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by

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Working Paper

Some economists believe that the work of neuroeconomists threatens the theory of economics. Glenn Harrison's paper "Neuroeconomics: A Critical Reconsideration" attempts to set the score, though the points he makes are hidden behind the fumes of his anger (Glenn W. Harrison 2008). The field of neuroeconomics is barely into its teenage years; and it is trying to do what? Redesign the field of economics developed over a hundred years? No, that is not what neuroeconomics is trying to do, in spite of all the efforts of some economists trying to place it into that shoebox. Neuroeconomics is a Mendelian-Economics of sort; it is a science that is able to generate data by fixing the environment to some degree and looking to see each individual's choices from the initiation of the decision-making process to its outcome. Standard economics (SE), on the other hand, looks at the average of the outputs of many individuals and proposes how the human chose those outcomes. The two fields, neuroeconomics and SE, are evaluating two sides of the same coin; one with and the other without *ceteris paribus*; they are not necessarily in conflict with one another.

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1. Introduction

Some economists believe that the work of neuroeconomists threatens standard economics. By "standard economics" I mean the type of economics that has been taught in universities as "economic theory" since Adam Smith provided its basic tenets; hereafter I call "standard economics" simply SE. SE is based on the foundation of many great thinkers, including von Neumann and Morgenstern, who established the four axioms of the expected utility theory that is so much questioned these days. SE is based on many assumptions of human behavior that were derived from observing the outcome of human decision-making. Such outcome is available to all economists from government databases and they portray what the population has consumed in the previous months and years.

Contrary to popular belief in many economic circles, neuroeconomics is neither psychology nor the study of functional magnetic resonance imaging (fMRI). Neuroeconomics is the scientific process of economics by which researchers from many disciplines cooperate and share methods in order to generate various scientific experiments that specifically prompt certain human or animal decision-making processes in order to evaluate the outcome in a controlled environment. Neuroeconomics contains methods that were developed by psychologists, neurologists, anthropologists, biologists, geneticists, mathematicians, physicists, and many other fields, including experimental and behavioral economists.

2. The War: *Ceteris Paribus*

Some of the statements found in the literature Harrison refers to undoubtedly give reason to his conclusions but those statements he critiques are not representative of the work of neuroeconomists; they provide only explanations of some of their methods. One may critique the

theory of the expected utility in the same way by which its axioms are so rigidly drawn—and many researchers (neuroeconomists, behavioral economists, and experimental economists) are doing just that. It seems that the tug of war is not over the merits of the two fields but its examples and explanations about the outcomes. Neuroeconomics does not question the fundamental concepts of SE without merit, since those concepts are derived from the outcome of decision-choices rather than the process itself. There is nothing wrong with looking at outcomes and formulating a theory as to the "why," so long as the answer to the "why" can, in fact, be placed into a forecast to yield the same results over and over again, as in "real" science.

The conventional thinking in SE is that a person's preferences will not change *ceteris paribus* when presented with two identical bundles at two separate times and if the goods in these bundles come with the same probability. Suppose this is true; an individual is presented with a set of bundles *A* and *B* and a few minutes later she is presented with the same set of bundles *A* and *B* in the exact same way and in the same combination as before, *ceteris paribus*. According to economics, if she chose bundle *A* before, since it is *ceteris paribus*, she will choose bundle A again, if she is consistent.

The problem in this example is not with the bundles or whether she prefers bundle *A* as state or not state preference; the problem is the *ceteris paribus*. There is no such that "at another time" if the *ceteris paribus* was evoked. By definition time has passed between the two choices. While mathematically such time differential can indeed be fixed to a *ceteris paribus* statement and consistency may be expected under that condition, in real life *time* means that several heart beats have passed, the person took at least one breath, and the person's entire internal chemistry has

changed. There is no such as *ceteris paribus* when it comes to real life. By definition we cannot have a valid economic theory that sets its most fundamental theories on *ceteris paribus*.

It is important to deliberate on these chemical changes because the essence of human consumption is based on the chemical state of the human brain at the moment the choice is being made. It is not possible to look at the outcome of these decisions and pretend that a *ceteris paribus* will provide enough stability for the same individual to make the same decision twice in moments passing in the same decision-choice task. Economists ask why we care to understand the human decision-making machine if we have the output to look at?

The purpose of economics is not to have beautiful and simple mathematical models but to have models that are useful for formulating business and policy decisions. Economics must be able to explain the outcome as well as understand the means by which those outcomes were achieved in order to help repeat the positive outcomes in the future. Forecasting what will happen based on what happened in the past is neither enough nor interesting; forecasting *how to create the desired outcome* is far more important and much more exciting. And this "how to" must encompass real humans so long as we talk about the economic activities of real humans.

