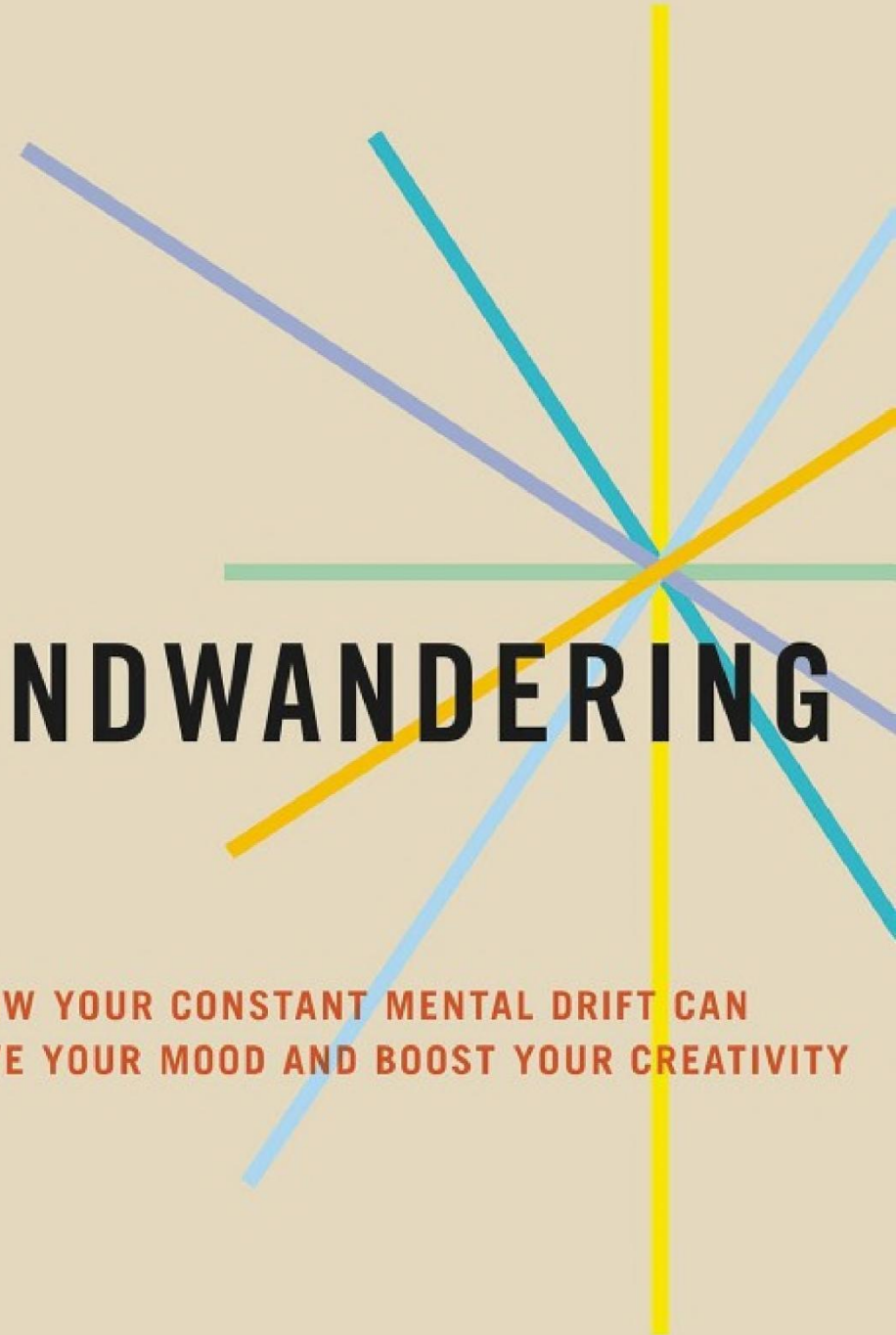

MINDWANDERING

HOW YOUR CONSTANT MENTAL DRIFT CAN IMPROVE YOUR MOOD AND BOOST YOUR CREATIVITY

MOSHE BAR

Contents

For my parents, Hila and Avi

States of Mind

TALKING ABOUT SEX, KINK, AND ADHD, CATIE OSBORN, AN ACTOR and a Shakespeare aficionado, confesses that before discovering the less conventional sexual practices of "kinkiness," her mind would often drift during sexual activities. In an interview for *Haaretz*, she says that discovering "kink" and BDSM was a purifying moment for her, helping her connect her mind with her body. When you are blindfolded and your partner slides an ice cube over your body, or drips hot wax on your skin, you stop thinking about the noise from the air conditioner or the squeaking of the bed. You are all immersed in the real thing. Indeed, extreme experiences drag you in by calling for your undivided attention. But once you've learned to give in and let the experience take you, it no longer needs to be reserved for extreme situations anymore. Imagine how your life could feel if eating a blueberry would be just as immersive as kink sex with hot wax on your skin, sucking in your entire mind. *Immersion* is a gift waiting inside our brain.

We all know how insistently mindwandering can hijack our attention, and as our lives have become so much more frenetic, people are increasingly worried about the quality of their mental experience; not just their ability to focus and get their work done, but their ability to enjoy their lives, to be truly, deeply engaged in them. I learned just how concerned they are when an op-ed I wrote, titled "Think Less, Think Better," was published by the *New York Times* a few years ago. In it I considered

"how much we overlook, not just about the world, but also about the full potential of our inner life, when our mind is cluttered." As resonant as the piece was, it didn't touch on the important insights I have to share about why our minds wander and how their preoccupations are actually vital to our well-being even though some of our mindwandering is indeed harmful.

So much attention has been paid to ways to unplug from the bustle, and that's absolutely to be commended. I'll share my own positive experiences with doing so in silent meditation retreats. But as a series of discoveries in neuroscience over the past several decades have revealed, the greater challenge is freeing ourselves from the distractions within, which disrupt our attention and intrude on the quality of our experience even when we are in a perfectly quiet place. In fact, they may do so even more in times of quiet.

