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Daniel Kahneman

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THINKING, FAST AND SLOW

Daniel Kahneman is a Senior Scholar at Princeton University, and Emeritus Professor of Public Affairs, Woodrow Wilson School of Public and International Affairs. He was awarded the Nobel Prize in Economics in 2002.

DANIEL KAHNEMAN

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In memory of Amos Tversky

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Introduction

Every author, I suppose, has in mind a setting in which readers of his or her work could benefit from having read it. Mine is the proverbial office watercooler, where opinions are shared and gossip is exchanged. I hope to enrich the vocabulary that people use when they talk about the judgments and choices of others, the company's new policies, or a colleague's investment decisions. Why be concerned with gossip? Because it is much easier, as well as far more enjoyable, to identify and label the mistakes of others than to recognize our own. Questioning what we believe and want is difficult at the best of times, and especially difficult when we most need to do it, but we can benefit from the informed opinions of others. Many of us spontaneously anticipate how friends and colleagues will evaluate our choices; the quality and content of these anticipated judgments therefore matters. The expectation of intelligent gossip is a powerful motive for serious self-criticism, more powerful than New Year resolutions to improve one's decision making at work and at home.

To be a good diagnostician, a physician needs to acquire a large set of labels for diseases, each of which binds an idea of the illness and its symptoms, possible antecedents and causes, possible developments and consequences, and possible interventions to cure or mitigate the illness. Learning medicine consists in part of learning the language of medicine. A deeper understanding of judgments and choices also requires a richer vocabulary than is available in everyday language. The hope for informed gossip is that there are distinctive patterns in the errors people make. Systematic errors are known as biases, and they recur predictably in particular circumstances. When the

handsome and confident speaker bounds onto the stage, for example, you can anticipate that the audience will judge his comments more favorably than he deserves. The availability of a diagnostic label for this bias—the halo effect—makes it easier to anticipate, recognize, and understand.

When you are asked what you are thinking about, you can normally answer. You believe you know what goes on in your mind, which often consists of one conscious thought leading in an orderly way to another. But that is not the only way the mind works, nor indeed is that the typical way. Most impressions and thoughts arise in your conscious experience without your knowing how they got there. You cannot trace how you came to the belief that there is a lamp on the desk in front of you, or how you detected a hint of irritation in your spouse's voice on the telephone, or how you managed to avoid a threat on the road before you became consciously aware of it. The mental work that produces impressions, intuitions, and many decisions goes on in silence in our mind.

Much of the discussion in this book is about biases of intuition. However, the focus on error does not denigrate human intelligence, any more than the attention to diseases in medical texts denies good health. Most of us are healthy most of the time, and most of our judgments and actions are appropriate most of the time. As we navigate our lives, we normally allow ourselves to be guided by impressions and feelings, and the confidence we have in our intuitive beliefs and preferences is usually justified. But not always. We are often confident even when we are wrong, and an objective observer is more likely to detect our errors than we are.

So this is my aim for watercooler conversations: improve the ability to identify and understand errors of judgment and choice, in others and eventually in ourselves, by providing a richer and more precise language to discuss them. In at least some cases, an accurate diagnosis may suggest an intervention to limit the damage that bad judgments and choices often cause.

ORIGINS

This book presents my current understanding of judgment and decision making, which has been shaped by psychological discoveries of recent decades. However, I trace the central ideas to the lucky day in 1969 when I asked a colleague to speak as a guest to a seminar I was teaching in the Department of Psychology at the Hebrew University of Jerusalem. Amos Tversky was considered a rising star in the field of decision research—indeed, in anything he did—so I knew we would have an interesting time. Many people who knew Amos thought he was the most intelligent person they had ever met. He was brilliant, voluble, and charismatic. He was also blessed with a perfect memory for jokes and an exceptional ability to use them to make a point. There was never a dull moment when Amos was around. He was then thirty-two; I was thirty-five.

Amos told the class about an ongoing program of research at the University of Michigan that sought to answer this question: Are people good intuitive statisticians? We already knew that people are good intuitive grammarians: at age four a child effortlessly conforms to the rules of grammar as she speaks, although she has no idea that such rules exist. Do people have a similar intuitive feel for the basic principles of statistics? Amos reported that the answer was a qualified yes. We had a lively debate in the seminar and ultimately concluded that a qualified no was a better answer.

Amos and I enjoyed the exchange and concluded that intuitive statistics was an interesting topic and that it would be fun to explore it together. That Friday we met for lunch at Café Rimon, the favorite hangout of bohemians and professors in Jerusalem, and planned a study of the statistical intuitions of sophisticated researchers. We had concluded in the seminar that our own intuitions were deficient. In spite of years of teaching and using statistics, we had not developed an intuitive sense of the reliability of statistical results observed in small samples. Our subjective judgments were biased: we were far too willing to believe research findings based on inadequate evidence and prone to collect too few observations in our own research. The goal

of our study was to examine whether other researchers suffered from the same affliction.

We prepared a survey that included realistic scenarios of statistical issues that arise in research. Amos collected the responses of a group of expert participants in a meeting of the Society of Mathematical Psychology, including the authors of two statistical textbooks. As expected, we found that our expert colleagues, like us, greatly exaggerated the likelihood that the original result of an experiment would be successfully replicated even with a small sample. They also gave very poor advice to a fictitious graduate student about the number of observations she needed to collect. Even statisticians were not good intuitive statisticians.

While writing the article that reported these findings, Amos and I discovered that we enjoyed working together. Amos was always very funny, and in his presence I became funny as well, so we spent hours of solid work in continuous amusement. The pleasure we found in working together made us exceptionally patient; it is much easier to strive for perfection when you are never bored. Perhaps most important, we checked our critical weapons at the door. Both Amos and I were critical and argumentative, he even more than I, but during the years of our collaboration neither of us ever rejected out of hand anything the other said. Indeed, one of the great joys I found in the collaboration was that Amos frequently saw the point of my vague ideas much more clearly than I did. Amos was the more logical thinker, with an orientation to theory and an unfailing sense of direction. I was more intuitive and rooted in the psychology of perception, from which we borrowed many ideas. We were sufficiently similar to understand each other easily, and sufficiently different to surprise each other. We developed a routine in which we spent much of our working days together, often on long walks. For the next fourteen years our collaboration was the focus of our lives, and the work we did together during those years was the best either of us ever did.

We quickly adopted a practice that we maintained for many years. Our research was a conversation, in which we invented questions and jointly examined our intuitive answers. Each question was a small experiment, and we carried out many experiments in a single day.

We were not seriously looking for the correct answer to the statistical questions we posed. Our aim was to identify and analyze the intuitive answer, the first one that came to mind, the one we were tempted to make even when we knew it to be wrong. We believed—correctly, as it happened—that any intuition that the two of us shared would be shared by many other people as well, and that it would be easy to demonstrate its effects on judgments.

We once discovered with great delight that we had identical silly ideas about the future professions of several toddlers we both knew. We could identify the argumentative three-year-old lawyer, the nerdy professor, the empathetic and mildly intrusive psychotherapist. Of course these predictions were absurd, but we still found them appealing. It was also clear that our intuitions were governed by the resemblance of each child to the cultural stereotype of a profession. The amusing exercise helped us develop a theory that was emerging in our minds at the time, about the role of resemblance in predictions. We went on to test and elaborate that theory in dozens of experiments, as in the following example.

As you consider the next question, please assume that Steve was selected at random from a representative sample:

> An individual has been described by a neighbor as follows: "Steve is very shy and withdrawn, invariably helpful but with little interest in people or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail." Is Steve more likely to be a librarian or a farmer?

The resemblance of Steve's personality to that of a stereotypical librarian strikes everyone immediately, but equally relevant statistical considerations are almost always ignored. Did it occur to you that there are more than 20 male farmers for each male librarian in the United States? Because there are so many more farmers, it is almost certain that more "meek and tidy" souls will be found on tractors than at library information desks. However, we found that participants in our experiments ignored the relevant statistical facts and relied exclusively on resemblance. We proposed that they used resemblance as a simplifying heuristic (roughly, a rule of thumb) to make a

difficult judgment. The reliance on the heuristic caused predictable biases (systematic errors) in their predictions.

On another occasion, Amos and I wondered about the rate of divorce among professors in our university. We noticed that the question triggered a search of memory for divorced professors we knew or knew about, and that we judged the size of categories by the ease with which instances came to mind. We called this reliance on the ease of memory search the availability heuristic. In one of our studies, we asked participants to answer a simple question about words in a typical English text:

> Consider the letter *K*.
>
> Is *K* more likely to appear as the first letter in a word OR as the third letter?

