Foundations of Decision Analysis

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GLOBAL EDITION

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PREFACE

Decisions are the only means you have to change your future life. We make decisions every day. Some decisions are routine, like choosing a television program to watch. Occasionally we make decisions that have profound effects on us and those around us. Gaining competence in decision making is a highly desirable attainment. Although many of the principles of good decision making have been known for centuries, there is little emphasis on this subject throughout our educational lives. The important concepts in this book could be taught in grade school and in high school. Yet when we ask graduate students about having taken previous courses in decision making, few say that they have. Students in professional courses from major companies with global interests have the same response.

The purpose of this book is to provide an opportunity to gain this mastery; to be able to achieve clarity of action in making any decision on which you focus your attention. One of the biggest obstacles in gaining decision competence is that most of us think we are pretty good at making decisions. Yet it is easy to demonstrate that even in relatively simple decision situations people make decisions that they see as unwise when they carefully review them.

Let us preview the major conceptual lessons that we will share. The most challenging phenomenon we face in decision making is uncertainty. Suppose for each alternative we face in making a decision we had a video showing the future course of our lives in as much detail as we wished. Then we could easily make the decision. Uncertainty is inseparable from all significant decisions. To become masters of decision making we must become competent in dealing with uncertainty. We must learn to surf on the sea of uncertainty rather than to drown in it. We must build clear thinking about uncertainty as a precursor to making a decision; we call this achieving clarity of thought.

Learning how to deal with uncertainty does not mean that we do not relish it in our lives. Who would want to live a life with a future calendar that is completely filled out so that, for example, you would know years in advance on each day when, where, and with whom you would be having lunch.

The most important distinction of decision analysis is that between a decision and the outcome that follows it. This distinction, once thoroughly understood, is a powerful aid to achieving clarity of action. Though it is common for people who make a decision followed by an unfortunate outcome to see the decision as bad, this is not clear thinking. Good decisions can have bad outcomes; bad decisions can have good outcomes. The quality of the decision depends only on the quality of the thought and analysis that you have used in making it.

The amount of analysis appropriate to a decision can range from virtually none to extensive computer modeling. Everyone will have extensive conversations about making important decisions–sometimes with others, sometimes with oneself. Mastering the concepts of decision analysis will increase the focus and usefulness of these conversations. While few decisions will warrant the extensive analysis possible using these methods, merely thinking using the concepts in this book can improve many of the choices we make every day. We find that as students become acquainted with decision analysis it changes their conversation with friends and colleagues.

An important distinction about any decision is its degree of revocability. Some decisions are very revocable, like changing the movie you will see once you arrive at the multiplex; other

decisions have limited revocability, such as amputating your leg for a medical purpose. The irrevocability of an important decision is a sign to invoke the power of decision analysis.

There is no point in valuing an outcome after the decision is made. You will be living the rest of your life beginning with that outcome or, as we prefer to call it, prospect. Once you commit yourself to making good decisions there is no place in your life for regret or guilt. *Good decisions never become bad; bad decisions never become good.*

Consider how evolution has prepared us for the modern world. What will befall an airplane pilot if he flies into the clouds and has no instruments? Soon he will think he is upside down when he is not, or not turning when he is. Without intervention he is likely to die. This is not a matter of his training or experience as a pilot, but rather that he is human. Humans never developed the ability to operate an aircraft without visual reference. Why not? Because before the invention of aircraft there was no evolutionary advantage to this ability. As long as you are standing on earth or swimming in the water, you know which way is down. Notice that birds that fly have no such problem. Duck hunters watching a flock fly into the clouds do not say, "Drop the guns, we will catch them as they fall." The many pilots of aircraft flying in bad visibility somewhere at this moment also have no difficulty, because the aircraft are equipped with instruments and the pilots are trained to read them. Even if a pilot feels he is upside down, his instruments show him that he is not.

