

## The disunity of neuroeconomics: a methodological appraisal

Roberto Fumagalli\*

*Department of Philosophy, Logic and Scientific Method, London School of Economics, London, UK*

The recent advancements at the interface between economics and neuroscience have encouraged neuroeconomists to raise several criticisms concerning the economic theory of choice. At present, however, there is little agreement with regard to the theoretical presuppositions and the explanatory aims of neuroeconomics. In this paper, I assess the scope and the significance of neuroeconomists' divergences, casting doubt on their attempts to provide a unified theoretical framework for analysing human choice behaviour. Moreover, I highlight some respects in which methodologically informed considerations can promote the consolidation of the neuroeconomic enterprise.

**Keywords:** neuroeconomics; economic models; economic theory of choice; economic methodology

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### Introduction

Over the last decade, neuroeconomists have put forward a number of critical remarks concerning the economic theory of choice.<sup>1</sup> Their considerations have prompted a variety of reactions among economists. To a first approximation, one may distinguish three prototypical positions in the economists' camp. On the one hand, the *sceptics* (e.g. Gul and Pesendorfer 2008; Harrison 2008a,b; Rubinstein 2008) doubt, and at times deny, the relevance of neuroeconomists' contributions for the economic account of decision making. On the other hand, the *enthusiasts* (e.g. Rustichini 2005) contend that incorporating neuro-physiological insights into economic models of choice will have significant, and arguably revolutionary, implications. In this highly simplified picture, a halfway position is advocated by the *moderates* (e.g. Smith 2007, chap. 14), who cautiously note that it is too soon to judge neuroeconomists' achievements and that the extent to which neuroeconomics will inform mainstream economic theory remains an open empirical question.

*Prima facie*, the moderate stance may seem preferable to the other two positions, as adopting a 'wait and see' attitude is less risky than pontificating about the future of economics and neuroscience. However, when it comes to assessing the potential for success in neuroeconomics, prudently postponing judgement does not appear to be the best way to evaluate the prospects of the discipline. After all, the fact that 'the case for mindful neuroeconomics [...] is mostly based on promise' (Camerer 2008a, p. 62) does not prevent one from examining the grounds on which such promise rests. In particular, one may argue that precisely because the advancement of neuroeconomics depends on somewhat speculative assumptions, it is especially important to discriminate between fruitful research avenues and misleadingly attractive dead ends.

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\*Email: R.Fumagalli@lse.ac.uk

This paper is organized as follows. In the first section, I identify some of the discrepancies which characterize different neuroeconomists' positions, paying particular attention to the definition of neuroeconomics, the way in which such a discipline is expected to inform the economic theory of choice, and the interdisciplinary relation that purportedly holds between economics and other sciences. In the second section, I examine the significance that neuroeconomists' divergences are likely to have for the development of the discipline. More specifically, I argue that those differences cast doubt on neuroeconomists' attempts to provide a unified theoretical framework for analysing human choice behaviour.<sup>2</sup> Furthermore, I highlight some respects in which methodologically informed contributions can promote the consolidation of the neuroeconomic enterprise.

To be clear, I am aware that methodological debates occasionally degenerate into self-referential speculative exercises, and I share the reluctance of the pragmatic neuroeconomist to engage in hair-splitting which might be of little help to the profession. Still, the neuroeconomic literature is growing very rapidly, with profound dissimilarities in the way different authors conceptualize and develop their research. In such a context, the opportunity – and arguably, the need – arises for a scrupulous methodological appraisal, which clarifies the scope and the significance of those discrepancies, enabling economists to more accurately assess the merits of neuroeconomists' proposals.

### **I. Into the labyrinth of neuroeconomics: a panoply of differences**

In elaborating their case in favour of 'mindful economics', neuroeconomists frequently employ a two-step argumentative strategy. In the first place, they cast doubt on the descriptive and normative validity of the traditional economic account of decision making. For instance, it is often argued – in line with some economists (e.g. Rustichini 2005, p. 202; Schotter 2008, pp. 71–72) and philosophers (e.g. Sugden 1991, sec. I–IV; Hausman 2008, pp. 130–139) – that rational choice theory faces frequent, statistically significant and robust descriptive failures; that axiomatic approaches typically fail to ground an informative account of economic behaviour; and that an exclusive reliance on observed choice data would constitute a limitation, rather than a virtue, for the economic theory of choice.

