

Draft:

Agents, Games, and Evolution

A Society of Ideas

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Draft: © Draft 31 October 2005

Part I, chapter 1, “Contexts of Strategic Interaction”

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File: abookwrapper.tex. Created: 2003-09-01, from age-master.tex.

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Chapter 1

Contexts of Strategic Interaction

Ideas have lives of their own. They arise at surprising times and come from surprising places. Ideas interact with other ideas. They become associated and these associations—or societies—lead to new social structures and to new ideas. These in turn may calve off in groups and form new societies. Of course, ideas live and have their being in human minds and cultural artifacts. Without us they wouldn't exist. Nor would most of us exist without the benefit of ideas that have created and sustained our civilization. Nor would there be animals without photosynthesizing plants, or photosynthesizing plants without photosynthesizing bacteria. Interdependence pervades.

The subject of this book is a certain society of ideas. I shall call it the AGE society (Agents, Games, and Evolution), without making any claim that the name ideally describes its subject. What name does? Like any interesting and reasonably complex society, AGE is a product, and continues to be a producer, of history. Its structure, its dynamics, even its constituents are often opaque and puzzling, and everything is in flux. Hence the need for study.

I shall not attempt to define the subject at hand. It likely can't be done and wouldn't be of much value even if it could. Hyperprecision would only be a distraction at this point. Rather, I will plunge in, immerse us at the center of AGE society, and explore from where we find ourselves. Better to start somewhere reasonable, then ask questions, attend to relevant problems and data, refine and recombine concepts and hypotheses, and build models and conduct experiments. All this is to be undertaken in an iterative, exploring, probing, nondeterministic search for sharper clarity, deeper understanding, and useful results. This shall be our mode throughout. If the process seems to be a sort of groping, adaptive muddling, so be it. The means are informed by the main results.

Let us begin, then, by discussing what I call *contexts of strategic interaction* (CSIs), also known as *games*. Here is a—perhaps *the*—main theme in our AGE society of ideas.

1.1 Games in the Wild

Games, or more descriptively *contexts of strategic interaction* (CSIs), are everywhere.¹ They pervade social situations and occur quite naturally (or appear “in the wild” as geneticists say of certain alleles). Two people play backgammon. They are in a game, or context of strategic interaction (CSI), because the reward (winning or losing) for each player depends at least in part on decisions made by the other player. One player cannot make a series of decisions that results in winning or losing, *independently of what the other player does*. The other player has to make decisions, too, and they matter. The context is interactive—two or more players are involved—and it is strategic because both players have interests, which they take into account in making their decisions.

Backgammon is representative of many games in that it is purely competitive.² One player’s win is the other player’s loss. The interests of the players are, we may assume, entirely opposed. In other CSIs (or games) the players’ interests are entirely coincident. These are what we call *games of pure coordination*. Two people are conversing by telephone when the connection is suddenly dropped. How should they attempt to resume the conversation? If both call back simultaneously both will get a busy signal or perhaps voice mail. They share a joint interest in mutually divining a decision that results in prompt and unfrustrated resumption of their conversation. Here we may assume the interests of the two agents are identical. Neither really cares who makes the new call, so long as it results in immediate resumption.

Lying between games of pure competition (e.g., backgammon) and games of pure coordination (e.g., resuming a broken phone call) are *mixed motive* games (or

¹The term game is perhaps an unfortunate one for a number of reasons. It suggests a certain frivolity, also that only contexts of pure competition are of interest. More importantly, we need a distinction between a situation involving strategic interaction and a model of such a situation. *Game* gets used for both. When necessary to differentiate, I’ll use $game_S$ for the situation, not always well defined with all vagueness left out, and $game_M$ for a model, presumably specified with great precision, of a $game_S$. Or, CSI for $game_S$ and game for $game_M$.

²At least approximately or often. Consider playing with a tyro and playing to lose for purposes of instruction.

CSIs). A small group negotiates where to have dinner. No two people have identical preferences, but everyone agrees that failing to come to a congenial decision quickly is the worst outcome. Remarkably subtle moves will typically attend this familiar situation. Bluff, bluster, threat, compromise, accommodation, probing, retreating, appeal to norms, humor, and much else are routinely employed with facile skill by everyone who participates in such groups.

How are we to understand games? In particular, how are we to predict and explain both behavior and outcomes in games? This is a large and important question. I remind the reader that our mode here is to make some progress through an “iterative, probing, nondeterministic search for sharper clarity and deeper understanding.” To this end, a rough characterization of our topic will be helpful:

Games, or CSIs, essentially involve at least two *agents* (or players) who make *choices* and receive *rewards* (or payoffs).³ The reward to an individual agent is based in part on its choices *and the choices made by the other agent(s)*, as well as the underlying structure of the situation.

Now consider a few representative, idiosyncratically-chosen examples of contexts of strategic interaction.

1.1.1 War

Much more than a pure, brutal contest of strength, war has been recognized from the earliest writings as a field of interactive decision making. Deception especially has been and remains a primary theme; it is inherently a strategic concept. Think of the Trojan horse incident told in the *Iliad* and the story of the Cyclops in the *Odyssey*. Think of the elaborate obfuscations undertaken by the Allies in World War II concerning the time and place of D-Day. Sun Tzu, in *The Art of War* (<http://www.chinapage.com/sunzi-e.html>), the oldest known military treatise, wrote this:

³Later, it will be useful to distinguish *rewards*, which are received after each move in a strategic situation, and *returns*, which are the net of the rewards obtained in a multi-move strategic context. Unless otherwise noted, what I say about rewards applies to returns and *vice versa*.

