*Economics and Philosophy*, **24** (2008) 449–457 
doi:10.1017/S0266267108002071

# THE SYLLOGISM OF NEURO-ECONOMICS

**Camillo Padoa-Schioppa**
*Washington University (in St. Louis)*

If neuroscience is to contribute to economics, it will do so by the way of psychology. Neural data can and do lead to better psychological theories, and psychological insights can and do lead to better economic models. Hence, neuroscience *can* in principle contribute to economics. Whether it actually *will* do so is an empirical question and the jury is still out. Economics currently faces theoretical and empirical challenges analogous to those faced by physics at the turn of the twentieth century and ultimately addressed by quantum theory. If "quantum economics" will emerge in the coming decades, it may well be founded on such concepts as cognitive processes and brain activity.

*The supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience.*

-Einstein 1934

Can neuroscience contribute to economics? Formulated a priori, the question is epistemological in nature, requires a proper definition of economics, and may be better left to a conversation between economists and philosophers. While this journal is a very appropriate arena for such a dialogue, this author – who is neither a philosopher nor an economist – is particularly unqualified to develop a formal and systematic argument. Thus more modestly, I will briefly present a few considerations that might lead to some optimism. I will argue that evidence gathered with neuroscientific methods *can* indeed (and some day *might*) help economists

* I thank L. Markson, A. Rangel and D. Ruff for helpful comments. My research is supported by a Pathway to Independence Award from the NIMH (MH080852).

develop more powerful theories. Far from formal, my reasoning will largely appeal to intuition and common sense.

## 1. ECONOMICS AS A NATURAL SCIENCE

Underlying my reasoning is the understanding of economics as a natural science, conceptually analogous to physics or biology. In this view, the object of economics is choice behaviour, in its diverse and multifaceted complexity. A few comments on this stance are in order.

First, while differing from classic definitions based on optimality (Robbins 1935, Samuelson 1970), the understanding of economics as a natural science does not necessarily reduce it to a purely descriptive (as opposed to normative) science. Indeed, the prescriptive/normative endeavour – devising and describing the best possible set of choices given preferences and constrains – certainly *is* part of the analysis of choice behaviour, whether or not actual choosers abide by those prescriptions. Let me illustrate this point with an example. Like any natural science, economics describes facts of life. One particular fact of life is that exponentials are the only discounting functions that ensure intertemporal consistency (which, per se, is certainly desirable). Another fact of life is that in many circumstances people's discounting functions are better described as hyperbolic. Both these facts of life pertain to choice behaviour and are thus legitimately described by economics.

Second, defining economics as the science of choice behaviour does not imply taking a position on the question of interest here – whether neuroscience can contribute to economics. Indeed, a full and satisfactory theory of choice behaviour could in principle be formulated ignoring completely the psychological and physiological processes that lead to choice. Alternatively, psychological and physiological evidence could be an essential part of the theory. Both these possibilities are left open by the definition.

Third, in the science of choice behaviour, like in any other natural science, different and competing theories should be distinguished empirically based on the usual criteria of accuracy, generality and parsimony. Of two alternative theories, we should deem preferable the one that best satisfies these criteria.

## 2. TERMS OF THE SYLLOGISM

Although the term "neuroeconomics" might suggest otherwise, that between economics, psychology and neuroscience truly is a *ménage à trois*. Loosely put, these three natural sciences have different objects. Economics is the science of choice behaviour, psychology is the science of thought, and neuroscience is the science of the brain. These rough definitions, given independently of one another, imply that economics, psychology

and neuroscience could in principle be separate sciences. The alternative hypothesis is that the three sciences, while operating at different levels, share a fundamental unity. In this latter view, methods, empirical results and theories proper of one science may bestow and support better theories in another science. Discussing whether neuroscience can contribute to economics essentially amounts to addressing whether there is fundamental unity or fundamental separateness between these three sciences.

