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CHALLENGES AND PROBLEMS OF NEUROECONOMICS: SEVERAL TASKS FOR SOCIAL SCIENTISTS

Abstract: *Neuroscience is a fascinating discipline – its dynamic progress has led to the emergence of new interdisciplinary research programmes with great potential. One of these research areas is neuroeconomics. As will be shown in this article, this discipline, which is difficult to clearly characterize and define, is faced with many problems. This paper argues that social scientists should be interested in the problems and tendencies in social neuroscience for several reasons. Neuroeconomics, and other disciplines inspired by neuroscience, will compete with their parent disciplines in many fields of interest. On one hand it will be necessary for scientists to define and defend the irreplaceable roles of their disciplines, but also critically evaluate the potential of new approaches on the other. In the context of this discussion, which reopens questions about the scientific status of economics and its roles, this paper introduces the main problems related to neuroeconomics. This paper concludes that these problems represent a wide domain for social scientists and methodologists of science.*

Keywords: *decision-making; methodology; neuroeconomics; philosophy of economics; philosophy of science*

Výzvy a problémy neuroekonomie: několik úkolů pro společenské vědce

Abstrakt: *Neurověda je fascinující disciplínou – její dynamický rozvoj podněcuje vznik nových interdisciplinárních výzkumných programů s velkým potenciálem. Jednou takovou oblastí je i neuroekonomie. Jak se ukáže v článku, tato disciplína, kterou je obtížné jednoznačně vymezit a určit její definici, se potýká se spoustou problémů. Článek argumentuje, že by se společenští vědci měli těmito problémy a tendencemi v sociální neurovědě zabývat, a to hned z několika důvodů. Neuroekonomie, a také další neurovědou inspirované disciplíny, budou svým mateřským oborům konkurovat v mnoha oblastech, přičemž bude nezbytné, aby vědci byli schopni na jedné straně definovat a obhájit nezastupitelné role svých disciplín, na straně druhé kriticky vyhodnocovat potenciál nových přístupů. V kontextu této diskuze, která znovu otevírá otázky ohledně vědeckého statusu ekonomie a jejích rolí, článek vymezuje základní problémy, s nimiž se neuroekonomie potýká. Práce dospívá k závěru, že tyto problémy představují široké pole působnosti pro společenské vědce a metodology vědy.*

Klíčová slova: *filosofie ekonomie; filosofie vědy; metodologie; neuroekonomie; rozhodování*

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Introduction[1]

This article is a survey study that reviews several comments on the problematic aspects of neuroeconomics. Moreover, this paper reflects on these problems in order to provide an overview of the contemporary challenges that emerge in a neuroeconomic research programme and defines several tasks for social scientists and methodologists of science. I have identified two main reasons for this reflection.

The first reason concerns the fact that anyone who starts studying economics in detail is confronted not only with mainstream economics (and all the other approaches that try to compete with mainstream economics within this discipline), but also with new fields of scientific research that deviate considerably from the traditional methods used in economics. In addition, these new approaches go beyond economics and enter into other disciplines such as psychology, the cognitive sciences, or neuroscience. Even the latter-mentioned neuroscience is influencing these alternative approaches in different ways, and various neuro-disciplines have emerged as a result. The situation is often confusing and there is little time to focus on all of these tendencies. Some supporters of neuroscience[2] believe that neuroeconomics has the potential to contribute to economics, and possibly that it could even achieve better results than traditional economic theories (especially for predictions). It is very problematic to assess the benefits of

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[1] A part of this article is based on extension and accuracy improvements of my two other texts. The first one is a short sketch of an idea to systematize problematical aspects of neuroeconomics which was published as a conference paper: Michal Müller, "Real People in Economics and the Challenge of Neuroscience," in *Knowledge for Market Use 2017: Economics – Decisions, Behavior and Normative Models*, ed. Pavla Slavíčková (Olomouc: VUP, 2017), 122–27. The second one is chapter eight from a dissertation dealing with the problem of risk: Michal Müller, "Riziko jako ekonomicko-filosofický problém: Epistemologie, vnímání rizika, etické důsledky," PhD diss., Palacký University Olomouc, 2018.

[2] For example: Colin F. Camerer, George Loewenstein, and Drazen Prelec, "Neuroeconomics: Why Economics Needs Brains," *Scandinavian Journal of Economics* 106, no. 3 (2004): 555–79; Colin F. Camerer, George Loewenstein, and Drazen Prelec, "Neuroeconomics: How Neuroscience Can Inform Economics," *Journal of Economic Literature* 43, no. 1 (2005): 9–64.

these new approaches due to several reasons.[3] In addition to the complexity of neuroscientific research, it is necessary to mention, as an example, manipulative marketing practices and inadequate argumentation. Everything is exacerbated by the fact that the fundamental problems connected to economics (and other social sciences) that cause an impossibility of exact predictions (especially the reflexive character of economic processes or arms races) still persist.[4] I am convinced that both economists and philosophers of economics need to take an interest in these new approaches, whether they agree with them or not, for the practical reasons indicated by Hastie and Dawes.[5] Neuroeconomics will compete with recent research and it seems that neuroscientists will be successful in obtaining research grants and in attracting both scientists and students beyond the field of decision-making research.[6] Economists, in my opinion, must respond to this situation. Firstly, they should be able to critically evaluate the potential of alternative research programmes. Secondly, they should be able to defend the irreplaceable role of economics that cannot be substituted by new approaches.

The second reason is related to the establishment of new laboratories and research centres beyond scientific faculties. I believe that further development of these workplaces can be expected in the future and social scientists will increasingly be attracted to new research opportunities. Social scientists will participate in neuroscientific research for different reasons. Some of them will be fascinated by these new disciplines and become interested in

[3] There is a wide range of literature concerning the problematical aspects of neuroeconomics. See for example anthology Caterina Marchionni and Jack Vromen, eds., *Neuroeconomics: Hype or Hope?* (London: Routledge, 2012).

[4] In discussing the philosophy of economics, there are serious doubts about the accuracy of economic laws. Philosophers of economics often talks about inexact laws, for example, Alex Rosenberg even claims that economic laws do not exist at all, that there are only generalizations that we consider to be laws. This is based especially on the reflexive character of natural selection. This reflexive process relates to the continual search for better adaptations. All patterns that relate to strategies within the arms race at the biological level will eventually come to end. Strategies relating to interpersonal interactions which are important for the social sciences are even less stable, which makes prediction problematic. See for example Alexander Rosenberg, "If Economics Is a Science, What Kind of Science Is It?," in *The Oxford Handbook of Philosophy of Economics*, eds. Harold Kincaid and Don Ross (New York: Oxford University Press, 2009), 55–67; Alexander Rosenberg and Daniel M. McShea, *Philosophy of Biology: A Contemporary Introduction* (New York: Routledge, 2008), 43; Petr Špecián, "Potřebuje ekonomie psychologii?," *Teorie vědy / Theory of Science* 37, no. 3 (2015): 279–301.

[5] Reid Hastie and Robyn Dawes, *Rational Choice in an Uncertain World: The Psychology of Judgment and Decision Making* (Los Angeles: SAGE, 2010), 297.

[6] Ibid., 297.

them. These academics will see the possibilities to enrich the social sciences with neuroscientific findings and they will believe in the progress of their disciplines. I think that even economists and other social scientists who are not interested in these neuroscientific tendencies will be confronted with the possibility to take part in this kind of research in the future. We will witness the emergence of many neuro-disciplines. I suppose that social scientists may also be attracted to neuroscience because of purely pragmatic and career reasons, especially in countries where it is not so prestigious to be a social scientist and where the total income of all academic staff is substantially dependent on obtaining grants. This tendency may lead to a situation where there will be laboratories without people who have been trained in empirical research. Moreover, if the most talented social scientists leave the social sciences, we can assume a further decline in the prestige of these disciplines.