18. All warfare is based on deception.
19. Hence, when able to attack, we must seem unable; when using our forces, we must seem inactive; when we are near, we must make the enemy believe we are far away; when far away, we must make him believe we are near.
20. Hold out baits to entice the enemy. Feign disorder, and crush him.
21. If he is secure at all points, be prepared for him. If he is in superior strength, evade him.
22. If your opponent is of choleric temper, seek to irritate him. Pretend to be weak, that he may grow arrogant.
23. If he is taking his ease, give him no rest. If his forces are united, separate them.
24. Attack him where he is unprepared, appear where you are not expected.
25. These military devices, leading to victory, must not be divulged beforehand.

Other themes abound, but deception and surprise remain keystones to military strategy. Other works on the short list of classics in military strategy include: *On War*, by Karl von Clausewitz, *The Prince*, by Niccolò Machiavelli, and *A Book of Five Rings*, Miyamoto Musashi.⁴ Liddell Hart, e.g., [20] is an especially persuasive spokesman for the importance of military deception and surprise. Thomas Schelling is uniformly insightful and a joy to read, e.g., [28, 26, 27, 29]. The *Memoirs* of Ulysses S. Grant are chock full of material to stimulate reflection on war and on interactive decision making in general. Here is my favorite passage. Grant is describing his first field command in the American Civil War.

My sensations as we approached what I supposed might be a 'field of battle' were anything but agreeable. I had been in all the engagements in Mexico that it was possible for one person to be in; but not in command. If someone else had been colonel and I had been lieutenant-colonel I do not think I would have felt any trepidation. ... As we approached the brow of the hill from which it was expected we would

⁴You may find these on-web at <http://www.gametheory.net/html/books.html#classics>.

see the enemy. . . my heart kept getting higher and higher until it felt as though it was in my throat. I would have given anything to have been back in Illinois, but I had not the moral courage to halt and consider what to do; I kept right on. When we reached a point from which the valley below was in full view I halted. The place where the Confederates had been encamped was still there but the troops were gone. My heart resumed its place. It occurred to me at once that [Colonel Thomas] Harris had been as much afraid of me as I had been of him. This was a view of the question I had never taken before; but it was one I never forgot afterwards. From that event to the close of the war, I never experienced trepidation upon confronting an enemy, though I always felt more or less anxiety. I never forgot that he had as much reason to fear my forces as I had his. The lesson was valuable.

—Ulysses S. Grant, *Memoirs*

1.1.2 Trading and Investing

“Buy low, sell high” is great advice if (and only if) you know what to do. As the song says about that special form of trade and investment called love, “Nice work if you can get it, And you can get it if you try.”

Examples of buying low or selling high? This is from *The Reader’s Digest*, June 2003, pages 76–7:

Customers at The Home Depot who overestimate how much paint they need return the unopened cans, which are stocked in the “Oops Paint” section. The “remnant” paint—perfect for bathrooms and other small projects—sells for \$5 a gallon and \$1 a quart (regular gallon prices are \$21 to \$25). “And it’s not all chartreuse,” says The Home Depot spokesperson Mandy Holton. “There are usually a lot of great neutrals.” Best time to buy: Sundays and Mondays, because folks return unwanted paint over the weekend.

More generally, traders and investors are in the business of finding assets that are either under-valued or over-valued in the market. In other words, they seek opportunities for *risky arbitrage*. Risky because—unlike the paint at The Home Depot—the values of the assets in question are typically not known with much certainty. Arbitrage because the traders are looking to buy assets that are under-priced (and then resell them at their proper prices) or looking to sell (“unload”)

assets that are over-priced. In any event, the trick is to have and exploit knowledge that is superior to what is represented in the market. The nature of this knowledge and the means of getting it vary greatly. An investor in equities may look deeply and carefully at the fundamentals of the companies. Which are and which are not well managed, well positioned, in possession of new products and alliances? An investor may look at the “technical” data, the trends and other movements in prices. In the extreme, so-called day traders do this in real time, attempting to out-guess the market, that is out-do the other traders in discerning what is over-valued or under-valued. Note that investing on analysis of fundamentals would seem to have less strategic content than investing on technical grounds.

On-line, Internet-based examples are readily available for those who wish to trade or just to study and learn. Tradesports (<http://www.tradesports.com>) is a real-time, on-line trading market that affords an excellent case for study. Academic analogs—but with real money if you want—are available for elections at Iowa Electronic Markets (IEM; <http://www.biz.uiowa.edu/iem/>; <http://www.biz.uiowa.edu/iem/markets/>) and the University of British Columbia Election Stock Market (<http://esm.ubc.ca/>). A *BusinessWeek* article, “The ‘Election Futures’ Market: More Accurate than Polls?”⁵ presents the case in a popular format that these markets predict election outcomes better than opinion polls. The Bush administration even toyed with creating a similar market for the purpose gauging intelligence in the Middle East (see “Bet on Terror: What Markets Can Reveal” by Floyd Norris in *The New York Times*, August 3, 2003). The idea was dropped after being exposed to public ridicule. Is it ridiculous? Consider: What would it take to “game” (distort for ulterior purposes) these markets? When would anyone want to do this? What might be done to prevent manipulation? Does it make sense to have an SEC for markets in international affairs?

There are always the public equity markets. Consider this comment on the bond market by a Salomon trader in the 1980s.

The men on the trading floor [Salomon’s bond trading area] may not have been to school, but they have Ph.D.’s in man’s ignorance. In any market, as in any poker game, there is a fool. The astute investor Warren Buffett is fond of saying that any player unaware of the fool in the market probably *is* the fool in the market. In 1980, when the bond market emerged from a long dormancy, many investors and even Wall Street banks did not have a clue who was the fool in the new game. Salomon bond traders knew about fools because that was their job.

⁵1996; <http://www.businessweek.com/1996/46/b3501116.htm>.

Knowing about markets is knowing about other people's weaknesses. And a fool, they would say, was a person who was willing to sell a bond for less or buy a bond for more than it was worth. A bond was worth only as much as the person who valued it properly was willing to pay. And Salomon, to complete the circle, was the form that valued the bonds properly.

