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Organizational Neuroscience: Taking Organizational Theory Inside the Neural Black Box

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This article introduces the reader to organizational neuroscience, an emerging area of scholarly dialogue that explores the implications of brain science for workplace behavior. The authors begin by discussing how going inside the brain adds new levels of analysis that can advance and connect theories of organizational behavior. They then present three concrete examples of what an organizational neuroscience perspective can achieve by extending current theory, providing new research directions, and resolving ongoing theoretical debates. Last, the authors address a number of deeper metatheoretical questions raised by neuroscience, concluding that it brings new insights that will force scholars to rethink their concept of human nature.

Keywords: *neuroscience; attitudes; emotion; justice; levels of analysis*

Technological and theoretical advances in neuroscience have continued to open up the internal workings of the human brain. This research reveals that many neural processes have evolved over millennia, often for specific purposes that are biologically programmed, frequently automatic, and relatively inflexible (Lieberman, 2007). Organizational scientists have

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gradually begun to take notice of these advances (Bergué, 2010). In this article, we argue that both new and existing theories of organizational phenomena can benefit from incorporating empirical findings, methodologies, and overarching themes from neuroscience. These themes elucidate particular networks of brain systems and processes responsible for the workplace attitudes and behaviors that organizational scholars have observed. Neuroscience can allow us to finally go inside the brain and investigate these primal causes of behavior.

Our interest lies in understanding the brain processes behind observed attitudes and behaviors and their implications for predicting and modifying these behaviors in the workplace. In this way, prior organizational theories are incomplete in the sense that they do not consider the most fundamental level of analysis. Our ultimate aim is to establish an *organizational neuroscience* perspective that strives to understand and incorporate the cognitive machinery behind our thoughts and actions into organizational theory (Becker & Cropanzano, 2010; Bergué, 2010). Leveraging this knowledge will reduce our level of analysis to the most basic building blocks of behavior. As we demonstrate, this additional level of analysis can extend current theoretical thinking, direct our attention in new scholarly directions, and resolve current theoretical contradictions and disputes. The ultimate promise of this perspective is to connect and unify our theories of organizational behavior.

Several social science fields have already embraced neuroscience (Camerer, Lowenstein, & Prelec, 2005; Dijksterhuis, Smith, Van Baaren, & Wigboldus, 2005). In economics, neuroscience has been used to investigate the motives behind individual behavior in interactive decisions (e.g., Sanfey, Rilling, Aronson, Nystrom, & Cohen, 2003). In marketing, neuroscience has helped illuminate the role of emotion in consumer choice (Hedgcock & Rao, 2009). Organizational scholars have recently begun to selectively draw on findings from neuroscience. Ashkanasy (2003) incorporated a neurological basis for affect into a model of organizational emotions, and Reynolds (2006) drew on a limited neuroscience perspective to develop a model of ethical decision making. Findings from neuroscience have also been utilized in recent theorizing regarding intuition (Dane & Pratt, 2007; Sonenshein, 2007) and organizational justice (Bergué, 2009; Dulebohn, Conlon, Sarinopoulos, Davison, & McNamara, 2009). This research has opened an important dialogue between organizational behavior and neuroscience, one that we aim to encourage further.

The Relationship Between Organizational Neuroscience and Existing Research Within Organizational Behavior

To begin this inquiry, we consider how organizational neuroscience relates to research that is already being conducted by management scholars. We start with a relatively focused discussion, describing how organizational neuroscience is unique but complementary to each. Afterward, we take a broader perspective and discuss organizational behavior more generally. We show that organizational neuroscience can be viewed as a new level of analysis within the organizational behavior literature. In the interest of clarity, we have eschewed a detailed treatment of brain function and organization. However, we encourage the interested reader to examine our short primer on neuroscience, which is presented in the appendix.

Organizational Neuroscience and the Three Existing Paradigms of Biologically Informed Management

Management scholars have recognized the importance of human biology. Though the empirical research is somewhat limited, existing applications tend to fall into three categories—evolutionary psychology, behavioral genetics, and physiological changes/symptoms. Each of these paradigms has provided scholars with a unique window into the relationship between human biology and work behavior.

Evolutionary explanations seek to account for work behavior by examining natural selection during *Homo sapiens*' ancestral development (Nicholson, 2000; Nicholson & White, 2006). For example, since "free riding" allows noncontributors to benefit from the effort of others, humans have evolved well-honed cognitive tools that enable us to detect cheaters (Tooby, Cosmides, & Price, 2006). Evolutionary approaches have also shed light on such important phenomena as leadership (Nicholson, 2005; Van Vugt, Hogan, & Kaiser, 2008) and reputation within work teams (Price, 2006).

Behavioral genetics research has examined the impact of genetic influences on behavior and response to the work environment (Arvey & Bouchard, 1994). Generally, it has posited that heritable genetic tendencies predispose individuals toward particular, relatively stable attitudes or dispositions (Ilies, Arvey, & Bouchard, 2006). For example, Arvey, McCall, Bouchard, Taubman, and Cavanaugh (1994) found evidence that genetic traits influence work values and job satisfaction. Other research has examined genetic influences on emergent leadership (Ilies, Gerhart, & Le, 2004) and entrepreneurship (Shane, Nicolaou, Cherkas, & Spector, 2010).

The third application of biology to work behavior, and probably the best known, explores physiological responses or symptoms as they pertain to work behavior (Semmer, Grebner, & Elfering, 2004). Much of this work has examined physical symptoms resulting from stressful conditions at work. For example, Wright, Cropanzano, Bonnett, and Diamond (2009) found that workers who had higher well-being tended to have lower pulse pressure than did their lower well-being counterparts. Perrewé and colleagues (2004) concluded that political skill could help workers maintain good cardiovascular health even when their environment was characterized by role conflict. Similarly, Wagner, Feldman, and Hussy (2003) found that employees had higher blood pressure when they worked with a troublesome supervisor and lower blood pressure when they worked with a more supportive supervisor.

Taken together these three research paradigms—evolutionary psychology, behavioral genetics, and physiological changes—have provided a useful foundation for a biologically informed perspective on organizational behavior. These three perspectives are notably reinforcing, and there are clear avenues for integration. Ilies et al. (2006) noted that the various genes that shape our behavior have emerged through a process of Darwinian evolution. Natural selection gives rise to our genome. Furthermore, evolution and genes express themselves through our physiology. For example, Colarelli, Spranger, and Ma (2006) argued that subtle differences have evolved in the neuroendocrine systems of men and women. These differences, in turn, predict gender specific behaviors in small groups.

What remains to be incorporated, however, are the relevant findings from neuroscience, such as the influence of our neuroanatomy. We believe that organizational neuroscience provides a missing piece to the puzzle. Inclusion of research from the brain sciences has the

potential to further complement and expand what we have already learned through the study of evolution, genetics, and physiology. To illustrate this promise, consider research on the emotion of envy. Hill and Buss (2008) have provided an evolutionary account of how envy evolved, and Smith, Combs, and Smith (2008) present evidence suggesting that jealousy can engender cardiovascular disease. Neuroscience research can take our knowledge a step further. In this regard, Joseph, Powell, Johnson, and Kedia (2008) describe envy's neuroanatomy. They found that envy involves a distinct neural network including the striatum, the amygdala, the anterior cingulate, and the insula. This suggests that envy is an automatic and not a deliberative response. Notice that the neuroscience reviewed by Joseph and her colleagues complements and reinforces the evolutionary account provided by Hill and Buss as well as the physiological account discussed by Smith and his coauthors. Collectively, these approaches provide a fuller explanation than either could deliver individually.

