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Social Science Information 2006 45: 5
DOI: 10.1177/0539018406061100

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Abstract. *Political scientists have access to a number of competing methodologies that marshal different forms of evidence for their arguments about political phenomena. Recently a new form of evidence has appeared in political science research and, more frequently, economics: spatially explicit and time-varying neurological activity of human subjects engaged in political or economic decision-making. As with any of the more standard methodologies, this approach carries with it a set of orienting theories linking hypotheses with the types of data induced to support or falsify these theories. While this new form of evidence is exciting, especially for the empirically minded social scientist, it deserves the utmost scrutiny. I provide a review of how neurological imaging is being used in the social sciences and consider several problems and prospects of using neuroimaging data in political science.*

Key words. *Economics – Neurological imaging – Political decision-making – Political science – Social sciences*

Résumé. *Les sciences politiques ont recours à des méthodes de recherche et à des évidences empiriques diverses pour étudier les phénomènes politiques. Récemment, les chercheurs en sciences politiques et plus souvent encore en économie se sont tout particulièrement intéressés à l'activité cérébrale, objectivable dans l'espace et variant dans le temps, de sujets humains en situation de prise de décision politique ou économique. Comme toute autre méthode de recherche, cette approche s'appuie sur des*

I should like to thank Roger Masters, Darren Schreiber, Peter Stone, George Marcus, and attending scholars at the 2004 Association of Politics and Life Sciences Annual Meeting, Chicago, IL, for helpful comments. Of course, all eventual mistakes remain my own.

DOI: 10.1177/0539018406061100 Vol 45(1), pp. 5–33; 061100

orientations théoriques, qui font le lien entre les hypothèses de recherche et les données destinées à étayer ou invalider ces théories. Si cette approche nouvelle semble prometteuse, tout particulièrement pour les chercheurs à l'esprit empirique, elle mérite d'être examinée en profondeur. L'article fait le point sur l'utilisation des résultats de l'imagerie cérébrale fonctionnelle en sciences sociales et considère les différents problèmes qu'elle pose ainsi que les perspectives nouvelles qu'elle peut offrir en sciences politiques.

Mots-clés. *Economie – Imagerie cérébrale fonctionnelle – Prise de décision politique – Sciences politiques – Sciences sociales*

> The prospect of big corporations or political lobbyists enlisting brain science to manipulate consumer and voter behavior has inevitably raised concerns in some quarters; a watchdog agency founded by consumer advocate Ralph Nader, for instance, has asked the US government to investigate neuromarketing companies on public health grounds. But given the current state of the science, these worries seem premature. Cognitive science is not yet close to explaining or predicting human decision-making in the real world, and even advocates . . . admit that companies need to be more informed about the technology of fMRI if they are to understand its limitations. It is easy to be seduced by colorful pictures of brain activity and to believe that these images are rich in scientific content. But the images are highly processed and cannot be interpreted without a detailed understanding of the analytical methods by which they were generated. Moreover, these images are invariably produced under controlled laboratory conditions, and it is a major leap to extrapolate to a genetically and culturally diverse population of people in an almost infinite variety of real-world situations.
>
> *Nature Neuroscience*, 2004

People make political decisions and, like all behavior and decisions, there is some underlying neurological process. The quest to be able to generate a more complete understanding of political behavior by bridging "multiple levels of analysis" and connecting political science to neuroscience is exceedingly complicated for a variety of reasons (see Cacioppo and Visser, 2003). Beyond the complexity of studying politics this way is the equally important question of whether or not information on how, or why, the brain operates in this or that way is *helpful* in explaining behaviors that are of interest to political scientists. Observing a pattern of brain activity "x" alongside behavior "z" does not necessarily give us a better understanding of why "z" happened, or why departures from "z" happened, in the context of the political questions we are interested in.

Even if we identify a very tight sequence of connections between multiple levels of analysis, starting with neurological activity and environmental stimulation and moving up through cognitive and psychological processes to political behavior, we must consider how much each component contributes to the political behavior being studied. If the neuroscience is not doing any real work in the theory, i.e. generating specific and testable hypotheses that build on and critique our current understanding of political behavior, then it is of little use to political scientists. If neuroscience can do this, or, keeping the introductory passage in mind, can be reasonably expected to be developing in a way that soon will, then political science *writ large* should be at least interested.

The sheer possibility that we can bridge multiple levels of analysis in a rigorous manner is motivated by relatively recent advances in more fundamental fields like neuroscience and studies of cognition. Given these relatively recent advances, it appears that a number of social science disciplines are becoming increasingly interested in this sort of interdisciplinary work. This is good for neuroscience too. Politics, and other social science fields like economics, provide a rich source of human behavior to study.

I would like to encourage a certain sense of caution in how political science proceeds. While neuroscience and related disciplines (e.g. cognitive science) continue to make significant progress, there still remain considerable conceptual and methodological problems within these "natural" sciences *and* within the state of biologically grounded political theory. I remain optimistic that some political questions can be illuminated with neurological techniques, but point out that research projects must be explicitly aware of how unsettled disputes and problems migrate into their own studies and how their own perspectives influence the questions and approaches they take to their neuroscience colleagues.

To make these arguments I briefly remind the reader of the ongoing debates among political scientists about making the study of politics "scientific". Next, I review a neurological imaging technique, fMRI (functional magnetic resonance imaging), and how it is already being used and published in peer-reviewed journals by political scientists and economists today. This motivates a discussion on how particular theories within political science might suggest different approaches to using neurological imaging. To show the mutual influence of different disciplines on each other, I consider how the neuroscientific community suggests different conceptual positions (e.g. modular vs distributed processing), burdens of evidence, and types of information needed for analyzing social phenomena. This section centrally argues that the quest for "data" happens alongside conceptual development *and* salient attention to the *limitations* (both empirical and conceptual) of all fields. Given the highly interdisciplinary nature of this type of research such humility is indispensable. I conclude by considering the prospects of future neuroimaging research on political concepts like alliance formation and social cooperation, and argue that, like it or not, neuroimaging techniques will be increasingly used in future research on politics and economics simply because advances in social neuroscience need the rich social phenomena these fields have traditionally studied.