—*Liar's Poker*, Michael Lewis [18, page 35]

1.1.3 Athletic Contests

There are sports, called games in common parlance, that have little or no strategic content. They amount more or less to contests of skill. Among them are golf, bowling, darts, skiing, track and field events, and bob sledding. Still other competitive games, such as billiards, have strategic content only with fairly advanced play. These are not, for the most part, of interest as CSIs, contexts of strategic interaction, and will not concern us further.

Many other athletic contests most unambiguously count as CSIs. Baseball has given us a wonderful strategic slogan, entirely appropriate for war and other games: "Hit 'em where they ain't." Wee Willie Keeler hit .432 in 1897. Asked how a man of his diminutive size could put together such an average, Keeler responded: "Simple. I keep my eyes clear and I hit 'em where they ain't."⁶ Deception—or the fake-out—plays as prominent a role in these athletic contests as it does in warfare. Think of the pitcher-batter duel in baseball, the fake-out moves in basketball, or the mixing of plays in American football.

Management of sports teams is as much a matter of strategic interaction as the play itself. In *Moneyball: The Art of Winning an Unfair Game*, Michael Lewis describes how the Oakland A's baseball team, with consistently small amounts spent on player salaries, is consistently able to contend in major league baseball and reach the playoffs [19]. In two words: risky arbitrage. The A's, and in particular their general manager Billy Bean, have identified predictive measures superior to those used by other teams, for example using on-base percentage instead of batting average to evaluate the worth of a batter. Better measures of value allow the A's to 'buy' (hire) under-priced players. They may not have the best team in baseball, but they have one of the best. Their efficiency in the sense of what it costs them to win a game is tops and they operate at a profit in a media market dominated by the San Francisco Giants baseball team.

⁶From <http://www.baseballtips.com/slang.html>.

1.1.4 Gambling

Many forms of gambling do not involve strategy or even much skill. Examples include playing slot machines and playing roulette. Not so with poker at the professional level. Poker is prototypical. It is to competitive games of strategy what robins are to birds: a standard, familiar, readily available example, displaying in typical form many of the characterizing features of the subject. Everyone over time gets roughly the same quality of hands, yet there is an enormous difference among players in their success rates. Everyone can count cards and figure the odds. What actually matters is bluffing, reading your opponents (discerning their “tells,” behavior such as slamming down chips that indicates what is in their hands), and preventing your opponents from reading you. The following fine passage from a master poker player is well worth quoting at length:

Let’s take a quick glimpse at the high-stakes poker world, an enterprise that yields several of my friends over a million dollars a year! At this level, too, luck is a factor on any given day, week, or month, but what’s different is that if you play better poker than your opponents do, pretty consistently, you’ll find that over almost any *two*-month period your winnings have exceeded your losses. Furthermore, if you play better poker than your opponents over a *six*-month period, your results will have moved very solidly in the winning direction. Making a few well-timed bluffs each day will add up to a lot of money each year!

In fact, if an inexperienced poker player were to sit down for a few hours with a group of world-class poker players, he would have virtually no chance to win over even an eight-hour period. This very fact is why five or six top pros might be willing to sit down in the same game with this fellow and each other: the money that even one amateur is likely to contribute makes it work their while to do battle with so many respected opponents.

This is why so many of the top poker players today drive fine cars and live in palatial homes [the author of this passage lives with his family in Palo Alto]. Right now, as you’re reading this book, there is a \$600–\$1,200-limit poker game at the Bellagio Casino in Las Vegas and a \$400–\$800-limit poker game at the Commerce Casino in Los Angeles. There is . . .

If that’s not enough action for you, four nights a week in Los Angeles,

there is a \$2,000-\$4,000-limit Seven-Card Stud game a Larry Flynt's Hustler Club Casino, with Larry himself often playing. In the \$400-\$800-limit poker game it's easy to take a \$25,000 swing in one hour. In the \$2,000-\$4,000-limit game, where movie stars, former governors, and billionaires play, it's not uncommon for someone to win or lose \$250,000 in one night. In these "nosebleed" poker games (the term refers to the altitude of the stakes), strategy, discipline, calculation of the odds, and practiced observation contribute to a game that involves much more skill. Better play wins more hands in the long run.

—*Play Poker Like the Pros* by Phil Hellmuth, Jr., 2003 [14, pages 4–5]

The society of poker players has given us an important concept—the *tell*—not only for poker but for CSIs generally. *Webster's Unabridged Dictionary* finds only two senses for *tell* as a noun. Quoting:

1. something that is told : TALK, TALE, ACCOUNT

“have a tell with you —Eden Phillpott”

2. [Ar *tall*]

: HILL, MOUND

specif : an ancient mound in the Middle East composed of remains of successive settlements — compare TEPE

The *Oxford English Dictionary* is no more helpful. The Wikipedia gets it right. Quoting:

Tell (poker)

From Wikipedia, the free encyclopedia.

In poker, a tell is a detectable change in a player's behavior that gives clues to that player's hand. Possible tells include leaning forward or back, placing chips with more or less force, fidgeting, changes in breathing or tone of voice, direction of gaze and actions with the cards, cigarettes, or drinks.

For example, a player with a weak hand, hoping to bluff, may throw his chips into the pot forcefully and with a direct gaze at a player he hopes to discourage from calling.

Tells may be common to a class of players or unique to a single player. A player gains an advantage if she observes another player's tell, particularly if that action is unconscious and reliable. However, better players may fake tells, hoping to lead their opponents into costly traps when they rely on the false information. So the observing, creating, and evaluating of tells can add another level to the play of poker.

Mike Caro has published the most comprehensive information on tells; his *Book of Tells* (ISBN 0897461002) is now a standard reference on the subject.

