Neuroeconomics: A Basic Review

(Neuroeconomía: Una Revisión Básica)

Abreu, Jose Luis*

Abstract. The foundations of economic theory were constructed assuming that details about the functioning of the brain's black box would not be known. But now neuroscience has proved the pessimistic prediction wrong; the study of the brain and nervous system *is* beginning to allow direct measurement of thoughts and feelings. These measurements are, in turn, challenging our understanding of the relation between mind and action, leading to new theoretical constructs and calling old ones into question.

Key words. Neuroeconomics, decision making, behavioral economics, bioeconomics, epistemology.

Resumen. Los fundamentos de la teoría económica fueron construidos asumiendo que los detalles acerca del funcionamiento de la caja del cerebro no serían conocidos La neurociencia ha probado que el estudio del cerebro y el sistema nervioso está comenzando a permitir mediciones directas de pensamientos y sentimientos. Estas mediciones son retadoras a nuestro entendimiento de la relación entre mente y acción, llevando a nuevos constructos teóricos y cuestionando los viejos constructos.

Palabras claves. Neuroeconomía, toma de decisiones, economía conductual, bioeconomía, epistemología.

Introduction

In the last two decades, following almost a century of separation, economics has begun to import insights from psychology. "Behavioral economics" is now a prominent fixture on the intellectual landscape, and has spawned applications to topics in economics, such as finance, game theory, labor economics, public finance, law and macroeconomics (Camerer and Loewenstein 2004). Behavioral economics has mostly been informed by a branch of psychology called "behavioral decision research," but other cognitive sciences are ripe for harvest. Some important insights will surely come from neuroscience, either directly, or because neuroscience will reshape what is believed about psychology which in turn informs economics. Neuroscience uses imaging of brain activity and other techniques to infer details about how the brain works. The brain is the ultimate 'black box'. The foundations of economic theory were constructed assuming that details about the functioning of the brain's black box would not be known. But now neuroscience has proved the pessimistic prediction wrong; the study of the brain and nervous system *is* beginning to allow direct measurement of thoughts and feelings. These measurements are, in turn, challenging our understanding of the relation between mind and action, leading to new theoretical constructs and calling old ones into

question (Camerer, Loewenstein y Prelec, 2005).

The Concept of Neuroeconomics

According to Zak (2004) economics is the science of decision-making, decisions that both involve others and those that do not. For this reason, economic models can be applied to a wide range of species and behaviors. Neuroscience, on the other hand, has an exquisite arsenal of measurement modalities, but historically has focused on characterizing a quite limited set of behaviors. Therefore, there is a natural affinity between neuroscience and economics as one has produced and tested many behavioral models without asking what produces the behavior, whereas the other is able to open the black box that generates behaviors but is searching for interesting behaviors to study. The expected benefits of neuroeconomics on each side of the shop are high. For economics, neuroeconomics research will lead to the building of models that predict economic and social behaviors better and that are grounded in neurobiology. This will allow economists to answer fundamental questions they are unable to address now such as: why do two individuals faced with the same information and incentives make different choices? Why does the same individual sometimes make choices that are inconsistent? How much is choice behavior affected by childhood development, if at all? Currently, most answers to economic questions focus on average choices, rather than individual or temporal variation in choices, and model building has a ‘what-if’ quality where new models are often built without any motivating data. In the application of economic models to policy, most laws seek to circumscribe extreme behaviors, not average behaviors, so an understanding of the interpersonal and intertemporal variation in choices is fundamental to effective public policy.

Rational agents display their rationality mainly by making decisions. Some decisions are basic (turn left or turn right), other ones concern more crucial issues (“to be or not to be”). Even abstinence is decision, as thinkers like William James or Jean-Paul Sartre once pointed out. Since choice is central to life, it is not surprising that many disciplines attempt to properly characterize decision-making. Philosophy, psychology and economics, among others, all have different and sometimes conflicting views about the nature of decision-making and the conditions that make it rational. Reviewing different construal of decision will therefore illuminate the importance of neuroeconomics at the theoretical level (Hardy-Vallée 2008).

Decision making refers to the process of forming preferences, selecting and executing actions, and evaluating outcomes. Decision making is defined as encompassing a wide range of behaviors having in common the basic generic structure of input–process–output–feedback. Input refers to the presentation of

separate stimuli, each predicting a measurable rewarding or aversive outcome; process refers to the appraisal of these stimuli and formation of preference; output refers to the action carried out in response to the selected stimulus. Feedback is the experience and evaluation of the outcome that follows the action perpetuated on the selected stimulus. It is used for learning about the values of the stimuli (Ernst and Paulus 2005).

