

“Groundbreaking . . .  
as entertaining as it is provocative.”

—KEN ROBINSON,  
New York Times bestselling author of *The Element*

# DEVIATE

**BEAU LOTTO**

**THE SCIENCE OF SEEING DIFFERENTLY**

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*To perceive freely...  
Through tempest...  
Violence un-cast...  
With courageous doubt...  
A tilted self...*

*Dedicated to those who walk tilted.*

## ACKNOWLEDGMENTS

All knowing begins with a question. And a *question* begins with a “*quest*” (to state the obvious), as does life. At the core of living, then, is the courage to move, to step with doubt but step nonetheless (sometimes off a cliff, which is a less good step). Fortunately, no one steps alone (except that last one). My shuffles expressed here were and are enabled by the courage of others who in different ways enable me to live: My deviant Mum and Padre and Janet, my four mad sisters, my gorgeous gremlins Zanna, Misha and Theo, and my essential and beautiful (co-)explorer and creator Isabel. All incredibly colorful people who have shown me new ways of seeing, sometimes against my will (sorry), always to my benefit eventually. They are “*my why*,” my foundation for attempting to see freely, and the motivation to support others in their attempt to do so.

I thank my teachers (and all teachers more generally). Most of our life happens without us there, since most of our perceptions were seeded by, if not out-right inherited from, others. Of particular importance to me have been the perceptions of one of the world’s leading neuroscientists Dale Purves, who was the initiator and distiller of my way of thinking and being in science and the science of perception. A mentor in the truest sense. Dale, along with Richard Gregory, Marian Diamond, Joseph Campbell, Houston Smith and Carl Sagan and their deviating-ilk reveal in action that *true* science (and creatively-critical-thinking in general) is *a way of being* that can transform. They are teachers who show us how to look (not what to look at). Teachers like Mrs Stuber at Interlake, Mrs Kinigle-Wiggle and Marshmellow, Mr Groom and Orlando at Cherry Crest, thank you. I also thank my core collaborators (teachers of a different kind): Isabel Behncke, who has expanded, opened and

grounded my knowledge personally and academically in essential ways (including the different grounds of Chile the kelp-beds to lake-beds), Rich Clarke, who has been core to the lab's activities and ideas since its inception, Lars Chittka, who taught me how to train bees, Dave Strudwick, who was essential to creating the lab's science education programme... and my diversity of PhD and Masters students in neuroscience, computer science, design, architecture, theatre, installation art, and music, such as David Maulkin, Daniel Hulme, Udi Schlessinger and Ilias Berstrom, who became experts in areas that I was not, and in doing so complexified the lab and my thinking in essential ways.

I also thank my highly engaged editors Mauro, Bea and Paul, my brilliant agent and friend Doug Abrams (whose ambition and impact in publishing is inspiring), and my tremendous support-writer Aaron Shulman without whom this 20-year project would never have been seen by me, much less anyone else. Together we struggled to innovate; i.e., to balance creativity and efficiency (or more accurately, they struggled to balance me patiently).

And I thank *you*. One of the most challenging things we can do is to step into uncertainty. I conceived of *Deviate* as an experiment in book-form, a place to share my necessarily limited understanding of perception as well as my speculations and opinions (inherited and seeded) in the hope—and I can only hope—that you would know less at the end than you think you know now, and in doing so understand more. In nature form (or change) comes from failure, not success. The brain—like life—does not search to live, but to not die. Which makes success an accident of what failure leaves behind when one is thoughtfully deluded enough to walk tilted (long) enough.

*The only true voyage of discovery...  
[would be] to possess other eyes, to behold the universe  
through the eyes of another.*  
—Marcel Proust



## INTRODUCTION

### The Lab of Misfits

When you open your eyes, do you see the world as it really is? Do we see reality?

Humans have been asking themselves this question for thousands of years. From the shadows on the wall of Plato's cave in *The Republic* to Morpheus offering Neo the red pill or the blue pill in *The Matrix*, the notion that what we see might not be what is truly there has troubled and tantalized us. In the eighteenth century, the philosopher Immanuel Kant argued that we can never have access to the *Ding an sich*, the unfiltered "thing-in-itself" of objective reality. Great minds of history have taken up this perplexing question again and again. They all had theories, but now neuroscience has an answer.

The answer is that we don't see reality.

The world exists. It's just that we don't see it. We do not experience the world as it is *because our brain didn't evolve to do so*. It's a paradox of sorts: Your brain gives you the impression that your perceptions are objectively real, yet the sensory processes that make perception possible actually separate you from ever accessing that reality directly. Our five senses are like a keyboard to a computer—they provide the means for information from the world to get in, but they have very little to do with what is then experienced in perception. They are in essence just mechanical media, and so play only a limited role in what we perceive. In fact, in terms of the sheer number of neural connections, just 10 percent of the information our brains use to see comes from our eyes. The rest comes from other parts of our brains, and this other 90 percent is

in large part what this book is about. Perception derives not just from our five senses but from our brain's seemingly infinitely sophisticated network that makes sense of all the incoming information. Using perceptual neuroscience—but not *only* neuroscience—we will see why we don't perceive reality, then explore why this can lead to creativity and innovation at work, in love, at home, or at play. I've written the book to *be* what it describes: a manifestation of the process of seeing differently.