This article introduces the main problems related to neuroeconomics and points out that these problems represent a wide domain for social scientists and methodologists of science. In other words, this article tries to provide an answer to the following question: what can I do as a social scientist or methodologist of science when I am confronted with the possibility to participate in neuroscientific research? The answer is based on a survey of related theoretical and methodological studies.

Before we start with the problems of neuroeconomics it is necessary to mention that the wider context of this discussion is related to behavioural economics. Moreover, as will be shown in the first section, there are authors who consider neuroeconomics as a part of behavioural economics, although this is but one of a range of views. Furthermore, the notion of neuroeconomics as an extension of behavioural economics is criticized by several authors as will be shown in later parts of this paper. These critics will argue that neuroeconomics should make an effort to unify its parent disciplines, not only to simply repeat behavioural experiments with neuroimaging technologies.

Although most behavioural economists endeavour to improve the empirical realism of neoclassical economics and point out that there are many unrealistic assumptions of economic models, Gerd Gigerenzer and Nathan Berg show that behavioural economists rely on "as-if" arguments as well as neoclassical economics. Behavioural economists defend models that fail as a realistic description of psychological processes.[7] Alternatively, Gigerenzer

[7] Nathan Berg and Gerd Gigerenzer, "As-if Behavioral Economics: Neoclassical Economics in Disguise?," *History of Economic Ideas* 18, no. 1 (2010): 133.

suggests the concept of ecological rationality, which is related to the success of cognitive strategies in environments of the world.[8] In the same tenet, as we will see later, several neuroeconomists and philosophers of science observe that neuroeconomic research based only on the extension of behavioural economics with neuroimaging does not provide a description of real decision-making processes due to the many reductions found in laboratory conditions.

Although some other problematic aspects of behavioural economics and neuroeconomics have the same roots, especially those of them related to the need to defend the relevance of additional information about the inner states of decision-makers to economics, discussions within neuroeconomics are different and more complicated in many ways. In the context of these problems it is relevant to ask if something like neuroeconomics (in the meaning of the ability to meet its goals) really exists as an independent and acknowledged scientific discipline. As we will see, neuroeconomics exists in several different ways. This fact makes an analysis of this discipline more complicated. Moreover, in contrast to behavioural economics, neuroeconomics faces a very hard problem based on efforts to make a synthesis of neuroscience with methods, models, and abstractions as employed in the natural sciences and other social scientific disciplines like economics and psychology. In the case of neuroeconomics, the problems of behavioural economics are extended and intensified by this fact and put into the context of state-of-the-art technologies.

In accordance with these problems, the first section of this article comments on the unclear definition of neuroeconomics and its several approaches that can be identified through an analysis of neuroeconomic rhetoric and the declarations of research goals by different research groups. The second part deals with the differences between economics and neuroeconomics. In the third section, I discuss the main theoretical and methodological problems connected with neuroeconomics. The discussion proposes possible tasks for social scientists and methodologists in order to deal with the challenges of neuroeconomics.

[8] Gerd Gigerenzer and Thomas Sturm, "How (Far) Can Rationality Be Naturalized?," *Synthese* 187, no. 1 (2012): 255.

1. Definition and Rhetoric of Neuroeconomics – Reflection of Coveted Interdisciplinarity

When we talk about neuroeconomics, the first problem we immediately come across is its *definition*. The label "neuroeconomics" is used for a variety of approaches that have emerged in last three decades. Although there are several commonalities in these approaches, such as employing neuroimaging technologies and some form of interdisciplinary connection to economics, psychology, and neuroscience, the goals and methods of these approaches differ. In this respect, Roberto Fumagalli mentions four approaches to neuroeconomics. The first is based on the declaration of interdisciplinarity and efforts to unify several disciplines into a single unified discipline, with which it will be possible to make a model of decision-making. The second approach applies economic theory to neuroscientific modelling. The third perspective of neuroeconomics can be characterized as an extension of behavioural economics. The fourth approach mentioned by Fumagalli is the application of neuroscientific techniques within an economic framework of decision-making.[9]

In this paper I use the term neuroeconomics for the entirety of neuroeconomic research programmes that may have different approaches, and I distinguish between these neuroeconomic approaches in the cases where it is necessary for the identification and specification of the analysed problem. The distinction between these approaches is only schematic; each research group may relate to different goals and methodologies. Moreover, these approaches may be combined and modified. From the perspective of the commonalities of the neuroeconomic approaches, and from the perspective of this article, I consider as adequate the definition provided by Vasily Klucharev, who understands neuroeconomics as a synonym for the neurobiology of decision-making. This definition does not put too much stress on the economic dimension of this discipline. Moreover, in the context of the ambitions of research groups, Klucharev distinguishes between *core neuroeconomics*, which is the neurobiology of decision-making that studies the neural mechanisms of decision-making, and the more ambitious *extended*

[9] Roberto Fumagalli, "Philosophical Foundations of Neuroeconomics: Economics and the Revolutionary Challenge from Neuroscience," (PhD diss., London School of Economics, 2011), 22–23.

neuroeconomics that tries to develop a unified theory of decision-making by connecting evolutionary, neurobiological, and social approaches.[10]

The beginnings of neuroeconomics has been connected to many optimistic statements about its character, goals, and potential to revolutionize economics. Nevertheless, the *unification of neuroeconomic parent disciplines* represents a significant and unsolved problem. According to Roberto Fumagalli, neuroeconomics is a highly fragmented discipline that does not foster unification.[11] Fumagalli points out that despite its advances, neuroeconomics has not achieved substantial progress regarding the interdisciplinary goals defined in its initial phase of research.[12] He is convinced that there are several reasons to have doubts about any attempts to develop a single unified model within neuroeconomics. The fact that different branches of neuroeconomics[13] diverge in their research goals, or the fact that there are dissimilarities in the interpretations of choice models provided by economists and neuroeconomists are among these reasons.[14] In the context of the above, it is important to point out that unification efforts within neuroeconomics represent a significant philosophical problem. Paul Glimcher, in this respect, claims that neuroeconomics "as a philosophical entity has to emerge in the same way that physical chemistry, biochemistry, and neuroscience emerged during the past century" and that the mere use of technology in neuroeconomics to scan brains does not represent an interdisciplinary synthesis. The solution of the unification problem requires philosophical efforts.[15] In Klucharev's terms it is possible to say that the goals of extended neuroeconomics have not been met. It seems that, with regard to the recent state of neuroeconomics, it is more suitable to understand neuroeconomics as the neurobiology of decision-making with an aspiration to extend its domain.

The vision of neuroeconomics, its goals, and approaches are created within scientific communication. Therefore, *the rhetoric of neuroeconomics* represents an important topic and is the problematical aspect of this research

[10] Vasily Klucharev, "Introduction to Neuroeconomics: Origin of Neuroeconomics," National Research University Higher School of Economics, 2014, YouTube video, accessed December 26, 2018, https://www.youtube.com/watch?v=vU2kxbMVxlI/.
[11] Roberto Fumagalli, "Five Theses on Neuroeconomics," *Journal of Economic Methodology* 23, no. 1 (2016): 77.
[12] Ibid., 78.
[13] I will comment on methodological distinctions of neuroeconomic approaches in the third section.
[14] Fumagalli, "Five Theses on Neuroeconomics," 79–80.
[15] Paul W. Glimcher, *Foundations of Neuroeconomic Analysis* (New York: Oxford University Press, 2011), xiii.

programme. An analysis of neuroeconomics in the context of its rhetorical advantages and disadvantages is given by Uskali Mäki.[16] From this analysis, two main tendencies can be distinguished – legitimate scientific communication related to a critical evaluation of neuroeconomic potential, and manipulative marketing. An important advantage in communication is the use of scientific rhetoric that is supported by the authority of prestigious scientific journals. Neuroeconomic texts also have the opportunity to appeal to scientific progress and to increase realism within the foundations of economics. There is also an emphasis on interdisciplinarity and the already mentioned unification of neuroeconomic parent disciplines. Moreover, it is possible to mention the form of articles that uses a variety of colourful diagrams and brain schemes as a great tool for attracting attention.[17]

Yet besides these rhetorical figures that scientists use both to defend their research programmes and for marketing, there is also argumentation that is inaccurate, and that which raises tempestuous reactions with many economists. Mäki shows that there are neuroeconomists who assert that it is possible to directly measure ideas and feelings.[18] An example of this rhetoric is an article by Camerer, Loewenstein, and Prelec.[19] Mäki is convinced that accepting this assertion as a true statement should be connected with a radical solution to the mind-body problem, and it seems that it is not easy to justify this radical solution.[20] This issue will be commented on to a larger extent in the third part of this paper.

