope, resilience, confidence, and optimism in 55 senior business or community leaders across a variety of industries. Ratings of transformational and visionary leadership were collected from three to five followers of each of the leader participants. Subsequently, qEEG data were collected from the 55 leader participants while they were in a resting state. qEEG recordings from high versus low psychological capital groups showed greater activation in the left prefrontal cortex than the low group. The low psychological capital participant group showed greater activation in the right prefrontal cortex and right amygdala, areas of the brain that are associated with negatively valenced emotions such as fear. Peterson et al. (2008) found high consistency between the more conventional psychometrically validated self-report measures and the qEEG data collected. These results point to the importance of emotions regarding psychological capital in leaders. For example, based on the study's findings, future research may need to look more closely at fear as a mechanism underlying low psychological capital.

Balthazard et al. (2012) focused on differentiating transformational from nontransformational leaders. They examined neurological correlates of transformational leadership using qEEG. More conventional psychometric methods of data collection included administering the Multifactor Leadership Questionnaire (MLQ) as a psychometrically based yardstick of transformational leadership. The MLQ was administered to followers or peers of the 200 participants. At rest, EEG was recorded from 19 electrodes, followed by power spectral analysis to develop and validate a discriminant function that classified individuals according to their transformational leadership behavior. The discriminant analysis, which involved a two-step, neural variable reduction and selection process, classified leaders with 92.5% accuracy. Results showed evidence that patterns in the spectral measures of leaders' brains relate to transformational leadership behavior and exhibited more activity in the frontal lobes relative to other parts of the brain. The frontal lobes are associated with executive functions such as planning, emotion management, and understanding meaning in complex communication and novel situations. Additionally, the amplitude asymmetry of transformational leaders' neural activity exhibited the opposite pattern from people with anxiety disorders. These results suggest that rather than thriving under internal states of high stress and arousal, transformational leaders seem to keep calm and control their emotions during difficult situations. They further demonstrate a distinction between transformational leadership and other types of leadership, and imply that van Knippenberg & Sitkin's (2013) contention to remove the higher-order label of transformational leadership may be unnecessary. Additionally, this study begins to answer van Knippenberg & Sitkin's (2013) call for alternative approaches to operationalize more precise elements of transformational leadership. In sum, the work by Balthazard et al. (2012) enhances our understanding of latent neurological mechanisms that underlie the transformational leadership characteristics of individuals.

As previously mentioned, Hannah et al. (2013) provided an example of using ON for construct development and how qEEG data can deepen our understanding of constructs beyond that which is possible from solely looking at self-report, psychometric data. Hannah et al. (2013) measured leader self-complexity through both self-report survey and qEEG. The goal of the study was to increase our understanding of the etiology and basis of leader self-complexity by developing neural profiles, and to determine effects of leader self-complexity on adaptive decision making. The qEEG data provide a neural measure of complexity that improved the model by accounting for unique variance in adaptive decision making beyond self-report measurement. In short, by using neuroimaging data, this study developed and operationalized a model of leader self-complexity and adaptive decision making.

In an investigation of inspirational leadership, Waldman et al. (2011) collected EEG at rest (i.e., intrinsic brain) recordings to connect neurological data with inspirational leadership behavior. The sample of 50 participants held leadership positions and made visionary communication statements during the study. Participants answered the following questions about the future of their organizations: (*a*) "Can you please describe your current plans for your organization, as well as plans for the future?" and (*b*) "As you look toward the future, can you formulate a vision statement for your firm?" Transcriptions were recorded, coded, and analyzed. Data from three to six direct reports to participants were collected as ratings on the MLQ (Bass & Avolio 1990). Vision was coded on a continuum from personalized to socialized such that communicating a socialized vision emphasizes social responsibility, necessity of followers to organizational success, and goals of the collective organization (House & Howell 1992). Results showed that participants who were high on socialized visionary communication tended to be rated as inspirational/charismatic. In addition, for those participants, EEG data showed higher neural connectivity in the right frontal portions of their brains, suggesting that there is a meaningful, neutrally based distinction between leaders who espouse socialized versus nonsocialized vision.

