S|S|S

Social Studies of Science
41(4) 515–538

DOI: 10.1177/0306312710397689
sss.sagepub.com
SAGE

The shortsighted brain: Neuroeconomics and the governance of choice in time

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Abstract
The young field of neuroeconomics converges around behavioral deviations from the model of the human being as *Homo economicus*, a rational actor who calculates his choices to maximize his individual satisfaction. In a historical moment characterized by economic, health, and environmental crises, policymakers have become increasingly concerned about a particular deviation for which neuroeconomics offers a biological explanation: Why do humans value the present at the expense of the future? There is contentious debate within the field over how to model this tendency at the neural level. Should the brain be conceptualized as a unified decision-making apparatus, or as the site of conflict between an impetuous limbic system at perpetual odds with its deliberate and provident overseer in the prefrontal cortex? Scientific debates over choice-making in the brain, we argue, are also debates over how to define the constraints on human reason with which regulative strategies must contend. Drawing on ethnographic and archival research, we explore how the brain and its treatment of the future become the contested terrain for distinct visions of governmental intervention into problems of human choice-making.

Keywords
economics, epistemology, governance, liberalism, neuroeconomics, neuroscience, policy, rationality

An undergraduate in jeans and a ponytail doffs her winter parka and climbs onto the bed of an fMRI [functional magnetic resonance imaging] machine. Joseph Kable, neuroscience postdoctoral researcher and economics neophyte, helps position the student's head and body so that she will be able to keep absolutely still through the hundreds of choice trials she will

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> undergo over the next hour and a half. He hands the young woman earplugs from a half-empty industrial-size box and positions a mirror above her eyes to reflect a computer screen placed at the back of the machine. Kable leaves the room and shuts the door. The lights go out and the machine begins its roar.
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> Outside the magnet room, where we watch through a glass panel alongside Kable, another screen flashes the first choice presented to the student inside the scanner: $212 in six months or $53 in two. Her answer is marked with a check: $212 six months from now. The next choice: $20 today or $50 in two months. Her answer: $20 today. (Authors' fieldnotes, 2006)

Since the late 1990s, a new space of scientific expertise has been emerging in the laboratories of elite universities, at the meetings of scientists and their public policy colleagues, in *Science* and *Nature* and other academic journals, and in the popular media. Located at the intersection of neuroscience, economics, and psychology, the field of neuroeconomics converges around behavioral deviations from the model of the human being as *Homo economicus*, a rational actor who calculates his choices to maximize his individual satisfaction. Neuroeconomists look to the biological substrate of the brain for clues to the puzzles of consumer action – why people often make decisions to buy, sell, invest, and trade in ways that seem to go against their best interest. Going a step farther than behavioral economists, who argue that policy designers need to take seemingly 'irrational' choices into account, neuroeconomists insist that they need to understand how such choices get made in the brain.

In this article we focus on neuroeconomic research into 'future discounting', or the tendency forego future well-being for immediate gratification.[1] This particular puzzle, a longstanding concern of liberal governance, has become a flash point for the young field. In experiments such as Kable's, above, neuroeconomists design tasks that can isolate and make legible the brain's evaluations of rewards in and over time, operationalizing the future in the form of 'inter-temporal choice', or a choice between something now and something later. Inside the scanner, the subject weighs her preferences. How long is she willing to wait for a given amount of cash? As she trades off the value of money against time, the scanner takes pictures of her brain activity. In these images, neuroeconomists attempt to discern the neural mechanisms by which human beings value – and often undervalue – the future.

In a historical moment when American policymakers increasingly link the shortsightedness of citizens' microeconomic decisions to urgent problems – from individual conditions such as addiction and obesity to collective conditions such as the credit crisis and even global warming – there are high stakes to probing the neurobiological mechanisms underlying humans' calculations (and miscalculations) about the future.[2] Why do Americans spend today when the financial demands of retirement require saving for the future? Why do they keep reaching for candy bars and fried food when they know that heart disease can result from high calorie diets? Ongoing crises of economy, health, and environment challenge the notion that individuals can be expected to comport themselves according to the tenets of rational action; the model of human beings as prudent choice makers conflicts too starkly with the actual behavior that has triggered contemporary calamities.

Although policymakers continue to encourage citizens to pursue their own self-interests as a path to maximizing collective well-being, they have begun to look to

neuroeconomics for a model of the human being that can lend conceptual support to economic, social, and health policies designed to address a subject different from the traditional rational actor. By arming themselves with an understanding of citizens as fundamentally calculating, but also neurologically ill-suited to the contemporary landscape of choice, lawmakers from Washington's heights to the corridors of state agencies hope to design policy interventions that can accommodate both the capacities and limitations of human decision-making.

But how exactly should these capacities and limitations be modeled? Within the field of neuroeconomics, there is heated debate around the mechanisms of future discounting, and the kind of model of the brain that best represents those mechanisms. Does future discounting reflect the constitutional myopia of a single value system within the brain, or an inner contest between impulsive and rational brain systems? In other words, should the brain be conceptualized as a unified decision-making apparatus, or as the site of conflict between an impetuous limbic system at perpetual odds with its deliberate and provident overseer in the prefrontal cortex? Does the problem lie with the brain as a whole, or in the balance between opposed neural systems? Although this debate does not neatly divide the field into its constituent disciplines, with all neuroscientists taking one side and all economists the other, it does fracture along epistemological lines: neuroscientists trained in the experimental methods of natural science tend to favor a 'single system' model that can accommodate the complex morphological and functional constraints of the brain, while economists' strong theoretical tradition leads them to favor a 'dual systems' model that can reduce the brain and its functions into mathematically manageable formulae.[3] As it turns out, each model of the biology underlying future discounting endorses a different vision of the human actor, different sites of accountability, and, potentially, different kinds of governance and remediation.

When the neuroeconomics of future discounting is drawn into policy debates, what becomes of its impassioned internal debate? How do differing models of the brain influence thinking about how, and whether, the government should regulate citizens' choices in the long-term interest of individuals and the nation? Does it matter to policy whether choices derive from a unified or split valuation system? In other words, do epistemological politics bear any relationship to wider governmental politics, and if so, what kind of a relationship is it?

These queries extend longstanding discussions among social scientists regarding the relationship between science and the broader social and political environment in which it is practiced. In the late 1970s, historians and sociologists of science argued that contexts of political insecurity and the clashing of rival beliefs in society at large could create conditions for novel and sometimes controversial scientific ideas to emerge, and that these ideas could loop back into public debate. Steven Shapin, for instance, showed how social and political concerns and values were debated and sometimes reconfigured in the so-called 'phrenology disputes' of 19th century brain science (Shapin, 1979). Our own study similarly focuses on a key dispute among the practitioners of an emergent field of brain science in a time of economic and political instability. We track the debate as it travels between the scientific field and the political field, where policymakers increasingly refer to neuroeconomic insights in the unresolved dilemmas surrounding contemporary behavioral regulation. Since the 1990s, an era that President George Bush

and the US Congress famously designated as the Decade of the Brain, 'notions of what it means to be particular kinds of persons, populations and political subjects are increasingly bound up with the meanings, explanations and theories of contemporary neuroscience' (Vrecko, 2010: 2).[4] Scientific debates over choice-making in the brain, we argue, are also contests over how to define the constraints on human reason with which governance strategies must contend.