A very common rhetorical figure employed by pioneers in neuroeconomic research is laying stress on the revolutionary character of neuroeconomics. This aspect of argumentation is analysed by Roberto Fumagalli in his dissertation.[21] Fumagalli points out that neuroeconomics is not revolutionary in any meaning of the word. Although he believes that the contributions of neuroeconomics will lead to better predictive and explanatory models of choice, he is convinced that these potential improvements will not cause revolutionary changes in economic theory.[22]

[16] Uskali Mäki, "When Economics Meets Neuroscience: Hype and Hope," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012).
[17] Ibid., 10–11.
[18] Ibid., 12.
[19] Camerer, Loewenstein, and Prelec, "Neuroeconomics," 556.
[20] Mäki, "When Economics Meets Neuroscience," 12.
[21] Fumagalli, "Philosophical Foundations of Neuroeconomics."
[22] Ibid., 17.

Excessive rhetoric may represent one factor in why social scientists are not able to express a willingness to cooperate. Neuroeconomics is able to provoke great enthusiasm and attract scientists even beyond its parent disciplines. Yet manipulative marketing is also a reason for its rejection. Moreover, as Paul Glimcher points out, substantial differences between the theoretical approaches of social scientists and the theoretical approaches of natural scientists often leads to both groups insisting on their own theories while the insights of other groups are of no interest.[23] I think that this *a priori* rejection, for example by economists, can lead to the isolation of the discipline. Neuroeconomics will still find many supporters due to its undeniable attractiveness, yet these admirers may be blind to its excesses. Neuroeconomics needs both scientists and academics who are able to ensure sufficient critical discussion. With regards to neuroeconomic rhetoric, Douglas Bernheim recommends neuroeconomists to better and more specifically express their visions, both to avoid exaggerated statements and to accumulate sufficient evidence of success.[24] Although neuroeconomics uses modesty as one of its rhetorical figures, Mäki points out that this modesty is especially employed when supporters of neuroeconomics talk about the usefulness of concrete findings for economic theory or business.[25]

Along with an analysis of the rhetoric of economics advocated by McCloskey,[26] it seems that an analysis of the rhetoric of neuroeconomics may represent a helpful activity that can reveal important information about the arguments employed within this research programme. Serious neuroeconomic rhetoric should consider the fact that there are several neuroeconomic approaches and that those approaches associated with greater ambition are not yet successful in achieving their goals. Supporters of the extended form of neuroeconomics should be cautious in their statements, as their inadequate argumentation may cast a bad light on entire research programmes that include several approaches. Yet despite the rhetorical excesses connected with the initial phase of neuroeconomic research, neuroeconom-

[23] Glimcher, *Foundations of Neuroeconomic Analysis*, 4.
[24] Douglas B. Bernheim, "Neuroeconomics: A Sober (But Hopeful) Appraisal," in *National Bureau of Economics Research Working Paper*, 55, accessed July 5, 2018, http://www.nber.org/papers/w13954/.
[25] Mäki, "When Economics Meets Neuroscience," 11.
[26] For example: Deirdre N. McCloskey, *The Rhetoric of Economics* (Madison: The University of Wisconsin Press, 1998).

ics is experiencing increasing popularity,[27] which indicates that its recent rhetoric is more successful.

2. Relationship between Economics and Neuroeconomics and Definition of Their Roles

As the previous section indicates, the *relationship between economics and neuroeconomics* and determining the neuroeconomic relevance to economics is not easy to interpret. Many discussions of these issues start with the very serious criticism provided by economists Faruk Gul and Wolfgang Pesendorfer, whose arguments neuroeconomists try to overcome. Gul and Pesendorfer are convinced that the data neuroeconomics is able to obtain has no relevance to economics because these disciplines deal with different issues and use different abstractions.[28] These authors argue that neuroscience cannot reject economic models because economic models make no assumptions and draw no conclusions about brain physiology. Neuroeconomics cannot therefore represent a revolutionary approach that could change economics, as it has no tool to deal with economics and its subject of interest.[29] Data that neuroscience is able to produce is redundant and unnecessary for economics because it is sufficient to use revealed preferences

[27] The growing popularity of neuroeconomics in the academic environment indicates not only an increasing number of studies and laboratories, but also an institutional formation of discipline in university study programmes which explicitly include the term neuroeconomics in the name of the study field ("Neuroeconomics," in *Maastricht University*, accessed December 20, 2018, https://www.maastrichtuniversity.nl/education/master/research-master-cognitive-and-clinical-neuroscience-specialisation-neuroeconomics, "Doctoral Program in Neuroeconomics," in *University of Zurich*, accessed December 20, 2018, https://www.oec.uzh.ch/en/studies/phd/neuroecon.html, "Master's Business Economics: Neuroeconomics," in *University of Amsterdam*, accessed December 20, 2018, http://ase.uva.nl/content/masters/business-economics-neuroeconomics/business-economics-neuroeconomics.html), respectively study programmes, that include neuroeconomics, but it is not officially mentioned in the name of the study programme ("Graduate Studies," in *Institute for the Study of Decision Making, NYU*, accessed December 20, 2018, https://isdm.nyu.edu/graduate-studies/, "Social and Decision Neuroscience PhD Program," in *Caltech*, accessed December 20, 2018, http://www.hss.caltech.edu/academics/graduate-studies/social-and-decision-neuroscience-phd-program, "Master's Programme 'Cognitive Sciences and Technologies: From Neuron to Cognition'," in *Higher School of Economics*, accessed December 20, 2018, https://www.hse.ru/en/ma/cogito/).

[28] Faruk Gul and Wolfgang Pesendorfer, "The Case for Mindless Economics," in *The Foundations of Positive and Normative Economics*, eds. Andrew Caplin and Andrew Schotter (New York: Oxford University Press, 2008), 4.

[29] Ibid.

to predict choices.[30] Gul and Pesendorfer stress that neuroeconomists ignore "the fact that economists, even when dealing with questions related to those studied in psychology, have different objectives and address different empirical evidence."[31]

Moreover, according to Gul and Pesendorfer, neuroeconomists believe that the development of psychology and neuroscience will enable neuroeconomics to answer philosophical questions.[32] As a result of these efforts, neuroeconomists, according to Gul and Pesendorfer, change the traditional relationship between economics and an economic agent to the relationship between a therapist and a patient. This approach leads us to the complex issue of paternalism. Gul and Pesendorfer are convinced that neuroeconomic "therapists" define "what is happiness" which strictly contradicts with the standard economic approach. Neoclassical economics is based on separating the role of an economist as a social scientist and the role of an economist as a potential adviser. In this context, neuroeconomics is a framework for paternalistic interventions.[33] The issue of so-called "light" or "libertarian" paternalism raises a broad debate in the context of neuroeconomics and behavioural economics. I believe it is appropriate that Gul and Pesendorfer mention this issue because there are a number of ethical questions related to paternalistic interventions. Specifically, the issue of autonomy is highly discussed.[34]

One of the neuroeconomists who reacted to the critique of neuroeconomics by Gul and Pesendorfer is Colin Camerer, who analyses the second argument related to the statement that rational choice theory is flexible enough to describe anomalies in behaviour by conventional language of

[30] Clithero, Tankersley, and Huettel call this criticism "Behavioral Sufficiency argument." See John A. Clithero, Dharol Tankersley, and Scott A. Huettel, "Foundations of Neuroeconomics: From Philosophy to Practice," *PLoS Biology* 6, no. 11 (2008): 2349.

