



NEUROSTRATEGY

THOMAS C. POWELL*

Saïd Business School, University of Oxford and St. Hugh's College, Oxford, U.K.

Brain research has contributed to economics, marketing, law, and other fields. Does strategic management need neuroscience? This paper examines the potential contributions of brain research to strategic management research and practice. The paper discusses the aims and methods of neuroscience, its strengths and limitations in social and economic research, and its potential contributions to strategy. The paper identifies specific research questions at the intersection of strategy and neuroscience and appraises the prospects for substantive collaborations between neuroscientists and scholars in strategic management. Copyright © 2011 John Wiley & Sons, Ltd.

INTRODUCTION

Without a doubt, brain research has arrived in the social sciences. Brain research has taken hold in economics (Camerer, Loewenstein, and Prelec, 2005), political science (Amadio *et al.*, 2007), social psychology (Willingham and Dunn, 2003), law (Chorvat and McCabe, 2004), anthropology (Adenzato and Garbarini, 2006), archaeology (Ben-Ari, 2008), and sociology (Franks, 2003). Output in neuroeconomics has risen exponentially for nearly a decade, with no signs of slowing (Glimcher *et al.*, 2009). Business schools are close behind, with researchers applying brain research to marketing (McClure *et al.*, 2004), leadership (Rock and Schwartz, 2007), finance (Kuhnen and Knutson, 2005), and human resource management (Lane and Scott, 2007).

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* Correspondence to: Thomas C. Powell, Saïd Business School, University of Oxford and St. Hugh's College, Oxford, U.K.
E-mail: thomas.powell@sbs.ox.ac.uk

This paper examines the potential fit between neuroscience and strategic management. Does strategic management need neuroscience? In at least one sense, the answer is clearly yes. Strategic management has long-standing interests in executive judgment and decision making and in the psychological foundations of strategy practice (Hodgkinson, 2008). If executive decision making and behavior matter, then the brain is already in the game; and the more we can learn about it, the better.

At the same time, strategy researchers need to understand what neuroscience can and cannot do and to maintain a healthy skepticism toward its more extravagant claims. In strategic management, some scholars may wonder whether processes within the individual brain can really inform research that takes the firm and industry as its primary units of analysis (Rumelt, Schendel, and Teece, 1994). In fields where brain research is further along, as in economics and social psychology, scholars have raised serious objections to brain research, some of which are relevant to strategic management.

The following section discusses new opportunities and potential contributions of neuroscience to strategy, and the next section discusses weaknesses and limitations. The paper then proposes specific research agendas in neurostrategy, and appraises the prospects of brain science for advancing research and practice in strategic management.

THE CASE FOR NEUROSTRATEGY

Brain localization is an ancient science, traceable at least to Hippocrates and the Roman physician Galen, whose localization theory came from inspecting the brains of sheep. In the modern era, Marie-Jean-Pierre Flourens (1794–1867) localized brain function by damaging a part of the brain and observing behavioral deficits, a method known as experimental ablation; Jean Baptiste Bouillaud (1796–1881) located speech in the frontal lobes and pioneered the theory of lateral asymmetry (differences in the left and right hemispheres); and Paul Broca (1824–1880) located speech in the part of the left frontal lobe now known as Broca's area.

In the present day, neuroscientists study brain localization at several levels of analysis—molecular, cellular, systemic, and behavioral. Behavioral neuroscience includes disciplines such as neuroeconomics and neuromarketing, which link activity in the brain to reputation, status, cooperation, trust, and altruism (social neuroscience); learning, perception, memory, and decision making (cognitive neuroscience); and feelings, passions, sentiments, and motivational states (affective neuroscience). Clearly, some of these areas address research problems in strategic management and suggest the possibility of linking strategy and neuroscience.

The case for neurostrategy relies on strategy's long-standing emphasis on general managers. The Academy of Management defines business policy and strategy as 'the field concerned with the roles and problems of general managers and those who manage multibusiness firms or multifunctional business units.' Nag, Hambrick, and Chen (2007: 944) defined strategy as 'the major intended and emergent initiatives taken by general managers on behalf of owners, involving utilization of resources, to enhance the performance of firms in their external environments.'

Strategic management rests on the assumption that the thoughts, feelings, and social relations of

general managers influence the activities and performance of firms. This is evident, for example, in strategy research on upper echelons (Hambrick and Mason, 1984), executive perceptions (Sutcliffe, 1994; Starbuck and Milliken, 1988), risk preferences (March and Shapira, 1992), beliefs (Dennell, 2008), cognitive schema (Prahalad and Bettis, 1986), attention (Ocasio, 1997), causal attributions (Powell, Lovallo, and Caringal, 2006), competitor perception (Zajac and Bazerman, 1991) and aspirations (Mezias, Chen, and Murphy, 2002). To the extent that cognition, affect, and social perception are seated in the central nervous system and brain, strategy researchers should welcome opportunities to explore the contributions of behavioral neuroscience.

But what are those contributions, exactly? The remainder of this section draws examples from neuroeconomics and other fields to explore the potential upside of neurostrategy. Three potential contributions are discussed: construct validation, theory testing, and informing strategy practice.

Construct validation

Strategy theories often use unobserved psychological constructs to explain observed behavior. For example, Fiegenbaum and Thomas (1988) inferred the existence of loss aversion in a sample of U.S. executives based on COMPUSTAT data. One of the ways neuroscience contributes to social research is by linking unobserved mental constructs such as loss aversion with physiological events in the brain. For example, it is conceivable that the psychologist's concept of loss aversion would give no clear pattern of brain activity or would give different patterns of brain activity under conditions regarded as theoretically similar. Tom *et al.* (2007) investigated this question and found evidence that loss aversion is neurally encoded in the striatum and ventrolateral prefrontal cortex (PFC). Such evidence does not prove the existence of a mental state called 'loss aversion'; however, in combination with behavioral findings, it provides *prima facie* support for the construct validity of loss aversion and facilitates further hypothesis development in prospect theory (Fox and Poldrack, 2009; Hsu *et al.*, 2009; DeMartino, Camerer, and Adolphs, 2010).

Another important mental construct in behavioral strategy is willingness to pay. A consumer's

willingness to pay derives from perceptions of subjective value or of differentiation in the firm's products and services. In strategic management, willingness to pay is essential to theories of competitive advantage, such as the resource-based view, which explain the excess of willingness to pay over the firm's opportunity costs. Is willingness to pay a valid psychological construct? Research in neuroeconomics has linked willingness to pay with specific regions of the brain, implicating the ventromedial PFC in the neural encoding of willingness to pay across a wide spectrum of products, activities, and experimental conditions, including the valuation of junk food, cash, and charitable contributions (Padoa-Schioppa and Assad, 2006, 2008; Chib *et al.*, 2009; Plassmann, O'Doherty, and Rangel, 2007; Hare *et al.*, 2010). The findings show that subjective valuation uses a common neural currency, providing *prima facie* evidence of the construct validity of willingness to pay.

In social psychology, Willingham and Dunn (2003) argued that neural evidence can help establish the *separability* of mental constructs. For example, many psychologists regarded aggression and passivity as extremes on one spectrum of behavior, but others regarded them as separate constructs. The debate could not easily be resolved by traditional means, but fMRI evidence showed that decisions to approach and withdraw engaged different parts of the brain, providing support for the latter view. Similarly, Amodio and Devine (2006) showed that prejudice and stereotyping, although conceptually related, involved different neural activations; Ersner-Hershfield, Wimmer, and Knutson (2009) showed that temporal discounting increased as people differentiated between present and future selves; and neural evidence showed that racism and sexism activate different parts of the brain, suggesting different psychological foundations (Dovidio, Pearson, and Orr, 2008). Given the prevalence of bipolar constructs in strategic management—exploration-exploitation, cost-differentiation, cooperation-competition—strategy researchers may find that neuroscience offers new ways of establishing construct validity and separability.

Theory testing

In some circumstances, neural evidence may help adjudicate theoretical debates. For example, in

social psychology, theorists debated for many years whether people's mental images are mainly pictorial or language based. The debate could not be resolved using traditional methods, but researchers using fMRI and brain lesioning showed that mental images are formed in the visual cortex, supporting the pictorial theory (Willingham and Dunn, 2003). In economics, Camerer (2008) argued that neural evidence may offer the best means of reconciling theories of ambiguity aversion—that is, the reluctance to choose when payoffs or probabilities are ambiguous. According to Camerer (2008: 372), 'the point of such tests is not to establish the neuroscience of ambiguity-aversion *per se* (although that may interest neuroscientists). The point is to use brain evidence to adjudicate empirically among theories which are particularly difficult to distinguish using the market-prediction test (for ordinary types of data).'