As we will show, governmental reformers seize upon the model of choice in the brain that they can most readily harness to their pre-existing political agendas, while the other model languishes; in the process, the potential for neuroeconomics to fundamentally reconfigure the choice-making subject of policy founders. We begin our story by laying out the field's ambitious bid to redefine the human choice-maker. Next, we closely examine the scientific debate around future discounting as it moves through academic conferences, scientific journals, media accounts, and scientific shop talk. Drawing on our interviews, observations, and literature reviews, we identify the moments of conflict, coalescence, translation, and incomprehension that arise in the course of this debate. The neuroscientists, psychologists, and economists participating in the new field invoke wide-ranging constituencies for their ideas, from authors and readers of popular accounts of science, to interested colleagues in far-flung subfields, to policymakers; their attempts to translate the biology of human choice for these audiences feed back into the scientific work itself, further linking the politics of academic fields to the broader social and political field. Finally, we examine how and why one model of the brain gains traction in discussions of policy reform, while the other falls away.

Economics comes to life

'[I]t has become abundantly evident', wrote two neuroscientists in the introduction to a special issue of *Neuron* published in 2002, 'that the pristine assumptions of the "standard economic model" – that individuals operate as optimal decision makers in maximizing utility – are in direct violation of even the most basic facts about human behavior' (Cohen and Blum, 2002: 197). As MIT neuroeconomist Drazen Prelec put it: 'Utility maximization has the advantage of being mathematical and precise, but the flaw of being incorrect' (interview with authors, 2006). The dissonance between observed human behavior and economic models devised to capture that behavior drove the ascendance of behavioral and experimental economics starting in the late 1970s.[5] Grounding their research in empirical data, either constructed in a laboratory or drawn from more naturalistic settings, these subfields have documented countless instances where human behavior does not seem to follow the laws of rational economic action; on the contrary, their data has shown that people systematically depart from such laws when they weigh information and judge probabilities.

Nevertheless, the theoretically-driven mainstream of economics has continued to dismiss such findings as amounting to an atheoretical and inconclusive 'collection' of behavioral anomalies, insisting that existing models can be refined to accommodate such divergences.[6] Over the last decade, the continuing resistance to behavioral and experimental approaches led a group of practitioners to search for scientific partners who could help them *explain* rather than merely catalogue anomalous behaviors. In their

eyes, the tools and techniques of neuroscience – particularly brain imaging[7] – offered the possibility of a unifying theory that could legitimately challenge classical rational actor models. The hope was that neuroscience could link the calculative anomalies they had been documenting for the last 25 years to the biological substrate of the brain. Instead of shoring up existing economic models to account for human departures from rationality, this radical new approach would query life itself as a way to derive alternative models – models based in nature rather than the self-referential discourse of mathematics.

Neoclassical economics formulates its understandings of human valuation and choice making without attention to psychological and biological processes. The field, which matured at a time when it was impossible to measure such processes at the neural level, instead developed parsimonious mathematical equations to predict choice behavior (Camerer et al., 2005). Mainstream economics continues to concentrate its efforts on refining such equations, uninterested in the actual mechanisms of choice making as these are assumed to mirror subjects' preferences. 'So far, the decision process has been, for economists, a black box', says Aldo Rustichini, an economist by training. Economists who believe that neuroscience can open the black box that their discipline has constructed around the choice mechanism often raise the ire of their neoclassical colleagues. Paul Glimcher, an NYU neuroscientist and early organizer of neuroeconomics, related an 'apocryphal and famous moment' that he witnessed at an early meeting of neuroscientists, psychologists, and economists, at Princeton University in 2001. Responding to the question of what contribution neuroscientific evidence might make to his field, a highly esteemed theoretical economist and mathematician uttered an expletive and the declaration: 'I think you contribute nothing to economics.' Behavioral economist Colin Camerer, another founder of the new field, has staked his career on the disagreement: anything less than neural-level explanation, he publically insists, is 'brainless economics'.[8] As Camerer sees it, economics should overcome its staunch conservatism and explore the choice-making processes that lie behind the skull and precede conscious acts of choice. To this end, the neuroeconomic partnership marries economic experiments that have been honed to solicit aberrant behavior with brain imaging, particularly functional magnetic resonance imaging (fMRI), a technology that tracks how brain states change in response to real-time experimental stimuli. During the administration of 'behavioral probes' such as the choice task presented at the start of this paper, fMRI records the intensity of cell-firing through different regions of a subject's brain, illuminating the neural pathways involved in each decision.[9]

Like economists, neuroeconomists characterize decision making as a process in which 'a system must assign value to each of its available choices' (Montague et al., 2006: 417). Instead of an abstract calculation, however, value assignment is understood to unfold along the neural circuitry of the brain. Neural tissue performs economic evaluation by means of what Read Montague at Baylor School of Medicine calls 'internal currency', translating the money metaphor into the cellular and chemical structures of the brain. 'Instead of dollars and cents', *The New York Times* explains, 'the brain relies on the firing rates of a number of neurotransmitters – the chemicals, like dopamine, that transmit nerve impulses' (Blakeslee, 2003). Levels of neural activation assign value by signaling how a given prospect has lived up to an individual's expectations in the past. In this

sense, choice is conceived as a fundamentally temporal process; past and future are essential reference points for every decision.

After the neural system has computed the difference between the expected and actual value of a particular reward, this value gets registered in the orbitofrontal/striatal system (OFS), an area of the brain that serves as 'a neural clearing house for comparing different needs and setting priorities for action based upon these' (Montague and Berns, 2002). For living creatures, the first step in any decision – whether to follow a flashing light that might promise food, for instance, or to walk away from it – is to query the OFS's database (which is constantly updated with new experience, so as to confer better predictions) and formulate a representation of likely reward associated with that decision. Choice making thus proceeds 'through a probabilistic policy'. As Glimcher's former mentor Wolfgang Schultz declared at a conference celebrating the publication of the first neuroeconomics textbook, 'the brain is a prediction machine'.

Competing models of choice in time

If the neural valuation system works by comparing choice outcomes across time, how does it assign worth to time itself? While it is clear that a reward's nearness or distance in time can amplify or diminish its worth (more proximate rewards, that is, are more highly valued), the rate by which individual brains discount the future is fuzzy at best. Until recently, the most commonly used framework to make sense of this rate came directly from economics. The theory of 'discounted utility' proposes that individuals discount future rewards by an amount that increases exponentially as a given reward recedes in time. An example of exponential discounting would be the stable, linear interest rates that banks pay to holders of savings accounts as compensation for delaying their consumption (see Ainslie, 2001). This theory leaves the rational actor model intact by assuming that people are unwavering and consistent in their rate of discount, marking down an entity's reward value in accordance with its temporally diminishing objective worth. As a widely read paper in neuroeconomics indicates, '[i]t is well accepted that rationality entails treating each moment of delay equally, thereby discounting according to an exponential function' (McClure et al., 2004: 504).

