2 What Is Decision Making?

Reporter: Have you made up your mind yet?

Yogi Berra: Not that I know of.

2.1 Definition of a Decision

A good image of what we mean by decision making is of a person pausing at a fork in the road, and then choosing one path—to reach a desired goal or to avoid an unpleasant outcome. The most important evolutionary situations that selected our basic decision-making capacities probably involved physical approach or avoidance—which waterhole, field, fruit tree, cave, stranger, mate, and so forth, to approach and which to avoid. In prehistoric times, bad decisions were punished in a dramatic manner; as the philosopher Willard van Orman Quine (1969) commented, "Creatures inveterately wrong in their inductions have a pathetic but praiseworthy tendency to die before reproducing their kind" (p. 126). In other words, animals, including humans, that make bad predictions of the future and consequently bad decisions tend to die before they can pass their genes on to the next generation; this is one reason that we, and other animals, are good at making survival decisions.

If we took a census of situations that we label *decisions* in the modern world, it would look quite different from the list of essential decisions in primordial environments. What college course should I enroll in next semester? Is the defendant innocent or guilty? Should I move my retirement investments from stocks to real estate? Which car should I purchase? Some, however, are still essential to survival and well-being: Should I marry my current partner? Should I have surgery or chemotherapy?

Table 2.1 is compiled from several surveys of examples of "decisions" reported by students, retired persons, academic historians, and decision textbook authors (see Allison, Jordan, & Yeatts, 1992, for a systematic study). (We present these examples exactly as they were stated by the sources—without any editorial changes.) It is worth noting that all of these decisions are deliberate, conscious accomplishments, although we probably want to call some highly automatic mental processes decisions as well. For example, it is useful to analyze automatic driving behaviors as a sequence of decisions, and a spate of scientific papers analyze the microsecond saccadic movements of the eyes as decisions (Newsome, 1997). However, for the most part we focus on more deliberate, controlled decision processes in this book. In addition, we briefly discuss the extended, long-term sequences of self-control behaviors that are often referred to as decisions, although only the initial events in those sequences could qualify as decision processes in the terms used in this book. For example, we might refer to the "decision" someone makes to lose weight, including long-term, persistent efforts as part of "the decision." But the self-control processes involved in implementation and adherence to such decisions lie outside of the scope of our discussion in this book.

A *decision,* in scientific terms, is a response in a situation that is composed of three parts: First, there is more than one possible course of action under consideration in the choice set (e.g., taking the right or the left path at a fork in the road). Second, the decision maker can form expectations concerning future events and outcomes following from each course of action, expectations that can be described in terms of degrees of belief or probabilities (e.g., the belief that the right-hand path becomes impassable a mile up the trail and that the left-hand path leads to a scenic lake with a good campsite). Third, the consequences associated with the possible outcomes can be assessed on an evaluative continuum determined by current goals and personal values.

The problem with this definition is that it includes so many situations that it could almost serve as a definition of *intentional behavior,* not just *decision behavior.* This is why we also rely on the collection of examples of decision behaviors to provide a more tangible sense of what counts as a decision for present purposes. The examples in Table 2.1 all fit the three-part definition: two or more courses of action, uncertainty about events that will affect the relevant outcomes, and positive-negative consequences contingent on the events. It is this integration of beliefs about objective events and our subjective evaluations of those events that is the essence of decision making.

Table 2.1 Examples of "Decisions" Generated by Four Samples of Respondents

Older Adults
Whether to buy a new or used car
Whether to move into a retirement community or to live alone in my house
To retire early or to work for another 10 years
Whether to choose cremation or burial after death
Which heir to leave my money to
How much money to give to which charities
Whether to have a knee operation
Whether to travel by plane or bus
Which presidential candidate I should vote for
What church to join
Whether to get married
College-Aged Adults
To go to college
What career or job to choose
To work while my children were preschoolers
Whether to fix my car or "junk" it
To get a job vs. graduate school
Whether or not to have my tongue pierced
Religious preference
To vocally defend some of my controversial viewpoints or to just keep quiet
To abstain from all drugs
To have my dog put to sleep
To confront my father about his drinking
Which parent to live with after a divorce
Whether and when to sever a relationship
Which college courses to take
Where I want to live next year
To visit an old roommate or not

(Continued)

Table 2.1 (Continued)

Scholars' Examples of Significant 20th-Century Historical Decisions
Johnson's decision to escalate involvement in Vietnam in the 1960s
Hitler's invasion of Russia (1941)
Supreme Court decision: *Brown v. Board of Education* in 1954 (desegregation of public schools)
Rosa Parks's decision not to give up her seat on the bus in 1956
Supreme Court decision: *Roe v. Wade* (to legalize abortion)
U.S. Public Health Service decision to put the birth control pill on the market, 1950s
King George's appointment of Churchill in 1940
U.S. election of Franklin Roosevelt (1932)
Truman's decision to support the Marshall Plan (1947)
Decision to establish the common market in Western Europe (1958)
Decisions of leaders to sign the Treaty of Versailles (1919)
Chamberlain's and Dadalier's decision at Munich to "appease" Hitler (1938)
Decisions Appearing as Examples in a Popular Decision-Making Textbook
Estimating the risks associated with nuclear war
Which medical treatment to use on a patient
Which lottery ticket to purchase
Which casino gamble to play
Whether to buy car insurance
Whether to support building a nuclear power plant
Deciding between two different financial (stock market) investments
Which classes to take
Which consumer product (e.g., television set) to buy or which apartment to rent

2.2 Picturing Decisions

We will use schematic "decision tree" diagrams to describe decision situations throughout this book. One of the major uses of these diagrams is to summarize the essential structures of personal or public decision situations in order to apply the principles of scientific decision theory to choose the best course of action. We will introduce this applied "decision analysis" approach in Chapter 11. But for the moment, we want to explain the method of constructing the diagrams so that we can use them to describe the tasks and situations that are important in research on decision-making behavior.

