Methodological Challenges and Advances in Managerial and Organizational Cognition

Neuroscience Methods: A Framework for Managerial and Organizational Cognition

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CHAPTER

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ABSTRACT

In light of the growing interest in neuroscience within the managerial and organizational cognition (MOC) scholarly domain at large, this chapter advances current knowledge on core neuroscience methods. It does so by building on the theoretical analysis put forward by Healey and Hodgkinson (2014, 2015), and by offering a thorough – yet accessible – methodological framework for a better understanding of key cognitive and social neuroscience methods. Classifying neuroscience methods based on their degree of resolution, functionality, and anatomical focus, the chapter outlines their features, practicalities, advantages and disadvantages. Specifically, it focuses on functional magnetic resonance

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imaging, electroencephalography, magnetoencephalography, heart rate variability, and skin conductance response. Equipped with knowledge of these methods, researchers will be able to further their understanding of the potential synergies between management and neuroscience, to better appreciate and evaluate the value of neuroscience methods, and to look at new ways to frame old and new research questions in MOC. The chapter also builds bridges between researchers and practitioners by rebalancing the hype and hopes surrounding the use of neuroscience in management theory and practice.

Keywords: Affect and cognition; behavioral sciences; managerial and organizational cognition; neuroscience methods; organizational neuroscience

The notion that cognitive capacities affect managerial understanding, perceptions of, and actions toward organizational environments is undeniably rooted in Herbert Simon's research agenda (Simon, 1955; March & Simon, 1958; for a summary, see Porac, 2014; for a perspective on the Carnegie School, see Gavetti, Levinthal, & Ocasio 2007). From those early seeds, research in managerial and organizational cognition (MOC) has flourished, incorporating a wealth of insights from the cognitive and behavioral sciences, giving rise to a scholarly domain that investigates the cognitive systems and architectures sustaining organizational life (see the Academy of Management MOC Division's Statement, https://moc.aom.org).

In the past few decades, MOC has grown vibrantly and produced a number of seminal contributions (e.g., Gavetti & Levinthal, 2000; Gavetti & Rivkin, 2007; Hodgkinson & Healey, 2008, 2011; Narayanan, Zane, & Kemmerer, 2011; Porac & Thomas, 2002). The development of refined theoretical apparatuses – from behavioral strategy (Hodgkinson, 2015; Powell, Lovallo, & Fox, 2011) to the microfoundations movement (Felin, Foss, & Ployhart, 2015; Gavetti, 2005), among others – have advanced understanding of the ways in which individuals' cognitive processes and their interactions, shape organizations.

Together with these theoretical advances, a reflection on the underlying methods has also become an integral part of the MOC research agenda. Notably, this demand has led to the influential volume edited by Huff (1990), who put forward a fundamental methodological framework and encouraged novel inquiries aimed at capturing the mental processes of decision making. One remarkable example, Hodgkinson and Johnson (1994) showed that it is possible to study the competitive environment by focusing on individuals' mental processes. By using a cognitive taxonomic interview approach, Hodgkinson and Johnson (1994) were able to map the mental models of managers in retailing chains and link such models to both intra- and inter-organizational competitive structures. More recently, Hodgkinson and Healey (2011) have further built on this achievement and inspired the field to focus further on the investigation of the psychological foundations of management. By doing so, they have also brought forward the potential of social cognitive neuroscience to advance current scholarly knowledge in management.

This initiative has joined other insightful exchanges focused on neuroscience across several fields interfacing with MOC, spanning from strategic management (e.g., Healey & Hodgkinson, 2014; Laureiro-Martínez, Venkatraman, Cappa, Zollo, & Brusoni, 2015; Powell, 2011) and neuroentrepreneurship (e.g., de Holan, 2014), to organizational behavior (e.g., Becker, Cropanzano, & Sanfey, 2011; Senior, Lee, & Butler, 2011). Correspondingly, some initial empirical outputs based on neuroscience methods have also begun to appear in the broader managerial literature (e.g., Bagozzi, Verbeke, Dietvorst, Belschak, van den Berg, & Rietdijk, 2013; Laureiro-Martinez, Brusoni, Canessa, & Zollo, 2015; Waldman, Wang, Hannah, & Balthazard, 2017).

Yet, I also recognize that neuroscience is currently not widely spread as a core research area within many business schools and management departments. Thus, as is often the case for emerging and novel research sectors (for an analysis, see Hodgkinson & Healey, 2008), the growing momentum behind the use of neuroscience has frequently been encountered with skepticism, communication gaps, fears of complexity, and so forth (e.g., Waldman, 2013). Moreover, trained neuroscientists working in business schools' are relatively rare, making the required interdisciplinary knowledge transfer to and from the management community more challenging than in other research areas, such as economics and psychology.

As a result, there has been scant attention thus far on why and how the neuroscience methodology can help to advance the existing MOC literature, and the adequacy, challenges, and advancements of neuroscience methods to MOC are yet to be fully explored.

In the chapter I aim to bridge this substantial gap by focusing specifically on the way in which distinctive features of key social and cognitive neuroscience (hereafter, neuroscience) methods can expand knowledge on how "organization members model reality and how such models interact with behaviors" – which are the defining features of the MOC domain (see the Academy of Management MOC Division's Statement, https://moc.aom.org).

My aim therefore is twofold: First, guided by the theoretical works of Healey and Hodgkinson (2014, 2015), I present a rationale to support the advancement of MOC scholarship using neuroscience methods. Second, I put forward a systematic explanation of such methods, offering a much needed procedural, yet still accessible, blueprint for each of the methods reviewed, highlighting their key features, advantages, and disadvantages. I realize that this coverage might be perceived as somehow more technically oriented than other more established methodological accounts in MOC. Yet, I also believe that such technical coverage is needed to promote a fuller understanding of what neuroscience methods may ultimately offer MOC to enable this interdisciplinary partnership. Using supporting examples throughout, I highlight various research avenues presented by the diversity and complexity of the neuroscience approaches currently available to MOC researchers.

All in all, the chapter brings forward a timely apparatus for fostering the development of MOC investigations using (and/or looking at) neuroscience and the anticipation of possible misunderstandings and/or overexcitement on what the related methods are and can effectively achieve (cf., Ashkanasy, Becker, & Waldman, 2014; Lindebaum & Jordan, 2014). In conclusion, I present my overall reflections on how best to advance the field of MOC by enabling researchers interested in using neuroscience methods to fully embrace calls for multidisciplinary and multilevel scholarship advocated both in mainstream neuroscience (e.g., Gazzaniga, 2004) and the most recent MOC scholarship (e.g., Huff, Milliken, Hodgkinson, Galavan, & Sund, 2016).

MOC and Neuroscience: Between theory and Methods

The guiding theoretical narrative of the present chapter is the overarching framework put forward by Hodgkinson and Healey (2011) and Healey and Hodgkinson (2014, 2015; see also the introductory chapter of this book) on the use of neuroscience in MOC.

In their seminal article Hodgkinson and Healey (2011) reveal how, notwithstanding several initiatives toward incorporating a fuller behavioral and cognitive perspective, management theory and research have minimized the exploration of key mental processes (i.e., affective and non-conscious processes). Significantly, the authors go further and show that integrating management theory with social cognitive neuroscience evidence can meaningfully address this need and advance our understanding of how the capacities of both individuals and teams (see also Healey, Vuori, & Hodgkinson, 2015) can shape firms' dynamic capabilities (Hodgkinson & Healey, 2011).

