10

NEUROSCIENTIFIC METHODS FOR STRATEGIC MANAGEMENT

Sebastiano Massaro[1]

In the past decade, social disciplines have looked with increasing interest at neuroscience. From anthropology (Adenzato and Garbarini, 2006) to law (Greene and Cohen, 2004; Jones and Shen, 2012), from politics (Connolly, 2002) to sociology (Franks, 2010), the integration of neuroscientific aspects into social studies has become a phenomenon of considerable interest. Business scholarship has not been immune from this trend with contributions crossing leadership (Ghadiri, Habermacher, and Peters, 2012), marketing (Ariely and Berns, 2010; Lee, Broderick, and Chamberlain, 2007) and strategy (Powell, 2011), among others. Accordingly, universities have created dedicated centers of research; journals and conferences have started to offer substantial space to the role of neuroscience in management; and several researchers have developed international partnerships aiming to extend these cutting-edge approaches.[2]

Although some scholars have questioned the appropriateness and viability of neuroscience to effectively advance social analyses and business research (e.g., Bennett, Hacker, and Bennett, 2003; Gul and Pesendorfer, 2008; Lindebaum and Zundel, 2013), the intensification and effects of this type of studies cannot be denied. Indeed, knowing more on how our brain works can help to advance our understanding of human cognition, emotions, behavior, and decision making, both inside and outside organizations.

In this work, I argue that to better appreciate how neuroscience can inform research in management, understanding the rationale of relevant neuroscience methods, is a fundamental step currently missing in the scholarship.[3] Only through this knowledge, will management scholars fully appreciate the potential of the related research and possibly incorporate further these instruments into their exploratory equipment.

By mainly concentrating on brain-imaging methods, this chapter provides an opening review, for both those researchers who are new to neuroscience, and those multidisciplinary-oriented scholars who are seeking to refresh their knowledge on the topic. Following an introductory excursus on the early applications of these methods to management studies, I will explain how they can be classified, and supply a core description of relevant techniques. Moreover, I will offer some evidence related to management scholarship, and in particular to strategy, one of the fields most attentive to neuroscience (e.g., Powell, 2011; Powell, Lovallo, and Fox, 2011). Finally, the chapter will pinpoint critical considerations for management research related to employing neuroscience approaches.

The partnership between neuroscience and management

The idea of coupling descriptions of human behaviors and the brain has actively engaged researchers for centuries (for a history of neuroscience see, e.g., Finger [2001]). Yet, the experimental partnership between cognitive neuroscience and social disciplines – nowadays often called social cognitive and affective neuroscience – has acquired wider resonance only in the past couple of decades, thanks to the emergence of *functional neuroimaging of behavior* (Raichle, 2003; 2009a), the combination of neuroimaging and behavioral research approaches. This research area generally refers to the use of technologies measuring hemodynamic, electromagnetic, or biophysical properties and changes in the brain and in the nervous system, following an experimental behavioral manipulation, task or stimulus, to provide visual metrics (e.g. graph, image, scan) of the underlying brain regions and neural functions. The resulting outcomes enable inferences about the relationships between neural substrates and behavioral or mental processes associated.[4]

One of the first techniques used to measure brain activity, *electroencephalography* (EEG), emerged in the 1930s when Berger (1929) demonstrated that electrical activity from the brain could be measured by placing conducting material on the scalp and amplifying the consequential signal. After Dawson (1951) developed a method of signal averaging, management research suggested EEG's use to investigate the neural basis of performance decrements in the workplace (Scott, 1966). The successive, essentially misleading, idea that the left hemisphere of the human brain would control *only* logic, analytical ability, sequential perception, and language, while the right hemisphere spatial and simultaneous perception, imagination, and intuition (for a review see, e.g., Gazzaniga and LeDoux [1978]) further inspired management inquiries. Mintzberg (1976) addressed the challenge of coupling neuroscience information with management research when he imprecisely claimed that "right-brain is holistic and the left-brain logical," suggesting differences in the brain hemispheres were compelling for business studies, training, and practice. Afterwards, such claims offered room to a body of management neuromythology supported by a rather lay dissemination (Hines, 1987). Those outcomes allowed, for instance, to argue that executives tend to use more right brain processing than analysts, and vice versa (Doktor, 1978), and contributed to setting the basis for the development of frameworks seeking to enhance managers' analytical and intuitive skills (Robey and Taggart, 1982).

Although EEG offered preliminary management-related findings obtained by examining brain activity, it is with the advent of tomographic techniques that the actual imaging takeover began.[5] In 1973, Godfrey Hounsfield (1973) introduced a breakthrough technique: *X-ray Computed Tomography* (CT). It had immediate impact; not only did it revolutionize medical clinical practice, facilitating screening and diagnosis, but it also provoked behavioral scientists to consider new ways of imaging the brain (Garvey and Hanlon, 2002; Raichle, 2009b; Rogers, 2003).

Subsequently, another type of tomography, *Positron Emission Tomography* (PET), enabled creating autoradiographs of brain functions (Tilyou, 1991). This ushered in the beginning of the "hemodynamic era" for functional brain-imaging: by injecting a radioactive pharmaceutical in a subject, it was possible to quickly measure blood flow changes and associate them with measurements of brain function (Phelps and Mazziotta, 1985). PET also made possible "experimentalizing" a strategy of *cognitive subtraction* with functional neuroimaging (Donders, 1969; Petersen *et al.*, 1988), which, although often questioned (Friston *et al.*, 1996; Sartori and Umiltà, 2000), has represented a pillar for numerous studies. Cognitive subtraction mostly relies on assumptions of *linearity* and *pure insertion*: an elicited mental component evokes an "extra" physiological activation that is the same regardless of preexisting mental and physiological contexts (Price and Friston, 1997). This suggests that functional imaging of behavioral processes can then be derived by subtraction of a control task from an experimental assignment, so that differences in brain activity can be attributed to selected mental components (Friston *et al.*, 1996). Due to its logistics (i.e. requirement for local presence of a particle accelerator) and concerns for participants' health (i.e., use of radioactive material) PET has not arisen as the technique of choice for most of management inquiries. However, it has been employed to identify neural substrates of phenomena such as planning (Dagher *et al.*, 1999), and risk-avoiding and ambiguity-avoiding behaviors (Smith *et al.*, 2002).

More recently, another neuroimaging technique has offered the ability to apprise where activity is occurring in the brain while we are performing experimental behavioral tasks or we are at rest. This is *functional Magnetic Resonance Imaging* (fMRI), which grounds on nuclear magnetic resonance physics (Bloch, 1946; Lauterbur, 1973; Purcell, Torrey, and Pound, 1946). The revolution in neuroscience arrived in 1992, when researchers associated Magnetic Resonance Imaging with brain activity-related changes in blood oxygenation. The signal arising from the unique combination of brain physiology and nuclear physics became known as the *Blood Oxygen Level Dependent* (BOLD) signal (Ogawa, Lee, and Tank, 1990).[6] There rapidly followed several evidences of BOLD signal changes in humans during "brain activation," giving official birth to fMRI (Bandettini *et al.*, 1992; Kwong *et al.*, 1992; Ogawa *et al.*, 1992). fMRI has dominated functional brain imaging of behavior research ever since, and has been the neuroimaging technique bringing the greatest promises to management research. For instance, some encouraging contributions have been those applied to strategic games (e.g., Sanfey *et al.*, 2003) and those investigating the neural underpinnings associated with strategic insight and intuition (e.g., Volz and von Cramon, 2006).

Classifications: Between resolution and functionality

To fully appreciate how neuroscience techniques can attempt to "open the black box of the brain," it is important to classify them under a systemic outlook, according to their distinctive characteristics. Experimental methods in neuroscience have traditionally been organized according to a matrixed perspective that considers and emphasizes the distinct spatial and temporal resolutions of each technique (Churchland and Sejnowski, 1988), as shown in Figure 10.1a.[7]

The concept of *resolution* is an essential prerequisite for understanding the essence of each neuroimaging procedure. Simply speaking, it allows providing answers for questions such as "how good is a brain scan image?" The response is commonly disentangled into concepts of spatial or temporal resolution, which are respectively the abilities to discriminate between two points in space and time (Menon *et al.*, 1998). A high spatial resolution determines a sharp image, while a low one gives a "pixely" appearance to the image; for example, when two spatially close (i.e., a few millimeters) anatomical structures are distinguishable in an image, this has a higher resolution than one when they are not discernable. Spatial resolution depends on the properties of the system that creates the images, such as gradient strength and digitalizing rate (Bandettini, 2002), being therefore limited by hardware and acquisition protocols. Several techniques provide spatial information of the human brain with high resolution, including fMRI and PET.

However, understanding the neuroscience of mental processes requires information not only on the spatial localization of brain activities, but also on their temporal evolution. Analyses with a temporal resolution of milliseconds can be conducted by electroencephalographic (EEG) and magnetoencephalographic (MEG) methods, which are based on the electric or magnetic activity caused by movements of ions inside and outside cellular membranes (e.g., Kristeva *et al.*, 1979). These methods provide almost real-time information on brain activity; yet, EEG has lower spatial localization and resolution.

The importance of understanding the properties of each method is fundamental. Limited resolutions bound practical applications of the techniques. Moreover, each technique allows a different examination of the neural functions specifically on the basis of its intrinsic characteristics. Some might believe the results obtained exploiting different resolutions of several techniques could just converge in an overall explanation of the neural processes. This claim however is inaccurate. Several other influences determine an experimental outcome, such as whether the process is recording physiological brain activity, or instead interfering with it, or stimulating the brain to change a behavioral response. Therefore, the appropriate methods and levels at which to examine brain function largely depend on the research question being addressed (Stewart and Walsh, 2006).

Organizational scholars have drawn from this resolution-based classification, arguing its ease in depicting the relative advantages and disadvantages of each method: as seen in Figure 10.1b, this categorization has helped delineating the

(a)

(b)