A key research topic in behavioral strategy is causal attribution, and many research questions remain open (Staw, 1975; Bettman and Weitz, 1983; Salancik and Meindl, 1984). For example, it is unclear whether self-serving attributions stem from errors in information processing, the need for self-esteem, or deliberate impression management (Powell *et al.*, 2006). Brain research on attribution is still in its infancy, but an fMRI study by Harris, Todorov, and Fiske (2005) found that dispositional attribution (the fundamental attribution error) recruits brain regions similar to those of mentalization, suggesting that people explain causation by mentalizing the views of human actors. Neural evidence also shows that differences in American and Asian attributions (Americans tend to make more dispositional attributions) are linked to cultural differences in automatic and controlled processing (Mason and Morris, 2010). Neural research on attribution needs further attention and offers a promising method for explaining the psychological foundations of attributional errors.

Many researchers have examined the escalation of commitment to failing strategies (Staw, 1981; Zajac and Bazerman, 1991), but its psychological motivations remain unclear—for example, escalation could stem from attribution errors, justifying past commitments, the need for decision consistency, or a genuine expectation of future payoffs (Schwenk and Tang, 1989). Using neural evidence, Campbell-Meiclejohn *et al.* (2008) found that escalations of commitment correlated with brain activity in areas of medial PFC and

anterior cingulate cortex consistent with a genuine expectancy of positive rewards. They also found that loss chasing had a strong appetitive component, not unlike the cravings of cocaine dependency. Decisions not to escalate involved cortical areas associated with uncertainty avoidance and disgust, suggesting that escalation involves at least two separate neural systems. The debate is not yet resolved, but neural evidence will play a key role in testing alternative explanations.

In some cases, neuroscience has assisted both in construct validation and theory testing. For example, behavioral economists have used games such as prisoner's dilemma and the ultimatum game to study the role of trust and social norms in competitive interactions. In the ultimatum game (Güth, Schmittberger, and Schwarze, 1982), player A is given \$10 to divide in some proportion between player A and player B, and player B can then accept or refuse the proposal. For example, player A may propose to keep \$8 and give \$2 to B. If B accepts, A gets \$8 and B gets \$2; if B refuses, both players get nothing.¹

A review of experimental results for the ultimatum game found that, on average, player A offered more than \$4 to player B and if the offer was less than \$2, B refused about half the time (Camerer, 2003). These results support the behavioral view that people do not act out of pure economic self-interest, but also take account of social norms and fairness. However, behavioral experiments could not establish the psychological validity of motivations like punishment and fairness or establish clear links between these motivations and observed behavior. For example, it was unclear whether subjects refused low offers out of revenge, disgust, or perceived injustice.

In a widely cited study, Sanfey *et al.* (2003) used fMRI scans to observe brain activity in 19 participants in 30 rounds of an ultimatum game. In the fMRI analysis, subjects who received low offers showed increased activity in three areas of the brain: dorsolateral PFC, anterior cingulate cortex (ACC), and the anterior insula. The magnitude of insula activations increased with the perceived unfairness of the offers and was greater for unfair offers from humans than from computers. It is

known that dlPFC encodes uncertainty and updates experience with new facts and that the insula registers negative emotions associated with taste and odor, particularly disgust. Together, the findings suggested that low offers in the ultimatum game induce neural conflict between executive cognition in PFC and visceral disgust in the insula, mediated by information processing in the ACC.

Informing strategy practice

Practitioners in applied fields like law, marketing, and politics have begun to integrate neuroscience with management and professional practice. Lawyers use brain scans to show the mental capacities of defendants, and jury consultants use neural evidence to predict punishment and retribution in jury decisions (Samson, 2007). Neuro-marketing consultants use brain scans to evaluate consumers' cognitive and emotional responses to product features, packaging, and promotional campaigns (Knutson *et al.*, 2007; McClure *et al.*, 2004). Neural studies of politically conservative and liberal voters enable candidates to target voters' cognitive orientations (Westen *et al.*, 2006; Knutson *et al.*, 2006; Amodio *et al.*, 2007).

Can neuroscience inform strategy practice? One area of potential contribution is behavioral self-control (Hare, Camerer, and Rangel, 2009). Behavioral economists have long noted that decision makers behave as though they have multiple selves—for example, a reflective and fairly rational 'planner-self' with long time horizons and an impulsive and unreflective 'doer-self' with limited capacity for delayed gratification (Thaler and Shefrin, 1981; Schelling, 1984; Ainslie, 1975). In economics, multiple-selves models have been used to explain addiction, procrastination, and self-binding commitments (Elster, 1985; Hoch and Loewenstein, 1991). In general management decisions, poor self-command manifests in problems like temporal myopia, excessive risk taking, ethical malfeasance, and escalations of commitment (Levinthal and March, 1993). In the firm as a whole, poor self-command gives rise to costly organization structures, controls, and incentives (Postrel and Rumelt, 1992).

Multiple-selves theories are consistent with general frameworks of neural organization, such as the triune brain model, and automatic (X-system) versus reflective (C-system) processing. The question for strategy practice is whether executives can

¹ If A is purely self-interested and believes B is the same, A will propose a large sum for A and just enough for B so that B's share is positive—that is, \$9.99 to A and \$0.01 to B. If B is purely self-interested, B will accept any positive offer.

control the C-system in a way that down regulates negative emotions in X-system structures like the amygdala. Neural evidence is beginning to emerge, and three areas—*affect labeling, reappraisal, and mindfulness*—have attracted the most attention.

Some psychologists believe that people can control negative feelings by the technique of ‘*affect labeling*’—that is, by writing their negative feelings on paper (Wilson and Schooler, 1991). However, the underlying psychological mechanisms of this method remained unclear. Neuroscience has begun to shed new light on the neural origins and impacts of *affect labeling*. For example, Hariri, Bookheimer, and Mazziotta (2000) found that *affect labeling* reduced activity in the amygdala, and Lieberman *et al.* (2007) found that writing negative emotions on paper activated an area of PFC (right ventrolateral PFC) which, in turn, led to a dampening of negative response in the amygdala. Moreover, studies show that *affect labeling* is more effective than other techniques. For example, trying to suppress negative emotions does not dampen the amygdala, and talking about negative emotions can make the situation worse by heightening arousal in the amygdala, insula, and cingulate cortex (Goldin *et al.*, 2008; Ochsner and Gross, 2005; Gross and John, 2003).

These results are suggestive, but *affect labeling* does not address the deep and persistent emotional pressures facing senior managers in large organizations. A more substantial method of self-regulation involves reframing problems into new emotional contexts—for example, reframing a new market entrant as both threat and opportunity, or viewing global expansion from the perspective of the host country. This method, known as *reappraisal*, allows people to detach themselves from anxieties, resentments, and other negative emotions that inhibit creative problem solving (Gross, 1998). *Reappraisal* involves more complex mental operations than *affect labeling* (Lieberman *et al.*, 2007), and neural studies show that *reappraisal* engages more areas of PFC, while down-regulating amygdala arousal using right ventrolateral PFC (Ochsner *et al.*, 2004; Schaefer *et al.*, 2003).

Executive judgment derives from experience, intuition, tacit knowledge, emotional maturity, and sensitivity to ambiguity and context (Vickers, 1965; Priem and Cycyota 2001; Tichy and Ben- nis, 2007; Kahneman and Klein, 2009). Weber and Johnson (2009) linked judgment to a cluster of psychological processes—memory, attention,

learning, and emotional processing—associated with cognitive mindfulness. In psychology, mindfulness implies the capacity to override automatic cognition by engaging with alternative points of view (Langer, 1997). In organization studies, mindfulness does not imply the denial of routines or automatic cognition, but the capacity to deploy them in strategic context (Weick, Sutcliffe, and Obstfeld, 1999; Levinthal and Rerup, 2006).

