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Expanding Neuroeconomics

Insights from psychology and neurobiology inform a new approach to economic rationality

With the stock market descending to record lows, increasing numbers of banks and financial institutions failing, countries and businesses going bankrupt, and people losing their homes and their jobs, understanding economic decisions and economic policy has never been more important. Why do people take out loans they will not be able to repay? Why did banks make loans to people who cannot possibly pay them back? Why would a company insure risk without reasonable risk assessment? What can a government do to stimulate an economy to grow, making new jobs and credit available? It is striking that after decades of research in economics, our understanding of economic behavior of people and institutions is so impoverished that all of our explanations are *ex post facto*.

Perhaps it is times like these, when scientists are confronted with the limits of their knowledge, that the need for new approaches and paradigm shifts becomes most acute. Unfortunately, new paradigms don't emerge overnight and new insights are not generated on demand. But perhaps the recognition of the boundaries of our current knowledge can encourage greater interaction across disciplines. Neuroeconomics represents just this kind of interaction and, while not brand new—it is arguably only about a decade old—it is young enough to offer the promise of new knowledge and insights (Egidi, Nusbaum, & Cacioppo, 2007). However, even

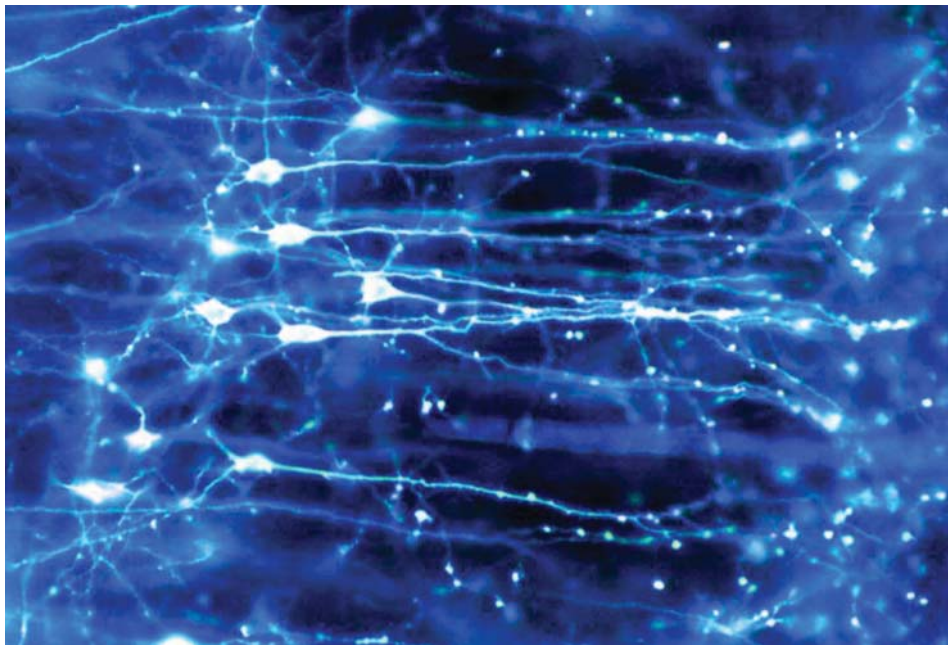
at its young age, there are glimmers of evidence that the current approach may need to expand its horizons beyond a focus on individual decisions to an emphasis on how social interaction and social contagion, social situations and context, and social emotions such as empathy, affect the individual making decisions.