Research has revealed that our brains are inherently active. A number of brain regions connected in what's dubbed the default mode network (DMN) are always grinding away, engaged in a number of different involuntary activities that neuroscientists collectively call mindwandering: from daydreaming to the incessant self-chatter and from ruminating about the past to worrying about the future. The brain regions most often identified as being part of the DMN include the medial prefrontal cortex, the posterior cingulate cortex, and the angular gyrus, but there are several more that come and go as part of this massive, large-scale network. Not only does all of this inner commotion tug our attention away from the present moment, but it can dampen the quality of our experience, lowering our mood and potentially contributing to anxiety and depression. Yet there's a method to this apparent madness. Evolution has clearly taught our minds to wander. According to various studies, they're caught up in mindwandering between 30 and 47 percent of our waking time, gobbling up a great deal of energy.[1] The logic of evolution suggests there must be something beneficial about it, and over the course of the past couple of decades, I and my neuroscience compatriots have identified a core set of its important functions.

One line of research has shown that some of the default activity is concerned with developing our sense of self, through all sorts of cogitating and monitoring. Another line of research has found that a good amount of the DMN's activity is involved with assessing other people, which is dubbed Theory of Mind (ToM), trying to sort out what others are thinking and what they think of us.

As these findings began coming out, I was initially puzzled about how on earth my own discoveries about the DMN's activity fitted with these other functions. My research then focused on something quite different—visual cognition—and I found the DMN was highly involved in the process. I was trying to figure out how we piece together clues in the visual environment to construct an understanding of what we're seeing. In one such study, I would ask subjects to identify ambiguous objects that I had somewhat obscured in photos. As it turned out, if I showed them, say, a fuzzy image of a hairdryer in the setting of a bathroom, they would identify it as a hairdryer, but if I embedded the same fuzzy hairdryer image in the setting of a workbench, surrounded by a lot of tools, they would identify it as a drill.[2] I realized they were identifying objects by making associations between them and the things around them. Why would the same brain network involved in that associative activity also be engaged in developing a sense of self and Theory of Mind skills?