Consider another example. For thousands of years, humans have been able to dive into deep water successfully for food or pearls. They would take a deep breath and hold it till they reached their goal and then return to the surface with their spoils. The development of scuba–self-contained underwater breathing apparatus–equipment has allowed people for many decades to do what only the most athletic of our ancestors could achieve. Suppose you are using scuba equipment and you have dived to a depth of 100 feet, about 3 atm, and then find that your equipment does not function. You are now far below the surface with only a lungful of air, air that is now extremely precious to you: you can't breathe. Your instinct is to head to the surface as quickly as possible and preserve what air you have. Unfortunately, following this instinct will probably kill you, for the lungful of air that you have will expand threefold by the time you reach the surface. This expansion will destroy the alveoli in your lung that allow you to breathe and admit air to your bloodstream. Following your instinct will kill you. Instructors point out that in this situation that as you slowly ascend, no faster than your smallest bubbles, you must blow out the air as you rise to avoid this misfortune. You must give up what is precious to you according to your instinct to save your life. (Of course it is even better to dive with a buddy who can assist you in these circumstances.) Here again before the invention of scuba there was no evolutionary advantage in having this be our natural behavior.

Finally, as you sit reading this, it is possible that under your chair there is a highly radioactive substance whose emissions will kill you by tomorrow. You have no alarm, since the ability to sense radiation was not of evolutionary value to our ancestors. If in our modern world you are concerned about the presence of radiation, there are many instruments that will warn you of its presence.

Now let us consider the evolutionary influence on decision making. While evolution has sensitized us to deal with judging the intentions of those we meet for millions of years, there is not any evolutionary knowledge of dealing with uncertainty. If each of us suddenly heard the roar of a live lion we would immediately react, though the noises of everyday life cause no alarm. There was an evolutionary advantage to being aware of dangers from other predatory forms of life that we have, fortunately, little reason to use frequently today. Yet someone can

sign a paper having profound effects on his future welfare without alarm since making marks on a paper does not inspire the natural fear induced by the lion's roar.

Just as knowledge and proper instruments have helped us overcome our evolutionary disadvantages in these areas, so also can they help us in becoming better decision makers. The essential commitment is to use our instruments rather than trusting our intuition.

It is easy to show, and we do so in several occasions in this book, that our intuition on matters of uncertainty is severely flawed. Using our instruments is essential for clear thinking. No matter how long you have studied the subject, solving probability problems intuitively is as likely to be successful as a pilot flying in bad weather without visible reference and without instruments. The list of people who have made reasoning errors about uncertainty looks like the roll call of famous scientists.

Once uncertainty has been mastered, the next step is to use our instruments for making decisions in the face of uncertainty to arrive at clarity of action. The decision procedure will apply to virtually every decision that you face. Once a student in decision analysis said that he could see using the methods we were presenting for financial decisions, but not for medical decisions. We replied that if we had to choose between using it for financial decisions and for decisions about the health of a family member, then we would hire a financial advisor to manage money and use decision analysis for family medical decisions. The reason is that we would want to use the best decision method for the health of family and we know no better method than the one we present in what follows.

This book summarizes what we have learned by teaching decision analysis to thousands of people in the United States and around the world in university classes and special professional educational programs. Dozens of doctoral students and colleagues have contributed to its development. We intend for this book to extend the appreciation and application of this field, with roots in centuries past, to the decision-makers of the future.

HOW TO USE THIS BOOK

Decision making in our daily lives is an essential skill, whose fundamentals should not rely on knowing much more than arithmetic. Often you can make the decision using easily explained concepts without any calculations. We have therefore written the early chapters of this book and certain later chapters to be accessible to a general audience. Readers with more mathematical and computational preparation can benefit from the remainder of the book after understanding the fundamentals.

To be specific, Chapters 1 through 17, Chapters 26, 29, and 33, as well as Chapters 37 through 40 provide the foundations of decision analysis using reasoning. The story is not in the math: a decision maker can, step by step, transform confusion into clarity of thought and action.

Other chapters in this book are intended to expose readers to problems that require a higher level of analysis, such as problems that may appear in organizations. They are covered in Chapters 18 through 25, Chapter 27, Chapter 28, Chapters 30 through 32, and Chapters 34 through 36. While the analyses in these chapters require a higher level of computation, they rely on the basic principles presented in Chapters 1 through 17. No knowledge of calculus is essential to proper understanding of any of these chapters.