Neuroeconomics is the study of the neural mechanisms that mediate economic decisions and it has developed from the synthesis of behavioral and experimental economics and cognitive neuroscience. On one hand, behavioral and experimental economics have focused on understanding how individuals make economic decisions, seeking to explain the principles that govern such decisions under risk, reward, uncertainty, and relative wealth. This research generally uses experimental designs that incorporate fundamental properties of economic situations such as auctions and measures behavior in the context of these tasks. On the other hand, cognitive neuroscience has focused on understanding cognitive processes more generally such as decision making, learning, memory, perception and attention. Researchers in this field use experimental designs generally drawn from cognitive psychology, but generally measure brain activity using functional Magnetic Resonance Imaging (fMRI; see Cabeza & Kingstone, 2001) or electrophysiology using scalp electrodes rather than behavior (see Fabiani et al., 2007). Some

researchers use behavioral tasks with patients with brain damage in particular areas of the brain to understand the contribution of specific neural regions (e.g., Koenigs et al, 2007). Other researchers intervene in brain function by stimulating the brain with electrical activity (e.g., Ojemann, 1991) or transcranial magnetic stimulation (TMS; Luber et al., 2007).

The combination of the fields of behavioral and experimental economics with cognitive neuroscience has yielded an explosion of new research investigating the neural processes which underlie economic decisions (see Glimcher et al., 2009). Much of this research has investigated a wide range of questions from the neural basis of utility and value, choice, risk, and uncertainty. What does learning about these neural mechanisms tell us about economic decisions and economic theories?

Behavioral and experimental economics has focused largely on understanding individual economic decisions. The apparent irrationality of the average economic decision maker has been well studied and documented as contrary to the assumptions of standard economics (e.g., Tversky & Kahneman, 1981). Rational choice theorists have continued to hew to the coldly rationalist model of the individual decision maker for several reasons. By questioning the generalizability of laboratory results to actual economical decision settings (e.g. Levitt & List, 2008),



by reasoning that what appears to be irrational is in fact rational but reflective of utility functions that were incorrectly or incompletely specified, or by noting that economic theory makes predictions about aggregate, not individual behavior, and irrationality does not have an impact on aggregate human behavior, economists seek to justify overlooking these findings. For instance, if the irrationality describing individual behavior is unsystematic, then the departure from rationality will sum to zero as one aggregates over individuals, leaving the rational choice theory of economic behavior intact.

Of course, behavioral economists and psychologists have contested the defense of rational choice. But perhaps it is more telling to remember that Federal Reserve Chairman Alan Greenspan used the term “irrational exuberance” in 1996 to describe what he viewed as an overvalued US stock market, acknowledging that irrationality was not confined to university experiments. Indeed, much of the current fiscal crisis could be viewed as a direct consequence of such irrational exuberance to incur debt without rational assessment of true cost or probable risk.

Furthermore, in the resulting fiscal crisis, there is now a widespread risk aversion that affects financial institutions and people alike. In spite of the infusion of supporting funds from the government to banks to promote lending and ease the credit crisis, credit is not flowing into the economy. Moreover, consumers are not spending even though there are few financial benefits to saving given the huge losses in investments and

the nearly vanished interest rate on savings accounts. From the irrational exuberance demonstrated by ill considered investment and exorbitant amounts of incurred debt to the current, overly excessive risk aversion, overwrought responses to situations are not easily explained by the individual, isolated economic decision maker.

The model of much of experimental economics and behavioral economics, as well as cognitive psychology and cognitive neuroscience, has focused on the individual and the comprehension of processes and mechanisms operating within an individual. This has produced substantial insights into the cognitive and neural processes that operate within each of us. In this respect, it is much like computer science which focuses on the architecture and processing within a single computer. This is a powerful model for understanding information processing and for developing new models and theories of human information processing. However, when computers are connected to each other in networks, there are emergent paradigms of information processing that are not predicted from studying the isolated system. Networks share information, distribute processing load, and parse problems into smaller components that can be attacked separately and thus handled more effectively and efficiently. The development of the Internet and new paradigms of commerce and social transaction directly reflect the power of networks that expand computing beyond the individual computer in ways that could not be anticipated from studying the isolated system. Moreover, the downside of such

computing networks such as the contagion of viruses and worms was also unanticipated. In much the same way, while there is much to be gained by studying how individuals make decisions, knowledge about the isolated individual can neither predict nor explain the synergies that emerge from social networks and social interactions.

