THE PLEASURE CENTER

TRUST YOUR ANIMAL INSTINCTS

MORTEN L. KRINGELBACH

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PREFACE

Few would choose to live a life without emotions, yet at the same time many people believe that our emotions are obstacles to intelligent action. Emotion is not reason's antithesis. On the contrary, it is fighting the pleasures and desires of life that is irrational, because they are essential to all human behavior. This book will help you understand the underpinnings of emotion in your brain. Pleasure (and its corollary, avoidance of pain) is central to this understanding, as it is the currency for all of our decisions, actions, and experiences. A better understanding of how pleasure and desire work in our brains can lead to important insights about our nature and, in time, may also improve treatment for those whose depression or mental illness robs them of their pleasure.

I investigate the many facets of pleasure, desire and emotion by probing the reward systems of the brain and, along the way, uncover the spectrum of human experience from the sensory inputs and memory, via emotion, through learning, decisions and consciousness, to madness, drugs and sex. I also present some of the most interesting new scientific

discoveries about pleasure and desire. Understanding and accepting how pleasures and desires arise in the complex interaction between the brain's activity and our subjective experiences can help us to make better decisions, find what helps us enjoy life, and lead happier lives.

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THE CHALLENGE

Know Thyself?

> The knowledge of good and evil is nothing else but the emotions of pleasure or pain, in so far as we are conscious thereof.
>
> Baruch Spinoza (1632–1677)

"Know thyself" was inscribed on the portico of the temple at Delphi, and the apparent uncanny accuracy of the oracular utterances depended precisely on that self-understanding. Nothing has interested us more than understanding ourselves—and other people. After thousands of years of searching, we are finally coming closer to a better understanding of the brain. More refined insights into its functions were not possible until the recent invention of new brain scanning techniques that have allowed us to track brain activity. Similarly further insights have come from deep-brain

stimulation techniques that have allowed us to help patients with otherwise treatment-resistant disorders.

CHALLENGING BRAINS

These new discoveries in brain science—or *neuroscience*, as it is also known—give us new insights into the human brain and the basis for a better understanding of ourselves. Indeed, research into pleasures, desires, and emotions may well force us to reconsider some of our basic and cherished beliefs. Pleasure is so important to our actions because it is central to how our brains are guided and sculpted through learning. From early childhood, the self is created in the brain through a struggle between genetics and flexible learning. Human brains are not blank slates on which anything can be written. Rather, the brain's fundamental structure has already been determined by genetic material assembled during our evolutionary history, and so certain universal forms of learning take place as part of the potential that is always present in nature. Language is a good example of a potential that is universal, or shared by all human beings. These universal learning potentials form the foundation of all our abilities. Although human experience—and thus our learning potential—is limited, it is flexible, so the self may take certain forms that can be divided into broad categories, which we call personality types.

THE ANATOMY OF PLEASURE

Pleasure and pain are essential to desires, motivations, and emotions. Experience makes it clear that we will always try

to obtain that which gives us pleasure and avoid that which does not. Our subjective experience of pleasure is rather extraordinary. Pleasure appears to evaporate when we direct our attention to it. The more we focus on the pleasure itself, the more it slips away. Yet, this is not the case when we direct our attention to the events leading to pleasure. The experience of pleasure involves intentionality and at least four distinct stages: engagement, acceptance, continuation, and subsequent return. For example, the pleasure of chocolate involves choosing chocolate over other foods, eating the first bite, and continuing the pleasant experience of eating until full. In the future, we will eat more chocolate. The scenario is similar in situations where we encounter someone we desire: We choose a person to stop and engage with; decide whether they actually are interesting (and interested in us); try to make the conversation last as long as possible; and desire to return as soon as possible.

We generally experience pleasure and pain in one of the three combinations: pleasant–unpleasant, relaxed–tense, or quiet–excited. The perceived pleasantness or unpleasantness is not usually experienced entirely in our selves, but rather depends on the perceived object or experience. How we anticipate and evaluate the object or experience are core aspects of pleasure and pain. Pleasure and pain are linked to reward values that guide how we learn, our preferences, and our behavioral priorities. This type of hedonic evaluation was named "utility" by the English philosopher Jeremy Bentham, following the Greek philosopher Epicurus. Although philosophers have remained skeptical of all versions of utility theory, many neuroscientists and economists have come to

believe that the anticipatory and evaluative elements of pleasure are fundamental to decision making. One example is the recent Nobel laureate in Economics, Daniel Kahneman, who reintroduced the concept of utility to describe how pleasure can help optimize decision making. Kahneman also created some important distinctions in his description of utility. He distinguishes between *experience utility* and *decision utility*. Experience utility is how much we like or dislike a choice we are making. Decision utility relates to whether we want or don't want the object of the choice.