Yet people and animals alike 'exhibit much steeper devaluation over the near term than is predicted by exponential discounting' (Montague et al., 2006: 433; see also Lowenstein and Prelec, 1992; Montague and Berns, 2002: 280). In other words, '[t]he exponential discount function fails to match several empirical regularities' (Chabris et al., 2008). Like pigeons and rats – although not to the same extreme – people sharply over-value immediate rewards relative to future ones (Laibson, 1997).[10] With this empirical finding, experimental and behavioral economists began to shift their thinking. Discounting appeared to be *hyperbolic* rather than exponential, following an inconsistent rate of discount that renders a discount curve in the shape of a hyperbola rather than a gradual slope (see Fig. 1).

What is going on in the brain to render the shape? For the remainder of this article, we will consider two divergent answers to that question. Does the inconsistent valuation seen in the phenomenon of hyperbolic future discounting arise from competition between two systems, or does a single system generate the inconsistency? In other words, does the

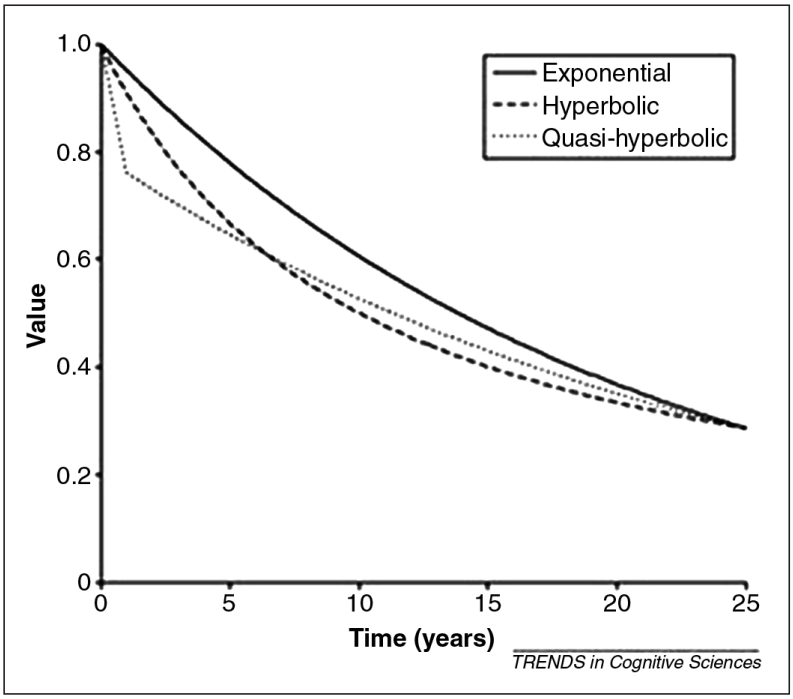

Figure 1. Graphical renderings of temporal discount functions (Berns et al., 2007: 483).

problem lie with the person as an integrated whole, or in a contest between competing selves? Neuroeconomists trained in axiomatic methods prefer to explain it by modeling the brain as the site of a conflict between opposing, mathematically representable systems, while those more attuned to the complexities of the biological data prefer to model the brain as a unified system of valuation whose laws we cannot yet mathematically parse. As we will see, epistemological differences among neuroeconomists not only animate the field's internal debate over future-discounting, but also play a critical role in determining which model of the short-sighted brain is most readily embraced in the policy field.

Of two brains

> In Aesop's classic fable, the ant and the grasshopper are used to illustrate two familiar, but disparate, approaches to human intertemporal decision-making. The grasshopper luxuriates during a warm summer day, inattentive to the future. The ant, in contrast, stores food for the upcoming winter. Human decision makers seem to be torn between an impulse to act like the indulgent grasshopper and an awareness that the patient ant often gets ahead in the long run. (McClure et al., 2004: 503)

The 'dual-brain hypothesis' represents a variation on the theme of split-selfhood that has been articulated at numerous points in Western thought. Plato famously described reason as a charioteer attempting to steer the twin horses of passion and spirit. Adam Smith wrote of the tension between interests and passions, arguing that coolheaded capitalist calculation could mitigate the dangers of hotheaded affect. Sigmund Freud developed a theory of the *Ego* as the site of a fraught battle between an overseeing *Superego* and a

shortsighted, impulsive *Id.* Later theories in the fields of psychology, cognitive science, economics, and political philosophy went on to reiterate the idea of the self as comprising distinct systems of competing tendencies, although notions of what constitutes these systems and the nature of the competition between them have shifted. Most posit two systems entwined in a bipolar relationship, such as controlled versus automatic (Benhabib et al., 2004; Schneider and Shiffrin, 1977), cold versus hot (Metcalfe and Mischel, 1999), effortful versus effortless (Baumeister, 2002), deliberative versus impulsive (Frederick et al., 2002), conscious versus unconscious (Damasio, 2008), planner versus doer (Thaler and Shefrin, 1981), patient versus myopic (Fudenburg and Levine, 2006), abstract versus visceral (Bernheim and Rangel, 2004; Loewenstein and O'Donoghue, 2006), and most simply, System 2 versus System 1 (Frederick and Kahneman, 2002).[11]

In contemporary neuroscientific versions of this hoary model, an affective system (described by words such as fast, emotional, unconscious, automatic, experiential, associationist, connectionist, and analogical) is understood as rooted in the mesolimbic areas of the brain, while a contrasting analytic system (described as slow, logical, conscious, hypothetical, creative, forward-looking, and abstract) is rooted in more recently evolved cortical regions which are impervious to the temptations of present rewards and reprise the themes of temperate affect said to emerge from the calculations of enterprise in early theorists of capitalism (Hirschman, 1977). Writing in *Science* in 2004, neuroscientists Samuel McClure and Jonathan Cohen teamed up with economists David Laibson and George Loewenstein to offer a distinctively neuroeconomic spin on split-selfhood, bearing the declarative (and, some would say, argumentative) title: 'Separate neural systems value immediate and delayed monetary rewards'. The highly influential piece has provided rich soil for the debate over the phenomenon of future discounting. In the experiment on which the article is based, subjects were asked to choose between Amazon.com gift certificates of different monetary amounts and delivery delays while lying in an fMRI scanner: $20 now or $30 in 2 weeks; $5 in 2 weeks or $10 in 4 weeks; $20 in 4 weeks or $40 in 6 weeks. The neural data recorded during the experiment's choice trials led the authors to conclude that distinct neural systems appraise near and far-term rewards (McClure et al., 2004: 504). Future discounting, they argued, reflects competition between a midbrain dopamine system that is activated by immediately available rewards, and prefrontal cortical areas that are activated by all prospective rewards, 'irrespective of delay' (McClure et al., 2004: 503).[12] The phylogenetically 'older' limbic system – emotional, impulsive, and myopic in its functioning – overrides the analytical, deliberative, calculating valuation of the 'newer', prefrontal cortex. Having begun their article with reference to Aesop's classic fable of the grasshopper and the ant, the authors finish by suggesting that 'within the domain of inter-temporal choice, the idiosyncrasies of human preferences seem to reflect a competition between the impetuous limbic grasshopper and the provident prefrontal ant within each of us' (McClure et al., 2004: 506).