David Mamet's 1987 movie *House of Games* includes an interesting discussion and visual reference to tells as an essential part of the plot. The 1998 movie *Rounders* contains an even more subtle use of strategy: at one point, "Mike" discovers a tell in his opponent (that he eats cookies in a particular way after he has bet a very strong hand), and after using it once, he reveals to the opponent that he has this tell; although this eliminates the usefulness of the tell itself, it upsets his opponent so much that it affects his later play.

–*Wikipedia*, [http://www.wikipedia.org/wiki/Tell_\(poker\)](http://www.wikipedia.org/wiki/Tell_(poker))

The Wikipedia is also better than the dictionaries on *tell* as a noun, not in the context of poker. Quoting:

Tell

From Wikipedia, the free encyclopedia. A tell (Arabic, or tel, Hebrew) is a mound site formed through successive human occupation over a very long timespan.

The word is used as a term in archaeology, particularly Middle-Eastern archaeology. It is sometimes used in a toponym, that is, as part of a town or city name, the most well known example being the city of Tel Aviv. Often a modern city is located next to an ancient mound with a similar tell name, for example the city of Arad is a few kilometers (miles) away from an ancient mound called Tel Arad.

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External link

* <http://www.webref.org/anthropology/t/tell.htm>

Tell is an English verb meaning “to speak to” or “to talk to”; also “to give an order”. For more information on what that is, see talking.

Retrieved from “<http://www.wikipedia.org/w/wiki.phtml?title=Tell>” This page was last modified 01:47, 19 Jun 2003. All text is available under the terms of the GNU Free Documentation License.

Note the meaning associations and similarities between these two senses of *tell*. The strategic sense of *tell* is lucidly on display in the following passage about the great baseball player and base runner, Rickey Henderson.

But Kennedy knew how devastating stealing could be: he had been with the San Francisco Giants in the 1989 World Series, when Henderson and the A’s swept the Giants in four games and Henderson set a post-season record, with eleven stolen bases.

Henderson agreed to give a demonstration, and there was a buzz as Goodman, Johnson, and the other players gathered around first base. Henderson stepped off the bag, spread his legs, and bent forward, wiggling his fingers. “The most important thing to being a good base stealer is you got to be fearless,” he said. “You know they’re all coming for you; everyone in the stadium knows they’re coming for you. And you got to say to yourself, ‘I don’t give a dang. I’m gone.’” He said that every pitcher has the equivalent of a poker player’s “tell,” something that tips the runner off when he’s going to throw home. Before a runner gets on base, he needs to identify that tell, so he can take advantage of it. “Sometimes a pitcher lifts a heel, or wiggles a shoulder, or cocks an elbow, or lifts his cap,” Henderson said, indicating each giveaway with a crisp gesture.

Once you were on base, Henderson said, the next step was taking a lead. Most players, he explained, mistakenly assume that you need a big lead. “That’s one of Rickey’s theories: Rickey takes only three steps from the bag,” he said. “If you’re taking a big lead, you’re going to be all tense out there. then everyone knows you’re going. Just like you read the pitcher, the pitcher and catcher have read you.”

He spread his legs again and pretended to stare at the pitcher. “O.K., you’ve taken your lead; now you’re ready to find that one part of the pitcher’s body that you already know tells you he’s throwing home. The second you see the sign, then *boom*, you’re gone.” [11, page 58]

Hellmuth's book has a great deal of information on Texas Hold 'em, which is generally the most popular form of poker in tournaments and is the variety of poker played at the World Series of Poker each year at Binion's Horseshoe Hotel & Casino in Las Vegas.⁷ *Positively Fifth Street* [24] by Jim McManus, a published poet, novelist, and professor, describes the 2001 World Series of Poker and the world around it. Strategic insight abounds in both works.

1.1.5 Business Strategy

The gambit, a term from chess, is a favorable trade, which the opponent may or may not realize is happening. The player offering the gambit offers a comparatively small loss in exchange for a larger gain in position or other form of resource. Here is something very like a gambit played big time in business.

Analysts called it "Marlboro Friday"—Philip Morris announced on April 2, 1993 that it would reduce the U.S. price of its premium brand of cigarettes by 20%. The tobacco manufacturer also said it would increase the budget for its domestic advertising by a substantial amount. R.J. Reynolds, Philip Morris's biggest competitor, responded by matching the price cut on its own premium brands (Camel and Winston among them) and by pouring more money into its own domestic advertising.

The pricing war that ensued cost both companies tens of millions of dollars. But was the domestic market share the real reason Philip Morris lowered the price of Marlboro cigarettes? Consider that just as R.J. Reynolds had depleted its cash resources trying to keep up with its chief opponent, Philip Morris was expanding aggressively into the Eastern European market, investing \$800 million in Russia and other regions that were formerly part of the Soviet Union. R.J. Reynolds was in no position to fight back, having spent so much money to maintain its market share in the United States, and Philip Morris won the battle for Eastern European market share, hands down.

⁷See <http://conjelco.com/wsop.html> and <http://www.binions.com/home.asp>. The Wikipedia has an introduction to Texas Hold 'em: http://www.wikipedia.org/wiki/Poker/Texas_holdem. At the World Series of Poker, No Limit Texas Hold 'em is the game. "No Limit" means that the largest bet permitted is the size of the current wealth outside the pot of the poorest player still in the hand. Once a player has bet all of his or her chips, the player is said to be "all in," since the player's wealth is all in the pot. Once a player is all in for a particular hand, other players may call but may not raise.

–“Global Gamesmanship” by Ian C. MacMillan et al., *Harvard Business Review*, May 2003 [22]

Sometimes you can even make a profit on a gambit:

One day earlier in his career [Robert] Dall was in the market to buy (borrow) fifty million dollars. He checked around and found the money market was 4 to 4.25 percent, which meant he could buy (borrow) at 4.25 percent or sell (lend) at 4 percent. When he actually tried to buy fifty million dollars at 4.25 percent, however, the market moved to 4.25 to 4.5 percent. The sellers were scared off by a large buyer. Dall bid 4.5. The market moved again, to 4.5 to 4.75 percent. He raised his bid several more times with the same result, then went to Bill Simon’s office to tell him he couldn’t buy money. All the sellers were running like chickens.