[31] Gul and Pesendorfer, "The Case for Mindless Economics," 4.

[32] Ibid., 6.

[33] Ibid.

[34] See Daniel M. Hausman and Brynn Welch, "Debate: To Nudge or Not to Nudge," *Journal of Political Philosophy* 18, no. 1 (2010); Mark D. White, *The Manipulation of Choice: Ethics and Libertarian Paternalism* (New York: Palgrave Macmillan, 2013). In the context of finding solutions, how to avoid ethical implications see Georege Loewenstein and Emily Haisley, "The Economist as Therapist: Methodological Ramifications of 'Light' Paternalism," in *The Foundations of Positive and Normative Economics*, eds. Andrew Caplin and Andrew Schotter (New York: Oxford University Press, 2008).

preferences, beliefs, and constraints.[35] Unfortunately, Camerer puts aside the first argument of "different question, different abstractions" because it is based on the definition of economics as a discipline that excludes non-choice data.[36] Although Camerer admits that conventional economic language can actually approach many neural phenomena, he considers it more effective to accept the constructs of other disciplines because the language of economics is clumsy. The other part of Camerer's argument is based on an attempt to point out that neuroeconomics has essentially the same aspirations as the theory of rational choice and is not in opposition. Neuroeconomists believe in the potential of broadening this theory by observing variables that are considered unobservable within the framework of rational choice theory.[37,38]

In order to provide a more detailed explanation of this approach, Camerer uses the analogy of the theory of the firm. In the past there were only models where a firm was represented as a combination of capital and labour without any consideration of its agents' interactions, exchanges, wage efficiency, social networks, culture, etc. However, we are now experiencing a new theory of the firm which has already overcome the fiction based on maximizing profit as the sole purpose of the company. According to Camerer, the same situation is associated with neuroeconomics because the neuroeconomic theory of the individual replaces the fiction of a maximizing individual with a more detailed description of how components such as regions of the brain, cognitive control, or neural circuits communicate and interact with each other and how it all affects the behaviour of an individual.[39]

I think that in the context of reflection about character and the roles of economics and neuroeconomics, the first argument mentioned by Gul and Pesendorfer, that economics and neuroeconomics employ different abstractions and answer different questions, is very important. This dichotomy is analysed by Emrah Aydinonat in his reflection about the explanatory relevance of neuroeconomics. Aydinonat agrees with Gul and Pesendorfer that there

[35] Colin F. Camerer, "The Case for Mindful Economics," in *The Foundations of Positive and Normative Economics*, eds. Andrew Caplin and Andrew Schotter (New York: Oxford University Press, 2008), 45.
[36] Ibid., 44
[37] Ibid., 45.
[38] In this context, Camerer mentions that Glimcher and Rustichini also consider mathematical, behavioural, and mechanistic approaches to a choice as a goal of neuroeconomics, which is very similar to the approach of a rational choice theory. See Paul W. Glimcher and Aldo Rustichini, "Neuroeconomics: The Consilience of Brain and Decision," *Science* 306, no. 5695 (2004): 452.
[39] Camerer, "The Case for Mindful Economics," 46.

are situations where the "different question, different abstraction" argument is valid and neuroeconomics is really irrelevant to economics. Nevertheless, there are also situations where neuroeconomics can be relevant. According to Aydinonat, neuroeconomics is more than inspirational and should be judged not only by its ability to improve economic explanations or models, but also by its ability to understand economic phenomena.[40] Although in all cases economics and neuroeconomics answer different questions, we can distinguish between situations where neuroeconomics is relevant for economics and situations where the reverse is true. Both examples can be found in a paper by Camerer and his colleagues.[41,42]

This does not mean, however, that neuroeconomics can only provide partial information on how specific conditions and contexts affect particular people in specific situations, but it seeks to examine how certain types of states and contexts affect behaviour in general.[43] Aydinonat concludes his reflections on the relevance of neuroeconomics by stating that "[i]f economics were right about everything, neuroeconomics findings concerning neural level mechanism could have been ignored safely," yet even in this case, the ignorance of neuroeconomics is illogical because the information related to lower level mechanisms enhances our general understanding of economic phenomena.[44]

Paul Glimcher alleviates this heated discussion by stating that that a number of negative approaches to neuroeconomics (including Gul and Pesendorfer) are reactions to a single view of neuroeconomics that is mainly popularized by articles by Camerer, Loewenstein, and Prelec. Glimcher also

[40] Emrah N. Aydinonat, "Neuroeconomics: More than Inspiration, Less than Revolution," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012), 60.

[41] The first example of Camerer et al. describes a driver who has car accident because of sleep. These authors say that the economic theory considers this fact as a choice by the driver which is connected with utility. They are convinced that biological mechanisms explain this situation better. Nevertheless, Aydinonat shows that Camerer, Loewenstein, and Prelec call choice something which is considered within economic theory as a consequence. See Camerer, Loewensteina, and Prelec, "Neuroeconomics," 563; Aydinonat, "Neuroeconomics," 61–62.

[42] The situation where neuroeconomic data is relevant is a situation where two people refuse to buy peanuts that are sold at a reasonable price. Person A is allergic to peanuts, so it is impossible to convince her to buy it. Person B has consumed too many peanuts during the last year and he got sick, which means that he could not be convinced to buy it. Economic theoretical models cannot distinguish between these situations. See Camerer, Loewensteina, and Prelec, "Neuroeconomics," 563; Aydinonat, "Neuroeconomics," 62–63.

[43] Ibid., 63.

[44] Ibid., 67

admits that in the context of positive economics, Gul and Pesendorfer are right – neuroscientific data is irrelevant to economics. However, Glimcher does not agree with the conclusion that Gul and Pesendorfer derive and considers it to be speculative. Gul and Pesendorfer are convinced that economics should remain unrelated to psychology and neuroscience.[45,46] According to Glimcher, neuroeconomic parent disciplines must be unified in a similar way to how biology and chemistry gave rise to biochemistry, or in a similar way to how other disciplines have become unified as we know from the history and philosophy of science. However, achieving this linkage is not possible without understanding the philosophical issues. These metaphysical questions are significant, despite the fact that many scientists do not pay attention to them because they believe that empirical research is sufficient.[47]

With regard to the discussion on the relationship between economics and neuroscience, Jaakko Kuorikoski and Petri Ylikoski are convinced that the "idea of a direct connection between economics and neuroscience is misguided" because neuroscience and economics "can only be integrated via psychological theories of decision-making."[48] Findings of neuroscience must be interpreted in the context of well-developed psychological theories. These findings have no evidential or explanatory relevance to economics *per se*.[49] Within mechanistic research, functional localisation is significant, but it does not explain anything. When we see that something happens in the brain during an activity, it does not mean that this observation explains that specific behaviour. Psychological variables are a necessary connecting

[45] Glimcher, *Foundations of Neuroeconomic Analysis*, xiv.

[46] Gul's and Pesendorfer's critique is also commented by several other authors. For example, Jack Vromen tries to point out in which way neuroscientific data can be considered useful for economics. See Jack Vromen, "Where Economics and Neuroscience Might Meet," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012). Despite his agreement with Gul and Pesendorfer that neuroscience deals with different questions and employs different abstractions, and despite his conviction that neuroeconomics does not represent revolutionary approach, Alessandro Antonietti is still convinced that "analysis of the psychological and neural correlates of financial choices" may be useful in efforts to "improve our comprehension of the causal chain connecting the former to the latter." Alessandro Antonietti, "Do Neurobiological Data Help Us to Understand Economic Decisions Better?," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012), 107–8.