In similar, more recent research, Waldman et al. (2016b) showed how an intrinsic measure of the default mode network (Boyatzis et al. 2014, Buckner & Vincent 2007) predicted ethical leadership behavior both directly as well as through ethical ideology, comprised of an interaction of relativism and idealism (Forsyth et al. (2008). In addition to showing a direct neurological basis

**Figure 1**

Team-based quantitative electroencephalogram (qEEG) technology.

of ethical leadership, this study points toward a neurological foundation for aspects of ethically based cognition, specifically relativism and idealism, which may be relevant to aspects of ethical behavior (e.g., organizational deviance) aside from leadership behavior per se. Thus, it points the way for research to examine how the intrinsic brain can affect a host of cognitive, emotional, and behavioral variables that are germane to a wide range of organizational behavior.

## 2.5. Reflexive-Based Neural Research

Empirical work using EEG data has not focused exclusively on intrinsic variables. Our review revealed an example of a study that took a reflexive approach. Waldman et al. (2015b) used qEEG technology (see **Figure 1**) to examine arousal or engagement levels on a second-by-second basis for individuals in 32 teams of MBA students. An interesting aspect of this study was that neurologically based arousal scores were normalized in an ipsative manner for each participant. That is, although common areas of the brain were associated with arousal across individuals, different levels of electrical energy were indicative of arousal within particular individuals. Thus, arousal during the team task was normalized for each individual based on an individually conducted pretask (i.e., baseline task) designed to determine the amount of electrical energy present for a given individual when that person is aroused or attentive. The teams solved a corporate social responsibility case. Following the team process, each individual was evaluated by respective team members in terms of emergent leadership. A key finding was that arousal on the part of fellow team members when an individual spoke during the team process was associated with that team member being seen as an emergent leader. Stated differently, team members who are ultimately viewed as team leaders tend to generate more arousal or attentiveness when they speak during team problem solving.

In sum, this study demonstrated several advantages of neuroscience methods by being the first to examine team processes or emergent states with a neurological lens and methodology. (Below we discuss further such future applications.) First, the qEEG measure of arousal was unobtrusive, and thus did not cause interruptions to the team process that are typical of survey measures; moreover, it was not subject to the biases and inaccurate assessments of observers. Accordingly, this measure has a high degree of ecological validity. Second, the qEEG measure could be attained in a continuous manner, thus reflecting the state-like manner of arousal or attentiveness (e.g., see Kahn 1990). In other words, in line with prior theory, arousal or attentiveness on the part of individuals comes and goes (i.e., is state-like) during a team process, and the qEEG technology employed by Waldman et al. (2015a,b) allows for the fleeting nature of such a variable.

Similar to EEG studies in ON, fMRI studies have thus far predominantly occurred in the area of leadership, and these fMRI studies have focused largely on reflexive variables. That is, the goal of this research has been to examine areas of the brain responding to various stimuli. In an exploratory fMRI study, Boyatzis et al. (2012) had executives recall past personal experiences with resonant and dissonant leaders. The results suggested that recalling resonant leaders did not produce widespread disengagement of the default mode network, which has been associated with such features as social awareness; self-projection into the future; and attempts to connect past, present, and future (see Waldman et al. 2016b). Resonant leaders also engendered more positive and emotionally engaging processing as suggested by anterior singulate and left insula activation. In stark contrast, dissonant leaders appeared to disengage the default mode network and engage negative emotional response as indicated by bilateral insula and frontal gyrus activation and negative activation of posterior cingulate cortex, as well as emotion regulation processing. This is consistent with an avoidance frame of mind, as the individual focuses his or her attention inward to contain and make sense of a painful experience. In addition to its neural focus, this study contributes to an important shift in leadership research in recent times toward understanding the deeper level effects of leaders on followers (Howell & Shamir 2005).