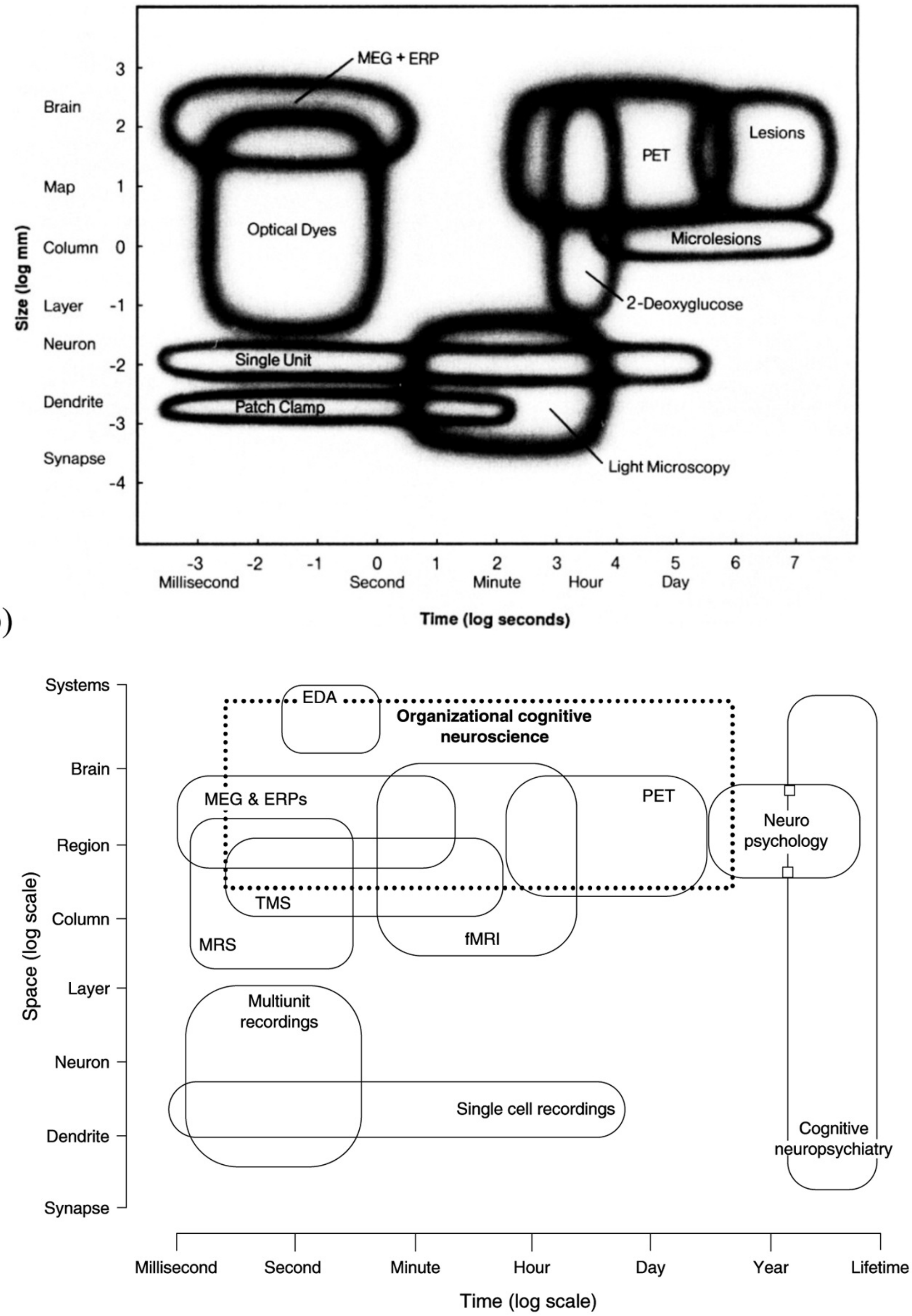


FIGURE 10.1 Spatial and temporal resolutions of neuroscience techniques

Notes: The vertical axes show the spatial extent of the techniques; the horizontal axes represent the time intervals over which information can be collected with each technique. Recordings from the central nervous system are often limited in resolution by the properties of nervous tissue and of the specific method.

Sources: (a) Churchland and Sejnowski, 1988; (b) Senior, Lee, and Butler, 2011.

preliminary experimental boundaries of *organizational neuroscience* (Becker, Cropanzano, and Sanfey, 2011; Senior, Lee, and Butler, 2011).

Kable (2011) has suggested a complementary framework to organize neuroscience techniques when applied to social sciences, on the ground of their underlying testing rationale. *Association tests* are those experimental methods that implicate a manipulation of a psychological state or behavior, the simultaneous measurements of the neural activity, and the following analysis of the correlation between the two. These include classic fMRI, PET, EEG, and MEG approaches. *Necessity tests* are instead those that involve a disruption of the neural activity and aim to show how this manipulation impairs a specific mental function. *Sufficiency tests* are those enhancing a neural activity and seeking to establish that this process results in a specific behavior or mental state. Necessity and sufficiency tests, such as lesion studies, neuropharmacological or Transcranial Magnetic Stimulation (TMS) experiments, are able to directly probe the causality between neural and mental states.

Overall, it is quite straightforward to argue that knowledge of these classifications represents an important apparatus for scholars who both seek to understand the technicalities, and also inquire what different kinds of evidence they should gather to allow the most appropriate inferences about brain functions.

The techniques

The main neuroimaging techniques examined in this chapter include functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), and electroencephalography (EEG). These methods generally allow identifying brain areas displaying increased activity, in comparison to controls, while the subjects are performing specific tasks.

Functional Magnetic Resonance Imaging (fMRI)

Functional Magnetic Resonance Imaging (fMRI) is probably the most known and widely applied neuroscience methodology in business research (Dimoka *et al.*, 2012). To understand the foundation of fMRI it is first necessary to appreciate the underlying principles of Magnetic Resonance Imaging (MRI). MRI exploits the fact that protons (atomic hydrogen nuclei) of our body in the presence of an external magnetic field behave like compass needles, aligning in parallel to that field (Le Bihan, 1996). Simply put, after electromagnetic pulses are applied to these protons (and then switched off), they emit detectable and characteristic radio signals, allowing a computer to reconstruct images of the inner organs (for a review, see Brown and Semelka [2010]). Imposing the magnetic field and pulses and acquiring the resulting signals requires specific equipment, consisting of an MRI magnet, a system of coils and signal amplifier systems (Figure 10.2). An MRI scanner is a cylindrical tube whose core is constituted by a very powerful electro-magnet (Chapman, 2006); a typical magnet, well-suited for fMRI research, has field strength of 3 Teslas (T).[8]

Functional MRI uses these principles to detect the magnetic signal from hydrogen nuclei in water (H_2O). It relies on differences in magnetic properties between venous (oxygen-poor) and arterial (oxygen-rich) blood, which allow revealing the changes in blood oxygenation and flow that occur in response to neural activity, the so-named *neurovascular coupling* (Logothetis *et al.*, 2001; Logothetis and Wandell, 2004). When a brain area is more active it requires more oxygen, and as a consequence blood flow increases to the active area (Fox and Raichle, 1986; Uludag *et al.*, 2004). By using the BOLD signal (Ogawa *et al.*, 1990) fMRI allows researchers to examine activation maps showing which parts of the brain are involved in a particular mental process (Bandettini *et al.*, 1992; Ogawa *et al.*, 1992; Kwong *et al.*, 1992).

Nonetheless, the extent, dynamics, and underlying mechanisms of neurovascular coupling are not yet fully understood (Attwell and Iadecola, 2002; Magistretti and Pellerin, 1999) and the BOLD signal depends on several parameters, so its biophysical link with neuronal activation is not yet entirely straightforward (Malonek *et al.*, 1997). Moreover, the fact that fMRI experiments elicit a BOLD signal does not indicate that subjects necessarily had psychological events associated with that part of the brain (Poldrack, 2006).

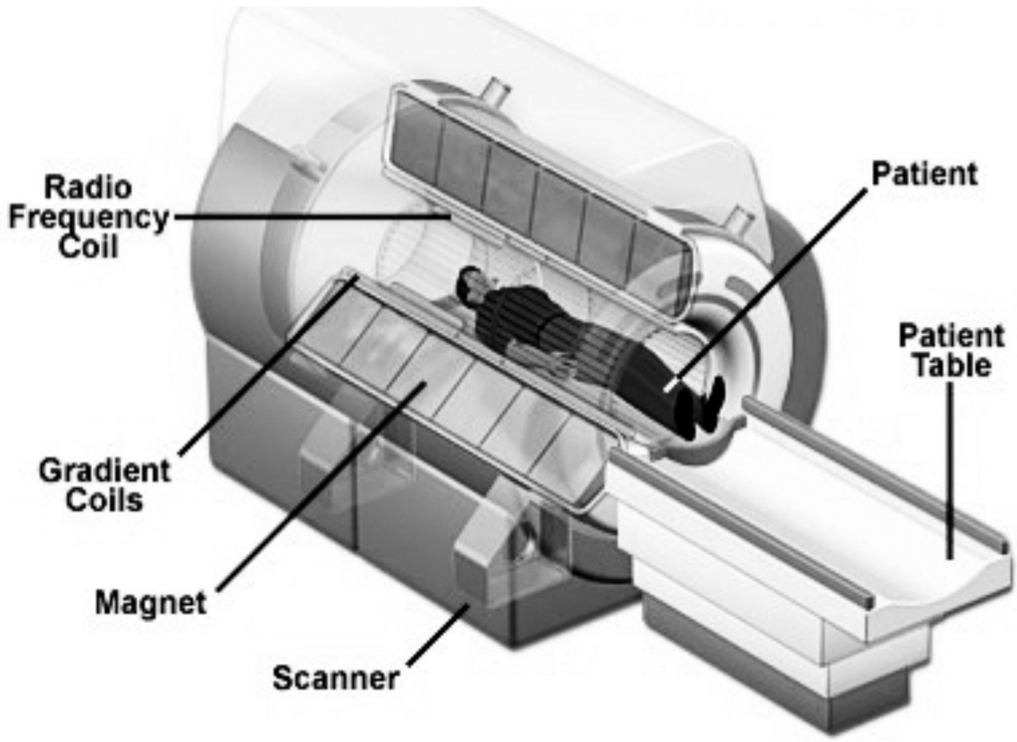


FIGURE 10.2 Main components of an MRI scanner

Source: http://www.themesotheliomalibrary.com

These concerns have lead to some research issues for fMRI research, which however can rely on high spatial (typically 3 millimeters) and high temporal (about 2 seconds) resolution (Song, Huettel, and McCharty, 2006).[9] For instance, the spatial localization of the BOLD signal can be distant from the actual site of neural activity, because the signal source includes various vascular networks sized from capillaries to large draining veins, and the physiological delay necessary for the mechanisms triggering the vascular response to work limits the temporal resolution of the technique (Le Bihan *et al.*, 2006). Research is constantly improving resolution parameters, yet these may be ultimately limited by our physiology. For example, the brain vascular supply is not regulated on the scale of individual neurons and might then be restricted to 0.5-1.5 mm (Menon and Kim, 1999).

Nonetheless, recent work has suggested that *water diffusion MRI* (for a review, see Beaulieu [2002]), could among other methods, overcome some of these limits: changes in the magnitude of diffusion of water molecules within cerebral tissue during neuronal activation would likely reflect transient changes in the microstructure of the neurons, which can then be imagined (Le Bihan, 2003). Although this suggestion has been challenged (Yacoub *et al.*, 2008), capturing such effects would have a remarkable consequence on neuroimaging applications in behavioral reserach, since they would be directly linked to neuronal events in contrast to blood flow effects, which are secondary.

Despite these and other concerns, fMRI has been extensively recruited in social sciences (e.g. Camerer, 2003; Crockett *et al.*, 2008; Damasio, 1994; Glimcher and Rustichini, 2004). Not surprisingly, it has also been the technique of choice to investigate several strategic management paradigms.

For example, fMRI studies have significantly contributed to investigating the neural basis for cooperation. Cooperation, the willful contribution of personal effort to the completion of interdependent tasks, including jobs, has been a mainstay in the management literature (e.g., Barnard, 1938; March and Simon, 1958; the whole special issue of the *Academy of Management Journal* 38(1) [1995]). McCabe and colleagues (2001) employed fMRI in two-person reciprocity games in which participants were facing both human and computer counterparts. They found that cooperation with humans was highly correlated with increased activation of brain regions responsible for joint attention and mutual gains, and decreased activation of regions associated with immediate reward gratification. This study prompted further exploration of other aspects key for management research, such as the role of fairness and trust in the workplace. For instance, equity theory (Adams, 1963; 1965) suggests that perceptions of fairness are job-related motivational grounds that can influence responses of job performers. Research has argued that fair treatment has positive effects on individual employee attitudes (e.g., satisfaction and commitment) and individual behaviors (e.g., absenteeism and citizenship behavior) (Colquitt *et al.*, 2001; Moorman, 1991), while unfair treatment conveys opposite behaviors and attitudes (Cohen-Charash and Mueller, 2007). Research has measured the neural responses and identified key correlates underlying social exchanges and sense of fairness in volunteers playing different strategic games, such as the prisoner dilemma, the ultimatum game, or the reciprocal trust game. For instance, King-Casas and colleagues (2005) found that reciprocity expressed by one social actor strongly predicts trust expressed by his or her partner, a behavioral finding mirrored by an increased activation in the dorsal striatum as compared to control conditions.