In the second place, neuroeconomists put forward various assertions to show how neuroscientific findings may inform the economic analysis of decision making. More specifically, some authors (e.g. Camerer, Loewenstein, and Prelec 2004, sec. III; Camerer 2008a, pp. 45–47) claim that, by incorporating neuro-physiological insights, economists can significantly increase the descriptive accuracy and the predictive power of their models. Others (e.g. Zak 2004, p. 1738; Glimcher, Dorris, and Bayer 2005, p. 214 and 221) contend that neuroeconomists will formulate models of choice that are at once mathematically tractable and grounded in empirical detail. Still others (e.g. McCabe 2003a, p. 294) maintain that more accurate knowledge of the human neural architecture will enable economists to better account for both the interpersonal and the intrapersonal variability of human choice behaviour.

As these considerations suggest, it would be overly simplistic to characterize neuroeconomists as a monolithic block of researchers who criticize the economic theory of choice from a unified perspective. In fact, a number of profound dissimilarities exist between different authors' positions. Some of these contrasts concern empirical issues, with significant debates arising in relation to specific features of the human neural architecture. For instance, Glimcher et al. (2005, p. 216) criticize Camerer, Loewenstein,

and Prelec (2005) for assuming that independent cognitive and affective systems underlie human decision making, and point out that there is no neuro-biological evidence that those systems ‘are fully distinct in the architecture of the primate brain’ (ibid., p. 252). Other disputes revolve around the plausibility of the economic theory of choice in light of neuro-physiological and neuro-biological findings. For example, while some authors (see e.g. Camerer et al. 2005, sec. IV–V) call various tenets of rational choice theory into question, others argue that utility theory ‘can be used as a central concept for the study of choice in economics, psychology, and neuroscience’ (Glimcher and Rustichini 2004, p. 449).

To illustrate the scope of neuroeconomists’ divergences, in the remainder of this section I compare the accounts that different authors advocate concerning the very *definition* of neuroeconomics, how such a discipline is expected to *inform* the economic theory of choice, and the *interdisciplinary relationship* that supposedly holds between economics and the biological and cognitive sciences. In particular, I provide methodologically informed considerations to illustrate that neuroeconomists’ use of the term ‘neuroeconomics’ is suggestive of a degree of unification and commonality of purpose that is not actually present in the current neuroeconomic literature. More specifically, I argue that distinct neuroeconomists (i) conceive of their own discipline in rather dissimilar ways, (ii) hold heterogeneous views as to how their research is going to impact on the economic account of decision making, and (iii) fundamentally disagree with regard to what disciplines will provide the building blocks of their framework for analysing human choice behaviour. Conceptually, these three issues are somewhat interconnected.<sup>3</sup> Still, they appear to be sufficiently distinct to deserve separate discussion.

### ***Definitional heterogeneity***

In spite of its relatively recent origin, neuroeconomics has been characterized in remarkably different ways, both by neuroeconomists and by other researchers (see e.g. Craver and Alexandrova 2008, p. 382 and 396; Gul and Pesendorfer 2008, p. 3; Harrison 2008b, p. 534). The following list illustrates the diversity of the definitions formulated by the pioneers of the discipline:

- (1) Some authors speak of neuroeconomics in distinctively *interdisciplinary* terms. McCabe (2003b), for example, depicts it as ‘an interdisciplinary research program with the goal of building a biological model of decision making’ (see also McCabe 2003a). In a similar vein, Glimcher and Rustichini (2004, p. 447) characterize neuroeconomics as the attempt to combine economics, psychology and neuroscience ‘into a single, unified discipline with the ultimate aim of providing a single, general theory of human behaviour’ (see also Glimcher et al. 2005, p. 214; and Rustichini 2005, pp. 203–204).
- (2) Other times, neuroeconomics is presented as a specific *application* of economic theory to neuroscientific modelling and theorizing. For instance, McCabe (2008, p. 346) maintains that neuroeconomics represents ‘an increasingly important route for the export of economic ideas’, while Glimcher et al. (2005, p. 253) argue that utility theory provides ‘the ultimate set of tools’ for modelling the workings of the human neural architecture (see also Platt and Glimcher 1999, p. 233).<sup>4</sup>
- (3) Some neuroeconomists characterize their discipline as an *extension* of distinct economic research programmes. For example, Camerer (2003) defines

neuroeconomics both as a ‘branch’ of behavioural economics, which ‘expands behavioral economics by using facts about brain activity’, and as ‘a new kind’ of experimental economics, which ‘expands experimental economics by measuring biological and neural processes to understand how people choose, bargain and trade’ (see also Camerer 2008a, p. 44). Zak (2004, p. 1737), instead, asserts that neuroeconomics is a ‘natural extension’ both of behavioural economics and of the bioeconomic research programme.<sup>5</sup>