Then it came to me, like a bolt: all these mental processes involve making associations. Our sense of self, research has shown, is largely a form of prediction about who we are, about how we will think, feel, and behave in different situations, associating how we've thought, felt, and behaved in similar situations in the past with how we will do so now and in the future. The same is true for how we develop our assessments of others. Associations are the building blocks of most mental operations.

This is, essentially, why so much of the DMN's mindwandering activity is concerned with thinking about the past and the future, taking us away from the now. We're

searching memory for associations to help us interpret what's happening in our lives and what might be coming. We're intently making all manner of predictions. Indeed, as I continued researching what people were thinking about when their DMN was active, I found that they're often creating elaborate scenarios of future events, like little movies about how situations in their lives are going to play out. No wonder so much of our mental energy is hogged by the DMN. After all, knowing how to interpret situations, establishing a sense of who we are, understanding others as best we can, and anticipating what turn of events we might need to be prepared for are all crucial to making our way through life.

The problem is that we can become so engaged in this consideration of the past and making predictions, and so reliant on associations that we've made based on experience, that for much of the time, we're disconnected from what's actually happening in the moment. This not only interferes with our focus but also leads to all sorts of misinterpretations that cause problems in our lives, such as when we mistakenly think someone is untrustworthy because they remind us of someone else who was. Or we might experience unnecessary anxiety that we're going to be laid off because our boss is acting in a way we associate, incorrectly, with displeasure in us. A preoccupation with the past and the future also leads us to lose some of our ability to perceive novelty. We're so inclined to perceive expected associations that we overlook unexpected connections, which stunts both discovery and creativity.

As I contemplated all of these findings about the DMN and mindwandering, I came to what for me has been a groundbreaking realization. We don't want to just clamp down on all mindwandering, which is just as well because that's virtually impossible. What we want to do instead is become more aware of when and how our minds are wandering. Then we can become more effective at directing that activity voluntarily as much as possible, so we can buckle down and focus on tasks or, alternatively, let ourselves be truly, deeply immersed in the experience of the moment. At other times, when we want to

stimulate our creativity, as well as our mood, we'll do best to free our minds to indulge in a good broad-ranging stroll. We want, in short, to work toward being able to bring the right mind to the right time.

Vital to building up our ability to do this is the understanding that so much of our mindwandering is aimed at helping us exploit our memories of past experiences, to assist us in figuring out how to solve problems at work or in our lives, drawing our attention inward. But in my lab, I found that we could induce a broadly associative type of mindwandering that is exploratory, ranging all over and open to novel perceptions. This type of mindwandering is like the polar opposite of rumination, which is narrowly focused on some memory or worry. And because I had read that rumination dampens mood, I decided to conduct studies to see if when our minds are engaged in this type of broad, exploratory mindwandering, our mood is lifted. Yes, it is! By merely reading chains of words that expand broadly, like the chain "wolf–moon–dark side–Pink Floyd–*The Wall*–Germany–EU," our mood becomes significantly more positive. This finding is as groundbreaking as it is simple to explain, and we currently use it to alleviate symptoms associated with depression, anxiety, and stress. Then we decided to see if when we improve people's mood, their minds would also begin engaging in broader-ranging mindwandering. They did! How astonishing: the causal connection goes both ways. This led us to conjecture that if people's mood was lifted, and they were engaging in broader-ranging mindwandering, they would also be more creative in providing solutions to tasks we assigned them. They were! These findings were thrilling, and they led me, through steps I'll narrate here, to the realization that our brains are constantly moving along a continuum between two fundamental, and opposing, states of mind, which I call exploratory and exploitatory, and the degree to which our mind is wandering and in what ways will dramatically differ in each.