Organizational Neuroscience, Levels of Analysis, and Hierarchical Reductionism

Scientists often explain phenomena by looking across different levels of analysis. By hierarchically integrating "higher" and "lower" explanations, our overall accounts become richer and more robust. According to Pinker (2002), *hierarchical reductionism* "consists not of *replacing* one field of knowledge with another but of *connecting* or *unifying* them" (p. 70, italics original). Hierarchical reductionism is a proper goal of science since an explanation at one level of abstraction will inevitably lead to questions that are better answered at other levels. Hierarchical reductionism ultimately seeks consilience, or the unity of scientific knowledge (E. O. Wilson, 1998). In this way, different research disciplines are not involved in a competition that yields one winner and a set of losers. Rather, each field of knowledge can benefit from what has been learned elsewhere.

The issue of levels is already familiar to organizational scientists (Morgeson & Hofmann, 1999). Generally, organizational scholars distinguish among (at least) three (Klein, Dansereau, & Hall, 1994). At the highest or most abstract is the organizational level of analysis, which includes such topics as strategy and structure. The organization can be further reduced to a collection of small groups or work teams, which exhibit meaningful collective behaviors. Groups, in turn, can be further reduced to individual people, which have their own particular knowledge, skills, and abilities. Researchers often specialize, targeting their scholarly efforts at one particular level or another, but there is a general recognition that each of these levels is important.

Organizational neuroscience adds an additional level of analysis. A potential benefit, which is also not without risk, is that this forces researchers to consider additional levels of reduction that deconstruct individuals to discrete brain processes (Ashkanasy, 2003; Barsade, Ramarajan, & Westen, 2009). The ultimate promise of these lower levels of analysis is that the neural mechanisms are largely homogenous across all individuals and are recruited to respond to numerous different organizational situations. That is to say, each neuron operates in the same way, and all brains are organized in a similar fashion. For example, we have seen

that the amygdala is involved in envy, but it is also involved in pride and satisfaction. Nonetheless, each brain is also unique due to genetics, experience, and culture (Park & Huang, 2010). In this way neuroscience will eventually allow us to build and connect our theories at multiple levels.

For all of its promise, organizational neuroscience also raises potential concerns. Some observers worry that more reductionist or molecular explanations supplant other accounts (Bickle, 2006; Pinker, 2002). For instance, Franklin (1987) remarked, “[W]e see mechanisms wherever we look. The smile of the baby that warms the mother’s heart and solidifies her love is reducible to chemical equations, and to mechanisms . . . mechanisms within mechanisms within mechanisms” (p. 202). This is a disturbing position, as it undermines the benefits that we have noted above. By suggesting that *all that matters* is the molecular level of analysis, such an approach implicitly (or perhaps even explicitly) ignores the different processes that occur at higher or more abstract levels of analysis (Morgeson & Hofmann, 1999). This perspective, which prioritizes neurobiological explanations above social scientific ones, has recently been termed *neuroessentialism* (Huettel et al., 2009). Neuroessentialism reflects the belief that all identity and behavior can be reduced to individual neurons (Bickle, 2006; Racine, Bar-Ilan, & Illes, 2005).

Neuroscientists have been mindful of this issue. To be sure, neuroscience has pursued reductionism with ruthless determination, making significant advances at decomposing brain functions to the molecular level (Bickle, 2006). At the same time, neuroscience has also recognized that interactions between higher and lower levels are necessary to explain the complexities of human cognition and behavior. For example, the computational approach to neuroscience relies heavily on *reconstructionism*. Reconstructionism is the process by which realistic models of individual neurons are incorporated into multilevel networks that recreate higher level emergent phenomena (O’Reilly & Munakata, 2000). It is becoming increasingly clear that in the future understanding, predicting, and altering cognition and behavior will require assimilating bottom-up as well as top-down mechanisms (Craver, 2002). As Pinker (2002) observes, this means that neuroscience theories and existing theories from organizational research can inform one another. Extending our inquiry to lower levels of analysis will not detract from more familiar higher levels of analysis but rather will undoubtedly illuminate and tighten the linkages between levels.

Applying Neuroscience to Organizational Behavior

Organizational neuroscience is best thought of as a paradigm or interpretive framework that sheds new light on existing problems as well as highlighting problems that might not otherwise have been considered. While no one article can review every potential area of application, nor could any single research team anticipate all of these in advance, it is worth considering a few examples that illustrate how a neuroscientific perspective can contribute to organizational science. Here we focus on three particular questions, each of which demonstrates a different type of contribution. We first take up the issue of the social environment and mirror neurons, suggesting that brain science can extend extant theories. We then turn our attention to neural processing and work attitudes, showing that new research questions

can sometimes become apparent when the problem is considered from the organizational neuroscience perspective. Finally, we discuss the potential to resolve existing conceptual disputes, illustrating this possibility by considering human self-interest and justice.

Expanding Our Understanding: Mirror Neurons and the Social Setting

Organizational scientists recognize the importance of the social setting. Phenomena such as work climates (Kuenzi & Schminke, 2009), organizational cultures (Schein, 1991), and other aspects of the social setting exert well-documented effects on employee attitudes and behaviors. In the face of so much evidence, what room is left for biological influences? Indeed, some scholars have found the evidence for situational effects so compelling that they have questioned whether *any* individual attribute—be it biological or otherwise—can appreciably affect workplace behavior (Davis-Blake & Pfeffer, 1989).

Organizational neuroscience proffers a unique perspective, suggesting that a neuroscientific analysis complements rather than supplants a social scientific one. Human beings are heavily influenced by their social setting *because of their biology*. People are wired to live and work in social groups (Cacioppo & Patrick, 2008; Goleman, 2006; Haidt, 2006). In addition to explaining individual differences, our biology also helps to explain why and how we are influenced by social stimuli (e.g., Mason, Dyer, & Norton, 2009). An animal of a more solitary disposition would be less influenced by conspecifics. For example, *Homo sapiens* exhibit a fuller range of mimicry than do members of other species (Gazzaniga, 2008). Seen from this vantage point, there is no contradiction between the coexistence of both social and biological influences. Indeed, the latter helps to generate the former. Though at first glance it might seem counterintuitive, organizational neuroscience expands our understanding of social influences by exploring the anatomical architecture that facilitates social influence.

Mirror neurons. Teams of researchers have long studied such important social phenomena such as group climate, norms, and emotional contagion in the workplace (Barsade, 2002; Ehrhart & Naumann, 2004; Ilgen, Hollenbeck, Johnson, & Jundt, 2005). According to Becker and Cropanzano (2010) workers automatically and often unconsciously imitate one another's behavior and feeling through the operation of the human mirror neuron system (MNS; Goleman, 2006; Keysers & Fadiga, 2008; Rizzolatti & Fabbri-Destro, 2008).

While other species are known to possess an MNS, the structure and role of the human MNS seems to be much more complex than other species. Similar to other primates, our MNS supports our ability to learn vicariously—simply by watching others (Atmaca, Sebanz, Prinz, & Knoblich, 2008; Oullier, De Guzman, Jantzen, Lagarde, & Kelso, 2008; Rizzolatti & Fabbri-Destro, 2008). However, the human MNS also responds to the dynamic motion, facial expressions, and sounds as well as the goal-directed actions of proximal others (Enticott, Johnston, Herring, Hoy, & Fitzgerald, 2008; Gazzola, Aziz-Zadeh, & Keysers, 2006; Rizzolatti & Craighero, 2004). In essence, our MNS continuously monitors and simulates the goals, intentions, and mental state of others around us (Atmaca et al., 2008; Oullier et al., 2008; Rizzolatti & Fabbri-Destro, 2008). In this way the human MNS is capable of creating automatic

and nonconscious social ties between individuals, including the building of work group and organizational cultures (Becker & Cropanzano, 2010).

Therefore, a fundamental purpose of the human MNS appears to be to support social interactions and increase cooperative behavioral coordination. Its effect is so robust that even two strangers who interact can reflect and coordinate their feelings and physical actions. This coordination occurs at such a level that it need not be intentional (Chartrand & Bargh, 1999, Study 1). For example, in one study McFarland (2001) had two research participants wear monitors that tracked their breathing. While interacting, the subjects' breathing patterns became either consistent (they inhaled and exhaled at the same time) or complementary (as one inhaled the other exhaled).

