The Logic of Life

Rational Economics in an Irrational World

BY TIM HARFORD

Tim Harford is a familiar presence in the pages of the *Financial Times*. And lately he's been branching out, hosting a series on economics for the BBC (*Trust Me, I'm an Economist*) and commenting on the dismal profession for American Public Media's *Marketplace*. Plainly, people like what they read/see/hear: His first book, *The Undercover Economist*, which was based on his *FT* columns, sold 600,000 copies in (count 'em) 25 languages. ¶ Harford's specialty is explaining economics to non-economists, using wit, charm and down-to-earth anecdotes to make the medicine go down painlessly. His latest book, *The Logic of Life: The Rational Economics of an Irrational World* is a guide to what might be called postmodern economics – efforts to find order in human behavior seemingly at odds with Adam Smith's economic man. Here, we excerpt the chapter on game theory, and how it has been fruitfully applied to subjects ranging from poker to addiction to nuclear war. — *Peter Passell*

At the Rio Hotel and Casino in Las Vegas, it is hard to say where the check-in line ends and the casino crowds begin. The bars, restaurants and public spaces of the hotel lobby seem to ooze into the gambling floors. Even in the quiet mid-morning hours, as the guests sleep off the night's excesses or enjoy breakfast, the hotel's lobby boasts a bewildering array of flashing lights and garish displays. Elderly gamblers in the middle-American uniform of baseball caps, khaki shorts and bulging T-shirts sit and feed quarters into the maw of the nearest slot machines. Sometimes the machines form a cocooning embrace as the seniors ride them like motorized wheelchairs. Occasionally – just often enough – the machines vomit coins into the laps of their riders.

Despite every effort to stimulate the senses, this is a tedious place. But the monotony is interrupted by a strange procession: A long-limbed man, his face concealed by a wall of facial hair, mirror shades and a cowboy hat, strides across the lobby. He is pursued by admirers and stops whenever requested to sign an autograph or to pose with a fan for a cell phone photo. Known to poker lovers as "Jesus," he is Chris Ferguson, one of the most recognizable and successful poker players in the world. He's in Las Vegas to try to reclaim his crown as World Poker Champion.

Ferguson, who is reported to have won more than $5 million in tournament play, is the best of a new generation of players trying to conquer poker with the branch of economics known as "game theory." It is a curious struggle, one that has pitted bespectacled geeks against hardened gamblers. It is also an object lesson in the remarkable intuitive rationality of the human mind.

Half a century of struggle by some of the world's smartest economists and mathematicians has produced an impossibly sophisticated poker strategy. All the while, thugs and hustlers have been bumbling along, playing the game the intuitive way. Don't underestimate the hustlers: We'll discover that 50 years of formal brilliance have yet to provide more than the tiniest advantage over the experienced judgment of "ordinary" professional gamblers. If you believe that ordinary people aren't rational, first try to outthink them. It may not be as easy as you expect.

Chris Ferguson's poker game aside, Las Vegas isn't the sort of place one links with the word rational. Across the lobby from Ferguson, the slot machine addicts mindlessly and joylessly feeding their quarters into machines they can have little chance of beating, seem to refute the idea that people can be counted on to behave rationally. But it turns out that the slot machine junkies, too, are more rational than you would suppose.

Economics is the study of how people

Chris Ferguson

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react to incentives in their environment, such as avoiding going to prison or catching AIDS. Sometimes those incentives result not from background factors, such as the toughness of the legal system or the presence of the AIDS virus, but from the actions of identifiable people: your spouse, your boss or your opponent at the card table.

These other people are not just background; they will try to anticipate one another's desires and strategies, try to respond to them and perhaps to thwart them. So to understand the complexities of these interactions, we need a special branch of economics: game theory.

In principle, game theory is just a special case of rational choice theory. In practice, game theorists have to be sensitive to small human irrationalities because they have large effects when people are trying to anticipate one another's decisions. Game theorists, then, must understand both rational behavior and human peculiarities. Far from being fatally undermined by the tics that make us all-too-human, rational choice theory is offering us insights into our inner battles – thanks to the efforts of a new type of economist more comfortable with a brain scanner than with the latest inflation statistics.

The Vegas lobby, with poker on one side and slots on the other, is a metaphor for how game theory has matured – a story that can best be told by contrasting two of the most famous game theorists. Both were cold war intellectuals, advising the U.S. government and using game theory to try to understand the riskiest of all games, nuclear war.

Game theory emerged from the mind of John von Neumann, a mathematical prodigy, when he decided to create a theory of poker. Von Neumann's academic brilliance offered penetrating insights, but the cold force of his logic could have led us to Armageddon. It was tempered by the earthier wisdom of Thomas Schelling. Tormented by a tobacco addiction he could not kick, Schelling nudged game theory into a direction that now offers us surprising insights into the minds of hapless slot machine addicts.

In the 1920s, the most ostentatiously brilliant man in the world decided to work out the correct way to play poker. John von Neumann, who later helped to develop both the computer and the atomic bomb, had been struck by an engaging new conceit: Could mathematics uncover the secrets of poker, seemingly a quintessentially human game of secrets and lies?

Von Neumann thought that he could develop a rational, mathematical explanation for much of life, and his theory would eventually be applied to the breakdown of diplomatic negotiations, the unexpected emergence of cooperation between enemies, the possibilities of nuclear terrorism – even the hidden side of dating, love and marriage. But as he explained to his colleague Jacob Bronowski, poker was the starting point: "Real life consists of bluffing, of little tactics of deception, of asking yourself what is the other man going to think I mean to do. And that is what games are about in my theory."

Bluff, deception and mind-reading are unpromising subjects for a mathematician to study, but if anyone could do it, it was Johnny von Neumann. His feats of calculation were notorious: At Princeton after the war, he helped to design the fastest computer in the world, before challenging it to a calculation contest and demonstrating he was faster. Nobody was surprised, either at the result or that von Neumann had suggested the contest.

On another occasion he refused a request to assist with a new computer aimed at solv-

ing an important problem, instead furnishing an immediate solution with pencil and paper. Although there were those who delved deeper, nobody was as quick as Johnny. In the popular imagination of the 1940s and '50s, von Neumann arguably outshined even his Princeton contemporary, Albert Einstein, and his colleagues joked that von Neumann was a demigod who, having studied humans intensively, was able to imitate them perfectly.

Nevertheless, to understand poker, von Neumann had to break new ground. Poker was not merely a game of chance, or a game of pure logic with neither random elements nor secrets, like chess. Poker, contrary to appearances, is a far more subtle challenge. Players bet in order to earn the right to compare cards at the showdown. But most of the important information in poker is private. Each player sees only one part of the jigsaw puzzle, and must piece together the bigger picture by observing what other players do.

