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The Added Value of Neuroscience Methods in Organizational Research

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Abstract

Historically, the lack of availability and prohibitive expense of brain imaging technology have limited the application of neuroscience research in organizational settings. However, recent advances in technology have made it possible to use brain imaging in organizational settings at relatively little expense and in a practical manner to further research efforts. In this article, we weigh the advantages and disadvantages of neuroscience applications to organizational research. Further, we present three key methodological issues that need to be considered with regard to such applications: (a) level of assessment, (b) intrinsic versus reflexive brain activity, and (c) the targeting of brain region(s) or networks. We also pose specific examples of how neuroscience may be applied to various topical areas in organizational behavior research at both individual and team levels.

Keywords

neuroscience, individual characteristics, teams

Until recently, little systematic attention has been paid to the human brain in organizational research other than to suggest metaphoric representations of cognitive structures that occur in one's mind, such as schemas that individuals might use as they process information (e.g., Lord & Maher, 1991). However, the study of cognition is not the study of cognitive neuroscience per se. The latter is considered an interdisciplinary area focused on understanding people's thoughts, emotions, and behavior by associating brain functions/structures with people's cognitive processes (Gazzaniga, 2004). This association involves neuroscanning or neurosensing technologies, such as functional magnetic resonance imaging (fMRI) and quantitative electroencephalogram (qEEG), respectively.

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Indeed, the potential application of such technologies to organizational research has been the subject of several recent review articles (Ashkanasy, Becker, & Waldman, 2014; Becker, Cropanzano, & Sanfey, 2011; Senior, Lee, & Butler, 2011; Waldman, Balthazard, & Peterson, 2011b) and a book (Waldman & Balthazard, 2015). While recent work has yielded some general insights for organizational researchers, we argue that it has not gone far enough to provide specifics for why or how researchers can get into the game, so to speak. In a nutshell, our goal is push the "approach-avoidance" continuum more toward approach and less toward avoidance in the minds of organizational researchers as they consider neuroscience applications to their own research endeavors.

We argue that the time is right for such applications. Neuroscience methods, especially those associated with EEG technology, are becoming more user-friendly, affordable, and practical for organizational research. Moreover, researchers are finding that quantified variables can be gleaned from neuroscience methods that can be readily used to complement the types of traditional variables and techniques (e.g., surveys) with which organizational researchers are accustomed (Hannah, Balthazard, Waldman, Jennings, & Thatcher, 2013; Waldman et al., 2011b).

Further, traditional research in organizational behavior is somewhat limited in terms of how constructs can be considered or measured or the variance for which they may account in important outcomes. In other words, the methodologies that form the mainstay of the organizational researcher's toolbox (e.g., surveys, observation, interviews, etc.) could use some new, or at least complementary, possibilities (Bono & McNamara, 2011). In short, we need new ways of considering or measuring many of the constructs in organizational behavior, and at least to some degree, neuroscience may help. On the other hand, we make no argument here that neuroscience methods might somehow replace more traditional approaches. To do so would be akin to the proverbial "throwing the baby out with the bathwater" (Ashkanasy, 2013, p. 311).

Moreover, we are cognizant of the image of organizational research in the eyes of the public, the media, and individuals who we enlist in our research as participants. Our continued overreliance on methodologies such as surveying might prohibit us from conducting more interesting and novel research (Colquitt & George, 2011). Could neuroscience help serve to build a more innovative and exciting image? We make no claims that it is a panacea, but our own experience would suggest an abundance of popular media interest (e.g., Blackman, 2014; Markowitz, 2013) as well as excitement on the part of potential research participants. Overall, it would appear that the world outside of organizational academics, or so-called real world, is ready for neuroscience applications. Obviously, it is possible for the real world to accept unscientific ideas, and thus, its readiness is not a reason in and of itself to embrace neuroscience methods. But at the same time, the importance of such a positive reception should certainly not be written off as unimportant or irrelevant.

With all of that said, the goals of the current article are threefold. First, we will weigh the advantages versus potential disadvantages of incorporating neuroscience methods in organizational research. Second, we will describe three key methodological issues that need to be considered in terms of neuroscience applications. Third, examples of recent research will be described, and we will consider several constructs and topics in organizational behavior (OB) that represent prototypical candidates for future research using neuroscience methods. We conclude with further considerations pertaining to research agendas and strategies.

Weighing the Pros and Cons of Neuroscience Applications

Following from the work of Powell (2011) and Senior et al. (2011), we see three key advantages of applying neuroscience to organizational research: (a) a better understanding of the ontological basis of constructs of interest, (b) creating more precise or enhanced measurement, and (c) enhancing the ability to predict important organizational phenomena. Although the second advantage is most directly tied to methodology per se, in the following, we examine each of these advantages and how they could apply to some important topical areas in organizational research.

The work of Hannah et al. (2013) provides an example of how these value-added advantages can come into play in organizational research. The goal of Hannah et al. was to form a better understanding of how leader qualities might predict adaptive decision making, which they defined as "solving problems creatively, dealing with changing, uncertain, or unpredictable work situations, and handling emergencies or crisis situations" (p. 395). The primary predictor of adaptive decision making in their research was leader complexity, which they operationalized psychometrically in terms of leader self-complexity. However, in order to more fully understand the nature and role of complexity, the authors also examined neurologically based conceptualizations. In turn, this led to a neurological operationalization of leader complexity that correlated moderately with their psychometric measure. Further, in the prediction of adaptive decision making, the neural-metric measure added unique variance. In short, this study shows how an understanding of an important construct (i.e., leader complexity) could be enlarged by neurological considerations, the measurement of that construct could be broadened, and by including neurological measurement, the prediction of an important outcome (i.e., adaptive decision making) could be enhanced.

Ecological validity represents an additional advantage of neuroscience methods. In simple terms, the assessment of the brain (i.e., through scanning or sensing technologies) cannot lie, fake, or be prone to the myriad of biases/errors that affect psychometric approaches to measurement. At the same time, we acknowledge potential threats to internal validity that are posed by instrumentation biases. For example, we recognize that putting an EEG headset on research participants could induce behavior that is unrelated to the task at hand (e.g., giggling, self-awareness regarding one's appearance with the headset, etc.), thus potentially damaging research objectives. However, in our experience, at least after a few minutes, issues along these lines seem to largely disappear, and participants become absorbed in the task at hand. Moreover, as will be shown and described further in the following, such technology is increasingly unobtrusive, and research participants may soon be able to wear virtually undetectable neurosensing devices (George, Haas, & Pentland, 2014).

We have made a case for the potential added value of neuroscience methods in organizational research. Nevertheless, following the cautionary writing of Waldman, Balthazard, and Peterson (2015), it is prudent to acknowledge two important considerations as such applications move forward in the future: (a) the potential for excessive reductionism and (b) ethical concerns. Lindebaum and colleagues have recently expressed skepticism regarding neuroscience applications to organizational research, and a key concern on their part is that complex, organizational phenomena cannot be readily reduced to neurons or clusters of neurons (i.e., brain regions) (Lindebaum & Jordan, 2014; Lindebaum & Zundel, 2013). The essential notion in these critiques is that brains per se do not perceive, feel, behave, or interact. Instead, whole people and groups of people are responsible for organizational behavior (Powell, 2011). It follows that attempts to connect neurological activity to organizational phenomena, especially at higher levels of analyses (e.g., leadership and team processes), can be difficult, if not unrealistic.