As any Scrabble player knows, it is much easier to come up with words that begin with a particular letter than to find words that have the same letter in the third position. This is true for every letter of the alphabet. We therefore expected respondents to exaggerate the frequency of letters appearing in the first position—even those letters (such as *K*, *L*, *N*, *R*, *V*) which in fact occur more frequently in the third position. Here again, the reliance on a heuristic produces a predictable bias in judgments. For example, I recently came to doubt my long-held impression that adultery is more common among politicians than among physicians or lawyers. I had even come up with explanations for that "fact," including the aphrodisiac effect of power and the temptations of life away from home. I eventually realized that the transgressions of politicians are much more likely to be reported than the transgressions of lawyers and doctors. My intuitive impression could be due entirely to journalists' choices of topics and to my reliance on the availability heuristic.

Amos and I spent several years studying and documenting biases of intuitive thinking in various tasks—assigning probabilities to events, forecasting the future, assessing hypotheses, and estimating frequencies. In the fifth year of our collaboration, we presented our main findings in *Science* magazine, a publication read by scholars in many disciplines. The article, which is reproduced in full at the end of

this book) was titled "Judgment Under Uncertainty: Heuristics and Biases." It described the simplifying shortcuts of intuitive thinking and explained some 20 biases as manifestations of these heuristics—and also as demonstrations of the role of heuristics in judgment.

Historians of science have often noted that at any given time scholars in a particular field tend to share basic assumptions about their subject. Social scientists are no exception; they rely on a view of human nature that provides the background of most discussions of specific behaviors but is rarely questioned. Social scientists in the 1970s broadly accepted two ideas about human nature. First, people are generally rational, and their thinking is normally sound. Second, emotions such as fear, affection, and hatred explain most of the occasions on which people depart from rationality. Our article challenged both assumptions without discussing them directly. We documented systematic errors in the thinking of normal people, and we traced these errors to the design of the machinery of cognition rather than to the corruption of thought by emotion.

Our article attracted much more attention than we had expected, and it remains one of the most highly cited works in social science (more than three hundred scholarly articles referred to it in 2010). Scholars in other disciplines found it useful, and the ideas of heuristics and biases have been used productively in many fields, including medical diagnosis, legal judgment, intelligence analysis, philosophy, finance, statistics, and military strategy.

For example, students of policy have noted that the availability heuristic helps explain why some issues are highly salient in the public's mind while others are neglected. People tend to assess the relative importance of issues by the ease with which they are retrieved from memory—and this is largely determined by the extent of coverage in the media. Frequently mentioned topics populate the mind even as others slip away from awareness. In turn, what the media choose to report corresponds to their view of what is currently on the public's mind. It is no accident that authoritarian regimes exert substantial pressure on independent media. Because public interest is most easily aroused by dramatic events and by celebrities, media feeding frenzies are common. For several weeks after Michael Jackson's death, for

example, it was virtually impossible to find a television channel reporting on another topic. In contrast, there is little coverage of critical but unexciting issues that provide less drama, such as declining educational standards or overinvestment of medical resources in the last year of life. (As I write this, I notice that my choice of "little-covered" examples was guided by availability. The topics I chose as examples are mentioned often; equally important issues that are less available did not come to my mind.)

We did not fully realize it at the time, but a key reason for the broad appeal of "heuristics and biases" outside psychology was an incidental feature of our work: we almost always included in our articles the full text of the questions we had asked ourselves and our respondents. These questions served as demonstrations for the reader, allowing him to recognize how his own thinking was tripped up by cognitive biases. I hope you had such an experience as you read the question about Steve the librarian, which was intended to help you appreciate the power of resemblance as a cue to probability and to see how easy it is to ignore relevant statistical facts.

The use of demonstrations provided scholars from diverse disciplines—notably philosophers and economists—an unusual opportunity to observe possible flaws in their own thinking. Having seen themselves fail, they became more likely to question the dogmatic assumption, prevalent at the time, that the human mind is rational and logical. The choice of method was crucial: if we had reported results of only conventional experiments, the article would have been less noteworthy and less memorable. Furthermore, skeptical readers would have distanced themselves from the results by attributing judgment errors to the familiar fecklessness of undergraduates, the typical participants in psychological studies. Of course, we did not choose demonstrations over standard experiments because we wanted to influence philosophers and economists. We preferred demonstrations because they were more fun, and we were lucky in our choice of method as well as in many other ways. A recurrent theme of this book is that luck plays a large role in every story of success; it is almost always easy to identify a small change in the story that would have turned a remarkable achievement into a mediocre outcome. Our story was no exception.

The reaction to our work was not uniformly positive. In particular, our focus on biases was criticized as suggesting an unfairly negative view of the mind. As expected in normal science, some investigators refined our ideas and others offered plausible alternatives. By and large, though, the idea that our minds are susceptible to systematic errors is now generally accepted. Our research on judgment had far more effect on social science than we thought possible when we were working on it.

Immediately after completing our review of judgment, we switched our attention to decision making under uncertainty. Our goal was to develop a psychological theory of how people make decisions about simple gambles. For example: Would you accept a bet on the toss of a coin where you win $130 if the coin shows heads and lose $100 if it shows tails? These elementary choices had long been used to examine broad questions about decision making, such as the relative weight that people assign to sure things and to uncertain outcomes. Our method did not change: we spent many days making up choice problems and examining whether our intuitive preferences conformed to the logic of choice. Here again, as in judgment, we observed systematic biases in our own decisions, intuitive preferences that consistently violated the rules of rational choice. Five years after the *Science* article, we published "Prospect Theory: An Analysis of Decision Under Risk," a theory of choice that is by some counts more influential than our work on judgment, and is one of the foundations of behavioral economics.

Until geographical separation made it too difficult to go on, Amos and I enjoyed the extraordinary good fortune of a shared mind that was superior to our individual minds and of a relationship that made our work fun as well as productive. Our collaboration on judgment and decision making was the reason for the Nobel Prize that I received in 2002, which Amos would have shared had he not died, aged fifty-nine, in 1996.

WHERE WE ARE NOW

This book is not intended as an exposition of the early research that Amos and I conducted together, a task that has been ably carried out

by many authors over the years. My main aim here is to present a view of how the mind works that draws on recent developments in cognitive and social psychology. One of the more important developments is that we now understand the marvels as well as the flaws of intuitive thought.

Amos and I did not address accurate intuitions beyond the casual statement that judgment heuristics "are quite useful, but sometimes lead to severe and systematic errors." We focused on biases, both because we found them interesting in their own right and because they provided evidence for the heuristics of judgment. We did not ask ourselves whether all intuitive judgments under uncertainty are produced by the heuristics we studied; it is now clear that they are not. In particular, the accurate intuitions of experts are better explained by the effects of prolonged practice than by heuristics. We can now draw a richer and more balanced picture, in which skill and heuristics are alternative sources of intuitive judgments and choices.

The psychologist Gary Klein tells the story of a team of firefighters that entered a house in which the kitchen was on fire. Soon after they started hosing down the kitchen, the commander heard himself shout, "Let's get out of here!" without realizing why. The floor collapsed almost immediately after the firefighters escaped. Only after the fact did the commander realize that the fire had been unusually quiet and that his ears had been unusually hot. Together, these impressions prompted what he called a "sixth sense of danger." He had no idea what was wrong, but he knew something was wrong. It turned out that the heart of the fire had not been in the kitchen but in the basement beneath where the men had stood.

We have all heard such stories of expert intuition: the chess master who walks past a street game and announces "White mates in three" without stopping, or the physician who makes a complex diagnosis after a single glance at a patient. Expert intuition strikes us as magical, but it is not. Indeed, each of us performs feats of intuitive expertise many times each day. Most of us are pitch-perfect in detecting anger in the first word of a telephone call, recognize as we enter a room that we were the subject of the conversation, and quickly react to subtle signs that the driver of the car in the next lane is dangerous. Our everyday

intuitive abilities are no less marvelous than the striking insights of an experienced firefighter or physician—only more common.

The psychology of accurate intuition involves no magic. Perhaps the best short statement of it is by the great Herbert Simon, who studied chess masters and showed that after thousands of hours of practice they come to see the pieces on the board differently from the rest of us. You can feel Simon's impatience with the mythologizing of expert intuition when he writes: "The situation has provided a cue; this cue has given the expert access to information stored in memory, and the information provides the answer. Intuition is nothing more and nothing less than recognition."

We are not surprised when a two-year-old looks at a dog and says "doggie!" because we are used to the miracle of children learning to recognize and name things. Simon's point is that the miracles of expert intuition have the same character. Valid intuitions develop when experts have learned to recognize familiar elements in a new situation and to act in a manner that is appropriate to it. Good intuitive judgments come to mind with the same immediacy as "doggie!"