[47] Glimcher, *Foundations of Neuroeconomic Analysis*, xv–xvi.

[48] Jaakko Kuorikoski and Petri Ylikoski, "Explanatory Relevance Across Disciplinary Boundaries: The Case of Neuroeconomics," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012), 119–20.

[49] Ibid., 120.

link between neuroscience and economics.[50] It seems that neuroscience itself cannot provide a platform for the unification of disciplines of different levels of analysis and that the development of the social sciences is essential for this unification. However, as it will be shown in the following section, the relationship between mental phenomena and neuronal activity is not clear as to how it relates to philosophical problems.

3. Scientific and Philosophical Nature of Neuroeconomics and its Relation to Methodological Disunity and Technical Problems

As it has been shown in the previous section, neuroeconomics fundamentally differs from economics. In this section I point out that, although in many respects neuroeconomics is closer to the natural sciences, it also relates to the important philosophical problem of the relationship between mind and body. Even if we go to the lower level of explanation, it is obvious that views on the neuronal architecture are not unified across neuroeconomic research programmes. At the end of this section I will point out that technological barriers represent obstacles to addressing these issues.

3.1 Scientific Nature of Neuroeconomics

There are several characteristics of neuroeconomics that differ from neoclassical economics. It involves, for example, increasing the realism of theories, a descriptive approach, and an attempt to connect it with a prescriptive approach, or inductive modelling. As was already mentioned in the first section, neuroeconomics places an emphasis on increasing realism as one of its rhetorical advantages. Nevertheless, neoclassical economics is often associated with antirealism (instrumentalism) which is known primarily from Milton Friedman's essay.[51] *Realism* in economics has been deeply analysed by Uskali Mäki.[52] Although many philosophers of economics agree that issues of the relationship between theory and reality are important, their views differ as to whether it is relevant when dealing with realism in economics. For example, Daniel Hausman does not think that Mäki's detailed interest

[50] Ibid., 125.
[51] Milton Friedman, "The Methodology of Positive Economics," in *Essays in Positive Economics*, Milton Friedman (Chicago: The University of Chicago Press, 1953).
[52] See for example Uskali Mäki, "Some Nonreasons for Nonrealism about Economics," in *Facts and Fiction in Economics. Models, Realism, and Social Construction*, ed. Uskali Mäki (Cambridge: Cambridge University Press, 2002).

in realism has a great importance because most economic theories do not postulate "unobservables."[53] However, due to the development of neuroscience, unobservable entities emerge. It is obvious that neuroeconomics is connected with terms such as neurons, mental states, mental processes, and so forth. Neuroeconomics seeks to cope with the following task: to affirm that theories and models based on the methodology of the natural sciences and by their descriptive approach can provide better predictions than instrumentalist theories, whose only criterion is predictive power. The aim of neuroeconomics is to link the description and the prescription.

Similar to behavioural economics, neuroeconomic empirical research is based on the *descriptive approach*. Individual researchers try to defend their position by placing it in the context of a prescriptive approach. At the same time, they point out that attempts to naturalize the phenomena of one level of analysis to a more fundamental level are not connected with efforts to replace a normative approach by a purely descriptive one. As Glimcher, Dorris, and Bayer show, neuroeconomics seeks to unify the prescriptive and the descriptive approaches to overcome the tensions we find in the history of economic thought. Neoclassical economic theories aim to define optimal decision making and employ the assumption of rational decision makers who maximize utility. These prescriptive economic theories are in contradiction with descriptive insights of behavioural economists and scientists who describe anomalies within economic theory.[54] Nevertheless, both approaches have their advantages. While the prescriptive model is characterised by its advantages of parsimony and efficiency, the descriptive model has the advantage of its predictive power. Although neuroeconomics is only in its beginnings, which are associated with many problems, it tries to create a model that would be at least in some ways a combination of both approaches.[55]

There are also differences in the approach to modelling. Moana Vercoe and Paul J. Zak comment on *deductive and inductive modelling* in their

[53] Daniel M. Hausman, "Laws, Causation, and Economic Methodology," in *The Oxford Handbook of Philosophy of Economics*, eds. Harold Kincaid and Don Ross (New York: Oxford University Press, 2009).

[54] One of the famous anomalies was described by Maurice Allais who pointed out to the fact that even supporters of expected utility theory are not able to decide in accordance to their theory. See Maurice Allais, "Le comportement de l'homme rationnel devant le risque: Critique des postulats et axiomesde l'ecole Americaine," *Econometrica* 21, no. 4 (1953): 503–46.

[55] Paul W. Glimcher, Michael C. Dorris, and Hannah M. Bayer, "Physiological Utility Theory and the Neuroeconomics of Choice," *Games and Economic Behavior* 52, no. 2 (2005): 213–14.

study. Economists usually propose mathematical models of behaviour. These models are then employed to derive theorems related to causal mechanisms. Empirical analysis is used in the following phases to test the causal claim. This approach, characterised mostly by its deductive character, leads to situations where there are many models that have not yet been empirically tested. Moreover, many models explain data with the same success. Unlike this approach, neuroeconomics is rather orientated to inductive modelling, which is based on an effort to identify physiological mechanisms responsible for behaviour. This approach is based on the assumption that physiological states affect human decision-making. Neuroeconomists, in an effort to support an inductive approach, argue with the results of experiments that point to deviations from the deductively based equilibrium theory.[56]

3.2 Philosophical Nature of Neuroeconomics

Neuroeconomics can also be characterised by its *philosophical problems*. These problems especially influence scientists to accept or refuse a specific methodology. The first philosophical problem relates to psycho-physical causality. The mind-body problem and questions related to *psycho-physical causality* have a direct impact on the acceptance or refusal of recent scientific tendencies in economics, especially behavioural economics and neuroeconomics. This refusal can be both ideological and philosophical. It is also not hard to imagine disagreements between supporters of behavioural economics and neuroeconomics. While some will accept the "mindful approach" from the position of behavioural economics, at the same time they can disagree with neuroscientific concepts that are based on forms of eliminative materialism. To illustrate the ideological refusal of neuroeconomics, it is possible to note that, for example, Ariel Rubinstein is unwilling to accept neuroeconomics due to his position on the mind-body problem. He fears "the approach in economics in which decision makers become machines with no souls."[57]

A philosophical analysis is provided by Giuseppe Lo Dico who shows that, for neuroeconomists, neurobiology represents a physical "anchor point" of economic and psychological constructs. Nevertheless, neuroeco-

[56] Moana Vercoe and Paul J. Zak, "Inductive Modeling Using Causal Studies in Neuroeconomics: Brains on Drugs," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012), 33–34.

[57] The reason for refusal eliminative scientific approaches can be also ideological. Ariel Rubinstein, "Comments on Neuroeconomics," *Economics and Philosophy* 24 (2008): 486.

nomic rhetoric does not suggest that neuroeconomists want to eliminate the vocabulary of psychology and economics and replace it with neurobiological, but rather they try to replace the "as if assumptions" of these disciplines.[58] Under this approach, entities of economics and psychology are considered to be physical entities, which means, according to Lo Dico, that the approach of neuroeconomists is based on the "mind-brain type identity theory," a philosophical approach which is based on *a priori* claim, not on *a posteriori* empirical evidence. Lo Dico admits that neuroeconomists do not identify their approach explicitly to identity theory, but he is convinced that for many neuroeconomists this attitude is typical. An example is, according to Lo Dico, a statement from Glimcher et al.[59] These authors point out that the expected utility function is a neural property. The theory of the identity of types is a very ambitious assumption, which, according to Lo Dico, has not been proven by neuroeconomists. The main reason is based on the fact that although this approach is evident in their rhetoric, they do not pay attention to the analysis of this philosophical position and its consequences. Correlating data from neuroeconomic studies is not empirical evidence of identity and it is not proof of a successful reduction of the mental to the neural. The acquired correlations between activity in a given neural region and behavioural reality may not indicate that this activity is necessary for a given mental phenomenon.[60] Neuroeconomics is thus confronted with metaphysical issues, and it will be necessary to deal with them in the future to successfully unify neuroeconomic parent disciplines. As we have noted above, even neuroeconomists like Glimcher are of the opinion that these metaphysical issues are significant.[61]