In parallel with this call, management research at large has begun to uncover the potential of neuroscience in its domains, giving rise to insightful exchanges and debates toward a more inclusive disciplinary understanding of neuroscience in management, a new research field known as organizational (cognitive) neuroscience (e.g., for differences between organizational and organizational cognitive neuroscience, see Becker et al., 2011 and Senior et al., 2011, respectively; for an inclusive definition of the field, see Massaro & Pecchia, in press). Correspondingly, the encounter of the managerial scholarly community with neuroscience has brought forward concerns related to reductionist approaches (e.g., Ashkanasy et al., 2014; Lindebaum & Jordan, 2014).

In response to such concerns, Healey and Hodgkinson (2014, 2015) have proposed a comprehensive socially situated perspective. This perspective indicates how neuroscience findings can advance knowledge of organizational phenomena through interaction with other social and contextual organizational features. This argument is in line with the understanding of MOC as a domain devoted to investigating individual, relational, and collective cognition in organizational contexts. That is, cognition is an "umbrella" construct (for a nuanced analysis, see Hodgkinson & Healey, 2008) and the nervous system of organizational actors is a part of the overall cognitive organizational architecture. Healey and Hodgkinson (2015) compare this socially situated perspective with an intra-individual view, the latter focusing on the role of the brain in MOC (see Figure 1 in Healey & Hodgkinson, 2015, p. 63). They argue that MOC cannot be entirely located in the brain because the brain is just one among several elements that modulates the complexity of cognition in organizations.

Following this call, I situate the use of neuroscience methods in MOC at the intersection between the intra-personal and the inter-personal socially situated viewpoints proposed by Healey and Hodgkinson (2015, as depicted in Figure 1.) Indeed, these authors further suggest that meaningful insights from neuroscience for MOC can be achieved by using multiple approaches (see for a related discussion Sharp, Monterosso, & Montague, 2012). Yet, because very little has been explored utilizing neuroscience methodology per se thus far, the realization of this call still remains a steep learning process for the MOC community.

To address this shortfall, I take inspiration from Huff's (1990) comprehensive overview of research methods in MOC. As Ginsberg (1992) explains, Huff's contribution suggests that interdisciplinary thinking can help to move beyond and above traditional knowledge: "(...) mapping is most attractive as a method for studying topics that are intrinsically cognitive for explaining variance that is *unexplained by other methods*" (italics added; Huff & Fletcher, 1990, p. 142). In the following sections, I mirror this insight and review the distinctive approach to capturing MOC provided by neuroscience methods. By extending earlier insights (Massaro, 2016), I present an enhanced and detailed interdisciplinary overview of several neuroscience

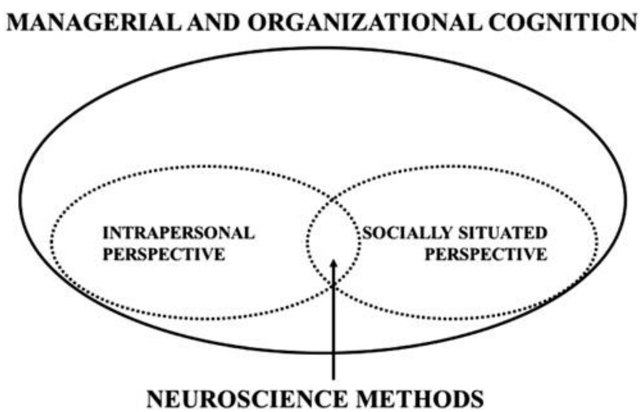

Figure 1: Integrating MOC and Neuroscience Theory and Methods. This Figure Follows the Framework by Healey and Hodgkinson (2014, 2015), Which Contrasts the Intrapersonal and Socially Situated Perspectives on Neuroscience in Management. Neuroscience Methods Work at the Intersection of these Perspectives.

methods. Indeed, I embrace recent prompts to appreciate neuroscience in its entirety (Massaro & Pecchia, in press), and understand neuroscience as a research avenue grounded on a broader theoretical perspective (Healey & Hodgkinson, 2014).

Thus, I discuss neuroscience methods as a set of tools able to inform knowledge on the mental processes of decision making beyond what can be explained currently by other approaches. Indeed, MOC researchers have often limited their efforts to the investigation of psychometric, self-report, and other observational data – notwithstanding construct validity issues (for a review, see Hodgkinson & Healey, 2008) – while lacking tools for probing more deeply into the unobservable mechanisms underpinning dynamic processes in play (Godfrey & Hill, 1995).

As we shall see, each of the neuroscience methods reviewed here allows researchers to "look under the hood" of cognition, effectively providing measurable, objective, and possibly generalizable neuro-physiological information on mental processes. As such, these methods can inform the findings of conventional studies, possibly refining or strengthening existing knowledge. Likewise, a neuroscience approach to MOC research promises to provide information that differs from that which can be captured by behavioral methods, allowing an entry point to mental constructs seized from both implicit, unobservable, and explicit, observable, awareness (Becker & Menges, 2013).

A Methodological Framework: Three Ways of Looking at Neuroscience Methods

In encountering neuroscience methods, several taxonomies are available across different literatures. Here, I classify neuroscience methods in three ways: by resolution, by functionality, and by sites of inference. Readers should note that, while such classifications are presented here in the context of MOC, these classifications and methods are applicable to any other management domain using neuroscience, from neurostrategy to organizational neuroscience, and so forth.

Resolution. Traditionally in neuroscience, methods are classified according to a matrix based on each technique's distinct resolutions. Distinct resolutions indicate the ability of a given technique to discriminate between points in space (i.e., spatial resolution) and time (i.e., temporal resolution) (e.g., Menon, Gati, Goodyear, Luknowsky, & Thomas, 1998).

Such an approach is highly valuable since it allows charting the techniques according to their ability to provide accurate information either on the spatial location of a neural event, or on the time in which it unfolds. This conceptualization is indeed useful to couple the needs of an experimental design or of a research question with the intrinsic technological capabilities of each method, as I shall explain below. Thus, for instance, if a researcher seeks to acquire information on "deep" brain regions engaged while a participant is undertaking a cognitive task, high spatial-resolution techniques, such as fMRI, are generally more preferable than less specific ones, such as EEG. Conversely, if a researcher is interested in understanding the precise timing of a neural event, then EEG typically offers more precise temporal information than fMRI.

Functionality. Recently, Massaro (2016) suggested that in management and organizational studies, the classification of neuroscience methods by resolution should be coupled with insights on their functionality provided by Kable (2011). That is, it is possible to conceive a classification of neuroscience methods on the basis of their underlying testing rationale. Thus, methods can be classified as association, necessity, or sufficiency tests.

Association tests are those methods that involve the manipulation of a mental state, the aligned recording of the neural activity, and a correlation analysis between the two. In contrast, necessity tests are those that imply a disruption of the neural activity to show the role of a specific mental function. Sufficiency tests are those augmenting (or reducing) neural activity and investigating if intervention results in a specific behavior or mental state. Common necessity and sufficiency methods include lesion studies or transcranial magnetic stimulation, which can assess the causality between experimental interventions and neural states.

Sites of inference. While management scholars have already benefited from the classifications above, the overall approach toward neuroscience has tended to study the brain alone (for a critique see Massaro & Pecchia, in press). In turn, this parceled and focalized understanding has led to a prolonged debate on what neuroscience investigations in management should encompass (e.g., Butler, Lee, & Senior, 2017), as well as provocative promptings on whether neurons and brains can "manage" organizations (for an analysis see Healey, Hodgkinson, & Massaro, 2016).