In recent years, functional magnetic resonance imaging studies have begun to covered other strategic management paradigms, embracing topics spanning from exploration and exploitation (Daw *et al.*, 2006) to escalation of commitment. For example, research has widely established how the inability to plan ahead often results in escalation of commitment, myopia of learning, or unnecessary risk taking (Levinthal and March, 1993). Escalation of commitment is that situation whenever a manager, or any decision maker, keeps committing considerable resources to a course of action in the hope of achieving a positive outcome, but instead experiences disappointing results (Staw, 1981; Brockner, 1992). Campbell-Meiklejohn and colleagues (2008) highlighted neural correlates of this complex behavior: in comparison to control conditions, decisions not to escalate were associated with increased activity in the anterior cingulate, left anterior insula, posterior cingulate, and parietal cortices, but decreased activity in the ventro-medial prefrontal cortex. Decisions to escalate were associated with a decrease of activity in the anterior cingulate, right anterior insula, and inferior frontal gyrus, but there was no increase in activity in comparison with the control condition, which instead suggested increased activity in the ventro-medial prefrontal cortex.

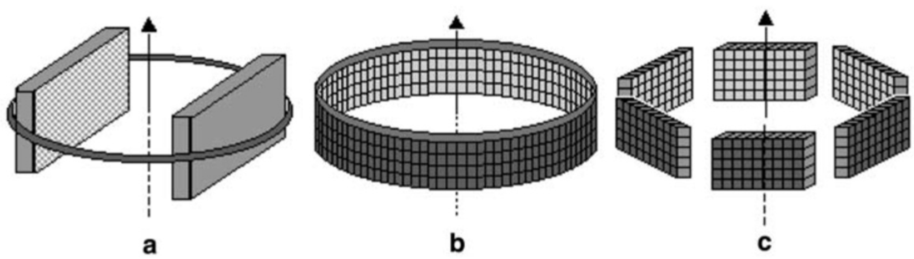
The burst of wide applicability in presenting such imaging research outcomes has perhaps raised the bitterest criticisms around fMRI results, despite scholars having highlighted actual limitations of the methodology (Logothetis, 2008; Poldrack, 2012). As seen above, spatial resolution barriers would not allow to map the intimate nature of individual neurons (i.e., in a voxel there are about 5.5 millions neurons) and directly distinguish between functional activities relevant to the task, irrelevant to the task, and noise. The averaging of imaging, which often leads to ignoring differences between individuals, random effect analysis, and statistical issues are other arguments often brought up to underlie problems of research reproducibility (Vul *et al.*, 2009; the whole *Perspectives on Psychological Science* issue 4(3), [2009] is a must read, dedicated to the issue of correlations in psychological research using fMRI). Recent investigations have started to address these concerns and suggest that increased reproducibility can be achieved through the combined results from multicenter fMRI studies (Stöcker *et al.*, 2005), the development of neuroimaging databases, the use of consistent protocols (Liu *et al.*, 2004), similar machineries, homogeneous sampling, and multiple comparisons correction methods (Poldrack *et al.*, 2011).

In any case, these considerations per se should not prevent management scholars from exploring the use of this methodology, since the debate is a current challenge accompanying the daily routine of every neuroimaging scientist. For one, an analysis of the rise of brain imaging methods from a socio-historical point of view (Beaulieu, 2000), has revealed that neuroscientists have a love-hate relationship with their images: these are useful for blending data and convenient for communicating results to a large audience; however, they hold incredible exposure to the most disparate criticisms.

Positron Emission Tomography (PET)

Positron Emission Tomography (PET) was one of the first techniques used to exploit the links between neural activity and metabolism to study brain functions (Phelps and Mazziotta, 1985; Raichle and Snyder, 2007). It is an analytical nuclear imaging technique, able to provide high spatial resolution images of functional processes occurring in the brain, and it has traditionally been used to make *in vivo* measurements of the anatomical distribution and rates of specific biochemical reactions (Gulyas *et al.*, 2002). The term nuclear signifies that the technique relies on radioactively labeled molecules (tracers). Similar to MRI, PET requires dedicated instrumentation, which includes a ring of detectors located around the patient's head (Turkington, 2001) (Figure 10.3).

In a typical PET experiment, a short-lived radioisotope of a biologically relevant element (carbon, nitrogen, oxygen, fluorine) is produced locally using a low-energy particle accelerator (i.e., a cyclotron). It is then synthetically bound to a biomolecule, usually glucose or oxygen, or to a drug, to form a physiological radiotracer able to emit positrons (positively charged particles of the mass of an electron). This radiotracer is then injected intravenously into the subject, so that it can bind to a specific receptor or enter into specific metabolic pathways. During the natural process of radioactive decay the positron is emitted and travels for a short distance within the brain, then collides with an electron. This impact produces two coincidental rays (gamma rays), which can be measured by the



(a) a rotating gantry

(b) circular

(c) polygonal rings

FIGURE 10.3 Examples of PET detectors

Source: Humm, Rosenfeld, and Del Guerra, 2003 detectors around the subject's head (Ter-Pogossian and Herscovitch, 1985). When two opposite detectors on the ring simultaneously recognize a gamma ray, a computerized system records this as a coincidence event. The computer records all of the coincidence events that occur during the imaging period and then reconstructs cross-sectional images. Bi- and three-dimensional images are often accomplished with the aid of an X-ray CT scan performed on the subject during the same session, in the same machine (Pelizzari *et al.*, 1989). Since the tracer accumulates in the brain in direct proportion to the blood flow, the greater the flow, the greater the radioactive count rate. Thus, the distribution and intensity of the uptake of the positron-emitting radiotracer indicates the underlying neural activity, and the *regional cerebral blood flow* (rCBF) works as the dependent variable (Raichle, 1979; Raichle, Martin, and Herscovitch, 1983).

PET presents several disadvantages in comparison to fMRI. Above all, it involves the use of ionizing radiations, which have potential harmful effects on the research subjects. Moreover, it affords relatively poorer spatial (4 millimeters) and temporal (30–40 seconds) resolutions and generally involves one to two measurements per subject, with each measurement reflecting neural activity averaged over one minute (Kato, Taniwaki, and Kuwabara, 2000).

Nonetheless, PET has provided intriguing insights on topics central to strategic management. One of the most productive lines of research developed around the concept of planning. Planning has been a growing topic in strategy inquiries since the 1950s (Payne, 1957), and has been identified as a variable able to both impact firm performance and have a role in strategic decision making (Ansoff, 1991; Armstrong, 1982; Mintzberg, 1994). Strategic planning decisions emerge from complex interactions among individuals with subjective interests and perception; understanding the respective neural correlates can inform further on both planning processes and theories. Several neuroimaging studies have independently addressed the issue. Associating PET studies with the Tower of London (TOL) task – an adaptation of the Tower of Hanoi (Anzai and Simon, 1979), which consists of moving colored balls within a limited number of moves in order to achieve a given goal configuration – researchers shed a light on the anatomic and physiological correlates of planning processes. Longer planning times and fewer moves to complete a problem are associated with significantly higher regional cerebral blood flow in the left prefrontal cortex, whereas execution time is negatively correlated with both left and right prefrontal rCBF (Baker *et al.*, 1996; Dagher *et al.*, 1999).

With the preponderant emergence of fMRI, more widely accessible and cheaper, the use of PET in social sciences has seemingly plateaued. Nevertheless, PET may still hold a relevant role for management scholarships. This technique measures blood flow in absolute terms (while fMRI measures changes in blood oxygenation), permitting therefore a more precise comparison between subjects, sessions, and brain regions (Minoshima *et al.*, 1994). Therefore, there is considerable reliability for research investigating associations within subjects across different tasks.

Moreover, PET has the unique ability to measure cerebral metabolism, hence associate differences in molecular synthesis with difference in behavior (Phelps and Mazziotta, 1985). For instance, in the striatum, differences in the synthesis of dopamine, a molecule frequently implicated in impulsive behaviors, has been associated with differences in reversal learning (Cools *et al.*, 2009). This phenomenon is connected to decisions made under emotional situations and conflicts (Fellows and Farah, 2003; Kovalchik and Allman, 2005), which are circumstances often experienced across several management levels (Huy, 2002).

Electroencephalography (EEG)

While measuring regional cerebral flow can provide a detailed anatomical mapping of active brain areas, the time resolution of the related methods is generally too slow to reveal the rapid flux of neuronal communication. Conversely, surface recordings of the electric fields emanating from active populations of neurons offer a higher degree of temporal resolution (on the order of milliseconds), but yield a less complete picture of anatomical sources. This method, called electroencephalography (EEG), is the oldest non-invasive method to measure brain activity (Nunez, 1995).

The existence of electrical currents in the brain was discovered by Richard Caton (1875), and the first electroencephalographic experiment was performed in 1929 by Hans Berger (1929), in which he discovered the *alpha rhythm*, waves with a uniform rhythm typical of a subject awake in a quiet resting state (Adrian and Matthews, 1934). Since this pioneering discovery, researchers have conducted thousands of experiments, leading to advances in both the recording systems and the understanding of brain functions (Freeman and Quiroga, 2013). Nowadays, it is acknowledged that our brain produces several types of brainwaves with different frequencies, and each of them is associated with particular mental states. As an example, *beta waves* have a frequency of 15–38 Hz and are characteristic of individuals who are fully awake and alert (Nunez, 1995).

EEG employs advanced signal processing methods to infer data about the brain through the scalp and skull (Niedermeyer and Lopes da Silva, 1995). It develops around the concept that neurons are excitable cells, which transmit information through electrical or chemical signals via dedicated structures called *synapses*. Populations of neurons are connected into networks and communicate with each other repeatedly by sending electrical impulses. The technique specifically measures the resulting electrical currents that flow underneath the scalp while short extensions of certain cortical neurons (the dendrites of pyramidal neurons) are excited (Atwood and Mackay, 1989). When the brain processes an event, thousands of these cells are activated at the same time, causing a fluctuation in voltage. In order to measure these signals a cap with several electrodes is placed on the subject's head. By quantifying the differences between the electrodes, the flow and strength of the electric field can be inferred (Tyner *et al.*, 1989). Since the signals that reach the scalp are very small (usually in the range of 1 to 100 μV) they are then amplified and converted into a digital form (Luck, 2005). However, because EEG detects electrical signals at the scalp, it can only measure activity coming from the cortex, making almost impossible evaluating direct activation in deeper lying structures (Bronzino, 1995). Moreover, EEG has a very high temporal resolution, hence allowing for very fast measurement within milliseconds. However, the low spatial resolution makes it challenging to precisely localize the source of the signal.

To be able to extract the correct electrical signal associated with a behavioral experimental task and distinguish it from the background noise, a functional EEG study requires multiple averaged measurements. By averaging signals, researchers can indicate that a certain task causes a specific activation of the measured brain region at a specific time stamp. Simply put, the resulting response is called event-related potential (ERP) (Squires *et al.*, 1976).

The preparation of a standard EEG setup takes a relatively long time (Lebedev and Nicolelis, 2006); however, an EEG assessment can be accomplished while people are seated and engaged in everyday activities, including conversations associated with the type of task the experiment involves. Being relatively inexpensive, non-invasive, and non-harmful for the participants of a study, EEG has been one of the most applied techniques in management studies.