Neuroscientists now study the more subjective nature of pleasure by matching people's reports of how much they are enjoying an experience with scans of their brain activity during the experience. Animals can't describe in words how much they are enjoying a particular experience, but the pioneering research of the American neuroscientist Kent Berridge has shown that pleasure often entails species-specific hedonic behaviors. For example, rats and mice contently lick their lips when given sweet-tasting food, whereas bad-tasting food will lead them to gape, shake their heads, and frantically wipe their mouths—just as infants do. By measuring the frequency of these behaviors, Berridge got a good measure of the rats' hedonic experience, which he then linked with measurements of their brain activity. As we shall see later, Berridge has shown that pleasure has at least two subcomponents, liking and wanting, which use partly separate brain pathways and may correspond to Kahneman's distinction between experience utility and decision utility.

Pleasure is produced by the activity and interaction of many different brain regions. Some of the processing is

conscious, but much—if not most—of this hedonic processing proceeds nonconsciously, so that we have rather little conscious insight into these processes. Studying them may give rise to a better understanding of our emotional brain. It may also force us to reconsider our beliefs about rationality and free will because if we are aware of only a small fraction of what goes on in our brain, how many of our decisions are we really consciously making? How reliable is our memory? How rational are our actions?

PLEASURE AND PAIN IN THE BRAIN

Pleasure and pain are closely linked with each other, but opinions differ over whether they are opposites or just different aspects of the same thing. While a stimulus rarely makes us both approach and avoid it at the same time, it is nevertheless clear that one can feel both pleasure and displeasure. These experiences and memories, as when we laugh at a happy memory but miss those involved or long for the return of past pleasures, are often described as bittersweet.

Desire is situated at the interface between motivation, pleasure, and reward. Most standard definitions relate desire to motivation, in the sense that if we desire something, we are motivated to bring it about. The Portuguese philosopher Baruch Spinoza wrote that "pleasure is the transition of a man from a less to a greater perfection," where perfection is the extent to which that man has realized his desires. The Canadian philosopher Timothy Schroeder has argued against such standard accounts of desire, instead linking intrinsic desire directly with the reward systems of the brain.

REASONABLE FEELINGS?

Recent research has shown that humans are mainly emotional beings who only occasionally use reason to their advantage. This insight contrasts sharply with the commonly held belief that human behavior can be explained through reason and rationality. Human history, however, also contrasts sharply with this belief by demonstrating that rationality has usually failed to rule, or to even affect, human behavior. Despite the fact that people can rationalize the motives for their actions after the fact, and identify the "best" option in a given situation, there is now mounting evidence that these subsequent rationalizations have little influence on the decision to take the action in the first place. What has been missing in how we see ourselves is an understanding of those desires, pleasures, emotions, and feelings that are central to our lives. Throughout history, emotion and rationality have been seen as opposing forces, with emotion being regarded as a lower animal instinct because it was out of the reach of reason, and therefore best suppressed. If we develop a proper understanding of our emotions, we will see that they do not conflict with reason.

THE BRAIN CAROUSEL

Fighting desires that we don't understand is both irrational and a huge waste of energy and resources. We are not suggesting giving in to all of one's impulses. Some, yes. But others we quite rightly need to resist. However, without understanding them, we will not know how to resist them.

Pleasure and desire underlie all of our decisions, so if we understand, accept, and even listen to them, we will not only be able to save time and energy, but we will—believe it or not—gain wisdom. Our emotions and desires are one of the only tools we have for understanding ourselves and others. Our emotions and desires have evolved over thousands of years because developing this type of an understanding is one of the best ways to protect ourselves and improve our lives. To understand our emotions and desires, we have to know how their components work in our mind and body. To that end, each chapter in this book explains a different component.

Chapter 2 shows how pleasure and reward values underlie our decisions.

Chapter 3 tries to grapple with our subjective conscious experience of pleasure.

Chapter 4 explores how difficult it has been to understand emotions by exploring how scientists have struggled to quantify them and their links to pleasure and desire.

Chapter 5 investigates the basis of our sensory experiences. Understanding these experiences will give us a basis for understanding our sensory pleasures, which are the likely building blocks and templates for the rest of our higher-order pleasures.

Chapter 6 investigates memory systems in the brain and their role in memories of pleasure.

Chapter 7 investigates learning in the brain, and how pleasure plays an important if undervalued role in education.

Chapter 8 focuses on the lack of pleasure in depression and mental illness.

Chapte 9 describes the effects of stimulants that can cause addiction, which can be thought of as wanting without liking.

Chapter 10 uncovers some of the pleasures of sex, from desire to climax.

Chapter 11 concludes the book by looking forward to what we can do with these ideas to improve both our individual lives and the world as a whole.

Brief Definition of Pleasure

Pleasure can be defined as a way of fulfilling the evolutionary imperatives of survival and procreation. This leads to a classification of pleasure in *fundamental* (sensory, sexual, and social pleasures) and *higher-order pleasures* (for example, monetary, artistic, musical, altruistic, and transcendent pleasures).

Pleasure is not a sensation but is instead linked to the anticipation and subsequent evaluation of stimuli. Pleasure is thus a complex psychological phenomenon with close links to the reward systems of the brain and as such consists of both conscious and nonconscious processes. There are at least three fundamental elements to pleasure: wanting, liking, and learning. The brain regions and brain mechanisms of these subcomponents of pleasure can be studied in both humans and other animals.