IN THE EXPLORATORY STATE, OUR MINDS ARE OPEN TO NOVEL INFORMATION—experiencing and observing the moment, willing to stomach

some uncertainty for the benefit of learning—our creativity is stoked, and we're in a relatively upbeat mood. If our minds are wandering, they'll be doing so in an enjoyable, free-ranging way. In the exploitatory state, on the other hand, we're focused on drawing from our past experience, relying on tried-and-true methods for interpreting the situation and for solving problems, preferring the certainty of the familiar over the thrill of the new, and our mood will be comparatively dampened. If our minds are wandering, they'll be doing so in a relatively narrow way. The exploratory is outward focused, bottom-up, and experiential, while the exploitatory is inward oriented, top-down, and procedural. Our minds are never really at one or the other extreme, but they will tend to favor more of one versus the other at any given moment.

The exploratory state sure sounds far more fun, but both are vital for our success and our well-being. The key is that as we go about any given task or experience, as much as we can, we want to muster the state of mind (SoM) that's optimal for the specific situation. And if we're on a vacation with our kids, we want to be in bottom-up, broad experiential mode as much as we can, fully enjoying the moments with them, not pulled constantly into mindwandering about our work or old mental templates. If we've got to get a report written by tomorrow morning, we want to be in top-down, narrowly focused mode. If we're searching for a big new idea—say, for a product to create—we want to be in broadly associative mindwandering mode.

A lot has been discovered and said already about how flexible our brains are. This is the key to our evolution and to our survival in most circumstances, and we are lucky for having such an elastic, open-minded brain. There is certainly no magical formula for gaining control over our mental state, but I have found that by being aware of the need to try to calibrate my state of mind on this exploratory/exploitatory continuum for the situation I'm in, I'm increasingly able to do so. I aimed to replicate here the exhilarating intellectual journey I and my neuroscience colleagues have traveled in making these findings. But I do also want to share some insights about building up more

ability to put our minds in the state we'd like them in. Some of these insights are organized and collated in the Appendix, and while they are not provided here as overly concrete prescriptions, applying them in everyday life could be a personal quest of discovery and adjustments.

One great help for me has been mindfulness meditation, and I'll share here how my experiences at silence retreats have helped me build up my awareness of my state of mind and purposefully nudge it the way I want it to go. But I'll also discuss how meditation, and developing a high degree of mindfulness, has limits when it comes to optimizing our mental state, not the least of which is that so many people find mindfulness training unpleasant. My research illuminates one reason for this. Meditation is an extremely narrow form of mental activity—the antithesis of broadly associative mindwandering—so it makes sense that it can be unenjoyable in some respects. In addition, mindfulness, if we were to rigorously impose it on ourselves constantly, would turn us into observers of our lives, making it harder to be fully engaged in the living of them, to be lost in the rush of experience. While mindfulness offers numerous advantages, and I recommend that all human beings at least give it a try, we very much want to have some of that utterly immersed-in-the-moment time in our lives.

As much as I've been gaining more control, my mind still wanders at plenty of times I don't want it to. Our minds always will to some extent. One of the biggest takeaways for me from my work on mindwandering is that I'm less stressed about that, because I know why it's going on. Just the other day, I took a professor visiting from Stanford, whose work and personality I greatly admire, for lunch in a Tel Aviv café. At some point in our conversation, he told me he had once heard something that had completely changed him, how he thinks and how he lives his life, and he wanted to share it with me. I have no idea what it was. Even in spite of that dramatic introduction, my mind drifted far away as he spoke, and I was too embarrassed once I realized what had happened to tell him I hadn't caught what he'd said. I can only imagine how odd he must have thought it was that I didn't

comment meaningfully about his revelation. Instead, I quickly changed the subject. Happily, though, I can report that my mind had wandered to something interesting in my own life. Perverse as our mindwandering can be, at least it generally does have a purpose.

