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Review

Can the neuroeconomics revolution revolutionize psychiatry?

Gregor Hasler

Psychiatric University Hospital, University of Berne, Bolligenstrasse 111, 3000 Berne 60, Switzerland

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ABSTRACT

Neuroeconomics is a rapidly growing new research discipline aimed at describing the neural substrate of decision-making using incentivized decisions introduced in experimental economics. The novel combination of economic decision theory and neuroscience has the potential to better examine the interactions of social, psychological and neural factors with regard to motivational forces that may underlie psychiatric problems. Game theory will provide psychiatry with computationally principled measures of cognitive dysfunction. Given the relatively high heritability of these measures, they may contribute to improving phenotypic definitions of psychiatric conditions. The game-theoretical concepts of optimal behavior will allow description of psychopathology as deviation from optimal functioning. Neuroeconomists have successfully used normative or near-normative models to interpret the function of neurotransmitters; these models have the potential to significantly improve neurotransmitter theories of psychiatric disorders. This paper will review recent evidence from neuroeconomics and psychiatry in support of applying economic concepts such as risk/uncertainty preference, time preference and social preference to psychiatric research to improve diagnostic classification, prevention and therapy.

Contents

1. Introduction

Economics, psychology and neuroscience are converging into a new, unified discipline referred to as neuroeconomics. The ultimate goal of neuroeconomics is to provide a single, encompassing theory of human behavior by understanding the processes that connect sensation and action, thus revealing the neurobiological substrate of decision-making (Glimcher and Rustichini, 2004). This theory can be used as a framework to study various psychological, social and neural systems including learning, movement, social cooperation, brain reward pathways and neurotransmitter systems. The increasing number of neuroeconomics papers published in leading scientific journals such as *Nature* and *Science* reflect the increased attention toward this new research discipline in the scientific community. The practical utility of neuroeconomics has yet to be determined, and its potential contribution to the field of economics is a matter of debate (Balleine et al., 2009). However, a growing number of experts consider psychiatry to be neuroeconomics' most promising field of application (Loewenstein, 1996; Rangel et al., 2008).

How much could psychiatry really benefit from neuroeconomics? Psychiatry research has a multifaceted history in terms of disease concepts and research methods. In the beginning of

E-mail address: gregor.hasler@puk.unibe.ch

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the 19th century, the field of psychiatry was mainly descriptive in nature. Janet (1889) and Freud (1905) were among the first to develop integrative bio-psycho-social theories to explain the causes, pathogenesis and symptoms of psychiatric conditions. These intuitive theories provided a theoretical framework and a great deal of explanatory power, contributing to the establishment of psychiatry as a respected clinical profession. Because the main assumptions of these theories could not be tested empirically at the time of inception, they facilitated dogmatism and devaluation of experimental inquiry that dominated psychiatry over decades and led to stagnation of psychiatric research (Kandel, 1998). The publication of the third edition of the *Diagnostic and Statistical Manual for the Classification of Mental Disorders* (DSM-III) in 1980 marked the official beginning of the current, 'atheoretical' phase of psychiatry, representing an important step in the fundamental redirection of the discipline toward a more scientific course. To provide reliable diagnoses for clinical practice, the DSM-III diagnostic criteria are based on clusters of clinical symptoms irrespective of etiology and pathophysiology. Using methods from epidemiology, sociology, psychology, pharmacology, neurobiology and genetics, this 'atheoretical' approach has provided large amounts of empirical data and important insights from specific perspectives. The lack of an encompassing conceptual framework, however, reduces the explanatory power of these data to comprehensively explain motivational forces in individuals diagnosed with psychiatric disorders. To bridge this gap, decision theory with transparent formal models and precise theoretical predictions could bring further scientific rigor to psychiatric research by providing a strong conceptual framework.

In this perspective paper, fundamental concepts from decision theory and related experimental neuroeconomics studies are reviewed and discussed in terms of their potential use as a framework for psychiatry research. Because we are mainly interested in the causes and pathogenetic pathways which can lead to acute states of distress, our focus will be on psychiatric risk factors as opposed to acute symptomatic distress. Given the rather non-specific risk factor profiles of psychiatric disorders and the high comorbidity among these disorders, specific DSM-defined disorders cannot be used as absolute reference points in psychiatric research (Hasler and Northoff, in press). As a result, most of our neuroeconomic hypotheses will not be disorder-specific but related to etiologically-associated groups of disorders.