Healey and Hodgkinson (2014) provided a reasoned or measured approach for dealing with the reductionism issue. Specifically, using what they termed a *socially situated perspective*, these authors lay out a balanced argument of how neurophysiological processes play a contributory but not all-encompassing role in organizational processes. Healey and Hodgkinson essentially considered how neurophysiological activity operates in social contexts in which higher-order psychological phenomena (e.g., cognition and emotions) and behaviors may to some degree be shaped by neurological processes of individuals. However, at the same time, such processes can also be molded in a recursive manner by the context of those individuals. Thus, there is a dynamic, recursive, and ongoing interaction between individuals, their neurological processes, and the greater organizational context.

The socially situated perspective is in line with both the reflexive/mirroring and intrinsic (or at rest) brains of individuals. That is, the brain may react reflexively to one's organizational context (e.g., leadership behavior that is shown to an individual). However, the ongoing, intrinsic brains of individuals may help determine behavior or qualities (e.g., leader complexity; Hannah et al., 2013). Moreover, based on the concept of brain plasticity (Hanslmayer, Sauseng, Doppelmayr, Schabus, & Klimesch, 2005; Monastra, 2003), it may be possible that the intrinsic brains of individuals could be molded over time by their organizational contexts. All of these possibilities are in line with the socially situated perspective put forth by Healey and Hodgkinson (2014).

As an additional concern, we suggest that organizational researchers who use neuroscience methods will need to pay close attention to what has been termed *neuro-ethics* (Marcus, 2002; Roskies, 2002; Wolpe, 2004). Neuro-ethics involves the implications of increasingly accessible neuro-techniques for both research and practice. First, there are issues of privacy and confidentiality. Although such issues pertain as well to more traditional, sensitive data that organizational researchers might collect (e.g., sexual preference, ratings of one's boss, etc.), the biological nature of neurological data makes their safeguarding on the part of researchers all the more important. Care will be especially needed to safeguard the storage of neurological data. While some researchers might worry about the approval of institutional review boards, our own experience would suggest that such approval is not a significant issue as long as confidentiality and informed consent are obtained.

Second, we submit that the ethical norms involved in doing organizational neuroscience research may differ from those pertaining to other forms of organizational research and should be guided by the possible benefit to others as determined by existing structures such as IRBs *and* a study's participants. For example, in the medical field, it may be acceptable to implant electrodes into patients' brains when there is likely a clinical benefit to others, the medical IRB has approved, and the participants have also approved, since there is a clear upside for them as well (Cerf et al., 2010; Pedreira et al., 2010). Third, it is always possible that as a result of a neurological assessment for research purposes, neural-based pathology of a study participant could be uncovered inadvertently. It is not altogether clear as to how, or even whether, such pathologies should be reported to participants. If such issues are discovered serendipitously as part of organizationally focused research, do the researchers have a moral obligation to report potential medical or pathological issues to research participants or even their employers (e.g., in instances where firms supply the participants)? Questions of this nature will become even more relevant over time.

In sum, while we recognize the potential limitations or cautionary issues surrounding neuroscience methods, we also believe that there are clear advantages to incorporating them in organizational research. In the next section, we overview some key issues that will need to be considered as research moves forward.

Neural Assessment Considerations in Organizational Research

Detailed descriptions of prominent neuroscience technologies (e.g., qEEG or fMRI) and their potential applicability to organizational research are available elsewhere (Balthazard & Thatcher, 2015; Waldman et al., 2011b). Our goal here is not to address or describe the details of those technologies per se. Instead, we overview more generic considerations, specifically: (a) how assessment can occur at either the individual or team level, (b) how assessment can target ongoing or intrinsic brain activity versus more reflexive brain activity in reaction to stimuli, and (c) the identification of relevant brain region(s). After presenting these considerations and illustrative research to date, we will consider examples of organizational constructs and issues to which neuroscience methods might be readily applied.

Individual Versus Team Assessment

Scanning or sensing technologies are at the core of neuroscience-based research methods. As mentioned previously, qEEG and fMRI have been prominent in organizational applications in recent years (e.g., Boyatzis et al., 2012; Hannah et al., 2013; Molenberghs, Prochilo, Steffens, Zacher, & Haslam, in press; Waldman et al., 2011a). Perhaps the typical conception that one might have of a brain scanning or sensing process is that it is applied to a single individual. Because of the nature of the machinery and technology, fMRI would most likely be limited to a laboratory setting, while qEEG is more portable and thus could be used more practically onsite in organizations. Nevertheless, based on past experiences and the nature of available technologies, either technology would seem to be only applicable to individual assessment in a serial manner (i.e., one individual participant followed by another).

With that said, Healey and Hodgkinson (2014) prognosticated that "it will soon be possible for researchers to scan the brains of multiple actors engaged in a wide variety of social activities, including those of the workplace" (p. 783). They went on to suggest that neuroscience methods could be used specifically to better understand interpersonal phenomena in organizations, such as consensus building, conflict, emotional contagion, and so forth. In a similar vein, George et al. (2014) described in futuristic terms how "big data" could potentially be used to analyze "team behavior, using sensors ... to track individuals as they work together ... or spend time interacting" (p. 325). George et al. further suggested that at some point in the future, big data could be seen as an alternative to more traditional techniques (e.g., observation and surveys) to produce real-time data pertaining to team dynamics.

Prognostications aside, the future to which Healey and Hodkinson (2014) and George et al. (2014) referred is, in reality, occurring now. That is, the type of futuristic technology that they envisioned is actually available now and has already demonstrated promising results. Specifically, Waldman, Wang, Stikic, Berka, and Korszen (2015) noted that traditional methods for assessing team processes and emergent states (e.g., surveys) are inherently subjective and are generally used during team downtime or after teams have been disbanded. As an alternative, it is possible to observe or videotape teams in real time. However, some observations (e.g., the extent to which individuals are truly engaged in a team process) can be difficult, prone to observer biases, and simply unreliable. Waldman, Wang, Stikic, et al. (2015) used wireless qEEG technology to simultaneously assess multiple team members in real time as they solved a case problem as a team (see Figure 1). The goal of their research was to understand the effect of leader communication on team engagement. They showed that individuals who were emergent leaders were able to generate more (neurologically assessed) engagement on the part of other team members when the leaders spoke during team meetings. In comparison, team members who were not seen as emergent leaders did not generate as much engagement when they spoke.

In their work, Waldman, Wang, Stikic, et al. (2015) assessed emergent leadership following a 45-minute team problem-solving task using a traditional survey measure. Neurologically assessed engagement was based on qEEG power spectral density (PSD) that could be measured on a millisecond basis and thus yields the type of big data described by George et al. (2014). As a measure of engagement, it had been previously associated with processes involving information gathering and sustained attention or alertness to both auditory and visual stimuli (Berka et al., 2004, 2005; Westbrook et al., 2004) and to identify individual differences in susceptibility to the effects of sleep deprivation (Berka et al., 2005). This neurologically based measure of engagement uses PSD variables along the midline (frontal, central, and parietal) regions of the brain that can discriminate participants' alertness. Waldman, Wang, Stikic, et al. showed that across an entire team process, the neurological measure was significantly correlated with a psychometric measure of team engagement.

Figure 1. Pictures of teams engaging in a problem-solving task while undergoing quantitative electroencephalogram (qEEG) assessment (note that the EEG equipment shown was developed by Advanced Brain Monitoring, Inc.).