Substantive topics and methodologies abound

Two recent sets of articles in *PS: Political Science and Politics* (July 2003) and *Perspectives on Politics* (June 2004) consider how political science continues to develop and refine increasingly rigorous sets of theories that try to adhere to some vision of scientific process. Whether through quantitative or qualitative approaches, all of the contributors acknowledge the need for some type of evidence in order to be able to evaluate competing hypotheses. This evidence comes in many forms, and, necessarily, is influenced by the particular theoretical perspective of each researcher. Regardless of the approach taken, all of these techniques require some sort of evidence that permits a researcher to say that some set of variables are important for our explanations and some set of variables are not. While a more complete review of the numerous methodologies and approaches to political science would be nice, it would distract from the focus of this article. A limited selection of perspectives that interested readers might consult includes King et al. (1994), contributions to Friedman (1995), Morton (1999), Marsh and Stoker (2002), Goodin and Klingemann (1998), Theodoulou and O'Brien (1998), Granato and Scioli (2004), Smith (2004), and Tingley (2004). Suffice it to say that there is a plurality of ways to study politics and that development of evidence is not done in isolation of the theoretical position of the researcher. This should be the case so long as researchers strive to compare the relative weight and progress of arguments across theoretical and methodological boundaries.

My goal here is to explore how we incorporate new "types" of evidence in a way that clarifies existing debates about interesting empirical questions instead of simply adding novel methodological techniques.

One new "type" of evidence that is slowly surfacing in political science and economics research is of how the human brain processes political and economic situations. To explore this let us briefly review how an increasingly popular neurological imaging technique, functional magnetic resonance imaging (fMRI),[1] measures neurological activity, and then see how some political scientists and economists are actually using neurological concepts and fMRI data.

BOLDly going somewhere

Why should social scientists be interested in the activity of the brain? Interested political scientists and economists seem to be offering similar rationales, e.g. compare the contributions to the 2003 *Political Psychology* special issue on neuroscience (especially Cacioppo and Visser, Lieberman et al., Morris et al., Phelps and Thomas), McDermott, 2004, and Camerer et al., 2004, 2005. First, many political and economic decisions are made automatically without conscious reflection or calculation. This is important for many reasons, but probably most of all because it calls into question the decision-maker postulated in many rational choice models.[2] Second, emotions influence decisions, and emotional responses have corresponding neurological dynamics. Several studies in political science have implicated the affective system in decision-making. The common theme here is that many decisions occur at an automatic level until some sort of stimulus is unexpected or novel. The emotional system assists in being able to "turn on" higher-level conscious systems that analyze and deal with the novelty at hand (Marcus et al., 2000; Lieberman et al., 2003). Third, the same behavior can have multiple explanations that turn on different neurological mechanisms which then have different *substantive* implications.[3] So, if we are to accept that on the surface neuroscience might offer political science important insights, how do we analyze the functioning of the brain?

In order for the brain to function it needs oxygen. The oxygen is supplied by blood whose level of oxygenization can be measured. Local changes in brain activity appear to cause local changes in oxygen use. The dominant method of measuring these changes is through monitoring the BOLD (blood-oxygen level-dependent) signal through fMRI. This operates by measuring the differences in magnetic distortion of excited hydrogen molecules in oxygenated versus deoxygenated blood. From these measures we can get relatively precise spatial and temporal resolution of oxygen use in the brain. Critical to understanding the BOLD signal are the physiological mechanisms that govern blood flow and the establishment of a ''baseline'' rate of oxygen usage from which to compare changes due to stimulus and selected behaviors. The physiological mechanism that produces changes in blood flow predicts that there will be an initial dip in the BOLD signal, then a peak above baseline level as the system overcompensates for oxygen usage, and then eventually back to baseline level (Beauchamp, 2002; Heeger and Ress, 2002; Logothetis, 2003). The fMRI technique is not foolproof or monolithically interpreted, and below I go into some problems, in terms of both debates within the neuroimaging field and limitations that the fMRI technique places on political and economic research.

The use of neuroimaging data, here illustrated by fMRI, has been much more common in economics than in politics. This is possibly because economic concepts are much more readily explored and imaged with fMRI. Questions about concepts like rewards and bargaining (Montague and Berns, 2002; Sanfey et al., 2003), advertising (e.g. see www.thoughtsciences.com or www.brighthouse.com/neurostrategies.html; for a popular media review of advertising research see Thompson, 2003; Wells, 2003), and mentalization (the ability to consider the intentions and perceptions of others: Bhatt and Camerer, 2005; Blakemore and Decety, 2001; Ramnani and Miall, 2004) have been studied using fMRI techniques. The theoretical perspective of how the brain processes economic decision-making (Bhatt and Camerer, 2005; Camerer, 2003a, 2003b; Cohen and Blum, 2002; Glimcher, 2003) and the necessary methodological tools (e.g. Montague et al., 2002) are advancing in step.

Several studies have investigated social cooperation with fMRI imaging, a topic in which economists and political scientists have long been interested (McCabe et al., 2001; Rilling et al., 2002). Similarly, the influence of moral judgment on decision-making has been evaluated using fMRI imaging, resulting in interesting distinctions in the ways the brain processes different types of moral dilemmas (Greene et al., 2001). Insofar as an important element of politics is the resolution of conflicts between different moral or ethical claims, such studies should be regarded as a welcome contribution to political science. Similarly, fMRI imaging in experiments on the influence of race on judgment formation (Phelps and Thomas, 2003; for a review, see Ochsner and Lieberman, 2001: 720–1) and political sophistication (Schreiber and Iacoboni, 2004) have yielded interesting results.