Research on mindfulness has grown dramatically in recent years, and has produced a subindustry of popular books, institutes, and executive seminars (Carroll, 2007). In a review of theory and research, Brown, Ryan, and Cresswell (2007) concluded that clinical and experimental mindfulness interventions nearly always improve short-term cognition and well-being, but that further research, with the aid of brain scanning and other neural methods, is needed to establish their lasting effects. Neuroimaging studies so far suggest that, whereas control subjects engage brain regions associated with subjective emotional response, trained mindfulness practitioners engage regions such as dorsolateral PFC and somatosensory cortex, which support emotional regulation and external sense perception (Farb *et al.*, 2007; Farb *et al.*, 2010). Neural research will play a key role in establishing whether managers can improve long-term emotional regulation through learned mindfulness (Rock, 2009).

THE CASE AGAINST NEUROSTRATEGY

Many observers predict a bright future for interdisciplinary neuroscience. In law, Chorvat and McCabe (2004: 1735) predicted that neuroscience will ‘tell us how to significantly enhance compliance with law at a minimal cost and to encourage better forms of social interaction. This research will probably completely change the way we view nearly every area of law.’ In economics, Zak (2004: 1746) argued that ‘neuroeconomics provides a unified framework to measure physiological activity during the process of choice, and in doing so opens a window into human nature.’ In executive leadership, Rock and Schwartz (2007: 2–3) wrote that ‘scientists have gained a new, far more accurate view of human nature and behavior change... Managers who understand the recent

breakthroughs in cognitive science can lead and influence mindful change.'

At the same time, some social scientists remain unconvinced. For example, Gul and Pesendorfer (2008) argued that neuroscience cannot test economic models because economic models make no predictions about the brain. Economists typically concern themselves with observed conditions and choices—for example, the impact of a tax increase on savings—and not with intervening processes. In summarizing the challenge facing neuroeconomists, Bernheim (2009: 38) argued that 'most economists are not convinced by vague assertions that a deeper understanding of decision making processes will lead to better models of choice.'

Similar suspicions could be raised about neurostrategy. It could be argued, for example, that neurostrategy cannot answer strategy questions because strategic management asks no questions about the brain. On the other hand, such objections seem to beg the main question, which is whether strategy *should* be asking questions about the brain. Moreover, the analogy from economics to strategy is imperfect. Strategy researchers have always been concerned with intervening decision processes, giving them equal weight with strategies and outcomes (Hofer and Schendel, 1978; Fredrickson and Mitchell, 1984). If neuroscience gives genuine insight into the mechanisms of strategic choice, then it has direct relevance to strategy research.

A more serious concern is that neuroscience is reductionist and, therefore, unhelpful in explaining collective behavior. Although strategic management deals with general managers and other individuals, most of its key phenomena—market entry, acquisition, international expansion, etc.—occur at the level of the firm, strategic group, or industry. Strategy has traditionally taken the firm and industry as its primary units of analysis (Rumelt *et al.*, 1994), and its leading theoretical influences—industrial organization, institutional theory, the resource-based view, evolutionary views, etc.—make few or no assumptions about individual psychology.

Another aggregation problem is that strategy constructs may not be localizable in the brain. In social psychology, Willingham and Dunn (2003) distinguished between the first-order constructs of cognitive psychology (e.g., attention, memory)

and the second-order constructs of social psychology that have first-order constructs embedded in them (e.g., stereotyping, conformity). There is no 'stereotyping lobe' in the brain, even though stereotyping remains an essential construct in social psychology. By analogy, researchers in neurostrategy will not find brain regions devoted to market entry or resource allocation. According to Willingham and Dunn (2003: 668), 'the concepts that social psychologists use have a theoretical integrity of their own and should not be abandoned in favor of constructs that may be localizable but that will not be functional in a social theory... Social psychology should reserve its right to develop theoretical constructs that may not be localizable.'

If strategy constructs do not map conveniently onto the brain, there is a risk that neurostrategy could divert scarce financial and human resources from more productive uses. Dovidio *et al.* (2008) argued, for example, that large investments in neuroimaging research on racial discrimination can divert social researchers from macro-level studies of racism's cultural and social origins. The authors also cautioned social scientists not to be seduced by the impressive explanatory reductionism of hard science, arguing that neural data, especially high-resolution brain scans, have a presentational allure that masks logical inconsistencies. The authors cited experiments by Weisberg *et al.* (2008) in which researchers described psychological phenomena to neuroscience students and naïve subjects and then explained them using either irrelevant neuroscience data or no neuroscience data. Both the students and naïve subjects found irrelevant neural data more convincing than no neural data.

A significant problem in data interpretation is *reverse inference*: the practice of using neural measures such as blood oxygenation levels to infer mental states for which a particular region of the brain is 'known'—for example, using amygdala signals to infer fear or insula signals to infer disgust. As Poldrack (2006) noted, the fact that fMRI experiments elicit a BOLD signal in the brain does not imply that subjects actually experienced psychological events associated with that part of the brain.² For example, the amygdala is associated not

² BOLD is the acronym for 'blood oxygenation level dependent effect,' the ratio of oxygenated to deoxygenated blood cells, which is the quantity measured in fMRI scans.

only with fear, but also with bodily movements and the perception of sharp corners and musical tones; and the insula is associated not only with disgust, but also with empathy, pain, spatial learning, pitch perception, and speech production (Phelps, 2009). As Phelps (2009: 247) pointed out: 'although reverse inference is a powerful technique for generating hypotheses and ideas that inspire additional studies or measurements, its use as a primary technique for determining a role for emotion is questionable.'

In 2008, a working paper by Edward Vul and colleagues, entitled 'Voodoo correlations in social neuroscience,' caused a major academic stir that soon spilled into the popular press. The paper, later published as 'Puzzlingly high correlations in fMRI studies of emotion, personality, and social cognition' (Vul *et al.*, 2009), charged that social neuroscientists had reported correlations incommensurate with the degree of statistical reliability in their underlying measures. The authors argued that researchers who link psychological measures with BOLD signals could seldom observe statistical correlations greater than 0.70, yet studies reported correlations exceeding 0.80 and, in some cases, 0.95. The authors concluded that 'a disturbingly large, and quite prominent, segment of fMRI research on emotion, personality, and social cognition is using seriously defective research methods and producing a profusion of numbers that should not be believed' (Vul *et al.*, 2009: 285).

The Vul *et al.* (2009) paper set off a chain of replies, rejoinders, and clarifications (e.g., Lieberman, Berkman, and Wager, 2009; Lindquist and Gelman, 2009). Lieberman *et al.* (2009) objected to both the tone and substance of the claims and argued that the paper was itself methodologically flawed. Poldrack and Mumford (2009: 212) also cited flaws in the paper, but wrote, 'we believe that the paper by Vul *et al.*, despite its shortcomings, has done a service to the fMRI community by highlighting the need for methodological care and the potential for bias that can arise with some forms of analysis. We hope that the field will take these lessons to heart and ensure that fMRI results are never again open to the claim of voodoo.' These issues are still being debated and they show the need for vigilance in correlating neural data with independent measures of executive judgment or social cognition.

In social psychology, Willingham and Dunn (2003: 664) posed the following question: 'Consider what a critic might say: 'So the amygdala is active when people experience fear. So what? Why are we better off knowing it is the amygdala rather than the caudate?'' The 'so what' question raises a key challenge to the value of neural data in the behavioral sciences. Psychologists knew about fear long before the advent of fMRI scanners, and the fact that fear correlates with blood signals in the amygdala, though of great interest to neuroscientists, may have no consequences for theory or practice in psychology. By analogy, fMRI experiments in strategic management might tell us that market entry decisions activate the PFC and ACC, but can they tell us anything new about strategy theory or practice? For example, we already know that markets attract excess entry due to the overconfidence of potential entrants, most of whom believe their abilities are above average (Camerer and Lovallo, 1999). In fMRI studies, overconfidence will give a consistent pattern of neural activations—say, in the ACC and striatum—and this would be neurally interesting. But a skeptic could still ask 'so what?' If we already knew that entrants chose suboptimally (excess entry) and we knew why (overconfidence), what did we learn from neuroscience?