The "Decision Analysis Core Concepts Map" at the end of this book is a useful tool to help you understand some of the main concepts presented. You can use this map in several ways. First, it summarizes some of the important concepts, and so it can be used as a checklist

for things you need to know. Second, it tells you the chronological order of concepts you need to understand before learning about another concept. An arrow from one concept to another helps you identify what you need to know before understanding a particular concept.

We do not require the reader to use any software for the analyses carried out in this book. Our purpose is to provide the foundations needed to solve the problems from fundamental principles. While software packages and spreadsheets undergo change in versions and upgrades, the concepts needed to solve these problems remain the same. An analyst should understand and know how to analyze problems from the first principles. We have presented much of the sophisticated analysis in tabular form to give the reader exposure to solving these problems numerically. To gain a better understanding of these chapters, we suggest that the reader repeat the tabular analysis on their own instead of just reading the chapters. The replication of these tables in spreadsheets or other current tabular forms can be assigned as homework problems in classes.

Chapter 37 provides an informative case study (The Daylight Alchemy) that has been used in many decision analysis classes as a final take-home exam. It captures many of the tools presented throughout the book.

Below are some suggestions for using this book in a classroom:

When teaching to an audience that has an interest in the foundations of decision making but less emphasis on the math or computations, the following chapters could be covered:

Chapters 1 through 17 introduce the foundations of decision analysis without requiring significant mathematical sophistication. Topics include characterizing a decision, the rules of actional thought, *u*-curves, sensitivity analysis, probability encoding, and framing.

Chapter 26 discusses multi-attribute decision problems with no uncertainty. The presentation prepares the reader to address multi-attribute problems where uncertainty is present.

Chapter 29 presents a fundamental notion about probability: when two people have differences in beliefs, we can construct a deal that both will find attractive, and we can also make money out of constructing those deals.

Chapter 33 analyzes decisions that involve a small probability of death, such as skiing or driving a car.

Chapters 37 through 39 explain how to use the decision analysis approach when there are large groups involved. They also discuss some impediments to quality decision making in organizations.

Chapter 40 discusses ethical considerations in decision making. Like any tool, decision analysis is amoral: you can use it to determine the best way to rob a bank. The ethics must come from the user.

Other chapters in the book are also relevant when teaching to a technical audience that would like to learn about large-scale problems and the computations involved. For example, seniors in an undergraduate engineering curriculum, MS students, or MBA students. For this audience, the instructor may wish to add any of the following chapters to the chapters listed above:

Chapters 18 through 25 discuss advanced information gathering from multiple sources, the concept of creating options in our daily lives, other types of *u*-curves that describe risk aversion, using approximate formulas for valuing deals, and the concept of probabilistic dominance relations that, when present, facilitate the determination of the best alternative.

Chapters 27 and 28 analyze multi-attribute problems where a value function for cash flows is determined and explain how to handle multiattribute decision problems with uncertainty.

Chapter 30 shows how to update probability after observing the results of an experiment.

Chapter 31 examines several auction types and illustrates how to use the basic concepts of decision analysis to determine the best bid and the value of the bidding opportunity.

Chapter 32 presents the concepts of risk scaling and sharing: how a decision maker can determine the best portion of an investment, how a partnership can share an investment, and how to establish the risk tolerance of a partnership.

Chapter 34 analyzes situations where a person is exposed to a large probability of death, such as may be faced in medical decisions.

Chapters 35 and 36 illustrate how to solve decision problems numerically by simulation and discretization.

We hope you enjoy reading the book and then applying this powerful way of thinking about decisions in your daily life.

1

Introduction to Quality Decision Making

CHAPTER CONCEPTS

After reading this chapter, you will be able to explain the following concepts:

- Normative vs. descriptive pursuits
- Reactive vs. proactive decision making
- Thought vs. action
- Decision vs. outcome
- What constitutes a good decision
- Stakeholders of a decision
- The six elements of decision quality
- The decision basis

1.1 INTRODUCTION

We all make decisions every day, but few of us think about how we do it. Psychological research has shown that people make decisions that after reflection they regard as wrong. Our purpose in this book is to provide a systematic process that enables quality decision making.