Despite their frequent use of metaphor, proponents of the dual-brain hypothesis frequently literalize the competition between the future-focused cortical regions and their present-biased mesolimbic challengers. On the first day of the 2007 annual meeting of the Society for Neuroeconomics, Randy Buckner, a neuroscientist from Harvard University whose task it was to educate economists on the basics of neuroscience, explained to his charges: 'These brain systems are probably competing with each other

in non-linear ways …. With fMRI we can see battles between brain systems as they are taking place.' Science journalists have seized upon this idea, writing articles with such titles as 'Brain battles between short term emotions and long term logic' (Parker, 2004; Princeton University, 2004).

In economics, the idea of internal competition preceded attention to the brain. Two decades before neuroeconomics existed, behavioral economists like Richard Thaler at the University of Chicago constructed a model of competition between internal selves, showing that it was possible to apply game theoretical approaches within a single individual by treating the individual as more than one system (Thaler and Shefrin, 1981). Departures from consistent rationality could then be understood as the result of game interaction between selves – in the case of hyperbolic discounting, between a rational–deliberative self able to consistently rate value over time (identified by economic shorthand as the *delta* parameter) and an emotional-irrational self prone to grab for immediate rewards (identified by economic shorthand as a *beta* parameter) (Elster, 1984); Phelps and Pollack, 1968). As vulgar as the *beta–delta* simplification seems, it offers heuristic elegance in the form of a neat equation that accurately predicts the inconsistent rates of temporal future discounting – regardless of whether or not it accurately depicts their brain mechanisms. Glimcher explains: 'At a mathematical level – which is what economists at heart love – it was a brilliant and important insight. Of course, the question was asked at the time, "But it's actually one person; so what does that mean? There are two people inside that person?" To which [Thaler] replied, "Well, maybe there really are two people inside that person – who knows? The brain is a strange thing …"' (interview with authors, 2005).

Thaler's student Colin Camerer, along with other game-theoretically influenced behavioral economists, thus come to neuroeconomics with a ready-made model of split agency in tow, and proceed to map its beta and delta parameters onto the physical brain through scanning technology. Neural regions that appear to be consistently active and exponentially evaluative no matter the time delay of a reward are designated as *delta*, while those which are 'activated disproportionately when choices involve an opportunity for near-term reward' are identified as *beta*. The hyperbolic curve of future discounting is reconceived as *quasi*-hyperbolic, for it reflects two different discounting rates operating at the same time, in tension (Laibson, 1997; see Fig. 1); decisions are understood as the vector outcome of competition between planful and impulsive systems.

One brain, one self

Although neuroscientists participating in the new field of neuroeconomics specifically look to economists for the heuristics and behavioral theories with which they can illuminate brain imaging data, many take umbrage at the cavalier manner in which their collaborators seek to simplify the complexity of the brain's neural system for the sake of explanatory power.[13] While the field of psychology has developed its own native 'dual-systems' and 'multi-modal' models of the brain, the *beta–delta* model that has come to dominate the neuroeconomics of future discounting is one that derives primarily from economics and its tradition of game theory – and one that neuroscientists and psychologists tend to regard as a gross distortion of the human choice-making process.

Instead of two selves competing for dominance inside the brain, they believe that the phenomenon of hyperbolic discounting must originate in an integrated set of systems working in concert to produce a value signal.

The disagreement can become quite fraught, as economist Julian Jamison describes: 'Neuroscientists get really annoyed, justifiably I think, when you say, "Here's the discounting region of the brain." They don't want it to be a discrete region, they want it to be a whole system' (interview with authors, 2005). Colin Camerer reports that NYU neuroscientist Elizabeth Phelps once 'stood up at an economics conference and said, "This whole idea of a limbic system as a separate system has been debunked. I don't know what you're talking about." It was like, "On behalf of neuroscience, I denounce you!"' (interview with authors, 2005). The stakes of the disagreement are high; for proponents of an integrated model of choice, the status of empirical evidence in the burgeoning science of neuroeconomics is at risk.

When a story on the young field appeared in *The New Yorker* (Cassidy, 2006; see also Coy, 2005; Parker, 2004), Phelps' colleague Glimcher could hardly contain his irritation at the journalist's portrayal of neuroeconomic research. The article led with a description of the brain as neatly divided into the older impulsive and newer controlled regions. As Glimcher explained to us, 'We biologists just can't wrap our heads around the idea of split agency, of a non-whole organism'. In his view, this idea purloins and misinterprets neurological data in a way that resurrects a kind of Freudian subject that has long been discredited in his field. Emotion-oriented neuroscientists such as Antonio Damasio have specifically argued that reason *depends* on emotion, and have even described emotion as a 'decision-making device'. 'Emotion is *in* the reason', Damasio pronounced at a gathering for the first neuroeconomics textbook (Damasio, 2008). He has gone so far as to banish the phrase 'limbic system' from his laboratory.

David Laibson explains why he avoids the phrase when speaking with his colleagues in neuroscience:

> Neuroscientists don't like the word 'limbic system' – it's too crude a term for all the different suborgans that sometimes get lumped together and sometimes get pulled apart. Do you want to count a dopamine projection into the prefrontal cortex as part of the limbic system? I do. What about the cingulate? It's an intermediate region between older dopaminergic systems and the more recently evolved cortical systems. Do you want to count it in the cortex or in the limbic system? The neuroscientists say, 'Why do I need to count them in one system or the other? These are separate brain organs – let's give them all separate labels.' I'm aware that a crude cortex–limbic dichotomy would irritate a neuroscientist, and so I try not to use the words 'limbic system'. (Interview with authors, 2005)

Yet even when Laibson adapts his vocabulary, the conflict between the morphological complexity of brain data and his field's striving for mathematical simplicity remains. Glimcher describes Laibson's responses to knotty experimental data as a theoretician's legerdemain: 'He told me once, "If you relax the assumptions, then [the *beta–delta* model] makes perfect sense." But wait a minute David – you aren't allowed to relax the constraints of the brain! It's not just a loose theory, it's a *physical entity*.' He reflects further on their exchange: 'The big problem is that the economists have this wealth of theory but not a very strong experimental tradition. They don't realize how important the

constraint set is for the solutions they have to come up with. So I often see these very smart guys making childish errors that would go away if they would sit down and take a couple of neuroscience classes' (interview with authors, 2005).[14]

Laibson offers his own set of reflections on the epistemological divide that Glimcher identifies:

> We economists take for granted that the world is complex, and we simplify it to do social science. No one would begrudge us that; that's what science is. So when I'm with economists I talk the way economists want to talk: *two brains.* It's just an approximation of the world, a good way of organizing the data. Neuroscientists are less willing to crudely simplify, they say, 'Don't tell me two brain[s]; there's billions of neurons, let's get serious about the neuroanatomy ... '. But a scientific theory of the world that gets it exactly right is too complicated to be useful. (Interview with authors, 2005)

Here, Laibson casts neuroscientists as mired in biological literalism, incapable of rising above the brain's forest of neurons to think in useful behavioral models. Although he and his fellow behavioral economists argue against the 'brainless economics' of their own discipline, they persist in starting from theory and working toward the empirical material, treating the brain as the testing ground and repository of neural evidence for revised models of human behavior.