Intragroup relations presents one area of organizational research where the integration of a neuroscience perspective will be important to advancing theory. While robust motor mimicry is well known, the chameleon effect goes further. Specifically, as the similarity of behavior increases participants in dyads appear to feel greater liking for each other. For example, Chartrand and Bargh (1999, Study 2) had laboratory participants work in dyads with an experimental confederate. In the experimental condition the confederate imitated the subject's posture and mannerisms; in the control condition the accomplice behaved more neutrally. Experimental participants reported liking the confederate more and having smoother interactions when they were mimicked. Likewise, Fraley and Aron (2004) observed that when individuals shared a humorous event they reported greater interpersonal attraction than when a shared event was neutral.

Mirror neurons and group affect. Prior work has demonstrated the presence of group-level affect among members of work teams (George, 1996, 2002; George & Bettenhausen, 1990). Given that one's feelings are usually thought of as an individual-level construct, this might initially seem puzzling. The strong influence of the MNS provides a parsimonious account of how work teams develop a shared affective tone. The MNS automatically processes and models the emotional expressions, movements, and sounds of others. Providing evidence to this effect, Totterdell, Kellet, Teuchmann, and Briner (1998) and Totterdell (2000) discovered that the moods of coworkers appeared to converge over time.

More striking, it has been demonstrated that viewing an emotional face produces a spontaneous reflection of the viewed emotion (Sato & Yoshikawa, 2007). Even more compelling evidence suggests that observers *actually experience* the emotions they reflect (Wicker et al., 2003). Viewing dynamic whole-body emotional scenes heightens this effect, producing increased response in the amygdala and insula and priming the brain and body for action (Nummenmaa, Hirvonen, Parkkola, & Hietanen, 2008; Pichon, de Gelder, & Grézes, 2008). Therefore, the MNS provides a basic neural mechanism for emotional contagion in groups, through which emotions can rapidly and unconsciously spread between group members. Additional research suggests that these effects can persist over time and may be moderated by factors such as emotion strength, frequency of interaction, and familiarity with interaction partners (Oullier et al., 2008).

Viewing rich and dynamic emotional scenes with multiple others produces more complex response in the mirror neurons and connected systems. The mirror neurons are capable of accessing multiple agents with conflicting emotions (Nummenmaa et al., 2008). We seem

able to simultaneously sense the anger in aggressors and fear in victims, integrate the overall emotional landscape, and implicitly judge whether to approach or avoid (Rizzolatti & Fabbri-Destro, 2008). This ability contributes to the unconscious coordination of feelings and action within groups (Rizzolatti & Fabbri-Destro, 2008; Shearer, Holmes, & Mellalieu, 2009). Mirror neurons represent but one advance that can expand our understanding of well-known phenomena. Far from contradicting the important influence of the social setting on workplace behavior, organizational neuroscience complements these pursuits by grounding them in biology. We evolved as social animals, and mirror neurons provide one mediating mechanism between neurobiology and group life.

The Influence of Implicit Attitudes

As we saw in the previous section, research on the MNS suggests that much of what people learn during socialization is processed nonconsciously within the brain. Consequently, many of the normative attitudes that originate from our MNS are tacit and not easily accessible for verbal self-report. Evidence suggests that work attitudes can sometimes simply be modeled from others (e.g., Weiss & Nowicki, 1981); as such they may not always be consciously available for careful scrutiny and dialogue. Even so, these nonconscious predispositions can influence our workplace behavior (George, 2009). With this in mind, both organizational scientists and neuroscientists have begun to stress the importance of differentiating between *implicit* and *explicit* attitudes (Cunningham, Zelazo, Packer, & Van Bavel, 2007). While both perspectives offer unique theoretical insights, an important advantage of neuroscience is that it also provides a range of methods for operationalizing and tracing implicit attitudes (Akinola, 2010; Camerer et al., 2005).

Despite important differences between the nature of implicit and explicit attitudes, our mind seamlessly aggregates them within our conscious narrative. As a consequence, we are often unaware of or discount our implicit attitudes (cf. Barsade et al., 2009; Westen, 2007). This phenomenon is interesting because it suggests that the ultimate cause of many behaviors may be understudied within organizational behavior. Studies that rely on self-report measures may inadvertently neglect implicit attitudes and thereby fail to capture and consider their important influences (Cunningham et al., 2007). Incorporating implicit attitudes into organizational research may help to improve the sometimes disappointingly weak relationship between measured attitudes and outcomes in the extant literature (Ajzen, 1988; Ross & Nisbett, 1991). To this end, neuroscience provides a promising window into the link between attitudes and behavior because it can discern whether a response is associated with activity in brain regions that perform implicit or explicit processing.

Overview of implicit and explicit attitudes. It is first necessary to establish a precise definition of implicit and explicit attitudes. We believe that most definitions in the extant literature have been far too narrow (for more comprehensive treatments, see Westen, 1998, 2007). Implicit attitudes occur automatically and very rapidly within the brain. They are primarily nonconscious, although we can sometimes become aware of our implicit attitudes. It is more correct to say that we have little insight into where implicit attitudes come from, often confusing a nonconscious bias with a self-justifying rationalization (Haidt, 2006; Westen, 2007). This

Table 1
Important Differences Between Implicit and Explicit Attitudes

Implicit Attitudes	Explicit Attitudes
Automatic	Deliberate
Limited cognitive access to processing	Extensive cognitive access to processing
Associative	Reflective
Relies primarily on past outcomes stored in long-term memory	Relies primarily on future outcome projections in working memory
More stable over time and resistant to change	More dynamic and malleable over time
Occurs primarily in older, deep brain structures of temporal lobe	Occurs primarily in newer, executive control structures of frontal lobe

is not to accuse individuals of intentional deceit. Rather, they could very well believe their rationalization to be factual even when it is not the true cause of their feeling or behavior.

Implicit attitudes arise primarily in the phylogenically older (developed earlier in our evolutionary history), deep-brain structures of the limbic system (see the appendix for more information). These attitudes derive from relative neural weights within long-term memory that map current environmental stimuli onto past experiences and outcomes. In this way, implicit attitudes are essentially primed by the current environment, based on past experiences, and emerge without consideration of future consequences.

Explicit attitudes differ from their implicit counterparts in a number of important ways. Table 1 provides a summary of the important differences. Compared to their implicit counterparts, explicit attitudes are more likely to result from deliberative reasoning. This gives rise to the most apparent difference between these two types of attitudes in that we are usually conscious of where our explicit attitudes come from. That is to say we are aware of the considerations and comparisons that went into formulating our explicit opinion. This occurs because explicit attitudes are processed in a different region of the brain (Cunningham, Raye, & Johnson, 2004). Whereas our implicit attitudes are produced in phylogenically older regions, the processing of explicit attitudes arise in the evolutionarily newer executive control structures of the frontal lobes.

Organizational change and the biasing effects of implicit attitudes. One challenge faced by organizations is to change and adapt in constructive ways in order to innovate and respond to circumstances. Many firms are unsuccessful in accomplishing this, and observers agree that dramatic change often requires long-term sustained effort and risk taking (Kouzes & Posner, 1995), perhaps even hiring a different workforce (Cable, 2007). Becker and Cropanzano (2010) suggest that one of the reasons change efforts fail is because managers focus on *explicit* attitudes and fail to appreciate or target *implicit* attitudes. As a result, organizational researchers and managers who do not consider the influence of implicit attitudes will tend to overestimate the ease with which individuals can adapt to change (T. D. Wilson, Lindsey, & Schooler, 2000). There are at least two reasons for this.