Moving this conversation toward a more inclusive and perhaps accessible understanding of neuroscience, calls for a complementary and more overarching classification of the methods suitable for use in MOC research. This third classification, is grounded on a given method's functional-anatomic sites of inference, namely the central (CNS) and peripheral nervous system (PNS). While it is not the aim of this chapter to provide a full anatomical coverage of the nervous system, I believe it is useful to summarize some of its key features to ease readers' command of the neuroscience terminology before venturing into the descriptions of its principal methods.

The human nervous system is a complex collection of nerves and specialized cells (i.e., neurons and glial cells) (for a comprehensive account, see Mai & Paxinos, 2011). Nerves are bundles of fibers that depart from the brain and spinal cord and reach out to other parts of our body. Neurons are specialized cells that transmit signals between separate parts of the body, and glial cells are specialized cells that support, defend, and partly nurture neurons. As shown in Figure 2, the nervous system has two main interacting anatomical components: the CNS and the PNS.

The CNS is primarily composed of the brain and the spinal cord. The PNS consists of sensory neurons, ganglia (i.e., groups of neurons) and nerves that interconnect and join the CNS. The PNS delivers information from the brain to the rest of the body, and vice versa. Functionally, the nervous system is classified under its two main branches: the somatic (i.e., voluntary component) and the autonomic (i.e., involuntary components). Here, I will also focus on that branch of the PNS called the automatic nervous system (ANS; Jänig, 1989). The ANS regulates several body functions such as heart rate (HR), pupil dilatation, respiration rate, and complex automatic behavioral responses like the "rest-and-digest" and "fight-or-flight" responses (McCorry, 2007). This regulation takes place through two branches of the ANS: the sympathetic and the parasympathetic branches. Importantly, these branches are always working and acting in opposition, being involved either in the preparation for action or in the relaxation of the body. The sympathetic branch responds to arousing stimuli, while more relaxing situations prompt responses from the parasympathetic branch, as summarized in Table 1.

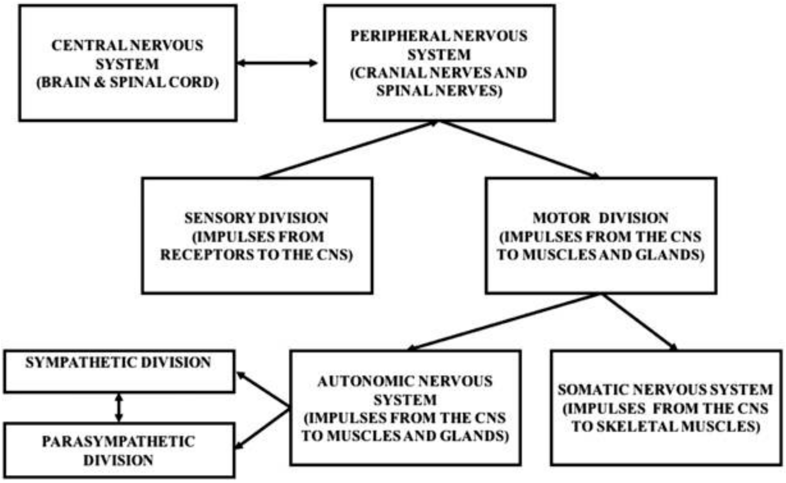

Figure 2: Anatomical Divisions of the Human Nervous System.

Before moving to a detailed description of the methods assessing these components of the nervous system, readers should note that the nervous system is a well-integrated and interconnected structure. Moreover, I will present specific research illustrations often taken from an intra-individual perspective as the majority of studies in neuroscience have focused on this perspective thus far. However, all the methods reviewed in the chapter can be used to inform both an intra-personal and a socially situated perspective on cognition. Even experiments that must be performed inside an experimental suite, like fMRI studies, can be employed in social interactions through approaches such as hyper-scanning (i.e., the simultaneous investigations of participants assessed with neuroimaging tools; Montague et al., 2002). Thus, the ultimate consideration on which neuroscience method a researcher should

Table 1: Parasympathetic and Sympathetic Activities.

Structure/Organ	Sympathetic	Parasympathetic
Heart	Increased heart rate	Decreased heart rate
Lung	Bronchial muscle relaxed	Bronchial muscle contracted
Pupil	Dilatation	Constriction
Stomach/Intestine	Reduced activity	Increased activity
Salivation	Reduced activity	Increased activity

use in MOC, requires familiarity with the details of the technique in question, coupled with a meticulous experimental design well suited to target the specific research question to be addressed in the investigator's study. As there is a wealth of research in mainstream neuroscience on the principles of empirical research design, in the followings sections, I will refer readers to these whenever appropriate.

Neuroscience Techniques for MOC

In providing a description of neuroscience methods for MOC, I necessarily had to limit the focus of the chapter to some selected techniques. Specifically, I focus on the following association methods: functional magnetic resonance imaging (fMRI), electroencephalography (EEG), magnetoencephalography (MEG), heart rate variability (HRV), and skin conductance response (SCR). Table 2 provides an overall summary of the key features of these methods. These methods constitute the most often used and debated neuroscience tools within management research more generally.

While these techniques do not cover the entire spectrum of the neuroscience methods currently available to researchers, I have purposely concentrated on these particular techniques because they are some of the most useful approaches to inform MOC. Indeed, as noted earlier, these techniques are all well suited to map onto both the intra-personal and socially situated perspectives of neuroscience in MOC (Healey & Hodgkinson, 2014, 2015). Moreover, given the application of neuroscience to MOC is at an early stage, it is sensible for readers to begin the encounter with neuroscience by first understanding cognition as it naturally unfolds, and then exploring the opportunities for its manipulation – an approach which also opens a set of important ethical questions.

Mapping the Central Nervous System

The most popular and popularized technique capable of providing maps of the "thinking brain" is undoubtedly fMRI. This method enables the creation of functional maps of the brain's activity by capturing changes associated with the cerebral blood flow. Yet, several other neuroscience tools possess the capacity to measure the brain's activity by assessing neurons' electric potentials (EEG)

Table 2: Overall Comparison of the Rationale, Key Technical Features, and Costs of Neuroscience Methods Covered in the Chapter.

Method	fMRI	EEG	MEG	HRV	SCR
Basic principle	Cerebral blood flow (e.g., BOLD signal)	Electrical impulses of pyramidal neurons	Neurons-generated magnetic fields	Modulation of ANS on heartbeats variations over time	Degree of conductance of a small amount of current passing through the skin (i.e., eccrine glands)
Temporal resolution	Low	High	High	High	High
Spatial resolution (brain localization)	High	Very low	Low	—	—
Availability	Medium/ High	High	Little	High	High
Ecological validity and portability	Little	Some (portable tools)	Little	High	High
Indicative costs	> millions $ (imaging suite) around 500/800 $ per subject/ session (usually 1 hour)	From 200 $ to 100.000 $	> millions $ (imaging suite) and around 1,000 $ per subject/ session (usually 1 hour)	2,000 $ (reliable full set-up)	10,000$ (reliable full set-up)

or the deriving magnetic fields (MEG). As we shall see, these techniques are all non-invasive and allow, among other features, the ability to capture how the "functioning" brain responds (e.g., is "activated") to experimental tasks (i.e., stimuli), as well as how it operates at rest.