From an epistemological point of view, Bennett and Hacker (2003) raised a problem known as the *mereological fallacy*, the fallacy of ascribing to part of something what can only be true of the whole. According to Bennett and Hacker (2003), brains do not think, feel, see, or believe—these are activities performed by whole human beings and not by their parts, and we cannot ascribe them to brains or nerve cells. According to Bennett and Hacker (2003: 70–71), 'we recognize when a person asks a question and when another answers it. But do we have any conception of what it would be for a brain to ask a question or answer one? These are all attributes of human beings. Is it a new *discovery* that brains also engage in such human activities? Or is it a linguistic convention, introduced by neuroscientists, psychologists, and cognitive scientists, extending the ordinary use of these psychological expressions for good theoretical reasons? Or, more ominously, is it a conceptual confusion? Might it be the case that there is simply no such thing as the brain's thinking or knowing, seeing or hearing, believing or

guessing...that is, that these forms of words make no sense?³

THE FUTURE OF NEUROSTRATEGY

The sometimes vehement tone of the neuro-skeptics can be interpreted either as a reaction against exaggerated claims in the scientific and popular press or as evidence that neuroscience has captured the attention of social scientists and must be taken seriously. In either case, the debate will not be resolved by arguments. In the short run, neuroscience will continue to ride a steep growth curve in the social sciences, and its long run contributions will be assessed on a timescale of decades.

What does it all mean for strategic management? Taking an optimistic view, one could argue that strategy is well positioned to benefit from neuroscience for two reasons. First, behavioral strategy has always taken a cognitive view of executive judgment and decision making; whether researchers focus on strategic decision biases or cognitive schema, neural evidence can be interpreted through existing theoretical paradigms. Second, there is a lot of neural evidence available. Strategy researchers interested in competitive positioning have access to neural studies on social norms and punishment in competitive interactions (Knock *et al.*, 2010); researchers interested in decision making under risk have access to studies on the roles of trust (Baumgartner *et al.*, 2009) and reputation (Izuma, Saito, and Sadato, 2008); researchers interested in loss aversion and reference point framing have access to neural data on prospect theory (Fox and Poldrack, 2009). In short, behavioral neuroscience has left a large trove of neural evidence to be mined for insights in strategic management, and neuroeconomics in

particular has acted as a silent benefactor to behavioral strategy.

In future years, strategy researchers will find that neuroscience is increasingly called upon to resolve debates in behavioral strategy. Behavioral strategists have good reasons to familiarize themselves with the relevant neuroscience and to explore how neural methods can assist in construct validation, theory testing and improved strategy practice. Many strategy researchers who focus on firms and industries may prefer to take a 'wait and see' attitude toward brain research, and this is understandable. But researchers who do not keep informed of developments in behavioral neuroscience will find themselves facing theoretical claims and empirical data they do not understand.

Some behavioral strategists may want to become actively involved in empirical neuroscience. Linking neuroscience with strategic management involves a steep learning curve and long lead times in resource accumulation and interdisciplinary relationship building. Before applying neural evidence to strategy problems, researchers need to avoid duplicating prior efforts by understanding the current state of play in neuroeconomics and related fields. At the same time, they need to create links with researchers in disciplines like economics and experimental psychology, which have strong communities of neuroscience expertise and cumulative research agendas in behavioral neuroscience.

Behavioral strategists should also familiarize themselves with research methods in neuroscience. Although much of the attention has fallen on brain imaging, neuroscientists use a wide range of technologies and methods. For example, transcranial magnetic stimulation (TMS) temporarily disrupts neural firing in a specific part of the brain, allowing researchers to determine whether the region is causally necessary to the task at hand. Behavioral neuroscientists increasingly use multimethod designs—for example, Blankenburg *et al.* (2010) combined TMS with fMRI scanning to study the effects of parietal cortex on attention processing in the visual cortex, and Hsu *et al.* (2005) combined fMRI scanning with a lesion method to study risk and ambiguity. It is also possible to link fMRI evidence with non-neural methods, such as hormone ratios or electromyography (EMG), which detects electrical potentials in muscle tissue—for example, Chapman *et al.* (2009) found that moral disgust in an ultimatum game activated the same

³ Bennett and Hacker's (2003) critique draws on a comment by Wittgenstein (1958: section 281) in *Philosophical Investigations*: 'Only of a human being and what resembles (behaves like) a human being can one say: it has sensations; it sees, is blind; hears, is deaf; is conscious or unconscious.' Not all predicates are limited in this way—e.g., it is not logically absurd to claim that a person is sunburned and her arm is sunburned; or that she is in Europe and her brain is in Europe. The critique applies to psychological predicates: 'it makes no sense to ascribe psychological predicates (or their negations) to the brain, save metaphorically... The resultant combination of words does not say anything that is false; rather, it says nothing at all, for it lacks sense' Bennett and Hacker (2003: 71). For a materialist reply, see Dennett (2007).

facial muscles as bad tastes. Even when using single methods, neuroscientists often view their work in relation to cumulative meta-streams of research that embrace diverse methods. For example, a recent EEG study using ultimatum games to study social compliance and punishment behavior (Knoch *et al.*, 2010) cited prior work on this problem using fMRI scanning (Spitzer *et al.*, 2007) and transcranial direct current stimulation (tDCS) (Knoch *et al.*, 2008). In short, research in neurostrategy will require an understanding of multiple methods and how they interact in the accumulation of experimental evidence.

On the ultimate question of whether strategic management needs neuroscience, it is tempting to answer '*yes and no*.' On the positive side, neuroscience brings new methods and ideas to a fast-growing segment of the strategy field—behavioral strategy—that has natural links with psychology and behavioral neuroscience. Behavioral strategists have much to gain from collaborating with neuroscientists, and ignoring neuroscience involves risk of obsolescence. On the negative side, behavioral strategy is not a large segment of the strategic management field and had not given rise to its own interest group in the first 30 years of the Strategic Management Society.⁴ For researchers focused on firm- and industry-level problems, neuroscience may remain peripheral in the foreseeable future, though researchers will probably seek ways to achieve closer integration between traditional and behavioral strategy.

There is another important but less obvious question to consider: Does neuroscience need strategic management? This question matters for two reasons. First, it asks whether strategic management has its own research agenda in neuroscience, apart from the agendas of neuroeconomics or other fields. Although this is necessarily uncertain, it is a question that needs asking sooner rather than later. Second, strategy researchers who want to conduct empirical neuroscience must show neuroscientists that strategy brings something new and interesting to their field—that is, that strategic management gives neuroscientists access to social science expertise and research insights they cannot get from economics, law, politics, or marketing. If

strategy offers nothing new to neuroscience, then the future of neurostrategy is severely limited.

The remainder of this section identifies topic areas in which strategy may offer something new to neuroscience. The discussion is exploratory, and some of these topics could arise in one form or another in other fields. However, strategic management has at least two distinctive features with direct implications for empirical neuroscience: its mission of linking research to strategy practice and its emphasis on executive judgment and decision making in the context of the firm. From the time of its founding, strategic management has defined the internally differentiated firm as a distinctive psychological context for research on judgment and decision making (Simon, 1947; Cyert and March, 1963). Decision making in firms seldom means an individual making a discrete choice, but involves complex judgments in a climate of goal conflict, group bargaining, politics, and compromise. Implementation is costly and nontrivial and requires managers to motivate actors not involved in the decision. Strategic decisions entail large resource commitments with consequences for stakeholders beyond the decision makers, including employees, communities, governments, and investors. On the whole, the decision environment of the firm poses psychological questions that are in some ways distinctive to the field of strategic management.

The next discussion identifies research topics suggested by the psychological context of strategic organization. For one of these topics (group decision making), the discussion gives a detailed illustration of a potential collaboration in neurostrategy. For the remainder, the topics are mentioned without further detail.

Group decision making

Group processes are studied in many fields, including politics, sociology, social psychology, and organizational behavior (Kerr and Tindale, 2004). Group phenomena such as social identity, self-categorization, and ingroup bias may have evolved from ancestral kinship relations, reciprocal altruism, or cultural evolution—for example, groups with strong pro-social norms may have increased their survival prospects in intergroup competition through more vigilant defense of ingroup values and resources (Mesoudi, 2009). In behavioral neuroscience, researchers have investigated the neural

⁴ In 2010, the SMS interest groups were: (1) competitive strategy; (2) corporate strategy and governance; (3) global strategy; (4) strategy process; (5) knowledge and innovation; (6) practice of strategy; and (7) entrepreneurship and strategy.

correlates of outgroup discrimination, conformity, and related phenomena (Amodio, 2008).

Strategic management researchers focus on group processes that influence strategic decisions in firms. In this area, strategy researchers have discipline-specific expertise and a set of distinctive research questions. For example, decisions in large firms rarely fall to a lone decision maker, but involve a top management team comprised of senior executives representing product divisions or functional areas (Hambrick and Mason, 1984). These executives bargain for resources and identify in various ways with the goals of the firm, the subunits to which they are accountable, and their own private aspirations. This makes it difficult for top management teams to reach optimal decisions for the firm and raises key questions about strategy process and practice.