2. Single-dimensional utility

Economists attempt to construct one single global formalism to describe all choice behavior. To this end, *utility* is defined as a measure of relative satisfaction. In expected utility theory, actual choice can be understood as if a single-dimensional utility index is maximized. These theories assume that subjects encode the values of all things (goods, services, leisure time, wealth) in abstract common units. From an evolutionary perspective, one might not expect the same brain systems responding to primary natural rewards such as water, food and sex to respond to abstract outcomes such as points in a computer game, which are not relevant for survival. However, there is convergent empirical evidence for a common representation of desirability in specific prefrontal brain regions (Chib et al., 2009; Critchley and Rolls, 1996). Together with many other investigations demonstrating neural correlates of utility in key regions of the valuation network (Plassmann et al., 2007; Tom et al., 2007; Weber et al., 2007), these results suggest that utility is useful concept for brain research. Given that the brain regions associated with utility (mainly the orbitofrontal and ventromedial frontal cortices, but also midbrain dopaminergic regions and their projection sites in ventral striatum, Fig. 1) are thought to be

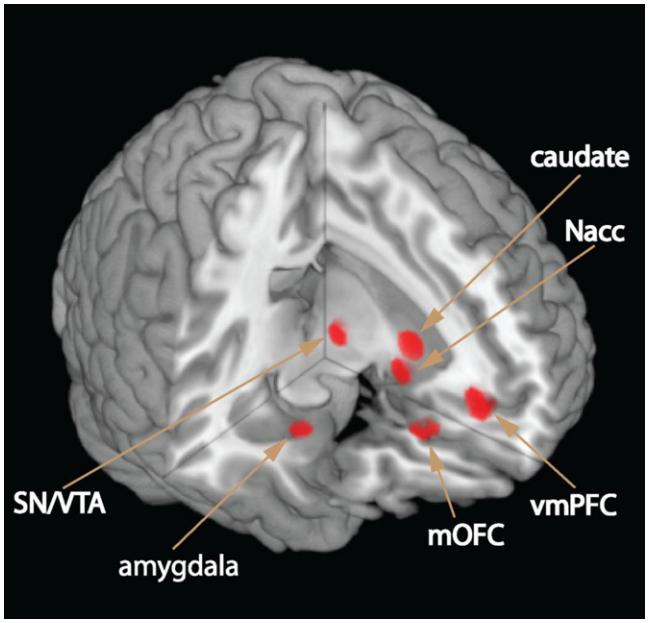

Fig. 1. Schematic illustration of the valuation network. Regions commonly implicated in evaluating rewards and risks in neuroeconomic imaging studies include dopaminergic neurons in the brainstem, such as substantia nigra (SN) and ventral tegmental area (VTA), which send projections to specific areas in the ventral striatum, such as the caudate nucleus and nucleus accumbens (Nacc). Dopaminergic projections also modulate neuronal activity in ventromedial Prefrontal Cortex (vmPFC) and medial orbitofrontal cortex (mOFC), which have repeatedly been shown to represent reward value. Figure was constructed by Jan Engelmann.

intimately involved in a wide range of psychiatric conditions characterized by emotional dysregulation (Hasler et al., 2006, 2004), one might hypothesize that dysfunction of this global valuation system is a major cause of psychiatric disorders. Three additional pieces of evidence support the notion that monoamine-related dysfunctions of a global valuation system contribute to a range of psychiatric conditions: (1) The monoamine neurotransmitters serotonin, norepinephrine and dopamine play important roles in the evaluation of rewards and punishments (Dayan and Huys, 2009). (2) At the same time, monoamine-modulating drugs demonstrate therapeutic effects in a wide range of psychiatric conditions including schizophrenia, mania, depression, obsessive-compulsive disorder, generalized anxiety disorder and panic disorder. (3) Finally, impairment of a global valuation/decision system could explain the fact that various psychiatric conditions co-occur in the same individual more frequently than expected by chance (e.g., up to 90% of individuals with obsessive-compulsive disorder also suffer from depression; (Hasler et al., 2005)).

Based on the assumption of an impaired global valuation system in psychiatric disorders, behavioral experiments using monetary incentives have been used to quantify psychopathology. Although lack of interest in natural rewards such as food and sex are considered key symptoms in depression, there is preliminary evidence that the lack of interest in money, a secondary reinforcer through which primary rewards can easily be acquired, can be used as a quantitative measure of depressive psychopathology. Specifically, there was a relatively strong correlation between depressive symptoms induced by experimental dopamine depletion and lack of interest in money as measured with the Monetary Incentive Delay task (Hasler et al., 2009a), suggesting that decision theoretic approaches are particularly well-suited for investigations of depression related to monoamine-deficiency. Alterations in the neural response to winning and losing money have been shown to be related to familial risk of depression (Gotlib et al., 2010), suggesting they are not mere consequences of the illness but