As we have already seen, employees may not be able to accurately verbalize the actual reason for their resistance to change. For example, an individual who is overly distressed by uncertainty might legitimize his or her opposition to change by attacking specific features of

a planned change effort. In this example, the opposition comes from an implicit response, and the explicit opinions serve only as creative rationalizations. A manager who is unaware of this deeper cause might seek to allay the stated concerns through reasoned communication. However, logical discourse is unlikely to be effective since it does not address the underlying implicit attitude that is actually driving the resistance to change. In addition, implicit and explicit attitudes are fundamentally different in terms of when and how they are produced in the brain. Implicit attitudes arise first, are affectively loaded, and remain largely outside of consciousness. Because they arise first, they can short-circuit other beneficial nonconscious and conscious processing. Thus, implicit attitudes can be especially pernicious since they can distort subsequent cognitive processing and bias our decisions and behaviors in detrimental ways.

To our knowledge, implicit attitudes have not been considered in organizational change research. Nevertheless, it is interesting to note that some change scholars have focused on the constraining effects of culture. Beach (2006) argues that change often requires leaders to alter aspects of the work environment that symbolize older ways of doing things, such as clothing and jargon. This concern with workplace stimuli that prime otherwise nonconscious ideas fits nicely with the literature on implicit attitudes (Becker & Cropanzano, 2010). It also serves to demonstrate that a neuroscience perspective can provide new insight to a wide range of organizational inquiry topics.

Workplace discrimination and the disassociation of implicit from explicit attitudes. Workplace discrimination is one area where implicit attitudes have already captured the interest of organizational scholars (Landy, 2008; Ziegert & Hanges, 2005). This research suggests a foreboding dark side of implicit attitudes. One of the most interesting findings from neuroscience is that implicit and explicit attitudes can often diverge (Lieberman, 2007). One may express a positive explicit attitude toward something or someone but hold a negative implicit attitude, or vice versa. The two need not push us in the same direction. This has important implications for the attitude-behavior link. In ambiguous situations, the implicit attitude may be the primary determinant of behavior. As we shall see, this helps to maintain group boundaries, but it may do so in a harmful fashion since out-group members may often be unfairly disadvantaged or excluded.

As an illustration, consider evidence demonstrating that individuals often hold nonconscious prejudices that they are not aware of and would not explicitly endorse (Quillian, 2006). There are times when we sincerely believe that we are not biased, though prejudice may nonconsciously manifest itself in ways that disadvantage others (Lane, Banaji, Nosek, & Greenwald, 2007). In one study, African American defendants were more likely to receive harsh sentences if they possessed a stereotypically "African" appearance. In such circumstances it may not be that the people involved were overtly (i.e., explicitly) racist, but rather their nonconscious feelings may have influenced how they responded to others (for more evidence, see Amodio & Devine, 2006; Dovidio, Kawakami, & Gaertner, 2002).

This research raises an interesting prospect. People may be biased against others without willfully choosing to do so. In fact, they might discriminate even though they are explicitly opposed to bigotry! Recall that implicit attitudes are automatically triggered by environmental inputs. For instance, a certain stimulus, such as the sight of a person from a different gender

or ethnicity, could prime an implicit prejudice that exists in long-term memory from previous experiences and exposures. Furthermore, it has been demonstrated that strong implicit attitudes can impede the processing of contradictory information (Westen, Blagov, Harenski, Kilts, & Hamann, 2006). In this way, implicit attitudes are generated immediately and can enforce group boundaries against “outsiders.” Of course, this sort of nonconscious discrimination is problematic because it forestalls advantageous social ties, reduces workplace diversity, potentially harms innocent people, and may at times be illegal.

While implicit attitudes have the power to influence behaviors, they also have important consequences for other nonconscious processes. In our discussion of mirror neurons, we saw that the human MNS relies on approach/avoid signals for other individuals based on a combination of emotional and goal-oriented cues (Rizzolatti & Fabbri-Destro, 2008). Implicit attitudes arise in the emotional center of the brain and affect the way that the MNS interprets others’ emotional states (Frith & Frith, 2008). Therefore, implicit biases may reduce the likelihood that an individual will mimic and seek to form a social tie with another individual even when the pair share common goals, interact frequently, and could form a mutually beneficial social connection. This coordination barrier may remain entirely outside consciousness and be quite resistant to outside attempts to bring the two together. An initial imaging study found evidence that the MNS indeed responded more strongly to racially matched partners (Molnar-Szakas, Wu, Robles, & Iacoboni, 2007). Thus, the interaction of multiple nonconscious processes can help to explain and predict the emergence of in-groups and out-groups that have concerned and puzzled a number of researchers.

Additional thoughts. In general, organizational behavior research has emphasized the impact of explicit attitudes on work-related outcomes (for a thorough review, see Brief, 1998). For example, some work has considered how attitudes result from carefully comparing what one has with what one wants (cf. Hulin, 1991) as well as considering the role of explicit social pressures (Ajzen, 1988). However, brain research suggests that this is not the only, nor is it necessarily the most compelling, way that people process information. Explicit attitudes tend to be formed in the frontal lobes. This more recently evolved portion of the human brain serves as the principle seat of conscious processing. Implicit attitudes tend to be processed in the limbic system. This is an older part of the brain and is closely tied to affect (see the appendix for additional information). By neglecting these basic facts about the brain, it is not surprising that the extant research investigating the association between work attitudes and work behaviors has sometimes produced disappointing results. Given the limits of explicit processing, future organizational research should consider implicit attitudes as well (Akinola, 2010; Barsade et al., 2009). These nonconscious predispositions likely play an important role in a wide variety of organizational phenomena.

Resolving Conceptual Debates: The Case of Universal Self-Interest

So far we have examined the possibility that organizational neuroscience can expand our understanding of workplace phenomena, such as the way that mirror neurons inform our understanding of social behavior. We have also seen that neuroscience can direct us to new

research questions, as when we consider the role of implicit and explicit attitudes. In this third example we consider an additional contribution—how organizational neuroscience can shed new light on contemporary conceptual debates.

To illustrate this possibility, we consider an ongoing debate within the area of organizational justice. Folger (1994, 1998, 2001; Folger & Salvador, 2008) and Lerner (1975, 1982, 2003) maintain that individuals often value fairness for its own sake. That is, justice is good in its own right, and people will sometimes forgo other valuable outcomes—including money—in the name of fairness. Others oppose this view (e.g., Colquitt & Greenberg, 2001; Gillespie & Greenberg, 2005; Greenberg, 2001). These researchers argue that people are concerned with justice only as a means of advancing their personal goals. Fairness is not an end in itself but rather a means to individual advantage. As Gillespie and Greenberg (2005) put it, “[T]he *only* ultimate goal(s) of individuals [is/]are self-directed” (p. 205, italics added). Self-interest is universal since it is the principal human motive.

The disagreement about universal self-interest takes on even greater importance when one considers its practical ramifications. Ferraro, Pfeffer, and Sutton (2005) observed that organizations were administered in accordance with managers’ preconceptions about human nature. If the leadership of a firm assumed that employees were motivated by egocentric self-interest, then they designed managerial systems with this in mind. Misdirected policies could be ineffective or, worse yet, might produce self-fulfilling prophecy—spurring the selfish behaviors that they presume to motivate us all.

The debate over universal self-interest is complex and involves a number of disciplines, including philosophy, social psychology, and management (for a review, see Cropanzano, Stein, & Goldman, 2007). No one piece of evidence is likely to be decisive. Even if organizational neuroscience cannot provide a complete answer, it does yield a very specific and testable prediction. If a concern with justice can be distinguished from a concern for personal gain, then it is likely these two issues are processed in different parts of the brain that are dissociable from each other. A number of scholars have argued that the human brain has specialized modules for moral decision making (e.g., Gazzaniga, 2008; Haidt, 2001). On the other hand, if all human concerns are ultimately concerns with the self, then processing related to fairness and processing related to self-interest should take place in the same brain centers.