Already in the 1980s, Robey and Taggart (1981; 1982) sought to establish a linkage between measures of managerial styles and brain activity recorded with EEG. Drawing on the insights on hemispheric dominance and on the initial claims of Doktor (1978) they argued relationships between cerebral dominance and scales able to assess distinct strategic leadership types. More recently, Waldman and colleagues (2011) focused on inspirational management and its association with electrical brain activity, by recording subjects' beta waves in terms of coherence. In this way they were able to measure the coordinated activity between multiple parts of the brain when the subjects were presented a visual task on activities related to inspirational leadership (Figure 10.4). They showed that coherence in the right frontal areas of the brain could offer the basis for social visionary communication, which helps to build followers' perceptions of charismatic leaders. Although this research pipeline has ambitious potential, with some authors foreseeing the eventuality to train managers to "replicate such brain patterns," its results shall be understood with caution (as reported in Dvorak and Badal [2007]).

EEG has been employed to understand several other management constructs, such as punishment behavior. This topic has received increasing attention from management researchers (Simons, 1991), as it is associated with important variables such as power, reward, cooperation, and fairness. For instance, when managers are considered to have punished others unfairly, they not only impair their own reputations, but also risk eliciting negative attitudes and counterproductive behaviors, weakening the perceived legitimacy of their authority (Ball, Treviño, and Sims, 1994). Knoch and colleagues (2010) disclosed that the right lateral prefrontal cortex may play a central role in punishment behavior: subjects with an active PFC region seem most likely to punish an unfair proposal, even though the action has disadvantages for themselves, and vice versa.

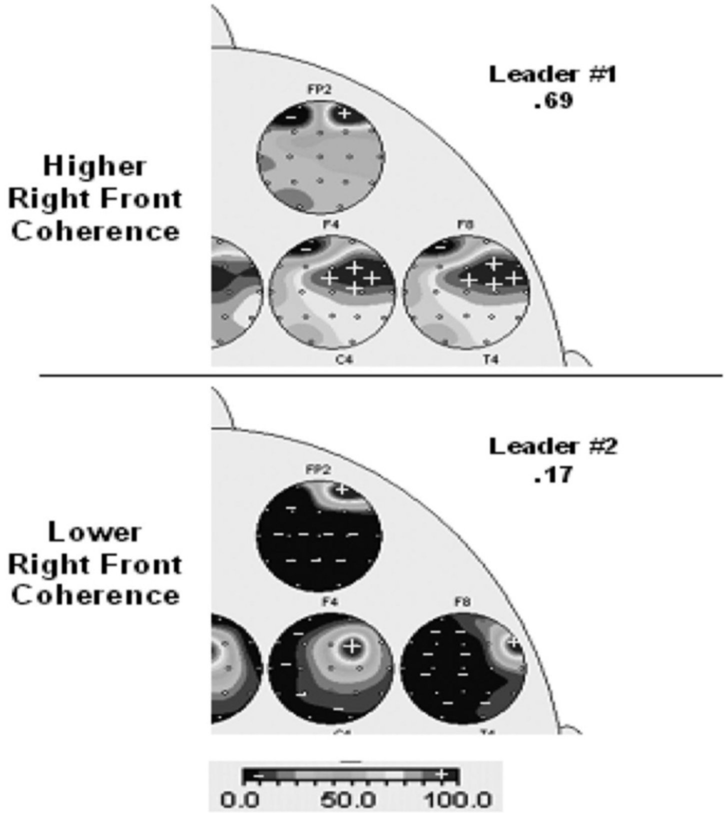


FIGURE 10.4 Spectral analysis of right front coherence in leadership research

Notes: The gradient shows the levels of coherence on 3 right frontal electrode locations, including areas at 0% (indicated by the minus signs), areas at 100% (indicated by plus signs), and in between. Dark regions with a + represent areas with high degrees of coherence (75% or higher); dark regions with minus signs characterize areas with low coherence (25% or lower). The numeric values indicate the summed averaged coherence scores for such brain regions in different leaders.

Source: Waldman, Balthazard, and Peterson, 2011

Lesion studies, VLSM, TMS, and MEG

It is central to highlight that while the techniques examined so far can identify brain activation, they cannot independently determine which of these areas are indispensable for performing the experimental task. This information can instead be provided by neuropsychological studies.

Among them, *lesion studies* are the oldest approaches to the study of mental functions. Already in 1861, Paul Broca (1861) suggested a relation between language and the brain's left hemisphere, setting the basis for localizing human brain function by studying the correlation between a behavioral disorder and the site of a brain injury. This approach has been the milestone for a long tradition of neuropsychological research, grounding the rationale of *cognitive dissociation*

(Caramazza, 1986; Shallice, 1988). Single dissociation occurs when damage in a brain region causes a disruption in one specific mental function but not in another, allowing inference that those functions are independent of each other (Kolb and Whishaw, 2009). Alternatively, double dissociation is conceivable when a subject with brain damage shows poor performance on one task and good performance on another task, while other patients show the opposite performance. This allows inference that the two related mental processes function independently of each other. Several researchers have criticized the logic or some of its applications, arguing, for example, that double dissociations do not necessarily imply a difference in processing mechanisms between tasks (Bullinaria and Chater, 1995; Chater and Ganis, 1991).

Despite these criticisms and the advancements provided by modern neuroimaging techniques, management research can still gather important investigative elements from lesion studies (Rorden and Karnath, 2004). One approach, for example, is that of grouping subjects according to the lesions' locations and comparing the performance of each group. This can be exemplified in attention studies. Attention is a topic of great interest in strategic management, since it fosters questions not only in problem solving (Bower, 1986; Newell and Simon, 1972), but also in aspects such as strategic issue diagnosis (Dutton, Fahey, and Narayanan, 1983), and organizational mindfulness (Levinthal and Rerup, 2006; Weick and Sutcliffe, 2006). In parallel, neuroscience studies on attention have proposed the existence of three systems of attention: orienting, alerting, and executive control (Posner *et al.*, 2007). Research has compared their efficiencies between differently brain-damaged subjects (frontal, temporal, and parietal lesions) and healthy controls using the Attention Network Test (ANT) (Raz and Buhle, 2006). A reduced efficiency of the executive network was found in patients with frontal lobe and parietal lobe injuries, patients with parietal lobe injuries showed a deficit in the orienting network, and analysis of lateralization indicated the right hemisphere superiority to the alerting system.

Subjects with brain damages, as those recruited for that research, can easily be enrolled from different sources (i.e., ischemic, tumor removal, degenerative diseases patients). However, aside from the fairly obvious ethical concerns, there are some practical implications in conducting large-scale lesions studies in management, since they require dedicated infrastructure and personnel. Moreover, a major drawback of this approach is that brain damage is not under easy experimental controls (Brett, Johnsrude, and Owen, 2002). This ongoing uncertainty means that it is difficult to control for phenomena such as brain reorganization, different severity of lesion, and more generally individual differences.

A combination of imaging and lesion studies could prove useful to overcome these difficulties and advance management investigations (Shallice, 2003). *Voxel-based Lesion-Symptom Mapping* (VLSM) is a relatively recent method for analyzing the relationships between behavioral deficits in a neurological population and lesion sites associated with those deficits. The major advantage of VLSM over classic lesion studies is that it allows researchers to examine such data without articulating behavioral and lesion sites' boundaries (e.g., parietal patients vs. frontal patients) (Bates *et al.*, 2003). For instance, Driscoll and colleagues (2012) have elucidated the neural bases of self-reported emotional empathy comparing a group of Vietnam combat veterans who had traumatic brain injuries with a group of non-brain-injured veterans, by using VLSM on computed tomographic scans. Empathy is essential for managing relations in organizations, and research has suggested that the ability to understand others' emotions enables a manager to foster strategic management (Nonaka and Toyama, 2007).

Another method alternative to classical lesion studies is offered by *Transcranial Magnetic Stimulation* (TMS). However, differently from classic lesion studies, this approach does not involve permanent brain damage. Transcranial magnetic stimulation is a non-invasive technique that electromagnetically induces very brief electrical current pulses through a coil placed above the brain area to be stimulated; this produces weak electrical currents in the underlying neurons (Walsh and Cowey, 2000). TMS thus holds a unique role in understanding how the brain works, because it can be used to disengage a brain area for a minimal time, allowing scientists to understand its functional role (Pascual-Leone, Bartes-Faz, and Keenan, 1999). TMS has a temporal resolution of milliseconds, while the spatial resolution depends on the coil and the target area, which can be located thanks to a navigator device (Stewart and Walsh, 2006).

Although promising, the neurophysiological effects of TMS are not fully understood, often leading to difficulties in interpretation of the results; it may have excitatory, as well as inhibitory effects on brain regions, and differences in TMS stimulation parameters can influence experimental results (Rorden and Karnath, 2004). Moreover, current TMS systems are able to directly disrupt regions only near the scalp, usually evoke slight changes in behavior, and may induce epileptic seizures if applied at high intensities (Sack and Linden, 2003). These limitations make the technique not yet ideal for investigating long-term and social effects, such as those characterizing organizations. Thus, one of the most promising research directions is to explore *multimodal imaging modalities*, the combined use of two or more experimental techniques able to complement each other (e.g., TMS and fMRI) (Siebner and Rothwell, 2003; Babiloni *et al.*, 2004).

Another neuroimaging method that might receive increasing resonance in management studies is *magnetoencephalograpy* (MEG). It uses signals emerging from the scalp and measures fluctuations in the magnetic field as a result of changes in neural activity (Hämäläinen *et al.*, 1993). Since the fields have strength of only 50–500fT (about 100 million times weaker than the Earth's magnetic field), MEG instrumentation requires the use of special devices placed on the subject's head (superconducting SQUID-based magnetometers), and a magnetically shielded room (Vrba and Robinson, 2002). Magnetoencephalography is specular to TMS: while MEG detects magnetic fields generated by neural currents, TMS induces currents in the brain via magnetic fields. Moreover, MEG provides elevated temporal resolution and, due to poor signal degradation, results in high spatial discrimination of neural contributions (Pascual-Marqui, Michel, and Lehmann, 1994). Finally, it allows for absolute measures, which are not dependent on the choice of a reference, introducing new opportunities to further investigation of strategic management topics.

Other neuroscience methods in management research

While this work has largely concentrated on neuroimaging technologies, it is necessary to mention that several other neuroscientific approaches (e.g., those measuring autonomic parameters, neurogenetics, and neuropharmacology techniques) can provide important information for management and strategy inquiries.

For instance, a method with the potential to offer novel insights in strategic management research is that of *eye-tracking*. Eye-movement data usually consist of eye fixations, when the gaze position is relatively still so that the foveae remain directed at a particular point in space and information is extracted from the stimulus (Pieters, 2008). The rationale of this method is then aimed at determining the spatial point at which a viewer's foveae are directed and the extent of time they remain focused there. For instance, eye-tracking has been employed in the evaluation of facial perception, which is an important antecedent to successful social and business communication, since human social inferences are derived largely from viewing facial expression (Schulte-Mecklenbeck, Kühberger, and Ranyard, 2011). Similarly, it can be employed to provide insights in the processing of risky decisions (Glöckner and Herbold, 2011).

Research in strategy could also be further supported by *neurogenetics* experimental procedures, investigating the basis of cognition, sociality, and behavior. Such method has already been applied to business disciplines, for instance to entrepreneurship (Nicolau and Shane, 2010). This type of studies generally relies on comparisons between twins or examines allelic differences, suggesting that genetic variances translate into functional differences. Neurogenetics may be particularly useful for strategy research by linking polymorphisms of selected genes affecting neurotransmitter systems, or by employing genome-wide approaches to investigate mental functions and behavioral phenotypes. For instance, research on exploration and exploitation has shown that basal ganglia support learning to exploit decisions that have yielded positive outcomes in the past, while the prefrontal cortex is associated to strategic exploratory decisions when the magnitude of potential outcomes is unknown. Distinct genetic processes sustain these differences: genes controlling striatal dopamine function (*DARPP-32* and *DRD2*) are associated with exploitation, while a gene controlling prefrontal dopamine function (*COMT*) is associated with "directed exploration" (Frank *et al.*, 2009).