The strongest hand takes all the accumulated bets, so the higher the betting, the more expensive it becomes to lose in the showdown. Yet in many hands there is no showdown, because one player bets aggressively enough to scare the others away. In short, there is no straightforward connection between what a player bets and the hand he holds.

Novices wrongly believe that bluffing is merely a way to win pots with bad cards. In the 1972 World Series of Poker, the famous hustler Amarillo Slim took the championship because he had bluffed so often that when he finally put all his chips in the pot with a full house (a very strong hand), his opponent, "Puggy" Pearson, was convinced that Slim was bluffing again, matched the bet, and lost. A player who never bluffs will never win a big pot, because on the rare occasions that he raises the betting, everyone else will fold before committing much money.

Then there's the reverse bluff: acting weak when you are strong. In what proved to be the final hand of the 1988 World Series of Poker, Johnny Chan (dubbed "the Orient Express" because he won money so quickly) passed up every opportunity to raise the stakes and meekly called his opponent's bets. By the last round of betting his opponent, Erik Seidel had become convinced that Chan didn't have a hand and Seidel bet everything he had. Chan matched his bet and turned over a straight, scooping $700,000 and the title of world champion for the second year running.


John von Neumann

Trying to deceive your opponent seems like a matter of psychology, not mathematics. Could there really be a rational strategy behind these bluffs – one that ignores the idea of psyching out an opponent? Would pure

mathematics nevertheless deliver those bluffing moves? Von Neumann thought so. His work on game theory reached its culmination in the 1944 book, *Theory of Games and Economic Behavior*, written with the economist Oskar Morgenstern. The book included a stylized model of poker in which rational players faced each other in a simplified setting.

To understand von Neumann's approach, imagine playing a round of von Neumann poker. The simple rules dramatically limit your ability to vary your bet or to go back and forth with your opponent, raising the stakes. Still, they capture something of the essence of the game. You and your opponent contribute a small ante to the pot, and then you go first.

The simple rules give you two options: You can either check or make a big bet. In this simplified game, when you check, the hands are compared at the showdown and the best hand wins the ante. (Your opponent doesn't get to make a decision at that point; like real poker, this is unfair, which is why players take turns.) But if you bet, then your opponent faces his own choice: He can fold, quitting the round and conceding the small ante to you, or he can call, matching your bet, which means a showdown for higher stakes.

What is the rational move? And what is your opponent's rational response?

Actually, the two answers are related. You shouldn't decide without considering his response, and he should not react to your bet without figuring out what strategy you have. The interrelatedness of both of your strategies is what makes this a problem game theory, rather than the probability theory, needed to understand roulette.

At first glance even this simple version of poker seems to collapse into an endless chain of reasoning. If you bet even with terrible cards, then your opponent should call the bet with any decent hand. Yet if you bet only with the best possible hands, then he should always fold when you bet. All we have is a thought process that runs, "If he thinks that I think that he thinks …"

Can't we say more? Yes we can, if we follow von Neumann's analysis. What von Neumann created was a theory of perfect decision making; he was looking for the moves that infallible players would make.

Game theory finds those moves by looking for opposing strategies that are consistent, in the sense that neither infallible player wants to change once he hears about the other player's strategy. Plenty of strategies don't meet this standard. For instance, if your opponent is very cautious, you should bluff a lot. But if you bluff a lot, your opponent shouldn't be so cautious. The two strategies don't match. They might be played by fools, but not by von Neumann's rational players.

Instead, we need to consider both players' strategies in combination. Your opponent's strategy is the simpler. Because the simple game gives you no option to fold, it also gives him no chance to bluff because you can't bluff someone who can't fold. (He, on the other hand, is allowed to fold, which means that you can try to bluff.)

Since he can't bluff, he should simply call you with his better hands and fold with his worse hands. The only question is how good a hand has to be before he should call with it. That depends on how often you bluff.

What, then, should you do? With an excellent hand, you should bet: You lose nothing if your opponent folds, while giving yourself a good chance of winning a big pot if he calls. But with a middling hand, you shouldn't bet: If he has a bad hand, he'll fold, and you'll win the ante – which is what you'd have won anyway by checking. But if he has a good hand, he'll call and win. It's heads he wins, tails you don't. You should check instead, and hope

your middling hand wins the ante.

What about with a terrible hand? The answer is surprising. Checking would be unwise, because the hands will be compared and you will lose. It actually makes more sense to bet with these bad hands, because the only way you will win anything is if he drops out, and the only way he might drop out is if you make a bet. Perversely, you are better off betting with awful cards than with mediocre ones, the quintessential (and rational) bluff.

There's a second reason for you to bet with terrible cards rather than middling ones: Your opponent will have to call a little more often. Because he knows that your bets are sometimes very weak, he can't afford to fold too easily. That means that when you bet with a good hand, you are more likely to be called, and to win when you are. Because you are bluffing with bad cards, your good hands make more money – just as Amarillo Slim's full house did in the 1972 final.

"Of the two possible motives for bluffing," wrote von Neumann, "the first is to give a (false) impression of strength in (real) weakness; the second is the desire to give a (false) impression of weakness in (real) strength."

What was remarkable about von Neumann's analysis was the way his tactics emerged from the logic of the game. Von Neumann had met the challenge he had explained to Bronowski and showed that bluffing, far from being some unfathomable human element to the game, was governed by the rules of mathematics. Von Neumann's message was that there is a rational, mathematical foundation even to the psychological game of bluffing at poker. And if he was right that poker is a meaningful analogy for everyday problems, his success implied that maybe, just maybe, there was a rational mathematical foundation to life itself.

Von Neumann's book was hugely celebrated as a manifesto for putting economics and the social sciences on a logical, mathematical footing. But the academics were soon disillusioned, finding that game theory was difficult to apply to the real world. For many years after von Neumann's death in 1957, academics struggled to bend game theory to problems of economics, biology and military strategy, but without living up to the expectations raised by *Theory of Games*. The problem was that von Neumann might have been regarded as a demigod, but for game theory to be useful, it needed to cope with the more limited brainpower of ordinary mortals.

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To understand the difficulty, consider how von Neumann himself saw a "game." It was a mathematical description of the link between strategies and possible payoffs. To work out a rational course, simply do the math.

That all seems very abstract, but von Neumann's game theory was abstract. If you're confused, you're beginning to appreciate the difficulties of his creation.