Social science theories suggest neuroscience data

We have briefly seen how neuroimaging studies can supplement investigations of hypotheses about how people behave politically and economically. Let us now delve into more detail about how different approaches to studying political decision-making suggest different types of neurological evidence.

Camerer et al. (2005: 16) suggest that the operations of the brain can be explained by whether they are controlled or automatic, and whether they are cognitive or affective (visualized as a 2×2 diagram). Controlled/cognitive behavior is the traditional domain of economic rational choice, where actors consciously attempt to satisfy some utility function that they can explicitly evaluate. Controlled/affective behavior is what is used by "method actors" who consciously elicit emotional reactions. Campaigning politicians who strategically use nonverbal displays (or body language) to elicit emotions provide a concrete example in politics. Automatic/cognitive processes indicate the advantageous responses to factual information (and hence are cognitive) but are produced automatically. Examples of this include object recognition and motor processes. Finally, automatic/affective responses include feelings associated with experiences (such as fear or elation) and biological feelings like hunger and sexual drive. Because each of these categories may implicate different regions of activation in the brain, or patterns of activation across regions, different types of neurological imaging evidence might be necessary depending on what is being studied.

To clarify how this framework might play out in political science, let me suggest a hypothetical explanation of why citizens vote the way they do. Much of modern political science describes political decision-makers as consciously selecting candidates based on their estimates of how the candidate will satisfy their values and material needs. This is a controlled and cognitive process, and, in theory, more likely to activate an executive region of the brain such as the lateral prefrontal cortex (Knight and D'Esposito, 2003) that implements the strategic pursuit of goals. Quite plausibly, voters might also prefer candidates in part because they are physically attractive (Schubert and Curran, 2001; Stolberg, 2004; Tingley, 2002, forthcoming; similarly, see Zebrowitz, 1994). This would correspond to automatic/affective processing because it elicits a non-controlled response that is highly affective and likely processed in part by elements of the limbic portion of the brain; that John Fitzgerald Kennedy and John Edwards seem "cute" are feelings that are just "there" and not the result of conscious deliberation. Explanation of voter behavior thus might have two different theories and two different predictions of neurological activity (similarly, see Todorov et al., 2005). Of course, elements of both processes occur. The point is twofold: first, the type of political explanation being offered affects the type of neurological evidence that would be suggested; second, if both processes occur, fMRI could be used to study their relationship.

Two (slightly) different models

To investigate these possibilities in direct relation to ongoing political science research that involves neuroscience I explore two developing literatures: the "reflective/reflexive systems" model (Lieberman et al., 2003) and the "Affective Intelligence" model (Marcus et al., 2000). While these models share a considerable amount, they seem to suggest slightly different approaches to the role of cognition and affect in human political behavior, or they at least mutually suggest a considerable, and important, point of limited understanding within neuroscience that runs all of the way up to political science.

Reflexive and reflective processing: the C/X model

The Lieberman et al. (2003) model posits two different neurocognitive systems: the X-system and the C-system.

> The X-system (named for the "x" in reflexion), consisting of the lateral temporal cortex, amygdala, and basal ganglia, spontaneously and often non-consciously integrates current goals, context, perceptions, and activated cognition into a coherent whole that guides the stream of consciousness and current behavior. The C-system (named for the "c" in reflection), consisting of the prefrontal

> cortex, anterior cingulate cortex, and medial temporal lobes, is recruited when the X-system fails to create coherent outputs from the different sources of input. (2003: 689)

According to this model, the X-system guides behavior by incorporating a large range of information (e.g. sensory and motor processing, emotional and social information) until the C-system recognizes a problem in the X-system processes. It then "interrupts" or "overrides" and attempts to resolve the task at hand. In neurophysiological terms that illustrate the complexities of the process: the C-system is monitored by the anterior cingulate which upon detecting a problem sends a signal to the prefrontal cortex where a serial processing system resolves the situation.

Essentially this is the same distinction between automatic and controlled processes discussed above (Camerer et al., 2005: 16), but with a specification of how and why the brain modulates between the two. In their application of this model, Schreiber and Iacoboni (2004) show that politically sophisticated subjects are more likely than unsophisticated subjects to have elements of the X-system activated when asked political questions. This is because political "sophisticates", who have facility with names, dates, or political concepts and have habits of "associative links formed through extensive learning histories" (Lieberman et al., 2003: 689), are well accustomed to the processing of political topics. Thus, this model considers the activation/deactivation of reflexive and reflective processes in the brain and how this is mediated by (1) actual familiarity with a set of political topics (which captures the degree of familiarity/novelty of the situation) and (2) emotional feedback that unconsciously provides motivation to "analyze" increasingly unfamiliar situations that generate feelings of unease.

"Affective judgment"

Marcus et al. (2000) emphasize the role of affect much more centrally. Their approach builds upon Gray's (1987) model of behavioral approach and behavioral inhibition.[4] "The Behavioral Approach System gauges the success or failure of recalled actions, contemporary experience, and anticipated activities that fall within the category of previously learned behaviors" (Marcus and MacKuen, 2001: 45–6). Emotions implicated by this system range from enthusiasm to depression, and assist in evaluating the success or failure of strategic action. The Behavioral Inhibition System

> generates moods of calmness and relaxation when the match of incoming sensory signals against anticipated normal execution of plans indicates nothing of concern. It generates moods of increasing nervousness and anxiety when the comparison of environmental information and what would be expected from normal execution of plans indicates a mismatch. (Marcus and MacKuen, 2001: 47)

The combination of the Approach and Inhibition systems, which are chiefly constituted by the limbic system of the brain, helps individuals navigate the myriad uncertainties of politics.[5] While the Affective Intelligence approach has yet to make use of neuroimaging techniques like fMRI, the neuroscience literature it builds from has certainly begun to. Because this approach posits some set of neurological processes, fMRI and other imaging techniques will provide a better delineation of what these processes are and how they change under various conditions. The point developed below is that there may be differences in the theories developed by political scientists about how the brain engages in political decision-making that, in turn, suggest different neurological processes that could be observed through imaging techniques like fMRI.