My argument for unity is based on the following syllogism (of sorts). If neuroscience will contribute to economics, it will do so by the way of psychology. In other words, discoveries about the brain will hopefully lead to better theories of thought, which in turn will hopefully lead to better theories of choice behaviour. The syllogism is based on two premises – that neuroscience can contribute to psychology, and that psychology can contribute to economics. These premises, I will argue, are well documented already. It thus follows that neuroscience can contribute to economics. Notably, this proposition is a statement of possibility. Whether any discovery about the brain will in fact lead to better economic theories is ultimately an empirical question. Current examples might not be the most compelling, but the field is in its infancy and time will tell.

In the following, I summarize the arguments that support the two premises of the syllogism.

## 3. PSYCHOLOGY AND ECONOMICS

Early economists were concerned as much with moral sentiments as they were with the wealth of nations.[1] Utilitarian theories of economic choice, deeply rooted in psychological theories of pain and pleasure, were built on a strong concept of value. Over generations, however, economists gradually embraced weaker assumptions. In the 1930s, it was finally realized that economic theory could dispense of subjective value all together, and simply be founded on revealed preferences (Samuelson 1938). For the non-economist, it is worth emphasizing that the formulation in terms of revealed preferences was a scientific and mathematical triumph, for it freed economic theory from the burden of scrutinizing the chooser's mind. In this light, the reluctance of mainstream economics to re-open that (finally sealed) Pandora's box appears very understandable.[2] Yet, current challenges to the standard model are hard to ignore.

While revisiting the relationship between economics and psychology, a few remarks are in order. First, although neoclassical economics is arguably "mindless" (Gul and Pesendorfer 2008), it is not quite "psyche-less". Indeed, the revealed preferences approach did not quite

[1] For a historic account of classic economic theories, see Niehans (1990).
[2] See for example Roth (1996).

remove psychology from economic theory. Rather, neoclassic economics embraced one particular psychological theory – Skinnerian behaviourism.[3] The central tenet of behaviourism is that all behaviours result from stimulus-response associations learned through experience. In other words, behaviourism describes the psyche as a large look-up table where different sets of stimuli are associated to different responses. In this view, mental states and cognitive processes either do not exist or do not need to be investigated by psychology. In the case of choice behaviour, subjects learn to associate a set of options to one particular action. Thus after training, "choosing" simply amounts to retrieving the proper association.[4] Behaviourism thus denies the existence of any other mental process, including the assignment of value. In other words, according to behaviourism value is not a psychologically real entity; it is merely a construct used by the observer to describe choices. Subsumed in economics, behaviourism thus translates into revealed preferences.

Importantly, although it plays a foundational (if largely implicit) role in neoclassical economics, behaviourism was and remains a psychological theory. In this respect, it should be noted that, as a psychological theory, behaviourism is largely outdated. Starting with Chomsky (1959), cognitive scientists indeed recognized that behaviourism fails the scientific standard of Einstein's initial quote. In nearly every domain of psychology, from language to perception, the associative model proved exceedingly simplistic and better psychological theories were formulated in terms of mental states and cognitive processes.[5] With respect to choice behaviour, for example, it was proposed that choosing entails two distinct mental processes – the assignment of values to the available options, and the comparison (or decision) between these values.[6] The continuing prominence of the revealed preferences approach in mainstream economics can thus be viewed as somewhat paradoxical. Behaviourism, a psychological theory, is essentially abandoned within psychology. However, it remains as a cornerstone in another discipline, namely economics.

[3] Ross (2005) provides a detailed discussion of the relationship between neoclassical economics and behaviourism.

[4] In fact, according to Skinner (1953), choice is "an illusion".

[5] The main argument against behaviourism is that associative learning does not account well for situations where individuals behave adaptively in the absence of previous learning. But such situations are actually very frequent. For example, in the context of language, people easily understand new grammatical sentences, and children learn new words with minimal exposure. Similarly, in the context of choice behaviour, humans can make effective choices in new, unprecedented situations – an ability also present in non-human primates (Padoa-Schioppa *et al.*, 2006).

[6] Padoa-Schioppa *et al.* (2006) present an argument for economic choice as a two-stage mental process. Similar proposals were made also by Glimcher *et al.* (2005) and Fellows (2004).