If one can simply measure engagement psychometrically at the end of a team process, then the logical question is why would one want to resort to the complexity of the type of neurological assessment that we have described? The answer lies in the fact that team processes and emergent states, such as engagement, are inherently fluid in nature. Psychometric procedures such as surveying simply do not afford a practical or ecologically valid means of getting at the fluidity involved in

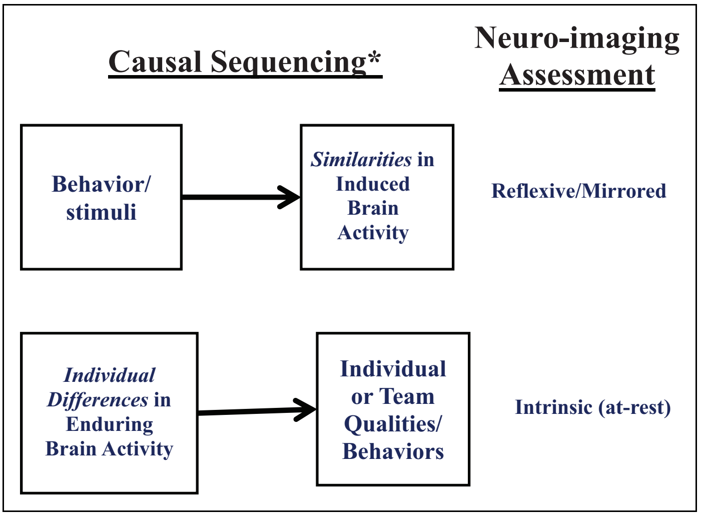

Figure 2. Alternative causal sequencing of brain activity in relation to behavior.

team processes and emergent states. One may argue that researchers could simply rely on observational techniques or the experience sampling method (ESM) (Beal & Weiss, 2003; Fisher, 2008) in an attempt to tap into such fluidity. However, it may be possible, and even likely, that individuals could mask or hide phenomena like engagement or even anger/conflict, with the upshot of unreliable or inaccurate observations on the part of researchers. In short, neurological assessment, while not replacing psychometric methods, could add value to the team researcher's toolbox. It should be noted that while the qEEG headsets shown in Figure 1 might appear to cause discomfort or anxiety, Waldman, Wang, Stikic, et al. (2015) reported anecdotal evidence to the contrary. For example, participants reported to have largely forgotten about the headsets minutes into their problem-solving task. With that said, it is inevitable that the type of team-based technology described previously will be further refined and made even more expedient for use by researchers in the future.

Reflexive Versus Intrinsic Assessment

Organizational research involves examining individual or team reactions to events and stimuli (e.g., leader pronouncements, job redesign, change efforts, etc.). It also involves a better understanding of ongoing qualities or traits, typically focused at the individual level (e.g., personality, values, leadership styles, etc.). Likewise, in neuroscience research, it is possible to assess neurological activity in reaction to stimuli while also focusing on relatively enduring structures of brain activity. The former has been referred to as reflexive, while the latter reflects intrinsic brain activity (Fox et al., 2005; Raichle, 2010; Raichle & Snyder, 2007).

These two models of neurological activity and their alternative causal sequencing are depicted in Figure 2. The model in the top portion of Figure 2 is based on a longstanding idea in neuroscience research that stimuli, oftentimes introduced in an experimental setting, can engender or induce brain activity, as compared to a homeostatic state, on the part of individuals. For example, researchers have used pictorial stimuli in an attempt to activate areas of the brain involved in moral reasoning (e.g., Greene, Nystrom, Engell, Darley, & Cohen, 2004; Moll & de Oliveira-Souza, 2007). We have also seen this approach recently in applications to management research (Bagozzi et al., 2013; Boyatzis et al., 2012; Dulebohn et al., 2016). It should be noted that the reflexive model need not exclusively employ experimental manipulations. For example, as described previously, Waldman, Wang, Stikic, et al. (2015) used this approach to show how the brains of followers would react to leader communication in ongoing team processes.

As further indicated in Figure 2, mirroring represents a particular form of neurologically reflexive activity. Instead of the injection of behavioral, pictorial, or other forms of stimuli, mirroring occurs when one imitates (i.e., mirrors) another person's emotions or empathizes with that other person (Iacoboni, 2009). As such, the stimulus for one's own emotion is another person's emotion. When an individual observes another person experience an emotion (e.g., pain, sadness, joy, etc.), that individual's mirror neuron system may activate and imitate that person's emotion at a neurological level.

In sum, the reflexive/mirroring conceptualization of brain activity fits "well with the view of the brain as driven by the momentary environmental demands" (Raichle & Snyder, 2007, p. 1084). It approximates the idea of individual *states* (as opposed to traits) in personality research (Waldman et al., 2011b). The assumption is that in order to better understand how portions of the brain are relevant to cognition and emotional processing, the brain may temporarily change in function or activity in response to environmental stimuli. By observing these changes, cognitive and emotional processing can be potentially isolated.

In recent times, neuroscientific research would also suggest that relatively stable and enduring individual differences in brain functioning or activity play a role in explaining cognitive, emotional, and behavioral qualities (Buckner & Vincent, 2007; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2012; Raichle, 2010). In other words, relatively enduring patterns of brain functioning may vary between individuals and account for *trait*-like differences in the neurological activity that they may "draw upon or harness" in the display of behavioral qualities (Healey & Hodgkinson, 2014, p. 774). This relatively stable activity of the brain is referred to as the *intrinsic* brain and is measured when an individual is in a resting state rather than while a person is engaged in a specific task, action, or behavior (Raichle, 2010; Raichle & Snyder, 2007). It is important to realize that a brain at rest does not correspond to an inactive brain. Rather, a brain at rest simply implies that the individual is not being asked to process information or is being subjected to purposeful stimuli. Indeed, Cacioppo et al. (2003) suggested that the brain in a resting state is not passive or inactive but instead is engaged in discernable activity. As an example of the use of this model in organizational research, Waldman et al. (2011a) showed how intrinsic, at-rest activity in right frontal regions of the brain is predictive of socialized visionary articulation on the part of leaders.

Brain Region(s) of Interest

Regardless of the unit of analysis (i.e., individual vs. team) or nature of assessment (i.e., reflexive vs. intrinsic), neurological measurement involves analysis of one or more regions of the brain. Inevitably, research attempting to connect neurological phenomena to individuals or even larger entities (e.g., teams) will identify and focus on one or more brain region(s) of interest. One possibility is to simply examine brain region(s) in a post hoc manner, for example, identifying brain region(s) that might become activated as a result of a stimulus. In contrast, we maintain that to push theory forward, it is imperative for researchers to consider a priori how certain region(s) may be relevant to a cognitive or behavioral phenomenon of interest. We recognize that given the nascent state of existing literature in organizational neuroscience, direct a priori evidence is limited. However, for the purpose of developing a priori theoretical arguments regarding relevant brain region(s), it may be possible for researchers to extrapolate from existing similar research in the social cognitive neuroscience literature (e.g., see Dulebohn et al., 2016; Hannah et al., 2013).

Two basic approaches are relevant to the theoretical and empirical targeting of brain region(s). First, one may attempt to localize relevant activity to relatively small areas of the brain. An example can be found in the work of Waldman et al. (2011a), who associated brain activity in the right frontal region of the brain with leader socialized vision. Second, more recent neuroscience theory and research would suggest that complex cognitive or behavioral phenomena might best be considered using a network framework based on the simultaneous assessment of multiple brain regions. Lindquist et al. (2012) described what they termed a *psychological constructionist approach* to argue that networks of the brain together produce psychological events and behavioral phenomena.