Similarities and differences

It should be clear that both the C/X and Affective Intelligence approaches share some significant conceptual similarities. All emphasize the role of habits, automatic responses, and controlled processes. The main difference appears to be that the Affective Intelligence approach more explicitly theorizes the way affective systems modulate and engage controlled decision-making; the approach offered by Lieberman and colleagues seems much more focused on information and cognitive processing. Lieberman et al. (2003) do not explicitly theorize how the C-system "detects" inconsistencies in the X-system other than specifying that the anterior cingulate is activated. It seems that Lieberman et al. suggest a combination of (1) logical coherency of the decisions and behaviors being produced by the X-system and (2) a dynamic system of feedback with affective processes like anxiety that are generated through interaction with the external environment and mediated through some part of the limbic system. For example, research by Schreiber and Iacoboni

(2004) that builds on this model explicitly explores responses to political and non-political questions which contain evaluations of specific policies or political beliefs necessitating the (implicit) evaluation of logical arguments about political and economic claims and resulting in an agree or disagree answer. Thus, on the surface, it seems that while both models recognize the difference between controlled and automatic processes, cognitive elements modulate the interaction between the two more centrally in Lieberman et al.'s account, whereas affective systems do much more work for Marcus and colleagues.

All of the authors admit they only offer hypothetical and limited models; isolating precise differences that generate testable hypotheses will aid progress in collaborations between political scientists and other fields. As constructed, the Lieberman et al. and Schreiber and Iacoboni conception of political ''sophistication'' puts less focus on the influence of either affective responses to unfamiliar situations or affective loadings onto memories involved with the political topic at hand (as suggested by Morris et al.'s [2003] hot-cognition model). Conversely, Marcus and colleagues, and those following the hot-cognition model, identify an important influence of emotion on how a subject's political ''sophistication'' actually plays out, without attention to the cognitive experiences or resources of the actor. As stated, this certainly is not to say that the model set out by Lieberman et al. (2003) does not include a role for emotion, and in several places they point out, albeit somewhat vaguely, how fear conditioning in the amygdala and Jeffrey Gray's approach to motivation fit in (Lieberman et al., 2003: 687–8), and how neurological imaging could investigate the way questions can differentially prime respondents depending on the emotions elicited in those questions (2003: 691). However, again the emphasis appears clearly on cognitive processes.

This difference is made even clearer, and underscores the importance of their differences in neurological models to political science, by considering how each attaches their results to particular conceptions of democratic politics. Marcus clearly sees the problem of low political participation as a result of too little emotion, arising from a dominant intellectual and cultural perspective that sees ''passion as the enemy of reason'': ''[t]he most serious damage is done by continuing to endorse the normative conception of citizenship as a singularly cerebral reflection on justice and the common good'' (2002: 135). Of course this is somewhat qualified by a previous statement:

> to say that negative campaigns and sensationalized presentations by candidates, activists, and the media create the conditions for reason does not mean that we should automatically endorse *any* use of emotion. The particular circumstances and particular choices must, as with all particulars, be judged on the individual merits. (2002: 134)

The central theme, nevertheless, is that people could care less about politics not because they lack some sort of cognitive ability or exposure, but instead because prevailing notions of democracy discourage the role of affect.

This is quite different from the story Schreiber (a co-author of the Lieberman et al. paper) tells. Political novices need "models of how experts connect their values to policy choices" (Schreiber and Iacoboni, 2004: 8). That is, novices need exposure to the way people familiar with politics, from armchair Sunday morning junkies to DC policy-makers, connect what they value to how they participate democratically. Thus, to the extent that politics is embedded in ongoing and changing dynamics with different people, issues, and arguments, at some level this becomes a process of doing what our students should do more of – following current events in a cerebral fashion. Thus political novices "are not at recess" when thinking about politics beyond their immediate social context, and what is needed to help them is some way to familiarize themselves with the cognitive components of the political process.[6]

These differences not only have significant implications for approaches to democratic theory and policy positions that seek to increase and enhance citizen participation, but they also stem from different ways to focus on how the brain interacts with the political environment. These differences highlight both the multifaceted nature of how people engage in, and are engaged by, the political process, and our limited understanding of the way the brain works.

One might argue that the foregoing discussion exaggerates differences in the way the authors conceptualize the role of cognition and affect in modulating automatic and controlled processes. While I believe that such an argument is incorrect, especially given the different implications these authors draw for democratic theory more generally, my analysis suggests at a minimum how none of these current theories offers an explicit neurological account of the precise way decision-making goes from being automatic to controlled (and vice versa). Similarly, these models leave the interaction between cognitive and affective forces relatively unspecified, in large part because their interaction is not well understood in the neuroscience literature in the first place. Take the following excerpt from leading neuroscientist Joseph LeDoux:

> [t]here is still more confusion than consensus about the relation between emotion and cognition and the place of these two concepts in a theory of mind. The source of the confusion, I believe, is that the terms "cognition" and "emotion" do not refer to real functions performed by the brain but instead to collections of disparate brain processes. For example, on the cognitive side we have perception, memory, attention, action, and so on. But each of these turns out to be shorthand terms for more fundamental processes – vision versus touch, implicit versus explicit memory, attention versus preattentive processes, etc. And each can also be broken down into more fundamental processes – for example, visual perception is not a single process but is made up of a variety of component functions (e.g. form, color, motion processes). Similarly, emotions are made up of component functions (subjective experience, stimulus evaluation, physiological responses, feedback, elicited behaviors, voluntary behaviors, and so on), and it is likely that the brain representations of at least some of these functions are unique for different emotions. Thus, the true nature of the relation between cognition and emotion will not be understood until the interaction rules that relate component processes on both sides of the cognitive–emotional equation are specified. (LeDoux, 2000: 129)

Since democratic theory has historically addressed the relationship between affect and reason (e.g., for a review of how contributors to *The Federalist Papers* approached this, see Marcus, 2002: chapter 2), and recent scholarship has begun to build models of political behavior based on evolutionary and neurological sciences, understanding the neurological mechanisms that modulate emotion and cognition should be of interest to the democratic project and political science in general. Thus, a more specific evaluation of how emotional and cognitive processes interact, even "override" each other, is warranted.