Fundamental to the approach was the assumption that both players were as clever as von Neumann himself. He wanted to understand what infallible play looked like, and his answer can, in principle, be applied to any two-player "zero-sum" game, including poker, where one player's loss is the other player's

gain. But in practice, there are two problems.

The first is that the game may be so complex that even the fastest computer could not calculate the perfect strategy. While von Neumann's analysis distilled some vital insights of good poker play with great elegance, it didn't go far as an instruction manual. The von Neumann model achieves its simplicity by limiting the number of players, their options and the type of hands they draw. Real poker's intricacies quickly become mind-boggling: Considering 10 possibilities per second, a player would have had to start calculating at the birth of the galaxy to find a game-theory solution for just two players of the most popular poker game, Texas Hold 'Em. And if real poker was too challenging, what about a real economic problem, such as negotiating a pay raise or working out a business strategy?

A theoretically perfect game-theory poker strategy will pass up big opportunities against fallible opposition – that is, against everyone.

The second problem is that game theory becomes less useful if your opponent is fallible. If player two is not an expert, player one should play to exploit his mistakes rather than defend against brilliant strategies that will never be found.

This problem is particularly acute for poker. A theoretically perfect game-theory poker strategy will pass up big opportunities against fallible opposition – that is, against everyone. Over the long run, as chance evens out, the strategy will not lose. But it may win only very slowly against weak opponents. One opponent may be bluffing too much; another opponent may never bluff. Punishing one mistake requires conservative play; punishing the other requires more aggression.

A real poker player who wanted to use von Neumann's theories would somehow need to be able to perform calculations that were beyond even the demigod himself. He would also have to wrestle with the problem of dealing with naïve opponents. It's no surprise, then, that Princeton University Press put out a slightly sheepish advertisement in 1949 to celebrate five years of anemic sales of *Theory of Games and Economic Behavior*. The ad said "Great books often take a while to achieve recognition … their influence far surpasses their readership." It mentioned "a few copies bought by professional gamblers" – but there is little evidence that von Neumann's theories made any immediate impact on poker.

It is a safe bet that young Walter Clyde Pearson was not a customer. "Puggy" Pearson's family in Kentucky was dirt-poor: The first time Pug saw white bread, he assumed it was cake. While von Neumann's publishers were defending *Theory of Games*, Pearson, stationed with the Navy in Puerto Rico, was cleaning up at pool and poker. In his 18-month stint he wired $10,000 home to his mother. Puggy was to invent the idea of tournament poker, and become world champion in 1973. And he did it all without an equation in sight.

Like many of the early gambling professionals, Puggy had a knack for getting into trouble. He first fled to Las Vegas in 1962 after cracking the skull of a Nashville bookmaker with a golf club. (The bookmaker swung first, after Pug accused him of cheating.) Puggy was a rough character, but poker was a rough business. He moved to Vegas for good in 1963 after burglars tied him and his wife up and ransacked their Nashville home. With a gun

in his face, Puggy bluffed them out of $5,000 by convincing them that all he had was the money in his pockets.

Puggy's close scrapes were hardly unusual. His rival Amarillo Slim was once robbed of $50,000 – the stakes on the table – by three armed men who broke into the house where he was playing. On another occasion, Slim was rescued from a pressure negotiation with the Mafia by an army of heavies sent by his friend, poker impresario Benny Binion. "You've never seen so many big hats and bulges in your life," Slim recalled.

These characters were a long way from Princeton. Even if a cerebral university professor could have used game theory to clean up from the likes of Puggy and Slim, he might not have fancied his chances of making it home with his wallet intact. But that is not why the professors stayed away from Vegas. It was because they knew that the very best von Neumann had to offer did not seem to hold out any immediate prospect of beating men like Puggy and Slim. It took two important developments for this to change.

The first was social. As the large entertainment corporations moved into Las Vegas, the casinos started to become places where anyone could feel that his physical safety was guaranteed, even if his wealth was not. The second was technological. The geeks found somewhere to practice: the Internet.

IRC poker was the craze among the deep geeks in the late 1980s, a simple program that used Internet relay chat, a precursor of today's online chat rooms, to deal cards and moderate a game of poker between players anywhere. This was the pre-World Wide Web Internet of glowing green numbers on black backgrounds, where only experts ventured. Nonetheless, thousands competed for bragging rights. Although no money was at stake, rising to the top of the IRC rankings meant beating the world's most obsessive geeks.

One of the leading players was a UCLA doctoral student named Chris Ferguson, who was studying artificial intelligence and trying to develop a program to play the board game Othello. Chris was exposed to both poker and game theory at an early age. His family members were avid games players, and his father was a math professor who taught game theory at UCLA. (The two published a paper on von Neumann's poker model.)

On some weekends, Chris drove to Las Vegas and covered his hotel bill by playing conservative poker against the tourists. But IRC poker, with its rapid play and the stream of electronic data it provided, was a much better laboratory for someone who wanted to get inside the game and see what made it tick.

It would be a mistake to think that the secrets of poker simply tumbled out of any computer programmed with the right game-theory equations. "If you want to play poker to make money, you're doing it for the wrong reasons," Ferguson told me a few minutes before sitting down to play at the 2005 World Series of Poker. "You have to love the game, and you have to like to work hard."

Just as von Neumann had had to simplify the game of poker before he could find the perfect strategy, Ferguson also started on a simple version of the game: Asian Stud, which is played with a deck of only 36 cards. Though simpler than Texas Hold 'Em, it is still a real game played in the casinos, and dramatically more complex than anything von Neumann was able to solve. Ferguson was using exactly the same game theory as von Neumann. But, backed by technology, he was able to work out the strategies required to play first Asian Stud and later Texas Hold 'Em.

Using ever-faster computers to crunch the numbers, Ferguson began by working out the probabilities of one hand improving enough

to beat another. Then came the game theory, which he used to explore which hands to bluff with and how often to bluff, and the trade-offs between raising the ante too little with a promising hand (which ran the risk of being overtaken by a lucky opponent), versus raising it too much and scaring people away.

Ferguson began to produce some unexpected conclusions. For example, he showed that the poker professionals were raising the ante too much with strong hands. The traditionalists believed that once you were convinced you were ahead, you should raise the stakes to force your opponents out and give them no chance to get lucky and overtake you. But Ferguson discovered that it was worth encouraging opponents to stay in and try to improve their cards. Sometimes those opponents would indeed get lucky and win, but on balance the strong hand would make more money with smaller raises.

