THE DOMAIN OF ORGANIZATIONAL COGNITIVE NEUROSCIENCE:

THEORETICAL AND EMPIRICAL CHALLENGES

Nick Lee
Professor of Marketing and Organizational Research
Aston Business School
Aston University
Birmingham, U.K.
B4 7ET
Phone: +44 (0) 121 204 3152
Email: n.j.lee@aston.ac.uk

Carl Senior
Reader in Psychology
School of Life and Health Sciences
Aston University
Birmingham, U.K.
B4 7ET
Phone: +44 (0) 121 204 4068
Email: c.senior@aston.ac.uk

Michael Butler
Reader in Management
Aston Business School
Aston University
Birmingham, U.K.
B4 7ET
Phone: +44 (0) 121 204 3053
Email: m.j.r.butler@aston.ac.uk

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Abstract

In this paper, we respond to the recent paper in the Journal of Management by Becker, Cropanzano, and Sanfey (2011) entitled Organizational Neuroscience: Taking Organizational Theory Inside the Neural Black Box. More specifically, we build on the ideas of Becker et al. (2011), to first clarify and extend their work, and then to explore the critical philosophical issues involved in drawing inferences from neuroscientific research. We argue that these problems are yet to be solved, and organizational researchers who wish to incorporate neuroscientific advances into their work need to engage with them.

THE DOMAIN OF ORGANIZATIONAL COGNITIVE NEUROSCIENCE: THEORETICAL AND EMPIRICAL CHALLENGES

For almost a decade, a small but growing body of researchers has sought to address a singular research question, with implications for management scholars across the globe; namely, what benefit can an understanding of the human brain have for the science and practice of management? As research in this area has progressed it has become more and more obvious that robust answers to this question need the input of a wide panel of experts from across both organizational science and mainstream cognitive neuroscience. Neither field alone possesses the theoretical, methodological, or practical tools necessary to fully address the scientific problems at hand. Thus we were delighted to see the recent paper in the *Journal of Management* by Becker, Cropanzano, and Sanfey (2011) entitled *Organizational Neuroscience: Taking Organizational Theory Inside the Neural Black Box*. We strongly share Becker et al.'s (2011) sense of excitement about the potential for neuroscientific advances to inform major advances in organizational sciences, while also recognizing that even well-established cognitive science can offer major insight into current organizational theory. In fact, we would go further than Becker et al. (2011), to argue that without the appropriate application of cognitive neuroscience, organizational science will find it far more difficult to advance at the same rapid rate that it has over the last century. Similarly, we consider that the ecological validity offered by organizational research settings is necessary for cognitive neuroscience itself to move forward at a similarly rapid rate (Lee, Senior, and Butler, 2011).

The present paper is partly expository, and partly theoretical. As such, our first purpose is to build on the ideas of Becker et al. (2011), and provide what we consider a number of

important clarifications and extensions to their excellent piece. However, we also move beyond such exposition to grapple with a number of critical philosophical problems that need serious consideration by any researcher interested in drawing inferences from neuroscientific research. These problems are yet to be solved, and cut to the very heart of neuroscience itself. As such, organizational researchers who wish to investigate the potential of neuroscience to inform their work need to engage with these inference problems, in order to avoid the nonsensical claims that seem to appear with such frequency in the popular press (e.g. Lindstrom, 2011).

First we outline our theoretical position, and clarify the position, role, and definition of what we have termed the *organizational cognitive neuroscience* approach (e.g. Lee and Chamberlain, 2007; Butler and Senior, 2007a; Lee, Senior, and Butler, 2011; Senior, Lee, and Butler, 2011), a specialized variant of social cognitive neuroscience (e.g. Lieberman, 2006). We show that Becker et al.'s (2011) organizational neuroscience framework is an essential component to a wider understanding of organizational and social cognitive neuroscience. Yet at the core of each of these approaches lies a singular common truth; for behavior and any form of activity in the brain to be related, that behavior *must* have played a beneficial role in our evolutionary development. That is, the behavior must be adaptive (see e.g., Nicholson, 2010), because of the huge evolutionary cost of developing specialized brain structures. While it is outside our present scope to provide full details of this process, Lee et al. (2011) have discussed the potential contribution of Edelman's neural Darwinism model as one possible mechanism by which behavior can moderate cortical architecture.

