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NeuroEconomics: An overview from an economic perspective

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Abstract

Until now, economic theory has not systematically integrated the influence of emotions on decision-making. Since evidence from neuroscience suggests that decision-making as hypothesized in economic theory depends on prior emotional processing, interdisciplinary research under the label of “neuroeconomics” arose. The key idea of this approach is to employ recent neuroscientific methods in order to analyze economically relevant brain processes. This paper aims to provide an overview of the current state of neuroeconomic research by giving a brief description of the concept of neuroeconomics, outlining methods commonly used and describing current studies in this new research area. Finally, some future prospects and limitations are discussed.

Keywords: Decision-making; Neuroscience; Economic theory

1. Introduction

Economics traditionally conceptualized a world populated by rational, self-interest guided, unemotional maximizers. Despite the undisputable success of economic models based on the homo oeconomicus concept, their limitations are nowadays hard to ignore. Experimental and behavioral economics have repeatedly revealed deviations from this classical theory. Subjects show non-opportunistic or reciprocal behavior and other “anomalies” and “paradoxes” that are not explicable with the traditional concept [17]. Consequently, psychological ideas were formalized and translated into testable predictions, thus leading to extended models of economic behavior. Rather than ignoring non-rational behavior, concepts like bounded rationality, bounded willpower or bounded self-interest arose and it was realized that economic behavior is frequently influenced by emotions and subconscious processes [5,39]. Since these “anomalies” were replicated in field experiments [44] focusing on the homo oeconomicus does not seem to be a promising option for advanced economic research [16,70,76].

Consequently, in the early 1970s extended economic models were developed using inputs from other scientific fields. For instance, the integration of psychology led to the development of *behavioral economics* [15,59], out of which several new models on decision-making evolved. A well-known example is depicted in Fig. 1. It contains a dual-process model that distinguishes between the two systems “intuition” and “reasoning”.

This model was introduced to explain seemingly contradictory results of experimental studies of judgments under uncertainty. Despite their unquestionable explanatory value, “intuition” and “rationality” are theoretical constructs. The existence of these underlying cognitive systems was postulated from observation and analysis of behavior, which in turn is used to explain behavior. Criticism from traditional economics concerns this *circular reasoning* as well as the fact that – in contrast to market shares, unemployment rates and economic growth – theoretical constructs are neither observable nor objectively measurable. The only way to solve this dilemma was to use tools or methods that enable researchers to investigate behavior in a new, more objective way. Since neuroscience provides these tools, researchers in several disciplines started to use neuroscientific tools in order to observe brain activities that underlie behavior.

However, the approach to analyze behavior from a neurobiological perspective offers different possibilities. Our ability to explain behavior scientifically with any kind of

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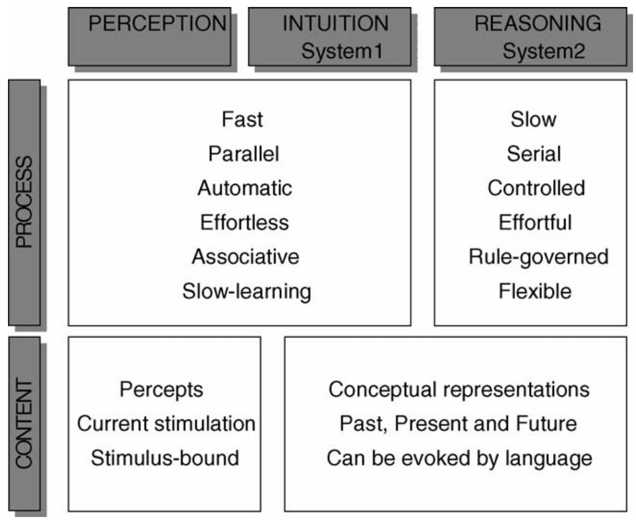

Fig. 1. Dual process model taken from [36].

analysis depends on the complexity of the respective system on one hand, and the available scientific tools on the other hand.

It is a futile attempt to try and explain the function of a human brain based on modeling individual activities of all estimated 10^{11} neurons and their interactions. Models must reduce this complexity by defining larger structures as functional units. With presently available methods, neuroscience allows to investigate brain structures that can be looked upon as such functional units.

Attempting to link both disciplines – economics and neuroscience – it becomes evident that they have to learn a lot from each other [5,71]. The protagonists of this interpretation defined *neuroeconomics* as the application of neuroscientific methods to analyze and understand economically relevant behavior [16]. This definition represents the current mainstream understanding of neuroeconomics. Compared to the model of the *homo oeconomicus* it implies a totally different idea of man. From a neuroscientific perspective his counterpart is the *homo neurobiologicus*, whose behavior and social and economic nature are the result of neurobiology. It is the latter that largely determines his thinking and feeling, deciding and acting, as well as his buying and selling, i.e. his economic life [5]. In this understanding neuroeconomics can contribute to create models of economy that are based on a realistic description of human behavior and the comprehension of the driving forces of this behavior.

Appreciating possible contributions of neuroscience to economic modeling requires a basic understanding of the applied neuroscientific methods such as functional imaging of the brain. Section 2 therefore provides an introduction to these methods for economists. Results from current neuroeconomic research are outlined in Section 3. Possible implications for economic theory will be discussed and future research prospects will be envisioned in Section 4.

2. Overview of selected neuroimaging techniques currently used in neuroeconomics

In principle all kinds of neuroscientific tools can be used to investigate economic decision-making. Table 1 summarizes the prevalent methods currently employed in neuroeconomic research. They can be roughly grouped into two categories according to the underlying mechanisms: procedures for measuring electromagnetic activity of the brain and those sensitive to changes of cerebral blood flow or metabolism.

2.1. Electromagnetic recordings

2.1.1. Electroencephalography (EEG)

EEG measures voltage fluctuations on the scalp. The underlying ion currents occur rather remote from the electrodes (across skin, skull and meninges) in surface-near cortex areas and result from changes in membrane conductivity elicited by synaptic activity and intrinsic membrane processes [46]. An electrode on the skin virtually "sees" the summed potentials generated by a large number of neurons.

While EEG with a temporal resolution of milliseconds and below can easily detect the time course of neural activity, spatial resolution is mainly limited by the so-called *inverse problem* [35]. As an infinite number of source configurations can generate identical potentials on the skin, estimated solutions of the inverse problem, i.e. source localization, therefore require appropriate a priori assumptions about sources and volume conduction to yield physiologically meaningful data [4,51].

2.1.2. Magnetoencephalography (MEG)

MEG is sensitive to changes of magnetic fields that are induced by the electrical brain activity. The temporal resolution can be compared to that of the EEG, so that this modality can, e.g. resolve the temporal sequence of different cortical activities involved in decision-making [9]. However, in contrast to the EEG, MEG is also able to depict activity in deeper brain structures [2,8,9]. The *inverse problem* basically applies to MEG as well, so that source localization depends on valid assumptions, too. Integrating the different brain imaging techniques could further improve currently existing models of source localization [46].

Table 1
Frequently used neuroimaging techniques

Changes in electric activity	Changes in cerebral blood flow/metabolism
Electroencephalography (EEG)	Positron emission tomography (PET)
Magnetoencephalography (MEG)	Functional magnetic resonance imaging (fMRI)