Opening the black box: examining the potential of neuroeconomics

Owen McLaughlin

Junior Sophister

mclaugho@tcd.ie

"I believe we are well on our way to the day where our theoretical concepts about decision making are shaped at least in part by findings from neuroscience"

Daniel Kahneman[1]

*"**Brain,** n. An apparatus with which we think we think."*

- Ambrose Bierce, the Devil's Dictionary.

Introduction

The rapid developments in the field of neuroscience have promised previously unparalleled insights into the workings of the human brain over a wide range of conditions and contexts. The field has attracted enormous interest from a variety of disciplines concerned with the mechanics underlying behaviour, including behavioural economics. The resulting research has pointed the way towards a new discipline, dubbed "neuroeconomics", which seeks to explore the potential relevance of neuroscientific findings to economic issues.

This article aims to provide an introduction, overview and critical appraisal of this new and evolving discipline. It will review the development of neuroeconomic ideas and the context from which they arose, as well as its methodology and research objectives. The case for neuroeconomics as a meaningful paradigm for economists will be examined and weighed against the arguments of sceptics, with the aim of determining what, if anything, economics can learn by opening the 'black box' of the human brain with the keys of neuroscience.

New answers to old questions: the development of neuroeconomics.

[1] Kahneman (2009: 525)

The field of neuroeconomics is, an extremely new one, being at most 15 years old (Damasio, 2009). It is the product of a synthesis of ideas which had been brewing for at least another decade; the first fruits of the developing dialogue between behavioural economics and the emerging field of neuroscience. Neuroeconomics' intellectual roots can be traced back much further: at least to the turn of the 20th century and even beyond[2]. They can be seen clearly in the attempts of the early students of political economy to relate such investigations to the 'psycho-physical' paradigm of the day, the same paradigm which informed the earliest investigations in psychology (Gazzaniga & Heatherton, 2006). William Jevons (1879: 12-13), for example, sought to uncover the "mechanics of utility and self-interest" which would establish a physical basis for the intuitions and mathematical models of economic choices (Quartz, 2008). Francis Edgeworth (1881) dreamed of a device, the hedonimeter, which would make possible the precise quantification of utility and happiness, and thereby ground the abstract idea of economic utility in direct human experience. However, despite these ambitions, such an instrument did not materialise as the author lacked a sufficiently scientific method of making such measurements (Collander, 2007). As these limitations became apparent, the prospect of a physical economics receded. William Jevons grew more sceptical in his later writings (Collander, 2007) but the most decisive rejection of this idea came from Vilfredo Pareto (1897) who concluded that:

> "…the natural sciences have progressed only when they have taken secondary principles as their point of departure, instead of trying to discover the essence of things… political economy has a great interest on relying as little as possible on the domain of psychology"[3].

Such intuitions marked and motivated the beginnings of a profound shift in economics during the early 20th century, one which would effectively divorce the field from any influences of the mind or the brain. This was the concept of revealed preference, an approach elaborated by Paul Samuelson in the 1930s as the 'Weak Axiom of Revealed Preference' (Samuelson, 1938). This straightforward idea – that it is the choices an agent consistently makes, rather than the mechanisms underlying them, which matter for economists – bore out Pareto's (1897) views. It allowed economists to dispense with the thorny problem of the 'essence of things' with regard to human choosing, substituting instead general axioms of idealised, efficient behaviour, which could be modelled more easily, but still provide an effective

[2] See Rustichini (2005) for an interesting consideration of the Smith's Theory of Moral Sentiments and other classical works from a neuroeconomics perspective.
[3] As quoted by Glimcher et al. (2009:7)

framework for analysing choices and resource allocation (Glimcher et al., 2009). It provided one of the crucial foundations of neoclassical economic theory, and marks the point at which economists "determined to be outside the purview of economics" made any effort to measure utilities or choices directly (Collander, 2007: 216).

The question of a physiological basis for economic variables then lay dormant for many years. However, as economic theory continued to evolve, research began to appear which seemed to undermine some aspects of the standard neoclassical axioms of choice. Maurice Allais (1953) identified a paradox in which choice making appeared to be inconsistent with the independence axiom of standard expected utility theory. Ellsberg's Paradox (1961) produced a similar result (Glimcher et al., 2009). Such findings were expanded upon in the celebrated work of Amos Tversky and Daniel Kahneman (see Kahneman & Tversky, 1979) who demonstrated experimentally a range of situations in which people appeared to consistently violate economic rationality as it was then defined. These developments ultimately provoked the emergence of the field of behavioural economics, which seeks to use intuitions and findings from areas of psychology to enrich economic models and theories. Over the following decades, the evolution of this approach witnessed some psychological concepts, such as framing effects and bounded rationality; enter the mainstream of economic discourse (Rubenstein, 2008). This has provoked debate and considerable criticism from neo-classicists (Glimcher et al., 2009).