"I showed a lot of my research to well-respected poker players," recalls Ferguson. "They pooh-poohed it, I think because they didn't understand it.… But I knew that what I was doing was accurate, and that disagreement showed that mathematics could outplay the best players in the world."

That self-confidence is typical of Ferguson. He knew that game theory would give him an advantage because the theory was right and the best players were wrong. However, while the advantage was real, it was small. Ferguson was uncovering the rational way to play poker, only to discover there was a huge overlap between the rational approach and the intuitive game played by strong players.

Ferguson initially made his name not by his success at the table but by his appearance. By the late 1990s he was one of the most recognizable sights in poker, earning the nickname "Jesus" as he hid his face behind a long beard and hair that cascaded over his shoulders, buttressed by wraparound mirror shades and a big cowboy hat. He never spoke during play, trying to remove any sign of human emotion; he didn't pay much attention to other players' nervous tics, either. He drew his information only from the cards, like a computer – or like von Neumann himself.

The age of rational poker began at the 2000 World Series in Las Vegas. After outlasting 500 rivals, the last two competitors faced each other in the glare of the television cameras. T.J. Cloutier, a 60-year-old Texas road gambler regarded by many as the best player yet to win the World Series, was playing Jesus himself. Cloutier was by far the more experienced player, but Jesus Ferguson had destroyed the field, and came to the table with 10 times as many chips as Cloutier.

Playing brilliantly and riding his luck, Cloutier ate into Ferguson's lead and was only slightly behind when he lured Ferguson into serious trouble. With several million dollars at stake, Cloutier's raise of $175,000 seemed timid and it convinced Ferguson that Cloutier was bluffing. Ferguson reraised to $600,000 and Cloutier pushed about $2 million in chips into the pot, going "all in."

Ferguson paused for five minutes, calculating the odds. Cloutier probably had a stronger hand than he'd expected. However, Cloutier was playing well and if Ferguson backed out now, his opponent would have a substantial lead. On the other hand, if Ferguson called and won, the World Series was his. He reckoned his chances at about a third – and that that was better than his chances if he folded.

Ferguson had slightly overestimated his chances. They were one in four. But Johnny von Neumann's angel must have been watching over Ferguson. When the last card – the nine – hit the table, Ferguson realized what had happened before the hushed crowd did.

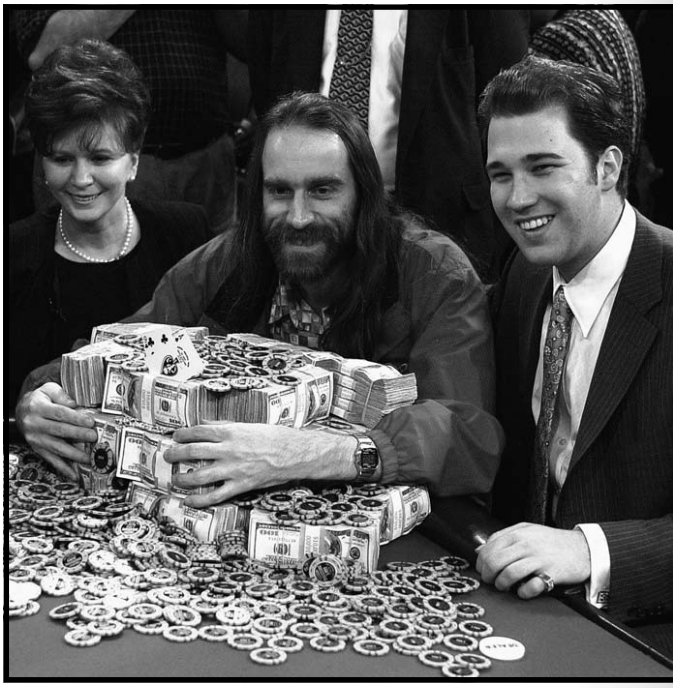
His arms shot into the air and he leaped up to embrace Cloutier.

Since then, he's proved that his success was no fluke. Only four men have more finishes in profit at the World Series than Ferguson (Cloutier is one of them), and Ferguson won more World Series events from 2000 to 2004 than any of his rivals had in a decade.

He has a particularly strong record "heads-up," facing just one other strong player. That is not surprising: Heads-up poker against another expert is the situation where von Neumann's game theory works best. All told, Chris Ferguson has a respectable claim to being the most successful tournament player of the 21st century.

The fact that it took over half a century for game theory to produce a world champion player might seem like a severe criticism of von Neumann's approach. The opposite is true. Game theory, remember, assumes rational players. If someone had simply read *Theory of Games* and then cleaned up at Vegas, it would have been proof that poker players were anything but rational. The very fact that Chris Ferguson's achievement was so hard-won and that the level of his play was not notably better than that of someone like T.J. Cloutier is exactly what game theorists need to assume. Ferguson's struggle was, in fact, an example of the way in which experience can produce rational decisions, even if the decision makers, like Puggy, Slim or Cloutier, are not necessarily conscious of the rational basis for all their actions.

Game theory often exposes such cases of unconscious rationality emerging from experience. Because the situations that game theory analyzes tend to be very complex, if you ask ordinary people to play the games in the laboratory, they'll bungle them. Give them a chance to learn the ropes, though, and they will often find their way much closer to the rational strategy, even if they do not know it.



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One famous example is "the winner's curse." The curse flows from a natural feature of auctions: You only win when every other bidder thinks you're paying too much. I can invoke the curse and produce crazy behavior by holding an auction for a jar of coins. If I ask a large number of people to estimate the value of coins, I am likely to get a remarkably accurate answer. Despite that, if I hold an auction for the value of the coins in a jar, offering to write a check to the winning bidder for whatever that value is, I am almost guaranteed to make big money because at least

one bidder will be too optimistic.

While the survey will produce the average view of the value of coins, the auction will not. Instead, the auction automatically selects the highest bid, the crazier the better. The survey uncovers what *New Yorker* columnist James Surowiecki calls "the wisdom of crowds." The auction, by contrast, finds the biggest sucker.

Knowing this, rational players would dramatically scale back their bids. They would reason like this: "I think the value of the coins in the jar is $20. So maybe I should bid $18 to leave some room for profit. But wait: Either I lose the auction, in which case it doesn't matter what my bid was, or I win the auction, in which case a hundred other people in this room thought it was worth less than $20."

"What would that tell me? Most likely that I overestimated the value of the jar of coins. Maybe I should bid more like $5. That seems very low – but if it happened to be the highest bid in the room, it wouldn't seem nearly so low anymore."

Only game theory experts actually reason this way, for the same reason that few people play good poker the first time they try: It's just too hard to figure out. But just as experienced gamblers work out how to play poker, so do experienced auction bidders work out how not to overbid.