Economics assumes that decision-making is based on a calculated effort at all times (Andrew Mas-Colell *et al.* 1995;Oliver E. Williamson 1993;John Quiggin 1993), which we now know is not the case. Let me quote, as Harrison did, Camerer, Loewstein and Prelec (2004, 2005) "…there is considerable evidence from neuroscience and other areas of psychology that the motivation to take an action is not always closely tied to hedonic consequences" (Colin Camerer

et al. 2004;Colin Camerer *et al.* 2005). Harrison responds by "…this is not what economics assumes at all. We say that choices reveal preferences, on a good inferential day…" (Glenn W. Harrison 2008) (page 8). So "choices reveal preferences" and "on a good inferential day."

It is raining where I am today—is this a good inferential day? Yesterday the sun was out for about an hour and I was out walking my dog and shooting pictures of the new flowers that pocked their heads out for the first time; was this a good inferential day? More importantly, are the two days equal in terms of what decision I will make and how these decisions will reveal my preferences? If on the rainy day one chooses bundle *A* and on the sunny bundle *B*, will that inform economics in any way? Note that *ceteris paribus* fixes rain or sun but the decision cannot be fixed in a *ceteris paribus* environment any more than the person who makes those decisions can.

If we assume these two different choices reveal preferences correctly, since those were two independent moments of the day and on average once choice *A* and once choice *B* is preferred, what is the policy-maker to conclude using the theory of consumer choice under uncertainty? What we see in these choices appear to be inconsistent preferences by this person and when we look at the population en-large and we look at the choice outcome for the week of all individuals in the US, we may conclude that the economy is in a particular state because individuals purchase this way and that—and on average it provides a particular result. Yet in reality, the choices did not reflect anything we can tie to the health and wealth of the society; the choices reflected the mood of the millions of individuals, which appeared to balance out—some chose bundle *A* and others bundle *B* as a result of the weather in the particular environment.

Thus when it comes to making a decision by a firm whether to manufacture more of products in the bundle *A* or those in the bundle *B*, economic theory should be able to tell the firm to produce *A* if good weather is likely and produce *B* in larger numbers when it is going to be raining. Current economic theories are not able to do that because they are not interested in the methods by which real humans make decisions and the weather is fixed under *ceteris paribus*. Harrison suggests that when a subject perceives something differently from other times, then "one can argue that it is a different task" (ibid, page 9). Thus Harrison would conclude that the choice between bundles *A* and *B* on a rainy day represents a different task from choosing among the same bundles on a sunny day. I beg to differ on this point; it is not the bundles that changed, it is not the task that changed, nor did the value of the bundles change. What changed is the *ceteris paribus*.

3. What's Your Hormone Got to Do with It?

It is hard to accept that people make decisions in a laboratory setting similarly to how they would make those same decisions in the real world. Harrison points out that the representation of a task in an artificial lab environment is different from a real one. Yet research shows that the representation of something fake is very real in the mind of an individual. Numerous studies show that both in humans and in monkeys, images or sounds of the real thing trigger the activation of the brain similarly to when the individual is actually engaged in doing that thing. Image of a hand (even if clearly a rubber hand) activates the exact same region of the brain as if the participant's hand itself was really pocked (Philip L. Jackson *et al.* 2006;Philip L. Jackson *et al.* 2005;India Morrison *et al.* 2004;Philip L. Jackson *et al.* 2005;H. Henrik Ehrsson *et al.* 2007). Hand to mouth actions in monkeys activate the exact same brain areas as when they simply listen to sounds that are associated with similar actions (Valeria Gazzola *et al.* 2006).

Experiments of the kind used in the laboratory have been taken out to real societies and the results show that not only do people behave similarly in lab environment and real life experiments, but that there is a cultural influence over how an economic choice is made (Joseph Patrick Henrich 2004;Joseph Patrick Henrich *et al.* 2005;Joseph Patrick Henrich *et al.* 2001). The most important aspect of these findings is that "rationality" is dependent on the culture of the beholder.

If economic theory holds, there is only one way to solve a particular problem. The meaning of "rational" has changed over the years but it remains controversial whether it is a term that should be used at all. At one point "rational" meant to be a *Homo economicus* in every respect, implying self-maximizing choices in a consistent fashion. Today we find that humans maximize elements in decision-making that are not visible if we only look at outputs—hence looking only at outputs provides faulty image of incentives and preferences.

The point of highest importance in decision-outcomes is the hormones of the human brain that fluctuate in the body in response to environmental stimuli. The same exact task will have a different outcome if a particular hormone is in high or low levels in the body—and yes, these hormones change naturally given external environmental and internal changes in the human body that are beyond observational possibilities. For example, a person will make choices differently based on whether he had traffic or could fly on the freeway on his way to work, if his team won or lost the game, or if he had sex recently or not. Women will have completely different chemical structures every minute, as part of their menstrual cycle they are in changes

continually. Given any choice task will lead to different economic outcomes given her monthly cycle, his luck on the freeways or his teams with their games (Paul J. Zak *et al.* 2005a).