The conventions of the decision tree diagram are that the situation is represented as a hypothetical map of choice points and outcomes that lead to experienced consequences, like a roadmap representing forks in a road and the objects that are located along the road. For example, we might summarize a medical situation concerning a knee injury, as in Figure 2.1. On the left is a choice point—we use squares, □, to indicate "choice points" at which the decision maker chooses a course of action; the lines represent choices that lead to the outcomes that follow from choosing each course of action. In the medical example, we imagine two possible courses of action: have a knee operation or do not have the operation. Events that are out of the decision maker's control are indicated by circles (○) representing uncertain outcomes, sometimes the actions of a competitor or just another less-than-perfectly predictable human agent; we don't know for sure, nor can we control which path we will take *out* of a circle. In the medical example, the upper path ("do not operate") is associated with two possible outcomes: The knee improves on its own (it was "normal" in the first place) or the knee remains in bad shape (it was truly injured). The lower path, representing the "have the operation" course of action, is also associated with two outcome paths: The operation is successful (maybe the operation was necessary and fixed the problem, or maybe the operation was unnecessary) or the operation is a failure.

On the far right-hand side of the diagram, we list the consequences that are associated with choice points and events in the decision tree. We will often summarize the decision maker's evaluations of those outcomes (traditionally called "utilities," but we prefer to call them "personal values") with numbers. Sometimes a decision problem is stated with numbers associated with the consequences (e.g., money payoff gambles; life-and-death medical and policy problems, with "lives saved–lives lost" tabulations). In these problems, we may use the numbers in the problem statement as summaries of consequences—but keep in mind that the subjective personal values of quantities like dollars do not bear a direct, linear relationship to the predicted or experienced personal values. (We'll discuss the issues of valuation of such consequences in Chapters 9 and 10.) When the consequences are not already quantified, by convention we'll use a 0 (worst) to +100 (best) scale for simplicity. We will always assign a 0 to the worst outcome we can foresee (in the decision tree) and a +100 to the best. In the medical example, the worst outcome would be to "have the operation and the knee is still in bad shape" (0); the best outcome would be "no operation and the knee recovers" (+100). We might assign a +80 to the outcome "operation is a success" and +20 to "no operation and the knee is still in bad shape." (In this age of HMOs and various forms of governmental and private health insurance, the task of "scaling" the value of life under various medical conditions, e.g., as "quality-adjusted life years," is enormously important.)

We will also express the decision maker's degrees of uncertainty in judging the possible outcomes that occur at the event nodes in the diagram in numerical terms. Here we will use a probability scale (from 0.00, could not possibly occur, to 1.00, certain to occur; although we often talk about probability numbers on different scales, e.g., "There's a 70% chance the Bears will beat the Packers," it is important to use the 0.00–1.00 scale to make sure the arithmetic calculations are correct). For example, if the decision maker judges that the probability the knee will recover with no operation is .30, we would assign that number to the corresponding path from the event node. Thus, we would

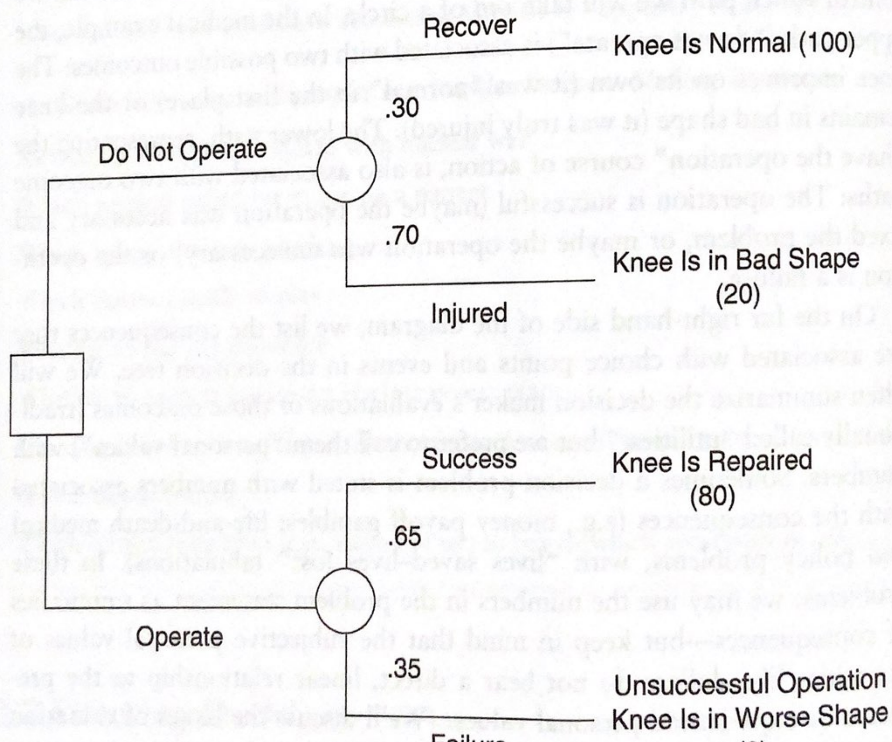

Figure 2.1 A hypothetical medical decision situation: An apparent knee injury requires a decision between whether to have an operation or not

assign .70 as the probability that the knee will remain in bad shape if there is no medical intervention. Since we expect that the chances of recovery would be higher if the patient has the operation, we might assign .65 as the probability the knee will recover if the patient decides to have an operation; thus, there is still a .35 probability of no recovery even after the operation.