- (4) Again differently, neuroeconomics is often regarded as an application of *neuroscientific* techniques and methods to the economic account of decision making. For instance, the economist Rustichini (2005, p. 201) speaks of neuroeconomics as ‘a set of papers that apply the concepts, methods, and technical tools of neuroscience to economic analysis’, and Zak (2004, p. 1737) depicts it as ‘an emerging transdisciplinary field that uses neuroscientific measurement techniques to identify the neural substrates associated with economic decisions’.
- (5) Finally, some authors distinguish a few senses in which the term ‘neuroeconomics’ may be employed and differentiate various *kinds* of neuroeconomic research. For example, Montague (2007a, p. 219) argues that ‘there are two natural neuroeconomics’, one which investigates ‘the way that neural tissue is built, sustains itself through time, and processes information efficiently’, and the other which primarily examines ‘the behavioral algorithms running on such neural tissue’. Ross (2008, p. 473), for his part, distinguishes ‘two styles of neuroeconomics’, namely neurocellular economics – which employs ‘the modelling techniques and mathematics of economics [...] to model relatively encapsulated functional parts of brains’ – and behavioural economics in the scanner – which ‘attempts to use neuroimaging data’ to foster the replacement of specific aspects of microeconomic theory ‘by facts and conjectures about human psychology’ (see also Harrison and Ross 2010).

To sum up, different researchers – and at times, the same author in different papers – propose quite dissimilar definitions of neuroeconomics and use such term to refer to distinct bodies of research. In this respect, one may well claim that we should not overemphasize the importance of drawing sharply defined disciplinary boundaries (Montague 2007b, p. 407) and that most of the characterizations presented above could be consistently endorsed. However, those accounts are exceedingly heterogeneous to be plausibly considered an expression of *one* and *the same* approach. Indeed, *pace* what many appear to presuppose, the definitional divergences in the literature are such that neuroeconomics is currently best characterized not so much as a single, unified discipline, but as a composite research programme consisting of a cluster of approaches.

### ***Incremental and radical approaches***

In a 1998 article, the economist Rabin distinguishes two ways in which behavioural and psychological findings may inform the economic account of decision making. On the one hand, he argues that some of those insights suggest *partial* modifications to the rational choice framework without challenging the way in which economic models are typically constructed, i.e. maximization of a utility function under variously definable constraints. On the other hand, he contends that the difficulties people encounter in evaluating their own preferences and experienced well-being point towards ‘a more *radical* critique’ of economic theory, casting doubt on economists’ modelling decision makers as maximizers

of ‘a coherent, stable, and accurately perceived’ utility function (Rabin 1998, p. 12, emphasis added; see also Rabin 2002).

In their 2005 manifesto, Camerer et al. propose a similar distinction concerning how neuroscientific findings may inform the economic theory of choice:

In the *incremental* approach, neuroscience adds variables to conventional accounts of decision making or suggests specific functional forms to replace ‘as if’ assumptions that have never been well supported empirically. [...] The *radical* approach involves turning back the hands of time and asking how economics might have evolved differently if it had been informed from the start by insights and findings now available from neuroscience. (2005, p. 10; emphasis added)

There are various ways in which the above passage may be interpreted. One reading suggests that incremental neuroeconomists rest content with enriching economic *models* in light of neuro-physiological insights, whereas radical neuroeconomists aim at implementing substantial – or even revolutionary – changes in the economic *theory* of choice. Now, one might think that this characterization misrepresents the radical approach as an implausibly ambitious project. Nonetheless, the advocates of neuroeconomics frequently put forward enthusiastic comments which seem to endorse such a far-reaching enterprise. For instance, Camerer et al. (2005, p. 10) boldly assert that neuroscience ‘points to an entirely new set of constructs to underlie economic decision making’ and Rustichini (2003) optimistically speaks of neuroeconomics as a ‘revolution’, which will soon provide ‘a theory of how people decide in economic and strategic situations’.

