

News Feature

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Driven to market

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Abstract

We're selfish and rational — that's what classical economics says. But play parlour games with brain scanners and you'll find we're pulled in different directions when it comes to money. Jonah Lehrer reports.

Read Montague spent the summer of 2003 thinking about soft drinks. His teenage daughter was working as an intern in his lab at Baylor College of Medicine in Houston, Texas, and Montague, a neuroscientist, wanted to find an experiment that she could "wrap her head around". After much deliberation, he came up with the perfect research topic: recreating the Pepsi Challenge. In a brain scanner¹ (</nature/journal/v443/n7111/full/443502a.html#B1>).

Pepsi launched this advertisement, one of the most famous of all time, in the early 1980s. Television ads showed people on the street being asked to sip cola blindly from two different glasses. Not surprisingly, the ads featured Coca-Cola aficionados who, much to their astonishment, found they preferred the taste of Pepsi.

But if Pepsi really tasted better, Montague wondered, then why would Coke still be more popular? When we are standing in the supermarket, faced by cans of Coke and Pepsi, what is happening inside our brains?

Montague is at the cutting edge of a new scientific field known as neuroeconomics, which uses the experimental techniques of neuroscience to understand how the brain makes economic decisions. Biology, of course, has long been used to explain human nature; evolutionary biology seeks the causes of behaviour in terms of its fitness benefit; and cognitive psychology aims to model decision-making. Neuroeconomics is different: it seeks to understand the most immediate causes of economic choices by seeing how the brain makes them. By studying the brain at work, neuroeconomists hope to resolve well known anomalies such as why stock markets are sometimes gripped by 'irrational' exuberance, or why people rack up huge credit-card debts to buy things they don't need.

The stubborn persistence of these perplexing phenomena defies classical economics, founded as it is on two assumptions about human nature: that we are rational and that we are selfish. When confronted with a variety of options, traditional economists expect us to evaluate the possibilities (rationality) and choose whichever best matches our personal preferences (selfishness). Their mathematical models require this predictable behaviour. What the eighteenth-century economist Adam Smith called the "invisible hand" of the marketplace is just the collective result of lots of reasonable people going about the business of trying to maximize their

own advantage. Such pure rationality is disconcertingly rare, however. Neuroeconomists want to explain why, and their research promises to affect everything from what cola we drink to how we save for retirement.

Fair play

The story of neuroeconomics began in the early 1980s with a parlour game, the ultimatum game, devised to investigate economic behaviour² (</nature/journal/v443/n7111/full/443502a.html#B2>). The rules are simple. An experimenter puts two people together and hands one of them \$10. This person (the 'proposer') has to offer some of the money to the other. The second person (the 'responder') can either accept the offer, in which case both players pocket their respective shares, or reject it, in which case the \$10 is taken from the proposer, and both players walk away empty-handed.

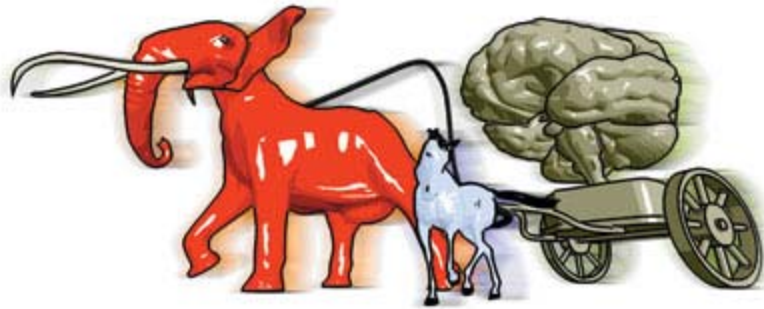
According to the predictions of classical economics, the game should always generate the same outcome. The proposer should offer the responder a minimal amount, \$1, and the responder should always accept it. After all, \$1 is better than nothing, and a rejection leaves both players worse off. If the ultimatum game played out this way, it would be a clear demonstration of our rational self-interest.

When the game is played, however, that doesn't happen. Instead of taking a small profit, responders typically reject any offer that they think unfair. Proposers tend to anticipate this 'irrational' rejection and, instead of offering a minimal amount, typically propose around \$4. This isn't a cultural prejudice: people around the world play the ultimatum game the same way. The only ones who obey the expectations of classical economics are autistic adults: because they don't take the feelings of the other player into account, they typically offer the minimum amount.

Why would someone make the seemingly irrational decision to reject free money? Evolutionary game theory provides some insight. In the real world, losing out on the money in the short term could mean getting a social benefit in the long term: a reputation for not being a pushover, for one thing³ (</nature/journal/v443/n7111/full/443502a.html#B3>). Players in the ultimatum game, however, don't have to worry about this: they play each other only once and have no information on their partner's reputation. But fairness still trumps reason. So what is going on inside the brain?