We will use probabilities (in the range from 0 to 1) to represent beliefs about what will happen. Usually we mean to summarize people's *subjective beliefs* about those events. Although we use numbers that might be interpreted as formal probabilities by a mathematician, we do not assume that these numbers necessarily behave like true probabilities. In fact, one of the important discoveries of psychological research is that subjective probabilities are not always consistent with mathematical probabilities. (Chapters 7 and 8 summarize many of the ways in which our judgments under uncertainty violate rules of formal probability theory.) When we mean to refer to mathematical probabilities, we will make sure the context is clear. (The Appendix in this book introduces the mathematical laws of probability.)

We will not spend much time in this book on how these numbers summarizing consequence values and outcome uncertainties might be extracted from people's thoughts about decision situations, but psychologists and economists have developed many useful scaling methods to solve these measurement problems. To spare the reader a lot of technical detail, we will usually just present plausible numbers. The reader who wants to understand these methods can find this information in many other sources (e.g., Dawes & Smith, 1985).

We will often use simple gambles to illustrate decision-making principles and habits. Gambles are the most popular experimental stimulus in research on decision making, and they provide well-defined, easy-to-understand decision dilemmas in situations where we can be sure that our research participants want to "maximize" the amount of money they earn in the experiment. So, let's work through the representation of a typical experimental gamble in terms of the decision tree diagrams. Consider the choice between two gambles we described in Chapter 1:

(a) With probability .20 win $45, otherwise nothing.

(b) With probability .25 win $30, otherwise nothing.

Figure 2.2 summarizes this situation in a decision tree diagram—when the outcomes are naturally scaled with meaningful numbers like dollar amounts, we will just use those numbers for clarity (rather than the 0–100 scale we use for more subjective outcomes). An interesting question, which is of practical importance for judgment researchers, concerns the extent to which human

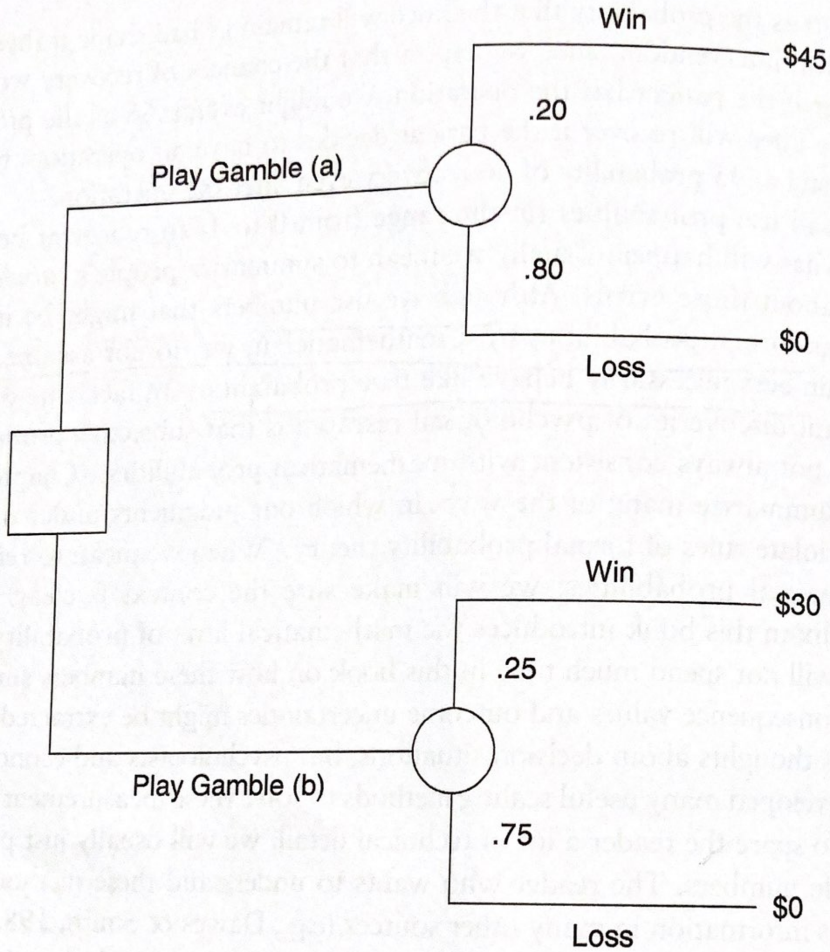

Figure 2.2 Decision tree representation of a simple money gamble that might be used as an experimental stimulus

thinking is the same both in crisp, well-defined gambles and in ambiguous everyday situations (like the knee operation; Lopes, 1994, provides a thoughtful discussion of this issue). We will frequently ask ourselves the following: Do the results from research in which people are asked to make choices among money gambles generalize to everyday decisions? If we know how a person chooses in an artificial gambling task, can we predict how that person will choose in an analogous naturally occurring decision situation?

2.3 Decision Quality, Revisited

The decision tree diagrams remind us that the crucial first step in understanding any decision is to describe the situation in which the decision occurs.

That step may sound trivial, but the attempt to construct a summary diagram forces us to answer difficult questions about what to include and, more difficult, what to exclude. Then the diagram prompts us to solve the challenging problem of *quantifying* the uncertainties and values that define the decision. Solving the problem of inferring how another person has conceptualized a decision situation is usually the toughest part of psychological research or applied decision analysis. (Much of the craft of research design involves creating experimental situations in which the researcher restricts the subject's thought processes and understands the effects of those restrictions on the subject's mental model of the experimental situation.)

If we believe that we have captured our subject's situation model in a decision tree diagram, it is relatively easy to calculate the decision that leads to the highest expected outcome by applying a rule that follows from decision theory (the four rational assumptions introduced in Chapter 1). This rule is called the *rational expectations principle*, and it is usually summarized as an equation:

$$\text{Utility} = \Sigma\ (\text{probability}_i \times \text{value}_i).$$

The equation prescribes that for each alternative course of action under consideration (each major branch of the decision tree), we need to weight each of the potential consequences by its probability of occurrence, and then add up all the component products to yield a summary evaluation called an *expected utility* for each alternative course of action (each initial left-hand branch). In our example medical decision (Figure 2.1), the calculations specify the expected utility for "have the operation" as +52 ([+80 × .65] + [0 × .35]) and for "do not operate" as +44 ([+100 × .30] + [+20 × .70]), implying that the rational decision would be to have the operation. In the case of the gamble (Figure 2.2), if we assume that the dollar values represent the decision maker's true personal values for those consequences (an assumption that needs to be carefully examined), the expected utility for gamble (a) is $9.00 ([$45 × .20] + [0 × .80]) and for gamble (b) is $7.50 ([$30 × .25] + [0 × .75]), implying the decision maker should choose to play gamble (a), if the expected value is the only consideration.