The relevant question here is whether any cognitive model that provides a better psychological account of choice behaviour than that provided by behaviourism can also lead to better economic theories than those based on revealed preferences. In my view, the answer should be affirmative unless proven otherwise. Indeed, it seems safe to assume that economic theories based on "good" psychological models will be at least as "good as economic theories based on "bad" psychological models. And indeed, numerous current economic models – from prospect theory (Kahneman and Tversky 1979) to models of hyperbolic discounting (Ainslie 1992) – are rooted in notions from cognitive science. Hence, although a comprehensive economic theory based on mental processes remains elusive (see below), it seems reasonable to conclude that psychology can indeed contribute to economics.

## 4. NEUROSCIENCE AND PSYCHOLOGY

In a time when MRI scanners bloom in psychology departments around the world, questioning whether neuroscience can contribute to psychology may seem futile. However, MRI scanners and colourful images do not per se address earlier arguments for separateness (von Hayek 1952, Fodor 1975). In a nutshell, these arguments reject a reductionist claim – that mental states can be precisely mapped into physical brain states and that psychology can thus be ultimately reduced to neuroscience. One challenge to reductionism follows from the observation that identical mental states may be physically instantiated in very different realizations.[7] Another challenge to reductionism comes from the enormous complexity of the brain. In practical terms, realizing that mind-to-brain reduction would amount to devising a large mechanistic model of the brain, where each element of the model represents one neuron and elements in the model are connected in ways that represent the synapses in the brain. That model would faithfully reproduce behaviour, and mental states would then be mapped into states of the model. Unfortunately (or fortunately), the human brain has (conservatively) some $10^{11}$ neurons and perhaps $10^{14}$ synapses. Here, the hopeful reductionist may want to take a tip from the statistical physicist.[8] If a microscopic theory of such a large system is impossible

[7] The multiple realizability argument (Fodor 1975) may not be found quite conclusive, for it does not rule out that one particular exemplar of brain may be modelled accurately.

[8] A perfect gas – a large number of small, non-interacting particles enclosed in a volume – is typically described by *macroscopic* variables such as temperature, pressure and entropy, which are related to each other by the laws of thermodynamics. However, each particle in the gas also obeys the laws of mechanics: for any particle, given an initial measure, the future position and velocity can be computed exactly. Thus in principle, it should be possible to provide a *microscopic* description of the gas in terms of the position and motion of each particle at any given time – a reductionist endeavour. What makes this endeavour

when elements are simple and non-interacting particles in a perfect gas, how can it be realized when elements are complex and interacting neurons? This route of reductionism thus seems impracticable.

Nonetheless, I believe that the methods of neuroscience have a lot to offer to psychology. In fact, the distinction between neuroscience and psychology is arguably fictitious. Although the levels of description are certainly different, cognitive processes and brain activity are ultimately one and the same. The problem is not *reducing* the mind to brain activity – the mind *is* brain activity. The problem is to understand the mind/brain. In this endeavour, psychological theories and neural models should go hand-in-hand. Of course, neuronal processes *are* very complex and often hard to decipher, but so are cognitive processes. And in many cases deeper inroads can be made going back and forth between the two levels of description than can be made by working at one level alone.

Examining neuronal responses in a specific condition amounts to studying a particular cognitive process, or some aspect of it. In other words, single neuron recordings and brain imaging are as much methods of psychology as they are methods of neuroscience. This is not just a statement of principles. In many circumstances, different and competing psychological models are hard to disentangle based on behavioural evidence, and measures of brain activity can support or rule out one particular hypothesis.[9] Instances in which neuronal findings have shaped subsequent psychological theories abound. For example, Marr's (1982) model of vision (a psychological model insofar as vision is a mental process) builds on the classic discovery of Hubel and Wiesel (2005) that neurons in the primary visual cortex respond to oriented bars. Their discovery rules out alternative models of vision, such as models based on punctiform stimuli. Another example is particularly relevant to choice behaviour. Consider a person sitting in a restaurant and choosing between two options on the menu – pizza and salad. While choosing, the person

impossible in practice is the astronomical number of variables due to the large number of particles (in the order of $10^{23}$). Indeed, among other problems, trying to measure the exact location and velocity of each particle at one specific time would be hopeless. Fortunately, although thermodynamic variables are less precise in a microscopic sense, they provide a very adequate description at the global level. (For a more general critique of reductionism, see Anderson 1972).

