

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:

$$17 \times 24$$

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, overriding 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 occupationhein occupatnal 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 i>Cy 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.

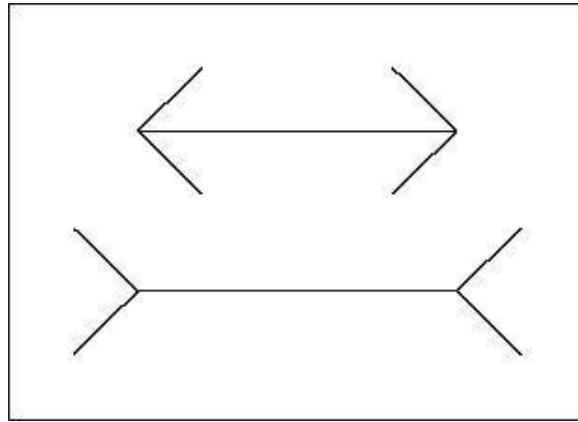


Figure 3

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 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 James 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 ²¹⁷at 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.”

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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 digit 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.”