“Then you be the seller,” said Simon.

So Dall became the seller, although he actually needed to buy. He sold fifty million dollars at 5.5 percent. He sold another fifty million dollars at 5.5 percent. Then, as Simon had guessed, the market collapsed. Everyone wanted to sell. There were no buyers. “Buy them back now,” said Simon when the market reached 4 percent. So Dall not only got his fifty million dollars at 4 percent but took a profit on the money he had sold at higher rates. *That* was how a Salomon bond trader thought: He forgot whatever it was that he wanted to do for a minute and put his finger on the pulse of the market. If the market felt fidgety, if people were scared or desperate, he herded them like sheep into a corner, then made them pay for their uncertainty. He sat on the market until it puked gold coins. *Then* he worried about what he wanted to do.

—*Liar’s Poker*, Michael Lewis [18, page 88]

1.1.6 Negotiation

Negotiation exemplifies strategic interaction *par excellence*. After all, there is no point in negotiating if your counter-party’s actions don’t matter to you. Familiar as negotiation is to everyone, it is useful to be reminded that often negotiation is not explicit, at least not at first. Here is a description of this sort of encounter “in the wild.”

To begin to negotiate the environment does not, of course, mean that you enter the negotiation with a clear-cut goal in mind. A clear-cut goal is not needed even in purely human negotiations. Suppose you pass a stall in a market every week and notice an antique ornament for sale. At first it seems ugly, but as it grows familiar, you catch yourself wondering how it would look on your shelf. One day it rains while you are crossing the market and you take shelter in the stall. The ornament is still there; for something to do you ask its price. Even when a low price is mentioned you automatically snort in contempt, for you have no intention of buying. . . or have you? During the week that follows you decide that the price really was low and think of a friend who has a birthday soon and might like it. Next week you stop and begin to bargain.

When did the negotiation begin? When you started to bargain? Or earlier, when you asked the price? Or earlier still, when you first noticed the ornament among an anonymous heap of others? Pointless to say, as pointless as to say where mind began.

—*Language and Species* by Derek Bickerton [2, pages 234–5]

1.1.7 Coordination, Symbiosis, Mutualism, Cooperation

Contexts of strategic interaction are not all adversarial in the sense that one agent's gain is another's loss (so-called *constant-sum* or equivalently *zero-sum* games). In *coordination games* all players gain if they can arrive at a common outcome and lose if they fail. Think of the game of finding someone you have separated from during a shopping trip. You both wish to meet up again, but did not plan for the separation and have no easy means of communication. Schelling's early treatment of such games is masterful and well worth reading today [28].

Biologists have named and studied several kinds of interactive decision making that—in terms of game theory lingo—is not constant-sum. Symbiosis and mutualism are two of the most important for our purposes.

Symbiosis (pl. symbioses) is an interaction between two organisms living together in more or less intimate association or even the merging of two dissimilar organisms.

The term host is used for the larger of the two members of a symbiosis. The smaller member is called the symbiont.

Symbiosis may be divided into two distinct categories: ectosymbiosis and endosymbiosis. In ectosymbiosis, the symbiont lives on the body surface of the host, including the inner surface of the digestive tract or the ducts of exocrine glands. In endosymbiosis, the symbiont lives in the intracellular space of the host.

An example of mutual symbiosis is the relationship between anemonefishes of the genus *Amphiprion* (family, Pomacentridae) that dwell among the tentacles of tropical sea anemones. The territorial fish protects the anemone from anemone-eating fish, and in turn the stinging tentacles of the anemone protects the anemone fish from its predators (a special mucous on the anemone fish protects it from the stinging tentacles).

The biologist Lynn Margulis, famous for the work on endosymbiosis, contends that symbiosis is a major driving force behind evolution. She considers Darwin's notion of evolution, driven by competition is incomplete, and claims evolution is strongly based on co-operation, interaction, and mutual dependence among organisms. According to Margulis and Sagan (1986), *Life did not take over the globe by combat, but by networking*.

(From: <http://www.wikipedia.org/wiki/Symbiosis>.)

(See [23] for a recent treatment of this theme by Margulis and Sagan.)

Mutualism is a interaction in which both organisms in a close relationship derive some degree of benefit. Mutualism is usually temporary or not obligatory.

(From: <http://www.wikipedia.org/wiki/Mutualism>.)

Lichens—those familiar greenish splotches on trees and rocks—present a most striking example of symbiosis.

Lichens have been described as “dual organisms” because they are symbiotic associations between two (or sometimes more) entirely different types of microorganism -

- a fungus (termed the mycobiont)

- a green alga or a cyanobacterium (termed the photobiont).⁸

There are many examples of symbiosis in nature, but lichens are unique because they look and behave quite differently from their component organisms. So, lichens are regarded as organisms in their own right and are given generic and species names. However, for taxonomic purposes the names are actually fungal names: lichens are regarded as a special group of fungi - the lichenised fungi.

There are an estimated 13,500 to 17,000 species of lichens, extending from the tropics to the polar regions. Some of them grow on the bark of temperate trees or as epiphytes on the leaves of trees in tropical rain forests. Others occupy some of the most inhospitable environments on earth, growing on cooled lava flows and bare rock surfaces, where they help in the process of soil formation, and on desert sands where they help to stabilise the surface and enrich it with nutrients (see Cyanobacteria [cf., footnote 8, page 16]). Some other types of lichen grow abundantly on tundra soils, providing a vital winter food source for animals (including reindeer and caribou) in arctic and sub-arctic regions. Yet other lichens grow on or in the perennial leaves of some economically important tropical crop plants such as coffee, cacao and rubber, where they are regarded as parasites.