CHAPTER ONE

ALWAYS "ON"

MUCH OF NEUROSCIENCE RESEARCH UP TO THE DEVELOPMENT OF brain scanning was somewhat akin to phrenology, the Victorian practice of inferring people's mental character by feeling the shape of their skulls. Of course, I'm overstating the case, but in studying the internal workings of the brain, the assumption for a long time has been that different areas within the brain would be dedicated to different tasks: one for language, another for memory; one for recognizing faces, another for feeling emotions. Over time, however, we came to realize that the operation and architecture of the brain are much more distributed over large networks than being modular and compartmentalized. Most, if not all, functions are accomplished via the activation and orchestration of multiarea networks. No single region, let alone individual neurons, accomplishes much without short- and long-distance cooperation. And in the context of mindwandering and the brain's default network that mediates it, it is worth noting that different states of mind, such as meditation and sleep, as well as different psychiatric conditions all affect not only the information content in this massive network, but also the extent of connectivity between the cortical nodes of this network. The different areas constituting the network could be more strongly or more weakly connected in different states, more or less synchronized with each other, and influence each other to different degrees. Now we know that the brain is broadly dynamic and flexible in its operation and in its characteristics.

Still, we are far from a solid understanding of even the most basic neural functions. I learned this with a shock as a student in the laboratory of Professor Shimon Ullman, a pioneer in the development of computer vision. At the time, I was just finishing studying electrical engineering, out of an ill-conceived notion of fulfilling my father's ambitions for me to be an engineer. I had quickly learned that I had absolutely no interest in chip design and that the only area of research in the field that captivated me was computer vision. The aim of this field was to mimic the way the human brain represents and recognizes images, and I discovered that at that time, thirty years ago, no one had a clear idea of how it is accomplished. I found that outrageous, and with the zeal of a young student with a whole lot yet to learn, I told Ullman so. He responded, as I recall, that I'd soon come to appreciate how complex the workings of the brain are. That I did. Sadly, it is still largely true that we have no hard knowledge of how the brain recognizes images, mainly some intriguing theories with preliminary support.

Fortunately, during my work in his lab, and then much more extensively in the cognitive psychology lab of another pioneer, Irv Biederman, a door was opened to a more productive, and exciting, new area of research that had just gotten under way, which I left to pursue. A major new way for studying the brain had recently been invented: fMRI (functional magnetic resonance imaging). The MRI machine itself, which uses magnetic fields and radio-frequency waves to image the anatomy of biological tissues, bones, and body organs, had been around for a few decades at that point, mostly in use in medical contexts. But the *f*, functional, MRI was the breakthrough neuroscientists had been thirsty for. By measuring blood flow, the functional part of fMRI allows us to infer where and when brain activity takes place. Maps of brain activity could be created by "sticking subjects in the magnet" and asking them to look at pictures, listen to sounds, count sheep—all sorts of tasks. We could look into the human brain during its normal, ongoing operation. Of course, that is with a few caveats, such as that what is measured is not exactly brain activation but rather a proxy,

and that even interpretations of data can be subjective, but a revolution nevertheless. This was a moment of extraordinary adventure; we were roaming around inside the pathways of the mind like hikers in the woods at night with flashlights. And we soon stumbled upon the first truly substantial finding through neuroimaging.

The Discovery of the Brain's Default Mode Network

Excited by the explosion of research, I got myself to Harvard Medical School, where Ken Kwong, Bruce Rosen, and collaborators were doing some of the most important work. My timing was fortuitous. A momentous discovery had recently been made: neuroimaging had paved the way to the discovery of the brain's default mode and of the prevalence of mindwandering in everyday life.

What made the advent of fMRI so groundbreaking is that we no longer had to compromise on analogies to animals' brains, we no longer had to make do with postmortem brains, we no longer had to infer the operation of the healthy brain from head and brain injuries (like that of the famous Phineas Gage or gunshot injuries in the Spanish Civil War), and we no longer had to limit ourselves to whatever can be recorded from patients during (or prior to) brain surgery. The result is beautifully colorful images that are taken as neural activation maps.