I am not concerned here with assessing the merits of the radical approach. Time will tell whether such a venture rests on solid foundations. Yet, I cannot refrain from noting how *much more* moderate the same authors have become just *a few* years after their initial announcements. As Camerer (2008a, p. 44) has recently stated: ‘These early neuroeconomics papers should be read as if they are speculative grant proposals which conjecture what might be learned from studies which take advantage of technological advances’. I am aware that one should not derive momentous implications from literally interpreting isolated statements, and that some exaggerations may be explained in light of the need to obtain public attention and funding. Even so, one expects neuroeconomists to advance much more measured claims in the future. For some authors’ propensity to overstate their own achievements has generated a lot of unnecessary confusion in the literature, making many economists needlessly sceptical about the prospects of neuroeconomic research.

### ***Interdisciplinary relationships***

Neuroeconomists advocate heterogeneous views concerning the interdisciplinary relationship that supposedly holds between economics and the biological and cognitive sciences. More specifically, some authors foresee a progressive *convergence* between – or even the *unification* of – economics and other disciplines. For instance, Glimcher and Rustichini (2004, p. 452) depict neuroeconomists as being after ‘a mechanistic, behavioral, and mathematical explanation of choice that transcends the explanations available to neuroscientists, psychologists, and economists working alone’. For their part, Camerer et al. (2004, p. 573) conjecture that ‘a biological basis for behavior in neuroscience [...] could provide some unification across the social sciences’.

Other times, neuroeconomists contend that, despite being at a relatively early stage of development, their discipline points towards variables and parameters which are more *explanatorily basic* than the ones typically considered by economists. In the words of Camerer et al. (2005, p. 27), ‘the traditional economic account of behavior, which

assumes that humans act so as to maximally satisfy their preferences, starts in the middle [...] of the neuroscience account'. Indeed, the same authors do not hesitate to proclaim that neuroeconomics will 'replace the mathematical ideas used in economics with more neurally-detailed descriptions' (Camerer 2005) and 'substitute familiar distinctions between categories of economic behavior [...] with new ones grounded in neural detail' (Camerer et al. 2005, p. 15).

It would be interesting, albeit outside the scope of this concise enquiry, to assess the plausibility of the aforementioned assertions in light of the vast literature on inter-theoretic reduction.<sup>6</sup> For now, let me give one reason for being cautious concerning some authors' transdisciplinary fervour. In their articles, the proponents of the radical approach typically fall short of specifying *why* exactly the ongoing cooperation at the interface between economics and neuroscience would prelude major interdisciplinary rearrangements. In particular, they are disappointingly vague concerning *what constructs* would replace the ones that are currently employed by economists. In fact, the pioneers of neuroeconomics do not even concur on *what disciplines* would constitute the foundation of their hypothesized framework for analysing choice behaviour. For example, some authors contend that elaborating informative neuroeconomic models will require 'both a top-down approach [...] from economics and a bottom-up approach [...] from cognitive neuroscience' (McCabe 2008, p. 349). Others argue that 'because economics is the science of how resources are allocated by individuals [...] the psychology of individual behaviour should underlie and inform economics, much as physics informs chemistry' (Camerer 1999, p. 10575). Still others go as far as to assert that 'ultimately, economics is a biological science' (Glimcher et al. 2005, p. 254) and that the 'methods and findings in the biological sciences need to be incorporated directly into economics if the discipline is to continue to produce relevant insights into human behavior' (Zak and Denzau 2001, p. 32).

To recapitulate, the aforementioned contentions express quite dissimilar views concerning the definition of neuroeconomics, how neuroeconomists are to inform the economic theory of choice, and the interdisciplinary relationship between economics and the biological and cognitive sciences. In light of such an assortment of heterogeneous proposals, one may call into question neuroeconomists' efforts to provide a unified theoretical framework for analysing human choice behaviour. In the next section, I examine what significance those divergences are likely to have for the development of the discipline and highlight some respects in which methodological considerations provide neuroeconomists with valuable assistance.