Note that these calculations assume we can describe the decision process in terms of numerical probabilities and values and that arithmetic operations (adding, multiplying) describe the decision maker's thought processes. The calculation also assumes that the decision maker thoroughly considers all (and only) the options, contingencies, and consequences in the decision tree model of the situation. As we will see, most everyday decisions are not as consistent or thorough as they would need to be to fit the rational expectations principle. However, the decision tree representation and calculations are a good place to start in creating a model to describe the decision thought process and, even if the representation is not descriptively accurate in all details, it may be useful as a model to analyze and improve our decision processes.

2.4 Incomplete Thinking: A Legal Example

Let's consider a complex decision that is made by many citizens of the United States, the acquit-convict decision that a criminal trial juror is asked to make. Figure 2.3 summarizes the contingencies and the consequences for a simple version of a juror's decision where there are only two possible verdicts, acquit or convict. (We'll ignore the possibility that the decision maker will "decide not to decide" and refuse to commit to a verdict, and we will avoid the complexities of multiple verdicts, e.g., innocent, or guilty of manslaughter, or guilty of second-degree murder, or guilty of first-degree murder.) According to decision theory, a rational juror should think through all four right-hand consequence terminals of the diagram, carefully assess his or her evaluation of each consequence, and then weight those consequences by their probabilities. In the diagram, we have inserted numbers to represent a juror's beliefs and feelings, and if we accept those numbers and perform a rational expectations principle calculation, this juror should conclude that the defendant is innocent and "acquit."

What is interesting is that people do not appear to engage in the thorough, consistent thought process that is demanded by the decision tree representation when they make these kinds of decisions in everyday life, even when they are in the jury box in a trial where their decision will have serious consequences. They do not appear to "think through" each of the options, to evaluate and weigh every one of the terminal consequence nodes in even a simple four-node tree like our example. Rather, people seem to focus on one or two nodes and reason extensively about those, but incompletely about the whole tree (Pennington & Hastie, 1991). Typically, people focus on the gains and losses associated with the decision they initially believe is most attractive, but ignore the gains and (especially) the losses associated with the other alternatives. Thus, jurors who form an early impression that the defendant is innocent usually evaluate only the consequences that might ensue if they make that decision.

This form of incomplete thinking is similar to the thinking of the clinician (discussed in Chapter 1) who was trying to assess the validity of the claim that child abusers never stop on their own. The clinician's thinking was dominated by his available experience. More generally, a decision maker's thoughts are dominated by his or her initial impression, a phenomenon referred to as a