But first, why does any of this really matter to you? Why might you need to deviate from the way you currently perceive? After all, it *feels* like we see reality accurately... at least most of the time. Clearly our brain's model of perception has served our species well, allowing us to successfully navigate the world and its ever-shifting complexity, from our days as hunter-gatherers on the savannah to our current existence paying bills on our smartphones. We're able to find food and shelter, hold down a job, and build meaningful relationships. We have built cities, launched astronauts into space, and created the Internet. We must be doing something right, so... who cares that we don't see reality?

Perception matters because it underpins everything we think, know, and believe—our hopes and dreams, the clothes we wear, the professions we choose, the thoughts we have, and the people whom we trust... and don't trust. Perception is the taste of an apple, the smell of the ocean, the enchantment of spring, the glorious noise of the city, the feeling of love, and even conversations about the impossibility of love. Our sense of self, our most essential way of understanding existence, begins and ends with perception. The death that we all fear is less the death of the body and more the death of perception, as many of us would be quite happy to know that after “bodily death” our ability to engage in perception of the world around us continued. This is because perception is what allows us to experience life itself... indeed to see it as alive. Yet most of us don't know how or why perceptions work, or how or why our brain evolved to perceive the way it does. This is why the implications of the way the human brain evolved to perceive are both profound *and* deeply personal.

Our brain is a physical embodiment of our ancestors' perceptual reflexes shaped through the process of *natural selection*, combined with our own reflexes as well as those of our culture in which we are embedded. These in turn have been influenced by the mechanisms of development and learning, which results in seeing only what helped us to survive in the past—and nothing else. We carry all of this *empirical*

history with us and project it out into the world around us. All of our forebears' good survival choices exist within us, as do our own (the mechanisms and strategies that would have led to bad perceptions are selected out, a process that continues to this day, every day).

Yet if the brain is a manifestation of our history, how is it ever possible to step outside the past in order to live and create differently in the future? Fortunately, the neuroscience of perception—and indeed evolution itself—offers us a solution. The answer is essential because it will lead to future innovations in thought and behavior in all aspects of our lives, from love to learning. What is the next greatest innovation?

It's not a technology.

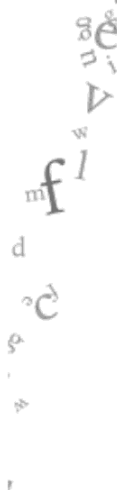
It's a way of seeing.

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Humans have the wild and generative gift of being able to see their lives and affect them just by reflecting on the process of perception itself. We can see ourselves see. That is what this book is fundamentally about: seeing your see or perceiving your perception, which is arguably the most essential step in seeing differently. By becoming aware of the principles by which your perceptual brain works, you can become an active participant in your own perceptions and in this way change them in the future.

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## Down the Rabbit Hole

Alice follows a white rabbit down a hole and ends up in a world in which fantastical things happen. She grows in size; time is eternally stopped for the Mad Hatter at 6 p.m.; the Cheshire Cat’s grin floats in the air, sans the cat. Alice must navigate this bizarre new environment and at the same time maintain her sense of self, no easy task for anyone, let alone a child. The book *Alice in Wonderland* underscores the virtue of being adaptive when confronting shifting circumstances. From the perspective of neuroscience, however, there is a much more powerful lesson: We’re all like Alice all the time—our brains must process strange new information arising from unpredictable experiences every single day, and provide us with useful responses—except that we didn’t have to drop through the rabbit hole. We’re already deep inside it.

My goal in *Deviate* is to reveal the hidden wonderland of your own perception to you as my more than 25 years of research have revealed it to me. You don’t have to be a so-called “science person.” Although I’m a neuroscientist, I’m not just interested in the brain only, since

neuroscience is so much bigger than just the brain. When neuroscience is applied outside the disciplines it is traditionally associated with—such as chemistry, physiology, and medicine—the possibilities are not just immense, but fantastically unpredictable. Neuroscience—when defined more broadly—has the potential to impact everything from apps to art, web design to fashion design, education to communication, and perhaps most fundamentally, your personal life. You’re the only one seeing what you see, so perception is ultimately personal. Understanding of the brain (and its relationship to the world around you) can affect *anything*, and lead to startling deviations.