Although the sampling collecting procedures for these studies are quite simple (a saliva or blood sample is usually sufficient), these analyses require advanced expertise and facilities. Moreover, due to the intimate nature of the approach, research findings are at high risk of producing serious ethical concerns or stigmatization (i.e., associating specific polymorphisms to supposed deviant attitudes or to targeted populations) (Illes and Racine, 2005).

Finally, *neuropharmacological* studies rely on the rationale that specific compounds excite or inhibit particular neurotransmitter actions (neurotransmitter loading or depletion), thereby influencing a subject's behavior. Also in this case, these approaches hold important concerns, in particular in relation to cognitive enhancement (Bostrom and Sandberg, 2009). Examples of this methodological approach are studies, which employ neuropeptides such as oxytocin and vasopressin (Heinrichs, von Dawans, and Domes, 2009). For example, research has proposed a role for oxytocin in modulating trust, thus influencing cooperative relations. Administration of intranasal oxytocin increased the amount of money that a social actor was ready to offer to a "trustee," who could return either a smaller or larger sum back to the person (Kosfeld *et al.*, 2005). However, oxytocin did not increase monetary distributions when the feedback was determined by a random draw, indicating that these results are specific to the social interaction between the two actors. In support to this research, imaging studies revealed that oxytocin decreased amygdala activity, independently from the experimental scenario, providing further insights into the neural mechanisms by which this neuropeptide regulates cooperation (Petrovic *et al.*, 2008).

Ethics, hype, and hope

Despite its complexity and technicalities, neuroscience research has engaged the interest and curiosity of several audiences, including non-expert scholars (Frazzetto and Anker, 2009). Since the 1990s we have seen the rise of a neuroculture (Rolls, 2012), with "neuro" concepts increasingly assimilated in the social sciences, including management research.

In response to this phenomenon, some scholars have argued that managerial, organizational, and strategy frameworks involve dynamic systems, multilevel analyses, depend on environment, interaction with people, tasks, and structures, and these paradigms cannot be fully appreciated with neuroscientific methods currently available (Powell, 2011). Others have associated neuroimaging research with phreonological cults (Dobbs, 2005; Simpson, 2005; Uttal, 2001), pointing out methods, such as fMRI, inform about the location of neural activities, yet offer a very plastic snapshot of the complex mental and behavioral processes occurring in the brain (Coltheart, 2006; Page, 2006). On the other hand, researchers have responded that functional neuroimaging allows for broader and more complex explanations, and have proposed connectivist and network frameworks (Cowell, Huber, and Cottrell, 2009; Rogers *et al.*, 2007; Rubinov and Sporns, 2010).

Moreover, neuroimaging methods were primarily conceived for clinical applications, and only later have been applied to behavioral and management inquiries. What could happen if some incidental pathological abnormality emerges during a management study? What if a non-clinical researcher thinks there is an abnormality, which is instead just an ordinary physiological variant, and worries the subject unreasonably?

These ethical issues are not insignificant (Grossman and Bernat, 2004). An unexpected finding may turn the naive desire of a volunteer to have a picture of his or her brain into a major incident with severe consequences impacting both health and everyday life (Kirschen, Jaworska, and Illes, 2006). And if it is unethical not to provide result interpretations, detecting pathological abnormalities is a relatively frequent event, especially with functional neuroimaging systems (Katzman, Dagher, and Patronas, 1999). Therefore, in order to minimize the impact of incidental findings, research protocols should include informed consent and adhere to detailed guidelines (Illes *et al.*, 2004) and research outputs should be examined and reported by qualified personnel able to flag minor normal variants as well as pathologies (Illes *et al.*, 2004).

Despite these vibrant considerations and debates, it is possible to claim that learning about the brain can help to understand further people's behaviors in firms and organizations; thus neuroscience methods can add to the understanding of management and strategy frameworks' elements on the basic neural process involved. To this end, knowledge on the techniques presented in this chapter represents a key instrument to acquire new awareness about those paradigms, and to ascertain the basis for a durable and doable association between neuroscience and management research. Nevertheless, researchers should not only understand and recognize both these tools' potentials and limitations, but also be careful about getting into the hype of including a "brain-talk" or neuroimage with any and every research output. For instance, there is growing evidence that an untrained audience too often trusts catchy neuroscience claims blindly (Racine, Bar-Ilan, and Illes, 2005; Weisberg *et al.*, 2008). Once research results are publicized, especially when linked to personality or social constructs, non-experts often relate with lay interpretations of these outcomes. Although this phenomenon should not be confused with the merits of sound research (Beck, 2010), it is also true that the way in which some findings are presented tends to be vigorously loaded (Racine *et al.*, 2010). Extensively incorporating brain region labels and scans, perhaps supported by amateurish statistics or imprecise anatomical knowledge, may become just rhetoric, if not supported by clear experimental and scientific agendas and precise methodological disclosure (Illes, 2006; McCabe and Castel, 2008; Weisberg *et al.*, 2008). Similarly, management scholars shall rethink the epistemological urge of outlining new "neuro" disciplines (Bennett, Hacker, and Bennett, 2003; Legrenzi and Umiltà, 2011). For one, here I have provided an introductory review on how experimental neuroscience for management and strategy must necessarily be considered as a set of instruments, suggesting that also uprising "neuromanagement" discussions must not disengage from the fuller understanding of the underlying neuroscience.

The hope in and the competitive advantage of neuroscience and management is thus an integrated framework, established through systematic understanding of neuroscientific methods, multidirectional communication, and planned collaborations between scholars as the most appropriate means to achieve a fuller knowledge on human strategic behavior.

Notes

1 I would like to thank Sigal Barsade, James Berry, Giambattista Dagnino, Martin Kilduff, and Simcha Jong for their useful suggestions.
2 Examples of these evidences include e.g. the Zhejiang University's Neuromanagement Laboratory; dedicated sessions at the Academy of Management Meetings; the Open Research Area NESSHI (www.nesshi.eu/) and the Human Brain (https://www.humanbrainproject.eu/) projects.
3 An all-inclusive analysis of the neuroscience methods would have to be book-length to cover each of the techniques presented in this chapter. A few examples of neuroscience-specific texts able to exhaustively address these topics, which however do not touch management paradigms, are: Cabeza and Kingstone, 2001; Senior, Russell, and Gazzaniga, 2006; Toga and Mazziotta, 2002.
4 The notion of functional neuroimaging of behavior employed in this work seeks to highlight the differences with the use of these techniques in clinical practice (i.e., clinical functional neuroimaging). I will interchangeably use the terms mental and behavioral to broadly encompass cognitive, emotional, and affective processes. Readers must note that there is direct inference when the investigator infers something about the role of particular brain regions in cognitive function. Reverse inference, which is instead not recommended, occurs when the investigator infers the engagement of particular cognitive functions based on activation in particular brain regions (Poldrack 2006).
5 Tomographic techniques are those methods that allow imaging a body by sections through a penetrating wave. They allow imaging of a slice through, rather than a projection of a three-dimensional structure (Natterer and Ritman, 2002).
6 Technically a T2* relaxation time.
7 This work does not review classic electrophysiological techniques (e.g., single- and multi-unit recordings, patch clamp; for more information on these methods, see Bretschneider and de Weille, 2006), and methods that currently have received marginal applications in the strategic management scholarship (e.g., Magnetic Resonance Spectroscopy [MRS]). Moreover, the work will solely cover neuroscience methods in humans, hence excluding those applications carried out in primates (for more information on this, see Murray and Baxter, 2006).
8 3 Teslas are roughly 60 thousand times greater than the Earth's magnetic field.
9 MRI and fMRI are also characterized by high *contrast resolution*, which is the ability to distinguish the differences between two arbitrarily similar but not identical tissues, such as white and grey matter (Bushberg *et al.*, 2002).

References

AA.VV. (2009) *Perspectives on Psychological Science*, 4(3).

AA.VV. (1995) *Academy of Management Journal*, 38(1).

Adams, J. S. (1963) "Toward an understanding of inequity", *Journal of Abnormal Social Psychology*, 67(5): 422–436.

Adams, J. S. (1965) "Inequity in social exchange," in L. Berkowitz (ed.) *Advances in Experimental Social Psychology*, 267–269, New York: Academic Press.

Adenzato, M. and Garbarini, F. (2006) "The As if in cognitive science, neuroscience and anthropology: A journey among robots, blacksmiths and neurons", *Theory & Psychology*, 16(6): 747-759.

Adrian, E. D. and Matthews, B. H. (1934) "The Berger rhythm: Potential changes from the occipital lobes in man," *Brain*, 57(4): 355-385.

Ansoff, H. I. (1991) "Critique of Henry Mintzberg"s The design school: reconsidering the basic premises of strategic management," *Strategic Management Journal*, 12(6): 449–461.

Anzai, Y. and Simon, H. A. (1979) "The theory of learning by doing," *Psycholgical Review*, 86(2): 124–140.

Ariely, D. and Berns, G. S. (2010) "Neuromarketing: The hope and hype of neuroimaging in business," *Nature Reviews Neuroscience*, 11(4): 284–292.

Armstrong, J. S. (1982) "The value of formal planning for strategic decisions: Review of empirical research," *Strategic Management Journal*, 3(3): 197–211.

Attwell, D. and Iadecola, C. (2002) "The neural basis of functional brain imaging signals," *TRENDS in Neurosciences*, 25(12): 621–625.

Atwood, H. L. and MacKay, W. A. (1989) *Essentials of Neurophysiology*, New York: Decker.

Babiloni, F., Mattia, D., Babiloni, C., Astolfi, L., Salinari, S., Basilisco, A., and Cincotti, F. (2004) "Multimodal integration of EEG, MEG and fMRI data for the solution of the neuroimage puzzle," *Magnetic Resonance Imaging*, 22(10): 1471–1476.

Baker, S. C., Rogers, R. D., Owen, A. M., Frith, C. D., Dolan, R. J., Frackowiak, R. S. J., and Robbins, T. W. (1996) "Neural systems engaged by planning: A PET study of the Tower of London task," *Neuropsychologia*, 34(6): 515–526.

Ball, G. A., Trevino, L. K. and Sims, H. P. (1994) "Just and unjust punishment: Influences on subordinate performance and citizenship," *Academy of Management Journal*, 37(2): 299–322.

Bandettini, P. A. (2002) "fMRI: The spatial, temporal, and interpretive limits of functional MRI," in Davis, K., Charney, D., Coyle, J. and Nemeroff (eds), *Neuropsychopharmacology: The Fifth Generation of Progress*, 343–356, Philadelphia: Lippincott Williams and Wilkins.

Bandettini, P. A. (2009) "What's new in neuroimaging methods?," *Annals of the New York Academy of Sciences*, 1156(1): 260–293.

Bandettini, P. A., Wong, E. C., Hinks, R. S., Tikofsky, R. S. and Hyde, J. S. (1992) "Time course EPI of human brain function during task activation," *Magnetic Resonance in Medicine*, 25(2): 390–397.

Barnard, C. I. (1938) *The Functions of the Executive*, Cambridge, MA: Harvard University Press.