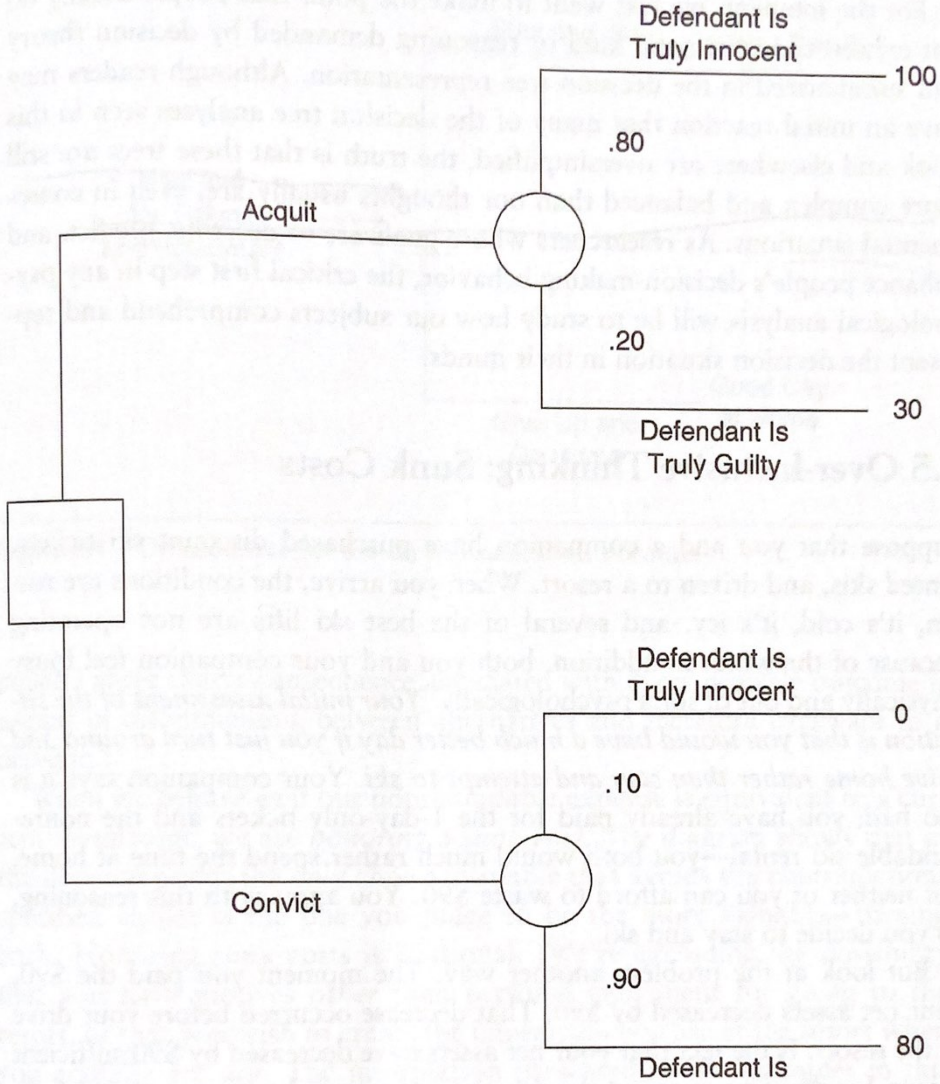

Figure 2.3 Decision tree for a stylized juror decision in a criminal trial

primacy effect or *confirmatory hypothesis testing* (Nickerson, 1998). Baruch Fischhoff (1996) reached a similar conclusion about people's thinking in more informal, everyday decisions such as teenagers' decisions about school, social, and family life (including some decisions about matters with serious consequences such as drug use, contraception, marriage, self-defense against criminal assaults, and career choices). Fischhoff observed a general tendency to focus on the few *most salient* possibilities and consequences and to ignore others, resulting in incomplete analysis (see also Galotti, 2002).

For the moment, we just want to make the point that people usually do not exhibit the systematic kind of reasoning demanded by decision theory and summarized in the decision tree representation. Although readers may have an initial reaction that many of the decision tree analyses seen in this book and elsewhere are oversimplified, the truth is that these trees are still more complex and balanced than our thoughts usually are, even in consequential situations. As researchers whose goals are to describe, predict, and enhance people's decision-making behavior, the critical first step in any psychological analysis will be to study how our subjects comprehend and represent the decision situation in their minds.

2.5 Over-Inclusive Thinking: Sunk Costs

Suppose that you and a companion have purchased discount ski tickets, rented skis, and driven to a resort. When you arrive, the conditions are rotten, it's cold, it's icy, and several of the best ski lifts are not operating because of the wind. In addition, both you and your companion feel lousy physically and out of sorts psychologically. *Your initial assessment of the situation is that you would have a much better day if you just turn around and drive home rather than stay and attempt to ski.* Your companion says it is too bad; you have already paid for the 1-day-only tickets and the nonrefundable ski rental—you both would much rather spend the time at home, but neither of you can afford to waste $90. You agree with this reasoning, so you decide to stay and ski.

But look at the problem another way. The moment you paid the $90, your net assets decreased by $90. That decrease occurred before your drive to the resort. Is the fact that your net assets have decreased by $90 sufficient reason for deciding to spend the day at a place you don't want to be? Still, you think that if you go home you will have *wasted* the $90; waste not, want not. Perhaps you are slightly overweight due to the same reasoning. Once you have paid for your food, you feel compelled to eat it all in order to avoid wasting it—even though the outcome of that particular policy is to decrease your dining pleasure *and* to make you fat.

The $90 you *have already paid* is technically termed a *sunk cost.* Rationally, sunk costs *should not affect decisions about the future.* If we draw a decision tree diagram, summarizing your situation as you stand in the ski resort parking lot wondering whether or not to use your lift ticket, we see that the $90 does not appear in your decision dilemma on the right side of the diagram (Figure 2.4). (Or you might include it in every consequence node, since it has already been spent; decision theorists [and most

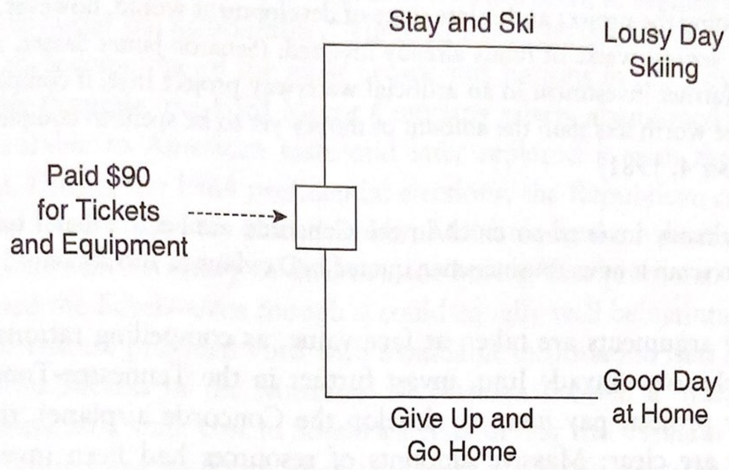

Figure 2.4 Decision tree for the ski trip sunk costs dilemma

people] agree that a consequence associated with every possible outcome is useless in discriminating between alternatives and therefore irrelevant to a decision.)

When we behave as if our nonrefundable expense is equivalent to a current investment, we are *honoring a sunk cost.* The diagram shows that at the decision point, the only choice available that avoids the contradictions specified earlier is the one you judge to be the more valuable—turning back. Honoring sunk costs is irrational. (We're excluding the possibility that you have motives *other* than personal enjoyment for going to the resort, or that you wish to create the impression you are at the resort when you actually are not. The information presented in the examples in this book is to be taken as the total information available to the decision maker. Naturally, if there is other information, or if there are other reasons for engaging in a behavior that are not specified in the examples, then the choices might be different.)