Of course we can ask whether studying the brain helps in any respect of understanding economic decisions. How does the brain help us understand economic behavior? We can start by relating aspects of individual economic behavior to brain mechanisms directly. For example, the concept of utility is fundamental to economic theories. Is there a part of the brain that directly relates to aspects of perceived value? There are indeed networks in the brain that respond in relationship to the value of a good.

It appears that the evaluation of utility is associated with activity in a neural network involving subcortical regions projecting to the frontal cortical areas (see Sanfey, 2004; Knutson & Peterson, 2005 for reviews). The subcortical regions of this network involve part of the basal ganglia and limbic system that are important in a wide range of functions from motor control to emotional processes. Some of these areas are involved in a neural “hedonic” response to immediate rewards (e.g., McClure et al., 2004a). There is some evidence for a dissociation of neural responses between expected value and actual value (Knutson et al., 2001).

The higher cortical areas include mostly the medial prefrontal cortex. One view of the medial prefrontal cortex (e.g., Knutson & Peterson, 2005) is that it is involved in calculating the probability of a positive reward. Indeed, research has indicated that prefrontal structures can be activated even in cases of evaluating abstract or symbolic gains or losses (e.g., O’Doherty et al., 2001). This is a slightly different interpretation than McClure et al.’s (2004b) view that these structures are part of the impulsive-passionate affective response system that drives the utility valuation of immediate rewards (see also Padoa-Schioppa & Assad, 2006; Plassmann et al., 2007). The expectation of an outcome seems different from the impulsive hedonic drive for immediate reward.

The notion of expectation of a reward may be very different from a simple probability. Patients with damage to these brain structures do not simply fail to anticipate a negative outcome in their choice behavior based on past probabilities—they also fail to

show physiological evidence of an affective reaction (Bechara, et al., 1997). As a result, Bechara and colleagues argued that these prefrontal structures can serve a regulatory role in behavior. By recording past affective experiences along with the context of their occurrence, the prefrontal cortex can influence cognitive determinations in other cortical regions through projections to nuclei that regulate neurotransmitters which then modulate other cortical circuits such as dopamine. Perhaps it does not require brain damage to the prefrontal cortex to lose the regulatory control over choices that involve high risk or provide immediate payoff—perhaps it is simple to have strong expectations of reward.

However, as described earlier in considering the computer science of individual computers and networks, there may be something important missing from a neuroeconomic model of utility, if the focus is limited to the individual. Across economic theories, utility is certainly critical to understanding economic decisions. In the studies just described, expectation can play a role in modulating choice behavior, perhaps by modulating experienced utility through cortical systems. But it is not clear why choice behavior would be affected if expectations are constant, if the face value of a reward is constant, and if other aspects of the received value are constant. Utility should not change.

Sanfey et al. (2003) had participants play a two-person economic game. Sometimes offers were made by a human partner and sometimes offers were made by a computer partner. Brain activity was measured using fMRI to assess the neural activity accompanying the economic decisions. When participants were presented with unfair offers compared to fair ones, there was activity in the anterior insula and anterior cingulate, regions in which activation has been found to correlate with negative social emotions, such as the feeling of social rejection (Eisenberger et al., 2003). These are not brain regions associated with utility. In fact, activity in the insula was proportional to the unfairness of the offers. Across participants, there was higher insula activity for unfair offers that were rejected. Additionally, participants who rejected the highest number of unfair offers showed higher insula activation (Sanfey et al., 2003). In this game, rejection of an offer comes at a cost—participants were willing to pay to punish unfair offers. Other research has suggested that such altruistic

punishment provides a neural reward even while incurring a monetary cost (de Quervain et al., 2004).

Morever it is important to note that these results held only when participants were given unfair offers by human partners. When offers were known to be made by a computer, not only did participants accept unfair offers more often, but the activity in the insula and anterior cingulate did not significantly increase for unfair offers (Sanfey et al., 2003). Clearly a decision made in a social setting can strongly depend on assumptions made by the participants. Indeed, anthropological research has shown that, across cultures, the willingness to incur costs to punish inequitable behavior varies with the willingness to engage in altruistic behavior (Heinrich et al., 2006). Cultural norms about individual behavior and socially appropriate behavior interact in the regulation of fairness by society. Prosocial behavior may depend on how cultures tell us we should think about each other.