## II. Finding a way through the labyrinth: the role of methodology

The previous section highlighted some of the discrepancies that can be found in the neuroeconomic literature. When it comes to assessing how those contrasts affect the prospects of the discipline, however, it would be of little import to simply complain about the diversity of neuroeconomists' positions. For clearly, *not all* of those differences call the advancement of neuroeconomic research into question. To appreciate this, consider the disagreements that have arisen over specific features (e.g. cortical and synaptic plasticity, degree of functional specialization) of the human neural architecture. Presumably, most of these contrasts will be eventually settled thanks to further developments in brain-imaging and brain-stimulation techniques. Moreover, as suggested by Vromen (2007, p. 161), even if 'several crucial issues in neuroscience are still unresolved', economists do not have to wait 'until neuroscience has grown more mature'

before incorporating neuroscientific insights into their models. For one may succeed in elaborating an informative neuroeconomic model without taking a definite position on all of those issues.<sup>7</sup>

Neuroeconomists may offer additional reasons to resist deriving far-reaching implications from their current disagreements. In particular, they may contend that the existence of those dissimilarities is quite *expectable* in light of the fact that neuroeconomics is in its first stages of development. Indeed, they might even argue that the existing contrasts, besides not representing a significant obstacle to the consolidation of the discipline, are signs of a lively and promising debate. After all – the argument would go – neuroeconomics is still in its infancy, and it is *desirable* that several approaches compete for defining the canons of its orthodoxy. As it is occasionally claimed in methodological discussions: ‘Don’t bother too much at first about the compatibility of different theories. Just wait, and let inter-theoretic competition decide which candidates will stand the test of time’.

*Prima facie*, the aforementioned recommendation seems to offer sensible advice, and nicely fits with the methodological prescriptions provided by some philosophers of science. Consider, for example, the Lakatosian caveat that research programmes often grow in an ocean of anomalies, and that adopting an exceedingly severe stance towards novel conjectures might lead one to prematurely abandon promising research avenues. Yet, as Lakatos’ critique of degenerating research programmes persuasively illustrates, even someone who advocates letting 100 flowers blossom is still allowed to weed. As I argue below, there are various reasons to think that neuroeconomists’ divergences negatively affect the prospects of their enterprise.

To begin with, the contrasts highlighted in the previous section concern not so much peripheral aspects, but rather some of the *central tenets* of neuroeconomics. In this respect, it would be excessive to assert that the existence of those discrepancies precludes the elaboration of instructive neuro-physiologically enriched models of decision making. For even if distinct neuroeconomists held inconsistent positions on a number of substantial issues, one (or some) of their approaches may still serve as a basis for developing informative models. At the same time, it is hard to see how neuroeconomists can provide a unified theoretical framework for analysing human choice behaviour, when they agree neither on the explanatory aims of their research nor on what constructs will serve as the foundation of their account of decision making.

In such a context, a proponent of neuroeconomics may protest that economics itself, in its early days, was characterized in dissimilar terms by prominent economists, and that nevertheless these discrepancies did not preclude its progress. However, the mere fact that economics progressed *in spite of* definitional and methodological diversity by no means licenses the inference that neuroeconomists’ divergences do not hinder the prospects of their discipline. To render this point more vivid, let us consider again the distinction between radical and incremental neuroeconomics presented in the previous section. These two approaches are based on rather different views of how neuroeconomics is to inform the economic theory of choice. In this respect, several neuroeconomic articles appear to face the following dilemma. On the one hand, radical contentions are typically too extreme or insufficiently qualified to withstand evidential scrutiny. On the other hand, incremental contributions rarely warrant the propaganda and the excitement that often accompany neuroeconomic research. For instance, while some authors’ reductionist claims rest on highly speculative presuppositions concerning the relationship between economics and other disciplines, others’ studies merely consist in monitoring the neural correlates of behavioural-economic decision processes and do not provide neuro-physiologically

enriched economic models (see Craver and Alexandrova 2008, p. 383; and Ross 2008, p. 474, for a similar remark).