Along this same line, Molenberghs et al.'s (2015) recent study investigated follower responses to inspirational leadership. Participants were presented with inspirational (collective-oriented) and noninspirational (self-oriented) statements by ingroup and outgroup leaders. The results from fMRI data indicated that followers showed greater semantic processing when ingroup leaders delivered inspirational messages and when outgroup leaders delivered noninspirational messages. This greater semantic processing activated areas of the brain associated with cognitive control, working memory, and emotion (ventral prefrontal lobes and inferior parietal lobes), and suggested that participants paid greater attention and assigned greater meaning to these messages. The authors suggest that these messages resonated more readily with followers (positively for ingroup leaders and negatively for outgroup leaders) because the message aligned with their expectations. When ingroup leaders delivered noninspirational, self-aggrandizing messages, followers showed greater activation in brain areas associated with cognitive deliberation, suggesting that they were evaluating the leader's intentions. In contrast, followers seemed to largely ignore inspirational messages from outgroup leaders. These findings shed new light on leadership by reinforcing the role of social identity in leadership (Hogg 2001). Furthermore, it seems that one cannot become a transformational leader by words alone and that transformational leaders who are inconsistent, which produced strong response in followers, are not likely to be seen as transformational for long.

A related study by Jack et al. (2013) explored with fMRI the brain-level effects of different coaching styles on mentees. They compared inspirational coaching (i.e., positive emotional attractor), which focuses on internal aspirations and strengths, with noninspirational coaching (negative emotional attractor), which focuses on external standards and weaknesses. The study involved coaching sessions, outside and inside the scanner, by the same coach. The results from the sessions inside the scanner indicated that inspirational coaching triggered increased brain processing in areas associated with mental visioning, global processing, an approach mindset, and increased social and emotional openness to the coach (i.e., activation in the bilateral occipital and posterior temporal lobes). Noninspirational coaching, in contrast, produced sympathetic nervous system arousal and greater activation in brain regions associated with negative affect (insula), narrowed attention/local processing, and avoidance motivation (prefrontal asymmetry). Therefore, the coaching approach that was utilized had profound effects on the brain areas and networks that were activated in the mentoree. These findings contribute to traditional research showing the benefits of positive coaching by providing brain mechanisms for established approaches and constructs in the coaching literature (Luthans & Youssef 2007, Sue-Chan et al. 2012).

In three ON studies not involving leadership, researchers applied fMRI to organizational justice. In the first study, Dulebohn et al. (2009) investigated whether procedural and distributive justice are distinct constructs, which had been the subject of debate in the literature. In a sample of undergraduates, the researchers found that although exposure to procedural and distributed justice shared some common neural processing, there were also significant differences. Distributive injustice produced neural processing associated with a strong emotional response (i.e., amygdala and insula portions of the brain) and subsequent cognitive conflict (prefrontal cortex and anterior cingulate cortex). In contrast, procedural justice produced patterns consistent with social evaluation and suppression of negative emotion (i.e., striatum and ventrolateral prefrontal cortex). These findings provided new insight into the mechanisms behind response to injustice and additional support to the notion that procedural and distributive justice represent related, but distinct, constructs (Colquitt et al. 2001). This study suggests that although both produce similar negative reactions, distributive injustice triggers greater cognitive deliberation, as compared to procedural injustice.

In a study of strategic decision making, Laureiro-Martínez et al. (2015) investigated the neural processing underlying exploitation and exploration decision making under conditions of uncertainty. In this study, experienced managerial decision makers made repeated decisions between exploitation (choosing the same as last time) and exploration (making a different choice from the previous trial). fMRI imaging results showed that exploitation decisions were associated with areas of the brain that have been previously associated with reward seeking (i.e., dopaminergic regions of the medial prefrontal cortex), whereas exploration was associated with other areas of the brain (i.e., anterior cingulate cortex, insula, and parietal lobes) that are indicative of executive control processing (i.e., attention, working memory, and deliberation). In addition, decision-making performance was not related to the number of exploration or exploitation choices, but rather knowing when to switch between the two, which activated a different network of brain regions (i.e., polar cortex, intraparietal sulcus, and ventromedial prefrontal cortex). In essence, successful managers used neutrally based, executive control to stick with lucrative options, despite a single setback, and to switch away from unfavorable options, despite a lucky payoff. Once again, exploration and exploitation are familiar concepts in organizational research (Gupta et al. 2006), and adding a neuroscience perspective helps to understand the mechanisms at work in the brain behind behaviors and attitudes, while also suggesting new insights for improving managerial performance. Indeed, Laureiro-Martínez et al. (2015) suggest training to improve cognitive control, while also highlighting common organizational conditions that might impair or deplete executive functioning in the brain.