A comparison, a test?

An example of a study that seems to *contrast* the approaches taken in the "Affective Judgment" and "reflective/reflexive" (C/X) models (a necessary precondition for a competing *test*), or at least focuses on the vagueness of how the "override" process works, is provided by an fMRI study by Pochon et al. (2002). The "Affective Judgment" perspective predicts that anxiety is increased when actors are in an unfamiliar context. This anxiety is then postulated to motivate conscious, rational, decision-making and "considered judgment". The cognitive nature of the C-system in the Lieberman model suggests that the role of emotion is less important in the actual "override" process. The brain's focus, during the override process, is on resolving the cognitive details of the decision task at hand, and thus difficulty in resolving these details is what drives the "override" process. Pochon et al. investigate reward systems in the brain and the cognitive difficulty of a task, thus blending motivational *and* cognitive elements. They suggest that with increasing cognitive complexity the limbic system (which integrally controls affective processes) is "gated", possibly so as to not interfere with (distract) the operation of higher-level cognitive areas like the dorsolateral prefrontal cortex.

> We suggest that a dynamic interplay is created between activated cognitive areas necessary to maintain a high level of cognitive performance (the network for WM [working memory] and attention) and affective areas deactivated because they may process counter productive signals interfering with performance. (2002: 5673)

Essentially this arises because as the cognitive demands of an experiment increase and the rewards that drive affective motivational responses also increase, an increase in anxiety could distract the subject and decrease the ability to keep up with an increasing cognitive load. The evidence suggested by Pochon et al. is that a gating mechanism occurs to reduce interference from the paralimbic system (such as the ventromedial prefrontal cortex) on cognitive systems like the dorsolateral prefrontal cortex. This gating process is related to the cognitive complexity of the task and the stakes at hand. The "override" process is initiated by emotional disturbance but then is gated and regulated depending on the cognitive demands of the task. One implication of this is that political scientists and economists might do well to consider more explicitly how the *stakes* and *complexity* of the decision environment influence behavior via interplay between cognitive and affective forces. This in turn might help neuroscience and related disciplines better study modulations between automatic and controlled processes.

Disagreements and limitations in the modern study of the human brain

The previous section argued that conceptual differences in "social" sciences can suggest different patterns of neurological activation as well as potential shortcomings in current neuroscience models.

This section argues a much more commonly stated, though not necessarily followed, idea that conceptual and technical problems in neuroscience and related disciplines can cause difficulties for social scientists interested in using insights and methods from these fields. First I consider the debate over ''modular'' vs ''distributed'' models of the brain. Then I discuss a series of technical difficulties and limitations of the fMRI technique, and show how these difficulties can have an impact on studies that would be of interest to social scientists.

Modular vs distributed information processing

Within neuroscience there is somewhat of a continuum of research perspectives on the question of modular (specific functions–specific brain modules) or distributed (specific functions–many brain regions) processing in the brain. While many studies seem focused on finding the functional properties of distinct neuro-anatomical regions, there is conflicting theoretical and empirical evidence resulting in caution regarding extreme positions in the modular/distributed debate (Cohen and Tong, 2001; for how this surfaces in *in vivo* and *in vitro* neurological studies, see Kurzban and Haselton, 2006; Steriade, 2001; Uttal, 2001). Indeed this issue has a very long history, a journey that is fascinating in its own right (Star, 1989).

For example, in considering the role of the amygdala in post-perceptual processing, Adolphs writes:

> [t]hese findings urge caution in the rigid assignment of cognitive processes to neural structures, because it is probable that a given structure participates in several processes, depending on the time at which its activity is sampled and on the details of the task and context. It is conceivable that the amygdala participates both in the initial, rapid evaluation of the emotional significance of stimuli, and in a later assessment within a given context and goal. (Adolphs, 2003: 169)

Note that Blank extensively investigates the role of the amygdala in research on aggression (2003b: 11–16). For studies to focus solely on the function of a given region, and/or exclude the influence of other regions, is clearly a mistake.

Furthermore, the role of a particular region not only is varied, but also can serve seemingly opposing functions. For example, the amygdala has been (partially) implicated in processing both negative feelings of fear and positive feelings associated with reward (Baxter and Murray, 2002). Lieberman et al. (2003: 683), based on a review of the extant literature with a most recent citation of 2002, maintain that in relation to affect the more important function of the amygdala is negative affect processing (although see Ochsner and Lieberman [2001: 726] for a review of the many different processes the amygdala has been implicated in). Clearly the function of the amygdala is neither agreed upon nor well understood in the neuroscience literature. A more multifaceted view of how the *various* functions of the amygdala could influence hypotheses would be preferable.

My purpose here is not to review debates about the role of the amygdala, or any other localized part of the brain, but instead to argue that hypotheses involving complex social behavior should explicitly incorporate ways that allow for the possibility that a particular region contributes to a behavior in more than one way and interactively with other regions. This requires an explicit formulation on behalf of political scientists and economists as to what psychological and institutional factors are relevant to the phenomenon being studied because the onus is placed on isolating exactly what the brain is responding to. Furthermore, a political theory that finds support from fMRI data that show activation or deactivation in a specific area is still limited in the comprehensiveness of the story it tells. For example, Schreiber and Iacoboni (2004) find that in political novices there is a deactivation in the medial posterior cortex when answering political questions, which might suggest a reallocation of resources. However, with the novices *as a whole* they did not find a significant *activation* in other regions, suggesting that the way political novices deal with cognitively challenging political questions is probably varied across individuals (Schreiber, personal conversation).