All these features make lichens interesting and significant in environmental terms. But lichens also pose challenging scientific problems - how do two or more microorganisms interact at the cellular, genetical and biochemical levels to produce a unique, hybrid organism?

(From: <http://helios.bto.ed.ac.uk/bto/microbes/lichen.htm>.)

A form of emergence occurs with lichens. Surprisingly, what appears to be, and in many ways is, a single individual is actually composed of, arises through the inter-

⁸Author's note: From the Wikipedia, www.wikipedia.org/wiki/Cyanobacteria: "Cyanobacteria or blue-green bacteria are a group of aquatic bacteria that obtain their energy through photosynthesis. They are often referred to as blue-green algae, even though it is now known that they are not related to any of the other algal groups, which are all eukaryotes. Nonetheless, the description is still sometimes used to reflect their appearance and ecological role. Fossil traces of cyanobacteria have been found from around 3800 million years ago, making cyanobacteria some of the earliest living things known." Implied but not said, the cyanobacteria are prokaryotes, of ancient origin and lacking a cell membrane. It is thought by some that photosynthesizing plants acquired or incorporated the genomes of photosynthesizing bacteria.

actions of, individuals from two distinct biological kingdoms. It is even surprising who first noticed this underlying, symbiotic structure.

Lichens are unusual creatures. A lichen is not a single organism the way most other living things are, but rather it is a combination of two organisms which live together intimately. Most of the lichen is composed of fungal filaments, but living among the filaments are algal cells, usually from a green alga or a cyanobacterium.

In many cases the fungus and the alga which together make the lichen may each be found living in nature without its partner, but many other lichens include a fungus which cannot survive on its own – it has become dependent on its algal partner for survival. In all cases though, the appearance of the fungus in the lichen is quite different from its morphology as a separately growing individual.

The true identity of lichens as symbiotic associations of two different organisms was first proposed by Beatrix Potter, who is best remembered for her children's books about Peter Rabbit. In addition to her books, she spent time studying and drawing lichens. Her illustrations are still appreciated for their detailed and accurate portrayal of the delicate beauty of these bizarre organisms.

(From <http://www.ucmp.berkeley.edu/fungi/lichens/lichens.html>.)

(Searching Google's image base on "lichens" turns up an excellent collection of images.)

Next, cooperation is—in its prototypical sense—a human social phenomenon, one that has been much noticed and remarked upon by social scientists, including game theorists. Cooperation, or roughly non-greedy behavior, has been called “the cement of society” [5] (by analogy with causation, which Hume called “the cement of the universe”). Without it, in the pungent phrasing of Thomas Hobbes, there would be

no place for industry, because the fruit thereof is uncertain; and consequently no culture of the earth; no navigation, nor use of the commodities that may be imported by Sea; no commodious Building; no Instruments of moving and removing such things as require much force; no Knowledge of the face of the Earth; no account of Time; no Arts; no Letters; and which is worst of all, continuall feare, and danger of violent death; And the life of man, solitary, poore, nasty, brutish, and short. (Hobbes, *Leviathon*)

(See, e.g., <http://plato.stanford.edu/entries/hobbes-moral/>, <http://www.philosophypages.com/ph/hobb.htm>.) Without cooperation we are lost. How, then, does it arise and how might it be sustained? Hobbes thought that realistically it was necessary to turn power over to a sovereign (king or powerful government)—a leviathon—who would enforce cooperation on society. Others have thought that perhaps cooperation could emerge and be sustained naturally, without a central authority, much as, say, lichens emerge and are sustained naturally. Is this possible? If so, what is required of the games and the players?

1.1.8 Conversation

When we speak we have in mind how others will react to what we say and what we do not say. In this regard, a representative news story—“Official’s comments set off euro’s surge. U.S. Treasury’s Snow said a weaker dollar would help U.S. exports. The dollar fell against the euro.” by David McHugh—appeared in *The Philadelphia Inquirer* on May 13, 2003. The first sentence says it all: “The U.S. dollar fell to another four-year low against the euro yesterday, inching closer to its all-time low, after U.S. Treasury Secretary John Snow said a weaker dollar would help U.S. exports.” Secretary Snow never said he favored letting the dollar fall, but what he did say, as he no doubt understood, led the markets to infer that he favored a decline in the dollar. This form of strategic interaction is rife in linguistic communication and even has a special name: conversational implicature. Examples abound. A sign at Big Sur Lodge, Pfeiffer State Park, near a food counter:

Stressed?
Spelled
Backwards
Is
Desserts

Translation: Buy a dessert from us; it’ll make you feel good. Or the concluding line in Hitchcock’s movie, “Frenzy”: “Mr. Rusk, you’re not wearing your tie.” Translation: You’re the necktie murderer and I’m placing you under arrest. Or the use of irony, as in “Rick, Major Strasse is one of the reasons the German Reich enjoys the reputation it has today,” from the movie “Casablanca.” Translations: (to Strasse) The Reich is an impressive accomplishment and you are a big part of it; (to Rick) Watch out, this guy Strasse is a very bad man. Or the dialog-less eating scene in the movie “Tom Jones” with Albert Finney. Translation: This

is just foreplay foreplay; the best is yet to come. See Paul Grice's "Logic and Conversation" [12] for the original treatment, still worth reading.

1.1.9 Games against Yourself

The long and justly celebrated story from the *Odyssey* of Ulysses and the Sirens continues to enchant and inform us. (Jon Elster has even written an entire book relating the story to modern social science [4].) From the perspective of strategic interactions, the story may be interpreted as a game played by Ulysses at one time against Ulysses at another time. At t_0 , before approaching within earshot of the Sirens, Ulysses foresees that Ulysses at t_1 , within earshot, will have preferences and inclinations quite at variance from Ulysses at t_0 and from Ulysses at t_2 , post the encounter with the Sirens (if he should live that long). So Ulysses at t_0 cleverly prevents Ulysses at t_1 from acting as Ulysses at t_1 would prefer. He hears the Sirens and lives to tell the tale.