As an example, the default mode network (DMN) is a network of brain regions that has gained recent attention. It has largely been evaluated in its intrinsic mode (see our earlier discussion) and accordingly could be indicative of meaningful individual differences in cognitive, emotional, and behavioral qualities (Buckner & Vincent, 2007; Fox et al., 2005; Raichle, 2010). Relevant areas of the brain that compose the DMN include the medial temporal lobe, medial prefrontal cortex, and posterior cingulate cortex, along with adjacent ventral precuneus and medial, lateral, and inferior parietal cortexes (Buckner, Andrews-Hanna, & Schacter, 2008; Raichle, 2010). Buckner and Carroll (2006) suggested that the DMN is associated with self-projection, which involves being able to shift one's perspective from the immediate context to an imagined future environment. In so doing, it involves individual differences in the ability to mentally navigate between the past (through memory) and the future (through projection). As such, variation in individuals' DMN structures reflects differences in how people may be able to anticipate and evaluate events prior to those events actually occurring (Buckner et al., 2008). In addition, the DMN involves a strong self-concept (e.g., an understanding of one's own emotions and values) as well as cognition pertaining to the perceptions or emotional/mental states of other people. Accordingly, the DMN is critical for predicting others' behaviors and engaging in interpersonal relationships (Boyatzis et al., 2014; Buckner & Carroll, 2006; Schilbach, Eickhoff, Rotarskajagiela, Fink, & Vogeley, 2008).

Lindquist et al. (2012) argued that a particular network might be relevant to multiple cognitive or behavioral phenomena. As applied to the DMN, following from the previous description, it would indeed appear that such a network might prove to be useful in understanding various phenomena in organizational behavior. Some examples include visionary leadership, ethical reasoning and decision making, and emotional intelligence. But even a more localized approach might reveal how a relatively small region of the brain could pertain to multiple cognitive or behavioral phenomena. For example, the amygdala has largely been connected to the emotion of fear (Ashkanasy, 2003). However, the amygdala has also been associated with other emotions (e.g., sadness, disgust, and happiness; see Sergerie, Chochol, & Armony, 2008) as well as the cognitive processing of stimuli that may engender various emotional responses (Lindquist et al., 2012).

Future Research Applications in Organizational Behavior

With the basic methodological and research considerations articulated previously in mind, we now turn our attention to specific topical areas in organizational behavior that might benefit or realize added value from neuroscience-based applications. We identify constructs at both the individual and team levels that we believe are good candidates or prototypes for the application of neuroscience methods. We chose five examples at the individual level of analysis (i.e., emotional intelligence, mood, cognitive ability, justice, and sensemaking) and three examples at the team level (i.e., emotional contagion, shared mental models, and leadership). This list is not meant to be exhaustive, as our intent is only to provide a representative sample of constructs to show how neuroscience may benefit OB research in a manner similar to that shown by Hannah et al. (2013). In Table 1, we refer to these example constructs as we summarize the problems or limitations with traditional methodologies that have been commonly used in organizational research as well as the benefits or added value of neuroscience-based approaches.

Table 1. Creating Added Value in the Research of Example Organizational Constructs Through Neuroscience Methodologies.

	Constructs	Problems/Limitations With Traditional Methodologies	Benefits or Added Value of Neuroscience Methodologies
Individual-level constructs	Emotional intelligence (EI)	• Lack of convergence within the EI construct and significant overlap with other constructs (Côté & Miners, 2006) ➢ May be due to reliance on subjective ratings or subjective scoring of EI instruments (Conte, 2005) • EI not able to predict organizational phenomena above and beyond other measures (Antonakis & Dietz, 2010) • Few antecedents of EI known or conceptualized	• Neuroscience measures may contribute to the validation of psychometric measures (Becker, Cropanzano, & Sanfey, 2011) • Increased understanding of EI construct by associating psychometrically-based operationalizations of EI with neural assessments. • May predict greater variance by linking performance with resting/intrinsic brain activity (see Waldman, Balthazard, & Peterson, 2011b) • Identify neural antecedents of specific dimensions of EI
	Mood	• Mood/affect generally limited to self-report measures subject to biases (e.g., Becker et al., 2011) • Difficult to psychometrically measure within-person variance of mood over time (Miner & Glomb, 2010) • Mood induction techniques vary greatly, and the intensity of induced mood may not be reported accurately (Mitchell & Phillips, 2007)	• Can complement self-report measures with neural measures that are not subject to the same biases (Becker et al., 2011) • Can continuously measure neural activity to assess within-person mood variance over a given time period • May use neural signatures to objectively identify participants' emotional intensities in order to predict greater variance in performance outcomes
	Cognitive abilities	• Some psychometric assessments of cognitive abilities are subject to cultural and racial biases (Agnello, Ryan, & Yusko, 2015) • Gap between measured cognitive abilities and application of those abilities in the workplace (Brouwers & van de Vijver, 2015)	• May create measures of cognitive abilities based on neural assessment that are not reliant on language or familiarity (e.g. Unsworth, Fukuda, Awh, & Vogel, 2015) • Provides alternative measurement to examine situational factors that enhance or inhibit cognitive performance in the workplace
	Organizational justice	• Need for integration of emotion and cognition in organizational justice research (Colquitt et al., 2013) • Confusion regarding the link between perceived justice violations and corresponding behaviors	• Examine neural activity associated with both emotions and cognition simultaneously within and between individuals • May map the possible perceived injustice→emotional response→cognitive regulation→observed behavior sequence

(continued)

Table 1. (continued)

	Constructs	Problems/Limitations With Traditional Methodologies	Benefits or Added Value of Neuroscience Methodologies
	Sensemaking	• Sensemaking is predominantly assessed using discursive methodology (Brown, Colville, & Pye, 2014) ➢ Automatic, implicit processes may not be assessed • Little is known about how, and at what stage, biases are introduced in the sensemaking process (see Lebiere et al., 2013)	• Combines discursive measures of explicit sensemaking with neurally based measures of automatic, implicit sensemaking (Becker et al., 2011) ➢ Identify when automatic sensemaking is taking place and assess associated outcomes • Combines neural and cognitive models, predict when biases are likely to be present, and identify controls that mitigate such biases (e.g., Lebiere et al., 2013)
Team-level constructs	Emotional contagion	• Aggregate self-report measures of emotional contagion ➢ Doherty's (1997) scale only assesses individuals' susceptibility to others' emotions ➢ Barsade (2002)'s approach subjectively determines when the contagion process occurs at a later time point ➢ No measure for how positive and negative emotional contagion emerge simultaneously • Video-coding ➢ People may hide their true emotions ➢ Reliance on coders' ability to recognize people's mood and emotional changes • The group emotional contagion explains 12% to 19% of variance of group outcome (Barsade, 2002). • Limited in examining why the contagion process occurs	• Complements ratings-based measures with neural measures (Becker et al., 2011) • Explores the dynamic of influence process such as neurological mirroring on a second-by-second basis (Hogoveen & Obhi, 2012). • How positive and negative emotional contagion can emerge simultaneously • The neurological measure of emotional contagion may predict more variance on outcomes • Mirror neuron activity (Rizzolatti & Craighero, 2004) may explain why the contagion occurs
	Shared mental models	• Attribute-rating: ➢ Hard to examine how different forms of shared mental models coexist, evolve, and develop	• Can examine team members' attributes simultaneously in the process of interaction without interruption (Waldman et al., 2013) • Complements ratings-based measures with neural measures (Becker et al., 2011)