Following the theoretical discussion, we detail the limitations that scientists working within such frameworks face. These are particularly worrying when considered in concert with the technological limitations of functional magnetic resonance imaging (fMRI), which appears to

be the method of choice for cognitive neuroscience research at present (Bandettini, 2007). We will see that a fundamental limitation in neuroimaging is an inability to infer complex social behavior from observations of specific activated brain regions. While mainstream cognitive neuroscientific research has started to address the various limitations of neuroimaging (see e.g., Vul, Harris, Winkelman & Pashler, 2009), there remains considerable philosophical and empirical interest in the issues (e.g. Klien, 2010). Thus, the time is most certainly right for those interested in applying cognitive neuroscience to management research to embrace this debate.

Finally, we will discuss the possible benefits that the organizational cognitive neuroscientific approach specifically can contribute to our understanding of managerial practice and human cognition in general. Here we will discuss a philosophical conjecture known as the forward inference approach. We will detail how only when combined with organizational cognitive neuroscience can forward inference approaches provide insights and benefits to managerial science and practice.

Organizational Neuroscience and Organizational Cognitive Neuroscience

To ensure that the management scholar is aware of the distinct approaches available it is important to discuss the differences and similarities in the various theoretical positions. However, it must be understood that a comparative discussion of Becker et al.'s (2011) organizational neuroscience (ON), social cognitive neuroscience (SCN e.g. Blakemore et al, 2004), and organizational cognitive neuroscience (OCN e.g. Senior et al. 2011) should not be understood as merely semantic, nor as simply neologistic fetishism. We do not see these frameworks as mutually exclusive, competing paradigms of which only one can emerge victorious (cf. Kuhn, 1970). Rather, organizational cognitive neuroscience is symbiotic with organizational neuroscience as described in Becker et al. (2011), as well as its older cousin social

cognitive neuroscience, to form a detailed theoretical framework that helps scholars to understand the complexities of the social behavior that occurs within organizations.

The simplest way to begin comparative discussion is to consider ON, OCN, and SCN in light of the distance from the brain where each perspective takes up its primary vantage point. For example, drawing from Becker et al. (2011), ON appears to be a fundamentally neuroanatomical perspective, in that it is concerned with the role that brain anatomy plays in the mediation of organizational decisions. Becker et al. (2011, p. 934) exemplify this perspective – even the title refers to the 'neural black box' – early in the paper, with comments such as "our interest lies in understanding the brain processes behind observed attitudes and behaviors … prior organizational theories are incomplete in the sense that they do not consider the most fundamental level of analysis." Throughout the paper, statements around the remit of ON support the neuroanatomical/physiological focus, such as "each neuron operates in the same way, and all brains are organized in a similar fashion", and in particular with the discussion of ON as a distinct level of analysis, concerning "levels of reduction that deconstruct individuals to discrete brain processes", involving "neural mechanisms" and "molecular explanations" (p. 936-937). Here, the primary focus is clearly the brain's physical substrates, and connections between them, with Becker et al.'s (2011, p. 934 emphasis added) stated aim for ON to "understand and incorporate the cognitive *machinery* behind our thoughts and actions into organizational theory" Further, Becker et al. (2011) give a number of examples of ON, all of which concern the functional specificity of certain substrates in the mediation of organizationally-relevant behavior, such as the discussions of mirror neurons, emotional contagion, implicit attitudes and so forth. Becker et al.'s (2011) ON approach can therefore be seen as the fundamental foundation for both social and organizational cognitive neuroscience.