In 2003, Alan Sanfey, Jonathan Cohen and their colleagues at Princeton University, New Jersey, used a technique called functional magnetic resonance imaging, or fMRI, to look inside the minds of people playing the ultimatum game⁴ (</nature/journal/v443/n7111/full/443502a.html#B4>). fMRI scans highlight areas of the brain that are more metabolically active than others and are therefore thought to have increased neuronal activity. The team found that 'unfair' offers led to brain areas such as the anterior insula, associated with strong, negative emotions such as disgust and pain, becoming more active. At the same time, there was activation of brain areas associated with information processing and long-term planning, such as the dorsolateral prefrontal cortex (DLPFC).

In two minds



C. DARKIN

When subjects were struggling to decide whether or not to reject an unfair offer, those whose anterior insula showed more activity than their DLPFC tended to reject unfair offers, whereas those whose brains exhibited the opposite pattern tended to accept them. This, says the team, suggests that competition between these areas influences decision-making — and emotions usually win. "The platonic metaphor of the mind as a charioteer driving twin horses of reason and emotion is on the right track," wrote the neuroeconomists Colin Camerer of the California Institute of Technology in Pasadena and George Loewenstein of Carnegie Mellon University in Pittsburgh, Pennsylvania, in an unpublished working paper. "Except that cognition is a smart pony, and emotion a big elephant."

This interpretation, in which the brain is capable of both deductive logic and irrational emotion, often simultaneously, is known as the 'dual-process' model and it remains controversial. "Imagine showing this model of cognition to an economist and a neuroscientist," Camerer says. "They'll both think it's wrong, but for opposite reasons. The economist will say it is too complicated: the brain only needs a rational system. The neuroscientist will say it's too simple, and that our brain regions can't be parcelled out into rational and irrational categories. Neuroeconomics is trying to find the middle ground."

The mind is a charioteer driving twin horses of reason and emotion. Except cognition is a smart pony, and emotion an elephant.
Colin Camerer and George Loewenstein

Some researchers don't think that middle ground has been found. Paul Glimcher, a neuroeconomist at New York University, warns that the dual-process model is not biologically accurate. "Experiments done on monkeys have never supported this notion of there being two fully independent decision-making systems," Glimcher says. "This doesn't mean that emotions don't exist or that they don't influence our behaviour. What it does suggest is that our emotions are not just a negative impulse that gets in the way of our rationality. They are much more integrated than that."

Rather than focus on brain-imaging research — which Glimcher dismissively calls "spots-on-brain" experiments — his lab records from neurons in specific areas of the cortex while monkeys are making 'economic' decisions, such as trying to maximize a reward of

fruit juice. Glimcher argues that rigorous neuroeconomics will require this sort of reductionism "to construct a general theory of neural decision-making". Other neuroeconomists counter that, although fMRI has serious limitations — Camerer admits it's a "very imperfect tool" with some "serious signal-to-noise problems" — it remains useful for giving insight into what the brain is doing.

Our emotions are not just a negative impulse that gets in the way of our rationality. They are much more integrated.
Paul Glimcher

Many neuroeconomists, however, judge their field by what it adds to economic theory rather than by its neurological precision. In these terms, some argue that the dual-process model has already been a success because it can explain behaviour that economists have not been able to. According to Andrew Lo, director of the Massachusetts Institute of Technology laboratory for financial engineering, "Economics has hit the wall. It has explained about as much as it can with the tools it has. There are too many inconsistencies between theory and data."

Thinking ahead

One anomaly that continues to confound economists is humanity's often irrational approach to the future. Instead of saving money for retirement, people tend to impulsively splurge on the present. Neuroeconomists are beginning to understand the neural roots of this behaviour. In a 2004 brain-imaging experiment led by Samuel McClure of Princeton, people were asked whether they wanted a low-value Amazon gift voucher now or a higher-value voucher in two to four weeks [5 \(/nature/journal/v443/n7111/full/443502a.html#B5\)](http://www.nature.com/nature/journal/v443/n7111/full/443502a.html#B5). McClure wanted to test a specific assumption of classical economics: the idea that we apply the same calculus to the future and the present. If that were true, then the same brain regions should become active whether we are thinking about the results of economic decisions in the future or in the present.

This isn't what McClure found. When his subjects contemplated receiving gift vouchers in the future, brain areas associated with rationality (such as the prefrontal cortex) became active. These cortical regions seemed to urge people to resist temptation and wait for the more valuable vouchers.

On the other hand, when people started thinking about getting a gift voucher right away, brain areas associated with emotion — the midbrain dopamine system, for instance — were also turned on. By manipulating the value of vouchers in each situation, the researchers could compare the levels of activation in the different regions. They discovered that the relative amount of activity was "directly associated with subjects' choices". People whose 'emotional' brain areas were more active opted for the spoils of immediate gratification.