People honor sunk costs, as the examples below illustrate:

> Finally, the day has finally come. You've got to think logically and realistically. Too much money's been spent, too many troops are over here, too many people had too many hard times not to kick somebody's ass. (Sergeant Robby Felton on the first day of the first Gulf War, January 16, 1991; and a more general remark attributed to proponents of continuing U.S. involvement in the 1960s war in Vietnam and the recent conflict in Iraq: ". . . our boys shall not have died in vain"; quoted in Dawkins & Carlisle, 1976)

> Completing Tennessee-Tombigbee is not a waste of taxpayers' dollars. Terminating the project at this late stage of development would, however, represent a serious waste of funds already invested. (Senator James Sasser, arguing for further investment in an artificial waterway project that, if completed, would be worth less than the amount of money yet to be spent to complete it, November 4, 1981)

> I have already invested so much in the Concorde airliner . . . that I cannot afford to scrap it now. (businessman quoted in Dawkins & Brockmann, 1980)

If these arguments are taken at face value, as compelling rationales for their conclusions (invade Iraq, invest further in the Tennessee-Tombigbee Waterway project, pay more to develop the Concorde airplane), the irrationalities are clear: Massive amounts of resources had been invested in mounting the war; therefore, we can't stop now, no matter what the current situation. Like lost lives, dollars must not be spent in vain. But limiting concern to the *future* consequences of choices, which is made clear when a decision tree is constructed, starting from the "present" on the left side and running to the future, is the best way to avoid honoring sunk costs. Conversely, honoring sunk costs violates the first criterion of rationality—that decisions should be based only on future consequences.

We should note that there is some ambiguity about the irrationality of these arguments for the speakers. Perhaps they are really rationalizations or are motivated by ulterior considerations: The soldier was quoted on the day the Gulf War started; he was about to risk his life anyway, with little choice about the matter. Why not think of a "logical and realistic" rationale for doing so? The senator was advocating further federal investment in his state, which would provide employment and other benefits to his constituents. Nonetheless, it is still puzzling that the speakers would expect others to find these sunk costs arguments convincing if they themselves did not accept their validity.

The descriptive, psychological point is that we have a habit of paying too much attention to past losses and costs when we make decisions about the future. Even in the context of our discussion of justifications of sunk cost thinking in terms of future consequences, there is ample evidence that we give too much weight to sunk costs in many practical decisions (Staw & Ross, 1989; Teger, 1980). With reference to self-improvement, we need to deal with the possibility of social disapproval as a potential future consequence of our decisions.

But consider some real-world *counter*examples: Hirohito, the Emperor of Japan, who on August 15, 1945, announced Japan's surrender at the end of World War Two by stating, "The war situation has developed not necessarily to Japan's advantage. . . . In order to avoid further bloodshed, perhaps even the extinction of human civilization, we shall have to endure the unendurable, to suffer the insufferable." He lived to see his country recover from the war to become one of the most prosperous nations in the world today. In another example, the Ford Motor Company wisely abandoned the Edsel as not suitable to American taste and later replaced it with the popular Mustang. During the 1964 presidential elections, the Republican candidate, Barry Goldwater, publicly chided Robert McNamara, the former president of Ford (then the secretary of defense), for having first promoted and then abandoned the Edsel—even though it could equally well be maintained that the Edsel venture provided Ford with invaluable information that led to the tremendous success of the Mustang. McNamara showed a much greater commitment to a sunk cost in Southeast Asia during the Vietnam War—as did the subsequent secretary of state, Henry Kissinger, who wrote, "We could not simply walk away from an enterprise involving two administrations, five allied countries, and thirty-one thousand dead as if we were switching off a television channel." The kindest interpretation of these commitments is that because the leaders of *other* nations honor sunk costs, the United States would have suffered a severe blow to its reputation as a wise world power had it failed to do so.

Another reason that some apparent sunk cost ventures may not be irrational is that the decision makers are choosing actions to project and preserve their reputations for being decisive or for not being wasteful. Just as the person who orders too much food might be labeled a poor judge of his or her own appetite and wasteful, these decision makers might be trying to protect their *future* reputations as morally consistent individuals or good decision makers. If, indeed, abandonment of a sunk cost negatively affects future reputation, then it may be wise not to do it. The auto maker who abandons the Edsel may be derided for making a "gutless" decision and lose future clout and actual power within his or her organization. The skier who gives up after having already paid $90 may be regarded not just as financially wasteful, but as confused or silly, and lose his or her friends' respect. Such future reputational costs are perfectly reasonable factors to consider in determining whether or not to abandon a particular course of action (see Figure 2.5). But the sunk cost *per se* should not be a factor. So long as other people believe in honoring sunk costs, the person who does not may be regarded as aberrant.

Some of these subtleties of interpretation were revealed in efforts to explain parental investment behaviors in human and nonhuman species. In a landmark, and still controversial, article on this topic, the anthropologist Robert Trivers (1972) defined parental investment as "any investment by the parent in an individual offspring that increases the offspring's chance of surviving (and hence reproductive success) at the cost of the parent's ability to

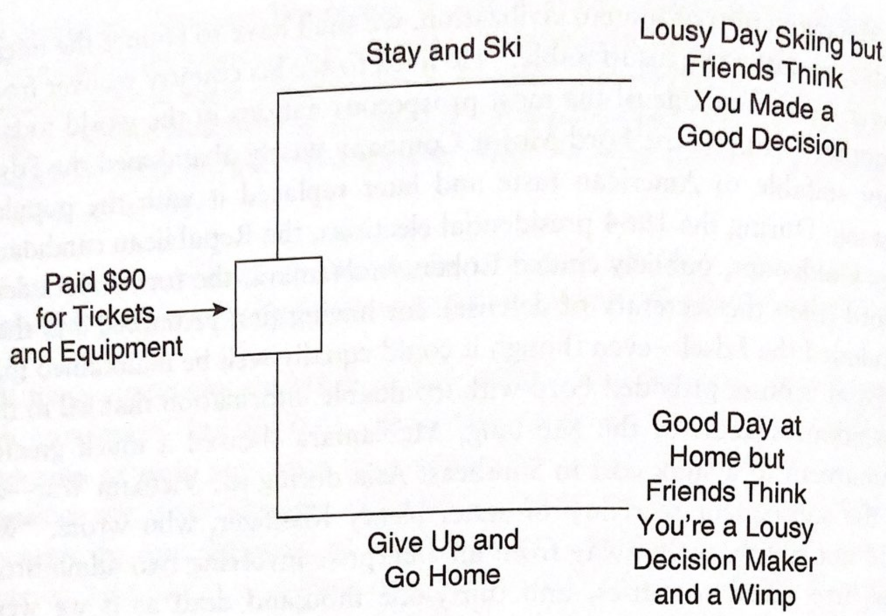

Figure 2.5 Sunk costs decision tree ski trip with reputational and self-concept costs included

invest in other offspring" (p. 139). Trivers used the concept of parental investment (e.g., differential feeding of young, defense of a nest) to explain diverse phenomena such as differential mortality rates between males and females, promiscuity, competition for mates, and nurturing strategies. Trivers's original explanation for the tendency of males to be more likely to abandon their offspring and mates than females exhibits a true sunk costs fallacy:

