On Money, Risk and the Brain

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I. Introduction

In the past few years neurofinance has emerged as a new field in economics and finance. The small but growing number of economists and neuroscientists involved in this new field have a common goal: to understand how people make economic decisions by analyzing how the brain works when these choices are made. The rise of the field was generated by the failure of the standard rational agent model used by economists in the last 50 years to explain a significant number of decisions made by individuals. Deviations from the optimal choices predicted by the standard model have been documented in the behavioral economics and behavioral finance literature for two decades. However, we still do not have a parsimonious new model that can explain all behaviors exhibited by economic agents, including the so-called deviations from those predicted by the standard model.

Neurofinance (also referred to as neuroeconomics) is trying to provide this new model of economic decision-making, based on how our brain operates when we are faced with choices. The failure of the standard model could potentially be caused by the lack of realism in its assumptions. Tools available to neuroeconomists allow for these assumptions to be tested -- for instance, we can find out whether the brain tracks expected values, risk, or inter-temporal discount factors. By looking inside the brain we can create a more realistic model of decision-making which hopefully is both parsimonious, and able to explain a much wide range of individual economic behaviors compared to the standard model. This article will review some of the puzzles (or deviations from the standard model) documented in behavioral economics and behavioral finance, and then describe several neuroeconomics studies that try to explain these puzzles by examining brain activation during decision-making.

II. Main findings in neurofinance regarding reward and risk processing in the brain

Expected utility theory is the standard economic model for choice under uncertainty. It posits that individuals are always rational, level-headed, and not influenced in their economic choices by their emotions. They always choose the alternative with the highest expected utility (or value). The expected utility of a risky choice is computed as the weighted average of the possible outcomes of the choice, where the weights are the probabilities of each of the outcomes occurring.

In trying to make more sense of individual behavior observed in financial markets, we can see where the assumptions of the standard model fail, and how we can augment or modify the standard model to explain reality better. The emerging neuroeconomics literature goes in both directions.

One stream of the literature analyzes the role of affect in financial decisions. Emotions may change people's choices, and it is not accounted for in the standard model. In a provocative paper, Lo and Repin (2002) found that professional traders experience emotional states characterized by high arousal during market events such as high price volatility, using peripheral measures of arousal, like skin conductance and heart rate. Their study, however, did not answer the question whether these emotional states help or hinder traders in their decisions.

The question of whether affective states can help us understand financial choice was the main focus in Kuhnen and Knutson (2005). They found that activation in two distinct brain areas known to participate in emotion processing, also known as the limbic system, can help predict financial choices. Specifically, activation in the nucleus accumbens (part of a deep brain region called the ventral striatum) preceded making risky investments, while activation in the anterior insula preceded making riskless investments. Excessive activation in the nucleus accumbens and the anterior insula also correlated with subsequently making an investment error by taking on too much risk, or too little risk, respectively. Hence, Kuhnen and Knutson (2007) substantiate the claim that affect can change one's financial risk taking behavior, and sometimes lead to suboptimal choices.

This evidence is consistent with the results of Bechara et al (1997), who found that individuals with brain lesions in areas involved in emotion processing tend to take risks in an experimental gamble task even when they result in high losses, and thus perform worse on the task compared with individuals without such dysfunction.

Related to the inclusion of affect as an important factor in decision making is prospect theory, proposed by Kahneman and Tversky (1979). It is able to explain some deviations from expected utility theory -- in particular, it can explain framing effects, namely, that individuals' choice differs on how a gamble is framed, either as an opportunity to avoid a certain loss, or as an opportunity to potentially add to an existing gain. The concept proposed by prospect theory is that people are more sensitive to the possibility of losses than to the possibility of gains of equal magnitude. As a result, individuals are willing to take a gamble in order to avoid a certain loss, but are not willing to take the same gamble after they have experienced a gain of the same magnitude. This phenomenon is referred to as "loss-aversion".

