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Brain Experts Now Follow the Money

By SANDRA BLAKESLEE

People are efficient, rational beings who tirelessly act in their own self-interest. They make financial decisions based on reason, not emotion. And naturally, most save money for that proverbial rainy day.

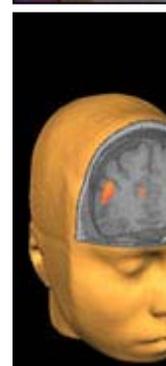
Right?

Well, no. In making financial decisions, people are regularly influenced by gut feelings and intuitions. They cooperate with total strangers, gamble away the family paycheck and squander their savings on investments touted by known liars.

Such human frailties may seem far too complicated and unpredictable to fold into economic equations. But now many neuroscientists are beginning to argue that it is time to create a new field of study, called neuroeconomics.

These researchers are busy scanning the brains of people as they make economic decisions, barter, compete, cooperate, defect, punish, engage in auctions, gamble and calculate their next economic moves. Based on their understanding of how fluctuations in neurons and brain chemicals drive those behaviors, the neuroscientists are expressing their findings in differential equations and other mathematical language beloved by economists.

"This new approach, which I consider a revolution, should provide a theory of how people decide in economic and strategic situations," said Dr. Aldo Rustichini, an



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economics professor at the University of Minnesota. "So far, the decision process has been for economists a black box."

Dr. Jonathan D. Cohen, a professor of cognitive neuroscience at Princeton, agreed. "Most economists don't base their theories on people's actual behavior," he said. "They study idealized versions of human behavior, which they assume is optimal in achieving gains."

To explore economic decision making, researchers are scanning the brains of people as they engage in a variety of games designed by experimental economists. The exercises are intended to make people anticipate what others will do or what others will infer from the person's own actions.

The games also reveal some fundamental facts about the brain that economists are just beginning to learn and appreciate:

¶ In making short-term predictions, neural systems tap into gut feelings and emotions, comparing what we know from the past with what is happening right now.

¶ The brain needs a way to compare and evaluate objects, people, events, memories, internal states and the perceived needs of others so that it can make choices. It does so by assigning relative value to everything that happens. But instead of dollars and cents, the brain relies on the firing rates of a number of neurotransmitters — the chemicals, like dopamine, that transmit nerve impulses. Novelty, money, cocaine, a delicious meal and a beautiful face all activate dopamine circuits to varying degrees; exactly how much dopamine an individual generates in response to a particular reward is calibrated by past experience and by one's own biological makeup.

¶ Specific brain circuits monitor how people weigh different sources of rewards or punishments and how they allocate their attention. A region called the anterior cingulate reacts when people make mistakes or perform poorly; some neuroscientists say it also registers gains and losses, financial and otherwise. A small structure called the insula detects sensations in the body. It is also involved in assessing whether to trust someone offering to sell us the Brooklyn Bridge.

These structures and neurotransmitter systems are activated before a person is conscious of having made a decision, Dr. Cohen said.

In a study published the current issue of the journal *Science*, Dr. Cohen and his colleagues, including Dr. Alan G. Sanfey of Princeton, took images of people's brains as they played the ultimatum game, a test of fairness between two people.

In the ultimatum game, the first player is given, say, \$10 in cash. He must then decide



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how much to give to a second player. It could be \$5, the fairest offer, or a lesser amount depending on what he thinks he can get away with. If Player 2 accepts the offer, the money is shared accordingly. But if he rejects it, both players go away empty-handed. It is a one-shot game, and the players never meet again.

Most people in the shoes of Player 2 refuse to take amounts under \$2 or \$3, Dr. Cohen said. They would rather punish the first player than feel cheated. "But this makes no economic sense," he said. "You're better off with something than nothing."

Brain images showed that when players accepted an offer they viewed as fair enough, a circuit in the front of their brains that supports deliberative thinking was activated.

But when they rejected an offer, the insula — which monitors bodily states, including disgust — overrode the frontal circuit. The more strongly the insula fired, the more rapidly the person rejected the offer, Dr. Cohen said. Moreover, the insula fired well before the person pushed the button to refuse an offer.

Economists can use this finding to quantify the contribution of emotion and deliberation in making decisions, Dr. Cohen said. It is possible to calculate how much emotion goes into evaluating the worth of economic activities and to study the neural underpinnings of bargaining when people don't want to let others take advantage of them.

Dr. P. Read Montague, a neuroscientist at Baylor University in Houston, is using gambling tasks to identify individual differences in willingness to take monetary risks. Bullish investors have different patterns of dopamine release compared with bearish investors, he said. And in a game of mutual trust, women's brains show a big dopamine or reward response when they are trusted by others; there is no such response in men's brains.

At other universities, neuroscientists are exploring brain activity aroused in various economic games. In the prisoner's dilemma, which tests a person's willingness to cooperate or defect, players show a particular pattern of neural firing before they betray another player. Cooperation is captured in dopamine flows. Similarly, it is possible to trace circuits activated when people anticipate making or losing money, decide to trust a stranger or punish freeloaders in a game of sharing public goods.

The brain is particularly responsive to unexpected or unpredictable rewards, said Dr. Gregory Berns, a neuroscientist at Emory University in Atlanta. When uncertainty is high, as in gambling situations, the brain can get high on dopamine and even become addicted to it.

Expectations alter economic experience. It feels better to get nothing when you expect \$10 compared to getting nothing when you expect \$90, researchers say.

Dr. Montague says the brain seizes on patterns and deludes itself into thinking that short sequences predict long ones. For example, after flipping three tails in a row, many people expect the next toss to be heads. By contrast, if a stock does well two quarters in a row, they expect it to continue doing well. Such intuitions lead people to adopt a false sense of confidence and tolerate losses for longer than they should, he

said.

Neuroscience may shed light on all sorts of economic behavior, said Dr. George Loewenstein, an economist at Carnegie Mellon University in Pittsburgh. "Under the influence of powerful emotions or drives, people often end up doing the opposite of what they think is best for themselves, even at the moment of acting," he said.

For example, many people will choose a small reward that arrives soon as opposed to a larger reward that arrives later. The future is uncertain. Why wait?

For now, neuroeconomic experiments tell more about individuals and small groups than about markets and economies, said Dr. Colin Camerer, an economics professor at the California Institute of Technology and author of a new book, "Behavioral Game Theory."

But plans are afoot to study the brains of many people in scanners linked by the Internet as they play economic games, Dr. Camerer said. The stock market is a reflection of decisions being made by millions of brains. Eventually it should be possible to study groups of brains to unravel mysteries about the formation of market bubbles and why they break. Or why people continue to spend money when the stock market falls. Or whether tax cuts will have a bearing on what people do.

"Your dopamine system plays off my dopamine system," Dr. Montague said. "You buy, I buy, I worry about you, our systems become entrained. You sell, I sell and so on. It may be possible to get to the bottom of this behavior."



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