Once you begin to see perceptual neuroscience this way, as I did several years ago, it becomes hard to stay in the lab... or at least the more conventional, staid conception of what a “lab” is. So, a decade ago I began redirecting my energies toward creating brain-changing, science-based experiences for the public: experiment as experience... even theater. The theme of one of my first installations at a leading science museum was *Alice in Wonderland*. The exhibit, much like Lewis Carroll’s strange, topsy-turvy novel, took visitors through illusions intended to challenge and enrich their view of human perception. This first exhibit—which I created with the scientist Richard Gregory, a hero in perception who shaped much of what I (and we) think about the perceiving brain—grew into many other settings, all of them based on the belief that to create spaces for understanding we need to consider not only how we see, but *why* we see what we do. To this end, I founded the Lab of Misfits, a public place open to anyone where I could conduct science “in its natural habitat,” a playful and rule-breaking ecology of creativity. This was most dramatically the case when we took up residency in the Science Museum in London.

My Lab of Misfits has enabled me to bring together primatologists, dancers, choreographers, musicians, composers, children, teachers, mathematicians, computer scientists, investors, behavioral scientists, and of course neuroscientists in a place where concepts and principles unite, where the emphasis is on innovation, and where we passionately investigate things we care about. We’ve had an official “Keeper of the Crayons” and “Head Player” (not *that* kind of player—as far as we know). We’ve published papers on nonlinear computation and dance, bee behavior and architecture, visual music, and the evolution of plant development. We’ve created the world’s first Immersive Messaging app

that enables gifting in physical space using augmented reality, which allow people to re-engage with the world. We've initiated a new way to interact with the public called NeuroDesign, which combines those who are brilliant at telling stories with those who understand the nature of the stories the brain desires. We have created an education platform that, with the *raison d'être* of encouraging courage, compassion, and creativity, doesn't teach children about science but makes them scientists, and has resulted in the youngest published scientists in the world (and the youngest main-stage TED speaker). Many of the ideas in *Deviate* were created, prototyped, and embodied through experience in this physical and conceptual "Lab of Misfits" space. This means the book is also a product of all these misfits, the interactions between them, and even more significantly, our interactions with historic and contemporary misfits outside the lab.

This brings me to a key theme in the pages ahead: that perception isn't an isolated operation in our brains, but part of an ongoing process inside an *ecology*, by which I mean the relation of things to the things around them, and how they influence each other. Understanding a whirlpool isn't about understanding water molecules; it's about understanding the interaction of those molecules. Understanding what it is to be human is about understanding the interactions between our brain and body, and between other brains and bodies, as well as with the world at large. Hence life is an *ecology*, not an environment. Life—and what we perceive—lives in what I call "the space between." My lab, and all my research on perception, draws on this inherent interconnectedness, which is where biology, and indeed life itself, lives.

Now I have started all over again and built my lab into a book—hopefully a delightfully misfit one, shot through with deviations. This creates a sense of danger, not just for me but for you as well, since together we will need to question basic assumptions, such as whether or not we see reality. Stepping into such uncertainty isn't easy or simple. On the contrary, all brains are deathly afraid of uncertainty—and for good reason. To change a historical reflex will have unknown consequences. "Not knowing" is an evolutionarily bad idea. If our ancestors paused because they weren't sure whether the dark shape in front of them was a shadow or a predator, well, it was already too late. We evolved to predict. Why are all horror films shot in the dark? Think of the feeling you often have when walking through a familiar forest at



night as compared to during the day. At night you can't see what's around you. You're uncertain. It's frightening, much like the constant "firsts" life presents us with—the first day of school, first dates, the first time giving a speech. We don't know what's going to happen, so these situations cause our bodies and our minds to react.

Uncertainty is *the* problem that our brains evolved to solve.

Resolving uncertainty is a unifying principle across biology, and thus is the inherent task of evolution, development, and learning. This is a very good thing. As you will have observed from experience, life is inherently uncertain because the world and the things that constitute it are always changing. And the question of uncertainty will become an increasingly pressing issue in all parts of our lives. This is because, as we and our institutions become more interconnected, we become more interdependent. When more and more of us are connected to each other, the effects of the metaphorical butterfly flapping its wings on the other side of the world are more quickly and more powerfully felt everywhere, increasing the pace of change (which is at the heart of a nonlinear, complex system). An increasingly connected world is also inherently more unpredictable. This creates fundamental challenges for living today, from love to leadership. Many of the most sought-after jobs today, from social media expert to web designer, weren't even around twenty years ago. A successful company, a thriving relationship, an environment free of dangers—the existence of these things today doesn't guarantee their continued existence tomorrow. You are never truly "untouched" in a connected, flux-filled world. There will always be events that blindside you, that you didn't predict, from the unforeseen change in weather spoiling your BBQ in London on a Saturday afternoon to those in London suddenly finding themselves living outside the European Union. This is why our brain evolved to take what is inherently uncertain and make it certain... every second of every day. The biological motivation of many of our social and cultural habits and reflexes, including religion and politics, and even hate and racism, is to diminish uncertainty through imposed rules and rigid environments... or in one's vain attempt to disconnect from a world that lives only because it *is* connected and in movement. In doing so, these inherited reflexes—by design—prevent us from living more creative, compassionate, collaborative, and courageous lives. With the making of this kind of certainty, we lose... freedom.