By contrast, for Glimcher and his neuroscientist colleagues, a model must be worthy of the data as well as useful. A physiologist of monkeys by training, he begins his inquiry with a deep understanding of the motor system – the neural pathways that control the message from a brain to the arm instructing it to reach for a piece of fruit. This motor function is the crucial last step of choice, the moment when an organism's preference is 'revealed' in the world. Moving in an opposite direction from that of economists, he begins with empirically concrete action – the extension of the arm and the hand's grasp, for example – and works back to the neurons that direct them. Instead of seeking to embed mathematics in the brain, he seeks to biologize choice-making. Glimcher is clear that the biology of valuation, choice, and action involves 'a unitary system, a convergence of inputs – not a cognitive, multiple self situation, with each side fighting for control over your arm' (Glimcher, 2008). His model assumes a single, unified self corresponding to a single, unified brain, and he disparagingly refers to the idea of a war between restraint and compulsion in a single brain as the 'Parkinsonian model' of human choice, evoking the tremor of a hand that cannot quite commit to the action it has initiated. He concludes: 'there must be a final common path and it looks like we have our finger on it' (Glimcher, 2008).

The published work resulting from the experiment described at the start of our paper is one piece of the story Glimcher wants to tell about human decision-making. He and his student Joseph Kable propose that a given individual's inter-temporal choice behavior reflects her own unique subjective discounting rate (Kable and Glimcher, 2007); depending on her disposition and past experiences, a subject may display a shallow curve (such as the medical student in the study who saved up her earnings from the experiment), a steep curve (such as the drifter who went skydiving with the study money), or anywhere in between (see Fig. 2). Every person expresses a particular style of trading off time and reward that forms the core of his or her decision-making in the world, and this style is

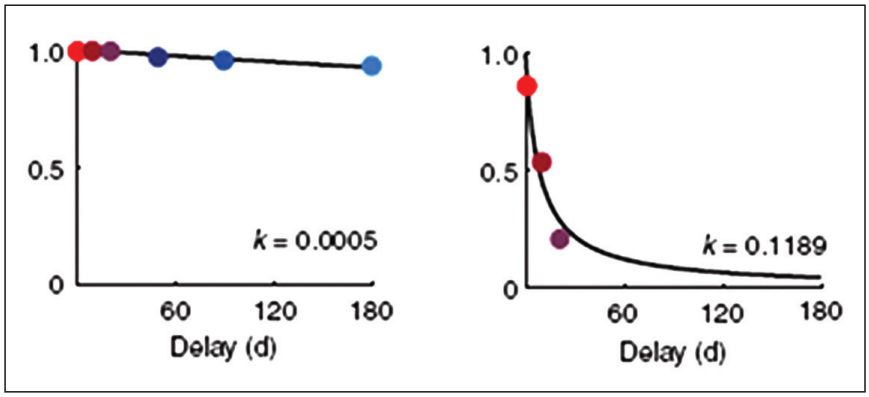

Figure 2. Discount rates of the most patient and the most impulsive subject in Kable and Glimcher's study (Kable and Glimcher, 2007: 1627).

revealed (much as preferences are revealed in choices, according to standard economics) in the image of an 'individual preference curve'. This curve matches the behavioral data of the subject's choices, and at the same time matches her brain activation; there is a one to one correspondence between the two.[15] The slope of her curve may change with experience, but at any given moment it describes the type of person she is: impetuous and unable to plan, or disciplined and skilled at long-term planning.

If the dual-systems model were true, Kable points out, one would expect impulsive subjects to have overactive *beta* areas; yet both *delta* and *beta* brain regions are active across subjects despite marked differences in their degree of impulsivity. This finding supports the case for a unified valuation system in the human brain and advances the idea that future discounting reflects a consistent response to objective changes in amount or delay of rewards rather than inconsistency in rates of discount as a result of competition between distinct inner selves. In other words, there are no impatient or impulsive *systems*, just impulsive or impatient *people.* Instead of *beta* (steep rate of discount) offsetting *delta* (shallow rate of discount), there is a stable rate of *subjective value* (neural discount rate).[16] Kable tells us:

> From a scientific viewpoint we haven't found any evidence for multiple competing selves in the brain, where there is one part of your brain that's this impulsive energy source and there's this other part of your brain that's a patient, forward looking energy source, and they're sort of duking it out for control over what you're going to do. Instead, if you're an impulsive person, the neural activity seems to be representing the value of rewards to an impulsive person. And if you're a patient person, the neural activity seems to be representing the value of rewards to a patient person. (Interview with authors, 2006)

Integration

On 11 January 2008, NYU hosted a conference to celebrate the publication of the first textbook in the field of neuroeconomics, providing a space for an extended moment of collective effervescence that would further institutionalize the field. The university's

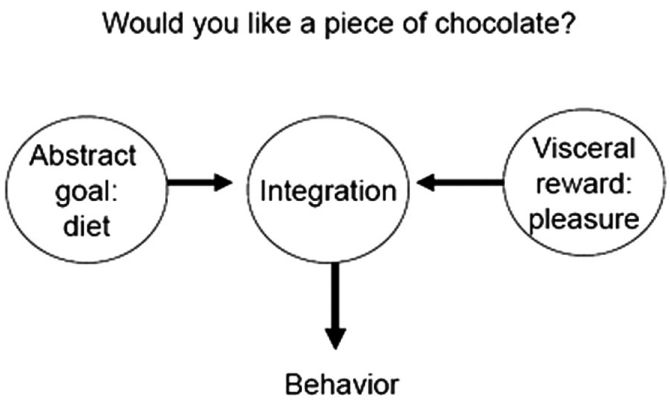

Figure 3. Human choice represented as the outcome of a consensus achieved between rational and impulsive systems (Cohen et al., 2008).

president, John Sexton, kicked off the weekend-long affair by lauding the 'extraordinary new field' for linking scientific research to problems in the real world. Neuroeconomics, he declared, is a whole that is greater than the sum of its parts. Among the attentive crowd of 400 sat Colin Camerer, Paul Glimcher and his student Joseph Kable, Brian Knutson, David Laibson, and Read Montague. In their presentations, which engaged the question of future discounting, proponents of one- and two-brain models seemed united in their attempt to move closer to a middle ground.

The bargain for compromise rested on the 'integrator notion of value' – the idea that the diverse regions of the brain involved in choice-making achieve consensus by feeding into a common point of integration where a definitive plan for action is formulated, instructing an arm to reach for a candy bar, for instance. In their conference presentation, Laibson represented behavior as a sort of mathematical division exercise that transpires at the site of integration (Cohen et al., 2008; see Fig. 3). Although this revised model retained a distinctly two-brain division between rationality (diet) and impulsiveness (pleasure), he and his colleague Paul Glimcher could meet up at the site of integration. 'If you look downstream enough', Laibson told the audience, 'you'll find what looks like an integrated system' (Cohen et al., 2008; see also Hariri et al., 2006; Kable and Glimcher, 2007; McClure et al., 2004; Tanaka et al., 2004). Glimcher, in the audience, nodded. Downstream, the brain assimilates variegated valuations into a single, definitive behavior signal.