Kim & James (2015) used fMRI to investigate the relationship between reflexive differences in emotional suppression and aggression, a facet of counterproductive work behavior (James & LeBreton 2010). Data were collected from participants using online surveying to assess five types of aggressive behavior from the participant and a significant other. Subsequently, during an fMRI session, participants were instructed to passively watch a set of pictures or to suppress their emotions while viewing the images. After viewing the images, participants then reported the intensity of their felt emotion. Kim & James (2015) found a significant correlation between aggression toward inanimate objects and neural activation in the brain associated with the experience and suppression of negative emotion (i.e., calcarine sulcus, insula, and cingulate cortex). These results suggest that the suppression, rather than the experience of negative emotions, primed aggressive behaviors, and the findings emphasize the potentially negative consequences of superficial—and unsuccessful—emotion regulation by managers and employees in organizations.

## 2.6. Moderators in Reflexive Studies

In addition to purely reflexive assessments in research, fMRI has also been used to explore how traits moderate reflexive brain processing (in reaction to stimuli) using traditional measures of individual differences. It would be possible and promising in the future to use neuroscience measures of intrinsic differences, such as those yielded by EEG, as moderators of reflexive brain processes. However, for now we illustrate the potential of such approaches by reviewing three studies that used more traditional, individual difference variables.

In the first study, Bagozzi et al. (2013) investigated the reflexive brain processing of Machiavellians. Participants were boundary spanning employees recruited from a university management training institute. After completing a self-report scale of Machiavellianism, they participated in two scanning sessions. The first investigated theory of mind, and the second investigated emotional empathy. The results suggested Machiavellianism as a moderator of the neural reactions to stimuli. Specifically, participants used mentalizing, which involved inferring and modeling the thoughts, feelings, and behavior of others through one's own perspective, to understand why characters in a story interacted in particular ways. In response to the stimulus, participants who were high in Machiavellianism showed reduced activation of regions of the brain associated with theory of mind processing (medial prefrontal cortex, temporoparietal junction, and precuneus). This means that in response to a stimulus involving listening to stories that require mentalizing, those individuals with a higher level of Machiavellianism were less able to think through the actions of others. In the second study, while viewing video clips of male and female faces that displayed a variety of emotions (anger, disgust, happiness, and surprise), those high in Machiavellianism showed greater activation in brain regions associated with perceiving emotions in others (pars opercularis and insula). These results show that Machiavellianism moderates the relationship between stimuli (facial expressions of emotions) and the neural response to those stimuli. The authors suggest that the results indicate that Machiavellian managers are better able to read the emotions of their employees, but that they processed these emotions less deeply and are less likely to internalize them. These findings help to explain how Machiavellians are often able to achieve greater performance, but perhaps at the cost of abusive supervision and unethical behavior (Dahling et al. 2014, Martinko et al. 2013).

Second, and in a follow-up to their earlier work (i.e., Dulebohn et al. 2009), Dulebohn et al. (2015) used fMRI imaging to investigate gender differences in how men and women process and respond neurologically to procedural and distributive justice stimuli. Their findings suggested that females automatically paid greater attention to procedural justice than did males. Furthermore, this increased processing in the salience system which comprises automatic processing that directs attention to self-relevant stimuli (including the anterior insula and anterior cingulate cortex) was associated with distinct behavioral responses in females. Similar processing and behavioral responses were not observed in men. In addition, females showed greater processing in the introspective system (including the dorsal medial prefrontal cortex and the cingulate cortex) than did males when evaluating distributive justice. This pattern of findings suggests that they assessed the instrumental and relational outcomes between themselves and others more than males did. In early trials, females were also more likely to reject unfair offers, but this tendency subsided as the experiment proceeded. The authors argued that females likely learned to suppress their desire to reject moderately unfair offers on relational grounds in order to obtain greater instrumental outcomes. These findings are consistent with the notion that females naturally tend to be more comprehensive and relational processors of justice information (Lee et al. 2000). Furthermore, by examining the neural underpinnings of this behavior, we can better understand mixed findings in the literature by illuminating important moderators and temporal progression of the behaviors in question. The findings of this study can also help to design better policies and training to help managers maintain fair work environments (Cohen-Charash & Spector 2001).

