Homo Neuroeconomicus:
A Review of Functional Magnetic Resonance Imaging of Game Trials on Economic Choice

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ABSTRACT
This paper discusses the development of a neuroeconomic model of decision-making (DM). The method used was a review of functional Magnetic Resonance Imaging of game trials on economic choice. Key centers in economic DM are Ventromedial Prefrontal Cortex, Dorsolateral Prefrontal Cortex, Frontopolar Cortex, Orbitofrontal Cortex, Anterior Cingulate Cortex, Amygdala and Ventral Tegmentum. The interaction of these centers determines individual risk-preference (NeM). The validity of NeM is consolidated by lesion-studies. NeM shows that relaxation exercises are complementary to physical fitness in the maintenance of mental health. Further, NeM explains the effect of “Early home-supported discharge” and how chess games support the learning of mathematics.

KEYWORDS
Bounded Rationality, Economic Choice, Gender Difference, Meditation, Neurocybernetics, Neuroeconomics, Risk-Aversion, Risk-Loving, User-Driven

1. INTRODUCTION
In 1955, Herbert Simon introduced the neoclassical paradigm of bounded (or imperfect) rationality (BR) in economic decision-making (DM). Simon realized that in practical life, rational decisions are limited by 1) insufficient information, 2) insufficient personal skills, and 3) shortage of time. Today, BR is challenged by economic psychology as introduced by (Kahnemann and Tversky, 1979). Neuroeconomics is a new transdisciplinary field of neuroscience, behavioral economics and cognitive psychology developed around new hypersensitive brain scanners as functional magnetic resonance imaging (fMRI). Early reviews were focused on how neuroscience could inform economics (Camerer et al., 2005), neuroeconomic research from the economics point of view (Kenning and Plassman, 2005), specific neurocenters relevant to economic decision-making (Loewenstein et al., 2006), and social decision-making (Sanfey, 2008). A recent neuroeconomic review identifies integration of reward seeking (RSS) and cognitive executive control (ES) as crucial to economic DM (Farb, 2013). RSS is a mesolimbic dopamine system originating in Striatum, passing the Midbrain and Anterior Cingulate Cortex (ACC) towards Orbitofrontal Cortex (OFC). ES is centered in Dorsolateral PFC (dLPFC) and is served by the Frontopolar Cortex (FPC) as well as posterior cortices as the visuospatial sketchpad in Intraparietal Sulcus (IPS) and semantic memories in Superior Temporal Sulcus.

A neuroreview assesses the schism between BR and cognitive psychology from the economics point of view (Camerer, 2008): Most economists think that neural evidence is unnecessary holding BR
as the central normative position. Other economists share the skepticism among cognitive psychologists and neuroscientists about how rapidly new techniques like fMRI will yield operational conclusions. Some economists do have a cautious optimism about the option value of neuroeconomics. Addressing this cautious optimism, the present study aims to synthesize BR and psychological coping developing a neuroeconomic model of DM.

2. MATERIALS AND METHOD

Neuroeconomics is not yet a medical search term (MESH) in PubMed. Searching for “Neurueconomics, decision making and fMRI” finds 63 studies, out of which only Sanfey et al. (2003) is a primary trial on an economic choice. However, the reviews cited above, reference other relevant trials (registered in PubMed) as listed in Table 1.

The following seven neurocenters are extracted from Table 1 for construction of a Neuroeconomic model in Section 3:

1) vmPFC, 2) dIPFC, 3) FPC, 4) OFC, 5) ACC, 6) Am and 7) VT

Table 1. Primary fMRI-trials on economic choice

<table>
<thead>
<tr>
<th>Author</th>
<th>Purpose</th>
<th>Method</th>
<th>Center</th>
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<tbody>
<tr>
<td>McLure et al. (2004)</td>
<td>The neural base of Intertemporal choices (IC)</td>
<td>fMRI of participants offered a choice between rewards at different points of time</td>
<td>ACC, Am1 and dIPFC</td>
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<tr>
<td>Daw et al. (2006)</td>
<td>The neural base of switching: explorative vs. exploitative economic choices</td>
<td>fMRI of healthy subjects performing a ‘four-armed bandit’ task involving repeated choices between 4 slot machines</td>
<td>FPC-IPS or dIPFC</td>
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<td>Goel et al. (2006)</td>
<td>The role of Prefrontal Hemispheric specialization in problem solving</td>
<td>Inference tasks were administered to 4 groups: Subjects dominated by the left PFC (dIPFC) with/-out brain injury and 2 other groups dominated by right PFC (FPC) with/-out injury</td>
<td>Dominance of dIPFC</td>
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<tr>
<td>Li et al. 2017</td>
<td>Neural correlates to cognitive Error</td>
<td>fMRI of 143 subjects performing a gain/loss framing task with data from &gt;8000 studies</td>
<td>dIPFC and Amygdala (Am)</td>
</tr>
<tr>
<td>Erk et al. (2002)</td>
<td>Neural base of symbols (cars) of wealth/dominance</td>
<td>fMRI of differential responses viewing photographs of limousines, sports cars and small cars</td>
<td>Ventral Tegmentum (VT)</td>
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<tr>
<td>Camille et al. (2004)</td>
<td>The neural base of regret</td>
<td>fMRI manipulating a simple gambling task on ‘counterfactual thinking’ to subjects with normal respective injured Orbitofrontal Cortex</td>
<td>OFC</td>
</tr>
<tr>
<td>Hare et al. (2014)</td>
<td>Rationality of DM in IC</td>
<td>fMRI of ventromedial PFC (vmPFC) respective dorsolateral PFC (dIPFC) in IC</td>
<td>vmPFC and dIPFC</td>
</tr>
</tbody>
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