This discovery has important implications. For starters, it helps explain why people often fail to save enough for their retirement. Because our emotions warp our better judgement, we delay saving. Loewenstein, who collaborated on the McClure paper, thinks that understanding how we make such decisions will help us develop better economic policies: "Our emotions are like programs that evolved to solve problems in our distant past. They are not necessarily well suited to modern life. It's important to know how they lead us astray so that we can design incentives and programmes to help compensate for our irrational biases."

What might a savings scheme informed by neuroeconomics look like? In March 2004, behavioural economist Richard Thaler of the University of Chicago, Illinois, testified before the Senate on ways to increase the national savings rate — US consumers currently have a savings rate close to zero⁶ ([/nature/journal/v443/n7111/full/443502a.html#B6](http://www.nature.com/nature/journal/v443/n7111/full/443502a.html#B6)). His plan was simple: rather than asking people if they want to start saving right away, companies should ask people if they want to opt into a savings plan that begins in a few months' time. This allows people to make decisions about the future without contemplating the present, bypassing our irrational emotions. McClure's brain research suggests that should be a smart approach, and indeed trial studies of Thaler's plan have been a resounding success: after three years, average savings rates jumped from 3.5% to 13.6%.

Credibility gap

Many experts remain sceptical of neuroeconomics, however. The Princeton economists Faruk Gul and Wolfgang Pesendorfer think it is based on a faulty premise. They argue that economic models should be judged by their success at explaining phenomena such as inflation or unemployment, not by "psychological realism".

In an attempt to close that credibility gap, neuroeconomists are trying to bring their experiments closer to the decision-making models of microeconomics, which studies individual behaviour. If they can't scan people's brains in the real world, they can at least bring a little bit of the real world into the lab. Take, for example, Montague's Pepsi Challenge experiment. Rather than playing parlour games in an fMRI machine, he monitored people's brain activity as they swallowed sips of soda¹ ([/nature/journal/v443/n7111/full/443502a.html#B1](http://www.nature.com/nature/journal/v443/n7111/full/443502a.html#B1)).



Read Montague puts his money where his mouth is in his rigorous version of the Pepsi Challenge.

When the Coke and Pepsi were offered unlabelled, people showed no measurable preference for either brand. Most of the time, they couldn't even tell them apart. Montague's second observation was telling: people strongly preferred drinks that were labelled as Coke, no matter what cola was actually delivered through the tubes. Brand trumped taste.

The fMRI scans revealed that when the drinks were offered unlabelled, the ventromedial prefrontal cortex (VMPFC) became active. This makes sense, because the VMPFC is involved with the processing of appetitive rewards such as sugary drinks. However, when the subjects drank a cola with a Coke label, more brain areas were turned on. The hippocampus and midbrain all reacted strongly to the red cursive of Coke but not to the blue Pepsi logo. This happened even when subjects were given Pepsi with a Coke label. Montague notes that the brain regions triggered by Coke have all been implicated in 'affective' — emotional — influences on behaviour. Brand power exerts a more powerful force over our emotions and decisions than we might like to think. "Advertising is a deeply biological game," Montague says. "The idea of Coke clearly affects our judgement."

Advertising is a deeply biological game. The idea of Coke clearly affects our judgement.
Read Montague

Trust me

People rarely make economic decisions in isolation like this: most involve interacting with others. So Camerer, Montague and Steve Quartz, also at the California Institute of Technology, decided to link their fMRI machines together and monitor different brains simultaneously [7 \(/nature/journal/v443/n7111/full/443502a.html#B7\)](http://www.nature.com/nature/journal/v443/n7111/full/443502a.html#B7). This allowed them to measure brain activity during social interactions, as subjects were learning to trust each other.

They invented a simple trust game in which an 'investor' has the option of entrusting money to a 'trustee'. Invested money gets tripled, and the trustee can then keep it all, or give some or all of it back to the investor. Because the game is typically played for ten rounds, however, with the investor receiving more cash to play with each round, each player has a selfish incentive to trust each other.

The researchers discovered that increased activity in the caudate nucleus — a region involved in the brain's reward pathway — of the trustee was directly correlated with the trustworthiness of the investor's behaviour. Furthermore, this activity appeared much more quickly in later rounds of the game, indicating that the trustees were forming an opinion of their partners.

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Why the caudate nucleus? The neuroeconomists speculate that a decision to trust someone else depends upon our expectation of getting a reward in the end. The caudate nucleus gets excited by the anticipation of material pleasures such as food, drugs and money, so it makes sense that it would also measure the rewards of our social interactions. Trust is therefore an admirable trait with selfish origins.

Neuroeconomists are bullish about their own potential. "Economics provides us with all sorts of elegant theories, and neuroscience gives us a new way of testing their predictions," says Loewenstein. "All we need is time." Daniel Kahneman, a psychologist at Princeton, agrees. "These researchers have the chance to come up with a general theory of decision-making that is both biologically and behaviourally accurate. They have the necessary experimental tools and are asking the right kind of questions. Now they just have to find some answers."

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