Third, in a team-based study, Stevens et al. (2012) used qEEG to collect data to model team-level engagement and analyze its relationship to team performance in a naval (submarine) setting. During a navigation task (the stimulus), qEEG measures of engagement fluctuated over periods of seconds to minutes. The focus of this study was on how neural network activation associated with engagement was synchronized among team members, and how that synchrony changed over segments of time called epochs. As measured by qEEG, engagement correlated with worse team performance, as indicated by delays in determining the position of the team's submarine. More experienced submarine navigation teams showed more cognitive flexibility in demonstrating more varied engagement patterns. Thus, experience moderated neural responses to stimuli present in the navigation task that was used in the experiment.

Taken together, our review of existing studies shows that fMRI may be useful, but somewhat limited to an examination of individuals and reflexive brain differences. qEEG, however, can be employed to explore phenomena at both individual and team levels, examining both intrinsic and reflexive brain differences. Other technologies, such as diffusion tensor imaging, have yet to be used in ON research, but hold intriguing potential for investigating intrinsic brain differences that may not be readily explored with qEEG (Park & Friston 2013).

## 3. RESEARCH CHALLENGES AND EMERGING DIRECTIONS

Prior work has laid out a comprehensive framework of promising research directions and topics for organizational scholars (e.g., Waldman et al. 2016a). Therefore, in this section we consider three emerging challenges and directions with regard to the incorporation of neuroscience in organizational research. They include (*a*) considerations of the theoretical basis of neural concepts and measures, (*b*) the communication of technical concepts to an audience of organizational researchers and practitioners, and (*c*) the use of team-based, neuroscience technologies.

### 3.1. Identifying a Theoretical Basis for Neural Concepts and Measures

When an organizational researcher enters the neuroscience realm, he or she encounters a new world of concepts and measures. As Balthazard & Thatcher (2015) outline, depending on the technology that is used to scan the brain, these variables can involve changes in blood flow and/or electrical activity in particular regions of the brain. Regarding the latter, the sheer amount of electrical energy can be considered, as well as connections between regions. To make matters more complex, electrical activity occurs in different bandwidths. As a result, neurological scanning can yield literally thousands of variables that can potentially be assessed on a second-by-second basis.

With such a myriad of possibilities, it is not surprising that an organizational researcher seeking to enter the neuroscience realm might be overwhelmed with the possibilities. Although a researcher could randomly search for relationships between neurological variables and organizational constructs of interest (e.g., leadership behavior), such a search would essentially amount to the proverbial fishing expedition. With so many possibilities in terms of variables to explore, it is inevitable that significant relationships would be found based solely on chance. Accordingly, as in other organizational research, we recommend attempting to provide a theoretical basis as to the choice of neurological variables that one might incorporate. Most of the studies reviewed here did just that and made theoretical predictions regarding specific types of brain processing. For example, Bagozzi et al. (2013) looked at specific regions associated with theory of mind and empathy processing.

But what might that basis entail? As revealed in Section 2 of this review, the limited research to date in ON does not provide an extensive foundation to which a researcher might refer. Thus, we recognize the challenge facing organizational researchers who attempt to incorporate neuroscience into their research. As an alternative to relying on existing ON research, one potential strategy is to extrapolate from existing areas of the broader and more longstanding domain of social cognitive neuroscience. Waldman and colleagues have taken such a strategy in their research connecting neuroscience concepts to leadership processes (e.g., Hannah et al. 2013; Waldman et al. 2011, 2016b). They referred to research in existing, social cognitive neuroscience literature dealing with such relevant topics as emotions, perspective taking, moral reasoning, and complexity. Similarly, we recommend that organizational researchers continue to extrapolate from existing neuroscience literatures as a more solid and direct foundation is built in ON.



## 3.2. Communicating to an Organizational or Management Audience

As with other disciplines, neuroscience is fraught with its own language and jargon. These terms refer to various regions of the brain, scanning techniques, and potential variables of interest. In addition, a common technique in reporting neuroscience-based findings is to visually or graphically depict a variable of interest (e.g., blood flow or electrical energy) in one or more brain regions. However, to the typical organizational or management researcher/practitioner, the terminology and graphical depictions can easily seem overwhelming.

We see at least three commonsensical solutions to this challenge. First, researchers need to navigate a balance between providing enough technical detail, versus providing unnecessary detail for an organizational/management audience. Second, as compared to a neuroscience scholars, organizational/management researchers and practitioners will require more rudimentary explanations. Third, more technical detail could be placed in the appendix of an article. In sum, although communication challenges exist, with proper consideration of the typical readership, they can be minimized.