1.2 NORMATIVE VS. DESCRIPTIVE

To begin, it is important to distinguish between descriptive and normative pursuits. Descriptive fields do what the name implies; namely, describe reality and actions as they are, while normative fields identify how they should be. For example, it sometimes happens that when we add a column of numbers from the bottom up using pencil and paper, we obtain a different sum than when we add the same column of numbers from the top down. When this occurs, we say that we have made a mistake because we have an arithmetic norm requiring that the sum of numbers be the same regardless of the order in which we add them. If we have no norm for what we are doing, we cannot say descriptively that we have made a mistake. The rules of arithmetic provide norms for arithmetical computations. Similarly, the foundations of decision analysis provide the norms for decision making.

   Consider the various fields of study at the University. Is physics a descriptive or a normative field? Although many results in physics have the names of laws, in fact, these findings are models of reality that aim to describe what is so. To confirm their descriptive ability, they must be tested by experiment. Even today, scientists still perform expensive, sophisticated experiments to see whether Einstein's model describes the physical behavior of the universe. While

Newton's model has been used for centuries and continues to be used today, Einstein's model is more descriptive of physical behavior at velocities approaching the speed of light.

In this book, our primary focus will be on normative decision making—how we should make decisions, rather than how we actually make them. Yet for three important reasons, we shall also address descriptive decision making. The first reason is motivational: If we do not learn through demonstration that we are faulty decision makers, we will not see the point of learning a powerful normative process. The second reason is practical: Descriptive models of human behavior may allow us to predict the natural conduct of the people affected by our decisions. Just as the results of a normative process like addition are no better than the numbers entered, the results of our normative decision process will be no better than its inputs. We need to understand that these inputs come from humans displaying various biases and distortions, and we must learn to control for such factors. Finally, our descriptive knowledge of how people receive information will enable us to present our results and have them understood.

You might wonder about the difference between what we naturally do in making decisions and what we would like to do upon reflection. In other words, why is there a difference between descriptive and normative behavior? One possible explanation is that in evolutionary terms, we still have the bodies and brains of our caveman ancestors. Even in the business district of a major city, hearing the roar of a lion will alarm us. For millions of years, this instinctual sense of alarm was critical for survival, but today it is of little value.

One consequence of our origins is that in many cases, our natural capabilities are better suited to the challenges of our ancestors than to the challenges of modern life. Examples abound:

- We cannot sense a highly radioactive environment, even though it could kill us in a matter of hours.
- If we lose visual reference while flying an airplane in bad weather, without instruments, we crash.
- If we are scuba diving and we lose our air supply at depth, our natural instinct to hold our breath and dash for the surface might end up killing us.

Though we do not have these capabilities, we have developed compensations for them all:

- We use Geiger counters to sense radiation.
- We use instruments to fly in bad weather.
- We learn through instruction that the unnatural act of releasing air gradually as you surface is the proper procedure when scuba diving.

Another consequence of our origins is that we have capabilities that once helped us to survive, but now may even lead us to harm.

- Millions of years ago if you had food before you, you ate it before it could spoil or be taken from you by another creature. Now this instinctive behavior at the buffet table can be ultimately harmful if it leads to diabetes or heart disease.
- Millions of years ago if someone challenged you, aggressive behavior toward him could save your life. Now, road rage can lead to injury and death.

Figure 1.1 presents a way to visualize the effects of our nature on decision making. Here we picture our choice of action as determined by the interaction between two decision systems: One **deliberative**, or reasoned; the other **affective**, or emotional. The **affective decision system** is the "hot emotional system." This system existed within the 6+ million year old brain, and was motivated by sex, fear, and hunger stimuli that were directly related to survival. It focused on stimuli that are here and now; proximate and immediate.