Yet upstream, conflict remains.[17] In an article proposing an "integrative framework," Laibson and his coauthors not only acknowledge that conflict endures, but flag the urgency of its resolution:

> We believe that models with multiple interacting/competing neural mechanisms represent the most promising research frontier. Such models are characterized by at least two classes of neural systems – patient systems that implement cool, analytic preferences and impatient systems that implement hot, affective preferences …. At the most general level, it is important to determine whether the brain has one all-purpose time discounting mechanism or whether the brain draws upon different systems, each with its own occasionally competing time perspective. (Berns et al., 2007: 486)

The politics of models

If we understand the precise mechanisms of future discounting, Laibson paraphrased for a journalist, 'we will be in a much better position to design policies that mitigate what can be self-defeating behavior' (Cassidy, 2006). Despite such claims for the importance of neuroeconomics to policy, the question remains: when it comes to policy design, does it matter whether self-defeating choices about the future stem from a brain divided by dueling forces, or from a brain unified by a common pathway? How does the tension between the data-driven realism of neuroscience and the model-driven mathematics of economics play out at the level of governance and intervention? In other words, how do the scientific politics shaping neuroeconomics' model of choice resonate among policymakers who hope to guide people toward decisions that can bring them long-term rewards?

Liberal governance seeks to ensure individual and collective well-being through the aggregate of its citizens' self-interested choices – choices assumed to be motivated by a common capacity for rational conduct. This philosophical framework directs individuals to develop an optimal course for their own futures through choice-making, faulting those who deviate from the normative social parameters by spending or consuming too much. Neuroeconomists, by locating the problem of shortsighted behavior in the biological substrate of the human brain, suggest that the moral bias of liberal governance is misplaced; future discounting does not indicate deficiencies of an abstract will, but rather, the workings of neural circuits. This morally neutral explanation frames humans' shortsighted temporal orientation as an evolutionary endowment that may have carried adaptive value in past contexts, but has become non-optimal (and even a liability) in our contemporary decision environment. There is a 'massive mismatch', as one neuroeconomist put it, between the template for successful behavior that developed in settings characterized by day-to-day demands of survival and the long-term investments that success in present day liberal democracies demands. While impulsivity may benefit capitalist economies by driving robust consumption, individuals themselves are not well served by the impulsive directives of the shortsighted brain. Nor are they well served by the regulative systems of contemporary capitalism, which are rarely designed in a way that follows 'how we are wired', as neuroscientist Hans Breiter explained (author interview, 2008).

The wiring of the neuroeconomic subject thus presents a challenge for policymakers: if human brains are inclined to overvalue the present or near future, then how to promote the delay of gratification or abstention from consumption? What measures can correct for our near-sighted biology? Neuroeconomics suggests that any adequate answer to these questions must acknowledge the role of human biology in decision-making. Rather than proceeding in ignorance or in denial of this biology, as do policies based on an assumption that rational action is a human universal, regulation should follow the 'way we are wired'. The new universal that emerges from such an approach is a species-wide frailty of reason located in the brain.

The scientific battles we have reviewed in this article can be understood as contests over how to model this frailty. In their different emplotments of the neural pathways involved in future discounting, one- and two-brain models present policymakers with

contrasting visions of human rationality and the synaptic limitations in which to ground applications of liberal philosophy and technique. In the remainder of this article, we examine how these contrasting visions in neuroeconomics relate to different approaches within policymaking, a field infamous for its own impassioned debates.

Whether in support of existing policies or reform agendas, lawmakers could be said to follow two general models of intervention when it comes to adjusting individuals' future discounting curves. The first seeks remediation at the *internal* level by changing the person's choice-making tendencies. Addressing the internal drivers of undesirable behavior has a long lineage in liberal governance strategies. From 19th-century budgeting instruction for the poor to contemporary head-start programs and courses on parenting skills for welfare mothers, liberal governance techniques have focused on education and training to boost the individual self-management skills that promise to advance liberal projects. The second type of policy intervention seeks to remediate future discounting at the *external* level, by reframing environmental cues in a way that can incentivize future-directed choice-making. Camerer and his colleagues in behavioral economics have used the term 'asymmetric paternalism' to describe this method of channeling citizens' choices toward their best long term interests, while causing no harm to those who already behave optimally (Camerer et al., 2003). Recently, behavioral economist Richard Thaler and political scientist Cass Sunstein have argued for a similar but milder approach they call 'libertarian paternalism', a variation of liberal governance that has taken center stage in the Obama administration.[18] Libertarian paternalists recommend altering the 'choice architecture' in which people make decisions so as to counter their myopic bias and encourage behavior that follows the principle of delayed gratification (Thaler and Sunstein, 2008). By transferring a portion of the responsibility for short-term thinking from the choice-maker to the environment, this policy approach seeks to regulate the setting in which a person encounters the conflict between near-term and long-term values. As we will now show, although dual- and single-brain models for future discounting lend themselves equally to internal and external governmental approaches, the two models are not equally compatible with current governance trends.

Following the dual-systems brain model, a weak *delta* area could be internally buoyed through education or pharmaceuticals formulated to coax an individual's inner actuary to squelch its reckless *beta* counterpart. 'Once we understand how the circuitry works, the next field is brain machines that help brains make better choices', observes Antonio Rangel, who began his career as an economist. He reflects on the potential policy implications of neuroeconomic work in this area and the 'brain machines' it may generate:

> Suppose we develop a way to test early on in life for certain parts of the brain that play a critical role in patience, self-control, things like that. And suppose we find out that a child's circuitry is not looking good. What do we do with that? These are technologies that are going to be available very soon because of work [in neuroeconomics]. (Interview with the authors, 2008)[19]

Although Rangel pushes beyond traditional liberal philosophies by diagnosing individuals' choice-making circuitry rather than characterizing them as un-virtuous or irresponsible, a classic logic of internal remediation continues to operate in his vision for policy: behavioral change must come from within choice-makers.[20]

A single-system brain model for future-discounting likewise accommodates this logic of governance. In the Glimcher and Kable study, pictures of steep and shallow discount curves depict subjects as impulsive or provident, distinguishing them according to the relative temporal myopia of their neural functioning (see Fig. 2). It follows that neural near-sightedness, once diagnosed, could be remedied at the internal level – either through pharmacology, or by therapeutic and educational measures that act on an individual's synapses. Such interventions would work to shift the unique inclination of a person's discounting curve.[21] Thus one- and two-brain brain models alike provide templates for internally-oriented policy interventions to redress nearsighted behavior.