Economics is typically defined as the science characterizing the optimal allocation of scarce resources. Note: economics is not about money (surprisingly, economics has produced very few deep insights about money!) even though money is a convenient way to determine how much someone cares about something. Fundamentally, economics models individuals valuing rewards and choosing among alternatives. Specifically, each decision involves (i) obtaining information from the environment regarding possible actions, (ii) valuing those actions, and (iii) choosing between them. Each of these three tasks is, in principle, measurable. Further, this hierarchy of how decisions are made can further be broken down into sub-tasks, including determining one's objective(s), filtering incoming information, accessing memories of related events, using heuristics and identifying constraints on cognitive processing (e.g. energy or time constraints), which are also measurable (Zak 2004).

Neuroeconomics is a natural extension of bioeconomics (Hirshleifer 1985; Gheslin and Landa 1999; Hirshleifer and Zak 2004). The bioeconomics research programme uses evolutionary biology to build models that predict human behavior (Zak 2002; Zak and Park 2002). A second progenitor of neuroeconomics is behavioral economics, a field that uses findings from cognitive psychology to better model human decision-making (Camerer 2003). Whereas bioeconomics has focused primarily on ultimate causes of behavior and behavioral economics has focused on how our evolved psychologies affect decisions, the neuroeconomics research programme seeks to discover proximate causes of choice behavior. It is proximate causes that probably provide the most leverage when seeking to affect behavior through policy. For example, introducing laws that seek to influence individual behavior can be done more effectively and precisely when the proximate mechanisms producing the behavior are known (Zak, 2004).

Economics, psychology, and neuroscience are converging today into a single, unified discipline with the ultimate aim of providing a single, general theory of human behavior. This is the emerging field of neuroeconomics in which consilience, the accordance of two or more inductions drawn from different groups of phenomena, seems to be operating. Economist and psycologists are providing rich conceptual tools for the study of the mechanism.The goal of this discipline is thus to understand the processes that connect sensation and action by revealing the

neurobiological mechanisms by which decisions are made (Glimcher and Rustichini 2004).

The University of Zürich in its research program (University Research Priority Program Ethics) actually is carrying out an important search for “the biological foundations” of moral behavior, because they have turned into relevant issues in social cognitive neuroscience and behavioral science. In particular, they study the moral role of emotions, the neural mechanisms of decision making, dispositions and behaviors such as empathy, trust and cooperation. Moreover, they have analyzed the “moral behaviors” in non human primates. These studies focus implicitly and explicitly on the main components of the moral agenda and they are part of a naturalization project called neuroscience of ethics, which challenges ethical philosophy and highlights the problem whether ethical questions (ethics of neuroscience) emerges from this research approach (Christen et al. 2007).

Sanfey et al (2006) affirm that despite substantial advances, the question of how we make decisions and judgments continues to pose important challenges for scientific research. Historically, different disciplines have approached this problem using different techniques and assumptions, with few unifying efforts made. However, the field of neuroeconomics has recently emerged as an inter-disciplinary effort to bridge this gap. Research in neuroscience and psychology has begun to investigate neural bases of decision predict-ability and value, central parameters in the economic theory of expected utility. Economics, in turn, is being increasingly influenced by a multiple-systems approach to decision-making, a perspective strongly rooted in psychology and neuroscience. The integration of these disparate theoretical approaches and methodologies offers exciting potential for the construction of more accurate models of decision-making.

Economics contributes to the joint endeavor of neuroeco-nomics by bringing its insights into the diverse outcomes that can arise from the strategic and market interactions of multiple agents, and through a set of precise, formal, mathematical models to describe these interations and outcomes. However, the aspect of economics that may prove most useful to neuroscientists (and, indeed, that has already begun to bear fruit) is its embracing of a unified theoretical framework for understanding human behavior – namely the idea that behavior can be interpreted as choosing alternatives with the goal of maximizing utility (Sanfey et al. 2006)

The unitary perspective of economics can be seen in the assumptions that it makes about the two essential dimensions of decision-making: choice (the evaluation of options and selection of actions), where economics assumes a consistent, stable set of preferences; and judgment (information processing and probability esti-mation),

with the assumption of a general reasoning system applicable to a wide range of problems. These assumptions have been criticized, as will be discussed later, but the concept of decisions being made by comparing the utility signals for each of the decision alternatives has led to some real developments and has played an increasingly important role in guiding research investigating the underlying brain mechanisms. Addition-ally, it is possible that well-established ideas from economics will shed light on one of the least developed, but most important, riddles for neuroscience: how the multiple, diverse and specialized neural systems of the brain coordinate their activities to solve complex and often novel problems and give rise to coherent, goal-directed behavior (Sanfey et al. 2006)