Deliberative – Affective Decision Systems
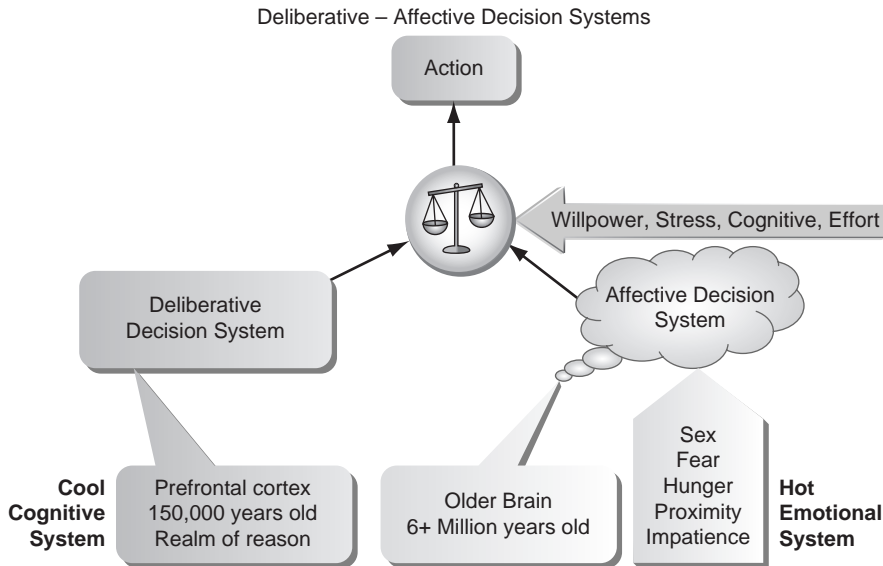
FIGURE 1.1 **Deliberative-Affective Systems**

In contrast, the **deliberative decision system**, or the realm of reason, is the "cool cognitive system." The final evolution of the human brain some 150,000 years ago resulted in the development of the prefrontal cortex, and along with that, the deliberative decision system. The prefrontal cortex enhanced, but did not replace, our "old" brains: As a result, the two systems coexist, often creating considerable internal conflict.

The pull of each system in determining action is influenced consciously, by willpower, and unconsciously, by factors such as stress and cognitive effort. We usually think of hard work as some kind of physical activity that will leave you exhausted. However, another kind of work, the cognitive effort involved in thinking, can end up exhausting your deliberative decision system, thereby increasing the influence of the affective decision system.

You might use willpower to avoid the tempting high calorie dessert by remembering that eating it will not serve your desire to lose weight. However, the jet lag you experience by flying through several time zones may create stress that will tip the scale toward the "hot" emotional system, resulting in poor reasoning during the next day's business conference.

Perhaps the simplest example of the struggle between the systems is to observe someone at a party eating handful after handful of peanuts and saying "I know I am going to regret this tomorrow."

We were not evolutionarily equipped to make many of the decisions we face in modern life. For example:

- Choosing among medical treatments that have uncertain and long run consequences.
- Making financial decisions, as individuals or companies, that will produce uncertain futures of long duration.

Making such decisions by "gut feel" is to hand them over to the affective decision system. As we proceed, we shall see many examples of affective decision making gone wrong. The purpose of this book is to develop our deliberative decision system and to increase its role in our decision making.

Learning normative decision making poses special challenges. We have all made thousands of decisions in our lives, and most of us think we are good at making them. If we offered

a course in breathing, a prospective student might say, "Why do I need a course in breathing? I breathe quite well already. I suppose you are going to tell me that if I am lying on the couch watching TV I can breathe at a slower rate than if I am running upstairs." Yet many people do have coaches for breathing: Singers, competitive swimmers, and even meditators.

While some of us may not need breathing coaches because we are not singers or competitive swimmers, none of us can escape making decisions. We know we have made decision mistakes, and that we may have developed flawed decision making habits. Increasing our ability to think clearly about decisions will benefit us throughout our lives and the lives of those we affect.

Since we are examining a human faculty in which most of us feel very competent, demonstrating the inadequacy of our present decision behavior may be discomfiting. If you take a course in calculus or Chinese history, you will rarely have to make a major change in how you think about yourself. You have a general idea of the subject, and you are going to learn much more about it. However, the content of the course will only occasionally challenge the way you are thinking about all the choices you make, major and minor, in your everyday life. In our subject, the challenge is continual. The benefit of grappling with that challenge is learning a powerful way to make decisions.