For example, construction companies frequently compete for jobs in which the lowest bid wins. When they do, they unknowingly adjust for the winner's curse using rules of thumb that produce rational bidding in the real world. But when economists put the same managers in the laboratory and ask them to bid in an auction, the managers are routinely hit by the curse.

Even professional soccer players have been shown to play perfect strategies when taking (or saving) penalty kicks, mixing the placement of their kicks in perfect accordance with the surprisingly complex prescriptions of game theory. It turns out that we don't need to be von Neumann to master complex strategies, as long as we're in a familiar setting.

That's fine when we have time to practice. But that wasn't true of the most important "game" to which game theorists applied their thinking in the 20th century – the game of world dominance played by the United States and the Soviet Union.

The cold war was a game that had to be played right the first time. And the creator of game theory was right at the heart of it. By the time *Theory of Games* was published, von Neumann was a leading mathematician on the Manhattan Project, where his proposal for a way to trigger the explosion of the atomic bomb was credited with dramatically accelerating its development. If it had been up to von Neumann's purely intellectual reasoning alone, many of the bombs he helped to create would have exploded on the Soviet Union.

Thankfully, there was another thinker on hand, whose deeper grasp of human foibles added a new dimension to game theory that, among other things, helped save the world from mutually assured destruction. Enter Thomas Schelling.

Some of America's best foreign policy and military strategists were in the room at Camp David one day in September 1961: a young Henry Kissinger; Colonel DeWitt Armstrong, the Pentagon's top authority on Berlin; McGeorge Bundy, President Kennedy's national security adviser; and John McNaughton, the top arms control aide of Defense Secretary Robert McNamara. They hadn't been sleeping much. The crisis in Berlin had been building for months since Soviet leader Nikita Khrushchev had demanded that U.S. troops with-

draw from their bases in West Berlin.

When the phone call arrived from the American base in Berlin, the news was bad. American forces had shot down Soviet planes, killing dozens, and riots were spreading across Eastern Europe. More terse communiqués over the next couple of days made it clear that matters were deteriorating: West German students started rioting, too. Soviet tanks encircled West Berlin and then the riots were used as a pretext for entering West Berlin. As they broke through the barricades, U.S. bombers responded, causing massive casualties. The Soviets had overwhelming local superiority, the Americans nuclear dominance: A nuclear exchange seemed inevitable. Would Kissinger and Bundy decide to press the button?

It wouldn't have mattered if they had, because those men at Camp David were just playing a game. The phone calls weren't coming from Berlin, but from a Harvard professor, the economist Thomas Schelling.

The real Berlin crisis had run out of steam a few weeks earlier without a shot being fired. Khrushchev had indeed asserted Soviet authority over West Berlin and declared that U.S. resistance would be an act of war. The young, inexperienced President Kennedy was being tested. He had turned to Schelling's strategic analysis of the situation ("We should plan for a war of nerve, of demonstration and of bargaining, not of tactical target destruction") before deciding – correctly – that Khrushchev was bluffing. Instead of invading, the Soviets began building the Berlin Wall in August, sat behind it, and glowered.

Schelling was just one of many cold war intellectuals at RAND, the Air Force's research arm, using von Neumann's game theory to dissect the possibilities of nuclear war. Applying a theory of poker to the project of mutual annihilation may seem unhinged, but that is exactly what von Neumann and his disciples did. The theory of zero-sum games wasn't up to the job, as we'll shortly see. But how else to develop nuclear strategy?

Von Neumann demanded an aggressive approach. Coincidentally or not, his mathematical analysis backed his instinctive hatred of the Soviet Union, the occupier of his native Hungary. In the late 1940s, he favored a surprise nuclear assault on the Soviet Union, before they were able to develop the bomb themselves. "If you say why not bomb them tomorrow, I say why not today?" he told *Life* magazine.

Von Neumann, who spent the last months of his life in a wheelchair after being struck by bone cancer in his 50s, was an inspiration for the deranged and similarly wheelchair-bound film character Dr. Strangelove. (The actor, Peter Sellers, claimed that the Mitteleuropean accent was based not on von Neumann but on Kissinger.) Von Neumann died in 1957, a few years before the cold war reached its defining crises in Berlin and then Cuba.

In game theory, von Neumann had crafted a tool that promised to analyze both poker and war. Yet, rhetorically pleasing as the analogy is, poker and war had very little in common analytically. Poker is a zero-sum game: One player's loss is another's gain. It is also a game with well-defined rules. War is neither well defined nor a zero-sum game. (Nor is life. Von Neumann was too quick to draw the parallel between life and poker.) It is much more desirable to avoid war altogether than to fight a destructive war that does not change the balance of power. So while war is certainly a conflict of interests, there is nothing zero-sum about it. Compared to the likely alternative of mutually assured destruction, the cold war was a win for both sides. Thomas Schelling's war games were part of his effort to bring that mutual win about.

Schelling realized that, however compelling


Thomas Schelling

the equations of game theory might be, you could not take the human element out of war. While von Neumann was the consummate mathematician, Schelling, originally a trade negotiator, was more interested in concepts that eluded mathematical formalization – credible threats, deterrence, and taboos. His ideas pushed the discipline of game theory away from the abstract and further into the mainstream of everyday human experience.

Schelling argued that real human strategic interactions were governed not only by von Neumann's mathematics, but by "focal points" that were invisible under a mathematical formulation of the problem. Schelling did not believe that game theory was useless, merely that most human interactions were so shot through with ambiguity that these focal points could be the ultimate guide to what might or should happen.

For example, a union leader might try to gain leverage in a negotiation over pay by publicly stating that his members wouldn't accept less than a 10 percent raise. Ten percent is a figure of no mathematical significance. Von Neumann would have seen no basis for it. Yet Schelling knew that once the declaration was made, it becomes significant. (And it will be a round number such as 10 percent, not 10.32 percent or 9.65 percent.)

Schelling's most famous example of a focal point was inspired by a time he'd lost a friend in a strange town and tried to work out where to meet him. Schelling used to pose the problem like this: You have arranged to meet a friend in New York tomorrow, but because of a breakdown in communications, neither of you know where or when to meet. What do you do? When Schelling asked his students, they suggested going to the clock at Grand Central Terminal at noon. (Those students would have traveled to New York by train. Tourists might have a different focal point – perhaps the Empire State Building.)

All this was still game theory, in that each player was acting rationally and trying to anticipate and respond to the strategy of the other player. But it was game theory of a simpler, more commonsense sort than von Neumann's. And for Schelling, common sense was exactly the point because the players of such games needed to understand one another.