Moving from an anatomical perspective to a cognitive (brain function) perspective, SCN focuses on how biological systems mediate social cognition and behavior, while OCN examines social cognition and behavior within the workplace (see Butler et al, 2007a,b; Decety & Keenan, 2006). Here, the emphasis of both approaches is on the plurality of techniques that converge on a further understanding of social behavior. Given that work is a form of species-specific social behavior, it has previously been argued that social behavior in the workplace should be considered separately from the wider social cognitive neuroscience approach (e.g. Senior et al., 2008; 2011). That said, it is important to acknowledge that OCN and SCN are emergent fields, and that topics of study can be often intertwined rather than exclusive. Certainly, there is considerable overlap between the two fields (cf. Blakemore et al., 2004)

In the OCN approach, the management scholar is interested in understanding how the biological systems as a whole (rather than solely the activation of specific brain regions) operate to mediate social processes. Thus, the main differences between ON and OCN/SCN occur at the level of analysis. Specifically, ON as presented in Becker et al. (2011), is conceptualized as a distinct level of analysis, concerning the understanding of the neural mechanisms behind organizational behaviors, and thus appears to focus on the process at a cellular/physiological level. However, OCN is conceptualized as a perspective that incorporates multiple levels of analysis, as does SCN. Drawing from Senior et al. (2011) OCN is interested not only in the structures and systems within the brain of relevance to organizational behavior, but also the interaction between those biological systems and cognition itself. Of course, there are certain overlaps. In particular, to gain a complete understanding of the moderating role of biological systems in the workplace (i.e. the goal of OCN/SCN), one must have an understanding of the

brain's functional architecture (the ON perspective). However, all of the various approaches face a fundamental question that is addressed next.

Neuroscientific Methodology and the Pure Insertion Hypothesis: What do Brain Scans Really Tell Us?

An important aspect of understanding the appropriate conclusions that can be drawn from functional neuroimaging data is a clear understanding of the typical experimental procedure. In the simplest sense, a brain imaging experiment involves what is known as subtractive methodology. In other words, brain activation caused by a particular experimental factor is subtracted from the activity that is present during a control state. For example, in a study regarding the perception of angry facial expressions, one would show examples of these affects and subtract any engendered activation from activity revealed on presentation of faces showing no affect. The computation of the subtractive response is the first stage of the statistical process that ultimately leads to a test of the experimental hypothesis. However at its core the basic subtractive approach implies the common-sense conclusion that if region *X* is active during task *A* (e.g. looking at angry faces) when compared to task *B*, then region *X* must be involved in the performance of task *A*. However, contrary to popular belief, this is not the case.

Rather than 'proving' that brain region *X* is associated with task *A*, the colorful imagery that is often presented with the findings of brain imaging studies merely indicates the level of confidence that we have with regards to whether the particular region of the brain is somehow implicated in the task. Simply put, with the data we have in such cases, it is impossible to infer a *lack* of involvement in a region which is *not* shown as activated. To make such an inference invokes the *pure insertion hypothesis*, which claims that engendered activity specific to a particular task remains unchanged when we add other tasks. For the subtractive approach

discussed above to work properly as a test of whether region *X* is associated with task *A*, the pure insertion hypothesis must be true. However as has been shown previously, this is far from guaranteed, and may be impossible to prove (e.g. Price & Friston, 1996).

Violation of the pure insertion hypothesis shows us that the traditional subtractive approach has limitations to its ability to help us fully understand the inherent complexities of the cognitive system. Brain regions may indeed be functionally specialized – i.e., that region *X* is specialized to perform a specific task – however such regions also need to interact in a hierarchical and dynamic fashion (Friston, 2000). Much existing work has already shown that the extent of this interaction is vast, with a number of regions throughout the entire brain operating together in a hierarchical fashion for both single, commonplace processes such as face perception, and for more complex processes such as social reward (Longe et al, 2009: Foley et al, 2011). Indeed, the advent of multivoxel pattern analysis as an analytic strategy that addresses patterns of activity, compared to identifying specific regions of activation, is an important development within cognitive neuroscience (e.g., Norman, Plyn, Detre & Haxby, 2006).