Another problem emerges in the context of different opinions about *the neural architecture of the brain*. At this point, it is important to remember, together with Fumagalli,[62] that neuroeconomics is not a unified research programme. Different concepts of mind (or the brain and its functions, respectively) lead to different approaches in neuroeconomics. In this con-

[58] Giuseppe Lo Dico, "Neuroeconomics, Identity Theory, and the Issue of Correlation," *Theory & Psychology* 23, no. 5 (2013): 576–90.
[59] Glimcher, Dorris and Bayer, "Physiological Utility Theory," 220.
[60] Lo Dico, "Neuroeconomics, Identity Theory," 576–90.
[61] Glimcher, *Foundations of Neuroeconomic Analysis*, 30.
[62] Roberto Fumagalli, "The Disunity of Methodologies: A Methodological Appraisal," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012), 20–21.

text, Fumagalli[63] mentions disapproval of Glimcher, Doris, and Bayer[64] with Camerer, Loewenstein, and Prelec,[65] who assume that human decision making is a product of two systems, cognitive and affective (emotional) that co-exist as independent entities within the neural architecture, resulting from their different evolutionary origins. Glimcher et al. on the other hand, are convinced that this idea, which was characteristic of the initial phase of research, is indefensible with the growing evidence of data, and it is better to prefer a coherent look at the neural architecture, which is rooted deeper in evolutionary theory than dualistic concepts.[66] Scott Huettel believes that although the dual-process approach was useful in psychology, it is not suitable for decision neuroscience. Based on studies carried out for example by Bechara et al.,[67] it is possible to state that some areas of the brain (such as the orbitofrontal cortex) can become important in different contexts for both cognitive and emotional contributions.[68] This dissimilarity in the view of the neuronal architecture is also considered one of the conceptual challenges of neuroeconomics.[69] Proponents of neuroeconomics must not only defend their reductionist stance on the mind-body problem, but also deal with complex issues related to the neuronal brain architecture. A major challenge remains the replacement of the dual-process framework with a new concept that would better reflect the findings of current research.

3.3 Problem of Methodological Disunity

The first problem worth mentioning, as has been indicated in previous sections, is the *disunity of methodologies*. Not only can neuroeconomics be defined in a variety of ways in the context of its goals and the characteristics their proponents consider important, but a variety of methodological approaches can also be distinguished. Roberto Fumagalli points out that the situation is complicated by the fact that different researchers (in some cases

[63] Fuamagalli, "The Disunity of Methodologies," 21.
[64] Glimcher, Dorris, and Bayer, "Physiological Utility Theory," 216.
[65] Camerer, Loewenstein, and Prelec, "Neuroeconomics: How Neuroscience Can Inform Economics."
[66] Glimcher, Doris, and Bayer, "Physiological Utility Theory," 216.
[67] Antoine Bechara, Hannah Damasio, and Antonio Damasio, "Emotion, Decision Making and the Orbitofrontal Cortex," *Cerebral Cortex* 10, no. 3 (2000).
[68] Scott A. Huettel, "Ten Challenges for Decision Neuroscience," *Frontiers in Neuroscience* 4 (2010): 1.
[69] See David V. Smith and Scott A. Huettel, "Decision Neuroscience: Neuroeconomics," *Wiley Interdisciplinary Reviews: Cognitive Science* 1, no. 6 (2010).

even the same researchers) employ dissimilar approaches and methods in different papers.[70]

Two groups of neuroeconomic research are distinguished by Don Ross and Glen Harrison. The first group Ross calls "neurocellular economics," the second group he calls "behavioral economics in the scanner."[71,72] While Don Ross[73] and Glen Harrison[74] recognize the potential in neurocellular economics, they are very sceptical about behavioural economics in the scanner. According to Ross, neurocellular economics can be characterized as a programme that "uses the mathematics of economic equilibrium analysis to write down models of brain cell activity for the sake of refining and comparatively testing hypotheses about neural learning that originate from computational neuroscience."[75]

Within this approach, the brain is similar to the market. It can be characterized as "massively distributed information-processing networks over which executive systems can exert only limited and imperfect governance."[76] Neurocellular economics is based on research conducted by Paul Glimcher[77] et al. Harrison and Ross point out that the potential of this approach is based on its empirical hypothesis that "dopamine signals in the ventral striatum and medial prefrontal cortex constitute a 'common currency' of reward that has many properties in common with the mainstream economist's concept of utility."[78] Glimcher is convinced that efforts to establish neuroeconomics must be based on a search for two objects; the neural and psychological correlates of utility and the mechanism that transforms this correlate of utility into choice.[79] According to Glimcher, there is empirical evidence which

[70] Fumagalli, "Philosophical Foundations of Neuroeconomics," 25–26.
[71] Don Ross, "Two Styles of Neuroeconomics," *Economics and Philosophy* 24, no. 3 (2008): 473.
[72] Jack Vromen in this context mentions "Glimcher et al. style" and "Camerer et al. style" neuroeconomics. Nevertheless, Vromen is convinced that the differences between these styles of neuroeconomics are not as dramatic as they at first seem. For his argumentation see Jack J. Vromen, "Neuroeconomics as a Natural Extension of Bioeconomics: The Shifting Scope of Standard Economic Theory," *Journal of Bioeconomics* 9 (2007): 145–67.
[73] Ross, "Two Styles of Neuroeconomics," 473.
[74] Glen Harrison and Don Ross, "The Methodologies of Neuroeconomics," in *Neuroeconomics: Hype or Hope?*, eds. Caterina Marchionni and Jack Vromen (London: Routledge, 2012).
[75] Ross, "Two Styles of Neuroeconomics," 474.
[76] Ibid., 473.
[77] Paul W. Glimcher, "Choice: Towards a Standard Back-Pocket Model," in *Neuroeconomics: Decision Making and the Brain*, eds. Paul W. Glimcher, Colin F. Camerer, Ernst Fehr, and Russell A. Poldrack (London: Elsevier, 2009).
[78] Harrison and Ross, "The Methodologies of Neuroeconomics," 87.
[79] Glimcher, *Foundations of Neuroeconomic Analysis*, 416.

suggests a two-stage mechanism of choice, and the task of neuroeconomics will be to explore the degree to which these stages are separable. Moreover, Glimcher claims that there are also findings that may indicate the first revision of economics by neuroeconomics.[80]

Yet on the contrary, behavioural economics in the scanner is based on repeating experiments conducted within behavioural economics, whereby the brains of participants are indirectly examined through brain-imaging technologies. These experiments involve settings which are characteristic of game theory (Prisoner's Dilemma, ultimatum games and so forth). Harrison and Ross connect this approach with many shortcomings.[81] Ross claims that advocates of this style of neuroeconomics commit similar logical mistakes to many behavioural economists. The most common mistake is based on the fact that behavioural economists in the scanner assume a reduction at two levels. In the initial phase, the institutionally embedded person becomes a lonely mind in the laboratory which is often the mistake of behavioural economists. After that, this lonely mind is then reduced to a single "decontextualized lone neurotransmitter system in the head."[82]

3.4 Technical Problems

Another necessary fact to consider is that neuroeconomics relates to several *technical constraints* and difficulties with *interpretations of data*. Perhaps some of the above-mentioned problems will be solvable in the future as newer technology becomes available. Among the variety of techniques used in neuroscience research, functional magnetic resonance imaging (fMRI) is the most commonly applied device, in particular the blood oxygen level dependent fMRI which "relies on blood flow dynamics in response to changing neural events."[83] In the light of the complexity of neuroscientific research and the need to use a number of statistical tools, Reid Hastie and Robyn Dawes note that neuroscientific studies seek to capture increased brain activity in different conditions. However, it is important to realize that many brain regions are active during individual tasks that experimental participants are exposed to. Further, it is possible to say that if we are alive, the entire brain is