Inquiring whether the brain encodes loss-aversion, and in particular, whether activation in the limbic system is relevant for this type of behavior, De Martino et al. (2006) found that the susceptibility to framing effects was associated with activity in the amygdala, which is part of the emotional, or limbic system, together with the ventral striatum and the anterior insula. They also showed that activation in the orbital and medial prefrontal cortex, which are not part of the limbic system, but are involved in high level cognitive functions, predicted a reduced susceptibility to the framing effect. In a paper in the same vein, Tom et al. (2007) analyzed whether loss averse behavior correlated with different neural sensitivity to gains and losses in brain areas that respond to monetary outcomes (such as the ventral striatum, part of the limbic system), and find evidence in support of this claim.

The behavioral bias induced by loss-aversion leads people to avoid taking risks even when they should. Given the importance of brain areas in the limbic system for the manifestation of loss-averse behavior, it is possible that disrupting this system may alleviate the bias, and as a result, may lead to people making more advantageous choices when faced with uncertainty. This idea was tested in Shiv et al. (2005). They show that the same individuals with emotional (i.e. limbic system) dysfunction as in the Bechara (1997) study are able to overcome loss-aversion, and as a result make better choices among experimental gambles.

Another stream in the neuroeconomics literature is focused on whether our brain tracks concepts on which the inferences of the standard model of choice under uncertainty are based. For instance, the model states that people choose the option that maximizes their expected utility, which is the sum of possible outcomes of the option, weighted by their probabilities of occurrence.

In support of some of the assumptions of the model, Knutson et al. (2005) shows that different brain areas track ingredients of expected utility theory: higher level brain areas (the medial prefrontal cortex) track probabilities, and lower level areas involved in affect processing and thus part of the limbic system (specifically, the nucleus accumbens) track anticipated reward magnitude.

Another dissociation assumed in choice theory so far is the one between risk and reward. For instance, the Capital Asset Pricing Model used in finance to value assets posits that these two quantities are important: investors are assumed to like higher expected returns and dislike return variance. Preuschoff et al. (2006) find support for this claim by showing that brain activation tracks both expectation and the variance of financial rewards.

III. What can investors and policy makers learn from neurofinance?

Neurofinance research is in its very early stages. We need more replication of the experimental findings mentioned so far, and we need to dig deeper to understand how our brain perceives risky alternatives, and makes decisions among those. It is much too early now to suggest applications of neuroscience technology to business, given the amount of work that needs to be done before we are certain that the effects documented so far in the literature are robust. And at the stage where these effects are deemed robust, we will be faced with important ethical issues. Suppose that it is true that one's brain activation in the nucleus accumbens is a predictor of the person's willingness to take risks, as suggested by the findings of Kuhnen and Knutson (2005). Should then a brain scan be included among screening tools used to recruit new traders, or CEOs, in order to see whose nucleus accumbens is more active? Will such a screening device be acceptable to all candidates? The answer is likely to be no. Brain activation may reveal one's true preferences and abilities, in which case having a brain scan as a job screening process breaches one's right to privacy.

The potential to use brain scans to learn what people really like, dislike or can do, is the main reason why companies have started to conduct neuromarketing studies and measure brain activation while individuals are presented with various products. In fact, in a new study, Knutson et al. (2007) show that they can predict what goods people purchase by measuring activation in the same areas of the limbic, or emotional system, as were shown by Kuhnen and Knutson (2005) to correlate to financial risk taking or risk avoidance. Knutson et al. (2007) find that how much a person liked a product correlated with activation in the nucleus accumbens, while charging excessive prices for the product activated the insula. Importantly, activation from these areas predicted subsequent purchases above and beyond self-report variables, meaning that measuring brain activation during product presentation is a very good way to predict future purchases of the good.

Findings from neuroeconomics can be used by policy makers, too, in order to increase social welfare. For instance, if the government wants to encourage workers to save more for retirement, it may design markets or financial policies that trigger the right part of the limbic system to induce the desired behavior. Or, if discouraging gambling in casinos is desired, potential gamblers can be exposed to ads or incentives that trigger their risk-averse part of the brain, and not the risk-seeking part. Knowing how the brain works when faced with uncertainty can only help us understand how we can make better choices for the long run.

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