At Burning Man in 2014, I had an experience that has stayed with

me—actually quite a few, but I’ll share this one here. It was a profound—and profoundly simple—example of how deviating can radically change one’s brain. As many know, Burning Man is a weeklong festival every August in the Nevada desert that brings together art, music, dance, theater, architecture, technology, conversation, and nearly 70,000 human beings. Costumes are ubiquitous—and at times a complete lack thereof (though often with body paint). It is a city-sized circus of free-form creativity... picture a giant pirate ship sailing along on wheels... that explodes on the desert floor, then vanishes seven days later, leaving absolutely no trace... an essential part of the Burning Man ethos.

On a windy day midway through the week, my partner Isabel and I were riding our bikes and getting to know the “city.” Desert dust swirled, silting us and our goggles in a fine layer of beige. We ended up in a camp of people from a town on the southern edge of the Midwest and met a guy I’ll call Dave. This was Dave’s first year at Burning Man, and he said it was turning out to be a transformative experience for him. At first I internally rolled my eyes at this. Being “transformed” at Burning Man has become not just a cliché but almost an imposed aspiration. If you don’t *transform* there, then you have somehow failed. But what is transformation? Of course, no one really knows because it is different for every person, which is why so many people at Burning Man hungrily chase signs of it all week, going around asking: “Have you been transformed?”

The more we talked to Dave, though, the more I realized he really was undergoing a deep shift in his perceptions of self and other. He was a computer programmer from a place with fundamentalist religious values and a narrow outlook on what was socially acceptable. In his town, you either learned to fit in or you were ostracized. Dave had learned to fit in... the business casual attire he wore at Burning Man reflected this. But it had clearly curtailed the possibilities of his life, curiosity, and imagination. Yet here he was, at Burning Man! It was the decision to *be there* that mattered. It was his choice... his intention enacted... to come, and the questioning manner he had brought with him.

As we stood there in his camp, he told us that the little green plastic flower that I saw stuck behind his ear—perhaps the least flamboyant adornment in Burning Man history—had provoked an epic struggle inside him. He had sat in his tent for two hours that morning weighing

whether or not to wear the flower. It had forced him to confront a complex host of assumptions in his mind—about free expression, masculinity, aesthetic beauty, and social control. In the end, he gave himself permission to question these assumptions symbolically manifested in a plastic flower, and stepped out of his tent. He seemed both pleased and uncomfortable, and in my eyes far more courageous than most of the people out there in the Nevada desert that day in search of something powerful.

As a neuroscientist, I knew that his brain had changed. Ideas and actions previously out of his reach would now be available to him if he was willing to question his assumptions, and in doing so create a new, unknown terrain of wondering. As a person, I was moved.

*This* is what transformation looks like: Deviation *toward* oneself. So simple. So complex.

Nothing interesting ever happens without *active* doubt. Yet doubt is often disparaged in our culture because it is associated with indecision, a lack of confidence, and therefore weakness. Here I will argue exactly the opposite. That in many contexts, to “doubt yet do... with humility,” like Dave, is possibly the strongest thing one can do. Doubt with courage and your brain will reward you for it through the new perceptions this process opens up. To question one’s assumptions, especially those that define ourselves, requires knowing that you don’t see the reality—only your mind’s version of reality—and admitting this, not to mention accepting the possibility that someone else might know better. In the pages-based lab of *Deviate*, not knowing is celebrated. The word “deviant” has all sorts of negative connotations, yet it comes from the verb “deviate,” which simply means not to take the established route. Whereas politicians emphasize unchanging routes, in our cultures we also idolize people who are deviators, from Rosa Parks and Oscar Wilde to William Blake, because we admire and are thankful for the unestablished routes they took... usually in hindsight, much more rarely in the present (indeed, like so many others, Blake’s work only came to be understood for its true value long after his death). The vast majority of Hollywood superhero movies are predicated on deviance. Have you ever met an average hero?

Doubt is the genesis of powerful, deviating possibilities. In this way, the human brain is able to shed constricting assumptions and see beyond the utility with which the past has trained it to see. As I like to say, *the cash is in the questions*.

## **Be Delusional**

The doubt-driven ride this book will take you on is going to *physically change your brain*. This isn't braggadocio, but a fact-based understanding of everything from the electric patterns of your thoughts to the neurons of your emotions. The simple act of reading can change your brain because two and a half decades of research have led me to one indisputable conclusion: what makes the human brain beautiful is that it is *delusional*.

I'm not talking about insanity. What I'm getting at has to do with the brain's imaginative powers of possibility and how richly they interact with behavior. We can all hold *mutually exclusive* realities in our minds at the same time, and "live" them out imaginatively.