FUNCTIONAL MAGNETIC RESONANCE IMAGING

fMRI experiments are performed in a dedicated, shielded, neuroimaging suite when a research participant is laying still and flat on his/her back, and with his/her head located inside a magnetic resonance (MR) magnet (i.e., the "scanner"). This magnet generates a powerful magnetic field – typically of 1.5 or 3 Tesla (T). As the magnetic field reaches areas deep below the skull, it is possible to acquire high-definition images of brain regions which are situated below the cortex, the outer layer of the brain. This is a powerful feature that is not generally available when using other methods reviewed in the chapter. Yet, it is also important to note that fMRI per se does not provide images of the anatomy of the brain. Such images can instead be obtained through structural imaging and coupled to functional analyses (Faro & Mohamed, 2010).

fMRI measures the brain's functional activity by assessing dynamic changes in the blood flow – the so named blood-oxygenated level dependent signal or BOLD (Logothetis, Pauls, Augath, Trinath, & Oeltermann, 2001; Ogawa, Lee, Kay, & Tank, 1990). This means that fMRI does not directly assess neuronal activity. Rather, the main rationale behind the use of fMRI in "mapping cognition" is based on the evidence that when a brain region or network of regions is engaged in an activity (e.g., an experimental task), the relative blood flow increases in that area (see, e.g., Zago, Lorusso, Ferrucci, & Priori, 2011). Due to the magnetic properties of the oxygenated blood it is possible to interpret the resulting BOLD signal as a specific "hemodynamic" function. This reflects brain functional activation during a given experimental condition compared to a control or baseline condition (Aguirre, Zarahn, & D'Esposito, 1998). fMRI images are then reconstructed through a series of complex statistical and analytical processes (for a typical fMRI output see Figure 3)[1].

These images, at their core, are composed of three-dimensional components (i.e., voxels) carrying information on the "scanned" brain. The voxel's size determines the spatial resolution of fMRI (about 1 mm^3). The temporal resolution, usually in the order of seconds, is poorer compared to other methods that are able to directly capture neuronal activity (i.e., EEG), essentially because the BOLD signal yields a delay compared to the physical site of activation (Kim, Richter, & Uğurbil, 1997).

In addition, when performing or evaluating fMRI research, it is important to pay attention to three core experimental features: the type of stimulus used, the design of the task and key steps of signal analysis. Two types of stimuli are generally used in fMRI research: block and event-related (see Amaro & Barker, 2006). In the block design, the repetitions of a stimulus are clustered together into a few short "blocks" per each stimulus. This design generally holds reasonable statistical power and is recommended for between-subjects research. In the event-related design, different stimuli are spread throughout the experimental session. While

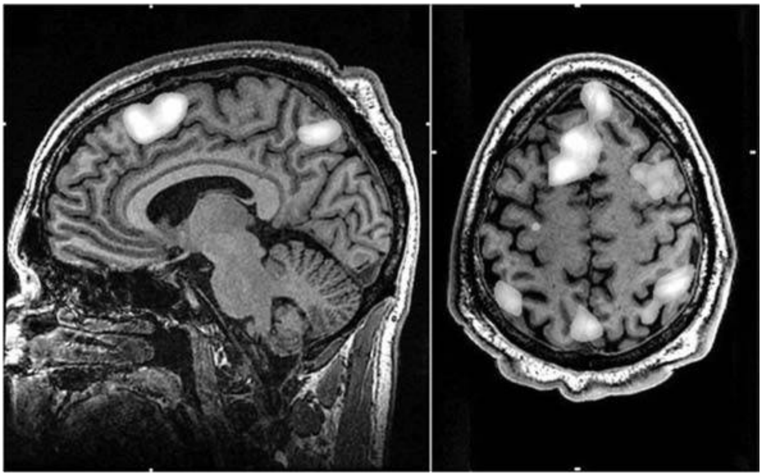

Figure 3: fMRI Output of a Participant Performing a Working Memory Task, Showing Functional Activation of Bilateral and Superior Frontal and Parietal Cortex (*Source*: Adapted from Graner, Oakes, French, & Riedy, 2013; https://commons.wikimedia.org/wiki/File:FMRI_scan_during_working_memory_tasks.jpg).

more complex, this design is more suitable for both between- and within analysis, thus better mirroring traditional MOC research strategies. A mixed approach, combining both block and event-related designs, is also a common research strategy (Petersen & Dubis, 2012).

With regard to task design, several options are available (for a review see Richards, Plate, & Ernst, 2013). The most diffused design is cognitive subtraction, which confronts the activity of distinct brain regions when engaged in a cognitive task (Friston et al., 1996). Cognitive conjunction is another common design, which allows for the identification of activated brain regions as a cognitive process unfolds in its different phases (Price & Friston, 1997). Finally, parametric designs and functional integration are more recent and sophisticated forms of design in which correlations between brain activity and changes in a chosen variable are measured, together with the mutual association between different brain regions' activities (see Penny, Friston, Ashburner, Kiebel, & Nichols, 2011). Recently such approaches have been used in studies when participants are not dealing with an experimental task, also known as the resting state (Di Martino et al., 2008).

Usually, the choice of research design in fMRI is coupled with a priori hypotheses on the neural sites involved in the task, stimulus, or behavior under investigation. Thus, researchers should identify a given region of interest (ROI) which then enables a clear-cut approach in the subsequent analysis (Poldrack, 2007). It is also important to keep in mind that while ROI are useful "guides," it is good practice for every research output using fMRI to include information on whole-brain scans performed, and that any neuroimaging study should always be supported by behavioral evidence and necessary computational models.

Finally, the analysis of fMRI information necessitates a combination of processing steps. These steps should be clearly documented in the relevant research outputs and performed with rigorous procedures in order to maintain the good quality of the signals and avoid the occurrence of false-positives (see Logothetis, 2008). The processing steps include: temporal correction of the images acquired (i.e., slice timing); correction for any head – and thus brain – movement; stereotactic normalization, which normalizes the subject's brain into standard references; and smoothing, which aims to better the signal-to-noise ratio and facilitate comparison between groups. Strother (2006) and Amaro and Barker (2006) provide detailed technical explanations of these steps. Interestingly, Laureiro-Martínez (2017), in this book, provides a visual outline of how these steps mirror the processes involved when analyzing think-aloud protocols in MOC research.

Pros and Cons. fMRI, as seen, has high spatial resolution, allowing for the identification of specific brain regions associated with a particular function. Moreover, fMRI is applicable to different types of tasks within MOC research. For this reason, as in all neuroscience-based research, it is vital to ensure that each experimental design is fit for investigating the research question and hypotheses under investigation. It is also important to mention that brain "activation" may be due to several spurious causes (e.g., individual differences, unspecific mechanisms, unrelated physiological processes) or analytical missteps (see Eklund, Nichols, & Knutsson, 2016) beyond the experimental task. To respond to this problem, research seeking to develop controls and analytical filters is a rapidly growing avenue (see, e.g., White, O'Leary, Magnotta, Arndt, Flaum, & Andreasen, 2001).

Criticism on the reverse inference problem which, while common in all neuroscience methods, has seen its peak with fMRI research (Poldrack, 2006). The reverse inference problem concerns backward reasoning, regarding specifically the issue of what mental process can be inferred from a measured brain activity. This type of inference can be highly problematic. For example, if an "emotional" brain region, like the amygdala, which is well known to be associated with fearful behavior (Davis, 1992), was to be active during an attention task, a researcher could be misled into thinking that attention may cause fear, potentially resulting in spurious research findings.

fMRI suffers from an intrinsic low temporal resolution and may well be prohibitive for researchers, with costs reaching up to 800 US dollars per participant/session. Importantly for MOC, the physical demands of the technique mean that fMRI research cannot be performed outside the imaging suite, raising issues of ecological validity in transferring laboratory findings to organizational contexts. Ecological validity is the degree to which the behavior identified in an experimental study reflects the behavior that occurs in natural (in our case organizational) settings. Given the technique's limitations, I suggest that in a context of integrated MOC, the ecological boundaries sought in any MOC or management study are important considerations to be addressed in the research design.