## 3.3. Beyond Individual-Level Assessment: Emerging Team-Based Technologies

Neuroscience has traditionally been based on the consideration and assessment of individuals. This is the case for various scanning technologies, such as fMRI and qEEG. Although the assessment of individuals is certainly pertinent to organizational researchers, organizationally relevant phenomena also occur in higher-level entities, such as teams. In fMRI, hyperscanning enables the simultaneous scanning of multiple participants, and recently, Healey & Hodgkinson (2014) predicted that it would soon be possible to simultaneously assess multiple individuals, for example, in a team setting. In turn, it would be possible to better understand the neurological basis of interpersonal phenomena in organizations. Along similar lines, George et al. (2014, p. 325) prognosticated how "big data" could potentially be used to analyze "team behavior, using sensors . . . to track individuals as they work together . . . , or spend time interacting." The sensors to which George et al. (2014) referred could include neurologically based sensing or scanning devices.

In actuality, the ideas Healey & Hodgkinson (2014) and George et al. (2014) presented are available today and are already offering some interesting possibilities. For example, as reviewed above, Waldman et al. (2015b) noted that traditional methods for assessing team aspects (e.g., team processes and emergent states) are inherently problematic and limited. Their study included the use of qEEG in a team setting to assess member arousal or attentiveness. Future work might use equipment as shown in **Figure 1** to assess other aspects of team processes or emergent states, such as positive/negative affect and interpersonal conflict, among others.

## 4. PRACTICAL IMPLICATIONS

An understanding of the neural processes that underpin organizational behavior may contribute to the design of better management policies and training programs. With regard to enhancing training and development, qEEG may be especially applicable because of its portable nature and potential for real-time feedback. qEEG technology is already being applied to leadership development to help executives remain calm in stressful situations (Kershaw & Wade 2011). Waldman et al. (2011) considered how qEEG and neurofeedback could be combined to potentially enhance aspects of transformational leadership, such as socialized vision. To date, this type of training has resided primarily within commercial enterprises, such as Advanced Brain Monitoring, Inc. (**http://advancedbrainmonitoring.com**). But in the future, we expect academically based applications to emerge, such as neurofeedback to improve the leadership skills of MBA students.

In addition to more positive applications, such as helping to identify and develop organizational leaders, ON research could be utilized to identify dangerous organizational members. As Bagozzi et al. (2013) show, Machiavellian employees can negatively affect the well-being of subordinates and peers. More broadly, so-called dark triad traits (narcissism, Machiavellianism, and psychopathy) have been linked to counterproductive work behavior and low job performance (O'Boyle et al. 2012), although at least some research would suggest a silver lining for narcissism in relation to performance outcomes (Owens et al. 2015).

Even more worrisome, corporate psychopaths not only impact the well-being of coworkers, they also expose the organization to costly moral hazard and even workplace violence (Boddy et al. 2010). Indeed, the proportion of psychopaths appears to increase at higher rungs of the corporate ladder (Dutton 2012). Brain imaging could ultimately provide the most reliable means of identifying truly psychopathic individuals before they reach senior leadership positions (Anderson & Kiehl 2012). Even, those who exhibit lesser degrees of dark triad tendencies would still certainly benefit from reflection and training, such as neurofeedback approaches (Waldman et al. 2011), before moving forward in their careers. We believe that this would help individuals themselves, as well as protecting coworkers, thus benefitting the long-term performance and interests of the organization.

A third area where ON can have important practical implications is the identification of entrepreneurial talent. There are many unanswered questions regarding the process of starting an organization and the qualities and performance of entrepreneurs who identify, evaluate, and exploit opportunities (Shepherd 2015). Neuroimaging may help identify neural profiles across different types of entrepreneurs who are adept at evaluating opportunities. For example, the ventromedial prefrontal cortex is important to the emotional processing involved in assessments of probable rewards for future behaviors (Purves et al. 2008). Given brain plasticity, neurofeedback could be used to train entrepreneurs in opportunity evaluation. Thus, ON can have some important practical applications at the outset or establishment of firms.