Human perception is so layered and complex that our brains are constantly responding to stimuli that aren't real in any physical, concrete sense, but are just as vitally important: our thoughts. We are beautifully

delusional because *internal* context is as determinative as our external one. This is verifiable at the neural level: fMRIs (functional magnetic resonance imaging, a technique for tracking brain activity through blood flow) show that an imagined scenario lights up brain regions the same way the real-life equivalent scenario does. In other words, ideas and thoughts and concepts have lives inside of us. They are our history, too, and directly feed our current and (maybe more importantly) future behavior. As such, our perception is much more plastic and subject to influence than we're often aware of or comfortable admitting. The stock market tends to go up when it's sunny, and down when it's not. The seemingly rational decisions we make, then, are actually guided by "invisible" forces of perception that we're not even conscious of.

Another example: In 2014 the Lab of Misfits organized our first party/study, an initiative we call The Experiment, which is designed to do many things. One is to improve the quality of scientific research by taking it out of the artificial situation of a lab and into authentic human situations. The situation we engineered was a true social gathering in which people ate and drank and talked in an old crypt with strangers with a larger theatrical context. For the participants it was designed to be purposefully ambiguous as to whether it was science, a nightclub, an interactive theater and/or cabaret, but it was a memorable experience in which they also served as subjects in an experiment-as-experience. The goal of The Experiment is to discover, challenge and raise awareness through "empirical embodiment" of what it is to be human. One of our experiences sought specifically to see whether people group themselves depending on how they perceive themselves as either powerful or not.

After the food, once everyone was full, relaxed, and enjoying themselves, we had people do a brief writing exercise to prime them into a perceptual state. Depending on the memory they were prompted to recall, they were primed into either a low-power state, a higher-power state, or a neutral-power state. What this means is that their recollection prompted them to unconsciously perceive themselves to be either less or more in control. We then had them walk in a large concentric circle within a big underground crypt space in a Victorian jail in East London. Next, we asked them to segregate themselves under two lights at opposite ends of the room—in short, to stand next to the people who "feel like you." That's all we said.

What happened shocked the guests as much as it did us scientists.

Without knowing who had been primed in which way, *the people organized themselves according to their power-state with two-thirds accuracy*. This means that well over half the people in each corner were with other people “like themselves.” This was astounding for two reasons: One, it showed how strongly the participants’ simple thoughts about themselves changed their own behavior; that is, their imagining changed their perceptual responses. Two, the people somehow perceived the imaginatively primed perceptions of others. What a wondrous example of how delusions affect not only our behavior, but the ecology in which we interact as well. In the chapters ahead, you will learn how to make your brain’s delusional nature enhance your perception.

I want to create a fresh layer of meaning in your brain that will be as real as anything else that has affected your perception—and your life. The narrative of this book embodies the process I’m going to teach you. I constructed it so that reading from first page to last *is* seeing differently. It will allow you to experience what creativity feels and looks like from the inside. Think of it as a software solution for your perception. When you’re done with the book, you simply change the context and reapply the software. Perhaps the most encouraging part is that you don’t have to acquire a new base of knowledge.

To fly a plane, you first have to train as a pilot, which involves a tremendous amount of specialization and practice. But in order to deviate into new perceptions, you already have the basics. You don’t have to learn to see and perceive. It’s an essential part of who you are, if not *the* essential part. In this sense, you already have a firsthand account of the subject of this book. Furthermore, the process of perception is the same process by which you change perception. This means you are your own pilot (in the context of your larger ecology). My task is to use the science of your brain to teach you a new way to fly, and to see anew what you thought you had already seen.

One of the ways I will do this is by applying my knowledge of perception *to your reading experience*. For example, the brain thrives on difference... on contrast, since only by comparing things is it able to build relationships, which is a key step in creating perceptions. This is why you will find deviant design elements, such as varying font sizes and occasionally puzzling images. On the page you will also find exercises, tests, and self-experiments that require your participation. (They won’t be tedious; in one I’m going to make you hold your eye

open and momentarily “go blind.”) When I began *Deviate*, I wanted to challenge assumptions about what a science book could be—my own step into uncertainty. What better space to do this than in a work about innovation and the brain, using the brain as my guide? This book is different in other ways as well.

In my view, as soon as you’ve told something to someone, you’ve taken the potential for a deeper meaning away from them. True knowledge is when information becomes embodied understanding: We have to act in the world to understand it. This is why *Deviate* will not give you recipes. Instead of a how-to guide that offers task-specific formulas, I will give you principles that transcend any single context. Just because you are able to make one fantastic meal by following a recipe doesn’t mean you are now a great cook; it means you are good at following the instructions of a great cook. While it may have worked once, it hasn’t given you the wisdom to make *your own* fantastic meal, as you have no idea why the recipe is a good one. *Understanding* why the recipe is a good one (and how) is one key aspect of what makes a chef a chef.