Unfortunately, professionals' intuitions do not all arise from true expertise. Many years ago I visited the chief investment officer of a large financial firm, who told me that he had just invested some tens of millions of dollars in the stock of Ford Motor Company. When I asked how he had made that decision, he replied that he had recently attended an automobile show and had been impressed. "Boy, do they know how to make a car!" was his explanation. He made it very clear that he trusted his gut feeling and was satisfied with himself and with his decision. I found it remarkable that he had apparently not considered the one question that an economist would call relevant: Is Ford stock currently underpriced? Instead, he had listened to his intuition; he liked the cars, he liked the company, and he liked the idea of owning its stock. From what we know about the accuracy of stock picking, it is reasonable to believe that he did not know what he was doing.

The specific heuristics that Amos and I studied provide little help in understanding how the executive came to invest in Ford stock, but a broader conception of heuristics now exists, which offers a good

account. An important advance is that emotion now looms much larger in our understanding of intuitive judgments and choices than it did in the past. The executive's decision would today be described as an example of the affect heuristic, where judgments and decisions are guided directly by feelings of liking and disliking, with little deliberation or reasoning.

When confronted with a problem—choosing a chess move or deciding whether to invest in a stock—the machinery of intuitive thought does the best it can. If the individual has relevant expertise, she will recognize the situation, and the intuitive solution that comes to her mind is likely to be correct. This is what happens when a chess master looks at a complex position: the few moves that immediately occur to him are all strong. When the question is difficult and a skilled solution is not available, intuition still has a shot: an answer may come to mind quickly—but it is not an answer to the original question. The question that the executive faced (should I invest in Ford stock?) was difficult, but the answer to an easier and related question (do I like Ford cars?) came readily to his mind and determined his choice. This is the essence of intuitive heuristics: when faced with a difficult question, we often answer an easier one instead, usually without noticing the substitution.

The spontaneous search for an intuitive solution sometimes fails—neither an expert solution nor a heuristic answer comes to mind. In such cases we often find ourselves switching to a slower, more deliberate and effortful form of thinking. This is the slow thinking of the title. Fast thinking includes both variants of intuitive thought—the expert and the heuristic—as well as the entirely automatic mental activities of perception and memory, the operations that enable you to know there is a lamp on your desk or retrieve the name of the capital of Russia.

The distinction between fast and slow thinking has been explored by many psychologists over the last twenty-five years. For reasons that I explain more fully in the next chapter, I describe mental life by the metaphor of two agents, called System 1 and System 2, which respectively produce fast and slow thinking. I speak of the features of intuitive and deliberate thought as if they were traits and dispositions

of two characters in your mind. In the picture that emerges from recent research, the intuitive System 1 is more influential than your experience tells you, and it is the secret author of many of the choices and judgments you make. Most of this book is about the workings of System 1 and the mutual influences between it and System 2.

WHAT COMES NEXT

The book is divided into five parts. Part One presents the basic elements of a two-systems approach to judgment and choice. It elaborates the distinction between the automatic operations of System 1 and the controlled operations of System 2, and shows how associative memory, the core of System 1, continually constructs a coherent interpretation of what is going on in our world at any instant. I attempt to give a sense of the complexity and richness of the automatic and often unconscious processes that underlie intuitive thinking, and of how these automatic processes explain the heuristics of judgment. A goal is to introduce a language for thinking and talking about the mind.

Part Two updates the study of judgment heuristics and explores a major puzzle: Why is it so difficult for us to think statistically? We easily think associatively, we think metaphorically, we think causally, but statistics requires thinking about many things at once, which is something that System 1 is not designed to do.

The difficulties of statistical thinking contribute to the main theme of Part Three, which describes a puzzling limitation of our mind: our excessive confidence in what we believe we know, and our apparent inability to acknowledge the full extent of our ignorance and the uncertainty of the world we live in. We are prone to overestimate how much we understand about the world and to underestimate the role of chance in events. Overconfidence is fed by the illusory certainty of hindsight. My views on this topic have been influenced by Nassim Taleb, the author of *The Black Swan*. I hope for watercooler conversations that intelligently explore the lessons that can be learned from the past while resisting the lure of hindsight and the illusion of certainty.

The focus of Part Four is a conversation with the discipline of economics on the nature of decision making and on the assumption that economic agents are rational. This section of the book provides a current view, informed by the two-system model, of the key concepts of prospect theory, the model of choice that Amos and I published in 1979. Subsequent chapters address several ways human choices deviate from the rules of rationality. I deal with the unfortunate tendency to treat problems in isolation, and with framing effects, where decisions are shaped by inconsequential features of choice problems. These observations, which are readily explained by the features of System 1, present a deep challenge to the rationality assumption favored in standard economics.

Part Five describes recent research that has introduced a distinction between two selves, the experiencing self and the remembering self, which do not have the same interests. For example, we can expose people to two painful experiences. One of these experiences is strictly worse than the other, because it is longer. But the automatic formation of memories—a feature of System 1—has its rules, which we can exploit so that the worse episode leaves a better memory. When people later choose which episode to repeat, they are, naturally, guided by their remembering self and expose themselves (their experiencing self) to unnecessary pain. The distinction between two selves is applied to the measurement of well-being, where we find again that what makes the experiencing self happy is not quite the same as what satisfies the remembering self. How two selves within a single body can pursue happiness raises some difficult questions, both for individuals and for societies that view the well-being of the population as a policy objective.

A concluding chapter explores, in reverse order, the implications of three distinctions drawn in the book: between the experiencing and the remembering selves, between the conception of agents in classical economics and in behavioral economics (which borrows from psychology), and between the automatic System 1 and the effortful System 2. I return to the virtues of educating gossip and to what organizations might do to improve the quality of judgments and decisions that are made on their behalf.

Two articles I wrote with Amos are reproduced as appendixes to the book. The first is the review of judgment under uncertainty that I described earlier. The second, published in 1984, summarizes prospect theory as well as our studies of framing effects. The articles present the contributions that were cited by the Nobel committee—and you may be surprised by how simple they are. Reading them will give you a sense of how much we knew a long time ago, and also of how much we have learned in recent decades.

PART ONE
Two Systems

1
The Characters of the Story

To observe your mind in automatic mode, glance at the image below.

Figure 1

Your experience as you look at the woman's face seamlessly combines what we normally call seeing and intuitive thinking. As surely and quickly as you saw that the young woman's hair is dark, you knew she is angry. Furthermore, what you saw extended into the future. You sensed that this woman is about to say some very unkind words, probably in a loud and strident voice. A premonition of what she was going to do next came to mind automatically and effortlessly. You did not intend to assess her mood or to anticipate what she might do, and your reaction to the picture did not have the feel

of something you did. It just happened to you. It was an instance of fast thinking.

Now look at the following problem:

17 × 24

You knew immediately that this is a multiplication problem, and probably knew that you could solve it, with paper and pencil, if not without. You also had some vague intuitive knowledge of the range of possible results. You would be quick to recognize that both 12,609 and 123 are implausible. Without spending some time on the problem, however, you would not be certain that the answer is not 568. A precise solution did not come to mind, and you felt that you could choose whether or not to engage in the computation. If you have not done so yet, you should attempt the multiplication problem now, completing at least part of it.

You experienced slow thinking as you proceeded through a sequence of steps. You first retrieved from memory the cognitive program for multiplication that you learned in school, then you implemented it. Carrying out the computation was a strain. You felt the burden of holding much material in memory, as you needed to keep track of where you were and of where you were going, while holding on to the intermediate result. The process was mental work: deliberate, effortful, and orderly—a prototype of slow thinking. The computation was not only an event in your mind; your body was also involved. Your muscles tensed up, your blood pressure rose, and your heart rate increased. Someone looking closely at your eyes while you tackled this problem would have seen your pupils dilate. Your pupils contracted back to normal size as soon as you ended your work—when you found the answer (which is 408, by the way) or when you gave up.

TWO SYSTEMS

Psychologists have been intensely interested for several decades in the two modes of thinking evoked by the picture of the angry woman and

by the multiplication problem, and have offered many labels for them. I adopt terms originally proposed by the psychologists Keith Stanovich and Richard West, and will refer to two systems in the mind, System 1 and System 2.

- *System 1* operates automatically and quickly, with little or no effort and no sense of voluntary control.
- *System 2* allocates attention to the effortful mental activities that demand it, including complex computations. The operations of System 2 are often associated with the subjective experience of agency, choice, and concentration.

The labels of System 1 and System 2 are widely used in psychology, but I go further than most in this book, which you can read as a psychodrama with two characters.