Bates, E., Wilson, S. M., Saygin, A. P., Dick, F., Sereno, M. I., Knight, R. T., and Dronkers, N. F. (2003) "Voxel-based lesion–symptom mapping," *Nature Neuroscience*, 6(5): 448–450.

Beaulieu, A. (2000) "The Space inside the skull: Digital representations, brain. mapping and cognitive neuroscience in the decade of the brain," Ph.D. Dissertation, Science and Technology Dynamics, University of Amsterdam, the Netherlands.

Beaulieu, C. (2002) "The basis of anisotropic water diffusion in the nervous system: A technical review," *NMR in Biomedicine*, 15(7–8): 435–455.

Beck, D. M. (2010) "The appeal of the brain in the popular press," *Perspectives on Psychological Science*, 5(6): 762–766.

Becker, W. J., Cropanzano R., and Sanfey A. G. (2011) "Organizational neuroscience: Taking organizational theory inside the neural black box," *Journal of Management*, 37(4): 933–961.

Bennett, M. R., Hacker, P. M. S., and Bennett, M. R. (2003) *Philosophical Foundations of Neuroscience,* Oxford: Blackwell.

Berger, H. (1929) "Uber das Elektrenkephalogramm des Menschen," *Arch. Psychiatrie Nerv.*, 87: 527–570.

Bloch, F. (1946) "Nuclear induction," *Physical Review*, 70(7–8): 460.

Bostrom, N. and Sandberg, A. (2009) "Cognitive enhancement: Methods, ethics, regulatory challenges," *Science and Engineering Ethics*, 15(3): 311–341.

Bower, J. L. (1986) *Managing the Resource Allocation Process*, Vol. 3, Cambridge, MA: Harvard Business Press.

Bretschneider, F. and De Weille, J. R. (2006) *Introduction to Electrophysiological Methods and*

Instrumentation, London: Elsevier.
Brett, M., Johnsrude, I. S., and Owen, A. M. (2002) "The problem of functional localization in the human brain," *Nature Reviews Neuroscience*, 3(3): 243–249.
Broca, P. (1861) "Perte de la parole, ramollissement chronique et destruction partielle du lobe antérieur gauche du cerveau," *Bulletin Society Anthropology*, 2: 235–238.
Brockner, J. (1992) "The escalation of commitment to a failing course of action: Toward theoretical progress," *Academy of Management Review*, 17(1): 39–61.
Bronzino, J. D. (ed.) (1995) *The Biomedical Engineering Handbook*, Vol. 1, Boca Raton, FL: CRC Press.
Brown, M. A. and Semelka, R. C. (2011) *MRI: Basic Principles and Applications*, Hoboken, NJ: Wiley.
Bullinaria, J. A. and Chater, N. (1995) "Connectionist modeling: Implications for cognitive neuropsychology," *Language and Cognitive Processes*, 10(3–4): 227–264.
Bushberg, J. T., Seibert, J. A., Leidholdt, Jr, E. M., and Boone, J. M. (2002) *The Essential Physics of Medical Imaging*, Philadelphia, PA: Lippincott Williams & Wilkins.
Cabeza, R. and Kingstone, A. (eds) (2001) *Handbook of Functional Neuroimaging of Cognition*, Cambrdige, MA: MIT Press.
Camerer, C. F. (2003) *Behavioral Game Theory: Experiments in Strategic Interaction*, Princeton, NJ: Princeton University Press.
Campbell-Meiklejohn, D. K., Woolrich, M. W., Passingham, R. E., and Rogers, R. D. (2008) "Knowing when to stop: The brain mechanisms of chasing losses," *Biological Psychiatry*, 63(3): 293–300.
Caramazza, A. (1986) "On drawing inferences about the structure of normal cognitive systems from the analysis of patterns of impaired performance: The case for single-patient studies," *Brain and Cognition*, 5(1): 41–66.
Caton, R. (1875) "Electrical currents of the brain," *Journal of Nervous and Mental Disease*, 2(4): 610.
Chapman, B. L. (2006) "Gradients: The heart of the MRI machine," *Current Medical Imaging Reviews*, 2(1): 131–138.
Chater, N. and Ganis, G. (1991) "Double dissociation and isolable cognitive processes," *Behaviour*, 5(9): 668–672.
Churchland, P. S. and Sejnowski, T. J. (1988) "Perspectives on cognitive neuroscience," *Science*, 242(4879): 741–745.
Cohen-Charash, Y. and Mueller, J. S. (2007) "Does perceived unfairness exacerbate or mitigate interpersonal counterproductive work behaviors related to envy?," *Journal of Applied Psychology*, 92(3): 666–680.
Colquitt, J. A., Conlon, D. E., Wesson, M. J., Porter, O. L. H., and Ng, K. Y. (2001) "Justice at the millennium: A meta-analytic review of 25 years of organizational justice research," *Journal of Applied Psychology*, 86(3): 425–445.
Coltheart, M. (2006) "What has functional neuroimaging told us about the mind (so far)?," *Cortex*, 42: 323–331.
Connolly, W. E. (2002) *Neuropolitics: Thinking, Culture, Speed*, Minneaoplis, MN: University of Minnesota Press.
Cools, R., Frank, M. J., Gibbs, S. E., Miyakawa, A., Jagust, W., and D'Esposito, M. (2009) "Striatal dopamine predicts outcome-specific reversal learning and its sensitivity to dopaminergic drug administration," *The Journal of Neuroscience*, 29(5): 1538–1543.
Cowell, R. A., Huber, D. E., and Cottrell, G. W. (2009) "Virtual brain reading: A connectionist approach to understanding fMRI," Paper presented at the 31st Annual Meeting of the Cognitive Science Society.

Crockett, M. J., Clark, L., Tabibnia, G., Lieberman, M. D., and Robbins, T. W. (2008) "Serotonin modulates behavioral reactions to unfairness," *Science*, 320(5884): 1739–1739.

Cushman, F. and Greene, J. D. (2012) "Finding faults: How moral dilemmas illuminate cognitive structure," *Social Neuroscience*, 7(3): 269–279.

Dagher, A., Owen, A. M., Boecker, H., and Brooks, D. J. (1999) "Mapping the network for planning: A correlational PET activation study with the Tower of London task," *Brain*, 122(10): 1973–1987.

Damasio, A. R. (1994) *Descartes' Error: Emotion, Reason, and the Human Brain*, London: Penguin Books.

Daw, N. D., O'Doherty, J. P, Seymour, B., Dayan, P., and Dolan, R. J. (2006) "Cortical substrates for exploratory decisions in humans," *Nature*, 441, 876–879.

Dawson, D. G. (1951) "A summation technique for detecting small signals in a large irregular background," *Journal of Physiology*, 494: 251–326.

Dimoka, A., Banker, R. D., Benbasat, I., Davis, F. D., Dennis, A. R., Gefen, D., and Weber, B. (2012) "On the use of neuropyhsiological tools in IS research: Developing a research agenda for NeuroIS," *MIS Quarterly*, 36(3): 679–702.

Dobbs, D. (2005) "Fact or phrenology?," *Scientific American Mind*, April 1–8: 24–31.

Doktor, R. (1978) "Problem solving styles of executives and management scientists," *TIMS Studies in the Management Sciences*, 8(2): 123–134.

Donders, F. C. (1969) "On the speed of mental processes," *Acta Psychologica*, 30: 412–431.

Driscoll, D. M., Dal Monte, O., Solomon, J., Krueger, F. and Grafman, J. (2012) "Empathic deficits in combat veterans with traumatic brain injury: A voxel-based lesion-symptom mapping study," *Cognitive and Behavioral Neurology*, 25(4): 160–166.

Dutton, J. E., Fahey, L. and Narayanan, V. K. (1983) "Toward understanding strategic issue diagnosis," *Strategic Management Journal*, 4(4): 307–323.

Dvorak, P. and Badal, J. (2007) "This is your brain on the job," *The Wall Street Journal*, September 20. Retrieved at: http://online.wsj.com/news/articles/SB119024585835733168

Fellows, L. K. and Farah, M. J. (2003) "Ventromedial frontal cortex mediates affective shifting in humans: Evidence from a reversal learning paradigm," *Brain*, 126(8): 1830–1837.

Finger, S. (2001) *Origins of Neuroscience: A History of Explorations into Brain Function*, New York: Oxford University Press.

Fox, P. T. and Raichle, M. E. (1986) "Focal physiological uncoupling of cerebral blood flow and oxidative metabolism during somatosensory stimulation in human subjects," *Proceedings of the National Academy of Sciences*, 83(4): 1140–1144.

Frank, M. J., Doll, B. B., Oas-Terpstra, J. and Moreno, F. (2009) "Prefrontal and striatal dopaminergic genes predict individual differences in exploration and exploitation," *Nature Neuroscience*, 12(8): 1062–1068.

Franks, D. D. (2010) *Neurosociology: The Nexus Between Neuroscience and Social Psychology*. New York: Springer.

Frazzetto, G. and Anker, S. (2009) "Neuroculture," *Nature Reviews Neuroscience*, 10(11): 815–821.

Freeman, W. J. and Quiroga, R. Q. (2013) *Imaging Brain Function with EEG: Advanced Temporal and Spatial Analysis of Electroencephalographic Signals*, New York: Springer.

Friston, K. J. (2005) "Models of brain function in neuroimaging," *Annual Review of Psychology*, 56: 57–87.

Friston, K. J., Price, C. J., Fletcher, P., Moore, C., Frackowiak, R. S. J., and Dolan, R. J. (1996) "The trouble with cognitive subtraction," *Neuroimage*, 4(2): 97–104.

Garvey, C. J. and Hanlon, R. (2002) "Computed tomography in clinical practice," *BMJ: British Medical Journal*, 324(7345): 1077.

Gazzaniga, M. and LeDoux, J. (1978) *The Integrated Mind*, New York: Plenum.