Just as behavioural economics was once again raising questions about the relevance of psychology to economic studies, a parallel discipline was emerging which promised a new paradigm for psychology itself. Huge advances in the technology of diagnostic imaging and other non-invasive methods in the discipline of neuroscience heralded the possibility of directly measuring the brain activity of healthy, conscious humans, potentially laying bare the precise neurological systems and variables mediating behaviour. This was a potentially revolutionary development and its tools were soon being applied to many areas of psychological study (Gazzaniga & Heatherton, 2006). However, its potential influence was broader than that. Discussions about the potential relevance of neuroscience extended far beyond psychology and inevitably touched upon economics (Lowenstein et al., 2008).

The first literature generally recognised as neuroeconomics (though predating the term itself) was Peter Shizgal and Kent Conover's *On the neural computation of Utility*, published in 1996. It bears this distinction because it was the first paper to attempt to explicitly set neurobiological processes in an economic framework: in this case, decision-making processes in the brains of rats. There followed a modest number of other papers of increasing complexity looking at decision making in the brain in the context of economic utility and its axioms

(Glimcher et al., 2009). These early[4] investigations were primarily neuroscientific experiments making use of some economic concepts, but behavioural economists were not far behind – Kahneman himself collaborated with Hans Breiter in a study which examined choice experiments of the prospect theory of utility through neural imaging (Breiter et al., 2001). In 2003, Paul Glimcher published *Decisions, Uncertainty and the Brain*, which summarised these developments and introduced neuroeconomics to a broader audience. Manifestos began to appear attempting to "explain what neuroscientists do and how their discoveries... might influence economic analysis" (Camerer et al., 2005).

In the ensuing dialogue between neuroscientists, behavioural and experimental economists, the concept and methods by which neuroscientific findings might be applied to economic problems (and economic methods to neuroscience ones)[5] began to crystallise, and neuroeconomics was born. From that point on, the number of papers dealing with the issue began to increase significantly, with over 100 appearing in 2006 alone. The Society for Neuroeconomics was inaugurated in 2005 and dedicated neuroeconomics centres have begun to appear (Glimcher et al. 2009). However, the question remained: what do these centres investigate? And what do neuroscientific concepts and methods actually mean for mainstream economics? Having established the context in which neuroeconomics evolved, the second half of this article now addresses this question.

The neuroeconomist's manifesto: rationale, methods and objectives.

> *"A better understanding of the brain is certain to lead man to a richer comprehension both of himself, of his fellow men, of society, and in fact of the whole world and of its problems."*
>
> John C. Eccles[6]

The above quote, from the accomplished early neuroscientist John Eccles, is a succinct summation of the promises of 'brain science' as something more than a subfield of anatomy or medicine. Its potential applications to psychology are readily apparent but these words form a clarion call to a much broader range of disciplines: philosophy, politics, the social sciences and – by no means least – economics. Neuroeconomics purports to answer that call. As has already been discussed, the

[4] Neuroeconomics is one of the only disciplines in which a paper published in the late 1990s can be described as 'early'.

[5] The interchange is by no means a one-way street (see Glimcher, 2003) but this article will focus on the application of neuroscientific methods to economics.

[6] Eccles (1973, foreword)

agenda and objectives of neuroeconomics are a developing debate but practically any statement of its tenets could ultimately be boiled down to a simple idea: the principle that knowing how the brain works in contexts relevant to economics (decision making, assessment of uncertainty, and so on) will provide observations and data relevant to economics as a science. This is a minimal definition, as different views exist as to what data is of relevance, how it should be collected, and to what purpose. However, an interest in the brain as the engine of the economic agent and a desire to investigate the workings of that engine, is the defining common theme.

In the union of neuroscience and economics, the contribution of the former is primarily methodological. Variables of interest range from broad observable measures such as blinking rate and reaction time[7], down to measures of the firing rate of a single neuron. Studies using functional Magnetic Resonance Imaging (fMRI) (which observe changes in blood flow in the brain to detect areas of activity) account for the great majority of experimentation in neuroeconomics thus far but experimental methods such as Transcranial Magnetic Stimulation (TMS), which can be used to temporarily excite or suppress neural activity in specific areas of the brain, have begun to attract interest (Camerer, 2008).

What the field of economics provides is both the framework and the direction for investigation, taking its cues primarily from groundwork laid by earlier developments in behavioural economics. Experiments in neuroeconomics focused initially on models of utility maximisation such as expected utility (Berns et al., 2001) and prospect theory (Breiter et al., 2001), but have since broadened to embrace areas as diverse as game theory (Houser & McCabe, 2009) economic decisions in a social context (Greene et al., 2001) and donations and philanthropy (Mayr et al., 2009).

Considering an experiment in detail, take, by way of example, the study by Paul Zak and colleagues who aimed to investigate "the physiologic mechanisms that support altruism and generosity" (Zak et al., 2007: 1128). This study captures a number of the ways in which the frameworks of neuroscience and economics can interact in an experimental setting. The experimenters chose a broad topic of interest to both economics and psychology (generosity) but interpreted it through an economic framework, the ultimatum game. This is a game theory paradigm in which two players must decide how to distribute a sum of money between them, one player making a one-shot offer which the other player can then accept or reject for both players. They describe the first player's objectives through an economic utility-maximisation model:

[7] Already used in some economic studies. See Rubenstein (2008).

$$\max_{bi,bj} b_i^{\beta} + \alpha b_j^{\beta}$$

Subject to: $b_i + b_j = M$

Where: b^{β} represents benefit to players i and j,
M represents money and,
α is a coefficient capturing empathy towards the other player

It is here that the neuroscience is introduced. The experimenters drew on an extensive psychological and neurobiological literature, positing a link between higher levels of reciprocity and trust and the neurotransmitter oxytocin. Before each game, experimenters administered a nasal spray to the players, half of which contained concentrated oxytocin and the other half a saline placebo. The result was a startling 80 per cent increase in the number of generous distributions proposed by players under the influence of oxytocin (Zak et al., 2007).