An additional reason for being concerned with the aforementioned divergences specifically relates to the explanatory goals that some leading neuroeconomists claim to pursue. In the first section, I concisely depicted the case in favour of ‘mindful economics’ as a two-step argumentative strategy. Such a case, in fact, rests on several interrelated arguments and is grounded on a vast and rapidly growing *corpus* of neuro-biological and neuro-physiological findings. Now, if neuroeconomists rested content with proposing a series of unrelated models, each designed to account for a specific phenomenon (see e.g. Kosfeld, Heinrichs, Zak, Fischbacher, and Fehr 2005; Zak, Kurzban, and Matzner 2005; Zak and Fakhar 2006; Zak, Stanton, and Ahmadi 2007, on how oxytocin may affect agents’ trust and generosity in various choice settings), then reconciling their approaches would not seem to constitute a paramount issue. Yet, when it comes to providing a ‘single, general theory of human behaviour’ (Glimcher and Rustichini 2004, p. 447) and ‘an entirely new set of constructs’ for the analysis of decision making (Camerer et al. 2005, p. 10), reducing the fragmentation which characterizes current neuroeconomic research becomes a particularly pressing concern. In this respect, various authors aptly warn against the risk of ‘giving rise to a proliferation of different models that are mutually incompatible not only in terms of the details, but also in terms of the overarching approach’ (Caplin 2008, p. 359).

At this point, one might object that neuroeconomists are better equipped to assess the merits of their proposals than armchair methodologists who hardly know how brain scans function. As I argued in this and the previous section, however, methodologically informed considerations provide us with valuable insights concerning the scope and the significance of neuroeconomists’ disagreements. Moreover, as I illustrate below, there are further respects in which neuroeconomists can benefit from methodologists’ assistance. Let me briefly examine two of these issues in turn.

In the first place, neuroeconomists occasionally acknowledge the need for a rigorous scrutiny of their claims (e.g. Camerer 2008a, p. 44), but do not always pay sufficient attention to definitional clarity and terminological consistency.<sup>8</sup> Furthermore, in formulating their criticisms of the traditional economic theory of choice, they still make severe conceptual mistakes (see e.g. Harrison 2008a, sec. 1, for a critical review). Economic methodologists can profitably help the proponents of neuroeconomics to scrutinize and amend the presuppositions underlying their remarks. Consider, for example, the contention (Loewenstein, Rick, and Cohen 2008, p. 647) that neuroeconomics ‘has primarily challenged the standard economic assumption that decision making is a unitary process [...] suggesting instead that it is driven by the interaction between automatic and controlled processes’. Such a claim apparently overlooks that economists, in assuming that a rational agent behaves *as if* she was maximizing her expected utility, do not take a position as to the number and the heterogeneity of the neuro-cognitive processes underlying her choices. Furthermore, the alleged fact that automatic and controlled processes interactively underlie decision making does not directly bear against the economists’ *as if* conjecture, since an agent can behave consistently with such an assumption even if decision making is not a ‘unitary process’.

A second respect in which methodological considerations offer helpful clarifications concerns the evidential basis of neuroeconomists’ assertions. In their articles, neuroeconomists often present fascinating neuroscientific findings, but sometimes

derive unwarranted or exceedingly general conclusions from the collected evidence (see e.g. Bernheim 2009, sec. 1.E, on how some neural findings have been improperly regarded as direct tests of economic models). In such a context, one looks with sympathy at the Feyerabendian spirit of those authors who, deeming neuroscience research to be ‘necessarily speculative’ (Camerer 2008b, p. 369), defend their right to test any sort of neural conjecture. Even so, the point remains that the reliability and the informativeness of brain-imaging and brain-stimulation studies have been called into question on several grounds.<sup>9</sup> Now, while many practising neuroscientists acknowledge and attempt to address these concerns, neuroeconomists frequently gloss over them as if they were of negligible importance. For instance, in dismissing the complaint that a small number of subjects are typically monitored in fMRI investigations, Bhatt and Camerer (2005, p. 432) rest content with claiming that ‘for most fMRI studies [16 subjects] is usually an adequate sample to establish a result because adding more subjects does not alter the conclusions much’. As shown by the history of lesion studies (see e.g. Bechtel 2002 and in press), one may occasionally gain informative neuro-physiological insights on the basis of a small experimental sample. However, it is still an open empirical question whether, ‘for most fMRI studies’, monitoring just a few subjects enables neuroeconomists to obtain robust findings. Moreover, the mere fact that the results of some experiments do not considerably vary when the size of the examined sample is increased does not license confidence in the accuracy of those findings. For one might get a set of stable experimental outcomes even in cases where the technology provides rather inaccurate measurements of the investigated phenomena.