Brain centers for fairness and self-interest. In recent years a number of scholars have proposed and tested what Bergu  (2009) terms “a model of neuro-organizational justice” (p. 129) that examines how justice information is processed by the brain (Dulebohn et al., 2009). These findings coupled with other advances have gone a long way toward resolving this long-standing debate. Evidence suggests that fairness considerations are processed separately from economic gain and self-interest. Initial studies showed unsurprisingly that being treated unfairly produces strong emotional reactions (Sanfey et al., 2003). This study employed a well-known economic decision-making task where pure self-interest predicts that participants should accept any proffered monetary amount, irrespective of the degree of unfairness in how much is offered. However, in reality players often turn down unfair offers, even at a monetary cost to themselves (Ketelaar, 2006). In the Sanfey et al. (2003) study, participants receiving unfair offers showed greater activation in the insula, a region associated with the processing of negative emotion. Furthermore, the level of insula activation predicted

the likelihood of participants rejecting an unfair offer. This finding is important but could be consistent with fairness or self-interest.

Two subsequent studies have provided further insight into this issue. The first demonstrated that being treated fairly activated brain areas associated with the processing of reward and confirmed that being treated unfairly produced negative emotional response (Tabibnia, Sapute, & Lieberman, 2008). This study employed a similar paradigm to Sanfey et al. (2003) and found increased activation in the amygdala, ventral striatum, and ventromedial prefrontal cortex when fair offers were received. Furthermore, these fair offers were almost always accepted. In contrast, unfair offers produced increased insular activation and frequent rejections as before. Participants who accepted unfair offers showed increased ventrolateral prefrontal cortex activation but failed to activate neural reward networks. This suggests that some participants were able to override their strong negative affective reactions to unfair treatment and pursue economic gain but that doing so was unsatisfying. Tabibnia et al. (2008) concluded that fairness processing was relatively automatic and intuitive. In addition, they suggested that although being treated unfairly was objectionable, fair treatment was intrinsically rewarding over and above monetary considerations.

A subsequent study explored the association between equity and efficiency of distributive outcomes (Hsu, Anen, & Quartz, 2008). In this study, participants had to distribute limited resources among third parties. They found that equity and efficiency were encoded in separate regions of the brain. Efficiency was associated with activity in the putamen, and equity (or rather inequity) was once again associated with activation in the insula. Moreover, inequitable options produced increased insula activation and were not selected even when those options produced more efficient outcomes overall than more equitable alternatives. The authors concluded that fairness perceptions emerge from moral intuition and emotional response rather than from cognitive consideration of economic efficiency or deontological principles.

Self/other fairness processing. The other key finding across studies has been that individuals process fairness for themselves and others in similar regions of the brain, especially for automatic implicit reactions to inequity (Frith & Frith, 2008; Hsu et al., 2008; Sanfey et al., 2003; Tabibnia et al., 2008). Other studies have shown that observing another party being treated unfairly triggers feelings of empathy (e.g., Singer et al., 2006). Empathy is an automatic and immediate identification of the emotions of others as if they were experienced by the observer himself or herself (Izard, 2009). Empathy stems from the MNS and causes us to respond emotionally and behaviorally as if the observed event actually occurred to us (Nummenmaa et al., 2008; Singer et al., 2006). Therefore, the triggering of empathy suggests that we take a personal interest against the unfair treatment of others (Patent & Skarlicki, 2005, 2010).

It has also been found that justice considerations are associated with self-referential thinking and "theory of mind" processing (Robertson et al., 2007). Theory of mind is a relatively automatic process that allows an individual to infer and simulate the mental states of others and place himself or herself in the shoes of the other people (Lieberman, 2007). Theory of mind is related to empathy but goes beyond basic emotional response and incorporates simulating the beliefs, goals, and intentions of the other party (Gallagher & Frith, 2003). This also

helps explain why individuals were more likely to sacrifice personal gain to punish injustice only when the victims of injustice were perceived to be fair players (Singer et al., 2006). Robertson and colleagues (2007) point to these findings to suggest that moral sensitivity to justice may rely on one's own emotional response and one's inference of the emotional response of other parties.

In this example we demonstrate the strength of organizational neuroscience as a paradigm for resolving certain conceptual debates. Two phenomena may make similar predictions at the behavioral level but could look quite different in terms of their neural processing. In the present case, moral dilemmas concerning fairness activate different regions of the brain than do those concerning economic gain. This provides support for a more modular model of the brain (Gazzaniga, 2008; Haidt, 2001) and is consistent with theoretical perspectives articulated by Folger (1994, 1998, 2001; Folger & Salvador, 2008) and Lerner (1975, 1982, 2003).

Implicit attitudes and (in)justice toward others. A neuroscience perspective also provides some other unique insights for justice research. Justice perceptions must also interact with other nonconscious processes. A number of neuroscience studies have found that there is a tendency for individuals to be more strongly affected by injustice toward themselves and less strongly affected by injustice toward others (Hsu et al., 2008; Sanfey et al., 2003; Tabibnia et al., 2008). These differential responses between unfair-to-self and unfair-to-others is even stronger among our evolutionary cousin, the chimpanzee (Brosnan, 2006). Going further, there is evidence that we are sometimes capable of disregarding the unjust treatment of out-group members, while being more concerned that similar others be treated with fairness (Clayton & Opatow, 2003). Findings such as these suggest that much like the MNS our justice perceptions take cues from other nonconscious brain processes that can moderate or even turn off justice processing. It follows therefore that implicit attitudes once again are likely to be an important factor in justice considerations.

There is also evidence confirming that negative implicit attitudes can affect the neural processing of justice perceptions in social settings. Roberson and Colquitt (2005) acknowledged that diversity in teams and organizations can act as a barrier to shared justice perceptions in their network model of justice. Incorporating a neuroscience perspective to this model provides a theoretical and testable basis for how this occurs. Most importantly for justice considerations, implicit attitudes may alter the way justice is processed in the brain. Specifically, the activation of out-group status could essentially turn off empathy and justice processing for those individuals. This could help explain the incongruous behavior of individuals who act justly in most aspects of their life but prove capable of gross injustice and even discrimination toward individuals of a particular group. Therefore, in many cases by helping to resolve theoretical debates, a neuroscientific debate may often also suggest new research directions.

The Riddle of Consciousness: Neuroscience and Human Nature

One of the most striking philosophical differences between neuroscience and organizational scholars has been their respective views of human consciousness. Many theories of

workplace behavior imply a high level of conscious control over our thoughts and actions. For example, research on work motivation has historically been concerned with explicit behavioral standards and decisions, despite the availability of evidence suggesting that individuals are also influenced by subconscious goals (Latham, Stajikovic, & Locke, 2010). Other theories are similar. Behavioral ethicists have often argued that moral behavior results from a logical analysis that produces moral intentions (Krebs & Denton, 2005), though support for this contention has been mixed (Haidt, 2001; Kish-Gephart, Harrison, & Trevino, 2010), and contemporary work shows a greater appreciation for moral intuitions (Sonenshein, 2007). Research on recruitment likewise often emphasizes conscious career decisions (Boswell, Roehling, LePine, & Moynihan, 2003; but see Crossley & Highhouse, 2005, for an important exception; Rynes & Cable, 2003).

The collective impression that emerges from organizational theory often portrays the individual as an active agent who weighs evidence to make deliberate decisions. However, this assumption has not always received empirical support. Of course, there is much to be said for conscious behavioral regulation. We argue rather that human consciousness has important limitations. Neuroscience takes a somewhat different view of human thinking and feeling. Brain research indicates that a good deal of processing takes place outside the limits of our conscious awareness. For this reason, organizational neuroscience would retain deliberative processes but also suggest that greater emphasis be placed on nonconscious processing.

The Limits of Consciousness

A distinction needs to be made between what the brain “perceives” and what the individual is aware of perceiving. The two do not always go together. For example, the primary visual cortex (located in the occipital lobe in the rear of the brain, discussed below and illustrated in the appendix) has specialized neurons that respond to specific visual features. Other regions of the brain process visual characteristics such as movement, color, and texture (Kolb & Whishaw, 2008). When the appropriate neurons fire the individual does not experience the firing neurons; rather, he or she has an overall phenomenal impression of the object. This subjective and conscious experience has been referred to as the “qualia” (Blackmore, 2005). We generally think of the objective experience and the qualia as roughly isomorphic. However, evidence suggests that they can sometimes become disassociated.