We sometimes describe the result of mastering this subject as installing a new operating system in your brain. You can now run powerful programs you could not run before, and you can no longer run the old programs. Do not embark lightly on this journey. There is an Eastern saying, "Better not to begin, but if you begin better to finish."

As Samuel Butler put it, "A little knowledge is a dangerous thing, but a little want of knowledge is also a dangerous thing." This book is not about making decisions only in a specific field, such as business or medicine. The concepts apply everywhere and are useful in all fields, as our examples will show.

1.3 DECLARING A DECISION

Decisions do not arise in nature. No one walks through a forest and says, "I have just spotted a wonderful decision." Decisions are declared by human beings. Sometimes they arise when we have what philosophers call a break in our existence—some change in our circumstances— that impels us to declare a decision. We can consider these decisions as reactive to the change. Whether we experience a change for the worse, like losing a job or falling ill to a disease, or a change for the better, like inheriting money, we face declaring a decision.

We can also declare decisions proactively, without any external stimulus. You can declare a decision about quitting your job or about taking up skydiving just because you want to. Figure 1.2 illustrates the different types of declarations.

Some of the most important decisions you can make are those you declare proactively. When Warren Buffett[1] was asked about the worst decision he ever made, he said, "The things I could have done and didn't do have cost us billions of dollars…" He viewed his worst investment failures as errors of omission, rather than commission—errors arising from a lack of proactivity.

Whether the decision is reactive or proactive, it is yours. The alternatives you have belong to you. You have total power over the alternative you select, but seldom over the consequences of selecting that alternative. We are using the word "alternative" in the American sense, rather than in the European sense. Saying, "We have one alternative" is understandable to an American, but a European might ask, "Alternative to what?" So when we say you have only one alternative,

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[1]Warren Edward Buffett (born August 30, 1930) is an American investor, businessman and philanthropist. Buffett has been one of the richest men in the world and has given most of his fortune to charity.

No Declared Decision

Change in Circumstance

Habitual Action

Declaring a Reactive Decision

Change in Circumstance

Conscious Choice

Chosen Response

Declaring a Proactive Decision

No Change in Circumstance

Conscious Choice

Chosen Response
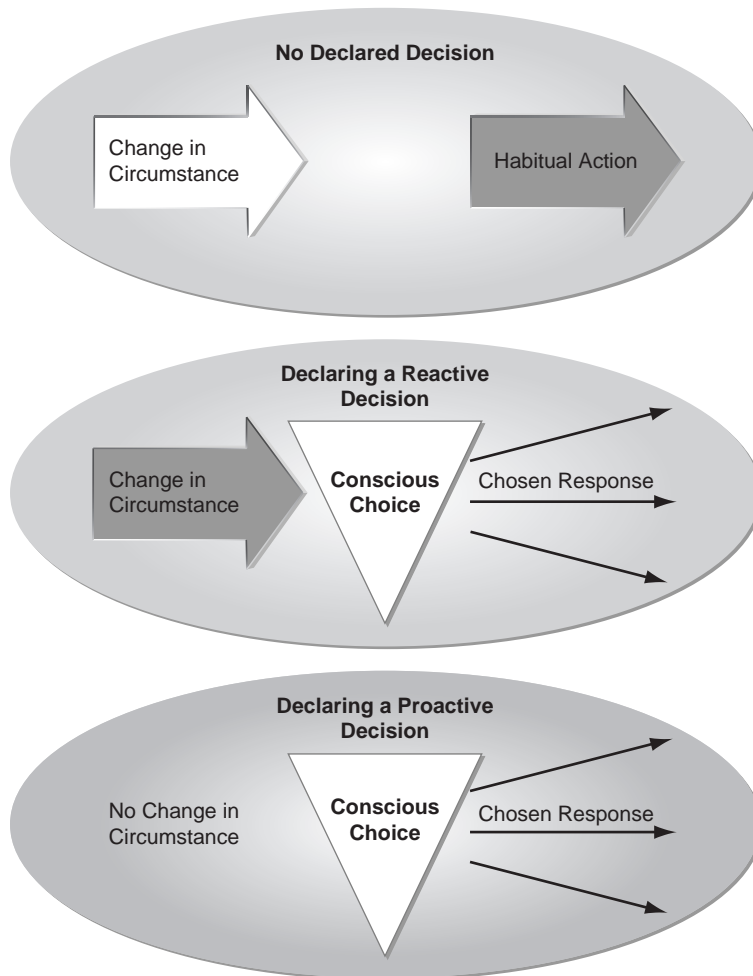
FIGURE 1.2 Declaring a Decision: Reactive vs. Proactive Decision Making