Robert Louis Stevenson's familiar story, *Dr. Jekyll and Mr. Hyde*, carries a similar theme. Thomas Schelling tells a fable about a man who is struggling to quit smoking. A friend who smokes arrives at his house, converses, and leaves without incident. The friend, however, forgets his jacket and our protagonist notices the jacket contains a package of cigarettes. Not having an immediate compulsion to smoke and knowing the friend will return tomorrow, he puts the jacket away. Later, upon reflection, he recovers the jacket, removes the cigarettes, and destroys them.

1.1.10 Confidence Games

The con man (or woman) first gets your trust, your confidence, and then abuses it for profit. "Take the money and run" is the operating creed. Confidence rackets are celebrated in literature, theater, and film. Examples include Herman Melville's novel *The Confidence Man*, Sinclair Lewis's novel *Elmer Gantry* (movie with Burt Lancaster and Jean Simmons), Jim Thompson's novella *The Grifters* (movie with Anjelica Huston, John Cusack, and Annette Bening), Guy Owen's short story "The Flim-Flam Man" (movie with George C. Scott and Sue Lyon), N. Richard Nash's play *The Rainmaker* (movie with Burt Lancaster and Katherine Hepburn), David Mamet's movie "House of Games" (with Lindsay Crouse and Joe Mantegna), and Meredith Wilson's Broadway musical *The Music Man* (movie with

Robert Preston and Shirley Jones). This is from a Penn Web site, August 2003:⁹

6:30 pm - 8:30 pm Confidence Games at the GSC

The GSC shows films about con artists:

Catch Me If You Can on 7/31;

The Thomas Crown Affair on 8/7;

The Spanish Prisoner on 8/14; and

The Grifters on 8/21.

Location: Graduate Student Center, 3615 Locust Walk

Category: Film

More info:

<http://www.upenn.edu/gsc/programs/film.htm#con>

Con games lie at the core of much detective fiction and fact, as well as recently popular email scams. There is a confidence business, indeed an industry, with its own lessons and skills. (This takes us beyond the scope of the book. Those wishing to go further might consult such works as *How to Become a Professional Con Artist*, by Dennis M. Marlock.)

1.1.11 Statesmanship

Ending this list on a less cynical note, George Washington is understood to have been a politically ambitious man throughout his life. He actively, deliberately sought and schemed for the power, influence, and adulation he ultimately received. Washington notoriously wore his military uniform during the deliberations on the Declaration of Independence, just to remind the other delegates of his availability for command. In pursuing his ambitions Washington consistently and consciously followed a strategy of seeking rewards by actually deserving to get them. Resigning from the army at the end of the Revolution, an unexampled act, was a move calculated to make him fit for political leadership in a democracy. Declining to run for a third term as president was a move calculated to secure the success of the new country and of Washington's legacy.

Napoleon on his deathbed and in prison lamented that "They expected me to be another Washington."

⁹See <http://www.gametheory.net/> for yet another list of game-related movies, as well as lots of useful material on game theory.

1.2 Why Study Games?

Why are we interested in contexts of strategic interaction (CSIs)? The examples just discussed will, I hope, make it plain that games are interesting because war, diplomacy, poker, business strategy, and so on are each interesting in themselves and each are examples from a larger pool of important phenomena meriting attention. Besides interdependent, interactive choice—the characterizing feature of games—we see the interplay of reasoning, calculation and reckoning, deception, skill, bluffing, power, adaptation, flexibility, cooperation, learning, arbitrage, coordination, norms, communication, markets, social organization, and much else that is pervasive in, and fundamental to our understanding of, the social order. (And belonging to the AGE society of ideas.) Games are interesting because they are vortices of many interesting phenomena. Social phenomena manifest themselves—play themselves out—in games.

What would we like to know about games? As in any field of science we seek to describe, explain, predict, and intervene. We wish to describe and classify games in the wild systematically. The previous section is merely a hint at a much-needed natural history of games. We wish to explain and predict game outcomes. This often called *solving the game* in the classical literature. We also wish to understand—explain and predict—how it is outcomes are reached. How do agents of various sorts (experienced humans, naïve humans, monkeys, rats, lichens, organizations, artificial agents) find and implement their strategies of play? How does play unfold over time (and over space when geography is relevant)? Finally, we seek understanding of games in order to intervene in the world. We might hope to improve our own play in strategic contexts, or to design better social institutions (such as markets for electrical power that resist manipulation—“gaming”—as in the Enron affair [33]), or to field artificial agents that labor on our behalves (perhaps for negotiation or purchasing over the Internet). The scope of potential investigation is both magnificent and beyond our means. We should be content with modest progress, while keeping ourselves reminded of the larger issues. That, at least, describes my aims in this essay.

1.3 Methods of Study

Games in the wild, we must always remind ourselves, are the primary phenomena that motivate study of contexts of strategic interaction. The games we make up or develop as abstract models are ultimately interesting only because they contribute

to understanding games in the wild. How, in particular then, can we study strategic interaction? Various ways are open to us:¹⁰

1. *a priori*. CSIs or games in the wild may be abstracted and reduced to formal models, then studied mathematically, typically upon assumption of axioms of rationality. From this perspective, the theory of games is a branch of mathematics. Much of classical game theory proceeds in this mode. Standard textbooks and reference works include [3, 9, 17, 21, 30].
2. *in vivo*. Games, or strategic situations, may be studied *in situ*, as they (more or less) naturally occur. This is an historical—“natural history”—mode of investigation, but of course the history may be contemporary and the means of study may use techniques from anthropology, sociology, or journalism. Pioneers of this approach include Thomas Schelling (e.g., [28, 26, 27, 29]), and Jon Elster (e.g., [4, 5]).
3. *in vitro*. We can study games by doing experiments with real (“wet”) agents, including humans (e.g., [7, 16]), monkeys (e.g., [8]), even blue jays (e.g., [32]). And why not lichens and bacteria? The literature uses such names as *behavioral game theory* and *experimental economics* to refer to these kinds of investigations.
4. Algorithmic or *in silico*. There is much to be learned about games by representing agents as decision algorithms that choose their plays, and then studying the behavior of the resulting system. Fundamentally, this method of simulation or experimental mathematics is a variant of the *a priori* method. Let us call it *algorithmic game theory*. By allowing ourselves to use computational methods (instead of purely analytic mathematics) we may greatly extend the range, scope, and realism of models addressed, and concomitantly reduce the stringency of the assumptions required.