Finally, due to the analytical complexity involved with fMRI, it is necessary to pay close attention to the statistical approach used in the analyses and to ensure that correlations between brain activations and mental processes are both accurate and reproducible (Zarahn, Aguirre, & D'Esposito, 1997).

Advancing MOC research using fMRI. fMRI is a versatile and informative technique for MOC research. For instance, in another chapter of this book, Laureiro-Martínez (2017) illustrates how fMRI offers a useful template to map similarities with 'distant' methods, such as the think-aloud protocol, further supporting the call for interdisciplinary methods in MOC evident throughout this volume.

Hodgkinson and Healey (2008) provide a comprehensive review of topics on which fMRI and other neuroscience methods can be applied, spanning from memory to attention, and beyond. It is indeed clear that any mental process, particularly from an intra-individual perspective focused on a microfoundational behavioral understanding of MOC, necessarily has some underlying components based on neural systems. One area in which fMRI can help to substantially advance MOC research is the interplay between cognition and affect in decision making. In one illustrative study, Vuilleumier, Armony, Driver, and Dolan (2001) used event-related fMRI to investigate whether brain responses to fearful vs. neutral faces were controlled by attention. Participants were asked to assess stimuli at given locations, and faces or unrelated stimuli (e.g., houses) were presented at relevant (or not) places. Moreover, the faces presented to the participants showed either a fearful or a neutral expression. The researchers found that the activation of fusiform gyri by faces was strongly affected by attention, but the left amygdala response to fearful faces was not (Vuilleumier et al., 2001). Additionally, the fusiform gyri activity was greater for fearful faces, regardless of the attention. These findings highlight the differential effects on how information from attention and emotion is processed, thus seeking to help clarify the long-standing debate on the roles of emotion and attention in management (e.g., Simon, 1987).

Similarly, the ability to regulate emotional responses is another important domain for managerial research (Hodgkinson & Healey, 2011; Healey, Hodgkinson, & Massaro, 2017). Ochsner, Bunge, Gross, and Gabrieli (2002) used fMRI to study the brain systems engaged in reappraising negatively salient situations. The researchers showed that increased activation of the brain's prefrontal regions (the brain's "executive centers") and decreased activation of the amygdala and orbitofrontal cortex were associated with emotional reappraisal (Ochsner et al., 2002). This suggests a distinct cognitive role in emotional reappraisal strategies, particularly in negative situations. This evidence may help to advance both research and practice in those situations in which managers are exposed to decision making in negative scenarios, such as when facing an organizational crisis (e.g., D'Aveni & MacMillan, 1990).

Finally, fMRI has proven to be an important tool in uncovering the neural mechanisms of moral decision making (see Cropanzano, Massaro, & Becker, 2017). In an influential study, Sanfey, Rilling, Aronson, Nystrom, and Cohen (2003) used fMRI in an Ultimatum Game to investigate the neural correlates of cognitive and emotional decision making. They showed that unfair offers triggered activity in brain areas related to both cognition (i.e., dorsolateral prefrontal cortex) and emotion (i.e., anterior insula). Due to the increase in activity of the anterior insula when unfair offers were rejected by research participants, the authors were able to propose a direct role for emotions in moral decision-making (Sanfey et al., 2003).

This body of evidence supports the call for investigating further the involvement of emotions in managerial situations involving attention, cognitive regulation, and decision making. This is an important opportunity to advance current scholarship focusing on affect (e.g., Cote & Miners, 2006) because fMRI enables the mapping of the neural systems associated with these constructs that are often beyond what is observable in traditional MOC research.

ELECTROENCEPHALOGRAPHY

Since the early efforts made to record brain electrical activity by Berger (see, e.g., Millett, 2001), EEG has rapidly become one of the most used techniques in cognitive neuroscience. EEG provides temporally precise information about the state of the brain in a given period, and information about activity changes induced by tasks, stimuli, or other events relative to a control condition, within a specific time span (i.e., event-related potentials or ERPs).

EEG records signals principally resulting from the electrical activity of a population of cortical neurons named pyramidal neurons (Nunez & Cutillo, 1995). Neurons are electrically charged cells and when a group of adjacent neurons are charged, they produce local currents that can be captured by the EEG apparatus. The ability to record these electrical signals gives EEG a very high resolution (i.e., milliseconds), enabling researchers to make inferences on the temporal unfolding of a cognitive process (for possible applications in MOC, see e.g., Dietrich & Kanso, 2010).

Conversely, the spatial resolution of EEG is less detailed. The electrical events are generated below the scalp and thus need to pass through different layers of tissue, which often results in an inaccurate representation of the brain activity (Nunez & Srinivasan, 2006). These layers, and the skull in particular, induce a distorting effect so that the recorded activity becomes a sum of several underlying sources (Makeig, Bell, Jung, & Sejnowski, 1996) and are the main reason for the poor spatial resolution of EEG (i.e., about 5–10 centimeters).

This issue leads to another important point for MOC researchers to note. Even with newly surfacing topographic methods such as quantified EEG (qEEG), it is not possible to directly infer the activity of brain regions which are located deep below the scalp. To provide a practical example, it is not feasible to directly "map" activities of areas such the hippocampus (i.e., a region involved in memory) or the amygdala (e.g., involved in emotional responses to fearful stimuli).

A standard EEG research design requires participants to perform a task while having conducting electrodes placed on precise locations of the scalp (see Towle et al., 1993). The electrodes are then connected to a digital amplifier that captures the electrical signals and transfers them to a computer for processing and analysis. Electrodes are either applied with a conducting gel/solution or are dry and are often positioned within a head-cap or helmet to facilitate wearability and preparation of the experiment (see also Grozea, Voinescu, & Fazli, 2011; Lopez-Gordo, Sanchez-Morillo, & Valle, 2014). The number of electrodes ranges from 8 up to 256: the higher the number of electrodes, the more reliable the signal output will be. However, the use of high-density set-ups also requires lengthy preparation time and such equipment is rarely portable. Figure 4 shows an example of what a typical EEG recording output looks like.

Pros and Cons. EEG enables researchers to capture instantaneous brain dynamics and monitor changes in the brain's activity and associated mental processes. Additionally, an EEG setup is relatively cheap, has fairly low maintenance and running costs, and does not require constant in-house R&D expertise (e.g., a machine technician, a radiologist) with associated costs, unlike fMRI.

Recently, the use of portable devices and dry electrodes has opened up new opportunities for EEG-based investigations. Such

Figure 4: EEG Traces during Resting State. Time is Expressed in Seconds on the Horizontal Axis, While Amplitude on a Scale of 100 μV on the Vertical Axis (*Source*: Adapted from Cherninskyi, 2017; https://commons.wikimedia.org/wiki/File:Human_EEG_without_alpha-rhythm.png).

devices are usually quite affordable and promise high ecological validity thanks to their portability. However, researchers should note that such affordable and portable devices commonly use a low number of electrodes (e.g., about 10), and often rely on proprietary algorithms for data analysis, thus not always ensuring fuller experimental control and research transparency.

EEG research also has important limitations: EEG signals have a high noise-to-signal ratio because they can detect signals from different sources other than the brain site of interest, such as eye blinking (Hoffmann & Falkenstein, 2008). Thus, as in any of the neuroscience techniques reviewed here, it is important to employ accurate artifact reduction and filtering algorithms before processing and analyzing data (Joyce, Gorodnitsky, & Kutas, 2004). Moreover, EEG has a fairly poor spatial resolution. This yields some challenges in inferring where the signal is truly generated. A mixed methods approach integrating EEG and fMRI and incorporating increasingly refined analyses is advancing possible solutions to tackle this problem (Ritter & Villringer, 2006).