With his emphasis on communication, it is not surprising that Schelling was the man who came up with the idea of the hotline to Moscow. He realized that a nuclear war could easily start as the result of some accident: a misunderstanding or a mistake by a radar operator. If a crisis started, the leaders of the

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United States and the Soviet Union could be looking at the wrong focal point, one in which there was a nuclear exchange. They would only be able to fix the situation before it escalated out of control if they could reach each other quickly and talk.

Yet no hotline existed, and Schelling proposed one in 1958. The famous "red telephone" was in fact a teletype machine with multiple backups. Even in the darkest hours of the cold war, the American and Soviet operators tested it every day by sending one another greetings. In retrospect the idea was obvious – especially after the superpowers lurched through the Berlin and Cuban crises. But it took Schelling to realize how important quick, communication might become.

Schelling also applied his focal point idea to trying to strengthen the taboo against using nuclear weapons. In the 1950s, the U.S. government was desperate to avoid the sense that such weapons were beyond the pale. President Eisenhower's secretary of state, John Foster Dulles, argued that inhibitions in the use of nuclear weapons were based on a "false distinction" between nuclear and conventional weapons that needed breaking down. "Somehow or other we must manage to remove the taboo from the use of these weapons," he stated in 1953. Eisenhower appeared to agree, approving a doctrine that nuclear weapons should be "as available for use as other munitions."

Schelling did not agree. His argument was that "bright lines, slippery slopes and well-defined boundaries" were everything in this debate. In the quest to avoid a full-blown nuclear exchange, only one focal point should be emphasized: that nuclear weapons could never be used. There was no such thing as a "minor" use of nuclear weapons just as one could not become slightly pregnant. The taboo was purely psychological – invisible to a mathematician like von Neumann, but real and very useful. Schelling put forward this view, as part of a broad theory of deterrence and arms control, in a series of seminars that he organized at Harvard University and the Massachusetts Institute of Technology in 1960.

Later that year, John F. Kennedy was elected president. The timing was perfect. Kennedy appointed as his national security adviser a Harvard dean who had participated in the autumn discussions of arms control, and as his White House science adviser an MIT professor who had been one of the group. Another member became deputy assistant secretary of defense for arms control; still another, general counsel of the State Department.

Schelling became the intellectual godfather of the Kennedy and Johnson administrations, introducing Robert Kennedy to Schelling's war games, advising former pupils as they held the reins of power, and providing the leading intellectual justification for the taboo against nuclear weapons. By the time Schelling broke his connections with the government in 1970, that taboo was as strong as it has ever been. When he accepted his Nobel Prize in 2005 – for economics, not peace – Schelling began by saying, "The most spectacular event of the past half century is one that did not occur. We have enjoyed 60 years without nuclear weapons exploded in anger."

Schelling compared the "minor" use of nuclear weapons to "one little drink" for an alcoholic: It is a slippery slope. The analogy was close to home; Schelling was fighting his own personal battle with cigarette addiction. In his 1980 essay "The Intimate Contest for Self Command," he tried to understand the person "whom all of us know and who some of us are, who in self-disgust grinds his cigarettes down the disposal swearing that this time he means never again to risk orphaning his children with lung cancer and is on the

street three hours later looking for a store that's still open to buy cigarettes ... who spoils the trip to Disneyland by losing his temper when his children do what he knew they were going to do when he resolved not to lose his temper when they did it."

Despite our obvious fallibilities, Schelling believed that addiction could be analyzed using the rational choice perspective of game theory. But he came to realize that his views were unorthodox when he was asked in the 1970s to join the National Academy of Sciences' committee on substance abuse and addictive behavior. All the other members of the committee – psychologists, sociologists, lawyers – believed that addicts were irrational and helpless. The reasoning was commonsense: Since smoking or taking heroin is addictive and can have horrible effects, people who choose to take up the habits must be irrational. Schelling wasn't quite so sure.

The extreme opposite view was most explicitly set out not by Schelling, but by economists Kevin M. Murphy and Gary Becker of the University of Chicago. Becker won a Nobel Prize for his work on human capital. Murphy, his young co-author, was inspiring the same sort of "demigod" anecdotes that had once surrounded von Neumann. One colleague recalled telephoning Murphy for advice on a mathematical problem that had been troubling him for weeks. "I imagine him sitting at his kitchen table, pencil in hand, scribbling equations on a napkin. He's dropped everything to help me with my problem, and in 10 minutes he's explaining aspects of it to me that I would never have seen. Then I hear a splash, and a squeal, then another splash, and it dawns on me: There's no pencil, no paper. Kevin's holding the phone to his left ear with his shoulder while he's giving his kid a bath."

Perhaps it will not be surprising to hear that, in 1988, Becker and Murphy produced a conclusion worthy of von Neumann. Addiction, they said, is entirely rational. People who consume addictive products – cigarettes, alcohol, slot machines – calculate that the pleasure of the habit will outweigh the pain.

For Becker and Murphy, a stroll through the lobby of the Rio Las Vegas hotel would have proved no challenge to the rational choice view of the world. Yes, the slot machine players were losing money. Some might even be addicted. But they had made a rational decision to start playing the machines, knowing there was a chance they'd end up miserable and hooked, and now they were making a rational decision to continue playing rather than endure the greater misery that would be involved in kicking the habit.

A rational decision not to kick an addiction, and even to start one? It sounds less outlandish if you consider a more commonplace addiction. I like to start my day by grinding fresh-roasted coffee beans and brewing them into a rich, aromatic cup of coffee. Every now and then I am careless and run out of beans. My head aches, I'm grumpy, I can't concentrate. I'm an addict in withdrawal. Of course I know that if I wait a few days I will be free of my addiction. Instead, I buy more beans; the coffee is worth it. Am I really so irrational? According to Becker and Murphy, the slot machine addiction, even a heroin addiction, is different only in degree.

It can also be rational to get hooked in the first place. Imagine a young man who is thinking of trying a new drug. He knows that everybody who tries it loves it, at least at first. Then some users find their lives degenerating into an increasingly desperate and futile attempt to recapture that initial buzz, leading to the pain of cold turkey or the anguish of eternal, unfulfilling addiction. Others seem able to enjoy the highs and remain quite con-

tent for the rest of their lives. He has no way of knowing into which category he will fall. Is it rational for him to ingest the drug?