When we think of ourselves, we identify with System 2, the conscious, reasoning self that has beliefs, makes choices, and decides what to think about and what to do. Although System 2 believes itself to be where the action is, the automatic System 1 is the hero of the book. I describe System 1 as effortlessly originating impressions and feelings that are the main sources of the explicit beliefs and deliberate choices of System 2. The automatic operations of System 1 generate surprisingly complex patterns of ideas, but only the slower System 2 can construct thoughts in an orderly series of steps. I also describe circumstances in which System 2 takes over, overruling the freewheeling impulses and associations of System 1. You will be invited to think of the two systems as agents with their individual abilities, limitations, and functions.

In rough order of complexity, here are some examples of the automatic activities that are attributed to System 1:

- Detect that one object is more distant than another.
- Orient to the source of a sudden sound.
- Complete the phrase "bread and . . ."
- Make a "disgust face" when shown a horrible picture.
- Detect hostility in a voice.
- Answer to 2 + 2 = ?
- Read words on large billboards.

- Drive a car on an empty road.
- Find a strong move in chess (if you are a chess master).
- Understand simple sentences.
- Recognize that a "meek and tidy soul with a passion for detail" resembles an occupational stereotype.

All these mental events belong with the angry woman—they occur automatically and require little or no effort. The capabilities of System 1 include innate skills that we share with other animals. We are born prepared to perceive the world around us, recognize objects, orient attention, avoid losses, and fear spiders. Other mental activities become fast and automatic through prolonged practice. System 1 has learned associations between ideas (the capital of France?); it has also learned skills such as reading and understanding nuances of social situations. Some skills, such as finding strong chess moves, are acquired only by specialized experts. Others are widely shared. Detecting the similarity of a personality sketch to an occupational stereotype requires broad knowledge of the language and the culture, which most of us possess. The knowledge is stored in memory and accessed without intention and without effort.

Several of the mental actions in the list are completely involuntary. You cannot refrain from understanding simple sentences in your own language or from orienting to a loud unexpected sound, nor can you prevent yourself from knowing that 2 + 2 = 4 or from thinking of Paris when the capital of France is mentioned. Other activities, such as chewing, are susceptible to voluntary control but normally run on automatic pilot. The control of attention is shared by the two systems. Orienting to a loud sound is normally an involuntary operation of System 1, which immediately mobilizes the voluntary attention of System 2. You may be able to resist turning toward the source of a loud and offensive comment at a crowded party, but even if your head does not move, your attention is initially directed to it, at least for a while. However, attention can be moved away from an unwanted focus, primarily by focusing intently on another target.

The highly diverse operations of System 2 have one feature in common: they require attention and are disrupted when attention is drawn away. Here are some examples:

- Brace for the starter gun in a race.
- Focus attention on the clowns in the circus.
- Focus on the voice of a particular person in a crowded and noisy room.
- Look for a woman with white hair.
- Search memory to identify a surprising sound.
- Maintain a faster walking speed than is natural for you.
- Monitor the appropriateness of your behavior in a social situation.
- Count the occurrences of the letter *a* in a page of text.
- Tell someone your phone number.
- Park in a narrow space (for most people except garage attendants).
- Compare two washing machines for overall value.
- Fill out a tax form.
- Check the validity of a complex logical argument.

In all these situations you must pay attention, and you will perform less well, or not at all, if you are not ready or if your attention is directed inappropriately. System 2 has some ability to change the way System 1 works, by programming the normally automatic functions of attention and memory. When waiting for a relative at a busy train station, for example, you can set yourself at will to look for a white-haired woman or a bearded man, and thereby increase the likelihood of detecting your relative from a distance. You can set your memory to search for capital cities that start with *N* or for French existentialist novels. And when you rent a car at London's Heathrow Airport, the attendant will probably remind you that "we drive on the left side of the road over here." In all these cases, you are asked to do something that does not come naturally, and you will find that the consistent maintenance of a set requires continuous exertion of at least some effort.

The often-used phrase "pay attention" is apt: you dispose of a limited budget of attention that you can allocate to activities, and if you try to go beyond your budget, you will fail. It is the mark of effortful activities that they interfere with each other, which is why it is difficult or impossible to conduct several at once. You could not compute the

product of 17 × 24 while making a left turn into dense traffic, and you certainly should not try. You can do several things at once, but only if they are easy and undemanding. You are probably safe carrying on a conversation with a passenger while driving on an empty highway, and many parents have discovered, perhaps with some guilt, that they can read a story to a child while thinking of something else.

Everyone has some awareness of the limited capacity of attention, and our social behavior makes allowances for these limitations. When the driver of a car is overtaking a truck on a narrow road, for example, adult passengers quite sensibly stop talking. They know that distracting the driver is not a good idea, and they also suspect that he is temporarily deaf and will not hear what they say.

Intense focusing on a task can make people effectively blind, even to stimuli that normally attract attention. The most dramatic demonstration was offered by Christopher Chabris and Daniel Simons in their book *The Invisible Gorilla*. They constructed a short film of two teams passing basketballs, one team wearing white shirts, the other wearing black. The viewers of the film are instructed to count the number of passes made by the white team, ignoring the black players. This task is difficult and completely absorbing. Halfway through the video, a woman wearing a gorilla suit appears, crosses the court, thumps her chest, and moves on. The gorilla is in view for 9 seconds. Many thousands of people have seen the video, and about half of them do not notice anything unusual. It is the counting task—and especially the instruction to ignore one of the teams—that causes the blindness. No one who watches the video without that task would miss the gorilla. Seeing and orienting are automatic functions of System 1, but they depend on the allocation of some attention to the relevant stimulus. The authors note that the most remarkable observation of their study is that people find its results very surprising. Indeed, the viewers who fail to see the gorilla are initially sure that it was not there—they cannot imagine missing such a striking event. The gorilla study illustrates two important facts about our minds: we can be blind to the obvious, and we are also blind to our blindness.

PLOT SYNOPSIS

The interaction of the two systems is a recurrent theme of the book, and a brief synopsis of the plot is in order. In the story I will tell, Systems 1 and 2 are both active whenever we are awake. System 1 runs automatically and System 2 is normally in a comfortable low-effort mode, in which only a fraction of its capacity is engaged. System 1 continuously generates suggestions for System 2: impressions, intuitions, intentions, and feelings. If endorsed by System 2, impressions and intuitions turn into beliefs, and impulses turn into voluntary actions. When all goes smoothly, which is most of the time, System 2 adopts the suggestions of System 1 with little or no modification. You generally believe your impressions and act on your desires, and that is fine—usually.

When System 1 runs into difficulty, it calls on System 2 to support more detailed and specific processing that may solve the problem of the moment. System 2 is mobilized when a question arises for which System 1 does not offer an answer, as probably happened to you when you encountered the multiplication problem 17 × 24. You can also feel a surge of conscious attention whenever you are surprised. System 2 is activated when an event is detected that violates the model of the world that System 1 maintains. In that world, lamps do not jump, cats do not bark, and gorillas do not cross basketball courts. The gorilla experiment demonstrates that some attention is needed for the surprising stimulus to be detected. Surprise then activates and orients your attention: you will stare, and you will search your memory for a story that makes sense of the surprising event. System 2 is also credited with the continuous monitoring of your own behavior—the control that keeps you polite when you are angry, and alert when you are driving at night. System 2 is mobilized to increased effort when it detects an error about to be made. Remember a time when you almost blurted out an offensive remark and note how hard you worked to restore control. In summary, most of what you (your System 2) think and do originates in your System 1, but System 2 takes over when things get difficult, and it normally has the last word.

The division of labor between System 1 and System 2 is highly efficient: it minimizes effort and optimizes performance. The arrangement works well most of the time because System 1 is generally very good at what it does: its models of familiar situations are accurate, its short-term predictions are usually accurate as well, and its initial reactions to challenges are swift and generally appropriate. System 1 has biases, however, systematic errors that it is prone to make in specified circumstances. As we shall see, it sometimes answers easier questions than the one it was asked, and it has little understanding of logic and statistics. One further limitation of System 1 is that it cannot be turned off. If you are shown a word on the screen in a language you know, you will read it—unless your attention is totally focused elsewhere.

CONFLICT

Figure 2 is a variant of a classic experiment that produces a conflict between the two systems. You should try the exercise before reading on.

Your first task is to go down both columns, calling out whether each word is printed in lowercase or in uppercase. When you are done with the first task, go down both columns again, saying whether each word is printed to the left or to the right of center by saying (or whispering to yourself) "LEFT" or "RIGHT."

LEFT	upper
left	lower
right	LOWER
RIGHT	upper
RIGHT	UPPER
left	lower
LEFT	LOWER
right	upper

Figure 2

You were almost certainly successful in saying the correct words in both tasks, and you surely discovered that some parts of each task were much easier than others. When you identified upper- and lowercase, the left-hand column was easy and the right-hand column caused you to slow down and perhaps to stammer or stumble. When you named the position of words, the left-hand column was difficult and the right-hand column was much easier.