[80] Ibid., 416–17.
[81] Harrison, "Neuroeconomics." Ross, "Two Styles of Neuroeconomics."
[82] Ross, "Two Styles of Neuroeconomics," 481.
[83] Sebastian Markett, "Functional Magnetic Resonance Imaging (fMRI)," in *Neuroeconomics. Studies in Neuroscience, Psychology and Behavioral Economics*, eds. Martin Reuter and Christian Montag (Berlin: Springer, 2016), 381.

active. The studies show the relative activity of the brain regions under different experimental conditions using various statistical criteria to determine activity of the key area.[84]

The problems of neuroimaging techniques are discussed in more detail by Robert Savoy[85] and Russell Poldrack.[86] Savoy reminds us that functional magnetic resonance is not a simple tool. For this purpose, he mentions animal physiological studies that have revealed different data. In addition, it is necessary to be able to correctly interpret the data acquired.[87] Savoy concludes that there is only one solution – rely on the mechanism of scientific correction which will consist of replicating the experiments. Given the huge amount of high-cost research, it cannot be assumed that it would be easy to repeat and investigate all experiments. Thus, it is clear that before there is more data available, it will be necessary to look sceptically at the results of current research.[88]

Poldrack considers it an important question whether cognitive processes can be inferred from data provided by neuroimaging techniques. It is necessary to distinguish between two kinds of inferences. The forward inference is based on the effort to determine brain activity in the context of an experimental situation. On the contrary, reverse inference is related to the determination of concrete cognitive process based on specific activity in the brain. Poldrack points out that this inference is not deductively valid, but it can provide some information and it can be helpful in formulating new hypotheses. However, it should be noted that the usefulness of this approach is greatly limited by the selectivity of activation in the areas of interest.[89] Although careless use of reverse inference is considered problematic, neuroscientists try to overcome this constraint. Florian Hutzler is convinced that this view of reverse inference is overly pessimistic, and he tries to come up with a revised formulation of reverse inference that points to the fact that it cannot be considered as a fallacy *per se*.[90] There are, of course, many other errors associated with fMRI research. Lieberman and Cunningham mention that

[84] Hastie and Dawes, *Rational Choice in an Uncertain World*, 302.
[85] Robert L. Savoy, "Experimental Design in Brain Activation MRI: Cautionary Tales," *Brain Research Bulletin* 67, no. 5 (2005).
[86] Russell A. Poldrack, "Can Cognitive Processes Be Inferred from Neuroimaging Data?," *Trends in Cognitive Sciences* 10, no. 2 (2006).
[87] Savoy, "Experimental Design in Brain Activation MRI: Cautionary Tales," 361–62.
[88] Ibid., 366.
[89] Poldrack, "Can Cognitive Processes Be Inferred from Neuroimaging Data?," 59.
[90] Florian Hutzler, "Reverse Inference Is Not a Fallacy Per Se: Cognitive Processes Can Be Inferred from Functional Imaging Data," *NeuroImage* 84 (2014): 1061.

fMRI analysis involves hundreds or thousands of false positives which is the result of noise in situations where there is no true effect. The task of statisticians is then to find methods to avoid these errors. Moreover, these authors note that another mistake, related to the situations when we are not able to recognize a true effect, is more serious in behavioural research because these errors are not reported in neuroimaging.[91] However, technological constraints and difficulties in interpretation are also connected with other neuroimaging devices, for example with electroencephalography.[92]

Discussion

It is not problematic to agree with Daniel Hausman that the extent of neuroscientific and behavioural contributions to economics is an empirical question that will be answered in the future.[93] It is a logical conclusion. But there are other questions. What should I do as a social scientist at the present level of knowledge when I am confronted with the possibility to take part in these innovative research projects? What are the specific tasks for social scientists?

Before dealing with specific tasks relating to problems that will be hard to solve without the involvement of social scientists, let me mention the tasks based on interdisciplinary cooperation. These are the topics I described in this paper – the effort to unify parent neuroeconomic disciplines, to define the relevance of neuroeconomic data in economics, and to solve philosophical, methodological, and technical problems. Reflections of these problems can be developed while replicating experiments, representing another significant task. In many articles it is possible to find passages where authors put stress on the necessity to replicate experiments.[94] The importance of replication is multiplied by the fact that, for example, in psychology many of

[91] Matthew D. Lieberman and William A. Cunningham, "Type I and Type II Error Concerns in fMRI Research: Re-Balancing the Scale," *Social Cognitive and Affective Neuroscience* 4, no. 4 (2009): 423.

[92] See Roberta Grech et al., "Review on Solving the Inverse Problem in EEG Source Analysis," *Journal of NeuroEngineering and Rehabilitation* 5 (2008), 25.

[93] Daniel M. Hausman, "Mindless or Mindful Economics: A Methodological Evaluation," in *The Foundations of Positive and Normative Economics*, eds. Andrew Caplin and Andrew Schotter (New York: Oxford University Press, 2008), 125.

[94] See, e.g., Lieberman and Cunningham, "Type I and Type II Error Concerns in fMRI Research," Colin F. Camerer et al., "Evaluating Replicability of Laboratory Experiments in Economics," *Science* 351, no. 6280 (2016).

the replicated studies do not achieve significant results.[95] During this study I mentioned Savoy's opinion that serious flaws in research may be detected in the processes of scientific correction. It is sure that all the problems that have been described are difficult to solve with armchair theorizing. With respect to all the mentioned problems, it seems that we can get closer to the answers in the process of critical experiment replication. It is a logical conclusion which we can intuitively accept. Unfortunately, there are serious obstacles in practice.

The first obstacle was noted by Savoy – it cannot be assumed that all experiments will be replicated due to the costs of research. The second obstacle may be related to the fact that replicating experiments can be considered by scientists as not as attractive as innovative research. Although no one claims that the replication of an experiment is secondary scientific activity, and most scientists are aware of its importance, the pressure on new discoveries and the achievement of prestigious results is not in line with this awareness. I suggest that replicating experiments should be a task for social scientists who are interested in neuroscience and want to contribute to this discipline. With replication it is possible to get first-hand experience with empirical research. Moreover, neuroeconomic studies should not be blindly repeated. Researchers should be aware of the challenges and problems that neuroeconomics is facing with regards to replicating experiments. Replication could lead not only to scientific correction – pointing to badly conducted research and misconceptions, but also to the possibilities of designing new research. Moreover, social scientists can help in formulating scientific questions that will be truly beneficial to the individual parent disciplines of neuroeconomics.

There are also tasks and important activities that are linked to the work of social scientists:

1) The first important comment relates to the importance of social sciences. Exploring social reality is an important part of science and should not be pushed into the background and it should not be considered less significant than exploring the world of the natural sciences. The importance of the social sciences is also illustrated by the example of neuroscience. It is economics, as a social scientific discipline with its characteristic methodology, that inspired neuroscience and stimulated its development. Klucharev, for example, describes neuroscience as a self-centred discipline, because there

[95] Open Science Collaboration, "Estimating the Reproducibility of Psychological Science," *Science* 349, no. 6251 (2015), aac4716.

are neurobiologists who think that by analysing certain areas of the brain it is possible to explain the processes of human decision-making. It is precisely economics that brings into neuroscience a dynamic element.[96] In this respect, social scientists should remain social scientists and strive to develop their discipline, but also to realize its limits. The development of the social sciences and their traditional approaches can be helpful in the development of the natural sciences. As we have already mentioned, Kuorikoski and Ylikoski believe that further development of neuroeconomics, among other things, will be conditioned by the improvements of psychological theories.[97] Social scientists should defend themselves from those approaches of neuroeconomics that use manipulative rhetoric based on the misinterpretation of the methods of social sciences and a naive belief that neuroeconomics can overcome its parent disciplines in a revolutionary manner. Developing the social sciences and finding a way to contribute to neuroscience is one of the ways to achieve a synthesis of parent neuroeconomic disciplines. It is also necessary to evaluate which of the goals of the different neuroeconomic approaches are achievable. For this purpose, an analysis of the scientific rhetoric and its arguments is necessary. This task belongs to the typical fields of interest of social scientists, and the insights of several philosophers of economics were mentioned in this paper, such as Mäki, Fumagalli, Ross, Aydinonat and others, who are trying to look at neuroeconomics without prejudices and provide constructive criticism.