Like the field of genetics, neuroscience concerns the biological foundations of who we are, of our essence. The relation of self to brain is, if anything, more direct than that of self to genome. Perhaps more important, neural interventions are generally more easily accomplished than genetic interventions. Yet until recently there has been little awareness of the ethical issues arising from neuroscience. Beginning in 2002, neuroscientists began to address these issues in the scientific literature and the field gained a name, ‘neuroethics’ . Neuroethics encompasses a large and varied set of issues, and initial discussions focused on various different subsets of those issues. Some neuroethical issues concern the practical implications of neurotechnology for individuals and society. Technological progress is making it possible to monitor and manipulate the human mind with ever more precision through a variety of neuroimaging methods and interventions. For the first time it may be possible to breach the privacy of the human mind, and judge people not only by their actions, but also by their thoughts and predilections. The alteration of brain function in normal humans, with the goal of enhancing psychological function, is increasingly feasible and indeed increasingly practiced. At the same time, progress in basic neuroscience is illuminating the relation between mind and brain, a topic of great philosophical importance. Our understanding of why people behave as they do is closely bound up with the content our laws, social mores, and religious beliefs. Neuroscience is providing us with increasingly comprehensive explanations of human behavior in purely material terms. Although the field of neuroethics is young and still evolving rapidly, the time seems ripe for a review in which the key issues of neuroethics, both practical and philosophical, are surveyed and placed in relation to one another (Farah 2005).

As we understand more about the details of the regulatory systems in the brain and how decisions emerge in neural networks, it is increasingly evident that moral standards, practices, and policies reside in our neurobiology. As we learn more about neural development, the evolution of nervous systems, and how genes are regulated, it has become evident that our neurobiology is profoundly shaped by our

evolutionary history. Our moral nature is what it is because our brains are as they are; so too, for our capacities to learn, reason, invent, and do science (Roskies 2002 in Churchland 2005).

Although our moral capacities are prepared during embryological development, they are not wholly configured at birth. One's social and cultural world, with its various regulatory institutions, deeply shapes the exercise of moral capacities in adulthood. These regulatory institutions include the standards prevailing in one's particular family and clan, the prevailing criminal justice system, the organization and style of government, schools, guilds, religions, and professional societies (Churchland 2000).

Recognition of these various determinants means that the traditional field of ethics must itself undergo recalibration. Philosophers and others are now struggling to understand the significance of seeing morality not as a product of supernatural processes, 'pure reason' or so called 'natural law', but of brains—how they are configured, how they change through experience, how cultural institutions can embody moral wisdom or lack of same, and how emotions, drives, and hormones play a role in decision-making. Some traditional assumptions concerning the roots of moral knowledge have been exposed as untenable. As these assumptions sustain reconfiguration, the beginnings of a new paradigm in ethics can be seen emerging. Owing to the natural and biological roots of morality, this new approach to ethics may be referred to as 'naturalized ethics', or more simply, 'as neuroethics' (Churchland 1991, 2002; Flanagan 1996; Campbell and Hunter 2000; Illes and Raffin 2002; Roskies 2002; Casebeer and Churchland 2003; Goodenough and Prehn 2004).

The new research on the nature of ethics is located at the interface of philosophy, jurisprudence, and many sciences—neuroscience, evolutionary biology, molecular biology, political science, anthropology, psychology, and ethology. These interdisciplinary inquiries will have profound, and rather unpredictable, social consequences, as people in general rethink their conventional ideas concerning the basis for moral standards and practices (Churchland 2005).

Some Remarks from the epistemological point of view

Payzan y Bourgeois-Gironde (2005) defined neuroeconomics as the joint experimental production between neural sciences and experimental economics. It is a natural outgrowth of laboratory economics, aimed at studying behavior in a controlled environment.

Two remarks are made by Payzan and Bourgeois-Gironde (2005):

• First it is necessary to justify the definition of neuroeconomics as joint production between different sciences. Indeed it presupposes a real interdisciplinary collaboration between economists and neuroscientists, one that would fulfil the promise of incorporation or integration. It appeals some common principle, since the crossbreeding of several fields – psychology, neurobiology, normative economics – into some, to be sure, quite elaborate experimental settings, is not by itself a unification of these fields, of their methods, nor of the principles that found them.