> At any point in time the individual whose cumulative investment is exceeded by his partner's is theoretically tempted to desert, especially if the disparity is large. This temptation occurs because the deserter loses less than his partner if no offspring are raised and the partner would therefore be more strongly tempted to stay with the young. (p. 146)

However, later analyses by the biologists Richard Dawkins (famous for popularizing the "selfish gene" concept from evolutionary biology) and Thomas Carlisle (1976) showed that it was more plausible that the mate desertion phenomenon was explained by the deserter's sensitivity to *future* consequences (an explanation that Trivers later endorsed)—namely, that the offspring who had already received the greatest parental investment were the most likely to survive to future reproductive maturity and would also require less parental investment in the future.

Interestingly, there appear to be no known examples of sunk cost fallacies in the life-survival decisions of nonhuman animals. Evolution and learning provide extremely effective mechanisms for selecting adaptive, even optimal solutions for species survival decision problems. Hal Arkes and Peter Ayton (1999) point out that human examples of sunk cost reasoning may result from people's tendency to overgeneralize rules for conduct such as "waste not, want not." Further confirmation is provided by the finding that younger humans (who are less likely to have internalized everyday truisms like "waste not, want not") are less likely to demonstrate sunk cost behaviors than adults. As Arkes and Ayton conclude, maybe the human adults are "too smart for their own good."

The subtleties of the sunk cost phenomenon have another message for those of us who favor controlled experiments as a primary scientific method. As noted above, naturally occurring examples of sunk cost errors are very hard to "prove" because there are so often subtle future considerations that *might* explain why a rational decision maker would appear to be showing the sunk cost fallacy. But experiments allow us to create refined situations in which "other considerations" can be eliminated. Hal Arkes and Catherine Blumer (1985) arranged to have three different theater ticket subscriptions sold to people who bought season tickets to the Ohio University Theater series. The experimenters arranged it so that, randomly, one-third of the patrons paid the full $15 price for the tickets, one-third paid $13 for the same package, and one-third paid $8. Compared with those who paid full price, those who purchased at a discount attended fewer plays during the subsequent 6-month season. Those who "sunk" the most money into the tickets were most motivated to use them. The experimental demonstration eliminates the interpretive ambiguity that is present in the (also important) naturally occurring examples.

To conclude on a practical note, the social problems that arise after abandoning a sunk cost can be ameliorated by a type of conceptual framing. The framing consists of explaining that one is not forsaking a project or enterprise, but rather wisely refusing "to throw good money after bad." Rationally, that is exactly what is involved in abandoning a sunk cost, which involves terminating a project or enterprise. Using this phrase, moreover, tends to enhance the credibility of the speaker, who is then relieved of the necessity to explain the irrationality of honoring such sunk costs. This "good money after bad" framing focuses the listener's attention on the *present* as the status quo and phrases the abandonment of a sunk cost as the *avoidance* of a sure loss (which is good). In contrast, honoring a sunk cost involves framing a *past* state as the status quo and abandoning it as the *acceptance* of a sure loss (which is bad). The person who abandons a sunk cost benefits from behaving rationally, and if the present is effectively framed as the status quo, he or she also enjoys the approval of others. Remember that President Kennedy achieved the height of his popularity shortly after he abandoned the Bay of Pigs invasion.

2.6 The Rationality of Considering Only the Future

The notion of ignoring sunk costs has arisen only with modern decision theory, which in turn is based on probabilistic thinking that arose in the Italian Renaissance. This thinking is based on the idea that probabilities can be assessed properly only with reference to *future* events. For example, consider a fair coin that has been tossed four times and is to be tossed a fifth time. The probability of its landing heads is 1/2. The pattern of previous results is irrelevant because they have already occurred and do not affect the way in which the coin is handled when it is tossed for the fifth time. For example, four previous heads do not make a fifth head unlikely—even though, in general, "four heads and a tail" (in any order) is an outcome 5 times more likely than five heads.

That the idea of limiting such probability assessments to future possibilities was not intuitively obvious prior to the Italian Renaissance (and may not be obvious today to most people who do not understand probability theory) can be inferred from answers proposed to a famous problem in Fra Luca Pacioli's *Summa de Arithmetica, Geometrica, Proportioni e Proportionalita,* published in 1494 (see David, 1962, for a discussion of the history of this problem). The problem is this: "A and B are playing a fair game of *balla,* in which six goals are required to win (see Figure 2.6). The game actually stops when A has won five rounds and B three rounds. How should the stakes be divided?" Paccioli thought that "past accomplishments"—prior wins—should determine the division. Paccioli's answer: 5:3.

One objection to this answer—dividing the stake proportionally to the number of rounds already won, *in the past*—is that it implies A should get the same amount (the entire stake) whether he or she has won one, two, three, four, or five rounds in a row against no wins by B, although A clearly is in a much better position the more rounds he or she has won. Moreover, it implies that A is more deserving when ahead 2 to 1 than when ahead 5 to 3, even though it is clear that A has a much better chance of winning the six-goal game from the latter lead.