2) The second way to contribute relates to the attitudes as seen from the other side. This is an attempt to use the knowledge of neuroscience for the development of the social sciences, especially economics. Social scientists have several ways to contribute. One possible contribution relates to collaborating on developing a decision theory that would be able to bridge the differences between these two disciplines. The second contribution concerns the endeavour to apply data that is available from past research. This second contribution is connected particularly to disciplines such as management or marketing where neural data can provide direct useful information without the necessity to develop a complex economic theory. The emphasis on searching for practical applications of neuroeconomic research is based on the fact that these studies are associated with large financial investments.

[96] Vasily Klucharev, "Introduction to Neuroeconomics: Neuroeconomics as a Multidisciplinary Field," National Research University Higher School of Economics, 2014, YouTube video, accessed December 26, 2018, https://www.youtube.com/watch?v=0dJ7zG0cRlo/.
[97] Kuorikoski and Ylikoski, "Explanatory Relevance," 119–20.

Moreover, social scientists have experience in dealing with complex social reality and they are sensitive to the limitations of the social sciences in order to make concrete predictions. Regarding the ability to predict real-world choices, Scott Huettel notes that neuroeconomics faces an empirical challenge based on generalizing choice outside of laboratory conditions. Current neuroeconomic contributions in areas such as marketing, game theory, or finance attempts to uncover potential regularities, but these laboratory insights do not provide predictions about choices in the real world. Huettel calls these conceptual influences "weak decision neurosciences." The challenge of neuroeconomics is to achieve "strong decision neuroscience," which is not an easy task.[98] Social scientists, aware of the difficulties that arise in exploring complex social reality, can provide valuable insights and draw attention to the uncritical acceptance of research results that fall more into the field of "weak decision neuroscience."

3) Another point is related to the previous one. Although the beginnings of neuroeconomics have been associated with overwhelming claims about the possibility of a revision of economics, the aim of neuroeconomics should not be to replace economics. Social scientists should be able to defend the idea that potentially "naturalized disciplines" cannot completely replace social sciences. Even neuroscientists like Glimcher do not believe "that all of economics can be reduced to neuroscience."[99] Moreover, the domain of economics is wider than the area of decision theory. It is necessary to take into account the relationship between economics and economy, public policy, or political philosophy. In this context, David Smiths and Scott Huettel remind us that neuroeconomic criticism is based on the fact that economic modelling operates with complex collective phenomena (for example, financial markets, voting behaviour, price bubbles) that emerge with the interaction of individual decisions.[100] It is difficult to define the contribution of neuroscientific data in efforts to deal with these collective phenomena. Moreover, as Glimcher points out, it is necessary to answer, among others, the following question: "are all concepts at the level of economics emergent or is it the case that some concepts are reducible (as is, or after modification) while others are emergent?"[101] Unfortunately, this metaphysical question remains

[98] Huettel, "Ten Challenges for Decision Neuroscience," 5.
[99] Glimcher, *Foundations of Neuroeconomic Analysis*, 25.
[100] Smith and Huettel call this argument the "Emergent Phenomenon argument." Smith and Huettel, "Decision Neuroscience." See also Clithero, Tankersley, and Huettel, "Foundations of Neuroeconomics," 2349–50.
[101] Glimcher, *Foundations of Neuroeconomic Analysis*, 30.

unanswered. It is therefore the task of social scientists to perceive the links between their traditional disciplines and new interdisciplinary research programs. As it was shown in the second section, neuroeconomists often make exaggerated statements about the relations of these disciplines without a real understanding of economics. In the context of the development of these new approaches, for social scientists it will be more important than ever before to be able to define the importance of their disciplines for society and to show that they cannot be easily replaced. Furthermore, the social sciences can help in the development of the natural sciences. The development of neuroscience and the emergence of social neuroscientific disciplines, such as neuroeconomics, is proof of that.

Conclusion

In spite of its interdisciplinary character and its declared ambition to unify its parent disciplines in a single field of scientific interest, neuroeconomics represents a rather fragmented research programme that can be characterized from the perspective of individual approaches in different ways. However, the views on the dissimilarities of these approaches differ, and it is possible to define the basic goals, ambitions, and visions of neuroeconomics. At least equally problematic is the question of the relationship between economics and neuroeconomics, respectively the discussion about the relevance of psychological and neural data to economics. It is clear from the debate, which offers different views on this relationship and points to various problems, that current neuroeconomics is fundamentally different from economics, especially in the fact that both disciplines are confronted with other research questions and are using other abstractions. However, a wide range of authors points to the fact that this distinction is not a significant obstacle to the potential contribution of neuroeconomic data to economics. Nevertheless, the problems of neuroeconomics can also be seen in a number of technical constraints and interpretation difficulties connected with the necessity to employ advanced statistical methods.

In this article, I attempted to briefly outline the basic problems and challenges of neuroeconomics, as I believe that economists, social scientists, and philosophers of economics who are interested in neuroeconomics should be familiar with them. As a result of the development of neuroscience and the emergence of new laboratories and cognitive research centres, social scientists and academics will increasingly be confronted with the possibility of participating in "neuro-research," or will be faced with the question of the

relevance of these approaches to their discipline. The recent dismal situation of social scientists in some countries, whose profession is not considered as prestigious as in the case of the natural sciences, can lead to ill-considered support of attractive research programmes without thorough critical philosophical reflection. In this paper, I made an effort to answer the question related to the potential contribution of social scientists and define their possible tasks within this research program.

I have proposed several domains of possible tasks. The first group deals with the analysis of neuroeconomic rhetoric and interdisciplinary challenges related to efforts to unify economics, psychology, and neuroscience into a single discipline and to lay the foundations for the emergence of neuroeconomics as a new entity. It has been suggested that this unification cannot be done without a philosophical contribution, as mere empirical research that only produces new data, is not sufficient in this respect. Adequate rhetoric and accurate improvements to arguments may lead to this discipline becoming more serious, and constructive interdisciplinary cooperation will meet the unification challenge. Another domain is connected to tasks to define the relation between economics and neuroeconomics, or to draw the relevance of neuroeconomic data to economics. Several tasks relate to methodology and the problems of interpreting the data. In this respect, it will be necessary to analyse different neuroeconomic approaches, their goals, ambitions, and successes in their implementation. Neuroeconomics faces a series of conceptual challenges, including, for example, the different approaches to the neural brain architecture. These problems may be reflected with replicating experiments, which will not only be seen as a mere repetition of already conducted research, but as replication in the context of efforts to deal with neuroeconomic challenges.

Besides cooperation with neuroeconomists in the above-mentioned domains, the specific contribution of social scientists lays in further developing their disciplines, improving their theories and in highlighting the most important aspects. Social science, as a discipline that studies dynamic processes in the complex world of human interactions, may inspire neuroeconomics and complete neuroeconomics by this element. Moreover, awareness of this characteristic of reality supports the critical attitude toward all revolutionary claims about the naturalization of the social sciences. Finally, it should be the social scientist who really confirms that there are ways these new neuroeconomic approaches can contribute to improvements in economics.

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