To illustrate how this neuroscientific account could change our view of human consciousness, consider the phenomenon of “blindsight” (e.g., Lehigh, Johansen-Berg, & Ptito, 2006; Stoerig & Cowey, 1997). In these instances, individuals with localized damage to the visual cortex can identify moving objects at better than chance even though they report that they see nothing and are not consciously aware of what they are responding to. Notice that in this example the brain perceives and acts on *something* in the environment but the individual has no conscious awareness of perceiving what it is acting on. The qualia (subjective conscious experience) is absent and disconnected from the brain’s response, yet the nonconscious perception remains able to influence behavior. Even with advances in technology, studying individuals with specific types of brain damage such as that described here has been and

continues to be one of the most informative methods of learning about how the brain functions (Kolb & Whishaw, 2008).

Blindsight becomes even more interesting when the perception of emotion is involved. Pegna, Khateb, Lazeyras, and Seghier (2005) examined patients who had lesions in their visual cortex. Once again their eyes and optic nerves were undamaged, but they were functionally unable to process the visual information in the normal conscious manner. However, when these patients were presented with pictures of human faces exhibiting positive or negative emotion, they were able to "guess" the faces' affect at better than chance levels despite having no conscious perception of the faces. Pegna et al. concluded that our emotional perception of others relies at least partly on the amygdala and that the amygdala is able to process raw input from the primary visual stream before it reaches the visual cortex and enters consciousness (Amunts et al., 2005; Kolb & Whishaw, 2008).

The subjects in blindsight research were "seeing" the target stimuli in a meaningful sense despite not being consciously *aware* of seeing it. Such evidence demonstrates more generally that our brains often respond to conditions and events in our environment without the conscious involvement of our mind. This presents an intriguing possibility. Perhaps consciousness, which occupies a central role in most theories of organizational phenomena, should share the stage with nonconscious processing. If so, then a somewhat different view of human behavior in organizations is likely to emerge, one that pays greater attention to implicit, internal influences that are hidden from us but play an important role in shaping our choices and behaviors.

Some neuroscience scholars go further and suggest that our actions are *never* initiated by conscious volition and that our experience to the contrary is only a masterfully orchestrated illusion of the mind (Libet, 2005; Wegner, 2002). Wegner relies heavily on findings that the muscle response for a simple movement precedes the conscious intention to move by approximately 500 milliseconds (Libet, 2005). It strikes us as unlikely that human beings could function normally without at least the illusion of conscious processing (for a similar view, see Blackmore, 2005; Dennett & Weiner, 1993). However, the idea is thought-provoking because it provides a hint of how a neuroscientific account of human motivation differs radically from traditional thinking.

The Binding Problem

Extending this line of thought further reveals yet another point of interest for organizational research. Neuroscience suggests that much of what we perceive as a unified experience actually masks the activity of different nonconscious and conscious neural systems and processes that are not necessarily always working in concert (Blackmore, 2005; Johnson, 2004; Kolb & Whishaw, 2008). Simply stated, even though we can almost always provide rational explanations for our thoughts and actions, we may often *only think* that we know the true reasons behind them.

Neuroscientists have termed this the "binding problem." The binding problem refers to the conscious sense that our perceptions, thoughts, decisions, and actions result from a unitary and contemplative process, even though the underlying neural mechanisms may often

be anything but unified and are frequently nonconscious (Kolb & Whishaw, 2008; O'Reilly & Munakata, 2000). This sense of unity is usually adaptive, as it simplifies our experience and allows us to navigate through a complex and uncertain world with confidence. However, like many practical adaptations, it also has other consequences. In this instance, the inner workings of our thought processes are largely inaccessible to direct introspection or external report (Johnson, 2004), at least until one or more component systems become impaired (Cowey & Stoerig, 1991). In this way, the binding problem has limited previous theorists' ability to discern the complexity of human attitudes and actions. This raises some interesting implications for the empirical work in organizational behavior that has relied heavily on self-report measures. We do not mean to suggest that it is not valid but rather that it will invariably favor conscious explanations of behavior and may fail to identify and account for nonconscious mechanisms that we have shown frequently undergird our choices and actions.

Another well-documented example of the binding problem can be found in research on split-brain patients (Gazzaniga, 2008). This research provides the most extreme example of the potential limits of overrelying on self-reported accounts of behavior. Split-brain patients are those who, for medical reasons, have had their corpus callosum severed. There is some degree of specialization between the left and right brain hemispheres, and the corpus callosum serves as the conduit for information exchange between the two hemispheres. If one divides a display screen such that each half is presented only to one half of the subject's visual field, then it becomes possible to present information to only one side of the brain at a time (Gazzaniga, 1992, 1998; Pinker, 2002; Restak, 1979). Now consider the results for one such patient (reported by Pinker, 2002, p. 43):

[I]f an experimenter flashes the command "WALK" to the right hemisphere . . . the person will comply with the request and begin to walk out of the room. But when the person . . . is asked why he just got up, he will say, in all sincerity, "To get a coke"—rather than "I don't know."

The mute right brain cannot answer the questions, so this task falls to the verbal left brain, but without an intact corpus callosum the latter hemisphere is unaware of the triggering "WALK" command. Hence, the left brain infers and reports a logical, albeit inaccurate, account of the behavior. In essence, the left brain is acting as an observer and not as a full participant in the individual's action.

Human behavior results from the interplay of different systems rather than from any one singular motivation. As a result, our actions can be pushed in one direction or another, depending on the balance of a variety of neurochemical processes (Johnson, 2004). This is an important insight because it demonstrates how our rationale for our behaviors can diverge substantially from their actual causes. It adds an additional level of understanding to our accounts of human behavior, by providing a new perspective on the individual (Pinker, 2002). Within this perspective humans are capable of decisive action in dynamic and uncertain conditions. We also naturally reflect on and develop a subjective reality to make sense of our actions. These subjective realities, however, can differ substantially from the objective reality. In the organizational context, sometimes these differences will have important consequences.

Notice how split-brain research dramatically illustrates the limits of subjects' conscious self-reports. Our brains automatically make sense out of our actions. In effect, the brain

provides a coherent narrative to itself! Hence, our self-reported accounts of individual intentions and actions will often be logical and consistent and even predictive of future outcomes and yet be wholly inaccurate with regard to describing the true mechanisms behind the behavior. This helps explain the observed inability of experts to pass on their knowledge by communicating their decision processes because they are largely inaccessible (Connolly, Arkes, & Hammond, 2000; Dane & Pratt, 2007). It may also help explain why individuals often find it difficult to recognize and change their own subtle discriminatory behaviors (Amodio & Devine, 2006). This research demonstrates how relying on self-report accounts, without objective confirmation, will tend to overestimate the role of conscious deliberation and intention and underestimate the role of nonconscious influences.

Summary

The available evidence from neuroscience poses a challenge for views of human behavior that ignore nonconscious processing. In this regard, organizational neuroscience will almost certainly advance our current thinking regarding a number of organizational phenomena and help to address concerns raised by scholars regarding nonconscious processing (Dane & Pratt, 2007; George, 2009; Sonenshein, 2007). It is not clear, however, how our views will evolve and what new understanding of human nature will ultimately arise because the precise nature of human consciousness remains a subject of contention (e.g., Dennett & Weiner, 1993; Fearn, 2005).