(Illusory) images

There are several technical problems with using fMRI that may or may not be relevant to researchers in political science or economics. The only reason why these problems bear mentioning is the need for awareness of possible conceptual or methodological problems from a separate field (neuroscience) complicating the study of something in another field (political science). For a political scientist to assume that technical and conceptual difficulties in neuroscience/

neuroimaging are minimal, at least in relation to their own experiments, would be unfortunate.

The measurements of decreases or increases in the BOLD signal are all compared to a "baseline" level that presumably assumes a lack of direct activation from external stimulus. This poses a difficult problem for several reasons. First, it appears that the "baseline" level of neurological activity "is already tuned to interpreting and categorizing the world as social" (Adolphs, 2003: 174). Thus, isolating the effect of neural activation must consider how the "background" activities of other regions also contribute to the process at hand. Establishing this "baseline" can be complicated not only by how an experiment is actually set up (in terms of the behavioral category selected as the "baseline"), but also by "task-independent" deactivations of particular regions by precise mechanisms that are not fully understood (Gusnard and Raichle, 2001; similarly see Overgaard, 2004). Second, the level of fMRI-captured BOLD signals over the baseline level of metabolism is quite small, further calling attention to significant effects of baseline activity on the observed amounts of the behavior of interest (Raichle and Gusnard, 2002; for example, see Schreiber and Iacoboni, 2004: 7).

Several theories involving political decision-making explicitly involve some conception of a baseline rate. In Lieberman et al. (2003), the C-system monitors the output of the X-system at some level. When the X-system cannot generate a coherent output, the C-system is activated. This suggests several questions. At what level is the C-system monitoring? That is, how "tuned in" is the C-system and how does this level differ across individuals? In the "Affective Intelligence" theory, emotions modulate the processing of information and ensuing behaviors. But given that the brain appears to do some monitoring of sensory input in an ongoing, non-specifically activated manner, where does the role of these emotions begin and end? To argue, as some theorists do, that emotions modulate sensory information before the details of political information are processed (Marcus et al., 2000: ch. 4) makes an assumption about a baseline level of monitoring that changes depending on feelings of enthusiasm or anxiety. Unfortunately, such theories of politics do not then specify what normal "everything makes sense" functioning in response to social stimuli looks like versus non-normal "this is not what is expected to be happening" functioning. Without a better understanding of the contribution of "baseline" activity to normal human functioning in response to diverse situations and types of information, investigations of neural activations will be necessarily vague in terms of what they imply.

The BOLD response may be affected by normal aging processes, moreover, complicating the interpretation of results that use subjects that span age groups or extrapolation of studies from one age group to another (D'Esposito et al., 2003). Given the questionable propensity for experimental studies to use college undergraduates, this may not be much of a problem in terms of internal validity. However, conflicting results using differing age demographics should be avoided by proper experimental designs that adequately incorporate provision for possible physiological differences due to age, personality, neurotoxins, and even effects of common substances like caffeine (Laurienti et al., 2002). Such findings may provoke interesting new research into the relationship between political (and economic) behavior and neuro-physiological changes over time or substance exposure.

Individual variations in brain anatomy pose a challenge for functional location in the brain (Brett et al., 2002). While significant steps have been made in permitting better localization, there still remain significant problems in anatomical localization without a better understanding of the functional properties of parts of the brain that are being localized. This becomes increasingly acute as localization moves to higher-order functions beyond the primary motor and sensory cortical areas. This is especially relevant to social scientific investigations as they are more likely to be interested in the functioning of sub-areas of the prefrontal cortex which pose significant difficulties in functional localization (Way, 2003).

Finally, fMRI does have a somewhat limited degree of time resolution, usually between 1 and 4 seconds, due to signal/noise problems that emerge. Additionally, higher temporal resolutions have revealed nonlinearities in the BOLD signal and the normalization of the BOLD signal takes between 16 and 20 seconds, creating similar temporal resolution problems (Pfeuffer et al., 2003). While other imaging techniques with better temporal resolution, such as event-related potential (ERP) measurements, can be used in conjunction with fMRI, a number of practical issues emerge due to the use of strong magnetic fields (Schreiber, personal conversation). Regardless, vast improvements have been made in the recent past and everything points to similar progress in the future. It is important to note that whether or not temporal resolution poses a problem for a specific study depends on the theorized time spans for which the brain is expected to be performing the experimental operations. Of course, such information might not be known beforehand.

Neurological activation and observable behavior

Social scientists have inevitably looked to some form of behavior as evidence for their theories. Whether this is voting, response timing, or changes in physiological conditions such as heart rate, some form of observable behavior is central to most social scientific inquiries. Neurological imaging provides a form of evidence that itself would not be considered a behavior, though most studies seek to align some sort of behavior with a pattern of neurological activation. However, in the neuroscience literature there are questions over whether behavioral evidence is *always* necessary in tandem with neurological evidence. Such arguments have interesting implications for how social scientists might use neurological imaging data.

Wilkinson and Halligan (2004) note that four possibilities exist when measuring behavioral responses along with neurological imaging: (1) a response in both; (2) a behavioral response but no neurological response; (3) a neurological response but no behavioral response; and (4) a response in neither. Obviously the first condition is most desirable. The second condition might occur when different environmental conditions recruit the same behavioral strategies but at different efficiencies. Such a case is predicted by theories that have a ''common cognitive-anatomical architecture that underlies several independent functions'' (2004: 71). The third situation is of most interest to Wilkinson and Halligan, who argue that in certain experimental conditions finding neural activity while not seeing direct behavioral changes is not necessarily indicative of some spurious neurological process. It is possible that the behavioral responses are too subtle to be picked up. Or,

> [t]his pattern could arise if the two experimental conditions tapped different underlying cognitive strategies, both which happened to impart similar time courses and patterns of error on task performance. In other words, condition 1 recruits strategy A, which occupies anatomical site X; condition 2 recruits strategy B, which occupies anatomical site Y; but both A and B operate at the same level of behavioral efficiency. (2004: 71)

The neuroimaging literature, or neuroscience more generally, has not yet formulated a procedure for how to approach these situations.