If you say no, read the paragraph above again but replace "trying a new drug" with "getting married" and "cold turkey" with "divorce." Getting married is not so different from getting hooked. It might not work out, it will restrict your future freedom of choice, and quitting if things turn sour is going to be extremely difficult. But it will probably be a lot of fun, too. The first-time drug user (or the newlywed) might be making a mistake, but he or she thinks that on balance the decision will pay off. That, according to Becker and Murphy, is what addicts do.

Becker and Murphy were not merely expressing their faith in rationality, but making some clear predictions. Rational addicts know that drinking or smoking today reinforces drinking/smoking tomorrow and is reinforced by drinking/smoking yesterday. So an alcoholic who expects an incoming government to raise taxes on booze may decide that this is an opportune time to work on kicking the habit, even if vodka is cheap right now. Rational addicts respond to predictable price changes before they even happen. So if Becker and Murphy are right, this is how real addicts should behave.

In fact, they found that reductions in cigarette consumption occur when a price increase is expected, but before the price actually rises. Another researcher discovered that gambling also looks like a rational addiction: An increase in the share of gambling revenues taken by racetracks reduces the amount bet not only in the current year, but in the next year and even in the previous year. Gamblers anticipate that betting will become more expensive and work on kicking the habit.

This behavior is easier to understand through an imperfect but revealing analogy: dealing with a forthcoming increase in your rent. It is difficult and costly to switch apartments, just as it's difficult to kick an addiction. So if your landlord gave you three months' warning of a rent increase, you might rationally start looking for a new place right away. If it was a local restaurant that was announcing that prices would rise in three months' time, on the other hand, you wouldn't feel any need to immediately start trying out alternative restaurants – you'd simply enjoy eating there while it was still cheap. It's pushing it to say you are "addicted" to your apartment (and not to the restaurant), but certainly you have a tie to the apartment that is difficult to break, and that has effects as an addiction does.

Since smoking or taking heroin is addictive and can have horrible effects, people who choose to take up the habits must be irrational. Schelling wasn't quite so sure.

Becker and Murphy also predict that because addiction is self-reinforcing, with each fix creating a greater desire for the next fix, cold turkey is the rational way to quit. The surprising implication is that addictive goods can be more sensitive to price changes than non-addictive goods, and that addicts may pay more attention to price than light users do. The light users can cut back if prices rise, while the heavy users might prefer to stop entirely. It sounds ridiculous, but turns out to be true: When a county raises liquor taxes, the local consumption of alcohol falls but the

local death rate from liver cirrhosis falls more sharply. In other words, when the price of booze increases, alcoholics are the ones who most cut down on their drinking.

Economists have also found that advertising for nicotine patches and gum seems to encourage non-smoking teenagers to smoke. That's easy to explain if teenagers are rational: The advertisements tell them that there are new ways to help them quit, so rationally it is less risky to begin the habit. Kevin Murphy told me he thought the discovery was "obvious" and completely unsurprising, "although it's always nice to see the evidence support the theory."

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For Schelling, addiction was neither purely irrational nor purely rational. It was a war, a battle for self-control. Schelling didn't mean this as a casual, poetic analogy. He meant that it was a battle that an addict could win, if only he or she had the right tactics.

Schelling sometimes told a story about a man whose wife was trying to quit smoking. Imagine, he said, that she had quit, but was having a tough time of it. Then a friend came to visit and accidentally left a pack of cigarettes lying around. The husband should pick up those cigarettes and flush them down the toilet before his wife's short-term cravings forced her to do something she didn't want to do. It was a simple contest in which the husband, able to appreciate the bigger picture, outwitted his addicted wife and her overwhelming impulses.

But then Schelling would recast the story: The man was single. He was the one who was trying to quit smoking and was struggling. When his friend left the cigarettes behind, the man tucked them into his pocket so that he could return them later. But after a glass of whiskey, the man started to find the cigarettes dangerously tempting. Before his impatient, addicted side gave in, the man's more strong-willed self realized what was likely to happen. He dumped the cigarettes into the toilet and pulled the chain. This is the same simple contest between two decision makers, one patient and one eager for a quick hit – but both decision makers were in the same body.

Schelling had to rely on introspection to develop what he called "egonomics," the view of addiction as a kind of mental civil war.

Now a bold new group of researchers armed with both brain scanners and rational choice theory, calling themselves "neuroeconomists," are starting to develop a view of the brain that provides some startling evidence for Schelling's split-personality model of decision making. Rather than reflecting and speculating, they can use high-tech scanners to see the "impatient" part of the brain.

This impatient part is called the dopamine system. You can give a snack to a monkey in a brain scanner and watch his dopamine system light up like a Christmas tree. The system seems to be designed to make instant forecasts of pleasure ("The snack will be delicious") as a way to make quick decisions about what to do ("Eat it!"). But addictive chemicals can cause the dopamine system to misfire, and some researchers even think that nonchemical addictions, such as playing slot machines, can do the same thing.

The other side in the mental civil war is

the cognitive system. Better able to guide longer-term choices in uncertain environments, it can be slow to operate. The dopamine system is fast and usually reliable but produces mistaken forecasts in some circumstances. Humans combine information from both, apparently a compromise produced by natural selection. Voila: Thomas Schelling's "egonomics," reborn as "neuroeconomics."

Lower-tech experiments can easily reveal the tension. In one, the experimenters offered some subjects a snack: fruit or chocolate. Seven out of 10 subjects asked for chocolate. But when the experimenters offered other subjects a different choice, the answer was different: "I'll bring you a snack next week. What would you like then, fruit or chocolate?" Three-quarters of the subjects chose fruit.

When the subjects were offered the choice of watching a lowbrow movie or a sophisticated critical success, well over half opted to watch something like *Mrs. Doubtfire*. Asked what they wanted to watch in a week's time, suddenly Krzysztof Kieslowski's *Three Colors: Blue* or *Schindler's List* seemed like the better choice for almost two-thirds of the subjects. When asked to make choices in advance, the subjects seemed to value the fact that watching *Three Colors: Blue* would make them wiser, more cultured persons for the rest of their lives. Offered the choice right now, a relaxed couple of hours watching jokes about fake breasts outweighed those longer-term benefits.

One of the researchers, Daniel Read of the London School of Economics, told me that when he subscribed to an Internet movie rental service, he kept changing his ranking of requested films so that the highbrow films never quite made it to the top of his waiting list. So if you want to watch more-cultured films, order them well in advance and then stay away from the rental Web site.

Schelling was not the first person to point out these tensions or to describe addiction as a battle for control of the self. But he was the first to think explicitly of the problem as a strategic one. Yet he made a woeful strategic error in his own battle. He quit smoking in 1955. But in 1958, sitting in a restaurant in London, he bought a cigar from "one of those ladies who used to go from restaurant to restaurant selling them." He thought he was immune, but spent many years "tormented," trying to quit again.