(continued)

Table 1. (continued)

Constructs	Problems/Limitations With Traditional Methodologies	Benefits or Added Value of Neuroscience Methodologies
	➢ Retrospective sensemaking may create perceptual bias • Concept mapping/card sorting ➢ Time consuming and labor intensive, takes longer to analyze (DeChurch & Mesmer-Magnus, 2010). • Shared mental models explain about 10% of the variance in overall team performance (DeChurch & Mesmer-Magnus, 2010) • Hard to determine how much sharing is optimal (Mohammed, Ferzandi, & Hamilton, 2010) • Examining factors that facilitate the development of shared mental mode is needed (Mohammed et al., 2010)	• Predicts more variance in outcomes • Examines intrinsic brain patterns to identify the optimal level of sharing (Waldman et al., 2013)
Leadership	• Survey measures involve attribution bias • Predictors are mostly self-report • Traditional measures explain only 10% of variance in outcomes • Limited knowledge regarding informal leadership formation	• Increased understanding of the leadership construct by associating psychometrically based operationalizations of leadership with neural assessments • Identify neural antecedents of specific types of leadership and leadership emergence • May predict greater variance by linking performance with resting/intrinsic brain activity • A second-by-second measurement of what may drive emergent leadership • Provides a basis for neurofeedback approaches to develop better leaders

Emotional Intelligence

There is an ongoing debate about how to best conceptualize emotional intelligence (EI). While some scholars argue that EI is best thought of as a set of individual traits (see Petrides & Furnham, 2001, 2003), others argue that EI is best conceptualized as a set of abilities (see Mayer, Salovey, & Caruso, 2008). This lack of conceptual clarity makes the measurement of EI challenging (Conte, 2005). For example, two of the most popular measures of EI are the Bar-On Emotional Quotient Inventory (EQ-i) (Bar-On, 2000) and the Mayer-Salovey-Caruso Emotional Intelligence Test Version Two (MSCEIT V.2; Mayer, Caruso, & Saolovey, 2000). The Bar-On EQ-i is based on a "mixed model" of EI that proposes that EI is a mixture of both cognitive abilities and personality traits (Khalili, 2012). It uses both self- and peer reports to measure EI (Cote & Miners, 2006). The MSCEIT V.2 is based on the ability model, which proposes that EI is a function of an individual's cognitive abilities that are used to manage emotions (Khalili, 2012; Zeidner, Matthews, & Roberts, 2004). It is a performance-based measure, and the "correct" response is determined by the most common response given by either a select group of participants (in the case of consensus scoring) or a selected panel of experts (in the case of expert scoring) (Conte, 2005).

The subjectivity inherent in such measures may contribute to the lack of convergence within the EI construct (see Muyia, 2009) as well as the considerable confusion regarding exactly what EI assessments measure (see Fiori & Antonakis, 2011, 2012; Fiori et al., 2014; Maul, 2012). Significant overlap between the Bar-On EQ-i and Big Five Personality measures and between the MSCEIT V.2 and General Mental Ability (Conte, 2005) furthers the lack of clarity in this area. These conceptual and measurement issues continue to call into question the precise meaning and operationalization of EI (see Davies, Stankov, & Roberts, 1998; Van Rooy & Viswesvaran, 2004).

Indeed, the subjectivity of measurement within the EI construct is a key limitation that neuroscience has the potential to address and is already beginning to do so. For example, Barbey, Colom, and Grafman (2014) identified some neurally based correlates associated with EI. Several studies suggest that there is a core imitation circuit in the brain composed of part of the superior temporal sulcus and the parietal and frontal mirror neuron areas (see Iacoboni, 2009). This imitation circuitry may then interact with the limbic system and insula to produce empathy for observed others (Iacoboni, 2009), which is one aspect of EI (Zeidner et al., 2004). Such studies show that it is possible to identify neural networks associated with specific dimensions of EI and thereby objectively assess when an individual is experiencing that dimension in a reflexive sense, as portrayed in Figure 2. Moreover, at rest/intrinsic measurement could assess relatively enduring brain features associated with empathy as a dispositional trait (Shamay-Tsoory, Aharon-Peretz, & Perry, 2009).

Although the neuroscience-based measurement of EI is in its nascent stages, we argue that research like that described earlier in this article may be relevant to the construct of EI in at least two major ways (see Table 1). First, it can contribute to the validation of existing measures (see Bagozzi et al., 2013; Becker et al., 2011). Second, by associating alternative, psychometrically based operationalizations of EI with neural assessment, we may obtain a better understanding of the EI construct. Similar insights were gained by Hannah et al. (2013) in their simultaneous examination of psychometric and neural-based measures of leader complexity.

The construct of EI suffers from both limitations in terms of its ability to predict organizational phenomena above and beyond other measures (Antonakis & Dietz, 2010; Barbey et al., 2014) as well as a lack of conceptualized antecedents that might predict EI. For example, Joseph, Jin, Newman, and O'Boyle (2015) recently found that EI does not explain any additional variance in job performance after controlling for other previously established performance predictors (e.g., conscientiousness). We argue that neuroscience methods can help alleviate these limitations in two major ways. First, neuroscience-based assessment may be used to predict greater variance in performance by identifying and measuring at rest/intrinsic neural networks (see Buckner & Vincent, 2007; Waldman et al., 2011b) associated with EI and then linking individual differences in these networks with workplace performance. While such an approach has not yet been done with EI, existing research in other areas has demonstrated the feasibility of such an approach (see Balthazard, Waldman, Thatcher, & Hannah, 2012; Waldman et al., 2011a). Second, neuroscience methods may be able to identify neural antecedents of various dimensions of EI, such as the type of neurally based antecedents of empathic tendencies on the part of individuals that we considered earlier (Peterson, Reina, Waldman, & Becker, 2015).

Mood

Mood has been conceptualized as an affective state that, as compared to specific emotions, is more general in nature (i.e., not directed at a specific object) (Baas, De Drue, & Nijstad, 2008). Additionally, mood tends to be of lower intensity, less overtly expressed, has less clear reasoning for occurrence, and is longer lasting (e.g., minutes or hours, instead of seconds) than emotion (Baas et al., 2008; Mitchell & Phillips, 2007). Because of these characteristics, most researchers use self-reported measures of mood and oftentimes repeated measures (e.g., ESM; Miner & Glomb, 2010) in an attempt to capture within-person variance over a given time period. However, as is the case with a number of constructs, self-report measures of mood are subject to several biases (e.g., social desirability and emotional recall error) (Becker et al., 2011; Miner & Glomb, 2010; Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Since an individual's mood may change quickly in reaction to environmental and interpersonal interactions and last only minutes, it is difficult to accurately measure within-person variance of mood over time, even using ESM (Miner & Glomb, 2010).

Neuroscience methods have the potential to address these limitations in a more ecologically valid manner. A number of neural networks that are associated with affective states have been identified (see Lindquist et al., 2012; Ochsner et al., 2004; Ochsner & Gross, 2005), and some studies have already used such networks to measure mood (see Mitchell & Phillips, 2007). Since neurally based measures are not subject to self-report biases (Becker et al., 2011), they may be very effective in at least complementing current psychometric measures of mood. Another advantage of neuroscience methods is the ability to continuously measure neural activity over a given period of time, perhaps accompanied by video recording, as demonstrated by Waldman, Wang, Stikic, et al. (2015). Similar methodology can potentially be used in mood research to more accurately assess within-individual mood variance in the workplace.