These tasks engage System 2, because saying "upper/lower" or "right/left" is not what you routinely do when looking down a column of words. One of the things you did to set yourself for the task was to program your memory so that the relevant words (*upper* and *lower* for the first task) were "on the tip of your tongue." The prioritizing of the chosen words is effective and the mild temptation to read other words was fairly easy to resist when you went through the first column. But the second column was different, because it contained words for which you were set, and you could not ignore them. You were mostly able to respond correctly, but overcoming the competing response was a strain, and it slowed you down. You experienced a conflict between a task that you intended to carry out and an automatic response that interfered with it.

Conflict between an automatic reaction and an intention to control it is common in our lives. We are all familiar with the experience of trying not to stare at the oddly dressed couple at the neighboring table in a restaurant. We also know what it is like to force our attention on a boring book, when we constantly find ourselves returning to the point at which the reading lost its meaning. Where winters are hard, many drivers have memories of their car skidding out of control on the ice and of the struggle to follow well-rehearsed instructions that negate what they would naturally do: "Steer into the skid, and whatever you do, do not touch the brakes!" And every human being has had the experience of *not* telling someone to go to hell. One of the tasks of System 2 is to overcome the impulses of System 1. In other words, System 2 is in charge of self-control.

ILLUSIONS

To appreciate the autonomy of System 1, as well as the distinction between impressions and beliefs, take a good look at figure 3.

This picture is unremarkable: two horizontal lines of different lengths, with fins appended, pointing in different directions. The bottom line is obviously longer than the one above it. That is what we all see, and we naturally believe what we see. If you have already encountered this image, however, you recognize it as the famous Müller-Lyer illusion. As you can easily confirm by measuring them with a ruler, the horizontal lines are in fact identical in length.

Now that you have measured the lines, you—your System 2, the conscious being you call "I"—have a new belief: you *know* that the lines are equally long. If asked about their length, you will say what you know. But you still *see* the bottom line as longer. You have chosen to believe the measurement, but you cannot prevent System 1 from doing its thing; you cannot decide to see the lines as equal, although you know they are. To resist the illusion, there is only one thing you can do: you must learn to mistrust your impressions of the length of lines when fins are attached to them. To implement that rule, you must be able to recognize the illusory pattern and recall what you know about it. If you can do this, you will never again be fooled by

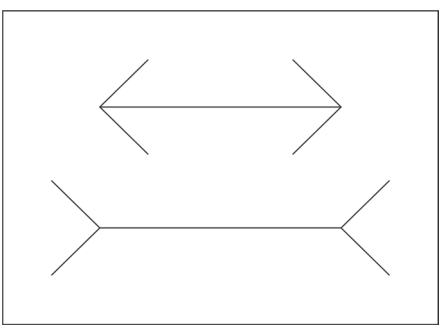

Figure 3

the Müller-Lyer illusion. But you will still see one line as longer than the other.

Not all illusions are visual. There are illusions of thought, which we call *cognitive illusions*. As a graduate student, I attended some courses on the art and science of psychotherapy. During one of these lectures, our teacher imparted a morsel of clinical wisdom. This is what he told us: "You will from time to time meet a patient who shares a disturbing tale of multiple mistakes in his previous treatment. He has been seen by several clinicians, and all failed him. The patient can lucidly describe how his therapists misunderstood him, but he has quickly perceived that you are different. You share the same feeling, are convinced that you understand him, and will be able to help." At this point my teacher raised his voice as he said, "Do not even *think* of taking on this patient! Throw him out of the office! He is most likely a psychopath and you will not be able to help him."

Many years later I learned that the teacher had warned us against psychopathic charm, and the leading authority in the study of psychopathy confirmed that the teacher's advice was sound. The analogy to the Müller-Lyer illusion is close. What we were being taught was not how to feel about that patient. Our teacher took it for granted that the sympathy we would feel for the patient would not be under our control; it would arise from System 1. Furthermore, we were not being taught to be generally suspicious of our feelings about patients. We were told that a strong attraction to a patient with a repeated history of failed treatment is a danger sign—like the fins on the parallel lines. It is an illusion—a cognitive illusion—and I (System 2) was taught how to recognize it and advised not to believe it or act on it.

The question that is most often asked about cognitive illusions is whether they can be overcome. The message of these examples is not encouraging. Because System 1 operates automatically and cannot be turned off at will, errors of intuitive thought are often difficult to prevent. Biases cannot always be avoided, because System 2 may have no clue to the error. Even when cues to likely errors are available, errors can be prevented only by the enhanced monitoring and effortful activity of System 2. As a way to live your life, however, continuous vigilance

is not necessarily good, and it is certainly impractical. Constantly questioning our own thinking would be impossibly tedious, and System 2 is much too slow and inefficient to serve as a substitute for System 1 in making routine decisions. The best we can do is a compromise: learn to recognize situations in which mistakes are likely and try harder to avoid significant mistakes when the stakes are high. The premise of this book is that it is easier to recognize other people's mistakes than our own.

USEFUL FICTIONS

You have been invited to think of the two systems as agents within the mind, with their individual personalities, abilities, and limitations. I will often use sentences in which the systems are the subjects, such as, "System 2 calculates products."

The use of such language is considered a sin in the professional circles in which I travel, because it seems to explain the thoughts and actions of a person by the thoughts and actions of little people inside the person's head. Grammatically the sentence about System 2 is similar to "The butler steals the petty cash." My colleagues would point out that the butler's action actually explains the disappearance of the cash, and they rightly question whether the sentence about System 2 explains how products are calculated. My answer is that the brief active sentence that attributes calculation to System 2 is intended as a description, not an explanation. It is meaningful only because of what you already know about System 2. It is shorthand for the following: "Mental arithmetic is a voluntary activity that requires effort, should not be performed while making a left turn, and is associated with dilated pupils and an accelerated heart rate."

Similarly, the statement that "highway driving under routine conditions is left to System 1" means that steering the car around a bend is automatic and almost effortless. It also implies that an experienced driver can drive on an empty highway while conducting a conversation. Finally, "System 2 prevented Jane from reacting foolishly to the

insult" means that James would have been more aggressive in his response if his capacity for effortful control had been disrupted (for example, if he had been drunk).

System 1 and System 2 are so central to the story I tell in this book that I must make it absolutely clear that they are fictitious characters. Systems 1 and 2 are not systems in the standard sense of entities with interacting aspects or parts. And there is no one part of the brain that either of the systems would call home. You may well ask: What is the point of introducing fictitious characters with ugly names into a serious book? The answer is that the characters are useful because of some quirks of our minds, yours and mine. A sentence is understood more easily if it describes what an agent (System 2) does than if it describes what something is, what properties it has. In other words, "System 2" is a better subject for a sentence than "mental arithmetic." The mind—especially System 1—appears to have a special aptitude for the construction and interpretation of stories about active agents, who have personalities, habits, and abilities. You quickly formed a bad opinion of the thieving butler, you expect more bad behavior from him, and you will remember him for a while. This is also my hope for the language of systems.

Why call them System 1 and System 2 rather than the more descriptive "automatic system" and "effortful system"? The reason is simple: "Automatic system" takes longer to say than "System 1" and therefore takes more space in your working memory. This matters, because anything that occupies your working memory reduces your ability to think. You should treat "System 1" and "System 2" as nicknames, like Bob and Joe, identifying characters that you will get to know over the course of this book. The fictitious systems make it easier for me to think about judgment and choice, and will make it easier for you to understand what I say.

SPEAKING OF SYSTEM 1 AND SYSTEM 2

"He had an impression, but some of his impressions are illusions."

"This was a pure System 1 response. She reacted to the threat before she recognized it."

"This is your System 1 talking. Slow down and let your System 2 take control."

2
Attention and Effort

In the unlikely event of this book being made into a film, System 2 would be a supporting character who believes herself to be the hero. The defining feature of System 2, in this story, is that its operations are effortful, and one of its main characteristics is laziness, a reluctance to invest more effort than is strictly necessary. As a consequence, the thoughts and actions that System 2 believes it has chosen are often guided by the figure at the center of the story, System 1. However, there are vital tasks that only System 2 can perform because they require effort and acts of self-control in which the intuitions and impulses of System 1 are overcome.

MENTAL EFFORT

If you wish to experience your System 2 working at full tilt, the following exercise will do; it should bring you to the limits of your cognitive abilities within 5 seconds. To start, make up several strings of 4 digits, all different, and write each string on an index card. Place a blank card on top of the deck. The task that you will perform is called Add-1. Here is how it goes:

> Start beating a steady rhythm (or better yet, set a metronome at 1/sec). Remove the blank card and read the four digits aloud. Wait for two beats, then report a string in which each of the original digits is incremented by 1. If the digits on the card are 5294, the correct response is 6305. Keeping the rhythm is important.