Advancing MOC research using EEG. Recently, EEG applications have enjoyed growing interest in management research. The resulting insights have mostly concentrated on leadership and qEEG approaches thus far (e.g., Balthazard, Waldman, Thatcher, & Hannah, 2012). However, the potential of EEG to advance MOC paradigms extends farther than that.

For instance, Klimesch (1999) explains that EEG oscillations in the alpha and theta bands (i.e., common waveforms classified according to their frequency, amplitude, shape, and sites on the scalp) distinctively reveal cognitive and memory task performance. Performance is generally related to an increase in the spectral power of alpha and a decrease in theta. In addition, alpha frequency yields substantial individual differences and its asynchrony is positively correlated with long-term memory, while theta synchronization is positively correlated with the ability to encode novel information (Klimesch, 1999). Such findings suggest that by appreciating distinct waveforms, EEG represents a useful technique for "mapping" research participants' performance to specific cognitive tasks, such as memory. This in turn offers measurable and objective variables to better understand the responses of individuals to complex workplace tasks requiring the retrieval of information stored in their long-memory repository. EEG may also promote novel insights into the micro-foundations of transactive memory systems in organizations (Argote & Ren, 2012).

Attention is another important area of research for MOC (e.g., Ocasio, 1997). In another illustrative study, Jung, Makeig, Stensmo, and Sejnowski (1997) demonstrate that in attention tasks, human alertness varies on a precise temporal scale and variation in the EEG spectrum relates to the level of alertness of the participants. These insights reveal important implications for research on managerial attention. Indeed, Jung et al. (1997) showed that accurate and almost real-time estimation of a participant's level of alertness is feasible using EEG measures, thus supporting the technique's ability to monitor mental states in attention-critical organizational settings.

While these are just a few examples, they clearly demonstrate that EEG can address a number of questions related to how MOC processes unfold. Along these lines, MOC research may use EEG as a technique to advance knowledge on how managers and employees respond to different workplace or organizational dynamics. In this way, researchers can explore intriguing questions such as what type of information can, and to what extent, affect an organizational actor's overall cognitive ability and reactions to different organizational cues.

MAGNETOENCEPHALOGRAPHY

MEG is a technique for recording the magnetic field produced from the electrical activity of neurons, where such electrical activity is coupled to the generation of magnetic fields (Hansen, Kringelbach, & Salmelin, 2010). In MEG, the fluctuation of these magnetic fields has similar temporal features to those seen in EEG. Moreover, this activity can be captured both continuously (i.e., as a sequence of oscillations) or as a change in response to experimental events, tasks, or stimuli. Given that the magnetic activity generated by the neurons is overall weak (10^{-15} Tesla), MEG relies on a system of superconducting sensors, called superconducting quantum interference devices (SQUIDs) to detect the arising field (Hari & Salmelin, 2012).

In a MEG experiment, the participant sits inside a shielded imaging suite and wears a helmet which contains hundreds of super sensitive magnetometers (SQUIDs). These SQUIDs enable the researcher to record the magnetic field generated by the "activated" neurons during the experimental session and in turn, derive inferences on the temporal and spatial properties of the correlates.

Pros and Cons. MEG yields several benefits, namely precise temporal resolution and a better spatial resolution relatively to EEG. This is because the magnetic fields are not greatly distorted by the tissues underlying the scalp and the large amount of sensors allows for the production of a more detailed "map" of the signal. Unlike EEG, MEG can precisely locate where the brain signal is generated on the cortex. Consequently, researchers are able to make detailed inferences about both the location and the duration of the cortical activity (Hansen et al., 2010). However, it is also true that the spatial resolution is less accurate compared to an MRI. Figure 5 illustrates a comparison between fMRI and MEG outputs. In addition, a MEG experiment is relatively easy to set up and requires a shorter preparation period than that required for EEG.

Notwithstanding these benefits, the cost of an MEG suite is quite prohibitive, at present reaching the order of millions of US dollars. Indeed, because the environment is affected by numerous electromagnetic sources, to avoid any signal interference, the MEG scanner is required to be placed in a protected shielded chamber. This set-up also requires availability of liquid helium, increasing maintenance and running costs. Moreover, there are comparatively fewer MEG centers available in the world than fMRI ones.

Advancing MOC research using MEG. As far as I know, MEG has not yet been used in management research. This is most probably due to both the high cost of the equipment and

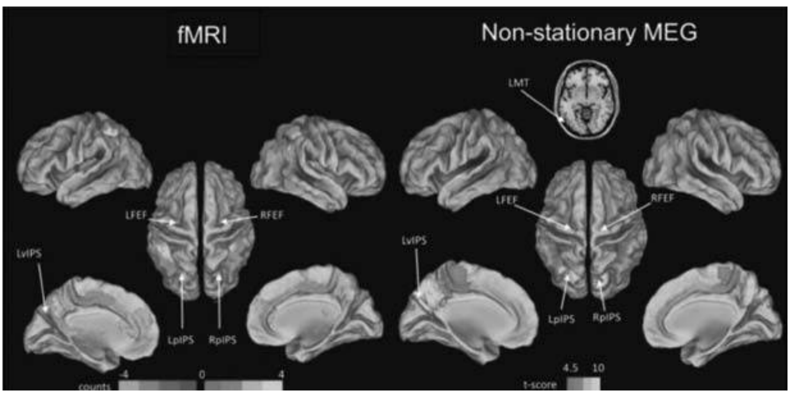

Figure 5: Visual Comparison of fMRI and MEG Imaging Outputs (*Source*: Adapted from Human Connectome Project, http://www.humanconnectome.org/about/project/resting-MEG.html).

the sub-optimal trade-off with the resolution parameters. Yet, MEG has recently seen an increasing use in cognate areas such as neuroeconomics.

In one revealing study, researchers found that well connected resting-state brain networks are correlated with better cognitive performance (Dolan, 2008). Building on this evidence, Douw et al. (2011) explained the relationship between resting-state MEG functional brain and global and domain-specific cognitive performance. The authors found that higher performance was related to increased local connectivity in the theta band and to higher network clustering, among other features. Moreover, the authors identified some gender differences within their sample of participants: women showed a smaller clustering and shorter band length, while higher cognitive scores in men were associated with increased theta band clustering. These results highlight the value of MEG in examining the complex underpinning of cognitive processing and may also promote further research on, for example, how gender differences are conceptualized and investigated in MOC (e.g., Powell, Butterfield, & Parent, 2002).

A classic study by Tallon-Baudry, Meyniel and Bourgeois-Gironde (2011) investigated how the human brain responds to economic monetary stimuli. It is well known that monetary incentives "trigger" the reward system in the brain (e.g., Thut et al., 1997). Tallon-Baudry et al. (2011) went further and explored how the specific features of monetary stimuli are identified by the brain. They found that the ventral visual pathway of the brain can distinguish between coins and neutral stimuli in one-tenth of a second, regardless of participants' familiarity with the currency. These findings support the idea that the representation of money is non-specific and independent from past experience, opening interesting avenues for research on mental representation in MOC.

Mapping the Peripheral Nervous System

While the techniques reviewed above focus on the brain, I now move on to discuss two other neuroscience methods that assess activity of the PNS – cardiovascular measures and electrodermal activity. While these measures have been thus far largely excluded from the ongoing conversation in MOC and organizational neuroscience at large, as I shall now explain, they represent reliable, cost-effective, and ecologically valid methods for

MOC investigations. Due to these features, these methods also hold promise for empirically facilitating a view of neuroscience in MOC that leverages the socially situated perspective provided by Healey and Hodgkinson (2014, 2015).