we mean that you have no choice. A cartoon once showed a chaplain offering comfort to a convict about to be executed in an electric chair. The caption was, "My advice is to pray to a saint who helps the wrong people by mistake."

Doing nothing is always an alternative. Suppose you go to a restaurant for dinner. The waiter presents the menu and then awaits your order. You say, "I will need a few more minutes." Shortly thereafter, he returns and you again request more time. Whenever the waiter returns, you repeat your request. What happens? The last time you see the waiter, he tells you that the kitchen is closed and that no more food will be served. You have chosen the "do nothing" alternative, and you have suffered the consequences.

To truly have alternatives in making a decision means that they are completely under your control. For example, you may say you have the alternative of getting a job with company ABC, but you do not. You have the alternative of applying for a job with company ABC. You may say you have the alternative of going to graduate school, but your real alternative is to apply to graduate school. Taking care in understanding alternatives is an important step in thinking clearly about decisions.

FIGURE 1.3   Number of Decisions vs. Analysis Effort

Once a decision is declared, knowing what to do may require little effort or extensive analysis. Most everyday decisions, such as what to have for breakfast or what clothes to wear, seldom require analysis. Other decisions, such as the purchase of a new home or car, may require more analysis, but are also less frequent. Figure 1.3 shows the number of decisions we face and the analysis effort they require.

Decision analysis works for all types of decisions. However, you can deal with simple decisions in a few minutes using common sense or some rules of thumb. You do not need an extensive analysis to decide what to have for breakfast.

More complicated decisions, however, are worthy of more thought. Using a simple checklist to remind us of things to consider and to help us identify common decision making errors might make the process easier. Examples of more complicated decisions are where to spend a vacation, or whether to buy a new television set.

The most important decisions we face deserve a much more refined analysis. They may involve elements of complexity, dynamics, and far-reaching consequences. They are worthy of, but frequently do not receive, the structured, rigorous decision process we will describe in later chapters.

Figure 1.4 shows the types of decisions we may face and methods to approaching them.
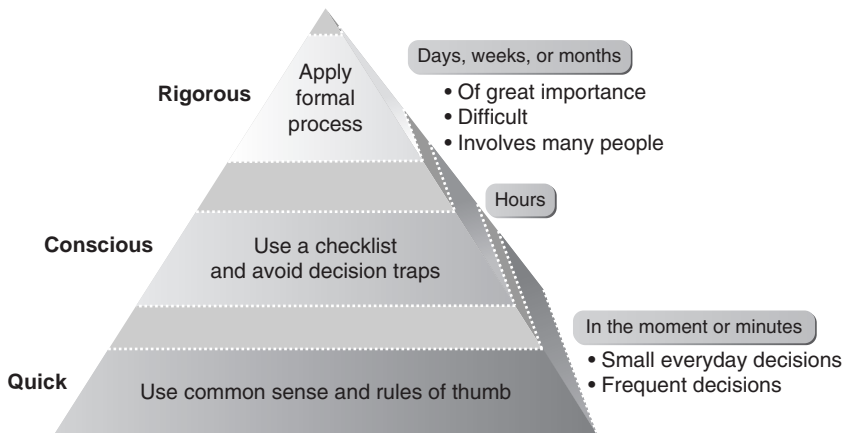
FIGURE 1.4   Hierarchy of Decisions

1.4 THOUGHT VS. ACTION

The mere idea of thinking about something does not mean we have made a decision. To better understand our decisions, we first make a distinction between "thought" and "action." Figure 1.5 illustrates all possible combinations of actions and thoughts. The diagram identifies four different regions.