### Concluding remarks

The recent advancements obtained at the interface between economics and neuroscience have encouraged some neuroeconomists to put forward quite ambitious assertions, which have fostered an intense debate in the economists’ community. At present, several authors welcome the opportunity to enrich specific *models* of choice in light of neuro-biological and neuro-physiological findings. At the same time, many economists remain convinced that current neuroeconomic research is de facto (e.g. Harrison 2008a,b; Rubinstein 2008) or even in principle (e.g. Gul and Pesendorfer 2008) incapable of triggering revolutionary modifications in the economic *theory* of choice.

In this paper, I identified some of the discrepancies which have emerged in the neuroeconomic literature, discussing the significance that those divergences are likely to have for the consolidation of the discipline. My reasoning can be summarized as follows. The accounts proposed by different authors are characterized by a *number* of *profound* dissimilarities, which concern not just specific terminological options, or secondary aspects of research, but the *central tenets* of neuroeconomics. By itself, the existence of these contrasts does not prevent neuroeconomists from elaborating informative neuro-physiologically enriched models of decision making. At the same time, it casts serious doubts on their attempts to provide a *unified* theoretical framework for analysing human choice behaviour.

To conclude, it is true that neuroeconomics is still in its infancy, and that considerable achievements may await its pioneers in the years to come. Yet, the time is ripe for beginning to distinguish between alluring marketing hype and well-founded hopes. As I have argued in this article, methodological considerations can offer valuable insights concerning the merits of current neuroeconomic research, prompting neuroeconomists

to reduce their divergences and to build their case in favour of ‘mindful economics’ on more solid empirical and conceptual foundations.

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### Notes

1. In this article, I use expressions such as ‘economic theory of choice’, ‘economic account of decision making’, etc. to generally refer both to decision theory and to game theory.
2. By ‘unified theoretical framework’ I mean a collection of studies which (i) share a sufficiently precise definition of neuroeconomics, (ii) are inspired by reasonably similar explanatory aims, and (iii) reflect consistent views concerning the relationship between economics and neuroscience.
3. For instance, disagreements about how neuroeconomics is going to inform the economic theory of choice may arise from the fact that different neuroeconomists define their discipline in dissimilar ways.
4. Indeed, those authors go as far as to claim that, while economists typically assume that ‘it is *as if* expected utility was computed by the brain’, neuroscience ‘suggests an alternative, and more literal, interpretation’, according to which ‘the neural architecture actually does compute desirability for each available course of action’ (Glimcher et al. 2005, p. 220).
5. The underlying idea (see also Vromen 2007, pp. 145–146) is that bioeconomics primarily investigates how past processes of natural selection influence contemporary humans’ choice behaviour, whereas neuroeconomics studies the current neural underpinnings of decision making.
6. Classic works include Nagel (1961, 1974), Schaffner (1967), Fodor (1974), Churchland (1981, 1985, and 1986), and Cartwright (1999). For some recent publications in the philosophy of neuroscience, see e.g. Bickle (1998, 2003, and 2006), Craver (2007), Craver and Alexandrova (2008), and Sullivan (2009).
7. For example, see Dayan (2001) on the possibility of developing different types of neural models which involve various degrees of anatomical and computational detail. See also Knutson, Rick, Wimmer, Prelec, and Loewenstein (2007) and Kuhnen and Knutson (2005), on the opportunity to increase the predictive power of some models of choice by investigating the activation patterns exhibited by a few neural areas.
8. For instance, compare the characterizations of neuroeconomics that Camerer puts forward in his works (e.g. 2005, 2008a,b). Despite invariably speaking of ‘neuroeconomics’, he employs such term in somewhat different senses.
9. See e.g. Uttal (2001), Van Orden, Pennington, and Stone (2001) and Henson (2006) for some caveats on the inferences that are commonly drawn in neuro-physiological and neuro-anatomical research; Harrison (2008a, sec. 2) and Vul, Harris, Winkielman, and Pashler (2009), on how the statistical manipulations and adjustments that raw neural data undergo may bias the interpretation of the subsequently reported findings; Van Orden and Paap (1997), Henson (2005) and Logothetis (2008) for a discussion of some limitations of current brain-imaging techniques and methods.

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