Some of these questions have been studied in behavioral experiments, such as how top management team members juggle the interests of the firm with those of the divisions or functions they represent. Blake (1959) called this the problem of 'organizational statesmanship,' or 'loyalty versus logic' (Blake and Mouton, 1961), and social psychologists ran many experiments to examine what happens when people try to optimize a joint decision while bargaining for resources on behalf of constituents. For example, Blake and Mouton (1961) and Benton and Druckman (1974) found that people bargain more competitively when representing constituents, and Duck and Fielding (2003) found that constituents prefer representatives who vigorously defend the group's position, even at the expense of other groups or the joint optimum.

These findings are interesting, but would be more useful to strategy researchers if they showed the mental states of constituents and representatives. This would allow researchers not only to explain what happened, but to predict behavior in experimental manipulations and real decision contexts. A top management team member might show loyalty to constituents for many reasons: psychological identification with subunit goals, perceived accountability to constituents, or disgust with the firm; and constituents might choose subunit loyalty over firm statesmanship out of self-interest, social comparison, ingroup bias, or identification with their representative. These conditions can be hard to adjudicate behaviorally,

and the corresponding mental states can only be inferred.

This is the kind of strategy problem where neuroscience can make a difference. For example, it is possible to modify a trust game so that, rather than bargaining for themselves, subjects bargain on behalf of one or more constituents who can either be known to the subject (for tests of social identification) or unknown (for tests of accountability) and who either share in the subject's payoffs or do not share. The research design goes beyond existing trustee-based studies, involving a stylized version of behavioral experiments on constituent representation, with repeated iterations and modifications for fMRI scanning. Previous studies have established a baseline for the neural encoding of cooperation, competition, and trust in interactive experiments using prisoner's dilemmas, ultimatum games, and trust games (Fehr and Camerer, 2007), and results can be compared with these baselines. For example, it is known that the neural processing of subjective rewards gives a different pattern of brain activations from the pattern associated with moral reasoning, or of regarding another person as part of the self (Dovidio *et al.*, 2008). The problem of constituent representation has many applications in strategy and organization, and neural methods offer a viable way of advancing this stream of research.

Attention

Attention is a shared topic of interest in strategic management (Ocasio, 1997) and cognitive neuroscience (Posner, 2004). In strategy, attention raises questions in problem identification (Starbuck and Milliken, 1988; Lyles, 1981); problem solving (Newell and Simon, 1972; Bower, 1967); resource allocation (Bower, 1970; Ansoff, 1965); strategic issue diagnosis (Dutton, Fahey, and Narayanan, 1983); and organizational mindfulness (Levinthal and Rerup, 2006; Weick and Sutcliffe, 2006). Strategy researchers interested in executive or group attention will find that these topics offer many points of contact with cognitive neuroscience.

Exploration and exploitation

Exploration and exploitation have been studied in animal, machine, and human learning (Krebs and Kacelnik, 1984; Kaelbling, Littman, and Moore,

1996; Cohen, McClure, and Yu, 2007; Daw *et al.*, 2006; Montague, King-Casas, and Cohen, 2006). Neural studies suggest that an area of the brain stem (the nucleus locus coeruleus) controls neurotransmitters that regulate the balance of exploration and exploitation (Aston-Jones and Cohen, 2005). In strategic management, exploration and exploitation refer to the tension between an organization's capacity to acquire new resources and its capacity to consolidate and operate effectively with existing resources (March, 1991; Sidhu, Commandeur, and Volberda, 2007). Using neural methods, it may be possible for strategy researchers to show how these individual and collective conceptions are merged in organizational decision making.

Decision making with uncertain implementation

In neuroscience experiments, the choices are often difficult, but implementation is usually trivial (e.g., pushing a button). In firms, implementation is usually more difficult than decision making, requiring motivation, resource mobilization, and major project implementation. Strategic decisions are often implemented partially, unsuccessfully, or not at all. Foreknowledge of uncertain implementation changes the psychological context of decision making—for example, by increasing ambiguity—and offers new opportunities for linking strategic management with behavioral neuroscience.

Corporate and competitive strategy

Research in corporate strategy deals with issues such as diversification, economies of scope, strategic alliances, and international expansion. The theory of dominant logic links corporate scope with executive cognition by attributing poor conglomerate performance to constraints on the cognitive schema of top executives (Prahalad and Bettis, 1986). Cognitive views of corporate strategy have clear links to behavioral neuroscience and offer many opportunities for collaborative research. The same is true for theories of competitive strategy that place the origins of competitive behavior in the cognitive schema of top managers (Baden-Fuller, Porac, and Thomas, 1989; Reger and Huff, 1993; Hodgkinson and Johnson, 1994). For example, neural methods would deepen our understanding

of executives' perceptions of industries and strategic groups and of the psychology of competitive versus cooperative strategies.

Firm routines and incentives

When costs and rewards are separated in time, individual decisions are subject to pathologies like impulsivity, procrastination, and addiction (Fudenberg and Levine, 2006; Gul and Pesendorfer, 2001; Akerlof 1991; Loewenstein 1988). Neural studies suggest that temporal discounting increases as people regard their future selves as distinct from their present selves (Ersner-Hershfield *et al.*, 2009). In strategic management, temporal discounting has been used to explain the structural features of firms—such as routines, hierarchy, incentives, and formal planning—which may emerge as solutions to the pathologies of individual self-control (Postrel and Rumelt, 1992). Habitual behavior and routines, as contrasted with goal-directed behavior, play prominent roles both in strategic learning in firms (Nelson and Winter, 1982) and in cognitive neuropsychology (Rangel, Camerer, and Montague, 2008; Lieberman, 2007), offering many joint opportunities for exploring the neural foundations of strategic behavior.

Leadership and entrepreneurship

In strategy practice, many people believe that innovative, risk-bearing entrepreneurs think and act differently than experienced managers of large corporations (Baron, 2007). Others believe that visionary and charismatic leaders think differently than less inspiring managers (Conger and Kanungo, 1987). Leadership research has already produced collaborations with neuroscientists and offers many ways of integrating neuroscience with strategy practice (Rock, 2009).

Decision making with advice

Executives often solicit external advice from firms like McKinsey and Boston Consulting Group. Consulting firms claim to add value by giving reputational weight to the firm's decisions, by taking an objective view of the firm, and by employing proprietary problem-solving processes. Research on the comparative thought processes of external

consultants and internal executives raises questions at the intersection of neuroscience, strategy research, and strategy practice. As technologies evolve, field researchers in neurostrategy will study such questions using technologies such as EEG and TMS, which do not restrict subjects to large and immovable scanners.

In raising these topics, the point is not that strategy researchers should immediately pursue them, but that productive collaborations with neuroscientists require distinctive research questions that can be addressed with neural evidence. Many scholars will find that their research questions do not require neural evidence or that the evidence already exists—for example, questions on moral choice, reputation, and social norms are being addressed in neuroeconomics. Rather than undertaking neurostrategy research, the next step is to engage seriously enough with behavioral neuroscience to determine whether a collaboration is necessary. Broadly speaking, a strategy topic does not require an empirical research program in neurostrategy unless it passes the following tests: (1) Does it address a core problem in strategic management research or practice? (2) Does it raise compelling new questions for neuroscientists? (3) Has it been neglected in other fields and is it likely to remain neglected? (4) Will neural evidence add to our understanding—and, if so, how (through construct validation, theory testing, or informing strategy practice)?

As a final point, strategy researchers should situate their neurostrategy problems within the theoretical conventions of neuroscience. Neuroscientists tend to evaluate theory from an evolutionary point of view, asking whether constructs and causal mechanisms could plausibly derive from considerations of survival, reproduction, or fitness. For example, a neural capacity for exploration and exploitation could have emerged from the survival value of foraging and storing resources in unstable environments; reference point framing could emerge from hierarchy and scarcity in animal and human competition; and impulsivity could survive as an evolutionary remnant of a time of short life expectancies and the absence of property rights to protect resources from expropriation. Neurostrategy questions that can be framed within evolutionary arguments are more likely to have theoretical legitimacy in neuroscience.