The work of Waldman et al. (2015b) points to yet another practical implication of the research reviewed here. The team-based, qEEG technology that they used could help managers to better understand how their verbal and nonverbal communication could have an effect, either positive or negative, on the teams that they lead. For example, certain forms of communication, such as communication with strong social responsibility content, may cause team members to become more aroused or engaged (Waldman et al. 2006). By employing qEEG technology in at least some team activities, managers might be coached to use certain forms or content of communication and to avoid others. The type of technology **Figure 1** portrays is progressing to the point of being both comfortable and nonobtrusive, thus allowing for more practical applications in teams.

## 5. CLOSING THOUGHTS AND CONCLUSIONS

In this concluding section, we consider several issues that researchers and practitioners will need to keep in mind as work in the ON area moves forward. These issues include (*a*) an understanding of the relevance of neural phenomena in the greater context of organizational behavior, (*b*) ethical concerns, (*c*) ON and its place in management/organizational journals, and (*d*) how researchers can get involved in ON research.

### 5.1. Excessive Reductionism and the Role of Context

An assumption of much of the research summarized in this review is that behavior in organizational settings can essentially be reduced to the neurons in the brains of organizational members. Indeed, although early basic neuroscience could be interpreted in this way, even early conceptual or thought pieces in the relatively brief history of ON cautioned that existing technologies were not capable of reducing behavior to the neuron level (e.g., Becker et al. 2011). Furthermore, Waldman et al. (2015a) cautioned ON researchers against engaging in excessive reductionism. Their cautioning was inspired by the work of Lindebaum and colleagues (Lindebaum & Jordan 2014, Lindebaum & Zundel 2013) that raised doubts about the extent to which complex aspects of organizing could be reduced to neurons or brain regions of individual organizational members. Lindebaum & Zundel (2013, p. 871), however, also stated that "the brain unquestionably plays an important role . . . [although] it may not always be the starting point triggering human behavior." To the contrary, although behavior certainly has its origins in specific neural networks, it will be many years before researchers will be able to understand the full complexity of the human brain. Of course, this does not take away from the utility of exploring the regions and networks of the brain to further organizational and management theory.

Healey & Hodgkinson (2014, 2015) put forth what could be viewed as a measured approach for dealing with the potential problem of excessive reductionism. Specifically, they posed what they termed a socially situated perspective of how neurological phenomena might contribute to—but at the same time interact with—contextual variables, with regard to our understanding of management and organizational processes. In essence, they suggested that organizational members exist in a social context in which cognition, emotion, and behaviors are largely shaped by neurological processes, but those processes can also be shaped recursively by an ongoing, dynamic context. As Waldman et al. (2015a) note, arguments along these lines actually follow from Bandura's (1999) social cognitive theory of personality, which emphasizes the interaction of individuals' traits, social learning, and the environment with regard to predicting behavior and outcomes.

Waldman et al. (2015a) also suggested that Healey & Hodgkinson's (2014, 2015) socially situated perspective could be combined with the attraction-selection-attrition model that was originally put forth by Schneider (1987). Thus, it may be possible that individuals with certain intrinsic brain structures tend to be attracted to, selected by, and retained in an occupation or organization when those structures are aligned with others (Schneider 1987, Schneider et al. 1998). That is, certain brain structures encourage specific types of cognition, which in turn, cause people to be attracted to, selected by, and retained in occupations or contexts that are compatible with those brain structures. It also follows that the intrinsic brain structures of individuals may be conditioned over time to adapt to their contexts, which then furthers their possible retention in those respective contexts. In short, although recognizing that the brain can affect behavior within a context, at the same time, the context can also have substantial effects on individuals' brains—both reflexively, as well as in terms of intrinsic brain structures.

Societal culture may represent a special application of the socially situated perspective. Most of the research summarized in this review occurred within Western societies, and predominantly the United States. However, the socially situated perspective would suggest that the intrinsic structures of individuals' brains may be affected by societal context; and moreover, reflexive activity of individuals' brains to various stimuli could be in part determined by one's societal context. Such possibilities could prove to be fertile ground for future research.