What are those colorful brain activations we see in fMRI studies? They are typically the result of a subtraction between what is evoked in the brain by two different experimental conditions. Imagine there is a study about emotional processing, specifically looking at what happens in the brain when we see happy faces compared with what happens in the brain when looking at sad faces. A participant (a "subject") is asked to lie still on the sliding MRI bed—with a big cage (radio-frequency coil) around her head, loud high-frequency noises from the machine, in cold temperature—and attend what is projected to her on the screen. The fMRI signal is measured for each and every presentation trial. The brain activity elicited by all trials of one condition (all the happy faces) is averaged together and is

when I am being asked why artificial intelligence algorithms do not behave like the human brains that they try to imitate, my answer is that AI is still more engineering than neuroscience. By making a computer perform a task with rigid boundaries of how to achieve goals, and with little accommodation for exceptions and improvisation, the artificial system lacks more implicit but immensely critical aspects of the human brain, such as flexibility and ingenuity.) So, in our context, once we realize that the brain is vigorously active when we are not busy with a specific goal, like when waiting in line, standing in the shower, or listening to something boring, knowing that this activity consumes significant energy should tell us that this activity must play some important role.

The second maxim, one that started in the mind of a young and naive postdoc but still serves me to this day, is that the brain always tells you, the inquisitive scientist, the truth. When things do not make sense, it is because you are not asking the right question or you are not asking the right question properly. The brain typically does not volunteer information, but the answers are there, waiting for us to arrive.

A relentless brain, always "on," what does it do when we are not busy? The chapters ahead will tell the story of that often perplexing but always thrilling path of discovery and how findings that seemed quite disparate have been coming together. But before delving into this journey of unveiling the purpose of the DMN and of mindwandering, let us first give our thoughts a serious examination.

CHAPTER TWO

CONNECTING WITH OUR THOUGHTS

WE DO NOT THINK ABOUT OUR THOUGHTS OFTEN ENOUGH, BUT thoughts are the building blocks of our mental life, and of mindwandering. Thoughts are how we get from one idea to the next. They can be verbal, visual, and more; they can be progressing fast or slow; they can span many different semantic topics; they are based on stuff we know and have stored in memory; they can be of varying emotional valance; and they are often manifested as an internal dialogue between me and I. Thoughts are the interface and the translation of our inner world to our conscious mind, which can then be communicated to the outside world, or just remain with us.

The Source of Our Thoughts

When thoughts are aimed at a specific goal, they follow an agenda and a clear structure, not predictable, but nevertheless with a coherent progression, like when solving a problem. They accumulate and advance toward that goal. Planning is a good example. There is a chair at home you wanted to fix yourself, and you are thinking of doing it tomorrow morning. You think of the stuff you need to gather, like glue, a dead-blow hammer, a scrub plane, a wood chisel, a saw, and a sanding block. You "travel" along the web of concepts you have in memory, and you


image
not
available

in context and state of mind that makes idle time feel like either death or bliss? It has to be more than that. In weeklong retreats of silence and meditation, we are able to stare at ants on the ground for eternity because the senses have opened up. Staring provides you with enough stimulation; you do not need to go anywhere when the senses are so sensitive, and everything suddenly looks so interesting.

Outside the comparison between retreats and the real world, it is curious why at times an interval of nothingness could be the launching pad for great creative ideas and at other times your mind seems to be empty with only one thought: "When will this end, for crying out loud?" There are various possible explanations for why boredom feels the way it does, from impatient personality to existential accounts connecting the feeling of boredom with the fact that people usually do not want to face their thoughts and would do anything to escape themselves. In some experiments it was even reported that people would rather give themselves small electric shocks than just sit quietly in front of a white wall.[5] Boredom feels like mental pain.