[9] Following on the analogy between the mind/brain and a perfect gas, there generally is a correspondence between macroscopic and microscopic variables, such that inferences about macroscopic quantities can be obtained from microscopic measures. For example, the temperature of a perfect gas is the average kinetic energy of particles in the gas. If the temperature could not be measured at the global level, a reasonable estimate could still be obtained by measuring and averaging the kinetic energy of, say, 100 particles. Analogously, when psychological quantities cannot be measured, or when psychological hypotheses cannot be tested at the macroscopic (i.e. behavioural) level, critical insights might be obtained based on microscopic (i.e. neuronal) measures.

presumably assigns values to the two options and subsequently decides by comparing these values. Within this general framework, two alternative psychological models have been proposed. According to the "good-based model", values are compared in the space of goods, where a decision is made between pizza and salad. Subsequently, an appropriate action is selected to implement that choice. According to the "action-based model", values are first attached to different possible actions, and the decision unfolds as a process of action selection. The issue is not fully resolved based on behavioural evidence alone. However, there is consensus that the controversy can be addressed based on neuronal measures.[10] In conclusion, neuroscience can certainly contribute to psychology.

## 5. A HOPEFUL OUTLOOK

The syllogism of neuroeconomics goes as follows. Neuroscientific discoveries can lead to better psychological theories, which can lead to better economic theories; therefore, neuroscience can contribute to economics. Will this actually happen?

Neoclassical economics faces a number of empirical challenges – hyperbolic discounting, loss aversion and framing effects, to mention a few. Current economic models that account for these phenomena maintain the structure of the classic theory, with the addition of one or more psychological parameters that explain deviance from rationality. For example, models of fairness add to the classic utility a term for social preferences (Rabin 1993). Similarly, models of intertemporal choice explain hyperbolic discounting as due to attentional limitations (Benhabib and Bisin 2005), or in terms of multiple selves (Laibson 1997). And models of addiction include the psychological parameter of hedonic value (Bernheim and Rangel 2004). This "patching" approach is undoubtedly a good first step. However, by the standards of a natural science, the patching approach has severe limitations, because new psychological parameters are invoked ad hoc and injected into the theory every time a new fallacy is to be explained. Furthermore, if we imagine collecting the current economic models that describe various deviances form the classic assumptions, the emerging economic agent is rather awkward. She always has stable preferences, except that her choices are also crucially influenced by strict attentional limitations (and nothing else) in a specific set of conditions, by the urgent need of social fairness (and nothing else) in another set of conditions, by the excessive distaste for loss (and nothing else) in

[10] One prominent version of the action-based model was presented by Glimcher *et al*. (2005). The good-based model was proposed by the author (Padoa-Schioppa and Assad 2006; Padoa-Schioppa 2007). Platt and Padoa-Schioppa (in press) discuss ways to address the controversy based on neuronal data.

yet another set of conditions, and so on. Can we hope for a more comprehensive economic theory?

At the turn of the twentieth century, physics found itself in a situation analogous to that faced by economics today. Newtonian mechanics and electromagnetism, which once seemed to provide a stable and comprehensive system, were challenged theoretically and empirically by phenomena such as black body radiation, the photoelectric effect and the Compton scattering.[11] Initially, classic theories were patched to account for one effect or the other, but within a few decades a new comprehensive theory emerged. To be sure, quantum physics is grounded on qualitatively different concepts – such as the uncertainty principle and the wave-particle duality – that would have been simply unthinkable in the classic mind frame. Will a "quantum economics" similarly emerge in the coming decades? It is hard to say. But when it does, it may well be grounded on such "unthinkable" concepts as cognitive processes and brain activity.