CONCLUDING REMARKS

Neuroscience has left an imprint on economics, law, marketing, and other disciplines and will continue to influence the social sciences. In strategic management, neuroscience offers new opportunities for strategy researchers to validate constructs, test theories, measure variables, and generate ideas, and it may offer ways to improve strategy practice. At the same time, neuroscience faces hard challenges in theory and measurement and has struggled to prove its capacity to solve traditional problems in the social sciences. On balance, researchers in behavioral strategy should explore the potential contributions of neurostrategy, even if the majority of strategy researchers remain on the sidelines. Strategy researchers can engage with behavioral neuroscience by evaluating its existing contributions to their research questions, identifying topic areas for neural research, and building relationships and institutional resources to support research in neurostrategy. With time, these relationships will lead to arrangements such as collaborative funded research projects, joint research seminars, and joint doctoral scholarships in neurostrategy. Even if neurostrategy remains a narrow specialization within the field of strategic management, it has the potential, on a longer time scale, to transform behavioral strategy. For researchers interested in the psychological foundations of strategic management, it offers exciting new opportunities at the frontiers of theory development and empirical discovery.

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REFERENCES

- Adenzato M, Garbarini F. 2006. The *as if* in cognitive science, neuroscience, and anthropology: a journey

- among robots, blacksmiths, and neurons. *Theory and Psychology* **16**(6): 747–759.
- Ainslee G. 1975. Specious reward: a behavioral theory of impulsiveness and impulse control. *Psychological Bulletin* **82**: 463–509.
- Akerlof GA. 1991. Procrastination and obedience. *American Economic Review* **81**: 1–19.
- Amadio DM. 2008. The social neuroscience of intergroup relations. *European Review of Social Psychology* **19**: 1–54.
- Amadio DM, Devine PG. 2006. Stereotyping and evaluation in implicit race prejudice: evidence for independent constructs and unique effects on behavior. *Journal of Personality and Social Psychology* **91**: 652–661.
- Amadio DM, Jost JT, Master SL, Yee CM. 2007. Neurocognitive correlates of liberalism and conservatism. *Nature Neuroscience* **10**(10): 1246–1247.
- Ansoff HI. 1965. *Corporate Strategy*. McGraw-Hill: New York.
- Aston-Jones G, Cohen JD. 2005. An integrative theory of locus coeruleus-norepinephrine function: adaptive gain and optimal performance. *Annual Review of Neuroscience* **28**: 403–450.
- Baden-Fuller C, Porac J, Thomas H. 1989. Competitive groups as cognitive communities. *Journal of Management Studies* **26**(4): 397–416.
- Baron RA. 2007. Behavioral and cognitive factors in entrepreneurship: entrepreneurs as the active element in new venture creation. *Strategic Entrepreneurship Journal* **1**(1/2): 167–182.
- Baumgartner T, Fischbacher U, Feierabend A, Lutz K, Fehr E. 2009. The neural circuitry of a broken promise. *Neuron* **64**(5): 756–770.
- Ben-Ari Y. 2008. Neuro-archaeology: pre-symptomatic architecture and signature of neurological disorders. *Trends in Neurosciences* **31**(12): 626–636.
- Bennett MR, Hacker PMS. 2003. *Philosophical Foundations of Neuroscience*. Blackwell Publishing: Malden, MA.
- Benton AA, Druckman DD. 1974. Constituent's bargaining orientation and intergroup negotiations. *Journal of Applied Social Psychology* **4**(2): 141–150.
- Bernheim BD. 2009. On the potential of neuroeconomics: a critical (but hopeful) appraisal. *American Economic Journal: Microeconomics* **1**(2): 1–41.
- Bettman J, Weitz B. 1983. Attributions in the board room: causal reasoning in corporate annual reports. *Administrative Science Quarterly* **28**: 165–183.
- Blake RR. 1959. Psychology and the crisis of statesmanship. *American Psychologist* **14**(2): 87–94.
- Blake RR, Mouton JS. 1961. Loyalty of representatives to ingroup positions during intergroup competition. *Sociometry* **24**(2): 177–183.
- Blankenburg F, Ruff CC, Bestmann S, Bjoertomt O, Joseph O, Deichmann R, Driver J. 2010. Studying the role of human parietal cortex in visuospatial attention with concurrent TMS-fMRI. *Cerebral Cortex* **20**(11): 2702–2711.
- Bower JL. 1967. *Strategy as a Problem-Solving Theory of Business Planning*. Harvard Business School Press: Boston, MA.
- Bower JL. 1970. *Managing the Resource Allocation Process*. Harvard Business School Press: Boston, MA.
- Brown KW, Ryan RM, Cresswell JD. 2007. Mindfulness: theoretical foundations and evidence for its salutary effects. *Psychological Inquiry* **18**(4): 211–237.
- Camerer C, Loewenstein G, Prelec D. 2005. Neuroeconomics: how neuroscience can inform economics. *Journal of Economic Literature* **43**: 9–64.
- Camerer C, Lovallo D. 1999. Overconfidence and excess entry: an experimental approach. *American Economic Review* **89**(1): 306–318.
- Camerer CF. 2003. *Behavioral Game Theory: Experiments in Strategic Interaction*. Princeton University Press: Princeton, NJ.
- Camerer CF. 2008. The potential of neuroeconomics. *Economics and Philosophy* **24**: 369–379.
- Campbell-Meiklejohn M, Woolrich R, Passingham R, Rogers RD. 2008. Knowing when to stop: the brain mechanisms of chasing losses. *Biological Psychiatry* **63**(3): 293–300.
- Carroll M. 2007. *The Mindful Leader: Ten Principles for Bringing out the Best in Ourselves and Others*. Trumpeter: Boston, MA.
- Chapman HA, Kim DA, Susskind JM, Anderson AK. 2009. In bad taste: evidence for the oral origins of moral disgust. *Science* **323**(5918): 1222–1226.
- Chib V, Rangel A, Shimojo S, O'Doherty JP. 2009. Evidence for a common representation of decision values for dissimilar goods in human ventromedial prefrontal cortex. *Journal of Neuroscience* **29**(39): 12315–12320.
- Chorvat T, McCabe K. 2004. The brain and the law. *Philosophical Transactions of the Royal Society, Series B* **359**(1451): 1727–1736.
- Cohen JD, McClure SM, Yu AJ. 2007. Should I stay or should I go? Exploration versus exploitation. *Philosophical Transactions of the Royal Society, Series B* **362**: 933–942.
- Conger JA, Kanungo R. 1987. Toward a behavioral theory of charismatic leadership in organizational settings. *Academy of Management Review* **12**(4): 637–647.
- Cyert RM, March JG. 1963. *A Behavioral Theory of the Firm*. Prentice Hall: Englewood Cliffs, NJ.
- Daw ND, O'Doherty JP, Seymour B, Dayan P, Dolan RJ. 2006. Cortical substrates for exploratory decisions in humans. *Nature* **441**: 876–879.
- DeMartino B, Camerer CF, Adolphs R. 2010. Amygdala damage eliminates monetary loss aversion. *Proceedings of the National Academy of Sciences* **107**(8): 3788–3792.
- Dennett DC. 2007. Philosophy as naive anthropology: comment on Bennett and Hacker. In *Neuroscience and Philosophy: Brain, Mind, and Language*, Bennett MR, Dennett DC, Hacker PMS, Searle J (eds). Columbia University Press: New York; 73–95.
- Denrell J. 2008. Superstitious behavior as a byproduct of intelligent adaptation. In *The Oxford Handbook of Organizational Decision Making*, Starbuck WH, Hodgkinson G (eds). Oxford University Press: Oxford, U.K.; 271–286.