Few people can cope with more than four digits in the Add-1 task, but if you want a harder challenge, please try Add-3.

If you would like to know what your body is doing while your mind is hard at work, set up two piles of books on a sturdy table, place a video camera on one and lean your chin on the other, get the video going, and stare at the camera lens while you work on Add-1 or Add-3 exercises. Later, you will find in the changing size of your pupils a faithful record of how hard you worked.

I have a long personal history with the Add-1 task. Early in my career I spent a year at the University of Michigan, as a visitor in a laboratory that studied hypnosis. Casting about for a useful topic of research, I found an article in *Scientific American* in which the psychologist Eckhard Hess described the pupil of the eye as a window to the soul. I reread it recently and again found it inspiring. It begins with Hess reporting that his wife had noticed his pupils widening as he watched beautiful nature pictures, and it ends with two striking pictures of the same good-looking woman, who somehow appears much more attractive in one than in the other. There is only one difference: the pupils of the eyes appear dilated in the attractive picture and constricted in the other. Hess also wrote of belladonna, a pupil-dilating substance that was used as a cosmetic, and of bazaar shoppers who wear dark glasses in order to hide their level of interest from merchants.

One of Hess's findings especially captured my attention. He had noticed that the pupils are sensitive indicators of mental effort—they dilate substantially when people multiply two-digit numbers, and they dilate more if the problems are hard than if they are easy. His observations indicated that the response to mental effort is distinct from emotional arousal. Hess's work did not have much to do with hypnosis, but I concluded that the idea of a visible indication of mental effort had promise as a research topic. A graduate student in the lab, Jackson Beatty, shared my enthusiasm and we got to work.

Beatty and I developed a setup similar to an optician's examination room, in which the experimental participant leaned her head on a chin-and-forehead rest and stared at a camera while listening to prerecorded information and answering questions on the recorded beats

of a metronome. The beats triggered an infrared flash every second, causing a picture to be taken. At the end of each experimental session, we would rush to have the film developed, project the images of the pupil on a screen, and go to work with a ruler. The method was a perfect fit for young and impatient researchers: we knew our results almost immediately, and they always told a clear story.

Beatty and I focused on paced tasks, such as Add-1, in which we knew precisely what was on the subject's mind at any time. We recorded strings of digits on beats of the metronome and instructed the subject to repeat or transform the digits one by one, maintaining the same rhythm. We soon discovered that the size of the pupil varied second by second, reflecting the changing demands of the task. The shape of the response was an inverted V. As you experienced it if you tried Add-1 or Add-3, effort builds up with every added digit that you hear, reaches an almost intolerable peak as you rush to produce a transformed string during and immediately after the pause, and relaxes gradually as you "unload" your short-term memory. The pupil data corresponded precisely to subjective experience: longer strings reliably caused larger dilations, the transformation task compounded the effort, and the peak of pupil size coincided with maximum effort. Add-1 with four digits caused a larger dilation than the task of holding seven digits for immediate recall. Add-3, which is much more difficult, is the most demanding that I ever observed. In the first 5 seconds, the pupil dilates by about 50% of its original area and heart rate increases by about 7 beats per minute. This is as hard as people can work—they give up if more is asked of them. When we exposed our subjects to more digits than they could remember, their pupils stopped dilating or actually shrank.

We worked for some months in a spacious basement suite in which we had set up a closed-circuit system that projected an image of the subject's pupil on a screen in the corridor; we also could hear what was happening in the laboratory. The diameter of the projected pupil was about a foot; watching it dilate and contract when the participant was at work was a fascinating sight, quite an attraction for visitors in our lab. We amused ourselves and impressed our guests by our ability to divine when the participant gave up on a task. During a mental

multiplication, the pupil normally dilated to a large size within a few seconds and stayed large as long as the individual kept working on the problem; it contracted immediately when she found a solution or gave up. As we watched from the corridor, we would sometimes surprise both the owner of the pupil and our guests by asking, "Why did you stop working just now?" The answer from inside the lab was often, "How did you know?" to which we would reply, "We have a window to your soul."

The casual observations we made from the corridor were sometimes as informative as the formal experiments. I made a significant discovery as I was idly watching a woman's pupil during a break between two tasks. She had kept her position on the chin rest, so I could see the image of her eye while she engaged in routine conversation with the experimenter. I was surprised to see that the pupil remained small and did not noticeably dilate as she talked and listened. Unlike the tasks that we were studying, the mundane conversation apparently demanded little or no effort—no more than retaining two or three digits. This was a eureka moment: I realized that the tasks we had chosen for study were exceptionally effortful. An image came to mind: mental life—today I would speak of the life of System 2—is normally conducted at the pace of a comfortable walk, sometimes interrupted by episodes of jogging and on rare occasions by a frantic sprint. The Add-1 and Add-3 exercises are sprints, and casual chatting is a stroll.

We found that people, when engaged in a mental sprint, may become effectively blind. The authors of *The Invisible Gorilla* had made the gorilla "invisible" by keeping the observers intensely busy counting passes. We reported a rather less dramatic example of blindness during Add-1. Our subjects were exposed to a series of rapidly flashing letters while they worked. They were told to give the task complete priority, but they were also asked to report, at the end of the digit task, whether the letter *K* had appeared at any time during the trial. The main finding was that the ability to detect and report the target letter changed in the course of the 10 seconds of the exercise. The observers almost never missed a *K* that was shown at the beginning or near the end of the Add-1 task, but they missed the target

almost half the time when mental effort was at its peak, although we had pictures of their wide-open eye staring straight at it. Failures of detection followed the same inverted-V pattern as the dilating pupil. The similarity was reassuring: the pupil was a good measure of the physical arousal that accompanies mental effort, and we could go ahead and use it to understand how the mind works.

Much like the electricity meter outside your house or apartment, the pupils offer an index of the current rate at which mental energy is used. The analogy goes deep. Your use of electricity depends on what you choose to do, whether to light a room or toast a piece of bread. When you turn on a bulb or a toaster, it draws the energy it needs but no more. Similarly, we decide what to do, but we have limited control over the effort of doing it. Suppose you are shown four digits, say, 9462, and told that your life depends on holding them in memory for 10 seconds. However much you want to live, you cannot exert as much effort in this task as you would be forced to invest to complete an Add-3 transformation on the same digits.

System 2 and the electrical circuits in your home both have limited capacity, but they respond differently to threatened overload. A breaker trips when the demand for current is excessive, causing all devices on that circuit to lose power at once. In contrast, the response to mental overload is selective and precise: System 2 protects the most important activity, so it receives the attention it needs; "spare capacity" is allocated second by second to other tasks. In our version of the gorilla experiment, we instructed the participants to assign priority to the digit task. We know that they followed that instruction, because the timing of the visual target had no effect on the main task. If the critical letter was presented at a time of high demand, the subjects simply did not see it. When the transformation task was less demanding, detection performance was better.

The sophisticated allocation of attention has been honed by a long evolutionary history. Orienting and responding quickly to the gravest threats or most promising opportunities improved the chance of survival, and this capability is certainly not restricted to humans. Even in modern humans, System 1 takes over in emergencies and assigns total priority to self-protective actions. Imagine yourself at the wheel of a

car that unexpectedly skids on a large oil slick. You will find that you have responded to the threat before you became fully conscious of it.

Beatty and I worked together for only a year, but our collaboration had a large effect on our subsequent careers. He eventually became the leading authority on "cognitive pupillometry," and I wrote a book titled *Attention and Effort*, which was based in large part on what we learned together and on follow-up research I did at Harvard the following year. We learned a great deal about the working mind—which I now think of as System 2—from measuring pupils in a wide variety of tasks.

As you become skilled in a task, its demand for energy diminishes. Studies of the brain have shown that the pattern of activity associated with an action changes as skill increases, with fewer brain regions involved. Talent has similar effects. Highly intelligent individuals need less effort to solve the same problems, as indicated by both pupil size and brain activity. A general "law of least effort" applies to cognitive as well as physical exertion. The law asserts that if there are several ways of achieving the same goal, people will eventually gravitate to the least demanding course of action. In the economy of action, effort is a cost, and the acquisition of skill is driven by the balance of benefits and costs. Laziness is built deep into our nature.