Ghadiri, A., Habermacher, A., and Peters, T. (2012) "Neuroleadership: The backdrop," in *Neuroleadership: A Journey Through the Brain for Business Leaders*, 1–15, Berlin: Springer.
Glimcher, P. W. and Rustichini, A. (2004) "Neuroeconomics: The consilience of brain and decision," *Science*, 306(5695): 447–452.
Glöckner, A. and Herbold, A. K. (2011) "An eye tracking study on information processing in risky decisions: Evidence for compensatory strategies based on automatic processes," *Journal of Behavioral Decision Making*, 24(1): 71–98.
Greene, J. and Cohen, J. (2004) "For the law, neuroscience changes nothing and everything," *Philosophical Transactions of the Royal Society*, 359(1451): 1775–1785.
Grossman, R. I. and Bernat, J. L. (2004) "Incidental research imaging findings Pandora's costly box," *Neurology*, 62(6): 849–850.
Gul, F. and Pesendorfer, W. (2008) "The case for mindless economics," in Caplin, A. and Schotter, A. (eds), *The Foundations of Positive and Normative Economics*, 3–39, Oxford: Oxford University Press.
Gulyas, B., Halldin, C., Sandell, J., Karlsson, P., Sóvágó, J., Kárpáti, E., and Farde, L. (2002) "PET studies on the brain uptake and regional distribution of [11C] vinpocetine in human subjects," *Acta Neurologica Scandinavica*, 106(6): 325–332.
Hämäläinen, M., Hari, R., Ilmoniemi, R. J., Knuutila, J., and Lounasmaa, O. V. (1993) "Magnetoencephalography: Theory, instrumentation, and applications to noninvasive studies of the working human brain," *Reviews of Modern Physics*, 65(2): 413.
Heinrichs, M., von Dawans, B., and Domes, G. (2009) "Oxytocin, vasopressin, and human social behavior," *Frontiers in Neuroendocrinology*, 30(4): 548–557.
Hines, T. (1987) "Left brain/right brain mythology and implications for management and training," *Academy of Management Review*, 12: 600–606.
Hounsfield, G. N. (1973) "Computerized transverse axial scanning (tomography): Part 1. Description of system," *British Journal of Radiology*, 46(552): 1016–1022.
Humm, J. L., Rosenfeld, A. and Del Guerra, A. (2003) "From PET detectors to PET scanners," *European Journal of Nuclear Medicine and Molecular Imaging*, 30(11): 1574–1597.
Huy, Q. N. (2002) "Emotional balancing of organizational continuity and radical change: The contribution of middle managers," *Administrative Science Quarterly*, 47(1): 31–69.
Illes, J. (ed.) (2006) *Neuroethics: Defining the Issues in Theory, Practice and Policy*, New York: Oxford University Press.
Illes, J. and Racine, E. (2005) "Imaging or imagining? A neuroethics challenge informed by genetics," *The American Journal of Bioethics*, 5(2): 5–18.
Illes, J., Moser, M. A., McCormick, J. B., Racine, E., Blakeslee, S., Caplan, A., and Weiss, S. (2009) "Neurotalk: improving the communication of neuroscience research," *Nature Reviews Neuroscience*, 11(1): 61–69.
Illes, J., Rosen, A. C., Huang, L., Goldstein, R. A., Raffin, T. A., Swan, G., and Atlas, S. W. (2004) "Ethical consideration of incidental findings on adult brain MRI in research," *Neurology*, 62(6): 888–890.
Jones, O. D. and Shen, F. X. (2012) "Law and neuroscience in the United States," in Spranger, T. M. (ed.) *International Neurolaw: A Comparative Analysis*, 349–380, Berlin: Springer.
Kable, J. W. (2011) "The cognitive neuroscience toolkit for the neuroeconomist," *Journal of Neuroscience, Psychology, and Economics*, 4(2): 63–84.
Kato, M., Taniwaki, T. and Kuwabara, Y. (2000) "The advantages and limitations of brain function analyses by PET," *Clinical Neurology*, 40(12): 1274.
Katzman, G. L., Dagher, A. P., and Patronas, N. J. (1999) "Incidental findings on brain magnetic resonance imaging from 1000 asymptomatic volunteers," *JAMA: the Journal of the American Medical Association*, 282(1): 36–39.
King-Casas, B., Tomlin, D., Anen, C., Camerer, C. F., Quartz, S. R., and Montague, P. R.

(2005) "Getting to know you: Reputation and trust in a two-person economic exchange," *Science*, 308(5718): 78–83.

Kirschen, M. P., Jaworska, A., and Illes, J. (2006) "Subjects' expectations in neuroimaging research," *Journal of Magnetic Resonance Imaging*, 23(2): 205–209.

Knoch, D., Gianotti, L. R., Baumgartner, T. and Fehr, E. (2010) "A neural marker of costly punishment behavior," *Psychological Science*, 21(3): 337–342.

Kolb, B. and Whishaw, I. Q. (2009) *Fundamentals of Human Neuropsychology*, New York: Macmillan.

Kosfeld, M., Heinrichs, M., Zak, P. J., Fischbacher, U., and Fehr, E. (2005) "Oxytocin increases trust in humans," *Nature*, 435(7042): 673–676.

Kovalchik, S. and Allman, J. (2006) "Measuring reversal learning: Introducing the Variable Iowa Gambling Task in a study of young and old normals," *Cognition & Emotion*, 20(5): 714–728.

Kristeva, R., Keller, E., Deecke, L., and Kornhuber, H. H. (1979) "Cerebral potentials preceding unilateral and simultaneous bilateral finger movements," *Electroencephalography and Clinical Neurophysiology*, 47(2): 229–238.

Kwong, K. K., Belliveau, J. W., Chesler, D. A., Goldberg, I. E., Weisskoff, R. M., Poncelet, B. P., and Turner, R. (1992) "Dynamic magnetic resonance imaging of human brain activity during primary sensory stimulation," *Proceedings of the National Academy of Sciences*, 89(12): 5675–5679.

Lauterbur, P. C. (1973) "Image formation by induced local interactions: examples employing nuclear magnetic resonance," *Nature*, 242(5394): 190–191.

Le Bihan, D. (1996) "Functional MRI of the brain principles, applications and limitations," *Journal of Neuroradiology*, 23(1): 1–5.

Le Bihan, D. (2003) "Looking into the functional architecture of the brain with diffusion MRI," *Nature Reviews Neuroscience*, 4(6): 469–480.

Le Bihan, D., Urayama, S. I., Aso, T., Hanakawa, T., and Fukuyama, H. (2006) "Direct and fast detection of neuronal activation in the human brain with diffusion MRI," *Proceedings of the National Academy of Sciences*, 103(21): 8263–8268.

Lebedev, M. A. and Nicolelis, M. A. (2006) "Brain–machine interfaces: Past, present and future," *TRENDS in Neurosciences*, 29(9): 536–546.

Lee, N., Broderick, A. J., and Chamberlain, L. (2007) "What is 'Neuromarketing?' A discussion and agenda for future research," *International Journal Of Psychophysiology*, 63(2): 199–204.

Legrenzi, P. and Umiltà, C. (2011) *Neuromania: On the Limits of Brain Science*, New York: Oxford University Press.

Levinthal, D. A. and March, J. G. (1993) "The myopia of learning," *Strategic Management Journal*, 14(S2): 95–112.

Levinthal, D. and Rerup, C. (2006) "Crossing an apparent chasm: Bridging mindful and less-mindful perspectives on organizational learning," *Organization Science*, 17(4): 502–513.

Lindebaum, D. and Zundel, M. (2013) "Not quite a revolution: Scrutinizing organizational neuroscience in leadership studies," *Human Relations*, 66(6): 857–877.

Liu, J. Z., Zhang, L., Brown, R. W., and Yue, G. H. (2004) "Reproducibility of fMRI at 1.5 T in a strictly controlled motor task," *Magnetic Resonance in Medicine*, 52(4): 751–760.

Logothetis, N. K. (2008) "What we can do and what we cannot do with MRI," *Nature*, 453(7197): 869–878.

Logothetis, N. K. and Wandell, B. A. (2004) "Interpreting the BOLD signal," *Annual Review of Physiology*, 66: 735–769.

Logothetis, N. K., Pauls, J., Augath, M., Trinath, T., and Oeltermann, A. (2001) "Neurophysiological investigation of the basis of the fMRI signal," *Nature*, 412(6843):

150–157.

Luck, S. J. (2005) “Ten simple rules for designing ERP experiments,” in T.C. Handy (ed.), *Event-Related Potentials: A Methods Handbook*, 16–32, Cambridge, MA: MIT Press.

Magistretti, P. J., Pellerin, L., Rothman, D. L., and Shulman, R. G. (1999) “Energy on demand,” *Science*, 283(5401): 496–497.

Malonek, D., Dirnagl, U., Lindauer, U., Yamada, K., Kanno, I., and Grinvald, A. (1997) “Vascular imprints of neuronal activity: Relationships between the dynamics of cortical blood flow, oxygenation, and volume changes following sensory stimulation,” *Proceedings of the National Academy of Sciences*, 94(26): 14826–14831.

March, J. G. and Simon, H. A. (1958) *Organizations*, Oxford: Wiley.

McCabe, D. P. and Castel, A. D. (2008) “Seeing is believing: The effect of brain images on judgments of scientific reasoning,” *Cognition*, 107(1): 343–352.

McCabe, K., Houser, D., Ryan, L., Smith, V., and Trouard, T. (2001) “A functional imaging study of cooperation in two-person reciprocal exchange,” *Proceedings of the National Academy of Sciences*, 98(20): 11832–11835.

Menon, R. S. and Kim, S. G. (1999) “Spatial and temporal limits in cognitive neuroimaging with fMRI,” *TRENDS in Cognitive Sciences*, 3(6): 207–216.

Menon, R. S., Gati, J. S., Goodyear, B. G., Luknowsky, D. C. and Thomas, C. G. (1998) “Spatial and temporal resolution of functional magnetic resonance imaging,” *Biochemistry and Cell Biology*, 76(2-3): 560–571.

Minoshima, S., Koeppe, R. A., Frey, K. A. and Kuhl, D. E. (1994) “Anatomic standardization: linear scaling and nonlinear warping of functional brain images,” *Journal of Nuclear Medicine*, 35(9): 1528–1537.

Mintzberg, H, (1976) “Planning on the left and managing on the right,” *Harvard Business Review*, 54(4): 49–58.

Mintzberg, H. (1994) “The fall and rise of strategic planning,” *Harvard Business Review*, 72(1): 107–114.

Moorman, R. H. (1991) “Relationship between organizational justice and organizational citizenship behaviors. Do fairness perception influence employee citizenship?,” *Journal of Applied Psychology*, 76(6): 845–855.

Murray, E. A. and Baxter, M. G. (2006) “Cognitive neuroscience and nonhuman primates: Lesion studies,” in Senior, C. E., Russell, T. E., and Gazzaniga, M. S. (eds), *Methods in Mind*, 43–69. Cambrdige, MA: MIT Press.

Natterer, F. and Ritman, E. L. (2002) “Past and future directions in x ray computed tomography (CT),” *International Journal of Imaging Systems and Technology*, 12(4): 175–187.

Newell, A. and Simon, H. A. (1972) *Human Problem Solving*, Vol. 14, Englewood Cliffs, NJ: Prentice-Hall.

Nicolaou, N. and Shane, S. (2009) “Born entrepreneurs? The genetic foundations of entrepreneurship,” *Journal of Business Venturing*, 23: 1–22.

Niedermeyer, E. and Lopes da Silva, F.H. (eds) (1999) *Electroencephalography: Basic Principles, Clinical Applications, and Related Fields*, 4th edn, Baltimore: Williams & Wilkins.

Nonaka, I. and Toyama, R. (2007) “Strategic management as distributed practical wisdom (phronesis),” *Industrial and Corporate Change*, 16(3): 371–394.

Nunez, P. L. (1995) *Neocortical Dynamics and Human EEG Rhythms*, New York: Oxford University Press.

Ogawa, S., Lee, T. M., Kay, A. R., and Tank, D. W. (1990) “Brain magnetic resonance imaging with contrast dependent on blood oxygenation,” *Proceedings of the National Academy of Sciences*, 87(24): 9868–9872.

Ogawa, S., Tank, D. W., Menon, R., Ellermann, J. M., Kim, S. G., Merkle, H., and Ugurbil,

K. (1992) "Intrinsic signal changes accompanying sensory stimulation: functional brain mapping with magnetic resonance imaging," *Proceedings of the National Academy of Sciences*, 89(13): 5951–5955.

Page, M. (2006) "What can't functional neuroimaging tell the cognitive psychologist?," *Cortex*, 42(3): 428–443.

Pascual-Leone, A., Walsh, V., and Rothwell, J. (2000) "Transcranial magnetic stimulation in cognitive neuroscience–virtual lesion, chronometry, and functional connectivity," *Current Opinion in Neurobiology*, 10(2): 232–237.

Pascual-Marqui, R. D., Michel, C. M., and Lehmann, D. (1994) "Low resolution electromagnetic tomography: A new method for localizing electrical activity in the brain," *International Journal of Psychophysiology*, 18(1): 49–65.

Payne, B. (1957) "Steps in long-range planning," *Harvard Business Review*, 35(2): 95–101.

