

**Monkey business:**

**Can capuchins understand money?**

**By Stephen J. Dubner and Steven D. Levitt**

**Keith Chen's Monkey Research**

Adam Smith, the founder of classical economics, was certain that humankind's knack for monetary exchange belonged to humankind alone. "Nobody ever saw a dog make a fair and deliberate exchange of one bone for another with another dog," he wrote. "Nobody ever saw one animal by its gestures and natural cries signify to another, this is mine, that yours; I am willing to give this for that." But in a clean and spacious laboratory at Yale-New Haven Hospital, seven capuchin monkeys have been taught to use money, and a comparison of capuchin behavior and human behavior will either surprise you very much or not at all, depending on your view of humans.

The capuchin is a New World monkey, brown and cute, the size of a scrawny year-old human baby plus a long tail. "The capuchin has a small brain, and it's pretty much focused on food and sex," says Keith Chen, a Yale economist who, along with Laurie Santos, a psychologist, is exploiting these natural desires -- well, the desire for food at least -- to teach the capuchins to buy grapes, apples and Jell-O. "You should really think of a capuchin as a bottomless stomach of want," Chen says. "You can feed them marshmallows all day, they'll throw up and then come back for more."

When most people think of economics, they probably conjure images of inflation charts or currency rates rather than monkeys and marshmallows. But economics is increasingly being recognized as a science whose statistical tools can be put to work on nearly any aspect of modern life. That's because economics is in essence the study of incentives, and how people -- perhaps even monkeys -- respond to those incentives. A quick scan of the current literature reveals that top economists are studying subjects like prostitution, rock 'n' roll, baseball cards and media bias.

Chen proudly calls himself a behavioral economist, a member of a growing subtribe whose research crosses over into psychology, neuroscience and evolutionary biology. He began his monkey work as a Harvard graduate student, in concert with Marc Hauser, a psychologist. The Harvard monkeys were cotton-top tamarins, and the experiments with them concerned altruism. Two monkeys faced each other in adjoining cages, each equipped with a lever that would release a marshmallow into the other monkey's cage. The only way for one monkey to get a marshmallow was for the other monkey to pull its lever. So pulling the lever was to some degree an act of altruism, or at least of strategic cooperation.

The tamarins were fairly cooperative but still showed a healthy amount of self-interest: over repeated encounters with fellow monkeys, the typical tamarin pulled the lever about 40 percent of the time. Then Hauser and Chen heightened the drama. They conditioned one tamarin to always pull the lever (thus creating an altruistic stooge) and another to never pull the lever (thus creating a selfish jerk). The stooge and the jerk were then sent to play the game with the other tamarins. The stooge blithely pulled her lever over and over, never failing to dump a marshmallow into the other monkey's cage. Initially, the other monkeys responded in kind, pulling their own levers 50 percent of the time. But once they figured out that their partner was a pushover (like a parent who buys her kid a toy on every outing whether the kid is a saint or a devil), their rate of reciprocation dropped to 30 percent -- lower than the original average rate. The selfish jerk, meanwhile, was punished even worse. Once her reputation was established, whenever she was led into the experimenting chamber, the other tamarins "would just go nuts," Chen recalls. "They'd throw their feces at the wall, walk into the corner and sit on their hands, kind of sulk."

Chen is a hyperverbal, sharp-dressing 29-year-old with spiky hair. The son of Chinese immigrants, he had an itinerant upbringing in the rural Midwest. As a Stanford undergraduate, he was a de facto Marxist before being seduced, quite accidentally, by economics. He may be the only economist conducting monkey experiments, which puts him at slight odds with his psychologist collaborators (who are more interested in behavior itself than in the incentives that produce the behavior) as well as with certain economist colleagues. "I love interest rates, and I'm willing to talk about their kind of stuff all the time," he says, speaking of his fellow economists. "But I can tell that they're biting their tongues when I tell them what I'm working on."