The tasks that we studied varied considerably in their effects on the pupil. At baseline, our subjects were awake, aware, and ready to engage in a task—probably at a higher level of arousal and cognitive readiness than usual. Holding one or two digits in memory or learning to associate a word with a digit (3 = door) produced reliable effects on momentary arousal above that baseline, but the effects were minuscule, only 5% of the increase in pupil diameter associated with Add-3. A task that required discriminating between the pitch of two tones yielded significantly larger dilations. Recent research has shown that inhibiting the tendency to read distracting words (as in figure 2 of the preceding chapter) also induces moderate effort. Tests of short-term memory for six or seven digits were more effortful. As you can experience, the request to retrieve and say aloud your phone number or your spouse's birthday also requires a brief but significant effort, because the entire string must be held in memory as a response is

organized. Mental multiplication of two-digit numbers and the Add-3 task are near the limit of what most people can do.

What makes some cognitive operations more demanding and effortful than others? What outcomes must we purchase in the currency of attention? What can System 2 do that System 1 cannot? We now have tentative answers to these questions.

Effort is required to maintain simultaneously in memory several ideas that require separate actions, or that need to be combined according to a rule—rehearsing your shopping list as you enter the supermarket, choosing between the fish and the veal at a restaurant, or combining a surprising result from a survey with the information that the sample was small, for example. System 2 is the only one that can follow rules, compare objects on several attributes, and make deliberate choices between options. The automatic System 1 does not have these capabilities. System 1 detects simple relations ("they are all alike," "the son is much taller than the father") and excels at integrating information about one thing, but it does not deal with multiple distinct topics at once, nor is it adept at using purely statistical information. System 1 will detect that a person described as "a meek and tidy soul, with a need for order and structure, and a passion for detail" resembles a caricature librarian, but combining this intuition with knowledge about the small number of librarians is a task that only System 2 can perform—if System 2 knows how to do so, which is true of few people.

A crucial capability of System 2 is the adoption of "task sets": it can program memory to obey an instruction that overrides habitual responses. Consider the following: Count all occurrences of the letter *f* in this page. This is not a task you have ever performed before and it will not come naturally to you, but your System 2 can take it on. It will be effortful to set yourself up for this exercise, and effortful to carry it out, though you will surely improve with practice. Psychologists speak of "executive control" to describe the adoption and termination of task sets, and neuroscientists have identified the main regions of the brain that serve the executive function. One of these regions is involved whenever a conflict must be resolved. Another is the prefrontal area of the brain, a region that is substantially more

developed in humans than in other primates, and is involved in operations that we associate with intelligence.

Now suppose that at the end of the page you get another instruction: count all the commas in the next page. This will be harder, because you will have to overcome the newly acquired tendency to focus attention on the letter *f*. One of the significant discoveries of cognitive psychologists in recent decades is that switching from one task to another is effortful, especially under time pressure. The need for rapid switching is one of the reasons that Add-3 and mental multiplication are so difficult. To perform the Add-3 task, you must hold several digits in your working memory at the same time, associating each with a particular operation: some digits are in the queue to be transformed, one is in the process of transformation, and others, already transformed, are retained for reporting. Modern tests of working memory require the individual to switch repeatedly between two demanding tasks, retaining the results of one operation while performing the other. People who do well on these tests tend to do well on tests of general intelligence. However, the ability to control attention is not simply a measure of intelligence; measures of efficiency in the control of attention predict performance of air traffic controllers and of Israeli Air Force pilots beyond the effects of intelligence.

Time pressure is another driver of effort. As you carried out the Add-3 exercise, the rush was imposed in part by the metronome and in part by the load on memory. Like a juggler with several balls in the air, you cannot afford to slow down; the rate at which material decays in memory forces the pace, driving you to refresh and rehearse information before it is lost. Any task that requires you to keep several ideas in mind at the same time has the same hurried character. Unless you have the good fortune of a capacious working memory, you may be forced to work uncomfortably hard. The most effortful forms of slow thinking are those that require you to think fast.

You surely observed as you performed Add-3 how unusual it is for your mind to work so hard. Even if you think for a living, few of the mental tasks in which you engage in the course of a working day are as demanding as Add-3, or even as demanding as storing six digits for immediate recall. We normally avoid mental overload by dividing our

tasks into multiple easy steps, committing intermediate results to long-term memory or to paper rather than to an easily overloaded working memory. We cover long distances by taking our time and conduct our mental lives by the law of least effort.

SPEAKING OF ATTENTION AND EFFORT

"I won't try to solve this while driving. This is a pupil-dilating task. It requires mental effort!"

"The law of least effort is operating here. He will think as little as possible."

"She did not forget about the meeting. She was completely focused on something else when the meeting was set and she just didn't hear you."

"What came quickly to my mind was an intuition from System 1. I'll have to start over and search my memory deliberately."

3
The Lazy Controller

I spend a few months each year in Berkeley, and one of my great pleasures there is a daily four-mile walk on a marked path in the hills, with a fine view of San Francisco Bay. I usually keep track of my time and have learned a fair amount about effort from doing so. I have found a speed, about 17 minutes for a mile, which I experience as a stroll. I certainly exert physical effort and burn more calories at that speed than if I sat in a recliner, but I experience no strain, no conflict, and no need to push myself. I am also able to think and work while walking at that rate. Indeed, I suspect that the mild physical arousal of the walk may spill over into greater mental alertness.

System 2 also has a natural speed. You expend some mental energy in random thoughts and in monitoring what goes on around you even when your mind does nothing in particular, but there is little strain. Unless you are in a situation that makes you unusually wary or self-conscious, monitoring what happens in the environment or inside your head demands little effort. You make many small decisions as you drive your car, absorb some information as you read the newspaper, and conduct routine exchanges of pleasantries with a spouse or a colleague, all with little effort and no strain. Just like a stroll.

It is normally easy and actually quite pleasant to walk and think at the same time, but at the extremes these activities appear to compete for the limited resources of System 2. You can confirm this claim by a simple experiment. While walking comfortably with a friend, ask him to compute 23 × 78 in his head, and to do so immediately. He will almost certainly stop in his tracks. My experience is that I can think while strolling but cannot engage in mental work that imposes a

heavy load on short-term memory. If I must construct an intricate argument under time pressure, I would rather be still, and I would prefer sitting to standing. Of course, not all slow thinking requires that form of intense concentration and effortful computation—I did the best thinking of my life on leisurely walks with Amos.

Accelerating beyond my strolling speed completely changes the experience of walking, because the transition to a faster walk brings about a sharp deterioration in my ability to think coherently. As I speed up, my attention is drawn with increasing frequency to the experience of walking and to the deliberate maintenance of the faster pace. My ability to bring a train of thought to a conclusion is impaired accordingly. At the highest speed I can sustain on the hills, about 14 minutes for a mile, I do not even try to think of anything else. In addition to the physical effort of moving my body rapidly along the path, a mental effort of self-control is needed to resist the urge to slow down. Self-control and deliberate thought apparently draw on the same limited budget of effort.

For most of us, most of the time, the maintenance of a coherent train of thought and the occasional engagement in effortful thinking also require self-control. Although I have not conducted a systematic survey, I suspect that frequent switching of tasks and speeded-up mental work are not intrinsically pleasurable, and that people avoid them when possible. This is how the law of least effort comes to be a law. Even in the absence of time pressure, maintaining a coherent train of thought requires discipline. An observer of the number of times I look at e-mail or investigate the refrigerator during an hour of writing could reasonably infer an urge to escape and conclude that keeping at it requires more self-control than I can readily muster.

Fortunately, cognitive work is not always aversive, and people sometimes expend considerable effort for long periods of time without having to exert willpower. The psychologist Mihaly Csikszentmihalyi (pronounced six-cent-mihaly) has done more than anyone else to study this state of effortless attending, and the name he proposed for it, *flow*, has become part of the language. People who experience flow describe it as "a state of effortless concentration so deep that they lose their sense of time, of themselves, of their problems," and their descriptions

of the joy of that state are so compelling that Csikszentmihalyi has called it an "optimal experience." Many activities can induce a sense of flow, from painting to racing motorcycles—and for some fortunate authors I know, even writing a book is often an optimal experience. Flow neatly separates the two forms of effort: concentration on the task and the deliberate control of attention. Riding a motorcycle at 150 miles an hour and playing a competitive game of chess are certainly very effortful. In a state of flow, however, maintaining focused attention on these absorbing activities requires no exertion of self-control, thereby freeing resources to be directed to the task at hand.

THE BUSY AND DEPLETED SYSTEM 2

It is now a well-established proposition that both self-control and cognitive effort are forms of mental work. Several psychological studies have shown that people who are simultaneously challenged by a demanding cognitive task and by a temptation are more likely to yield to the temptation. Imagine that you are asked to retain a list of seven digits for a minute or two. You are told that remembering the digits is your top priority. While your attention is focused on the digits, you are offered a choice between two desserts: a sinful chocolate cake and a virtuous fruit salad. The evidence suggests that you would be more likely to select the tempting chocolate cake when your mind is loaded with digits. System 1 has more influence on behavior when System 2 is busy, and it has a sweet tooth.