*Deviate* is designed to innovate your thinking by giving you new awareness, which creates the freedom to change. The first half will explore the mechanics of perception itself, making you reconsider the “reality” you see and helping you to know less than you think you know now. Yes: that is my aim, for you to actually know *less* overall, while understanding more. The second half will then make this understanding practical by giving you a process and technique to deviate in your life.

When you finish this book, I have only one true hope: that you will embrace the perceptual power of doubt. This book is about celebrating the courage of doubt, and the humility that comes with understanding your own brain. It’s about why we see what we do, and how recognizing that we don’t have access to reality leads us to get more things right. Which is all just another way of explaining why I wrote this book: so that you too will be a misfit.

## CHAPTER 1

### Being in Color

When you woke up this morning and opened your eyes for the first time, did you see the world accurately, the way it really is? If you said no, let me ask the question a different way: Do you believe in illusions? Most of us do. If so, then by definition you believe that the brain evolved to see the world accurately, at least most of the time, given that the definition of *illusion* is an impression of the world that is different from the way it really is. And yet we don't see the world accurately. Why? What is going on inside our complex brains (or more precisely, in the complex interaction between our brain and its world) that makes this so? First, however, we must address an urgent empirical question and satisfy that human need to “see it with my own eyes”: Where is the proof that we don't see reality? How can we *see* that we don't see it? The answer to this question is where we begin to dismantle our assumptions about perception.

In February of 2014, a photo posted on Tumblr went viral on a global scale and inadvertently spoke to just this issue of the subjectivity of perception—and spoke loudly. The questions it raised about what we see generated thousands more questions across Twitter and other social media and on TV, as well as in the minds of people who kept their astonishment private. You may or may not have encountered the photo, but if you did you'll remember the image itself gave the phenomenon its name—*The Dress*.

It all started with a wedding in Scotland. The mother of the bride had sent a photo of the dress she was going to wear to her daughter: a straightforward gown of blue fabric with stripes of black lace running across it. Yet the photo itself was anything but straightforward for perception. The bride and groom couldn't agree on whether it was white with gold stripes or blue with black stripes. Baffled by their disagreement, they forwarded the image to people they knew, including



their friend Caitlin McNeill, a musician who was performing at the wedding. She nearly missed her stage call because she and her bandmates (who, like the couple, didn't see the dress the same) were arguing about the image.<sup>1</sup> After the wedding, McNeill posted the slightly washed-out photo on her Tumblr page with this caption: "guys please help me—is this dress white and gold, or blue and black? Me and my friends can't agree and we are freaking the fuck out." Not long after she published this short commentary, the post hit viral critical mass and, as the saying goes, the photo "broke the Internet."

Over the following week The Dress ran its course as most viral phenomenon do, with the explosive, out-of-nowhere virality becoming as much the story as the item—in this case a simple photo of a piece of clothing—that instigated it. Celebrities tweeted and feuded about it, reddit threads proliferated, and news organizations covered it. Those of us who research color were suddenly inundated with requests for interviews, as it seemed everyone wanted to know why they saw the colors differently. Even the usually sober *Washington Post* published the sensationalist headline: "The Inside Story of the 'White Dress, Blue Dress' Drama That Divided a Planet."<sup>2</sup> Yet in spite of the overheated excitement and debate, people were having an important conversation about science—to be precise, *perceptual neuroscience*.

I found this remarkable on several levels, but most profoundly in that it hinted at the way meaning is a plastic entity, much like the physical network of the brain, which we shape and reshape through perceptual experiences. Understanding this, as we'll see in later chapters, is the key to "re-engineering" your perceptual past to liberate unforeseen thoughts and ideas from your brain cells. The Dress phenomenon was a perfect example of how meaning creates meaning (as news agencies around the world started reporting a story largely because it was being *reported* elsewhere and therefore assumed to be meaningful, and thereby making it meaningful), which is a fundamental attribute of perception itself. But I was also struck by the fact that it wasn't the illusion per se that was grabbing people's attention, since we are accustomed to them (though usually as simple "tricks"). What seemed to grab people was that they were seeing it differently from each other. We are very familiar with having different conceptual views about things, though. So how and why was this different? It came down to this: it was because it was color.

We are OK with speaking a different language than another person,

but when my friends, loved ones, and others whose perception and grasp of reality I trust differ at such a fundamental level as color, this raises... for a beautiful moment, albeit too brief... deep, largely unconscious existential questions about how I see the world around me. It unnerved something at the core of how people understood their very consciousness, selves, and existence. As the actor and writer Mindy Kaling tweeted on February 25th, in the midst of the frenzy of #TheDress (one of her many impassioned tweets about it): “I think I’m getting so mad about the dress because it’s an assault on what I believe is objective truth.”