Mindless economics and new phrenology: the case against neuroeconomics.

> "Populating economic models with "flesh-and-blood human beings," was never the objective of economists."
>
> (Gul & Pesendorfer, 2005: 12)

"The brain boggles the mind." – James D. Watson[8]

The study described in the previous section is a classic example of neuroeconomic research and its findings: the identification of a neurobiological mechanism (a neurotransmitter in this case) which has an observable moderating effect on an economic outcome (the results of an ultimatum game). As such, it is inherently significant to anyone interested in how the brain works in the context of economic activity. However it is imperative to ask: what impact do results such as this have on the field of economics as a whole, outside of any crossover with neuroscience? What does the knowledge that oxytocin mediates generosity mean to a classically-trained economist? The answer, potentially, is nothing.

This, at least, is the view of the sceptics and critics of the application of neuroscience to economics. This counterblast to the prevailing enthusiasm for neuroeconomics at the beginning of the 21st century is expressed most strongly in a

[8] Ackerman, S. (1992, Foreword)

widely read and controversial paper by economists Frank Gul and Wolfgang Pesendorfer entitled “The Case for Mindless Economics” (Gul & Pesendorfer, 2005)[9]. The views being propagated by these authors are essentially a modern extension of Pareto's (1897). Neoclassical economists, the authors argue, already possess the tools necessary to fully explore the behaviour of agents in the context of economic activity; the internal workings of those agents are irrelevant. Other sceptics have methodological concerns – small sample sizes, an over reliance on findings in artificial laboratory settings and exaggerated confidence in the reliability of neuroscientific data. Harrison (2008: 534) warns that neuroeconomists may become the "new phrenologists" if they continue to simply point out areas of the brain active in economic situations without more thorough proof of causation.

The sceptic’s objection (Rubenstein, 2008) is fundamentally this: neuroeconomics has missed the point of conventional economic analysis. Its purpose is not only to describe, but to model and crucially, predict economic behaviour. Grounding the often highly streamlined models of behaviour used by economic analysts in physiological reality will only be meaningful if doing this increases their predictive power.

Conclusion: the case for a mindful economics.

> “...sciences which have found new tools have always become more productive by using them.”
>
> (Camerer, 2008: 19)

The argument of Gul and Pesendorfer (2008) could almost be summed up in three words: revealed preference works. In its short history thus far, neuroeconomics has provided fascinating findings of interest to economists, even sceptical ones (Spiegler, 2008). That said it has yet to convince such sceptics that its findings are anything more than an "entertaining sideline" (Rubenstein, 2008: 493) to the progression of economics as a whole.

What, then, can neuroscience do for economics? Colin Camerer (2005: 28) argues that neuroeconomics "needs – at a minimum – to provoke thought, and suggest interesting, fresh perspectives on old problems". If the debate now raging in the literature is any indication, it has certainly succeeded. Furthermore, that neuroeconomic research can motivate or inspire innovations in other areas (for

[9] Initially presented as a response to Camerer et al.'s (2003) manifesto *Neuroeconomics* and subsequently replied to by Camerer (2008). The fierce and sometimes personal debate between them is a striking example of the controversy which often surrounds the birth of a new discipline.

instance behavioural economics) is evident even to strident opponents (Gul and Pesendorfer, 2008). However, it can do more than that. In the first instance, neuroeconomics can provide physiological explanations which are compatible with existing models (as in the example above), but it can also suggest new ones which can meaningfully enrich traditional models (Bernheim, 2009). In particular, as neuroscience and psychology isolate characteristics which vary between people in systematic ways – "types of brains" (Rubenstein, 2008: 493) – introducing these as variables into economic models could have valuable results. Furthermore, neuroeconomic "non-choice" data can be of great value as an adjudicator between competing models in areas of economics (such as the various proposed alternatives to expected utility) where there are a large variety of different models each claiming to be the most accurate predictor (Rustichini, 2005).

Neuroeconomics is a young field, and one which has suffered from immense academic hype in both of its parent disciplines (Spiegler, 2008). It is true that it has yet to produce a 'smoking gun' which revolutionises economic theory and sends all would-be economists reaching for the nearest textbook on introductory neuroscience. Opening the black box has not lead to an instant revolution, but nor has it been a waste of time. It has helped ground abstract ideas in the reality of the brain, rendering the unobservable observable. It has provided a powerful new framework for evaluating models of economic behaviour and made a strong case for the potential to enrich them. Most importantly, it is still in its infancy, and given time to mature, it may yet help change the way we think we think about economics.

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