Neuroscientists have made a good deal of progress toward understanding a number of issues such as person perception, attitude formation, and so on, and in many instances it will be relatively straightforward and useful to incorporate their advances into the related fields within organizational behavior. The more complex problem, which attempts to explain how a purely material substrate, such as the brain, can give rise to our subjective experience of consciousness (i.e., qualia) has proven less tractable. There is as of yet no consensus on this question. Given this ambiguity, we cannot readily borrow an available neuroscientific model to fill this hole in our knowledge. Rather, the contribution of neuroscience in this regard is more general and underscores the fact that consciousness remains a conceptual riddle. A number of authors have asserted that nonconscious processes need to play a greater role in organizational theory (Barsade et al., 2009; Dane & Pratt, 2007; George, 2009). An organizational neuroscience approach will undoubtedly bring new insight to this issue.

Conclusion

Advances in neuroscience have already made their presence felt in such business areas as marketing (Hedgcock & Rao, 2009) and economics (Camerer et al., 2005; Sanfey et al., 2003). We argue that an *organizational* neuroscience paradigm would bring three essential benefits, which exist in the penumbra of our review.

First, organizational neuroscience would help extend existing theories. Specifically, we observed that hierarchical reductionism promises a new, deeper level of analysis. Consequently, neuroscientific investigations will add detail to our accounts of human behavior, while further

linking our field more closely to other scientific disciplines. In so doing, organizational neuroscience will promote consilience (E. O. Wilson, 1998). Here we looked at one example of how the MNS can provide a biologically sound mechanism for a number of social influences.

Second, organizational neuroscience will encourage new research directions. Explorations of the brain and behavior tend to emphasize the role of nonconscious processing, while most current theories of organizational behavior focus on conscious choices. Combining these two paradigms would encourage scholars to ask questions that might not otherwise come to mind. Barsade and colleagues (2009) illustrated this possibility in their recent review of implicit affective processing. Building on this and related work, we demonstrated the important role of implicit attitudes in workplace change and discrimination as promising examples.

Third, perspectives from organizational neuroscience can help scholars resolve existing conceptual disagreements. Issues that are difficult to differentiate at one level of analysis may become more distinctive at the level of neural processing. In this article we discussed the controversy over universal self-interest and justice. Studies that have compared moral to economic decision making have shown that the brain processes for each type of concern occur in different areas. This suggests that there is a biological substrate for human morality.

These are powerful benefits, which could do much to advance our science. However, organizational neuroscience, valuable though it may be, also confronts us with the risk of neuroessentialism. Brain science has much to contribute, but it also could learn much from other perspectives and levels of explanation. Researchers should see these different paradigms as mutually informative and enriching. On another level, we suggest further that neuroscience may encourage management scientists to think about human beings from new perspectives. Though the riddle of consciousness has yet to be solved, organizational scholars should be aware of the limits of cognitive explanations for behavior.

To this end, there are a number of ways that organizational scholars can assimilate an organizational neuroscience perspective. We recommend that everyone keep abreast of the findings and themes emerging from basic neuroscience research and consider how these might influence and inform their own research. This approach requires only time and effort and has already proven profitable to a number of theoretical and empirical efforts in organizational behavior (e.g., Ashkanasy, 2003; Bergu , 2009; Dane & Pratt, 2007; Reynolds, 2006). In this way we can help relate and test the sometimes esoteric neuroscience findings in the real world.

We hope, however, that some scholars will go further and engage directly in the dialogue and practice of organizational neuroscience research. This research encompasses a variety of experimental methods (for an overview, see Camerer et al., 2005). A number of these methods, such as neuroendocrine measures, skin conductance, and event-related potential (ERP), could be readily adopted by organizational behavior scholars with relatively modest expenditures of time and money (Akinola, 2010; Figner & Murphy, *in press*; Luck, 2005). In fact, the required equipment likely already exists in many psychology departments. As a start, these methods could allow organizational behavior researchers to directly investigate the role of implicit processes and emotional arousal in organizational phenomena.

Other methods such as functional magnetic resonance imaging (fMRI) are much more resource intensive and would initially require organizational behavior scholars to collaborate with neuroscience scholars. Neuroscientists are open to this prospect, however, as evidenced

by the collaboration that produced this article and recent research in other fields (Hedgecock & Rao, 2009; Huettel et al., 2009). Organizational behavior scholars who are willing to pursue this avenue will help to push organizational neuroscience research in exciting new directions such as how and why managers make ethical (and unethical) decisions or whether and how serial entrepreneurs perceive risk differently than others, to name just a few. We believe that our generation of scholars is fortunate to live in a time when technological advances are rapidly expanding our understanding of the human brain. We hope that we have shared a little of the excitement and a lot of the potential to be found in organizational neuroscience.

Appendix

A Neuroscience Primer

This appendix provides a short introduction to the principles of neuroscience and demonstrates that the brain itself operates with at least three additional levels of analysis. It is intended to help organizational behavior scholars consider how predicted and observed behaviors might be manifested within the brain. The field of cognitive neuroscience has risen rapidly in prominence in recent years due primarily to a series of technical advances (Bickle, 2006; Gazzaniga, 2008; Johnson, 2004; Lieberman, 2007). The advent of brain-imaging techniques and computational modeling has allowed neuroscientists to look inside the black box “computer” of the human brain. To date, functional magnetic resonance imaging (fMRI) has been the most influential technique in the neuroscience tool kit for understanding brain functions at the neural level.

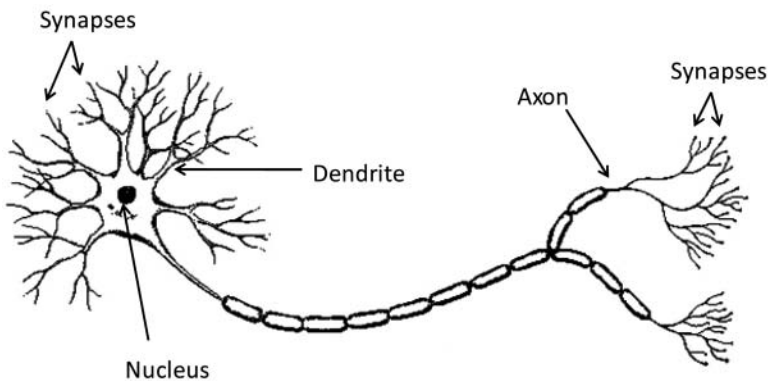
The cumulative body of imaging, physiology, and modeling data has yielded an increasingly coherent picture of the cognitive architecture and function of the human brain. The emerging picture requires us to revisit our previous conceptions and theories of human behavior. In this section, we introduce the reader to individual neurons, how groups of neurons are organized into specialized functional regions, and, finally, how brain regions interact to produce thoughts and behaviors.

Neurons

The brain is composed of an intricate web of billions of interconnected neurons that are organized in such a way as to produce regions that are highly specialized, interconnected, and cross-functional. This makes the brain an amazingly powerful, parallel processor capable of handling immense amounts of sensory and stored data each millisecond (Clithero, Tankersley, & Huettel, 2008). Important advances in understanding how neurons function are allowing researchers to develop and test more informed hypotheses of human cognition and behavior.

Figure A1 depicts a typical neuron. Input signals arrive from sensory cells or other neurons through the dendrites and are then integrated in the cell body. When a certain threshold of stimulation is reached, the neuron fires and sends an output signal to other neurons via the axons. The synapse is the junction of an axon of one neuron with a dendrite of another neuron (Kolb & Whishaw, 2008). These complex workings of electrical signals and neurotransmitters within the neuron can be simplified by thinking of them as detectors (O'Reilly & Munakata, 2000). Individual neurons look for very specific patterns of inputs in the current environment that match previous events and turn on when certain thresholds are exceeded. This process is referred to as “integrate and fire” because each synapse has a

Figure A1
Typical Neuron



connection strength that allows some inputs to be weighted more heavily than others (O'Reilly & Munakata, 2000). A neuron fires only if the integrated inputs exceed its particular threshold. Therefore, neurons provide essentially dichotomous outputs (dormant/fire).