Schelling's days as a strategist gave him a playbook of tricks and tactics to try to recover from that initial stumble. Not all of them were successful. Schelling realized he didn't have the strength of will simply to quit smoking, but he also knew that a vague promise to himself to cut down would be easily dodged by his impatient, cigarette-craving side. So he decided to create a "bright line," just as he had argued for a taboo against the use of nuclear weapons. He told himself that he would not smoke until after the evening meal. He obeyed that rule for years. But unfortunately Schelling's weaker half was also an expert strategist, and the hapless professor found himself hunting for sandwiches at around 5:30 p.m. so that he could have a smoke without having violated the letter of his self-imposed law.

Schelling's strategy was right from the negotiator's textbook: Make a specific, (apparently) unambiguous commitment. That was what President Kennedy had done when facing Khrushchev over Berlin. Rather than saying something vague, such as "We will take the steps necessary to defend our interests," he made an unambiguous statement. Four days after reading Schelling's analysis of the problem, he announced on television, "We have given our word that an attack upon that city will be regarded as an attack upon us all."

That public commitment made it hard for

Kennedy to ignore any attack, and thus dissuaded Khrushchev from making one. But as a good negotiator knows – and as Kennedy showed later in the Cuba crisis – when the line causes irreconcilable differences, you work out a way to compromise without actually erasing the line. You can see the same tactics at play when a union leader publicly declares that members will not accept less than a 10 percent pay increase. The whole idea of that sort of announcement is to add credibility to the threat to walk away from the talks. And you can also see from pay negotiations why the tactics don't work as well as the negotiators might hope. The clever response is to find weaselly ways to undo the commitment: What about 10 percent staggered over the next three years? Or what about a 10 percent raise this year, provided certain onerous productivity targets are met?

Or what about a sandwich at 5:30 in the "evening," and a cigarette at 5:33?

No economist has come up with a convincing explanation for why these taboos and focal points work. But work they do, albeit imperfectly. Why else do people try to quit smoking on January 1 rather than on February 24?

An addict, like a negotiator, may be able to gain an advantage by making binding decisions in advance. An everyday example is the dieter who shops for food over the Internet, and only after a good meal, so that he is not tempted by the sight of cakes and chips. A more sophisticated example, designed by economists Richard Thaler (University of Chicago) and Shlomo Benartzi (UCLA), is a financial scheme called Save More Tomorrow in which corporate employees boost their pensions by earmarking a proportion of future pay raises to their retirement accounts. The idea has nearly quadrupled retirement savings.

In both cases, the forward-thinking person outwits the impatient or weak-willed person who inhabits the same body. Schelling wryly observed that it is not always easy to tell whose side you should be on. People can save too much, exercise too much, diet too much and commit themselves to "improving" activities – subscriptions to *The New York Review of Books* or memberships to the Royal Opera House – that they do not truly want.

In real negotiations, too, a negotiator can strengthen his position by tying his hands. This is what any shop assistant does when they tell you he's not authorized to offer you a discount. But such tactics can backfire, just as they do for the person who never uses her gym subscription.

In the film *Dr. Strangelove* the Russians build a doomsday device, a computer that will launch every Soviet warhead if it detects signs of an American attack. Such a device is obviously risky, but by making retaliation certain it should make the surprise attack far less likely. This is the reasoning of Dr. Strangelove, the fictional von Neumann. Needless to say, predictable human error intervenes and things do not go quite according to plan. (Whom did the director Stanley Kubrick consult while scripting the movie? None other than Thomas Schelling.)

Suddenly it is not so hard to see how an alcoholic's rational side can successfully decide to quit after reading about an increase in liquor taxes in the local newspaper – but the very same person could kill herself drinking if she got hold of another bottle. While addicts can make the wrong choices, contradict themselves and be tormented by their frailties as Schelling was, they can also weigh costs and benefits, anticipate temptations and take steps to put those temptations out of reach.

Schelling himself won his personal civil war after a 15-year struggle. When I met him

in 2005, he had gone three decades without smoking. At the age of 84, he was the picture of health.

Thinking back to Las Vegas, it is clear that Ferguson's triumph at the 2000 World Series of Poker was a landmark in the history of game theory. In many ways, though, it was atypical. Ferguson's approach was directly descended from von Neumann's pure mathematical brilliance. But while modern economics still drips with mathematics, much of the most successful game theory is of the Schelling variety: simpler in theory and more aware of the messy details of real situations.

Just three weeks before Ferguson's victory, for example, the British government had scored a little win of its own, raising £22 billion (roughly $44 billion) in a mobile phone license auction designed by game theorists – arguably the most high-profile success of game theory in recent years. Oxford economist Paul Klemperer, one of the lead designers of the U.K. mobile phone auctions, later explained that successful auction design did not require fancy mathematical game theory, but basic economic ideas that any undergraduate could explain: encouraging bidders to come to the auction, closing loopholes and preventing cheating. Success or failure depended on getting the fundamentals correct in an ambiguous world. Like Ferguson, the auction's designers used computers to explore all the possibilities. But unlike him, they were looking for simple strategies, clear focal points and glaring errors.

And while Ferguson's grasp of advanced game theory continues to make him one of the most feared faces at the poker table, more-humble Schelling-style battles for self-control are being fought out at the doors of the Rio Casino. Some gambling addicts cannot reach the slot machines because the casino manager and his security guards will intercept them and politely guide them to the exit. These men and women have been barred from the Rio and all the other casinos owned by the world's largest operator, Harrah's.

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Who barred them? Not the police or the management of Harrah's, but the better halves of their brains. Anyone who suffers from a gambling addiction – a misfiring of the dopamine system when the slot machines are in sight – can call Harrah's or log on to Harrah's Web site and volunteer to be banned. The rational decision maker outwits the short-sighted addict with the help of the casino's image recognition software and a couple of friendly bouncers. If you can't win the battle with yourself, you can recruit allies.

Game theory shows us the hidden logic behind poker, war and even addiction. It is inevitably a way to view the world through the lens of rationality, but is most effective when it uncovers simple, commonsense rationality in unexpected circumstances. Von Neumann, the self-confident "demigod," would have expected his beloved game theory to be achieving triumphs in Las Vegas. He might have been more surprised to learn that modern game theory has as much to do with the internal dilemmas of the slot machine junkies as with the brilliance of Chris "Jesus" Ferguson on the other side of the lobby. M