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NEUROECONOMIC MODELS OF DECISION-MAKING

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Abstract *Over the past decade, there has been increasing evidence describing economic models of decision making, the neural processes underlying behavior, the deep structure of human preferences, and the regions of activation in the brain observed in judgment and decision making in economic contexts. The aim of the present study is to examine and evaluate the potential of neuroeconomics to help in constructing models of economic decision making, the neurobiological mechanisms that are responsible for making economic choices, and the psychological process of economic decision making.*

Key words:
Neurobiological mechanisms; economic decision making

JEL Codes:
C45; D87; D81

1. Introduction

Although researchers have discovered some important findings regarding the computation of decision values, the neurobiological and computational mechanisms at work in economic behavior, the neural process of decision making, and the consequences of decisions made in real-world contexts, there is still a great deal that is unknown and that requires further empirical inquiry. In the present paper, we focus on the actual computational and neurobiological processes behind human behavior, the relationship between psychological processes and their neural implementation, the dynamics of economic behavior, and the rise of neuroeconomics. The purpose of this article is to gain a deeper understanding of the use of brain imaging to investigate processes of economic decision, the transformative potential of neuroeconomics, and the different cognitive and motivational processes driving human behavior, and the computation and the comparison of decision values underlying goal-directed behavior.

2. The Potential of Neuroeconomics to Help in Constructing Models of Economic Decision Making

Neuroeconomics emerged from within behavioral and experimental economics. Neurological damage influences mental state, but relating damage to mental state is difficult because the latter is not directly observable. Non-invasive brain stimulation techniques provide causal knowledge and, in combination with imaging tools, isolate whole decision networks that are causally involved in the generation of choices. (Glimcher *et al.,* 2008) Experimentally induced variation in neural activity (Hunter, 2013a) in specific regions of the brain changes people's willingness. Neural activity *causally* determines economic choices. The neural computations necessary for making choices (Corsani, 2013) are stochastic. The choice process can be systematically biased and suboptimal. Consumption choices can be biased by simple manipulations of subjects' visual attention and the opportunity costs of time. The observed pattern of the neuronal encoding of decision values (Nicolăescu, 2013a) implies that choices will fail to satisfy the independence of irrelevant alternatives, and mistakes are more likely to occur if the range of values that subjects need to consider is bigger. One cannot simply use revealed preferences to measure welfare. Neuroeconomics contributes to a positive theory of the mistakes that people make in their choices. The decision value signals are precursors, and not consequences, of the choice process. Attention might affect how attributes are computed and how they are weighted in the decision value computation, and can affect how decision values are compared at the time of choice. Knowledge about the systems involved in the computation of decision values (Zaharia *et al.,* 2013) provides clues about the structure of the choice correspondences. The likelihood and size of decision mistakes increases with the range of values that needs to be encoded. Exogenous shifts in attention can bias choices in systematic ways. Environmental cues that direct attention towards the long-term features of the stimuli may lead to healthier decisions. (Fehr and Rangel, 2011) Neuroeconomics can improve the match between the demand for biological concepts in

economics (Naito, 2013) and what economic models can offer to neuroscience, developing the conceptual interface needed to help neuroscience and economics identify general principles of behavior. Shifting contexts can change the extent to which decision makers rely on particular sorts of neural computations. Neuroscience provides a wealth of tools for assessing differences among individuals. Socioeconomic status may have latent effects on how people express preferences and make decisions. Cues that nudge behavior can alter economic preferences and subsequent real-world choices. (Levallois *et al.*, 2012)

Neuroeconomics aims to build a neural model of decision making in economic environments. The neural processes associated with small neuron populations provide the physical and physiological basis for measuring brain responses. Systems neuroscience contributes a substantial body of knowledge about brain function. Contextual factors can influence which structures and systems are employed to perform a certain function. Brain regions involved in affect significantly impact economic decision making. The neural networks involved in choice go beyond evaluation of the pain and pleasure of a purchase. Expectation can play a role in modulating choice behavior, through an attentional-memory network involving dorsolateral cortex. Trust and betrayal are important elements of social interaction that takes place in economic exchanges. Patterns of brain activity are sensitive to participants' moment-by-moment experiences. Social interaction systematically modifies aspects of cognitive and affective mechanisms. Neuroscience has made more explicit the kinds of processes involved and has changed the way we think about longstanding theoretical concepts such as utility (individuals are characterized by bounded rationality). (Egidi, Nusbaum, and Cacioppo, 2008)