FIGURE 1.5   Regions of Thought and Action

REGION 1: THOUGHT WITHOUT ACTION   Consider what you do in your daily life. Are there times when you have thought without action? A little reflection shows that the answer is "Yes." For example, we can think "What a beautiful cloud!," or "I should quit this job!," or "I am bored." This region also includes feelings you may have towards someone or something. Much of our self-talk is thought without action, and perhaps that is a good thing.
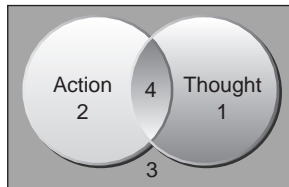
Reflection

Think of other situations where you may have thought but not acted.

REGION 2: ACTION WITHOUT THOUGHT   Is there action without thought? Once again, the answer is "Yes." A simple example is a reflex response to a stimulus, like crying after cutting an onion. A more thought provoking example is riding a bicycle. Can you imagine trying to use an instruction manual for riding a bicycle? The manual would describe things like steering head angles, tire contact areas, and the center of gravity of the combined human-bicycle system. We learn to ride a bicycle automatically without thinking, so a manual like this would be of little use.

Walking is another great example of an inborn ability or a trained skill. No explanation involving muscle contraction will help.

Reflection

To illustrate the advantage of coaching even when a skill has been learned and performed automatically without thinking, consider the following question:

Suppose you are riding fast on your bicycle and wish to turn to the left around a curve as quickly as possible. In what direction do you turn the handlebar?

The common answer is that you turn the handlebar to the left. Very experienced bicycle and motorcycle riders know that the correct answer is to turn the handlebar to the right. This is clear if you observe motorcycles racing counter clockwise around a circular dirt track. They all have their handlebars turned to the right, away from the center of the circle.

For this to be the correct answer, what must be true of cycle design?

Even without instincts or training, you can take appropriate action in new situations, without thought, by acting on your inner knowledge. Buddha would call it "right action:" Just do it. However, it is often difficult to make spontaneous and correct decisions in our personal or professional lives. Complexity, uncertainty, or conflicting values may confuse us.

Reflection

Think of other situations where there is action but no thought.

REGION 3: NO THOUGHT-NO ACTION   Are there situations where there is no thought and no action? One example is being in a coma. The state of consciousness produced by proper meditation might be another.

Reflection

Think of other situations where there is no action and no thought.

REGION 4: THOUGHT AND ACTION—"ACTIONAL THOUGHT"   Finally, we may want to think about what to do, which we call **actional thought**. When we think about a decision, we are practicing actional thought. But what constitutes high quality actional thought? One answer is decision analysis, our present endeavor.

1.5 WHAT IS A DECISION?

We now need to ask a fundamental question, "What is a decision?" A frequent answer is that it is a choice, or a choice among alternatives. But we want more precision in our understanding. The following is our definition of a **decision**:

> *A decision is a choice between two or more alternatives that involves an irrevocable allocation of resources.*

Suppose a friend tells you that he has decided to buy a new Rolls-Royce. How will you know when he has actually made the decision? Is it when he has visited the dealer to look at Rolls-Royces, or when he has made an appointment to return to buy the car? You will know he has bought a Rolls-Royce when he gives the dealer his cashier's check for the purchase price and the dealer has given him the registration and the keys. If your friend drives around the block in his new car and decides that he does not like it after all, can he just ask the dealer for his money back? The dealer may well say, "I see, you want to sell us a pre-owned Rolls-Royce in excellent condition. Here is our offer." His offer will typically be less than the number on the cashier's check he recently received. The difference is the monetary resource that your friend has committed in making the purchase.

A resource deserves its name if it is something that is scarce and valuable. Money is a resource; the time in our lives is a resource. Thinking about a decision takes time: The decision to think about a decision is an irrevocable use of that time. The decision to buy the Rolls-Royce by handing over the cashier's check represents an irrevocable loss of resources—the difference between what you pay for it and what you could sell it for after accepting ownership. Every decision, then, is irrevocable in the sense that the resources committed to it will be at least partially lost.