A further limitation of the subtractive experimental approach concerns the interpretation of quantitative differences in the data. It is fundamentally impossible to infer the functional importance of a defined region *X* by comparing the relative differences in the activation of *X* across tasks *A* and *B* (Nair, 2005; Logothetis, 2008). In short, while we already argued that a greater degree of activity for task *A* doesn't necessarily mean that region *X* is correspondingly responsible for that task, it is also the case that the *amount* of activity detected in *X* does not necessarily directly correspond to how important region *X* is for that task.

Given the issues outlined above, and notwithstanding the popularity of fMRI specifically, which is such that one may be forgiven for assuming that fMRI is the *only* method available to

the cognitive neuroscientist, it seems relevant to wonder what in fact neuroimgaging is able to teach us, and why it is so popular. Of course, answers to such musings are complex and readers should be under no illusions that methods such as fMRI have in the last 20 years revolutionized our understanding of human cognition. However to assure the continuation of this revolution into the organizational sciences, it is vital that organizational researchers understand a number of philosophical issues concerning inference (cf. Poldrack, 2011), *before* they begin designing, conducting, and reporting studies based on cognitive neuroscience methods. It is particularly important to stress that the simple application of organizational contexts to neuroimaging work is unable to by itself solve any of these issues. Rather, the challenge is for organizational researchers to become cognizant of the inherent challenges in this area, before designing research programs.

Forward and Reverse Inference

In the context of functional neuroimaging (regardless of specific modality), forward inference refers to an analytical approach that – rather than simply look for activation in a particular region of the brain – uses *patterns* of brain activation to distinguish between competing cognitive theories. The now-classic example of this particular approach is given by Henson (2006) who combined aspects of the subtractive approach discussed above with a forward inference framework to demonstrate a distinction in the dual-process theory of recognition memory. Henson's demonstration showed that there were differences in the pattern of brain activation for two different types of recognition memory that ostensibly occurred within the same regions, thus showing us that there must have been a distinction in the cognitive processes that underpin the differences that were examined.

For the management scholar, such a demonstration may seem so obvious as to be redundant. It is indeed common-sense to assume that differences in a particular cognitive task would indeed imply differences in the underlying cortical signature. However it may be surprising to note that such an approach is not often the case within mainstream cognitive neuroscience. Indeed in the latter case it is more common to use the reverse inference model (Poldrack, 2006). When making a reverse inference, the cognitive neuroscientist would effectively use a measure of engendered cortical activation to infer that a particular region of the brain is involved in a particular task. Take for example, the early work on face perception (as one example of an adaptive social skill) that revealed a 'dedicated' region in the ventral surface of the cortex to be implicated in its perception (Kanwisher et al, 1997). Thus, in the reverse inference model, the activation is used as evidence that region *X* is associated with the task.

Again, at a superficial level this seems to be a fairly straightforward approach. Certainly, this particular approach is enjoying a resurgence, with the rise of applied neuroscience research in fields such as economics or moral psychology, where the underlying cognitive process, or specific region that mediates a particular process, is considered to be unknown (e.g., Greene et al., 2011). Of course, OCN is very much a member of this newer research fraternity, and as such one would assume that reverse inference would be an ideal means by which we can understand more about cognition in the workplace. However, there are a number of limitations attached to the reverse inference approach that, if reverse inference is used alone, we feel render it broadly untenable for OCN.

The most fundamental issue is that the reverse inference approach "reflects the logical fallacy of affirming the consequent" (Poldrack, 2008, p. 223). In other words, it is impossible to be confident in the assignment of a particular cognitive task *A* to a particular active region of the