This is the crux about perception and self that The Dress brought up for so many: there is an objective “truth” or reality, *but our brains don’t give us access to it*. We got a shocking “look” at the cracks in our highly subjective reality through the photo of the dress—and it was a bit upsetting, or at least unsettling. The key for understanding how to enhance creativity through an understanding of perception... as you will soon see... is the following: this brief step into the most fundamental of uncertainties was also *exciting* for people. It freaked them out a bit yes, but it thrilled them, too.

For me personally, it was even more exciting, since I got to observe in real-time as millions of people took a dramatic step forward in understanding. Yet some people also wrote off The Dress: “OK, *my perception didn’t see reality this time, but it usually does.*” “No!” I wanted to shout. “You never, ever see reality!” Unfortunately, this essential point never became the central “story” of The Dress, though some in the scientific community took advantage of the opportunity to engage a broader audience with a topic that in any other cultural moment would have seemed abstruse and irrelevant. In May 2015, for example, *Current Biology* simultaneously published three studies of The Dress. One found that the distribution of colors of the dress corresponded to “natural daylight,” which makes it harder for your brain to differentiate sources of light from surfaces that reflect light (more on this in the next chapter). Another study made a discovery about how the brain processes the color blue, revealing that things have a greater probability of appearing white or gray to the human eye when “varied along bluish directions.” The last study, which surveyed 1,401 participants, found that 57 percent see the dress as blue/black, while the white/gold perception of the dress was more common in older people and women. Additionally,

on a second viewing, participants' perception sometimes switched white/gold to blue/black, or vice versa. In short, the viral photo proved to be an ideal experimental object to further the study of visual perception.<sup>3</sup>

Still, none of this answers the question of why the hell people saw that dress differently.

#TheDress tapped into not only how perception works, but why it matters so much to us. It illustrates the extremely counterintuitive nature of our brain. If we saw the world as it really is, then things that are the same should look the same. Likewise, things that are different should look different... always, to everyone. This seems sensible and correct, something we can count on from our perception (or so we thought). After all, seeing different intensities of light is the simplest task the visual brain performs, so simple that even some jellyfish can do it—and they don't even have a brain.

Yet perceiving light is not actually as straightforward as it may seem, despite the fact that we do it every waking millisecond. The billions of cells and their interconnections devoted to it are evidence of its difficulty. We rely on this perceptual skill to make instinctive decisions that serve us as we move through the world. The Dress, however, revealed that just because we *sense* light, we don't necessarily *see* the reality of it.

In the first of the images that follow, each circle is a different shade of gray. It's easy to perceive the varying gradations. Things that are different should look different, and they do.

In the second image we are looking at two circles of identical shades of gray.

Now look at the third image. The gray circle on the left inside the dark box looks lighter than the gray circle on the right inside the white box. They appear to be two distinct shades of gray.

*But they're not.* They are the exact same gray.

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This is the objective reality—which is fundamentally different from our perceptual reality. What’s more, every reader of this book will perceive these three images the same way you did, with the same departure from the physical reality of what is printed on the page. What is more, it is not simply that dark surrounds make things look lighter than light surrounds. The opposite can also be true: light surrounds can make things look lighter and dark surrounds can make things look darker as shown in the fourth image, where the central regions, which look like circles obscured by four squares, appear differently light in the way just described.

But the most powerful message here is one that never came up during the viral Dress phenomenon. What is true for vision is indeed true for *every one of our senses*. What people realized about the subjectivity of their sight also goes for every other facet of their “reality”: there are illusions in sound, touch, taste, and smell, too.

A very well-known example of tactile “gaps” between perception and reality is called the “Rubber-Hand Illusion.” In this so-called trick, a person is seated at a table with one hand resting in front of them, while the other is out of sight behind a divider. A fake hand is set down in front of the person in place of the outof-sight hand, so they have what looks more or less like their two hands resting on the table, except that one of them isn’t theirs (which of course they’re aware of). Then the “experimenter” begins lightly brushing the fingers of the hidden real hand and the fake visible hand at the same time. Sure enough, the person immediately starts identifying with the fake hand as if it were theirs, feeling as if the brushing sensation is happening not behind the hidden divider, but on the fake hand they suddenly feel connected to. For the purpose of perception, that hand becomes real!

The Rubber-Hand Illusion is what’s called a *body transfer*, but our brain’s way of processing reality... rather than giving it to us directly... also opens us up to other slightly freaky “mix-ups” of the senses. Researchers have shown, for example, that we are capable of hearing “phantom words.” When listening to nonsense sounds, our brains pick out clear-seeming words that aren’t actually there in the audio. There is also the “Barber’s Shop Illusion,” in which a recording of snipping scissors gives the impression of the sound getting closer or farther depending on the volume rising or lowering, when the sound isn’t changing position at all. Or think of the common experience of sitting in

a stationary car or plane, and when the car or plane next to you begins to move, at first you think you are the one in motion. There are many, many more phenomena like these.