One way to foresee epistemological soundness is to follow Popper in asserting that a common principle of rationality provides the ultimate unity of behavioral and social sciences (Popper 1967). This common principle constitutes the cement of neuroeconomics. Indeed some epistemological coherence can be fostered by the consideration that the ways of interpreting behavior that each of these fields applies rely on a common principle of rationality. Namely the epistemological unity of the different aspects – psychological, neurobiological and economical – of experimental data provided by neuroeconomics studies, are implicitly unified because it is presumed that in one way or another the agent systematically follows some reasons that can explain her apparent behavior. This principle needs not be qualified in general, but it can be qualified in the various situations that the agent meets; and what specific experimental data may contribute to provide is precisely those local justifications that are needed in view of the whole coherent account of human behavior.Therefore we are entitled to think of neuroeconomics as a real incorporation leading to the previously alleged «joint production», because of the shared rationality principle.

• Second notice that the provisional definition purportedly restricts neuroeconomics to the experimental domain of economics. It is necessary to raise some major issues related to the experimental specificities of neuroeconomics. It is important to focus on the relation between neuroeconomics and the «a priori domain» of economics: papers in economics can be now illustrated with pictures of the brain, but how these pictures can be an element of economic theorizing?

There are three possible main views of how neuroeconomics may relate to economics: neural data can be used to test, to hypothesize, or to induct. According to which of these three views – respectively Deduction, Abduction, and Induction – is privileged, neuroeconomics may be said to be established as epistemologically autonomous or not. The first view is an hypothetical-deductive understanding of economics. Neural data obtained in specific experimental settings are confirmatory

data, relevant only to the extent that they constitute a way of testing existing theories. They lend the latter a veneer of realism in the sense that descriptions of brain-mechanisms can be seen as specific tests of behavioral predictions made by the theory. It has been shown that this hypothetical-deductive approach leads to an «epistemological circle» and should definitely be considered as a dead-end.

Now the connections between neural functioning and economics can be encompassed in quite a different epistemological framework, one which can be recommended and illustrated in the following. An abductive understanding of those connections amounts to consider that neural data – now endowed with scientific primacy – may help build hypotheses or refine extant ones in order to create maximal compatibility between data and theoretical premisses. Abduction, here, means that neural data are not, as such, predicted or deduced by theoretical premises of economics. Differently, they serve to update the models by suggesting new hypothesis and urging new insights.

The abductive conception of economics urges behavioral economists toward a greater heuristic (adaptation of one's hypotheses to account for new data) and hermeneutic (emphasis put on the purpose of explaining human behavior in all its relevant manifestations for economists) understanding of their task. Still the primacy of the existing theories remains, to the extent that the new hypothesis are a way of rationalizing – by updating them – the latter. The essence of neuroeconomics is not abduction. It points to a somewhat ideal epistemological relation between neural data and economics that would constitute neuroeconomics as a fully epistemologically autonomous scientific discipline. This relation is inductive. It means an extension of the behavioral topics of interest. Empirical exploration comes first, then the models intervene in a second – still essential – step. Once the researcher is involved in an inductive logic, each new empirical fact helping at understanding the way human-being actually functions will be meaningful, even though no economic model has ever dropped an anchor in this new direction. This inductive pathway is possible only to the extent that neuroeconomics rests on the common rationality principle mentioned before. The latter both suppresses the institutional delimitation between the traditional objects of interest proper to each field, and the primacy of preexisting theories (Payzan and Bourgeois-Gironde 2005).

References

Camerer, C. F. 2003. Strategizing in the brain. Science 300, 1673–1675.

Camerer, Colin., Loewenstein, George. and Prelec, Drazen. 2004. Neuroeconomics: Why Economics Needs Brains. Scandinavian Journal of Economics, Vol. 106, No. 3, pp. 555-579, September 2004