The classic Frank Capra movie, “It’s a Wonderful Life,” portrays two clear stereotypes from a banking and finance system that is all but gone from the 21st Century. The protagonist, George Bailey, has the prosocial plan of establishing affordable housing for the people of his town. These are people he knows well, both in their strengths and weaknesses. The antagonist, Mr. Potter, is the epitome of homo economicus in his approach to man-

aging his financial affairs, with the concept of concern for his fellow townspeople entirely irrelevant to his economic decisions. However, both Bailey and Potter approach economic decision making in a way that has slowly vanished from our current financial system: both men know the people they are dealing with economically and, although coming to different assessments of the financial strengths and weaknesses of these people, social connection plays an important role in economic decisions, as does theory of mind (e.g., Rilling et al., 2004), perspective taking (Decety & Sommerville, 2003), and empathy (Decety & Jackson, 2006).

The current mortgage and housing crisis, and perhaps much of the credit crisis in general, has emerged from a very different milieu of financial decision making than that of the Capra movie era. Isolated from real social information about borrowers, there is an assumption that certain kinds of economic data are sufficiently objective, diagnostic, and reliable to ground decisions about credit. However, the ability to transfer risk from the loan originator serves to decouple the decision process from the outcomes of those decisions. Asset appraisal gets short shrift because risk will get transferred. For example, real estate appraisals are often carried out on comparable sales without even a close inspection of the properties inside and out. Lip service to due diligence trumps real long-term knowledge about individuals



and assets. Mortgage brokers act as dissociated financial agents, and institutions that make loans resell them to shed risk. This separates the loan decision process from the outcomes.

The credit business is not the only aspect of economic decision making that has eliminated social knowledge from the process. Trading is no longer strictly a face-to-face business with known agents. Faceless artificial intelligence handles transactions so quickly that artificial restraints have been put in place. Investments are managed without much social knowledge. In short, the social brain no longer serves as a way of governance over the economic engine in spite of the development of social needs throughout the course of our evolution (Cacioppo & Patrick, 2008).

Trust and cooperation are important elements of social interaction which take place in economic exchanges. Social cooperation produces increased activity in the basal ganglia and the medial prefrontal cortices (King-Casas et al., 2005; Rilling et al., 2004), consistent with increasing utility and bias for cooperation. However, with strong prior expectations about the trustworthiness a potential economic partner has, successive interactions have little impact on the basal ganglia (Delgado et al., 2005). Reputation and personal knowledge matter in economic decisions and in the brain activity that relates to the utility of successful economic transactions.

Much of the research in neuroeconomics analyzes patterns of brain activity simply by searching for the reliable peak of activity. While this may characterize the strength of specific brain responses, it overlooks the fundamental nature of neural systems as networks of regions rather than individual isolated mechanisms. Just as behavioral and experimental economics has focused on the individual rather than the social network, much of cognitive and social neuroscience has focused on individual brain regions rather than dynamically coordinated neural systems. While some studies have begun to regress behavioral data onto brain activity (e.g., Plassmann et al., 2007) in order to understand brain-behavior relationships more directly, and others have examined the interaction between activity in one person's brain and activity in another person's brain (King-Casas et al., 2005) to understand joint neural changes in social interaction, it will be necessary to develop more sophisticated analytic models in neuroeconomics that consider the

covariance among brain regions rather than simple magnitude of activity. Neuroeconomics needs to find ways of understanding interaction between brains rather than the individual brain operating in isolation. Social psychology has long discussed the need for comprehending the power of social situations in shaping individual behavior. At the same time it is important to understand individual differences in the response to such

social situations. Neuroeconomics needs to move beyond the paradigm of carrying out behavioral and experimental economics studies simply using brain imaging (cf. Cacioppo et al., 2003). It is important to explore broader notions of how individual differences and social situations interact to dynamically assemble the neural networks that mediate economic decisions. **H**

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