In what follows, we shall draw upon each of these methods. Our main focus methodologically, however, will be on algorithmic (or *in silico*) studies of artificial agents. Such studies may be, and have been, conducted from a variety of perspectives. Agents may be modeled as naked strategies (what we call *identity-centric* agents), possibly reactive or adaptive strategies, that play in tournaments (e.g., Axelrod’s original and seminal study [1]) or that play in a populated ecology which evolves under the replicator dynamic (e.g., [1, 10, 31]) or that play in a differentiated geography (aka: spatial games; e.g. [6, 13]).

¹⁰I am grateful for the discussion in [25].

Again, we shall draw upon these and related studies but focus our efforts elsewhere. That focus has four main aspects:

1. *Finite, non-ideal* contexts of strategic interaction. Agents are finite beings. Their rationality, their abilities to reckon and foresee, are limited. The algorithms with which we model these agents must be computable¹¹ and computable without exorbitant use of resources. Play unfolds in a finite population, for a finite time, and in a finite space. A major theme will be to compare and contrast results under finite, non-ideal and infinite, ideal regimes of play. Classical game theory employs what philosophers call an *externalist* theory of rationality. Here we are asking different questions and shall be focusing on *internalist* notions of rationality. The upshot of this point will emerge as we proceed.
2. *Identity-centric* more so than strategy-centric agents. Humans, and indeed monkeys and blue jays, in contexts of strategic interaction may be said to *have* strategies (rather than to *be* strategies), and to be capable of changing them in response to experience. These players, and most of the agents we shall consider, may meaningfully be said to have identities distinct from the strategies they employ at any given time. They are more than naked strategies. In particular, they are
3. *Exploring, probing* agents, not merely reactive agents. Humans, monkeys, blue jays, and most of our agents face the exploration–exploitation dilemma/tradeoff, addressed throughout the machine learning literature.

Finally, the strategic contexts we will focus on will be

4. *Chronic* and *social* more so than acute and singular, *ongoing* and *widespread* more so than unique. The games may be *repeated* or *iterated* or be like other games that will be played, rather than being unique, non-repeatable events.

A word of elaboration and justification for this last aspect of our focus. Contexts of decision, or choice, may be distinguished into *strategic* (or game-theoretic, the principal subject of this book) and *parametric* (not strategic, the principal subject of the field of decision analysis). Further, contexts of decision or choice may be distinguished into *acute* (“one-shot” or once-only) and *chronic*. Herrnstein’s name for chronic choices [15]—*distributed*—is an apt description, and I shall use

¹¹Technically, effectively computable, which I assume to be coterminus with the partial recursive functions. We are only interested in algorithms that implement partially recursive functions.

it. Chronic decisions or choices are distributed, usually in time. We may think of habits as chronic decisions that are, or become, more or less settled. The following table, then, summarizes this framework:

	Acute (one-shot)	Chronic (distributed)
Parametric	decision analysis	decision analysis
Strategic	classical game theory	this essay

Table 1.1: Framework categorizing decision/choice contexts

Further, as I have noted, decision contexts may be distinguished into *individual* and *social*, although this distinction is perhaps more applicable to strategic than to parametric contexts. In any event, there will be much emphasis in what is to follow on *social* aspects of distributed strategic choice.

We often *are* inclined to think of games in terms of acute, dramatic points of decision. This is captured in the penultimate stanza of “Casey at the Bat” (Ernest L. Thayer, alias Phin, page 4 of the San Francisco *Daily Examiner*, June 3, 1888).

The sneer has fled from Casey’s lip, the teeth are clenched in hate.
 He pounds, with cruel violence, his bat upon the plate.
 And now the pitcher holds the ball, and now he lets it go,
 and now the air is shattered by the force of Casey’s blow.

Of course the final stanza is

Oh, somewhere in this favored land the sun is shining bright.
 The band is playing somewhere, and somewhere hearts are light.
 And, somewhere men are laughing, and little children shout,
 but there is no joy in Mudville – mighty Casey has struck out.

But first, many games, many contexts of strategic interaction, *are* distributed or chronic, or approximately so. Agents do business with a particular merchant, doctor, lawyer, restaurateur repeatedly. Agents have friends, partners, lovers, spouses, colleagues they encounter more than once. Agents have competitors in the market for more than a day. Agents are embedded in societies. Very often indeed, strategic contexts cannot be separated from the future or the past.

And second, is Casey’s situation really unique, even for Casey? True enough, Casey is in a zero-sum game in the sense that only one team can win. It is also

true that in any given at-bat the pitcher in baseball has the advantage; anyone can strike out. Most likely, however, there will be another game tomorrow or the next day. Casey's interest lies in maximizing the expectation of his future contributions to the team. Getting angry, pounding the bat, focusing exclusively on this game and this moment is, perhaps, not the wisest of moves on Casey's part. Better to take the long view. Better to have the pitcher strike you out than for you to strike yourself out. Perhaps the long view can inform the acute. Perhaps, at least sometimes, learned policies of play in the chronic case should drive or at least inform play in the acute case. What follows has among its aims the investigation of such conjectures and their ramifications.

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