- Dovidio JF, Pearson AR, Orr P. 2008. Social psychology and neuroscience: strange bedfellows or a healthy marriage? *Group Processes and Intergroup Relations* **11**: 247–263.
- Duck JM, Fielding KS. 2003. Leaders and their treatment of subgroups: implications for evaluations of the leader and the superordinate group. *European Journal of Social Psychology* **33**: 387–401.
- Dutton JE, Fahey L, Narayanan VK. 1983. Toward understanding strategic issue diagnosis. *Strategic Management Journal* **4**(4): 307–323.
- Elster J. 1985. *The Multiple Self*. Cambridge University Press: New York.
- Ersner-Hershfield H, Wimmer GE, Knutson B. 2009. Saving for the future self: neural measures of future self-continuity predict temporal discounting. *Social, Cognitive, and Affective Neuroscience* **4**: 85–92.
- Farb NA, Anderson AK, Mayberg H, Bean J, McKeon D, Segal ZV. 2010. Minding one's emotions: mindfulness training alters the neural expression of sadness. *Emotion* **10**(1): 25–34.
- Farb NA, Segal ZV, Mayberg H, Bean J, McKeon D, Fatima Z, Anderson AK. 2007. Attending to the present: mindfulness meditation reveals dissociable neural modes of self-reference. *Social, Cognitive, and Affective Neuroscience* **2**: 313–322.
- Fehr E, Camerer CF. 2007. Social neuroeconomics: the neural circuitry of social preferences. *Trends in Cognitive Sciences* **11**(10): 419–427.
- Fiegenbaum A, Thomas H. 1988. Attitudes toward risk and the risk-return paradox: prospect theory explanations. *Academy of Management Journal* **31**(1): 85–106.
- Fox CR, Poldrack RA. 2009. Prospect theory and the brain. In *Neuroeconomics: Decision Making and the Brain*, Glimcher PW, Camerer CF, Fehr E, Poldrack RA (eds). Academic Press: New York; 145–173.
- Franks D. 2003. Mutual interests, different lenses: current neuroscience and symbolic interaction. *Symbolic Interaction* **26**(4): 613–630.
- Fredrickson JW, Mitchell TR. 1984. Strategic decision processes: comprehensiveness and performance in an industry with an unstable environment. *Academy of Management Journal* **27**: 399–423.
- Fudenberg D, Levine DK. 2006. A dual-selves model of impulse control. *American Economic Review* **96**: 1449–1476.
- Glimcher PW, Camerer CF, Fehr E, Poldrack RA (eds). 2009. *Neuroeconomics: Decision Making and the Brain*. Academic Press: New York.
- Goldin PR, McRae K, Ramel W, Gross JJ. 2008. The neural bases of emotion regulation: reappraisal and suppression of negative emotion. *Biological Psychiatry* **63**: 577–586.
- Gross JJ. 1998. The emerging field of emotion regulation: an integrative review. *Review of General Psychology* **2**(3): 271–299.
- Gross JJ, John OP. 2003. Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology* **85**(2): 348–362.
- Gul F, Pesendorfer W. 2001. Temptation and self-control. *Econometrica* **69**(6): 1403–1436.
- Gul F, Pesendorfer W. 2008. The case for mindless economics. In *The Foundations of Positive and Normative Economics*, Caplin A, Schotter A (eds). Oxford University Press: New York; 3–39.
- Güth W, Schmittberger R, Schwarze B. 1982. An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior and Organization* **3**(4): 367–388.
- Hambrick DC, Mason PA. 1984. Upper echelons: the organization as a reflection of its top managers. *Academy of Management Review* **9**: 193–206.
- Hare TA, Camerer CF, Knoepfle DT, O'Doherty JP, Rangel A. 2010. Value computations in ventral medial prefrontal cortex during charitable decision making incorporate input from regions involved in social cognition. *Journal of Neuroscience* **30**(2): 583–590.
- Hare TA, Camerer CF, Rangel A. 2009. Self-control in decision-making involves modulation of the vmPFC valuation system. *Science* **324**: 646–648.
- Hariri AR, Bookheimer SY, Mazziotta JC. 2000. Modulating emotional response: effects of a neocortical network on the limbic system. *NeuroReport* **11**: 43–48.
- Harris LT, Todorov A, Fiske ST. 2005. Attributions on the brain: neuro-imaging dispositional inferences, beyond theory of mind. *NeuroImage* **28**: 763–769.
- Hoch S, Loewenstein G. 1991. Time-inconsistent preferences and consumer self-control. *Journal of Consumer Research* **17**: 492–507.
- Hodgkinson GP. 2008. Strategic management. In *Introduction to Work and Organizational Psychology: A European Perspective* (2nd edn), Chmiel N (ed). Blackwell: Oxford, U.K.; 329–350.
- Hodgkinson GP, Johnson G. 1994. Exploring the mental models of competitive strategists: the case for a processual approach. *Journal of Management Studies* **31**: 525–551.
- Hofer CW, Schendel D. 1978. *Strategy Formulation: Analytical Concepts*. West Publishing: St. Paul, MN.
- Hsu M, Bhatt M, Adolphs R, Tranel D, Camerer CF. 2005. Neural systems responding to degrees of uncertainty in human decision-making. *Science* **310**(5754): 1680–1683.
- Hsu M, Krajbich I, Zhao C, Camerer CF. 2009. Neural response to reward anticipation under risk is nonlinear in probabilities. *Journal of Neuroscience* **29**(7): 2231–2237.
- Izuma K, Saito DN, Sadato N. 2008. Processing of social and monetary rewards in the human striatum. *Neuron* **58**: 284–294.
- Kaelbling LP, Littman ML, Moore AW. 1996. Reinforcement learning: a survey. *Journal of Artificial Intelligence Research* **4**: 237–285.
- Kahneman D, Klein G. 2009. Conditions for intuitive expertise: a failure to disagree. *American Psychologist* **64**(6): 515–526.
- Kerr NL, Tindale RS. 2004. Group performance and decision-making. *Annual Review of Psychology* **55**: 623–655.

- Knoch D, Gianotti LRR, Baumgartner T, Fehr E. 2010. A neural marker of costly punishment behavior. *Psychological Science* **21**(3): 337–342.
- Knoch D, Nitsche MA, Fischbacher U, Eisenegger C, Pascual-Leone A, Fehr E. 2008. Studying the neurobiology of social interaction with transcranial direct current stimulation: the example of punishing unfairness. *Cerebral Cortex* **18**: 1987–1990.
- Knutson B, Rick S, Wimmer GE, Prelec D, Loewenstein G. 2007. Neural predictors of purchases. *Neuron* **53**: 147–156.
- Knutson KM, Wood J, Spampinato M, Grafman J. 2006. Politics on the brain: an fMRI investigation. *Social Neuroscience* **1**(1): 25–40.
- Krebs JR, Kacelnik A. 1984. Time horizons of foraging animals. *Annals of the New York Academy of Sciences* **423**: 278–291.
- Kuhnen CM, Knutson B. 2005. The neural basis of financial risk taking. *Neuron* **47**: 763–770.
- Lane V, Scott S. 2007. The neural network model of organizational identification. *Organizational Behavior and Human Decision Processes* **104**(2): 175–192.
- Langer EJ. 1997. *The Power of Mindful Learning*. Addison-Wesley: Reading, MA.
- Levinthal DA, March JG. 1993. The myopia of learning. *Strategic Management Journal* **14**(4): 95–112.
- Levinthal DA, Rerup C. 2006. Crossing an apparent chasm: bridging mindful and less-mindful perspectives on organizational learning. *Organization Science* **17**(4): 502–513.
- Lieberman MD. 2007. Social cognitive neuroscience: a review of core processes. *Annual Review of Psychology* **58**: 259–289.
- Lieberman MD, Berkman ET, Wager TD. 2009. Correlations in social neuroscience aren't voodoo: commentary on Vul, *et al.* *Perspectives on Psychological Science* **4**(3): 299–307.
- Lieberman MD, Eisenberger NI, Crockett MJ, Tom S, Pfeifer JH, Way BM. 2007. Putting feelings into words: affect labeling disrupts amygdala activity to affective stimuli. *Psychological Science* **18**: 421–428.
- Lindquist MA, Gelman A. 2009. Correlations and multiple comparisons in functional imaging: a statistical perspective (commentary on Vul, *et al.*, 2009). *Perspectives on Psychological Science* **4**: 310–313.
- Loewenstein G. 1988. Frames of mind in intertemporal choice. *Management Science* **34**: 200–214.
- Lyles MA. 1981. Formulating strategic problems: empirical analysis and model development. *Strategic Management Journal* **2**(1): 61–75.
- March JG. 1991. Exploration and exploitation in organizational learning. *Organization Science* **2**(1): 71–87.
- March JG, Shapira Z. 1992. Variable risk preferences and the focus of attention. *Psychological Review* **99**: 172–183.
- Mason MF, Morris MW. 2010. Culture, attribution, and automaticity: a social cognitive neuroscience view. *Social Cognitive and Affective Neuroscience* **5**: 292–306.
- McClure SM, Li J, Tomlin D, Cypert KS, Montague LM, Montague PR. 2004. Neural correlates of behavioral preference for culturally familiar drinks. *Neuron* **44**: 379–387.
- Mesoudi A. 2009. How cultural evolutionary theory can inform social psychology and vice versa. *Psychological Review* **116**(4): 929–952.
- Mezias SJ, Chen YR, Murphy P. 2002. Adaptive level adaptation in an American financial services organization: a field study. *Management Science* **48**: 1285–1300.
- Montague PR, King-Casas B, Cohen JD. 2006. Imaging valuation models in human choice. *Annual Review of Neuroscience* **29**: 417–448.
- Nag R, Hambrick DC, Chen M-J. 2007. What is strategic management, really? Inductive derivation of a consensus definition of the field. *Strategic Management Journal* **28**(9): 935–955.
- Nelson RR, Winter SG. 1982. *An Evolutionary Theory of Economic Change*. Belknap Press: Cambridge, MA.
- Newell A, Simon HA. 1972. *Human Problem Solving*. Prentice Hall: Englewood Cliffs, NJ.
- Ocasio W. 1997. Towards an attention-based view of the firm. *Strategic Management Journal*, Summer Special Issue **18**: 187–206.
- Ochsner KN, Gross JJ. 2005. The cognitive control of emotion. *Trends in Cognitive Science* **9**: 242–249.
- Ochsner KN, Ray RD, Cooper JC, Robertson ER, Chopra S, Gabrieli JD, Gross JJ. 2004. For better or for worse: neural systems supporting the cognitive down- and up-regulation of negative emotion. *Neuroimage* **23**: 483–499.
- Padoa-Schioppa C, Assad JA. 2006. Neurons in orbitofrontal cortex encode economic value. *Nature* **441**: 223–226.
- Padoa-Schioppa C, Assad JA. 2008. The representation of economic value in the orbitofrontal cortex is invariant for changes of menu. *Nature Neuroscience* **11**(1): 95–102.
- Phelps EA. 2009. The study of emotion in neuroeconomics. In *Neuroeconomics: Decision Making and the Brain*, Glimcher PW, Camerer CF, Fehr E, Poldrack RA (eds). Academic Press: New York; 233–250.
- Plassmann H, O'Doherty J, Rangel A. 2007. Orbitofrontal cortex encodes willingness to pay in everyday economic transactions. *Journal of Neuroscience* **27**(37): 9984–9988.
- Poldrack RA. 2006. Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences* **10**(2): 59–63.
- Poldrack RA, Mumford JA. 2009. Independence in ROI analysis: where is the voodoo? *Social, Cognitive, and Affective Neuroscience* **4**: 208–213.
- Posner MI (ed). 2004. *Cognitive Neuroscience of Attention*. Guilford Press: New York.
- Postrel S, Rumelt RP. 1992. Incentives, routines, and self-command. *Industrial and Corporate Change* **1**(3): 397–425.
- Powell TC, Lovallo D, Caringal C. 2006. Causal ambiguity and management perception. *Academy of Management Review* **31**(1): 175–196.