Each model, however, differently renders the object of intervention, and this difference proves critical to their respective policy appeal. Internal interventions following a dual-systems model would target the *delta* function that purportedly lies within every person, while interventions following a single-system model would seek to alter certain individuals' subjective valuations – the preferences that dispose them to skydive today rather than deposit cash in a savings account for growth and future use. Within the policy arena, the second enterprise falters, for it posits a subject who is uniquely distinct from every other subject, and whose behavior cannot be parsed into discrete irrational and rational elements. Although the dual-systems model allows for the possibility that individuals will have distinct discount rates based on the particular ratio of *delta* to *beta* functionality in their brains, the fact that it neatly separates these functions (instead of unifying them as in the one-brain model) sustains a longstanding tenet of liberal governance: the notion that every member of the polity can be expected to harbor the same essential capacity for rational evaluation. The one-brain model presents a problem for liberal governance by distributing this faculty unevenly across the population, and by diluting its potential strength within each person. Unlike the two-brain discounter, the one-brain discounter has no pristine site of rationality to which policymakers might appeal; she does not suffer from an anemic inner actuary who might be resuscitated with the right policy tools, but from the unconflicted expression of a singular value system. The single-system brain model thus saddles policymakers with the difficult task of formulating policies whose broad social application could address myopic individuals' discount curves without impinging on the individual freedoms of the rest of the population – freedoms around which liberal governance is organized. Unsurprisingly, conservative politicians assiduously condemn policies that appear to compromise individual choice; yet lawmakers of all stripes avoid endorsing such policies, including the self-proclaimed 'choice architects' who must dodge frequent criticism for doing exactly that.[22]

Just as the dual-systems brain model prevails when it comes to justifying policy measures that intervene at the internal level, it trumps the single-system model when it comes to justifying the strong new trend in policy interventions that work externally, through environmental reconfigurations. In fact, choice architects and their allies explicitly invoke the two-brain model to ground their approach, which a reporter for *The New Yorker* has described as 'a new political philosophy based on the idea of saving people from the vagaries of their limbic regions' (Cassidy, 2006). In their bestseller and new policy bible, *Nudge: Improving Decisions about Health, Wealth, and Happiness*, libertarian paternalists Thaler and Sunstein (2008) feature the conflicted human brain as the

source of systematic errors in human judgment. They name the phylogenically older limbic, or 'Automatic', system 'Homer Simpson' and set this glutton against the hyper-rational 'Dr Spock' of the 'Reflective' system. The trick to regulating, they argue, is to organize decision environments in a way that tips the balance in the Vulcan's favor. Their proposed interventions range from placing fruit instead of cheesecake at the end of a lunch line, requiring that companies automatically set aside a portion of their workers' salary in a retirement plan (while allowing employees to opt for withdrawing the funds), and encouraging mundane banking options such as Christmas clubs to support the creation of 'mental accounts' in which individuals can set money aside for future times and goals (Thaler, 1985; Thaler and Sunstein, 2008; also see Zelizer, 1997).[23]

Even as neuroeconomists themselves continue to argue about the mechanisms of future discounting, the two-brain model prevails in policy discussions. Working with this model as a somatic template, policy designers – including those who would alter the choice environment and those who would alter choice-makers themselves – can strategically fashion policies that address the *delta* regions of the brain, coaxing rationality from citizens and thus guiding them toward both individual and collective good.

The dual-systems model has gained traction in the political domain not only because it preserves an uncorrupted, undiluted human rationality that policymakers can readily attempt to leverage, but also because of the longstanding, close relationship that exists between economics and public policy. Economists are well practiced at traversing the divide between academic and governmental fields, translating policy problems into research questions and their research into policy-palatable terms. In this two-way feedback, policy practices are shaped by economic research as economic research is shaped by policy practice. As financial crises, epidemic obesity, and global warming have raised troubling questions about mainstream economic models of rational action, the work of behavioral economists has attained a new prominence among policymakers. In a bid to further legitimize their claim that viable economic models must take human irrationality into account, these economists have opened the policy conversation to brain science.

Yet unlike their economist counterparts, neuroscientists have little experience translating their work into terms that are readily graspable by practical-minded politicians. One-brain advocates compromise the political life of their model by insisting on the biological complexity of the brain; meanwhile, a two brain heuristic based on preexisting models of future-discounting in economics makes simplified sense of this complexity. In the political arena, the dual-systems model intersects neatly with long-standing depictions of reason stemming from psychology and philosophy – not to mention popular 'folk models' such as the grasshopper and the ant, the devil and the angel, Dr Jekyll and Mr Hyde, and most recently, Homer Simpson and Dr Spock. The two-brain model can be understood as a 'boundary object' (Star and Griesemer, 1989) that crosses smoothly between scientific, political, and popular domains, simultaneously lending scientific authority to a political project and political relevance to a scientific model of human reason.

By tracing the pathways of this object and the larger debate around future-discounting of which it is a product, we have also traced the possibilities and limits that arise in the feedback loops between science and politics. The contemporary quandaries of liberal

governance at once amplify the salience of future-discounting as a scientific problem for neuroeconomics and constrain the field's potential to redraw the notions of choice, prudence, and responsibility that undergird existing policy designs. Neuroeconomics' endeavor to move beyond the rational actor of classical economics and political philosophy languishes as its dual-systems model recuperates the human subject that liberal governance and its policy technicians have always addressed. Although dual-systems advocates recast this subject as neurological rather than moral, and as an incipient, rather than a consistent, rational actor, they preserve intact its essential capacity for rationality – and thus for governability within a liberal framework. In other words, although they demote this capacity from the irreducible and abstract 'will' of *Homo economicus* to the material and chemical mechanisms of a 'homunculus economicus' in the brain, they nevertheless enable the continued reign of the rational actor at the helm of liberal governance. In effect, the reduction of this 'actor' to a discrete neural system permits governors to proceed with a familiar set of scripts. With the two-brain model, even libertarian paternalists, seemingly radical in their argument that governance must acknowledge human irrationality, can continue to craft policies that appeal to rationality.

Acknowledgements

We would like to thank the neuroeconomists who shared their work and insights with us, especially Kacey Ballard, Colin Camerer, Paul Glimcher, Julian Jamison, Joseph Kable, Brian Knutson, David Laibson, Kenway Louie, Read Montague. The paper has benefited greatly from the counsel of Chris Kelty, Rogan Kersh, Andy Lakoff and Antonio Rangel, Michael Lynch, Stephen Rosenberg, the anonymous reviewers for SSS, and the participants in May 2008 'Our Brains Ourselves' workshop, organized by Anne Harrington and Nikolas Rose. Our collaborative research was funded by the National Science Foundation Program on Science & Society grant 0621037.

Notes

1. For a discussion of the category of 'well-being' and the different ways that the disciplines of economics and neuroscience engage with this term, see Jamison (2008).
2. 'Intertemporal preferences', write the authors of a recent publication in the field, 'affect policy debates about long-run challenges, such as global warming' (Berns et al., 2007: 161).
3. It is not that the economists participating in neuroeconomics discount empirical evidence, nor that neuroscientists eschew theoretical explanation; in fact, their collaboration is grounded in a mutual commitment to both. Nonetheless, their respective disciplinary sensibilities incline the former toward parsimonious explanatory heuristics of the brain, while the latter are more comfortable with rich description of biological realities. Our goal here is not to take sides, but to track the particular form this epistemological tension takes within the interdisciplinary scientific space of neuroeconomics, and how it affects the life of the new field beyond its formal boundaries.
4. In the last two decades, a growing number of sociologists, anthropologists, and historians of science have begun to study the neurosciences (Beaulieu, 2001, 2002; Cohn, 2004; Dumit, 2003; Harrington, 1992; Lakoff, 2009; Rose, 2007; Vidal, 2009). These scholars share in their conviction that 'the facts, theories and practices that emerge from brain research are always cultural and historical products, with particular political and economic trajectories – and should be analyzed as such' (Vrecko, 2010: 4).