## REFERENCES

Ainslie, G. 1992. *Picoeconomics: the strategic interaction of successive motivational states within the person*. Cambridge: Cambridge University Press.

Anderson, P. W. 1972. More is different. *Science* 177: 393–6.

Benhabib, J. and A. Bisin. 2005. Modeling internal commitment mechanisms and self-control: a neuroeconomics approach to consumption-saving decisions. *Games and Economic Behavior* 52: 460–92.

Bernheim, B. D. and Rangel, A. 2004. Addiction and cue-triggered decision processes. *American Economics Review* 94: 1558–90.

Chomsky, N. 1959. A review of B. F. Skinner's *Verbal Behavior*.*Language* 35: 26–58.

Einstein, A. 1934. On the method of theoretical physics. *Philosophy of Science* 1: 163–9.

Fellows, L. K. 2004. The cognitive neuroscience of human decision making: a review and conceptual framework. *Behavioral and Cognitive Neuroscience Reviews* 3: 159–72.

Fodor, J. A. 1975. *The language of thought*. New York: Crowell.

Gamow, G. 1966 [1985]. *Thirty years that shook physics: The story of quantum theory*. New York: Dover Publications.

Glimcher, P. W., Dorris, M. C. and Bayer, H. M. 2005. Physiological utility theory and the neuroeconomics of choice. *Games and Economic Behavior* 52: 213–56.

Gul, F. and W. Pesendorfer. 2008. The case for mindless economics. In *The foundations of positive and normative economics*, ed. A. Caplin and A. Schotter. New York: Oxford University Press.

Hubel, D. H. and T. N. Wiesel. 2005. *Brain and visual perception: the story of a 25-year collaboration*. New York: Oxford University Press.

Kahneman, D. and A. Tversky. 1979. Prospect theory: an analysis of decision under risk. *Econometrica* 47: 263–91.

Laibson, D. 1997. Golden eggs and hyperbolic discounting. *Quarterly Journal of Economics* 112: 443–77.

Marr, D. 1982. *Vision: a computational investigation into the human representation and processing of visual information*. San Francisco: W.H. Freeman.

[11] For a historic reconstruction, see Gamow (1966).

Niehans, J. 1990. *A history of economic theory: classic contributions, 1720–1980*. Baltimore, MD: Johns Hopkins University Press.
Padoa-Schioppa, C. 2007. Orbitofrontal cortex and the computation of economic value. *Annals of the New York Academy of Sciences* 1121: 232–53.
Padoa-Schioppa, C. and J. A. Assad. 2006. Neurons in orbitofrontal cortex encode economic value. *Nature* 441: 223–6.
Padoa-Schioppa, C., L. Jandolo and E. Visalberghi. 2006. Multi-stage mental process for economic choice in capuchins. *Cognition* 99: B1–13.
Platt, M. L. and C. Padoa-Schioppa. in press. Neuronal representations of value. In *Neuroeconomics: Decision making and the brain*, ed. P. W. Glimcher, C. F. Camerer, E. Fehr and R. A. Poldrack. New York: Academic Press.
Rabin, M. 1993. Incorporating fairness into game theory and economics. *American Economics Reviews* 83: 1281–302.
Robbins, L. C. R. 1935. *An essay on the nature and significance of economic science*, 2nd Edn. London: Macmillan.
Ross, D. 2005. *Economic theory and cognitive science: microexplanation*. Cambridge, MA: MIT Press.
Roth, A. E. 1996. Comment to Tversky's "Rational theory and constructive choice". In *The rational foundations of economic behavior*, ed. K. J. Arrow, E. Colombatto, M. Perlman and C. Schmidt, pp 198–202. New York: Macmillan.
Samuelson, P. A. 1938. A note on the pure theory of consumers' behavior. *Economica* 5: 61–71.
Samuelson, P. A. 1970. Maximum principles in analytical economics. Nobel memorial lecture.
Skinner, B. F. 1953. *Science and human behavior*. New York: Macmillan.
von Hayek, F. A. 1952. *The sensory order: an inquiry into the foundations of theoretical psychology*. Chicago: University of Chicago Press.