An example of this sort of issue emerging in social scientific work using neuroimaging is reviewed by Phelps and Thomas (2003). Reviewing studies of facial recognition and bias between racial groups, they note how explicitly measured racial bias (via surveys) did not correlate with either implicit measurement of race bias (via a "startle" measurement using unfamiliar faces of in and out group races) *or* the activation of the amygdala. However, interestingly, the implicit measurement of preconscious bias and neurological activation of the amygdala were correlated.

> By showing a brain region whose activation response is correlated with indirect [preconscious] but not direct [conscious] measures of evaluation, this study supports the idea proposed by social psychologists that attitudes toward social groups can be expressed both directly and indirectly and that these two means of expression may represent different underlying processes. (2003: 752)

The implication here is that we must be very careful when choosing the types of behavioral data to examine in conjunction with the imaging data.

Disagreement among neuroscientists is illustrated by Phelps and Thomas, who argue contra Wilkinson and Halligan for the indispensability of behavioral measures.

> Functional neuroimaging techniques pick up on signals indicating brain activity. These signals, by themselves, do not specify a behavior. Only by linking these brain signals with behavior do they have psychological meaning [. . .] Assessing brain activity may aid our understanding of a behavior, but the psychological meaning of these brain signals comes from their link to behavior. Discovering the brain activation pattern linked to a behavior does not change the importance of that behavior. It is also unlikely to tell us something about ourselves that we could not conclude from the behavior itself. (2003: 755)

Obviously this issue has important implications for both the design of experiments and the ability to make inferences from neurological and behavioral information. Clearly, studies of interest to political scientists will need some sort of behavioral component but, depending on what is being studied, it is unclear what should minimally be expected. The idea that different behaviors are activated with differing degrees of efficiency, and that our measures of behavior may not be nuanced enough to pick up on behavioral changes, suggests the need for critical inquiry into establishing evidential requirements.

These issues are by no means an exhaustive list of problems that face social scientists interested in using neuroimaging techniques such as the increasingly popular fMRI. Additional issues include the appropriate statistical procedures (Lee et al., 2004), analysis design for acceptable statistical significance calculations (*Nature Neuroscience*, 2001), and necessity of lesion studies for ruling out spurious relationships in imaging data (Adolphs, 2003: 166). It warrants restating that these methodological problems can migrate into the substance of the social scientific theories being evaluated. For example, given that the baseline neural activity could be processing some part of the environmental challenge (say, exposure to the face of someone in "another" race), results that do or do not show activation in a particular region (say, the amygdala) are difficult to interpret. Without a better conceptual understanding in neuroscience itself, significant mistakes can be made in interdisciplinary work that is too aggressively optimistic about the current state of neuroscientific understanding.

fMRI (coffins) and the "real" world

I believe that a passing note is needed on the use of neuroscience for studying, or extrapolating to, socially situated behavior in the real world. The vagaries of culture have an enormous influence on the ways in which people interact. So do the functional psychological mechanisms that were produced by the evolutionary development of our species (Cosmides and Tooby, 1992, 1994). So too do their interactions (Tingley, 2004). S*pecific* instantiations of decision-making are influenced by a network of symbolic representations that constitute our political and economic marketplaces. Identities do exist. Party (product) loyalties are encouraged or discouraged by more than the cost and benefit of proposed policies (akin to the price and quality of commercial products) and their neurological substrates. This poses a crucial difficulty for "neuropolitics". While the way symbolic relationships are neurologically represented, such as the "hot-cognition" model of memory or the "Coke/Pepsi" research[7] that was popularly reported, has been *roughly* explored, neuroscience appears limited in the precision that it can offer. The associative memories and identities, institutions, and social possibilities that "symbols" help tie together are extremely complex in their own right. To suggest, as some prominent political scientists (e.g. Bates et al., 1998; Johnson, 1997, 2000) have done, that elites strategically manipulate symbols and rituals certainly pierces the complexity of political decision-making, but the contribution of neuroimaging techniques to these complicated processes will remain limited for the near future. While this represents a considerable problem, it should be viewed primarily as a rallying call for future research. Here especially, conceptual and empirical progress in neuroscience can be greatly reinforced by using properly designed studies in political or economic contexts.

Conclusion

The possibilities for interesting interdisciplinary work between political scientists and neuroscientists are immense. For example, the study of coalition formation has long been a principal focus for political scientists. Ranging from individualistic rational choice theories to more modern institutional theories, theories of coalition formation play a central role in the study of politics. Accessing the neurological and psychological dimensions of coalition formation would be a welcome avenue of research. What are the neurological substrates of screening potential partners? As coalitions become more salient, are there changes in how the brain monitors possible disruptions or deviations? Is the decision by someone with political experience to join a coalition identical in process to what a political novice would use? More generally, the prospect of social cooperation (such as in the prisoner's dilemma) is a central theme in political science. The political decision-making underlying coalition formation and cooperation involves (to name just a few) trust, monitoring, reputation, reciprocation, evaluation of the intentions of others, and estimation of payoffs and rewards. All these traditionally central concepts are beginning to be probed in neuroscientific work, as illustrated by a recent study of altruistic norm enforcement (de Quervain et al., 2004). Both political scientists and neuroscientists stand to gain from working together to better explicate many crucial features of modern political science, just as increasing numbers of economists have begun to explore neuroscientific methods.