CARDIOVASCULAR MEASURES

The heart is an involuntary muscle which provides a constant blood flow all over the body. The cardiac cycle consists of a sequence of events between heartbeats and is composed by two main moments: diastole, in which the heart is at rest and the blood flows into the heart, and systole, when the electrical activity generated by pacemaker cells leading to contraction and the blood is pumped out of the heart (Saladin & Miller, 1998). Along with this activity, the heart is under control of the ANS, which influences the overall electrical activity of the organ (Burgess, Trinder, Kim, & Luke, 1997).

This electrical activity can be detected via an electrocardiogram (ECG) acquired by placing several electrodes on the participant's chest. These electrodes record the electrical potential produced by the heart's muscles contraction over one heartbeat, generating a waveform, where the peak of ventricular responding is named as R peak. From ECG data, two main indexes of the ANS can be inferred: HR and HRV. Indeed, the sympathetic branch of the ANS induces the heart to beat faster by releasing noradrenalin, while the parasympathetic (vagal) branch causes the heart to slow down by means of acetylcholine release (Levy & Martin, 1984).

HR is an index defined as the amount of R peaks within 1 minute (expressed in beats/minute or bpm). An adult HR ranges from 60 to 100 bmp. HR is affected by individual characteristics such as age, fitness, and lifestyle. In addition, stress and emotional states can affect HR. Such influencing characteristics and factors not only call for attention in controlling these during an experiment but are also suggestive of opportunities for designing targeted research (i.e., looking at the role of stress in MOC).

More recently, a set of indexes that focuses on the variation over time of the interval between consecutive heartbeats – HRV – has emerged in the management and MOC literature (see Massaro & Pecchia, in press). HRV is defined as the fluctuation over time of the interval between consecutive heartbeats taken at the R peak (Sztajzel, 2004). HRV offers several measures that can be grouped into three main categories. The first category includes time domain measures (Kleiger, Stein, Bosner, & Rottman, 1992), which are the simplest indexes to compute, obtained by traditional descriptive statistics of heartbeats, such as mean and variation of consecutive RR intervals. These indexes strictly correlate and are assumed to reflect ANS parasympathetic activity.

The second category covers frequency-domain measures which are based on the relative portion of different frequency areas (Montano et al., 2009). HRV can be evaluated in terms of very-low frequency (VLF; 0.003–0.04 Hz), low frequency (LF; 0.04–0.15 Hz), and high frequency (HF; 0.15–0.4 Hz), by looking both at the peak of the frequency and at the spectral power (i.e., the area below the curve in Figure 6).

HF is generally interpreted as a marker of vagal modulation, while LF is interpreted as being a marker of both sympathetic and parasympathetic activity. Despite some controversy, the HF to LF ratio (HF/LF) has been recurrently used as an index to describe the global instantaneous balance between sympathetic and vagal nerve activities (i.e., the sympatho-vagal balance; Malliani, 1999).

The third category of HRV measures covers nonlinear indexes (Mansier et al., 1996). Different to the linear indexes referred to above, these are non-stationary and are suitable to appreciate

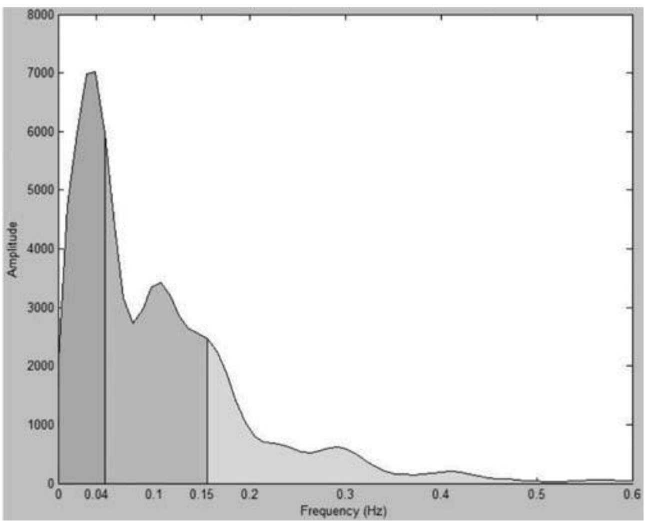

Figure 6: HRV Power Spectrum Showing High, Low, and Very Low Frequencies (From the Right to the Left).

how HRV reflects a chaotic system – which is dynamic, nonlinear, and rapidly evolves over time. The most commonly used HRV nonlinear features are entropy, scaling exponents, and fractal dimensions.

Pros and Cons. These cardiovascular measures are relatively easy to measure, non-invasive, versatile, and are generally low cost. The use of wireless and portable instruments to record ECG data, such as cardiac bio-patches, has allowed researchers to capture cardiovascular indexes in different experimental settings, thereby helping to preserve ecological validity.

The main drawback of these measures is associated with inter- and intra-individual differences, which necessitate a within-subject design and the need for proficient analytical expertise. Moreover, it is important for researchers to note that these indexes have low specificity and are useful to provide information on the overall cognitive states of research participants. Recently, Fooken (2017) has shown that HRV holds large external validity, offering support for the use of this method in MOC research.

Advancing MOC research using cardiovascular measures. HRV measures have been widely used to assess central constructs in organizational theory and research (for a detailed review see Massaro & Pecchia, in press). For example, research has associated HRV with the cognitive dimensions of the flow state associated with a task and such measures have been used to infer a participant's mental load (Keller, Bless, Blomann, & Kleinböhl, 2011). Recently, Castaldo, Montesinos, Melillo, Massaro, and Pecchia (2018a) have shown that HRV features are highly correlated with performance over a repeated mental task and that HRV features and dynamics diminish with repetitions, while performance increases. Moreover, Tripathi, Mukundan, and Mathew (2003) have shown that manipulating cognitive demands in mental task variants reveal the susceptibility of certain spectral components of HRV to cognition, in particular, when the cognitive load is centered on working memory.

HRV also holds implications for the practical implementations of neuroscience methods in organizations. Leveraging on the increasing portability and wearability of equipment capable of recording ECG data (e.g., bio-patches), controlled HRV protocols may soon make organizational interventions aimed at performance enhancement more efficient (for a preliminary study on short time recordings, see, e.g., Castaldo et al., 2018b). There is rising evidence of the effectiveness of HRV neurofeedback – a protocol that aims to communicate to people on how to change their level of physiological arousal by modulating their own responses (McCraty, 2005).

ELECTRODERMAL ACTIVITY

Our skin, which is highly innervated by our PNS, protects the body from external agents and preserves our physiological balance. These functions are partly controlled by the activity of two kinds of glands: apocrine and eccrine. The palms of our hands possess an elevated concentration of eccrine glands, and their activity can be inferred by the recording of electrodermal activity (Boucsein, 2012).

Skin conductance, measured in microsimens (mS), is the most accessible and most widely used form of measuring electrodermal activity (Prokasy, 2012). As the glands' activity increases the amount of electrolytes on the skin, skin conductance involves the conductance of a small amount of current passing through the skin, which in turn reflects the activity of the sympathetic nervous system.

Skin conductance is usually measured in terms of oscillations between tonic and phasic activity (Lim et al., 1997). While the former describes variations in skin conductance level irrelevant to a task, the phasic tone denotes conductance changes induced by stimulus presentation and it is elicited within 5 seconds from the stimulus. The phasic increase of skin conductance arising after a stimulus presentation is known as skin conductance response (SCR) (see Figure 7). When arousing stimuli activate cognitive processing, the body responds by stimulating the eccrine glands.