brain *X*, outside of the possibility that other processes may have also contributed to activation of region *X* during task *A*. Indeed, Poldrack (2008) formulated the 'reverse inference paradox', which suggests that the more complex a cognitive task, the less chance there is of identifying a discrete cortical response. Given the complexity of the social behaviors faced by the management scholar, it is likely that this limiting factor will play a significant role in deciding which approach to adopt (see e.g., Senior, Lee & Butler, 2011 for a further discussion). Rather, we argue that for the application of neuroimaging techniques to flourish within the organizational cognitive neuroscientist's repertoire, the forward inference approach would also need to be adopted. It should be noted that mainstream cognitive neuroscientists are starting to move further away from the limitations of the reverse inference paradigm with the developmental of analytic strategies that examine the *patterns* of engendered activity across entire volume of interest with approaches such as multivoxel pattern analysis (e.g., Haxby, Gobbini, Furey, Ishai, Schouten & Pietrini, 2001). Such an approach has already started to provide radical insights into the workings of the human brain (Chiu, 2010) and will likely provide more in the years to come. Further, we argue that, with the use of the forward inference approach, OCN has a unique opportunity to provide us with fundamental insights about human cognition.

Of course, we do not wish to imply that the reverse inference approach is completely without merit. Indeed there are a number of significant reports that have employed this paradigm to reveal much about our cognitive system. Rather we would subscribe to Kosslyn's (1999) caveats, and maintain that the revelation that a specific brain area is activated in association with a specific task should only be taken to mean that this area is probably involved in some way (although this level of involvement could be very minor or even incidental to the main issue at

hand). It can therefore be targeted in subsequent experimental endeavors to provide a convergent portfolio of evidence as to the necessity of that region.

Taking this in hand, the reverse inference approach can be used to identify the so-called cognitive domain of specific regions in the human brain (Christoff & Owen, 2006). For example, while a region in the ventral cortex is seen to be implicated in face perception, we cannot say that it is *the* region specifically and solely responsible for the perception of faces. However, it can be argued that the area does have a specific cognitive domain (i.e. faces) that overlaps with other areas. Again considering the inherent complexity of workplace behaviors, the reverse inference approach can be used to identify regions that are defined by high degrees of cognitive complexity, such as regions of the prefrontal cortex (Christoff & Gabrielli, 2000). However, we cannot then make the inference that these regions are those solely involved in behaviors such as effective leadership. Rather, by taking such findings a stage further and applying a forward inference approach, it may be possible to start to identify management traits which may differentially involve such regions. Such a multilevel approach has already been advocated in the cognate disciplines, which may help address these inferential problems (Yarkoni et al, 2011).

Adaptive Behaviors in the Workplace

As seen above, combining forward and reverse inference paradigms has strong potential to advance management science. However, when this combined perspective is mated with an acceptance of the evolved/adaptive nature of human behavior, management research can reap even greater benefits. To take but one example, there is a school of thought in the mainstream management sciences that urges organizations to reconfigure themselves to ensure that they facilitate behavior within their workers that is parsimonious with their evolutionary past (see e.g. Nicholson, 1998). In such research, it is argued that that the natural social processes that we are

predisposed to favor – such as friendliness, social interaction and emotion-based decision making – should be encouraged in the workplace, to facilitate a more natural way of managing and working. To many this is hardly contentious; one only has to imagine the idiosyncratic organizational culture in companies like Google, IDEO, or Blizzard, to see how aligning the workspace with the nature of employees can facilitate high quality output in certain cases (e.g., Coy, 2006; Gallo, 2006). Yet at a more fundamental level it is also possible to identify core social processes within our evolutionary past, that are at the heart of contemporary theories of effective management.

Take for example, the notion of transformational leadership, which is regarded as being a more socially aligned mode of leadership when compared to transactional leadership (Judge & Piccolo, 2004). Here, it is said that effective leaders can identify a particular work situation and employ various inspirational and challenging strategies to motivate workers to achieve various goals. The components of transformational leadership are well described elsewhere (see e.g. Avolio, Bass & Jung, 1999). What is of more importance for our purposes is the recent finding that these traits enjoy parsimony with our evolutionary past at both a physiological and neurophysiological level (Senior et al, 2011b,c; Lee et al, 2011).