Camerer, Colin., Loewenstein, George. and Prelec, Drazen. (2005). Neuroeconomics: How Neuroscience Can Inform Economics. Journal of Economic Literature, 43(1), 9-64.
Campbell, R. and Hunter, B. 2000. Moral Epistemology Naturalized. Calgary: University of Calgary Press.
Casebeer, W. D. and Churchland, P. S. 2003. The neural mechanisms of moral cognition: a multiple-aspect approach to moral judgment and decision-making. Biology and Philosophy 18, 169–94.
Christen, Markus., Jaeggi, Adrian., Kaufmann, Ina., Matusall, Svenja., Miller, Nicole and von Rohr, Claudia Rudolf. 2007. Naturalizing moral agency - prospects and perils. University of Zürich. University Research Priority Program Ethics. http://www.iou.uzh.ch/bwl/downloads/poster_genf_druckversion.pdf
Churchland, P. S. 1991. Our brains, our selves: reflections of neuroethical questions. In: Roy DJ, Wynne BE, Old RW (eds) Bioscience and Society. New York: Wiley, 77–96.
Churchland, P. M. 2000. Rules, know-how, and the future of moral cognition. In:
Campbell, R. and Hunter, B. 2000. Moral Epistemology Naturalized. Calgary: University of Calgary Press.
Churchland, P. S. 2002. Brain-Wise: Studies in Neurophilosophy. Cambridge, MA: MIT Press.
Churchland, P. S. 2005. "Moral decision-making and the brain" In Neuroethics: Defining the Issues in Theory, Practice and Policy , edited by J. Illes. Oxford University Press, New York
Ernst, M. and Paulus, M . 2005. Neurobiology of Decision Making: A Selective Review from a Neurocognitive and Clinical Perspective . Biological Psychiatry. Volume 58 , Issue 8 , Pages 597 – 604.
Farah, Martha. 2005. Neuroethics: the practical and the philosophicalTrends in Cognitive Sciences, Volume 9, Issue 1. pages 34-40.
Flanagan, O. 1996. Self-Expressions: Mind, Morals and the Meaning of Life. Oxford: Oxford University Press.
Gheslin, M. and Landa, J. T. 1999. The emerging discipline of bioeconomics: aims and scope of the journal of bioeconomics J.Bioecon. 1, 5–12.
Glimcher, Paul. and Rustichini, Aldo. 2004. Neuroeconomics: The Consilience of Brain and Decision Science.Oct 15; 306, 5695; ProQuest Medical Library pg. 447
Goodenough, O. R. and Prehn, K. 2004. A neuroscientific approach to normative judgment in law and justice. Philosophical Transactions of the Royal Society of London, Series B 359, 1709–26.
Hardy-Vallée, Benoit. 2008. Decision-Making: A Neuroeconomic Perspective Social Science Research Network. Department of Philosophy University of Toronto. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1004584
Hirshleifer, J. 1985 The expanding domain of economics. Am. Econ.Rev. 75, 53–68.
Hirshleifer, J. and Zak, P. J. 2004 The bioeconomics of social behavior: introduction. J.Bioecon. 6, 1–2.
Illes, J. and Raffin, T. 2002. Neuroethics: a new discipline is emerging in the study of brain and cognition. Brain and Cognition 50, 341–4.
Payzan, Elise. and Bourgeois-Gironde, Sacha 2005. Epistemological foundations for Neuroeconomics. (IJN - Institut Jean-Nicod - CNRS : UMR8129 - Ecole Normale Supérieure de Paris - Ecole des Hautes Etudes en Sciences Sociales). Paper Series at Ideas.http://ideas.repec.org/p/hal/papers/ijn_00000658_v1.html http://jeannicod.ccsd.cnrs.fr/docs/00/05/36/88/PDF/ijn_00000658_00.pdf sbgironde@hotmail.com
Popper, Karl. 1967. The rationality principle. New Brunswick: Popper Selections,

Princeton, NJ, Princeton University Press Edition, 1967.
Roskies, A. 2002. Neuroethics for the new millennium. Neuron 35, 21–3.
Sanfey, Alan., Loewenstein, George., McClure, Samuel. and Cohen, Jonathan. 2006. Neuroeconomics: cross-currents in research on decision-making. Trends in Cognitive Sciences. Vol.10 No.3.
Zak, P. J. 2002. Genetics, family structure, and economic growth J. Evol. Econ. 12, 343–365.
Zak, P. J. and Park, K.-W. 2002 Population genetics and economic growth. J. Bioecon. 4, 1–37.
Zak, Paul. 2004. Neuroeconomics. Philosophical Transactions of the Royal Society B (Biology), ISSN: 0962-8436 (Paper) 1471-2970 (Online) Issue: Volume 359, Number 1451 / November 29, 2004 Pages: 1737 – 1748.

***About the author**

El Dr. José Luis Abreu is a Research Professor at Universidad Autónoma de Nuevo León in Monterrey, Mexico. Email: abreu@spentamexico.org