It is sometimes unclear, even to Chen himself, exactly what he is working on. When he and Santos, his psychologist collaborator, began to teach the Yale capuchins to use money, he had no pressing research theme. The essential idea was to give a monkey a dollar and see what it did with it. The currency Chen settled on was a silver disc, one inch in diameter, with a hole in the middle -- "kind of like Chinese money," he says. It took several months of rudimentary repetition to teach the monkeys that these tokens were valuable as a means of exchange for a treat and would be similarly valuable the next day. Having gained that understanding, a capuchin would then be presented with 12 tokens on a tray and have to decide how many to surrender for, say, Jell-O cubes versus grapes. This first step allowed each capuchin to reveal its preferences and to grasp the concept of budgeting.

Then Chen introduced price shocks and wealth shocks. If, for instance, the price of Jell-O fell (two cubes instead of one per token), would the capuchin buy more Jell-O and fewer grapes? The capuchins responded rationally to tests like this -- that is, they responded the way most readers of *The Times* would respond. In economist-speak, the capuchins adhered to the rules of utility maximization and price theory: when the price of something falls, people tend to buy more of it.

Chen next introduced a pair of gambling games and set out to determine which one the monkeys preferred. In the first game, the capuchin was given one grape and, dependent on a coin flip, either retained the original grape or won a bonus grape. In the second game, the capuchin started out owning the bonus grape and, once again dependent on a coin flip, either kept the two grapes or lost one. These two games are in fact the same gamble, with identical odds, but one is framed as a potential win and the other as a potential loss.

How did the capuchins react? They far preferred to take a gamble on the potential gain than the potential loss. This is not what an economics textbook would predict. The laws of economics state that these two gambles, because they represent such small stakes, should be treated equally. So, does Chen's gambling experiment simply reveal the cognitive limitations of his small-brained subjects? Perhaps not. In similar experiments, it turns out that humans tend to make the same type of irrational decision at a nearly identical rate. Documenting this phenomenon, known as loss aversion, is what helped the psychologist Daniel Kahneman win a Nobel Prize in economics. The data generated by the capuchin monkeys, Chen says, "make them statistically indistinguishable from most stock-market investors."

But do the capuchins actually understand money? Or is Chen simply exploiting their endless appetites to make them perform neat tricks?

Several facts suggest the former. During a recent capuchin experiment that used cucumbers as treats, a research assistant happened to slice the cucumber into discs instead of cubes, as was typical. One capuchin picked up a slice, started to eat it and then ran over to a researcher to see if he could "buy" something sweeter with it. To the capuchin, a round slice of cucumber bore enough resemblance to Chen's silver tokens to seem like another piece of currency.

Then there is the stealing. Santos has observed that the monkeys never deliberately save any money, but they do sometimes purloin a token or two during an experiment. All seven monkeys live in a communal main chamber of about 750 cubic feet. For experiments, one capuchin at a time is let into a smaller testing chamber next door. Once, a capuchin in the testing chamber picked up an entire tray of tokens, flung them into the main chamber and then scurried in after them -- a combination jailbreak and bank heist -- which led to a chaotic scene in which the human researchers had to rush into the main chamber and offer food bribes for the tokens, a reinforcement that in effect encouraged more stealing.

Something else happened during that chaotic scene, something that convinced Chen of the monkeys' true grasp of money. Perhaps the most distinguishing characteristic of money, after all, is its fungibility, the fact that it can be used to buy not just food but anything. During the chaos in the monkey cage, Chen saw something out of the corner of his eye that he would later try to play down but in his heart of hearts he knew to be true. What he witnessed was probably the first observed exchange of money for sex in the history of monkeykind. (Further proof that the monkeys truly understood money: the monkey who was paid for sex immediately traded the token in for a grape.)

This is a sensitive subject. The capuchin lab at Yale has been built and maintained to make the monkeys as comfortable as possible, and especially to allow them to carry on in a natural state. The introduction of money was tricky enough; it wouldn't reflect well on anyone involved if the money turned the lab into a brothel. To this end, Chen has taken steps to ensure that future monkey sex at Yale occurs as nature intended it.

But these facts remain: When taught to use money, a group of capuchin monkeys responded quite rationally to simple incentives; responded irrationally to risky gambles; failed to save; stole when they could; used money for food and, on occasion, sex. In other words, they behaved a good bit like the creature that most of Chen's more traditional colleagues study: Homo sapiens.

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