From a behavioral perspective however, the identification of such adaptive traits is not as clear cut, and management scholars regularly face difficulty with their identification across various situations. Take for example the possibility that an effective leader may motivate the work force but do little to inspire, and vice versa. Here we face a question regarding how best to identify the effective traits that have an adaptive value. According to evolutionary theorists, transformational traits such as the ability to inspire a group would be favored by natural selection over the ability to motivate (Van Vugt & Schaller, 2008; Van Vugt et al, 2008).Yet, given that

the ability to both inspire and motivate are intertwined at the behavioral level they are often impossible to separate. However, if the specific adaptive trait could be identified it would then be theoretically possible to fashion management practices around it. Such application would ultimately lead to the 'natural' way of management that Nicholson (Nicholson, 2010), and others (Whitty, 2011), previously describe.

The above discussion provides further evidence that there is limited utility in the reverse inference model for organizational cognitive neuroscience. Merely asking managers to engage in a series of tasks designed to evoke inspirational or motivational behavior when situated in a brain scanner would obviously a) engender activity in a range of overlapping cortical areas, and b) the activated regions will possibly start to exhibit differential activity when the participants are asked to make inspirational versus motivational leadership decisions. Unfortunately, as shown above this does not provide any real evidence that region *X* is specifically involved with a particular type of leadership. In fact, the need to identify whether or not a particular region of the brain is activated during a particular task has yet to be convincingly proved, as already discussed. Perhaps more crucially it tells us nothing about whether or not a specific process has any form of value from an evolutionary standpoint.

Of course, as we have made clear throughout this commentary the dichotomy implied by the notions of reverse and forward inference is not strictly correct. As Klein (2010, p. 188) notes 'the two process are often intertwined in practice'. Indeed, when used in the context of multiple or even competing cognitive theories of organizational processes, the utility of a combined forward/reverse inference model in helping to understand the inherent complexity of management behavior is far more certain. By interpreting the complex patterns of cortical activity that are revealed for both types of tasks, and identifying differences in such activity, it

may indeed be possible to identify the process that has enjoyed the evolutionary benefit and the process that would be of real relevance to the manager. However, *a priori* predictions must be made from theory, rather than simply placing managers in brain scanners and trying to *post hoc* interpret their brain activity. It is worth bearing in mind that the above notion of embedded cognition is firmly established in the cognitive science literature, and scholars have used this approach to help understand a variety of problems that arise from fields as diverse as artificial intelligence and psychiatry. However, it has yet to explored within the management sciences (Anderson, 2006; Waters, Rock, Dragovic & Jablensky, 2011).

Thus, here we present an empirical challenge for the community at large. It is yet to be seen whether or not an analysis of the patterns of cortical activity can be used to differentiate between various management traits, and if so whether such traits lead to effective behavior in the workplace. Although, we are certain that such research could result in extremely impressive brain scan images, which may or may not be of interest to the popular press – whatever their scientific usefulness. Rather, we believe that for OCN to thrive, studies that have a distinct forward inference component to their design are needed. This is one way in which we can start to make inroads into identifying the core traits that constitute effective behavior in the workplace.

Concluding Remarks

The perspective we offer here should be read in parallel with the approach argued by Becker et al. (2011) – they are complementary. The application of neuroscience to management is a nascent field but one that promises to enrich our fundamental understanding about our working lives. In that context, it is vital to engage in progressive, and informed, debates about theory, method and applications to practice.

We have carefully drawn a theoretical distinction between OCN and ON, suggesting that the presentation of ON in Becker et al. (2011) is as a single, distinct level of analysis, concentrating its interest on processes at a neurobiological level. This level is a subset of the overarching OCN research agenda as presented in Senior et al. (2011), which itself focuses on social processes within the workplace and is thus a specialized application of SCN (Lieberman, 2006). Nevertheless, both OCN and ON (as well as cognitive neuroscience itself) share methodological concerns regarding the interpretation of data from brain scans, and the role of inference. By exploring adaptive behaviors in the workplace, using the specific example of transformational leadership, we propose that a multilevel approach is used to help resolve these inference problems. In particular, a combined forward/reverse inference model will help to identify cortical activity, the context of that activity and potentially the influence of evolutionary psychology on workplace behavior.

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