- Pralahad C, Bettis R. 1986. The dominant logic: a new linkage between diversity and performance. *Strategic Management Journal* **7**(6): 485–501.
- Priem RL, Cycota CS. 2001. On strategic judgment. In *The Blackwell Handbook of Strategic Management*, Hitt MA, Freeman RE, Harrison JS (eds). Blackwell: London, U.K.; 493–519.
- Rangel A, Camerer C, Montague PR. 2008. A framework for studying the neurobiology of value-based decision-making. *Nature Reviews Neuroscience* **9**: 545–556.
- Reger RK, Huff AS. 1993. Strategic groups: a cognitive perspective. *Strategic Management Journal* **14**(2): 103–124.
- Rock D. 2009. *Your Brain at Work*. HarperCollins: New York.
- Rock D, Schwartz J. 2007. Why neuroscience matters to executives. Available at: www.strategy-business.com (accessed 15 September 2011).
- Rumelt RP, Schendel D, Teece D (eds). 1994. *Fundamental Issues in Strategy: A Research Agenda*. Harvard Business School Press: Boston, MA.
- Salancik GA, Meindl JR. 1984. Corporate attributions as strategic illusions of management control. *Administrative Science Quarterly* **29**(2): 238–254.
- Samson K. 2007. Brain scans gain momentum as forensic evidence, but jury is still out on its relevance. *Neurology Today* **7**(7): 11–14.
- Sanfey AG, Rilling JK, Aronson JA, Nystrom LE, Cohen JD. 2003. The neural basis of economic decision-making in the ultimatum game. *Science* **300**: 1755–1758.
- Schaefer A, Collette F, Philippot P, Van der Linden M, Laureys S, Delfiore G, Degueldre C, Maquet P, Luxen A, Salmon E. 2003. Neural correlates of 'hot' and 'cold' emotional processing: a multilevel approach to the functional anatomy of emotion. *NeuroImage* **18**: 938–949.
- Schelling T. 1984. Self-command in practice, in policy, and in a theory of rational choice. *American Economic Review* **74**: 1–11.
- Schwenk CR, Tang M. 1989. Economic and psychological explanations for strategic persistence. *Omega* **17**: 559–570.
- Sidhu JS, Commandeur HR, Volberda HW. 2007. The multifaceted nature of exploration and exploitation: value of supply, demand, and spatial search for innovation. *Organization Science* **18**(1): 20–38.
- Simon HA. 1947. *Administrative Behavior: A Study of Decision-Making in Administrative Organizations*. Macmillan: New York.
- Spitzer M, Fischbacher U, Herrnberger B, Gron G, Fehr E. 2007. The neural signature of social norm compliance. *Neuron* **56**: 185–196.
- Starbuck WH, Milliken FJ. 1988. Executives' perceptual filters: what they notice and how they make sense. In *The Executive Effect: Concepts and Methods for Studying Top Managers*, Hambrick DC (ed). JAI Press: Greenwich, CT; 35–65.
- Staw BM. 1975. Attribution of 'causes' of performance: a general alternative interpretation of cross-sectional research on organizations. *Organizational Behavior and Human Performance* **13**: 414–432.
- Staw BM. 1981. The escalation of commitment to a course of action. *Academy of Management Review* **6**: 577–587.
- Sutcliffe KM. 1994. What executives notice: accurate perceptions in top management teams. *Academy of Management Journal* **37**(5): 1360–1378.
- Thaler RH, Shefrin HM. 1981. An economic theory of self-control. *Journal of Political Economy* **89**: 392–406.
- Tichy NM, Bennis WG. 2007. *Judgment: How Winning Leaders Make Great Calls*. Penguin: New York.
- Tom S, Fox CR, Trepel C, Poldrack RA. 2007. The neural basis of loss-aversion in decision-making under risk. *Science* **315**: 515–518.
- Vickers G. 1965. *The Art of Judgment*. Chapman & Hall: London, U.K.
- Vul E, Harris C, Winkielman P, Pashler H. 2009. Puzzlingly high correlations in fMRI studies of emotion, personality, and social cognition. *Perspectives on Psychological Science* **4**: 279–290.
- Weber EU, Johnson EJ. 2009. Mindful judgment and decision making. *Annual Review of Psychology* **60**: 53–85.
- Weick KE, Sutcliffe KM. 2006. Mindfulness and the quality of organizational attention. *Organization Science* **17**(4): 514–524.
- Weick KE, Sutcliffe KM, Obstfeld D. 1999. Organizing for high reliability: processes of collective mindfulness. *Research in Organizational Behavior* **21**: 81–123.
- Weisberg DS, Keil FC, Goodstein J, Rawson E, Gray J. 2008. The seductive allure of neuroscience explanations. *Journal of Cognitive Neuroscience* **20**: 470–477.
- Westen D, Blagov P, Harenski K, Kilts C, Hamann S. 2006. Neural bases of motivated reasoning: an fMRI study of emotional constraints on partisan political judgment in the 2004 U.S. presidential election. *Journal of Cognitive Neuroscience* **18**: 1947–1958.
- Willingham DT, Dunn EW. 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): 662–671.
- Wilson TD, Schooler JW. 1991. Thinking too much: introspection can reduce the quality of preferences and decisions. *Journal of Personality and Social Psychology* **60**: 181–192.
- Wittgenstein L. 1958. *Philosophical Investigations*. Basil Blackwell: Oxford, U.K.
- Zajac EJ, Bazerman MH. 1991. Blind spots in industry and competitor analysis: implications for interfirm (mis)perceptions for strategic decisions. *Academy of Management Review* **16**: 37–56.
- Zak PJ. 2004. Neuroeconomics. *Philosophical Transactions of the Royal Society, Series B* **359**: 1737–1748.