People who are *cognitively busy* are also more likely to make selfish choices, use sexist language, and make superficial judgments in social situations. Memorizing and repeating digits loosens the hold of System 2 on behavior, but of course cognitive load is not the only cause of weakened self-control. A few drinks have the same effect, as does a sleepless night. The self-control of morning people is impaired at night; the reverse is true of night people. Too much concern about how well one is doing in a task sometimes disrupts performance by

loading short-term memory with pointless anxious thoughts. The conclusion is straightforward: self-control requires attention and effort. Another way of saying this is that controlling thoughts and behaviors is one of the tasks that System 2 performs.

A series of surprising experiments by the psychologist Roy Baumeister and his colleagues has shown conclusively that all variants of voluntary effort—cognitive, emotional, or physical—draw at least partly on a shared pool of mental energy. Their experiments involve successive rather than simultaneous tasks.

Baumeister's group has repeatedly found that an effort of will or self-control is tiring; if you have had to force yourself to do something, you are less willing or less able to exert self-control when the next challenge comes around. The phenomenon has been named *ego depletion*. In a typical demonstration, participants who are instructed to stifle their emotional reaction to an emotionally charged film will later perform poorly on a test of physical stamina—how long they can maintain a strong grip on a dynamometer in spite of increasing discomfort. The emotional effort in the first phase of the experiment reduces the ability to withstand the pain of sustained muscle contraction, and ego-depleted people therefore succumb more quickly to the urge to quit. In another experiment, people are first depleted by a task in which they eat virtuous foods such as radishes and celery while resisting the temptation to indulge in chocolate and rich cookies. Later, these people will give up earlier than normal when faced with a difficult cognitive task.

The list of situations and tasks that are now known to deplete self-control is long and varied. All involve conflict and the need to suppress a natural tendency. They include:

avoiding the thought of white bears
inhibiting the emotional response to a stirring film
making a series of choices that involve conflict
trying to impress others
responding kindly to a partner's bad behavior
interacting with a person of a different race (for prejudiced individuals)

The list of indications of depletion is also highly diverse:

deviating from one's diet
overspending on impulsive purchases
reacting aggressively to provocation
persisting less time in a handgrip task
performing poorly in cognitive tasks and logical decision making

The evidence is persuasive: activities that impose high demands on System 2 require self-control, and the exertion of self-control is depleting and unpleasant. Unlike cognitive load, ego depletion is at least in part a loss of motivation. After exerting self-control in one task, you do not feel like making an effort in another, although you could do it if you really had to. In several experiments, people were able to resist the effects of ego depletion when given a strong incentive to do so. In contrast, increasing effort is not an option when you must keep six digits in short-term memory while performing a task. Ego depletion is not the same mental state as cognitive busyness.

The most surprising discovery made by Baumeister's group shows, as he puts it, that the idea of mental energy is more than a mere metaphor. The nervous system consumes more glucose than most other parts of the body, and effortful mental activity appears to be especially expensive in the currency of glucose. When you are actively involved in difficult cognitive reasoning or engaged in a task that requires self-control, your blood glucose level drops. The effect is analogous to a runner who draws down glucose stored in her muscles during a sprint. The bold implication of this idea is that the effects of ego depletion could be undone by ingesting glucose, and Baumeister and his colleagues have confirmed this hypothesis in several experiments.

Volunteers in one of their studies watched a short silent film of a woman being interviewed and were asked to interpret her body language. While they were performing the task, a series of words crossed the screen in slow succession. The participants were specifically instructed to ignore the words, and if they found their attention drawn away they had to refocus their concentration on the woman's behavior. This act of self-control was known to cause ego depletion. All the volunteers drank some lemonade before participating in a

second task. The lemonade was sweetened with glucose for half of them and with Splenda for the others. Then all participants were given a task in which they needed to overcome an intuitive response to get the correct answer. Intuitive errors are normally much more frequent among ego-depleted people, and the drinkers of Splenda showed the expected depletion effect. On the other hand, the glucose drinkers were not depleted. Restoring the level of available sugar in the brain had prevented the deterioration of performance. It will take some time and much further research to establish whether the tasks that cause glucose-depletion also cause the momentary arousal that is reflected in increases of pupil size and heart rate.

A disturbing demonstration of depletion effects in judgment was recently reported in the *Proceedings of the National Academy of Sciences*. The unwitting participants in the study were eight parole judges in Israel. They spend entire days reviewing applications for parole. The cases are presented in random order, and the judges spend little time on each one, an average of 6 minutes. (The default decision is denial of parole; only 35% of requests are approved. The exact time of each decision is recorded, and the times of the judges' three food breaks—morning break, lunch, and afternoon break—during the day are recorded as well.) The authors of the study plotted the proportion of approved requests against the time since the last food break. The proportion spikes after each meal, when about 65% of requests are granted. During the two hours or so until the judges' next feeding, the approval rate drops steadily, to about zero just before the meal. As you might expect, this is an unwelcome result and the authors carefully checked many alternative explanations. The best possible account of the data provides bad news: tired and hungry judges tend to fall back on the easier default position of denying requests for parole. Both fatigue and hunger probably play a role.

THE LAZY SYSTEM 2

One of the main functions of System 2 is to monitor and control thoughts and actions "suggested" by System 1, allowing some to be expressed directly in behavior and suppressing or modifying others.

For an example, here is a simple puzzle. Do not try to solve it but listen to your intuition:

A bat and ball cost $1.10.
The bat costs one dollar more than the ball.
How much does the ball cost?

A number came to your mind. The number, of course, is 10: 10¢. The distinctive mark of this easy puzzle is that it evokes an answer that is intuitive, appealing, and wrong. Do the math, and you will see. If the ball costs 10¢, then the total cost will be $1.20 (10¢ for the ball and $1.10 for the bat), not $1.10. The correct answer is 5¢. It is safe to assume that the intuitive answer also came to the mind of those who ended up with the correct number—they somehow managed to resist the intuition.

Shane Frederick and I worked together on a theory of judgment based on two systems, and he used the bat-and-ball puzzle to study a central question: How closely does System 2 monitor the suggestions of System 1? His reasoning was that we know a significant fact about anyone who says that the ball costs 10¢: that person did not actively check whether the answer was correct, and her System 2 endorsed an intuitive answer that it could have rejected with a small investment of effort. Furthermore, we also know that the people who give the intuitive answer have missed an obvious social cue; they should have wondered why anyone would include in a questionnaire a puzzle with such an obvious answer. A failure to check is remarkable because the cost of checking is so low: a few seconds of mental work (the problem is moderately difficult), with slightly tensed muscles and dilated pupils, could avoid an embarrassing mistake. People who say 10¢ appear to be ardent followers of the law of least effort. People who avoid that answer appear to have more active minds.

Many thousands of university students have answered the bat-and-ball puzzle, and the results are shocking. More than 50% of students at Harvard, MIT, and Princeton gave the intuitive—incorrect—answer. At less selective universities, the rate of demonstrable failure to check was in excess of 80%. The bat-and-ball problem is our first encounter with an observation that will be a recurrent theme of this book: many people

are overconfident, prone to place too much faith in their intuitions. They apparently find cognitive effort at least mildly unpleasant and avoid it as much as possible.

Now I will show you a logical argument—two premises and a conclusion. Try to determine, as quickly as you can, if the argument is logically valid. Does the conclusion follow from the premises?

All roses are flowers.
Some flowers fade quickly.
Therefore some roses fade quickly.

A large majority of college students endorse this syllogism as valid. In fact the argument is flawed, because it is possible that there are no roses among the flowers that fade quickly. Just as in the bat-and-ball problem, a plausible answer comes to mind immediately. Overriding it requires hard work—the insistent idea that "it's true, it's true!" makes it difficult to check the logic, and most people do not take the trouble to think through the problem.

This experiment has discouraging implications for reasoning in everyday life. It suggests that when people believe a conclusion is true, they are also very likely to believe arguments that appear to support it, even when these arguments are unsound. If System 1 is involved, the conclusion comes first and the arguments follow.

Next, consider the following question and answer it quickly before reading on:

How many murders occur in the state of Michigan in one year?

The question, which was also devised by Shane Frederick, is again a challenge to System 2. The "trick" is whether the respondent will remember that Detroit, a high-crime city, is in Michigan. College students in the United States know this fact and will correctly identify Detroit as the largest city in Michigan. But knowledge of a fact is not all-or-none. Facts that we know do not always come to mind when we need them. People who remember that Detroit is in Michigan give higher estimates of the murder rate in the state than people who do not, but a majority of Frederick's respondents did not think of the city when questioned about the state. Indeed, the average guess by people