Pros and cons. Electrodermal activity has been widely used in neuroscience and cognitive research (e.g., Schmidt & Walach, 2000). This method not only allows for the gathering of continuous data, but also results in producing data that is easily

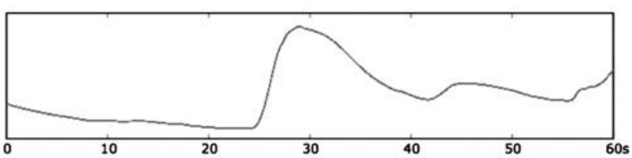

Figure 7: A Typical Pattern of Skin Conductance Response over 1 Minute (*Source*: Adapted from: https://commons.wikimedia.org/wiki/File:Gsr.svg).

detectable and reliable. The experimental set-up is unobtrusive, compact, often wearable and wireless, and relatively cheap (i.e., usually less than 500 US dollars).

Notwithstanding these advantages, the related analysis aligned to this method has some key limitations. Notably, it is not possible to assess the valence of a response using this method. That is, even in presence of an increase in electrodermal activity, it is not possible to infer the nature of the emotive state the participant is experiencing (e.g., positive vs. negative emotions). Moreover, several confounding factors can affect the quality of the data, such as external temperature, repetition of experimental design, and physiological conditions of the participant.

Advancing MOC research using electrodermal activity. Measuring electrodermal activity is a particularly useful way to collect data on cognitive and affective processes as they are manifesting within the body. For instance, SCR is considered to be a good marker of individual state and trait characteristics of emotional responsiveness. Indeed, SCR has been widely used in decision making research.

Notably, SCR has offered substantial support to the somatic marker hypothesis (Bechara & Damasio, 2005). The somatic marker hypothesis suggests that several somatic markers are linked to the ventromedial prefrontal cortex (vmPFC), an area within the brain implicated in executive and strategic decisions. Bechara, Damasio, Tranel and Damasio (2005) found that individuals with impaired vmPFC underperformed in decision making tasks and did not manifest any SCR modulation in response to fair conditions or losses. Bechara et al. (2005) concluded that SCR is an ideal marker to infer information about emotional arousal in decision making. This research highlights the potential of electrodermal recordings to extend research in MOC. SCR in particular provides the ability to "map" the fast-paced states of individuals and thus can be used to explore the reactions of managers and employees to organizational cues (Hodgkinson and Healey, 2011).

Discussion and Conclusions

In this chapter, I have built on the theoretical insights offered by Healey and Hodgkinson (2014, 2015) on the use of neuroscience in management in order to present and discuss key neuroscience methods that offer the non-incremental potential to advance MOC research and more generally, management research. For each of the methods reviewed in the chapter, I have presented an overview, their benefits and limitations, and offered some examples of how such methods might advance MOC research.

The review of neuroscience methods provided in the chapter should enable management researchers to acquire a more technical introduction to neuroscience techniques and provide researchers with a more cohesive vision of MOC and neuroscience. I am also hopeful that leveraging this knowledge, MOC researchers will be empowered to better understand and identify the most suitable methods to tackle their research questions (i.e., what they should measure), appreciate the boundaries and opportunities of each technique, as well as some of the key associated practicalities, costs, and benefits of each.

Specifically, I have divided these techniques according to their main anatomo-functional sites of inference. This approach was utilized for several reasons. First, it has allowed me to align my review with the theoretical insights for studying neuroscience in MOC advanced by Hodgkinson and Healey (2014, 2015). Second, my framework sustains the idea that neuroscience in MOC can extend investigations beyond the brain per se (Massaro & Pecchia, in press). Lastly, I hope that my systematization will alert researchers to the fact that the most appropriate research method to be used is always the one most closely aligned with the research questions being investigated. For instance, if ecological validity is a priority, then the portable and wearable tools usable in EEG and HRV would offer a non-trivial advantage. On the contrary, if researchers were more interested in understanding the neural correlates of managers' mental processes, then the techniques featuring higher spatial resolution would likely be their primary choice.

Within this chapter, I have also argued that the theoretical advancements achievable by using neuroscience in MOC will necessarily result from a careful integration of the aforementioned techniques with more traditional ones. For one, I mentioned the compelling need to support any neuroscience study with behavioral data. Thus, as Huff (1990) demonstrated, novel methods in MOC, like neuroscience methods, should ultimately be used to gain additional sources of insight into organizational life. Keeping this core concept as reference, and extending earlier insights on neuroscience methods in management (Massaro, 2016), here I have argued that neuroscience techniques can complement current techniques within MOC, pending a fuller understanding of their methodological underpinnings.

To this end, I believe that this methodological knowledge will also enable researchers to address some important questions at the frontiers of MOC, such as 'Can neuroscience reliably address issues of construct validity in this field? What is the most suitable theoretical position able to merge MOC and neuroscience? How can emerging topics in MOC research, such as emotional self-regulation, morality, and cooperation, be advanced by neuroscience methods?' As discussed throughout, readers should consult Hodgkinson and Healey (2008) for a comprehensive review of topics and arguments in MOC on which neuroscience methods can be beneficially applied.

The insights of the chapter can also be extended to the needs of practitioners. Indeed, interest in using neuroscience methods to inform business applications in decision making is an area of application that is rapidly expanding (Waytz & Mason, 2013). For one, despite known limitations and caveats (see Massaro, 2015), neurofeedback represents one of the most auspicious opportunities to convert neuroscience research into business practice. Added to this, increasing news of brain–computer interfaces and "neuroscience-informed" approaches in the workplace are becoming regular headlines in the media, showing an increasing demand from the "real-world" of academics enabled with expertise ready to address and inform novel business opportunities.

All in all, I am confident that the knowledge presented in this chapter offers useful insights to deepen understanding of the cognitive architecture of organizational life. At the same time, I caution readers not to fall for the "seductive allure" of neuroscience (Weisberg, Keil, Goodstein, Rawson, & Gray, 2008). Neuroscience and its methods require specialized knowledge, and expertise, often accompanied by complex analytical skills. Over-simplifying the underlying methodology of a study risks invalidating its findings, resulting in the production of amateurish research and questionable insights, or possibly worse, replicating knowledge which may be already well established in mainstream neuroscience. Unfortunately, we are already witnessing a growing body of "improvisational" neuroscience experts, and accompanying research missteps, are rapidly surfacing in the management literature at large, even in top scholarly outlets. Concluding the chapter on a more optimistic note, I recommend that the management community at large work in closer partnership with trained neuroscientists and, albeit not straightforwardly, seek to establish a common working language. Hopefully, this chapter offers a supportive step toward this end and will thus enable researchers to fully "cross the traditions" (Hodgkinson & Healey, 2008) of these exciting disciplines.

Note

1. For ease of dissemination some of the images included in this chapter are purposively taken from available online open sources.

Acknowledgments

I am indebted to the editors of this book, Robert J. Galavan, Kristian J. Sund, and Gerard P. Hodgkinson, for the invitation to write this chapter, their kind availability, and useful feedback. I would also like to thank Daniella Laureiro-Martinez for her suggestions on an earlier version of this manuscript and to Mark P. Healey and Karen Nokes for their help at the final stages of revision. I am grateful to Giovanni Gavetti for the long conversations (and longer hikes) that have massively helped me to renew my attention to the neurocognitive sciences. Special thanks, beyond his editorial duties, to Gerard P. Hodgkinson for the numerous dialogues over the past few years and his enthusiasm in promoting intersections and distinctions between management and neuroscience.

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