## 5.2. Ethical Concerns

With any physiological measure, including neurological assessment, ethical concerns readily come to mind. For ON researchers, data collection and storage issues are relevant. Regarding the former, both fMRI and qEEG do not involve any notable health risks as part of data collection processes. However, fMRI can seem confining to some participants, which at a minimum, could cause discomfort. In terms of data storage, researchers need to be particularly in tune to confidentiality issues, although perhaps the same can be said for other, sensitive measures that might be assessed (e.g., sexual preferences and attitudes).

The practical implications that we pointed out above could make for even more controversial ethical concerns. For example, based on the type of intrinsic neural research reviewed above, it could be possible for organizations to attempt to screen individuals for job positions on numerous neural measures indicative of cognitive, emotional, or behavioral tendencies. The ethical basis of forcing a job applicant to submit to such screening, however, or the subsequent storage and use of neural data, certainly can raise ethical concerns in terms of employee selection or placement.

Furthermore, the type of neuroenhancement techniques that we have described (e.g., neurofeedback) might also be problematic. On the one hand, we acknowledge the lamenting of Lindebaum (2013, p. 298) who characterized neurofeedback as potentially "dehumanizing," and also queried "who possesses the moral and ethical authority to stipulate what a socially desirable brain profile might be or look like?" (Lindebaum 2013, p. 300). On the other hand, we purport that ethical considerations are assuaged if the goal of neurofeedback is to make leadership qualities that are known to foster effectiveness (e.g., transformational leadership qualities) more likely, participants are fully informed as to the cognitive or behavioral changes that may occur, and the neural data that are yielded by the process remain confidential. Our viewpoint was recently backed by Ashkanasy et al. (2014).

## 5.3. Professional Considerations of Organizational/Management Researchers

We fully recognize that the training, experience, and background of most organizational/management researchers are far afield from neuroscience. Even if a desire to be involved is present, using the classic approach-avoidance conflict, researchers will likely find more reasons to avoid, rather than approach. With that said, however, in this final section, we provide some observations and insights that might push the pendulum more toward approach for researchers who have not heretofore considered neuroscience in their own research programs.

First, we recognize the need for researchers to publish. For organizational/management researchers, that means organizational/management/applied psychology journals, rather than neuroscience-based journals. In our experience, and in our communication with the editors of the former category of journals, there do not seem to be any inherent barriers to ON research. Rather, the articles overviewed in this review would point toward the contrary. One issue with which editors must deal is finding appropriate reviewers. However, as time goes on, and more ON researchers emerge, this issue will become less of a concern.

Second, we recognize that the costs associated with neuroscience research may seem daunting. Traditional approaches of management/organizational researchers (e.g., surveys, interviews, and lab experiments) are relatively inexpensive compared to neural methods, which often require significant equipment and software investment (Waldman et al. 2015a). To offset these costs, researchers may need to seek external funding, share the financial burden between universities and associated departments, etc.—all of which they may be unaccustomed to doing. With all of this in mind, the good news is that much of the research that we highlight, in particular research involving qEEG technology, is relatively inexpensive. And as with other technological innovations, the costs are progressively decreasing over time.

A final issue involves research collaboration. As noted above, most researchers in management or the organizational sciences neither are trained nor have experience in neuroscience. As such, in line with suggestions put forth by Waldman (2013), we recommend that interested researchers seek out collaborators who have in-depth knowledge of neuroscience theory and methods. Given the presence of university silos (i.e., departmental/college structures), it is not common to see interdisciplinary collaborations. As an alternative, we recommend reaching out to commercially based, neuroscience organizations that incorporate the scientist/practitioner model in their business operations. Some of the research reviewed here has relied on such collaborations between academics and neuroscientists who operate outside of universities.

In conclusion, empirical research in organizational neuroscience has progressed over the past decade. Numerous examples depicting how neuroscience can contribute to our understanding of management and organizations are now present in our top journals. Given the increasing interest among management and organizational researchers, coupled with advancing technology and lower costs, we expect this trend to continue into the future. Moreover, we expect to see interesting and beneficial practical applications based on this growing body of knowledge. Rigorous research and thoughtful practical applications of organizational neuroscience present challenges, but at the same time, we foresee it to be a growing area for impactful future work.



## DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

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Annual Review of Organizational Psychology and Organizational Behavior

Volume 4, 2017

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## Errata

An online log of corrections to *Annual Review of Organizational Psychology and Organizational Behavior* articles may be found at http://www.annualreviews.org/errata/orgpsych