3. The Neurobiological Mechanisms that Are Responsible for Making Economic Choices

Democratic and libertarian societies ask their citizens to make many decisions that involve uncertainty and risk. As citizens have taken on more decision responsibility, unpredictability and uncertainty of decision outcomes has increased. There is no single measure of "risk attitude" that can be inferred from observed levels of risk-taking. Multiple processes are in play when a preference between different risky options is constructed. Even for static risk-taking applications, task and choice set differences may influence risk-taking behavior. Apparent risk-taking varies when preferences between risky options are expressed in different ways. Gain vs. loss framing of choice options and the way decision-makers have learned about outcome distributions (Prager, 2013) affects risky choice. The behavior of people in situations of risk and uncertainty is multiply determined. The success of neuroeconomic methods may significantly contribute to greater acceptance of behavioral models by traditional economics. (Weber and Johnson, 2008) The economic model of individual decision-making is based on the action set, preferences, and beliefs. People derive nonpecuniary utility (i) from mutual cooperation in social dilemma (SD) games and (ii) from punishing unfair behavior in these games. Many people exhibit social preferences and more people typically show trust in the existence of these preferences. Emotions are an overpowering force that inhibits rational behavior. (Fehr, Fischbacher, and Kosfeld, 2005) Model-based functional magnetic resonance imaging (fMRI) can provide information about what variables and quantities are encoded in the brain when an individual makes decisions, fMRI can demonstrate whether two different kinds of decisions use similar or different neural processes, fMRI can be used to test whether different individuals perform the same decision in different ways, and directly incorporating neural measures into models could improve predictions of economic behavior. (Kable, 2011) The endowment effect is the difference between the minimum amount of money one is willing to accept to part with an owned good and the maximum amount of money one is willing to pay to buy the good. The endowment effect is a manifestation of loss aversion. Individuals treat losses as if they were more impactful than comparable gains. The cost of fMRI is justifiable when underlying processes are difficult to articulate, either because they occur outside of awareness or because people are reluctant to report the truth. It may be unclear whether the identified correlates are driving the behavior in question or whether the neural activity is a byproduct of the process that is driving behavior. Specific cognitive or emotional processes are often inferred from activation in a particular region. (Rick, 2011)

4. The Psychological Process of Economic Decision Making

Modern economics entails positing agents with simple, stable preferences, people are endowed with effortlessly rational, error-free cognition, and people interact with each other in ways that are relatively frictionless, yielding equilibrium behavior. Modern economics can gain insight into the nature of human preferences through the study of other closely related primates. Human consumers evaluate their choices in terms of their expected payoffs (Hunter, 2013c) and of arbitrary reference points, tending to be loss averse. (Santos and Chen, 2008) Neuroeconomics stands on the shoulders of a wealth of behavioral and neural evidence. The efficient harvesting of rewards from the

real world depends on signals originating both within and outside the organism. In exchanges with other humans, efficient reward harvesting requires an agent to model their partner and their future interactions with their partner. Reward processing in the human brain (Pera, 2014a) can be tracked using fMRI across a wide spectrum of stimuli or internal states that qualify as rewarding. (Read Montague, 2007) Decision making is not a unitary process – a simple matter of integrated and coherent utility maximization. The brain involves a melding of diverse specialized processes that are integrated in various ways when the brain faces different types of problems. Judgment and behavior are the result of the interaction between multiple, often conflicting, processes. The assumptions underlying economic models (Nicolăescu, 2013b) are increasingly consistent with psychological intuition and empirical reality. There is a range of decision-making phenomena that are not well explained by any existing unitary models of risky decision making. People are sensitive to differences between outcomes and reference points, rather than to absolute end-states. In the real world, people often make decisions without explicit knowledge of probabilities. Conflicts between affect and deliberation are likely when people face certain moral dilemmas. (Loewenstein, Rick, and Cohen, 2008) Economic decisions may be affected by cultural differences in neurocomputational processing (Makó and Mitchell, 2013) underlying attention. Narrower allocation of attention may be associated with more impulsive and inconsistent temporal discounting. Incorporating cultural differences in neuroeconomic decision processes may establish more efficient economic policies. (Takahashi *et al*., 2009) Neuroscience can help us build better models of economic decision making (Hunter, 2013b): an understanding of the neural architecture involved in decision making (Pera, 2014b) might help us to model economic choice. Understanding of brain function can help to put constraints on models of economic decision making. The same area of the brain is responsible for loss aversion and ambiguity aversion. (Dean, 2013)

5. Conclusions

The results of the current study converge with prior research on neurological constrains that can rule out certain types of decision making processes, the neural processing of consumer behavior, neuroscience investigations of how the brain computes preferences and makes choices, and the neural processes underlying human choice. As a result of these earlier research findings, this study sought to determine the biological processes that underlie economic choice, the understanding of economic behavior, the biological mechanisms of decision making, and the causal role of brain structures in behavior. The findings of this study have implications for the roots of our economic behavior, the deeper structure of our systematic economic biases, the neural basis of social decision making, and the mechanisms that underlie human behavior.

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