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One of the first people to pick up on what seemed a “kink” in visual perception was Johann Wolfgang von Goethe, the eighteenth-century man of letters we know today as the father of modern German literature. In his day he was famous (though also slightly infamous, as you’ll see) as an omnivorous dabbler across disciplines, as likely to throw his energies into osteology (the study of bones) as he was to immerse himself in botany. While literature was his first love, Goethe was above all else a man of passion, often described as being wild in nature, so much so that as a young man his friends referred to him as the “wolf ” and the “bear.”<sup>4</sup> (In his college days in Leipzig, his out-of-fashion

Frankfurt dress style also amused his peers.) But he was able to tame this wolfish unruliness into a high-society charisma as he became a literary celebrity in his twenties, the Duke Karl August soon appointing him to several state roles, including Director of the War Department. Goethe's headstrong and even reckless hunger for new intellectual experiences returned in full force in the late 1780s when his "*manysidedness*," as a biographer once labeled it, led him to study light and color.

Goethe had recently spent a very happy two years in Italy. There he had become acquainted with the German painter Johann Heinrich Wilhelm Tischbein while also exploring his own talents in the fine arts. He eventually accepted that he had none, but he returned to Germany with a reignited interest in the natural world artists sought to capture. "No one acquainted with the charm which the secrets of Nature have for man, will wonder that I have quitted the circle of observations in which I have hitherto been confined," he wrote in an unpublished essay. "I stand in no fear of the reproach that it must be a spirit of contradiction which has drawn me from the contemplation and portraiture of the human heart to that of Nature. For it will be allowed that all things are intimately connected, and that the inquiring mind is unwilling to be excluded from anything attainable."

This declaration led to one of history's most legendary examples of a literary personage disastrously elbowing his way into the halls of science. Depending on who you ask, what transpired was either a rewardingly poetic misadventure into a realm the belletrist innocently misconstrued, or an arrogant and willfully wrongheaded foray into a field where he did not belong. In reality it was a mixture of the two—neither and both. Goethe's passionate way of being wasn't well suited to the cold-hard-facts approach of science, yet his writerly eye for the revelatory moment did play a key role in his scientific forays when he had his own moment, albeit a *falsely* revelatory one.<sup>5</sup>

Drawn to optics, Goethe had borrowed a prism to test Newton's groundbreaking work that refracted white light into its constituent colors, a discovery that today would have likely won Newton a Nobel Prize.<sup>6</sup> Executing the experiment incorrectly, and far from fully versed on the theory behind it, Goethe expected to beam the full spectrum of color on the wall of his home, only to beam nothing. The wall remained a white blank on which he could project his rapidly growing conviction: "Newton's theory is false!"

Ardently sure that contemporary science was terribly off course in understanding light, he took leave of his diplomatic responsibilities to devote himself to physics. Scientists of the time ridiculed him while *littérateurs* and nobles cheered him on, certain that the wild wolf of a poet would dethrone Newton. The Duke of Gotha gave him a laboratory; a prince sent him new, better prisms from abroad. Then in 1792, while conducting his inquiry, Goethe noticed that a white light could produce shadows *with colored hues*. Likewise, colored lights changed hues depending on the “*opaque*,” or semi-transparent, medium they passed through. A yellow light could redden all the way to ruby through the opaque. This too appeared to violate Newton’s physical laws purporting to explain light, and the disconnect created a still deeper chasm in Goethe’s understanding of Newton’s theories that purported to explain reality. So he narrowed his focus to work out this problem and was sucked into a twenty-year obsession with color and perception.

In works like *The Sorrows of Young Werther*, the tumultuous story of a young man’s unrequited love, Goethe proved himself to be a poet of the human interior, so perhaps it’s no surprise that when it came to color he at first wasn’t always able to step outside the cave of his own perception to see that the disjuncture was inside. Like most of us, he took for granted that he saw reality; after all, his prodigious mind had allowed him to “see” human realities so clearly in his writing, not to mention that perception was well over a century away from growing from a concept into a locus of science. Soon enough, however, he gave up the idea that the seemingly mismatched hues were due to some physical quality of light that science had yet to explain. Instead, he gradually realized that the colored appearance of certain shadows was a result of human perception’s interaction with its environs—not a mystery of the world but a mystery of the mind.<sup>7</sup> Yet he could only uselessly paw at the reasons *behind* this strange mystery inside his own brain, so he became a scrupulous recorder of every phenomenon of light he observed.

The subject of color consumed Goethe to the point that, in 1810, he published a massive tome on his investigations called *Zur Farbenlehre*, or *Theory of Color*. The “science” of the book has long since been dismissed, most notably his attacks on Newton. Goethe’s taxonomic opus did, on the other hand, incite intense philosophical discussion, leading Wittgenstein to pen *Remarks on Color* and Schopenhauer to write *On Vision and Colors*. Yet Goethe’s encyclopedic descriptions of