Our understanding of the human brain, and its relation to higher levels of explanation in the study of humans, will come from *both* the development of theory and collection of evidence; fMRI and related technologies give political scientists and economists an expansive new source of raw data. However, just as a failure to focus on conceptual, as opposed to empirical, progress undermines political science "pre-neuropolitics" (Johnson, 2002, 2003), so should we be concerned about similar problems with the development of "neuropolitics". To this end, political scientists, economists, and neuroscientists need to work with each other in ways that explicitly acknowledge limitations in their conceptual framework and measurement techniques. This will serve to prevent empirical studies based on incompatibilities between multiple levels of analysis or spurious explanations. Furthermore, the general tenor of such research need not set off alarms in the general public about neuroscience evidence influencing political and economic decisions (e.g. *Nature Neuroscience*, 2003, 2004; Wahlberg, 2004).

Let me also address some points about the practicality and/or feasibility of using imaging techniques like fMRI in social science research. First, it is not necessarily the case that an fMRI study will be much more expensive to conduct than a study gathering and using data from, say, the US National Election Study (NES) (Schreiber, personal notes). Furthermore, funding needs can be distributed across disciplines, especially if political scientists become adept at posing questions that the biological sciences would find revealing for their own purposes. Second, as Camerer et al. note, "(c)ould creating a general multiple-system model of the brain really be that much harder than doing general equilibrium theory" (2004: 575)? Their point is merely that the difficulty of pursuing some new methodology, and thus the amount of time and resources a project requires, should be evaluated in reference to other methodologies in use.

Given that political science seems to be discussing the merits of different "scientific" approaches to political science, such as ongoing debates on rational choice theory, neuroscience may be able to provide fresh perspectives on seemingly incommensurable research traditions. Lupia's (2002) efforts to bring formal modeling of psychological processes into political explanation, Bueno de Mesquita and McDermott's (2004) recent statement on prospect theory, and Blank's (2003a) discussions of public policy all seem to suggest the ground is fertile for novel approaches to inquiry in political science. While political science can gain from research in neuroeconomics, political science rightly speaks to a number of empirical questions that are uniquely or highly political. Politics offers an extremely rich source of information about human emotion, cognition, and behavior: alliance formation, provision of public goods, use of force, and partisanship, to name just a few. These are early stages of a new set of theories and investigative methodologies; further scientific exploration should tread slowly yet surely.

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Notes

1. I do not focus on other imaging technologies, such as positron emission topography (PET), because of the growing frequency with which fMRI is being used (PET requires the administration of a radioactive substance into the blood stream) and because many of my general arguments will cross-apply.

2. Of course, rational choice theory does not specify that people must be "conscious" or in "control" of their decision-making process in order to be rational, or even modeled as being rational (my thanks to Peter Stone for reminding me of this; Ordeshook, 1995: 178). However, in my experience the way rational choice theory is most often used is in explanations where the posited actors *are* conscious and acting intentionally. This stems from the intentionalist form of explanation being used (Elster, 1983; Tingley, forthcoming) and a number of problems that arise in explanations of rational behavior that posit unconscious decision-making. For example, if a decision process is unconscious, what mechanisms are posited that connect the external environment with the unconscious execution of strategies based on previously held beliefs and preferences? Of course, the neuroscience program explored here is trying to build those mechanisms instead of relegating them to the black box that rational choice theorists purportedly try to avoid (Boudon, 1998).

3. Camerer et al. (2005), citing Romer (2000), gives the example of two people who do not eat peanuts. One person likes the taste of peanuts but consciously does not eat them because of an allergy. The other person had an averse experience with peanuts but can still eat them; not eating peanuts is a habit formed from a harsh memory. The observation of "not eating peanuts" can be explained in two ways. However, each method of explaining suggests different economic consequences like differences in price elasticity. The fellow who gets a foul taste from peanuts could be paid to eat them, but the one who risks severe anaphylactic shock would not, or at least only in a significantly more lucrative manner. Thus, the economic concept of price elasticity is clarified by recognizing the different neurological processes that underlie the "revealed" preference of not liking peanuts. The work of Darren Schreiber and colleagues suggests a similar example from political science: responses to political questions can be habit-based due to a high degree of familiarity with the issue (sophistication) or the result of a highly conscious effort to construct a response given a very low level of familiarity with the subject (Lieberman et al., 2003; Schreiber and Iacoboni, 2004). As discussed below, their work has explicitly incorporated neuroimaging techniques into their study designs.

4. Interestingly, Marcus and MacKuen (2001) find that the third piece of Gray's model, relating to "fight–flight"-type interactions, is "of limited application" to the study of politics, presumably because of the primitiveness that such a situation involves (2001: 44). Morikawa et al.'s (2002) analysis of cognitive requirements in "hawk–dove" games paints a more central picture for "fight–flight" situations in political interaction.

5. Another well developed theory, which I do not cover here only for simplicity's sake, is known as the "hot-cognition" model. It argues, among other things, that political concepts are stored in memory with affective associations attached to them. Thus, exposure to these concepts generates automatic affective impressions upon recall (Lodge and Taber, 2000; Morris et al., 2003). For a general review of the role of emotions in politics, see Marcus (2000, 2002, 2003).

6. Schreiber acknowledges that such a reading of his work is plausible, though he maintains more of an agnostic stance here: both affective and cognitive forces can plausibly modulate responses to political "facts" and arguments. Further, how both of these systems do this is not well understood, largely because much of the study of affect in relation to politics is too oriented towards the study of disaffiliative affect like fear and anxiety (Schreiber, personal conversation).

7. See Lodge and Taber (2000) for their "hot-cognition" model that has not been extended to political symbols, but, readily and importantly, should be. In an unpublished study, Read Montague and colleagues examined how the more salient "brand name effect" of Coca-Cola is neurologically represented in the prefrontal cortex (see Thompson, 2003).

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