Experimental studies of mood generally involve artificially inducing the desired mood state in order to predict a hypothesized outcome. However, such studies vary greatly in mood induction techniques, and self-report scales are used to measure the intensity of the mood induced (Mitchell & Phillips, 2007). Recent research in neuroscience has the potential to increase the predicted variance in outcomes by providing a neural-based measure of affective intensity.

For example, machine learning is a computer function that uses a "vector of features (independent variables) to predict the value of a continuous outcome variable" (Chang, Gianaros, Manuck, Krishman, & Wager, 2015, p. 20). Chang et al. (2015) identified a neural signature that predicts emotional intensity ratings that they referred to as picture-induced, negative emotion signature (PINES). PINES involves the amygdala, periaqueductal gray, dorsomedial prefrontal cortex, ventral occipital cortex, ventromedial temporal lobe, and posterior cingulate cortex, among other regions, and these researchers were able to use PINES to predict emotional intensity ratings with 93.5% accuracy in participants (Chang et al., 2015). Therefore, it is now possible to objectively compare emotion intensities across participants. Future studies involving other forms of affect are needed to enable better prediction of mood-related performance outcomes across a variety of mood states.

Cognitive Ability

Cognitive ability is a broad construct that incorporates a multitude of characteristics that together enable individuals to "reason, solve problems, think abstractly, and learn quickly" (Becker, Volk, & Ward, 2015, p. 57). While numerous cognitive abilities exist, assessment efforts have focused mainly on general intelligence (g) due to its robust ability in predicting human performance and research showing that the use of other measures or constructs often provide little incremental, predictive validity over g (Kuncel, Hezlett, & Ones, 2004; Lubinski, 2004; Schneider & Newman, 2015).

The use of psychometric general intelligence assessments has come under increased criticism. Some researchers have argued that such assessments use language that is culturally specific and that some questions require knowledge of content not specific to the ability being measured (e.g., Agnello, Ryan, & Yusko, 2015). As a result, differences in test scores across racial and cultural groups have been observed. These score differences have raised concerns about the possibility of unintentional group discrimination and have led researchers to a call for alternative assessments that are not subject to the same limitations (Agnello et al., 2015; Becker et al., 2015).

The field of organizational neuroscience has the potential to effectively answer this call (see Table 1). Researchers are identifying neural signatures that reflect individual differences in cognitive abilities that, according to Carroll (1993), are subsets of g. For example, Unsworth, Fukuda, Awh, and Vogel (2015) used EEG to measure individual differences in electrical, contralateral delay activity (CDA), which were associated with activity in the prefrontal cortex involved in both working memory capacity as well as efficiently selecting the information that is granted access to working memory. Unsworth et al. found that individual differences in CDA also predicted other cognitive abilities, such as fluid intelligence and long-term memory.

Since neural measures of cognitive abilities do not rely on specific language or familiarity with content not being measured, it is likely that these measures will not be subject to the same racial or cultural discrimination concerns, as compared to current psychometric measures. Although they are not yet ready to replace psychometric tests, studies such as Unsworth et al. (2015) may provide the building blocks necessary for neurally based measures in the not too distant future.

In spite of the fact that general cognitive ability has been shown to predict workplace performance, there continues to be a gap between cognitive ability measured in a relatively sterile environment and observed application of that ability in solving everyday problems in the workplace (Becker et al., 2015; Brouwers & van de Vijver, 2015). This gap suggests that situational factors, such as emotion, task requirements, and so forth, may impact the application of cognitive functioning in the workplace. For example, Mitchell and Phillips (2007) found that the majority of evidence suggests that positive mood inhibits performance on planning and memory tasks but enhances performance in tasks requiring innovation or new information.

One possible explanation for these results lies in the neuroscience literature. In their constructionist model of emotion, Lindquist et al. (2012, p. 124) proposed that experienced emotions are a product of: (a) "internal mental representations based on bodily changes" (e.g., elevated heart rate), referred to as core affect, and (b) categorization of those mental representations as a specific emotion based on perceived situational factors. Additionally, research has shown that cognitive abilities may be prioritized (enhanced or inhibited) based on experienced emotion. For example, the amygdala enhances certain cognitive abilities such as vigilance when an individual is experiencing fear (see Blair, 2006; Lindquist et al., 2012; Whalen et al., 2013). In sum, our discussion suggests that the combination of core affect and situational factors may activate neural structures associated with a specific emotion, which then may enhance or inhibit neural structures associated with specific cognitive abilities.

While neuroscience cannot yet provide a definitive answer as to why there is a gap between measured intelligence and applied intelligence in the workplace, our considerations here show that neuroscience does have the potential to provide a theoretical framework and the analytic techniques necessary for advancing research in this area. For example, researchers could apply the theoretical framework discussed in the preceding paragraph to the example taken from Mitchell and Phillips (2007) and then use neuroscience methodology to test that framework. In the studies reviewed by Mitchell and Phillips, positive affect was artificially induced. Participants were then presented with various tasks requiring either innovation or planning and long-term memory. This suggests that it is possible that the induced positive affect resulted in the enhancement of neural networks associated with innovation while inhibiting networks associated with planning and long-term memory. Such ideas could provide the theoretical framework that may explain how a situational factor (e.g., positive affect) may cause a gap between measured intelligence and applied intelligence.

Neuroscience also provides the necessary tools to test such a framework. EEG coherence measures (see Waldman et al., 2011b) may be used to identify neural networks associated with positive affect, and researchers could then observe changes when situational factors are introduced (e.g., tasks requiring innovation). Additionally, measures of EEG power spectral density (see Waldman et al., 2011b, 2013) may identify resulting reduced activity in other areas of the brain associated with planning or long-term memory.

Organizational Justice

Organizational justice has been conceptualized in four major ways, all of which involve an individual's perceptions of fairness. Procedural, distributive, and interactional justice involve perceptions of fairness regarding the methods used to determine various outcomes, the level of rewards received in relation to the amount of input, and the level of respect given and timely sharing of information in a personalized manner, respectively (Colquitt, 2001). The fourth conceptualization, deontic justice, is the extent to which an individual perceives that a general moral code has been violated (Cropanzano, Goldman, & Folger, 2003). It differs from the first three in that it is not directed inward toward the individual but is instead concerned with perceptions of justice violations toward others (see Massaro & Becker, 2015).

Though interest in justice research has intensified over the past decade (Colquitt et al., 2013), at least two important concepts continue to present challenges. First, although it is clear that justice involves both cognitive and emotional components, it is difficult to study both components at the same time in order to examine their integrated effects on justice (Colquitt et al., 2013). Second, there is some confusion regarding the link between justice perceptions and corresponding behavioral responses. For example, research has suggested that the impulse to punish aggressors when an injustice is witnessed is pervasive and automatic (Folger, Cropanzano, & Goldman, 2005). However, Rupp and Bell (2010) suggested that this automatic response may be cognitively regulated, thereby preventing an individual from acting when an injustice is perceived. We argue that organizational neuroscience research methods may help illuminate the underlying emotional and cognitive processes involved in justice perceptions as well as the associated behavioral outcomes. Such illumination will not only answer calls for the integration of emotion and cognition in justice research (see Colquitt et al., 2013) but more practically, help us understand why people choose to act, or not act, in the presence of injustice.