Pelizzari, C. A., Chen, G. T., Spelbring, D. R., Weichselbaum, R. R., and Chen, C. T. (1989) "Accurate three-dimensional registration of CT, PET, and/or MR images of the brain," *Journal of Computer Assisted Tomography*, 13(1): 20–26.

Petersen, S. E., Fox, P. T., Posner, M. I., Mintun, M., and Raichle, M. E. (1988) "Positron emission tomographic studies of the cortical anatomy of single- word processing," *Nature*, 331(6157): 585–589.

Petrovic, P., Kalisch, R., Singer, T., and Dolan, R. J. (2008) "Oxytocin attenuates affective evaluations of conditioned faces and amygdala activity," *The Journal of Neuroscience*, 28(26): 6607–6615.

Phelps, M. E. and Mazziotta, J. C. (1985) "Positron emission tomography: human brain function and biochemistry," *Science*, 228(4701): 799–809.

Pieters, R. (2008) "A review of eye-tracking research in marketing," in Naresh, K. M. (ed.), *Review of Marketing Research*, Vol. 4, 123–214, Bingley, UK: Emerald Group Publishing Limited.

Poldrack, R. A. (2006) "Can cognitive processes be inferred from neuroimaging data?," *TRENDS in Cognitive Sciences*, 10(2): 59–63.

Poldrack, R. A. (2012) "The future of fMRI in cognitive neuroscience," *Neuroimage*, 62(2): 1216–1220.

Poldrack, R. A., Kittur, A., Kalar, D., Miller, E., Seppa, C., Gil, Y., and Bilder, R. M. (2011) "The cognitive atlas: Toward a knowledge foundation for cognitive neuroscience," *Frontiers in Neuroinformatics*, 5: 5–17.

Powell, T. C. (2011) "Neurostrategy," *Strategic Management Journal*, 32(13): 1484–1499.

Powell, T. C., Lovallo, D., and Fox, C. R. (2011) "Behavioral strategy," *Strategic Management Journal*, 32(13): 1369–1386.

Price, C. J. and Friston, K. J. (1997) "Cognitive conjunction: A new approach to brain activation experiments," *Neuroimage*, 5(4): 261–270.

Purcell, E. M., Torrey, H. C., and Pound, R. V. (1946) "Resonance absorption by nuclear magnetic moments in a solid," *Physical Review*, 69(1–2): 37.

Racine, E., Bar-Ilan, O., and Illes, J. (2005) "fMRI in the public eye," *Nature Reviews Neuroscience*, 6(2): 159–164.

Racine, E., Waldman, S., Rosenberg, J., and Illes, J. (2010) "Contemporary neuroscience in the media," *Social Science & Medicine*, 71(4): 725–733.

Raichle, M. E. (1979) "Quantitative in vivo autoradiography with positron emission tomography," *Brain Research Reviews*, 1(1): 47–68.

Raichle, M. E. (2003) "Functional brain imaging and human brain function," *The Journal of Neuroscience*, 23(10): 3959–3962.

Raichle, M. E. (2009a) "A paradigm shift in functional brain imaging," *The Journal of Neuroscience*, 29(41): 12729–12734.

Raichle, M. E. (2009b) "A brief history of human brain mapping," *TRENDS in Neurosciences*, 32(2): 118–126.

Raichle, M. E. and Snyder, A. Z. (2007) "A default mode of brain function: A brief history of an evolving idea," *Neuroimage*, 37(4): 1083–1090.

Raichle, M. E., Martin, W. R., Herscovitch, P., Mintun, M. A., and Markham, J. (1983) "Brain blood flow measured with intravenous H_2(15)O. II. Implementation and validation," *Journal of Nuclear Medicine*, 24(9): 790–798.

Raz, A. and Buhle, J. (2006) "Typologies of attentional networks," *Nature Reviews Neuroscience*, 7(5): 367–379.

Robey, D. and Taggart, W. (1981) "Measuring managers' minds: The assessment of style in human information processing," *Academy of Management Review*, 6(3): 375–383.

Robey, D. and Taggart, W. (1982) "Human information processing in information and decision support systems," *MIS Quarterly*, 6(2): 61–73.

Rogers, B. P., Morgan, V. L., Newton, A. T., and Gore, J. C. (2007) "Assessing functional connectivity in the human brain by fMRI," *Magnetic Resonance Imaging*, 25(10): 1347–1357.

Rogers, L. F. (2003) "Helical CT: The revolution in imaging," *American Journal of Roentgenology*, 180(4): 883–883.

Rolls, E. T. (2012) *Neuroculture: On the Implications of Brain Science*, New York: Oxford University Press.

Rorden, C. and Karnath, H. O. (2004) "Using human brain lesions to infer function: A relic from a past era in the fMRI age?," *Nature Reviews Neuroscience*, 5(10): 812–819.

Rubinov, M. and Sporns, O. (2010) "Complex network measures of brain connectivity: Uses and interpretations," *Neuroimage*, 52(3): 1059–1069.

Sack, A. T. and Linden, D. E. (2003) "Combining transcranial magnetic stimulation and functional imaging in cognitive brain research: Possibilities and limitations," *Brain Research Reviews*, 43(1): 41–56.

Sanfey, A. G., Rilling, J. K., Aronson, J. A., Nystrom, L. E., and Cohen, J. D. (2003) "The neural basis of economic decision-making in the ultimatum game," *Science*, 300(5626): 1755–1758.

Sartori, G. and Umiltà, C. (2000) "How to avoid the fallacies of cognitive subtraction in brain imaging," *Brain and Language*, 74(2): 191–212.

Schulte-Mecklenbeck, M., Kühberger, A., and Ranyard, R. (2011) "The role of process data in the development and testing of process models of judgment and decision making," *Judgment and Decision Making*, 6(8): 733–739.

Scott Jr., W. E. (1966) "Activation theory and task design," *Organizational Behavior and Human Performance*, 1(1): 3-30.

Senior, C. E., Russell, T. E., and Gazzaniga, M. S. (2006) *Methods in Mind*, Cambridge, MA: MIT Press.

Senior, C., Lee, N., and Butler, M. (2011) "PERSPECTIVE – Organizational Cognitive Neuroscience," *Organization Science*, 22(3): 804–815.

Shallice, T. (1988) *From Neuropsychology to Mental Structure*, New York: Cambridge University Press.

Shallice, T. (2003) "Functional imaging and neuropsychology findings: How can they be linked?," *Neuroimage*, 20(S1): 46–54.

Siebner, H. and Rothwell, J. (2003) "Transcranial magnetic stimulation: New insights into representational cortical plasticity," *Experimental Brain Research*, 148(1): 1–16.

Simons, R. (1991) "Strategic orientation and top management attention to control systems," *Strategic Management Journal*, 12(1): 49–62.

Simpson, D. (2005) "Phrenology and the neurosciences: Contributions of FJ Gall and JG Spurzheim," *ANZ Journal of Surgery*, 75(6): 475–482.

Smith, K., Dickhaut, J., McCabe, K., and Pardo, J. V. (2002) "Neuronal substrates for choice under ambiguity, risk, gains, and losses," *Management Science*, 48(6): 711–718.

Song, A. W., Huettel, S. A., and McCarthy, G. (2006) "Functional neuroimaging: Basic principles of functional MRI," in Cabeza, R. and Kingstone, A. (eds) *Handbook of Functional Neuroimaging of Cognition*, 21–52, Cambridge, MA: MIT Press.

Squires, K. C., Wickens, C., Squires, N. K., and Donchin, E. (1976) "The effect of stimulus sequence on the waveform of the cortical event-related potential," *Science*, 193(4258): 1142–1146.

Staw, B. M. (1981) "The escalation of commitment to a course of action," *Academy of Management Review*, 6(4): 577–587.

Stewart, L. and Walsh, V. (2006) "Transcranial magnetic stimulation in human cognition," in Senior, C. E., Russell, T. E., and Gazzaniga, M. S. (eds), *Methods in Mind*, 1–27, Cambridge, MA: MIT Press.

Stöcker, T., Schneider, F., Klein, M., Habel, U., Kellermann, T., Zilles, K., and Shah, N. J. (2005) "Automated quality assurance routines for fMRI data applied to a multicenter study," *Human Brain Mapping*, 25(2): 237–246.

Tang, Y. Y. and Posner, M. I. (2009). "Attention training and attention state training," *Trends in Cognitive Sciences*, 13(5): 222–227.

Taggart, W., Robey, D., and Kroeck, K. (1985) "Managerial decision styles and cerebral dominance: An empirical study," *Journal of Management Studies*, 22(2): 175–192.

Ter-Pogossian, M. M. and Herscovitch, P. (1985) "Radioactive oxygen-15 in the study of cerebral blood flow, blood volume, and oxygen metabolism," *Seminars in Nuclear Medicine*, 15(4): 377–394.

Tilyou, S. M. (1991) "The evolution of positron emission tomography," *Journal of Nuclear Medicine*, 32(4): 15N–26N.

Toga, A. W. and Mazziotta, J. C. (eds) (2002) *Brain Mapping: The Methods*, Vol. 1, San Diego: Elsevier.

Turkington, T. G. (2001) "Introduction to PET instrumentation," *Journal of Nuclear Medicine Technology*, 29(1): 4–11.

Tyner, F. S., Knott, J. R., and Mayer Jr, W. B. (1989) *Fundamentals of EEG Technology: Clinical Correlates*, Philadelphia: Lippincott Williams and Wilkins.

Uludag, K., Dubowitz, D. J., Yoder, E. J., Restom, K., Liu, T. T., and Buxton, R. B. (2004) "Coupling of cerebral blood flow and oxygen consumption during physiological activation and deactivation measured with fMRI," *Neuroimage*, 23(1): 148–155.

Uttal, W. R. (2001) *The New Phrenology: The Limits of Localizing Cognitive Processes in the Brain*. Cambridge, MA: MIT Press.

Volz, K. G. and von Cramon, D. Y. (2006) "What neuroscience can tell about intuitive processes in the context of perceptual discovery," *Journal of Cognitive Neuroscience*, 18(12): 2077–2087.

Vrba, J. and Robinson, S. E. (2002) "SQUID sensor array configurations for magnetoencephalography applications," *Superconductor Science and Technology*, 15(9): R51.

Vul, E., Harris, C., Winkielman, P., and Pashler, H. (2009) "Puzzlingly high correlations in fMRI studies of emotion, personality, and social cognition," *Perspectives on Psychological Science*, 4(3): 274–290.

Waldman, D. A., Balthazard, P. A., and Peterson, S. J. (2011) "Leadership and neuroscience: Can we revolutionize the way that inspirational leaders are identified and developed?," *Academy of Management Perspectives*, 25(1): 60–74.

Walsh, V. and Cowey, A. (2000) "Transcranial magnetic stimulation and cognitive neuroscience," *Nature Reviews Neuroscience*, 1(1): 73–80.

Weick, K. E. and Sutcliffe, K. M. (2006) "Mindfulness and the quality of organizational attention," *Organization Science*, 17(4): 514–524.

Weisberg, D. S., Keil, F. C., Goodstein, J., Rawson, E., and Gray, J. R. (2008) "The seductive allure of neuroscience explanations," *Journal of Cognitive Neuroscience*, 20(3): 470–477.

Willingham, D. T. and Dunn, E. W. (2003) "What neuroimaging and brain localization can do, cannot do and should not do for social psychology," *Journal of Personality and Social Psychology*, 85(4): 662.

Yacoub, E., Uludag, K., Ugurbil, K., and Harel, N. (2008) "Decreases in ADC observed in tissue areas during activation in the cat visual cortex at 9.4 T using high diffusion sensitization," *Magnetic Resonance Imaging*, 26(7): 889–896.