5. Beginning with Kahneman and Tversky's (1979) influential Prospect Theory and extending to Vernon Smith's (1991) development of scientific experimentation for economic inquiries, the subfields of behavioral and experimental economics made major strides in destabilizing economics' resistance to empirical models of behavior. As testament to these strides, Smith and Kahneman, a psychologist by training, shared the 2002 Nobel Prize in Economic Sciences (Tversky had since passed away and so was not eligible to receive an award).
6. These refinements include the idea of 'bounded rationality' (Gigerenzer and Selten, 2002; Rubinstein, 1998; Simon 1984), in which rationality is compromised by constraints on information and time, and 'rational addiction', in which failure to value the future is considered a rational choice (based on rational calculation) to forego future well-being for present pleasure (Becker and Murphy, 1988).
7. Neuroscientific imaging and measurement technologies include PET scans (positron emission tomography, to measure the brain's chemical activity), magneto-encephalography (to measure the brain's magnetic fields), single neuron imaging (a precise but invasive technique used only in animals), and fMRI (functional magnetic resonance imaging), which measures blood flow around neurons across time.
8. Camerer's opening salvo rallied Princeton's Faruk Gul and Wolfgang Pesendorfer to the defense. In 2005 they drafted a paper titled, 'The case for mindless economics', in which they wrote that 'Neuroscience evidence cannot refute economic models because the latter make no assumptions and draw no conclusions about the physiology of the brain' (Gul and Pesendorfer, 2008: 4).
9. Brain imaging technologies and techniques pose challenging problems for research design, statistical analysis, and the assertion of correlations (between blood flow and behavior), as both neuroscientists and social analysts have noted (see Beaulieu, 2001, 2002; Cohn, 2004; Dumit, 2003; Hanson and Bunzl, 2010; Kriegeskorte et al., 2009; Lakoff, 2009; Leopold, 2009; Vul et al., 2009). For the purposes of this paper, however, we will describe the process of scientific reductionism in neuroeconomics and fMRI imaging without elaborating a critical position.
10. Although neuroeconomists place humans on a continuum with animals in their project to biologize choice-making, their account sets humans off from pigeons, rats, monkeys, and other representatives of the animal kingdom. Lacking 'the more recently evolved, uniquely human capacity for abstract, domain general reasoning and future planning' (McClure et al., 2004: 506), even the most advanced primates cannot manage to wait for a reward longer than a few minutes, as Laibson told us: 'The monkey has a future which moves out of focus much more rapidly than the human future moves out of focus. We have retirement plans and we're putting money away for events 60 years away, but the monkey obviously isn't doing any planning beyond seconds or minutes' (interview with authors, 2005). The 'human capacity' to conceptualize and act in relation to the future becomes a critical facet of humans' broader designation as uniquely rational beings.
11. This list was compiled by a team of neuroeconomists and presented in a PowerPoint slideshow at NYU in January 2008 (Cohen et al., 2008).
12. Lakoff (2009) offers a history of the idea of human rationality in the psychological, physiological, and cognitive sciences, ending with the contemporary assignment of planning and strategizing capacities to functions of the prefrontal cortex. Tracing the shifting epistemic milieux surrounding measures of reasoning capacities such as sorting tests, he shows how these milieux shape reason as a certain kind of scientific object. The vision of reason in neuroeconomics (that is, the ability to effect goal-oriented decisions under uncertain conditions) maps neatly on to the contemporary point in this conceptual history.
13. Lynch (1985) was one of the first social scientists to have examined how brains are 'clarified' and 'mathematized' through what he called the 'rendering practices' of neuroscientific

visualization (see also Star, 1983). In the merger of neuroscience and economics, mathematical approaches particular to economics enter into the set of practices by which brains are 'rendered' and interpreted.

14. As it happens, that year Glimcher had invited Colin Camerer to NYU and had arranged for him to take a basic neuroscience class.
15. Ironically enough, Glimcher – the neuroscientist most vocal in his frustration with economists' tendency to mathematically model – makes the claim that his work offers evidence for some of the same neoclassical assumptions about human behavior that his behavioral economist counterparts wish to challenge via neural data. For example, his demonstration of a 'continuous underlying scale for subjective value' (Kable and Glimcher, 2007: 1632) gives biological weight to the reality of the preference function, while the unity of his decision-making model recapitulates theories of 'revealed preference' by smoothing the pathways between subjective value (or preference) and choice. Behavioral economists who support the dual-brain hypothesis challenge the idea that valuation and choice directly map onto each another (for example, Rangel, 2008).
16. In the paper, Kable and Glimcher attempt to interpret their data using the 'theoretically defined' parameters of the steep *beta* and shallow *delta* discount rates, but find that the data better fit with the single neural discount rate they have identified (Kable and Glimcher, 2007: 1630).
17. Since the conference at NYU, there have been further attempts to move beyond one- and two-brain models by considering how different brain regions and functions might "modulate" each other in the process of human choice-making (see Hare et al., 2009; Figner et al., 2010; Kable, 2010). Yet these attempts preserve the essence of the original tension, leaving unresolved the question of whether "modulation" proceeds through competition or collaboration. As Kable indicates in his commentary on this recent work, it is not clear whether certain brain areas "provide input to, rather than override, valuations computed elsewhere in the brain" (Kable, 2010: 524)
18. Writing in *The New Republic*, Franklin Foer and Noam Scheiber (2009) dub Obama's political philosophy 'nudge-ocracy', invoking the title of Thaler and Sunstein's (2008) bestseller *Nudge* to characterize the administration's endorsement of environmental and market incentives to guide individuals toward more responsible choices.
19. As Rangel (2008) reported in his talk at NYU, various studies have linked intelligence (measured by IQ tests or career choice) with the capacity to delay rewards; in 24 studies, nearly all found a positive relationship. One study found that a single standard deviation increase in a subject's math test score was associated with a 9.3% increase in the subject's likelihood of choosing patiently. This sort of work comes dangerously close to making the brain a justification for class and economic success.
20. Rose (2010) has coined the term 'screen and intervene' to describe the logic of contemporary governance strategies that seek to identify potentially criminal individuals through neural markers that indicate a tendency toward impulsivity and other 'antisocial' behavior. He argues that such strategies are part of a broader logic of governance based on principles of risk management and pre-emptive intervention. In the course of his argument, he cites the opposition of libertarian paternalist Sunstein (2005) to this regulative stance.
21. Although both single- and dual-system models of the brain are amenable to internal methods of governance, the areas and functions of the brain that each would target would presumably differ, as would the mechanisms of intervention into those areas.
22. The danger of being characterized as paternalist is readily apparent in the introduction that Glenn Beck, the Fox News host, gave Cass Sunstein, newly appointed to a top post at the Office of Information and Regulatory Affairs: 'He [Sunstein] is the author of the book *Nudge. Nudge* is basically a book that looks at Americans as a bunch of lab rats. And he knows all the tricks and all the levers to make them behave the way he wants them to. Just a little nudge

here and little nudge there. People still have a choice. Of course, they do. But they really don't' (Thursday 22 April 2010). It is no surprise that advocates of 'libertarian' and 'asymmetric paternalism' are careful to emphasize their commitment to freedom of choice and to regulations that impose little or no restriction on those who are fully rational' (Camerer et al., 2003: 1212).

23. Pat O'Malley (1996: 198) has described such techniques as comprising a kind of 'privatized actuarialism' that reflects the enterprising values of contemporary capitalist societies.

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