Massaro and Becker (2015) pointed out that regarding justice, "Emotion and cognition are so tightly entwined that both must be considered" (p. 262). Since neurosensing technology such as qEEG can simultaneously monitor brain networks associated with both emotion and cognition, it is uniquely suited to study the effects of emotion and cognition on justice. However, such technology can also monitor many individuals simultaneously (see Waldman et al., 2013). Since justice is by nature an interpersonal phenomenon measured on an intrapersonal scale, neuroscience methodology may be the only viable means to find answers to such questions as: How does a supervisor's emotional state impact the employee's cognitive perceptions of interactional justice, and does a negative emotional reaction to a perceived injustice by one person result in perceptions of justice violations by another person, thus setting off a contagion of such perceptions?

Organizational neuroscience may also help us understand the link between perceptions of injustice and corresponding individual behaviors. This is particularly interesting when considering deontic justice. For example, even though individuals have an automatic, emotional response to perceptions of injustice (Colquitt et al., 2013), neuroscience research has indicated that such responses may be regulated by cognitive functions involving the dorsolateral prefrontal cortex (dlPFC; Massaro & Becker, 2015). This research raises important questions. Is there a window of time between perceiving injustice and responding to that perception in which individuals may regulate their response? If so, how long is that window, and can various interventions help increase its length as well as help individuals respond appropriately? For example, when witnessing someone being assaulted in public, what prevents another individual who is high in deontic justice from intervening? Organizational neuroscience methodology such as qEEG scanning may identify both the brain networks involved as well as the sequence and length of time each network is active. Thus, it may be the key in answering such questions and in turn help create a better work environment.

Sensemaking

Sensemaking has been conceptualized as "the process through which people work to understand issues or events that are novel, ambiguous, confusing, or in some other way violate expectations" (Maitlis & Christianson, 2014, p. 57). This process is cyclical and involves: (1) sensing environmental cues, (2) comparing these cues to established mental models in order to (3) categorize them (i.e., assign meaning), and then (4) using these categorizations as a basis for action aimed at imposing order on the environment (Maitlis & Christianson, 2014; Sandberg & Tsoukas, 2015; Weick, Sutcliffe, & Obstfeld, 2005). Additionally, sensemaking is thought to be an ongoing, implicit process that becomes explicit during crises (Mills, Thurlow, & Mills, 2010) and is comprehended through words (Weick et al., 2005). Emphasizing this point, Weick (1995) asked, "How can I know what I think until I see what I say?" (p. 18). And indeed the majority of research in this area has used discursive methodology to measure sensemaking (Brown, Colville, & Pye, 2014; Maitlis & Christianson, 2014).

The preceding discussion highlights two assumptions regarding sensemaking. First, individuals are able to bring ongoing, implicit sensemaking into conscious awareness at will. Second, and related to the first assumption, the verbal representation of sensemaking is an accurate reflection of the actual psychological processes involved. However, these assumptions may not be altogether valid. A review by George (2009) suggests that each step in the sensemaking process described previously may take place automatically, without conscious thought, and therefore individuals may not be fully aware of the reasons behind their actions. We also know that when individuals are not aware of the reasons behind their actions, they may "invent" inaccurate but plausible alternate explanations (see Becker et al., 2011). Further, they are likely to act in ways congruent with the automatic psychological processes and not necessarily the verbalized ones (George, 2009).

The possible prevalence of automatic sensemaking processes that greatly influence individual actions but are not accurately reported discursively presents two major limitations. First, since the vast majority of sensemaking research employs discursive methodology (Brown et al., 2014), it is likely that significant portions of individual sensemaking are not being measured or analyzed. Second, these automatic sensemaking processes may introduce biases that affect individual actions in such a way as to hinder performance (Ascoli, Botvinick, Heuer, & Bhattacharyya, 2014; Lebiere et al., 2013).

Recent research suggests that neuroscience methods guided by cognitive models may help in efforts to overcome these limitations. For example, Cassenti, Kerrick, and McDowell (2011) used the ACT-R (Adaptive Control of Thought-Rational) model in conjunction with EEG measures of brain activity to divide participants' overall mental processes during a task into smaller mental segments representing more specific mental processes. Lebiere et al. (2013) used the ACT-R framework to identify neural networks that may be associated with specific steps in the sensemaking process, including the parietal cortex and motor cortex, which are involved in the perception of environmental cues; the ventrolateral prefrontal cortex and dorsolateral prefrontal cortex, which may be involved in comparing cues to existing mental models; and the basal ganglia, which may be involved in the categorization and coordination of sensemaking activity. Lebiere et al. then used this framework to identify confirmation bias introduced during the first step of the sensemaking process to identify when such bias is likely to occur and then propose procedures to mitigate such biases.

Together, the aforementioned research suggests that it may be possible to identify several segments of the sensemaking process and measure the neural activity associated with each process. The resulting data may provide at least two key advantages (see Table 1). First, it may be possible to assess when an individual is engaged in automatic (implicit) sensemaking and then estimate its impact by examining decisions that immediately follow. Second, neural assessment may help identify inherent biases in the sensemaking process and therefore make it possible to design organizational policies and procedures that are aimed at overcoming these biases (see Ascoli et al., 2014).

Emotional Contagion

Switching to examples of team processes or emergent states, as shown in Table 1, we focus on emotional contagion, shared mental models, and leadership. Regarding emotional contagion, if an individual or individuals "catch" the emotions of others, either consciously or unconsciously, emotional contagion occurs (Barsade, 2002; Pugh, 2001). Such contagion can be either positive or negative, as people can catch both the optimism and fear of others. Previous research has attempted to assess emotional contagion processes using self-report surveys and video coding (e.g., Barsade, 2002). For example, Doherty (1997) developed a 15-item scale to measure individuals' susceptibility to others' emotions. Samples items include: "When someone smiles warmly at me, I smile back and feel warm inside" and "I cry at sad movies" (Doherty, 1997, p. 136). Another common way to assess contagion is to ask experts to code participants' facial expressions and gestures (e.g., Barsade, 2002).

While these methods are prevalent in emotions research, as outlined in Table 1, they are potentially flawed in several ways. First, participants may hide their true emotions by intentionally controlling their verbal and nonverbal behavior during observation as well as when answering survey questions. Moreover, Doherty's (1997) scale only assesses individuals' susceptibility to others' emotions and does not measure the actual process of contagion. Barsade's (2002) approach determines when the contagion process occurs subsequent to the interaction using a subjective method that relies on coders' abilities to recognize people's mood and changes in emotions. In addition, we are unaware of instruments that measure the occurrence of both positive and negative emotional contagion simultaneously.

Neuroscience techniques can be potentially useful in the assessment of contagion for two reasons. First, individuals cannot fake brain activity, and thus attempts to assess contagion neurologically are more ecologically valid than either surveys or observation. Second, neuroscience methods do not rely on the type of global, retrospective measurement employed by Doherty

(1997). In other words, neuroscience could allow for more precision in terms of content of contagion (e.g., positive vs. negative emotions) as well as real-time (rather than retrospective) assessment (Peterson et al., 2015).

Further, current research in the area of emotional contagion is at least somewhat limited in explaining outcomes. For example, using video recording, Barsade (2002) was able to explain 12% to 19% of the variance in group-level outcomes. Perhaps neuroscience-based methods could add to such prediction. In addition, it is still not clear why contagion processes occur. Neuroscience techniques might provide insights into why and how emotional contagion happens. Specifically, we propose that team members may "catch" each other's emotions (excitement or fear) through mirror neuron activity (Rizzolatti & Craighero, 2004). Mirror neurons in an individual's brain are activated when he or she observes another person's emotions or attitudes and then imitates that person's emotions neurologically (Rizzolatti & Craighero, 2004). Researchers could examine the brain activity of team members on a second-by-second basis during a team process to see whether mirroring activities are occurring. In short, neurological assessment might be used to help form a better understanding of how individuals transfer both positive and negative emotions in teams. Thus, perhaps in combination with psychometric assessment, the neurological assessment of emotional contagion may help predict variance in outcomes such as team conflict, cohesion, and shared vision.