Most recent neuroeconomics research using hormonal studies show that the human reward system in the brain prefers to maximize its utility in the currency of dopamine rather than money or more apples and less oranges. It is also clear that eating apples and oranges translate into pleasure in the brain, which activates the reward center, evoking an economic system that is completely invisible to economists looking at outputs. It was a great surprise, and at first often under attack, when it was found (in labs and in life experiments) that humans are willing to punish at a cost to themselves. Why would a rational human chose less money over more money, *ceteris paribus*? Attacks came from all sides, saying that people must not understand the game, they want to please the researchers, the amount of money at stake is too small, or that they play differently in labs from real life. But then new experiments captured the utility of punishing: hormonal reward in the brain (Tania Singer *et al.* 2006;James H. Fowler 2005;D. J-F. DeQuervain *et al.* 2004).

Hormonal research shows that indeed, many economic decision-making can be stimulated one way or another by the natural variations of hormonal levels (Paul J. Zak *et al.* 2005b;Paul J. Zak *et al.* 2004), or the use of administered hormones that are set to stimulate a particular part of the brain. For example, landmark studies showed that the hormone Oxytocin makes people more trusting (Michael Kosfeld *et al.* 2005) and more generous (Paul J. Zak *et al.* 2007;Angela A Stanton 2007). Oxytocin is manufactured in the human brain in various amounts throughout the day. Environmental stimuli as simple as a salesman tapping a shopper's shoulder to say "how are

you?" in a used car dealership may make the shopper release more Oxytocin, which then makes him more trusting toward the sales rep. Hormonal variations in the brain are not there to trick economists; they have been there throughout human evolution, each with specific roles. Oxytocin, for example, has the role to support communication with strangers as well as to create bond between mother and child at the moment of birth—among many more functions.

Some other hormones of importance are better known from the news or from individual experiences even by laymen. The rush of adrenaline in dangerous situations is well known to assist the person to get out of danger. The same hormone may help the market trader make quick decisions in a quick-action market day, be it bull or bear day. We can find parallel to this and other activities in non-human primates, showing us the evolutionary necessary connection of our hormones to our development and to everyday decision-making.

If a researcher can change the decision-making outcome of a person by the administration of hormones that all people otherwise already have (in other words hormones are not drugs), can we say that decision-making can be modeled without the understanding of the chemical structure of the brain?

4. Molecular Rationality

Yet interestingly, some of the debate over the separation of SE and neuroeconomics is possibly futile because neuroeconomics shows that indeed humans appear to be consistent and the tenets of the expected utility theory's four axioms may well stand the times. In experiments with games with hormonal stimuli, studies find that humans are stimulated similarly and the outcome of their

decision-making follows the predictions—sometimes linearly. Some clever animal experiments show why.

We know that the Orbitofrontal cortex (over the eyes under the orbit of the eyebrows) has neurons that encode actual utility values. Monkeys, for example, with single-neuron experiments in the Orbitofrontal cortex make their decision-choice based on certain numbers of drops of juices they receive. Amazingly, experiments like these lead to the setting up of each monkey's specific utility function based on the clearly identifiable indifference curves it possesses for the juices (Camillo Padoa-Schioppa 2007). A most fascinating study with monkeys showed that they have personal and social values similarly to humans. Images were shown to monkeys and they could choose to look at them for some quantity of juice (the price), some of which they were willing to pay to see, while for other images they were willing to pay to go away. In particular, male monkeys were found to want to pay with juice currency to see the photographed faces of dominant males and the amount they paid for this was more than what they were willing to pay to see the faces of females, while they demanded even higher juice-pay to look at photographed faces of less dominant males than they perceived themselves to be (Robert O. Deaner *et al.* 2005).

Since it is possible to decipher the exact utility function of an individual given the measure of the currency exchange for goods and services, also through the examination of a single brain cell, and since the particular brain cell remains consistent so long as it is not tricked my varying probability of juice payments (M. L. Platt, P. W. Glimcher 1999), it is possible to address whether economic theory is capable to provide a particular decision-outcome. If, for example, we

find that the brain sometimes chooses apples and other times oranges in a *ceteris paribus* environment with single-neuron experimenting, then we know that an economic theory requiring consistency will not be the correct one. On the other hand, if cells choose consistently under *ceteris paribus* conditions in a single-neuron experiment, we then know that neuroeconomics has provided support rather than critique of economic theory.

As this research is not yet complete even with monkeys, and it has not actually yet begun with humans because of the obvious logistical nightmare of single-cell experimenting, all we can say for now is that molecularly speaking, every single human is made of the same chemical elements and bonds. It is not going to take hundreds of years for neuroeconomics to find a model that will fulfill the need of economists but give this nascent science some room to grow. It is a wonder what it can show; why not look and listen or even participate?

5. Conclusion

Economics stands only to gain from the tools of neuroeconomics. Of course, similarly to the standard supply and demand model taught in every introductory economics class, the benefits accrue to the average and not to each individual. It is possible that some economic theories will be proven wrong and those who coined them will feel hurt and bruised. On the flip side, there will be many whose theories will be proven to stand taller than ever.

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