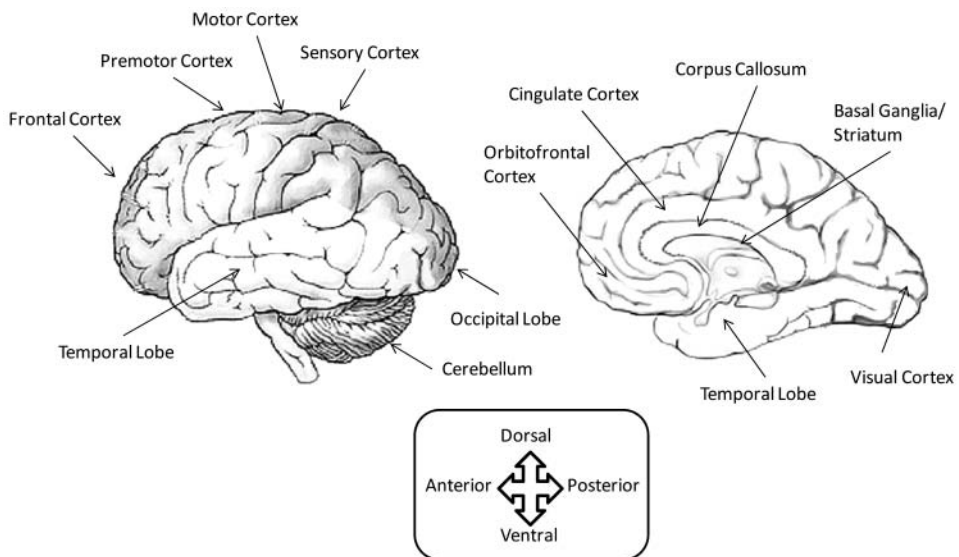
This seeming limitation is overcome in the cortex by the fact that each neuron receives inputs from and provides outputs to many other neurons. Neurotransmitters at the synapse such as glutamate and dopamine provide the vehicle for communication between neurons. In this way, inputs set off cascades of neuron firing that select increasingly specific categorizations of the features present in the environment. This selection process produces a hierarchical nesting of neural prototypes that culminate in cognitions, behaviors, and attitudes based on current conditions and past experience (Kolb & Whishaw, 2008; O'Reilly & Munakata, 2000).

Brain Regions and Neural Networks

Individual neurons and even small groupings of neurons cannot produce complex brain functions. The boundaries between regions are often ill defined, but Figure A2 shows a map of some major brain regions. Unfortunately, there is no simple metaphor for describing how networks of neurons within brain regions operate. Some regions perform highly specialized processing such as the visual cortex, ventral striatum (reward), and amygdala (emotion). Other areas such as the prefrontal cortex perform much more flexible processing such as deliberation and conscious control of emotions.

To understand how neural networks function within and across brain regions, it is important to realize that there are two primary types of neurons in the brain—excitatory and inhibitory. Excitatory neurons send neurotransmitters to other neurons that signal them to fire. In contrast, inhibitory neurons send neurotransmitters that suppress the firing of other neurons. The axons of excitatory neurons can reach across the brain to numerous different brain regions, whereas inhibitory neuron axons appear to project only within local cortical areas. Unfortunately, it is extremely difficult to map out these neural connections within the cortex. Even when connections can be identified, it is currently impossible to determine the relative weights of connections.

Figure A2
Basic Brain Anatomy

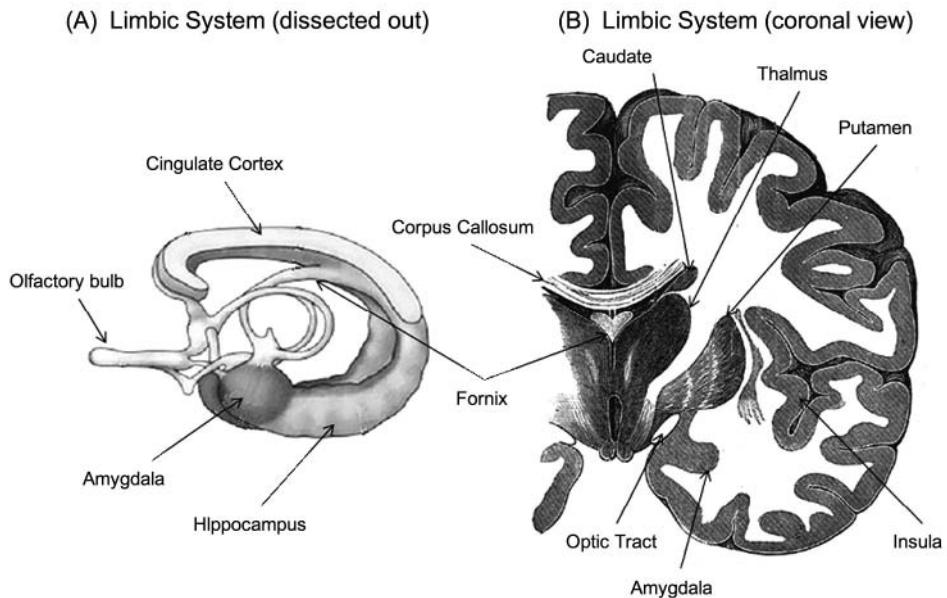


Nonetheless, the operation of these neural networks is characterized by two important features (O'Reilly & Munakata, 2000). The first feature is the prominence of bidirectional connections between neurons. Bidirectional connections provide two-way information flow and allow pattern completion of output prototypes to take place when only limited input information is available. Once enough lower level characteristics of a pattern are present, the appropriate higher level prototype becomes activated. Bidirectional connections between brain regions allow the brain to perform top-down as well as bottom-up processing. In this way, once a higher level prototype becomes activated, it activates all of its corresponding lower level units and suppresses noncorresponding lower level units. This provides a great deal of neural flexibility and stability. For example, if woods, brown, large, and roar are present, this process allows one to conclude that there is an angry bear nearby and it is time to run away.

The second important feature of neural networks is that patterns of inputs are mapped onto prototypes through a competitive "winner-take-all" process that relies on both excitatory and inhibitory neurons (Camerer, Lowenstein, & Prelec, 2005; O'Reilly & Munakata, 2000). Once neurons representing a prototype receive sufficient excitatory input to fire, they trigger inhibitory neurons that suppress excitatory neurons representing competing prototypes. Suppression occurs regardless of how close alternative prototypes were to becoming activated themselves. The benefit of such a process is that we are able to respond to information that is often ambiguous with decisive thoughts, feelings, and actions. The downside is that we are unaware of and often overestimate the relative surety of our attitudes and actions (Gawronski & Bodenhausen, 2006). As in the previous example, we would not wait around to see if what we actually glimpsed was a guy in a brown jacket who tripped over a stump.

There is growing evidence that some brain regions including the limbic system within the temporal lobe (see Figure A3) are specialized for automatic processes (e.g., amygdala and basal ganglia) while others manage controlled processes (e.g., prefrontal cortex). Other regions, like the anterior cingulate

Figure A3
The Limbic System



cortex, seem to operate as a buffer between automaticity and control (Lieberman, 2007). The distinction between automatic and controlled processes has been useful in understanding why some areas of the brain are more involved in certain processes (Ochsner & Lieberman, 2001). However, we need to keep in mind the characteristics of neural networks described above: interconnectivity, bidirectionality, and competition. There is not a strict division between these two processes. In truth, the brain is able to integrate and switch between automatic and controlled processing seamlessly, with no brain process being completely automatic or completely deliberate (Marcus, 2008). The interaction of brain systems remains an area of neuroscience where much remains to be learned, and organizational scholars should continue to monitor its progress and participate in the discourse.

The takeaway message of this primer is that the brain, though possessing specialized regions, operates as a flexible and well-integrated system that relies on a mixture of bottom-up and top-down processing capabilities. The interaction of these common systems and stored information structures ultimately produces all of the attitudes, behaviors, and decisions of interest to organizational scholars. Incorporating these principles promises to help connect and ultimately unify our theories of organizational behavior.

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Erratum

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