It was not until 64 years later that G. F. Peverone proposed a solution that doesn't have the problems listed above (or others) and is consistent with the principle of considering only future events. According to Peverone's solution, the more consecutive goals won, the higher the proportion of the stake, and a player ahead 5 to 3 should receive a higher proportion of the stake than a player who is ahead 2 to 1. Peverone's insight was that the division of the stake should depend on each player's *future* probability of winning the six-goal game.

The solution is based on two principles. First, where p is the probability that A will be the first person to win six rounds *looking forward* from the current situation, p is the proportion of the stake that should be given to A. Second, p is computed by analyzing all of the possible rounds *remaining* (in the future) before A or B wins a total of six. The correct computation begins by noting that when A is ahead 5 to 3, the only way B can win six first is to win three consecutive rounds. Since the game is fair, that probability is $(1/2) \times (1/2) \times (1/2)$, or 1/8. (Regrettably, Peverone actually miscalculated p in his original essay.) Hence, because B's probability of winning is 1/8 and A's probability is 7/8, the split should be 7:1 for A and B, respectively. Similar calculations can be used to determine A's proportion of the stake when A has won five consecutive rounds, when A is ahead 2 to 1, and so on. When A has won six, A has a probability of 1 of having won, and of course receives the whole stake.

In general, the past is relevant, but only for estimating *current probabilities* and the desirability of *future states.* It is rational to conclude that a coin that has landed heads in 19 of 20 previous flips is probably biased, and that therefore the probability it lands heads on the 21st flip is greater than 1/2. It is not rational to estimate the probability of landing heads on the 21st toss by assigning a probability to the entire pattern of results *including those that have already occurred.* (Again, the probability of five straight heads when tossing a fair coin is 1/32; and the probability of a fifth head *given four heads*

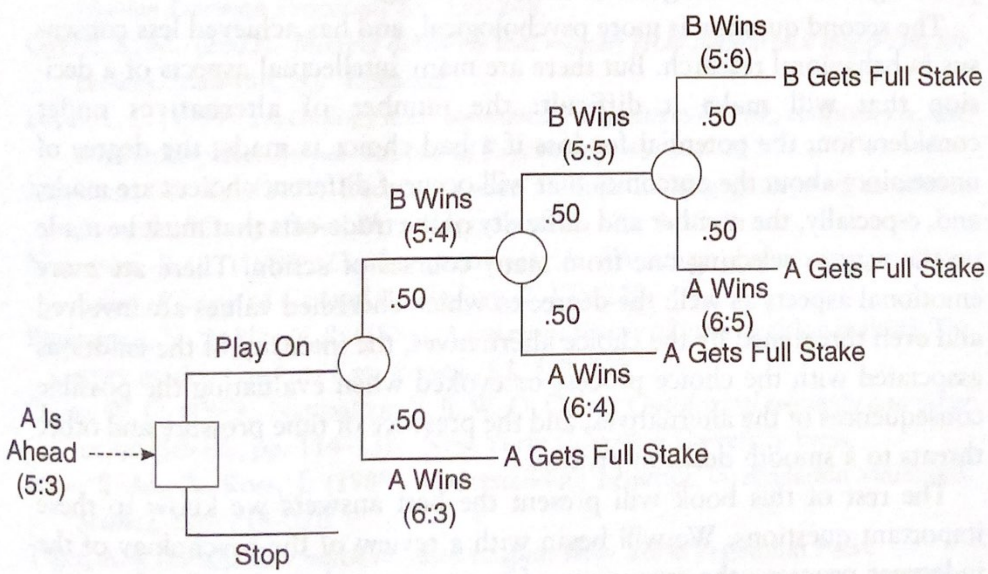

Figure 2.6 Decision tree for the game of balla

in the past is 1/2.) Rational estimation of probabilities and rational decision making resulting from this estimation are based on a very clear demarcation between the past and the future.

Rational decisions are based on a thorough assessment of future possibilities and consequences. The past is relevant only insofar as it provides information about possible and probable futures. Rational decision making demands the abandonment of sunk costs, unless such abandonment creates future problems outweighing the benefits of abandonment (e.g., the reputational costs discussed in the ski trip example). Today really *is* the first day of the rest of our lives.

2.7 The Rest of This Book

Two very general questions about decisions have dominated psychological research on this topic: What makes a decision good? And what makes a decision difficult? The answer to the first question has traditionally been with reference to principles of rationality: A decision is a good one if it follows the laws of logic and of probability theory, and their implications for behavior summarized in traditional decision theory. We will see that this standard is still the dominant one in professional evaluations of "goodness," although there has been a shift to include other measures of goodness. How robust is the decision process, and can it prevail over challenging conditions such as limited computational capacity ("brain power"); missing information; or in a chaotic, "nonstationary" environment? And how stable or "survivable" is the decision process in a competitive, "zero-sum" environment where it is pitted against other antagonistic decision strategies?

The second question is more psychological, and has achieved less consensus in behavioral research. But there are many intellectual aspects of a decision that will make it difficult: the number of alternatives under consideration; the potential for loss if a bad choice is made; the degree of uncertainty about the outcomes that will occur if different choices are made; and, especially, the number and difficulty of the trade-offs that must be made on the way to selecting one from many courses of action. There are more emotional aspects as well: the degree to which cherished values are involved and even threatened by the choice alternatives, the intensity of the emotions associated with the choice process or evoked when evaluating the possible consequences of the alternatives, and the presence of time pressure and other threats to a smooth decision process.

The rest of this book will present the best answers we know to these important questions. We will begin with a review of the psychology of the judgment process—the extensions of our perceptual systems that let us go beyond the information given to us through our senses (Chapters 3 through 8).

Then we will cover the rapidly advancing and still controversial subject area of the psychology of personal values and utilities (Chapters 9 and 10): How do we know and predict what we like? And we will conclude with an introduction to modern rational decision theory and some of its more psychologically valid modern descendants (Chapters 11 and 12).

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