Shared Mental Models

A shared mental model refers to how team members possess organized, common understandings of team knowledge (Klimoski & Mohammed, 1994). To measure various shared mental models, researchers have developed alternative structural assessment techniques (Schvaneveldt, 1990) (see Table 1). One technique is to have respective team members rate how well their fellow team members perform various tasks (e.g., "Team members are cross-trained to carry out other members' tasks") and team interactions (e.g., "Team members trust each other") (Lim & Klein, 2006, p. 408). Their resulting evaluations provide the ratings for shared task mental models and shared teamwork mental models. In one examination, researchers asked team members to specify their team's actions according to corresponding rows or columns on the map (Marks, Zaccaro, & Mathieu, 2000). Map overlapping was then used to compute the team's shared mental model.

Perceptual biases may hinder retrospective ratings of attributes or actions. Self-ratings may also limit examinations of how shared mental models coexist, evolve, and develop (Klimoski & Mohammed, 1994). Moreover, data analyses based on concept mapping are time-consuming, labor intensive, and complex (DeChurch & Mesmer-Magnus, 2010). Consequently, researchers have called for new tools to examine shared mental models and their development (Mohammed, Ferzandi, & Hamilton, 2010). Neuroscience-based measures are potentially more accurate and convenient for capturing shared mental models since they can measure in-the-moment brain patterns related to task expertise and team interactions (Waldman et al., 2013). For example, brain activity can be compared across teams or within teams to determine convergences and divergences. Thus, while current static measures of shared mental model measures explain only about 10% of overall team performance, researchers can potentially study changing brain patterns to gain a better understanding of how shared mental models evolve (DeChurch & Mesmer-Magnus, 2010).

Moreover, little research has focused on examining factors that allow shared mental models to evolve. Neuroscience technology can help reveal why team members show similar brain activities. For example, teams that have shared mental models might be composed of members with similar, intrinsic brain signatures.

Leadership

Leadership has been examined at both individual and collective levels in terms of leadership qualities and effects. At the individual level, researchers have examined different leadership qualities, such as transformational leadership (Bass & Avolio, 1990), ethical leadership (Brown, Treviño, & Harrison, 2005), and empowering leadership (Srivastava, Bartol, & Locke, 2006). At the collective level, researchers have examined the dyadic leader-member relationships (e.g., leader-member exchange; Graen and Uhl-Bien, 1995) and some plural forms of leadership (Denis, Langley, & Sergi, 2012), such as shared leadership (Wang, Waldman, & Zhang, 2014). The most traditional approach in measuring leadership is the use of survey measures in which respondents are asked to provide their perceptions of leaders' behaviors. For instance, Bass and Avolio (1990) developed a Multifactor Leadership Questionnaire to measure transactional and transformational leadership.

However, this traditional survey approach is limited in several aspects (see Table 1). First, survey measures are subject to attribution biases (Waldman & Balthazard, 2015). Second, trait theories of leadership have focused on self-reported, individual characteristics predicting one's leadership. Few biological factors of leadership development have been examined (Li, Wang, Arvey, Soong, Saw, & Song, 2015). Third, current survey measures of leadership have limited power to explain leader effectiveness. Researchers have determined that leadership variables such as transformational leadership account for less than 10% of total variance in outcomes (Waldman & Balthazard, 2015; Wang, Oh, Courtright, & Colbert, 2011). Fourth, we have little knowledge of how followers are inspired both cognitively and emotionally by others to become emergent leaders in a team.

A neuroscience approach can provide benefits to leadership research. First, instead of relying on people's perceptions, researchers can utilize brain scanning or sensing technologies to provide a more objective measure of leadership that is not subject to attribution biases. For example, Waldman et al. (2011a) examined how part of the right frontal cortex is related to visionary leadership, and Balthazard et al. (2012) found that transformational leaders are different from nontransformational leadership in terms of their neural activities in the frontal region of the brain. Second, besides examining certain parts of the brain, a more complex measure of brain network and connectivity among regions can provide more insights into leaders' actions. For example, Waldman, Wang, Hannah, and Balthazard (2015) examined how a neural network index such as the default mode network (Buckner & Vincent, 2007) could predict ethical leadership beyond traditional survey-based predictors, such as ethical ideologies (Forsyth, O'Boyle, & McDaniel, 2008). Third, neurological measures can explain extra variance in leadership decision making and leadership effectiveness. For example, as described earlier, Hannah et al. (2013) showed that a neurological measure of leadership complexity could predict unique variance, beyond a psychometric measure of complexity, in leaders' adaptive decision making.

Moreover, a reflective approach is useful in exploring leader-member interactions and leadership emergence in teams. For instance, instead of relying on people's perceptions of their relationship with leaders, researchers could actually examine followers' mirroring system in the brain. This can help us examine how followers imitate leaders' or peers' behaviors to form shared leadership in teams. Furthermore, a second-by-second basis measure of team members' brain activities can provide insights about what situational factors drive members' cognitions and emotions to become informal leaders. Moreover, neuroscience might provide new methods of developing effective leaders through, for example, neurofeedback techniques (Waldman & Balthazard, 2015).

Conclusions

In this article, we have focused on some key issues pertaining to the incorporation of neuroscience methods in organizational research. We considered the overall advantages and disadvantages of such methods as well as issues that need to be taken into account, including the level of assessment (i.e., individual vs. team), intrinsic and reflexive brain activity, and an understanding of brain regions. We further described examples of research to date and considered some constructs in the organizational sciences that represent excellent candidates for future research using neuroscience methods.

We conclude with a brief discussion of research agenda strategies. First, it should be apparent in our discussion that qEEG represents the primary technology that organizational researchers might implement moving forward. It represents an increasingly cost-effective and practical (e.g., portability) technology to enrich many of the research issues or efforts of organizational researchers. For example, through a focus on the intrinsic brain, predispositional constructs of interest can be assessed through qEEG in a highly ecologically valid manner. In addition, the reflexive brain can be examined on a second-by-second basis, individually or in a team context, in relation to various stimuli that might be introduced in either a manipulated or a natural manner. In terms of manipulation, a trained confederate could introduce stimuli (e.g., alternative forms of leadership), and the effects on individuals or teams could be recorded. Alternatively, more naturally occurring stimuli (e.g., the effects of team members on each other) could be examined. In short, qEEG technology is now well positioned to help researchers pursue such applications.

Second, we note the obvious interdisciplinary nature of organizational research that includes neuroscience methodology. It is possible for organizational researchers to venture into neuroscience applications on their own, without collaboration from actual neuroscientists who might have years of experience with the types of issues and technologies mentioned here. However, as argued by Waldman (2013), given the lack of neuroscience expertise and experience of most organizational researchers, collaboration with actual neuroscientists is largely a necessity. Individuals with neuroscience backgrounds can be found either in university departments or in firms that specialize in neuroscience-based research and applications. A related issue pertains to publication outlets. Organizational researchers may not be concerned about publishing their research in primarily neuroscience-based journals. However, as suggested by a number of the citations in this article, management and organizational journals are increasingly including articles with neuroscience theory and methods, and we expect that trend to continue into the future.

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