When we are bored we feel that time hardly passes, which is also the case when we suffer. It is a strange state: we do not do anything, yet our mind seems full; we ruminate on nothingness. What is more, pure boredom kills curiosity and creativity. This is intriguing because we know we need an empty and available mind to be creative and have room for curiosity. This is one of those puzzles we scientists like to encounter because they open up new grounds for new understandings. So, some emptiness of mind breeds creativity and curiosity, and some emptiness is unbearably annoying; characterizing the difference is sure to yield something interesting. The idleness that Bertrand Russell praised cannot be the one that makes us bored.

Distinguishing types of emptiness is directly related to our drive for understanding the effect of thought and our inner world on the quality of experience.[6] Roughly speaking, there are three possible states of idleness: doing nothing and being bored (with individually varying levels of tolerance to this state); doing

nothing but being calm and relaxed about it, like at a meditation retreat or on the beach on a vacation; or doing nothing but mindwandering extensively and having creative and constructive thoughts. What is really of interest is that some idleness situations allow and are even conducive to mindwandering, but in other states, even in a very similar situation, your mind is not as crafty, and even if you tell yourself, "Okay, I'm stuck here, so I might as well daydream in the meantime or fantasize about something fun," it does not work.

At first it may seem that we prefer to mindwander only when it comes at the expense of something else we need to be doing, some sort of an escape from the moment. But the real explanation is that mindwandering is controlled beyond our conscious reach, so the mind will wander by need regardless, assuming the resources are available. This supports the notion that mindwandering serves a function, and it is not subjected to our voluntary control of when to wander or where to wander. That we cannot mindwander by conscious decision is also why it is so hard to stop mindwandering at will. We cannot start and we cannot stop mindwandering voluntarily.

What we can do, instead, is understand how the subconscious decides for us to mindwander or not, why, and when. In mindfulness meditation we actually try, indirectly, to take control over the operation of the subconscious. We make it stop sending us to wander. The way we do it is not forcefully, but gently. The subconscious mind sends us wandering, via our conscious mind, about a certain thought; we embrace this conscious thought and move on. We refuse to fight it but rather accept it and observe it instead. After we let it go, be it through labeling or anything else, the subconscious sends the next thought, and the same thing happens. Thus, to empty our mind, what we actually do is empty our subconscious mind, until there is nothing for it to send us wandering to. The opposite—making ourselves mindwander at will when we seek new ideas or just mental entertainment to replace a boring situation—you now know, requires no task and a positive mood.

Habits of the Mind

Just as habits of behavior "die hard," so do habits of the mind. Habits are a double-edged sword. On the one hand, they are an ingenious mechanism that evolution has instilled in us to automatize our interactions, thereby saving us time and helping us survive better. You learn something for the first time, and then you get to do it again, and again, and again, learning from your mistakes, learning what feels best for you, and at some point you perfect it. Then your brain starts delegating this skill, or habit, from your conscious mind, which initially required much deliberation and attention for every step, to your more automatic subconscious mind, which can do the exact same thing without bothering the conscious you. This skill is now said to be automatic, which is a habit, like a mental autopilot, freeing your mind for other things, such as acquiring new experiences.

Those things that you learn and practice and then outsource can be, for example, how to make an omelet and how to drive a car, how to recognize a risky situation, and how to plan your escape route from a boring gathering. It can also help you "jump" to conclusions. Autopiloting how to drive means not thinking about the physical and attentional operations required to drive safely. You just do it, which explains why we all tend to forget long stretches of our daily commute because our mind was not part of the process and therefore wandered off and did not pay attention to what the subconscious mind took care of in the background. Mental autopiloting, similarly, means performing mental operations without consciously thinking about them too much. A good analogy is solving simple multiplications from the multiplication table. As a young child, you had to work hard to answer when your teacher asked how much is eight times nine because you actually calculated it. Gradually, the response becomes automatic. You just say seventy-two without thinking. This is not much of a delegation to the subconscious as it is an associative mental shortcut to bring you straight to the final answer based on your experience. The neural path that used to lead you to the answer as a child has been replaced by a direct connection.