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DECISIONS

Social Intelligence in the World

Those who will not reason, Perish in the act;
Those who will not act, Perish for that reason.

W.H. Auden (1907–1973)

A 3-year-old boy climbed the fence surrounding the enclosure for the great apes in the Chicago zoo and fell some 20 feet onto the concrete below, rendering him unconscious. The lowland gorilla Binti Jua picked up the boy and sat gently cradling him for a while. She then carried him back to an entrance to the enclosure and continued walking with her 17-month-old baby on her back, as if nothing had happened. The boy eventually recovered fully.

Binti Jua quickly became a minor celebrity, and some politicians used her actions as an example of the altruism

needed in society. If such moral behavior can be exhibited by a gorilla, then why is it so difficult to find in humans? However, some scientists argued that Binti Jua learned this behavior from humans in the first place, as she had been raised by humans and had used a doll to practice her maternal skills. For them, Binti Jua's behavior was not a moral act, but solely a symptom of confused maternal instinct. Arguments about confused maternal instincts seem weak when you consider that Binti's maternal needs were fulfilled—she carried her own baby on her back throughout the incident. It is also difficult to see how a highly intelligent animal, such as a gorilla, would be unable to distinguish a fully clothed boy from her own gorilla baby. There is some research to support the claims of morality over confusion. The Dutch primatologist Frans de Waal and other scientists have claimed that the higher primates display at least basic moral behavior. If higher primates can be said to be capable of acting morally, it may well be the end of the long-cherished notion that humans are the sole moral animals. Whatever its cause, it seems difficult to argue against Binti Jua's act being positive and intelligent, and being what she wanted to do, what pleased her. In fact, a growing body of research suggests that feelings of pleasure play a key role in both our conscious decisions and how we understand our nonconscious ones.

Although pleasure and desire underlie all of our decisions, this does not mean that we are driven solely by self-interest. Some of our greatest pleasures in life come from social interactions with others. We are very social animals, and we share this sociality with other types of animals. If we are to understand our emotional brain, we have to understand what drives

our social brain. We can mirror ourselves in the other higher primates and see that despite our cultural veneer, we are still, for better or worse, similar to other animals, particularly in our social behavior. It is well documented that chimpanzees show regionally determined behavior that probably should be deemed as at least the beginnings of culture. Many of the moral qualities we appreciate—and detest—in other humans are found in other primates. Humans also have animal vices that we keep on a short leash.

THROUGH THE LOOKING GLASS

We use each other as social mirrors. This behavior begins early—newborn babies appear to imitate *others*' facial expressions to relate their *own* feelings. Of course, as blind children exhibit normal facial expressions, there must be a large degree of genetic influence as well. Experiments with primates have shown *mirror neurons* in the frontal part of the brain. These are neurons that act both when an animal itself reaches for an object, and when it observes another animal reaching for an object. The discovery of mirror neurons demonstrated that monkeys have mental representations of the actions of others, which are important for understanding the intentions of others. In humans, this ability has developed so far that we continuously try to read other peoples' intentions on their faces.

In 1970, the American psychologist Gordon Gallup carried out an experiment in which he placed a dot on the forehead of a chimpanzee, so that it could only be seen when the chimp looked in a mirror. Gallup's experiment showed that

most animals are unable to recognize themselves in a mirror. Chimpanzees, bonobos, orangutans, and dolphins—but not, for example, gorillas—will notice the dot. This self-recognition also becomes easier with age: chimpanzees appear to recognize themselves at around 6 years; human infants exhibit self-recognition at around 1½ years. As passing the mirror test is age dependent, it is possible that a hierarchy exists in the brain for the acquisition of advanced mental abilities. An individual must always acquire the capability of self-recognition before acquiring the ability to attribute intentional motives, desires, and goals to others.

The Beginning of Morality

Gallup's discovery of self-recognition in chimpanzees was the first step in showing whether they have the prerequisites for morality, such as intentional behavior, desires, pleasures, and emotions. More recent experiments have investigated the ability of chimpanzees to see themselves and others as thinking beings. One important experiment tried to verify whether a chimpanzee can use intentional knowledge to determine where food has been hidden. Initially, a researcher hid food in one of the four boxes while another researcher would wear a bag over his head or leave the room, so it was clear that only one of the researchers knew the location of the food. This researcher always would point to the correct box, but the other researcher would point at random. Using only the information from the first researcher, the chimpanzee would find the food, demonstrating that it was able to use intentional knowledge.

Morality may have developed as a result of the social mirror found in gregarious animals. Each individual is constantly being monitored by others. The resulting interplay produces the elements that constitute morality: sympathy, attachment, helping, emotional bonds, and presiding social rules. Further attributes include adaptation and special care for the injured and handicapped. Also important is reciprocity, such as the abilities to give, act, and avenge, including aggression toward rule-breakers. These, in turn, require the ability to handle conflicts through mediation and the constant maintenance of stable social relations. All of these characteristics are well documented in a number of social animals, but they are far more developed in humans, which is probably among the reasons that some people think that humans are the only moral animals. It might be worth remembering that, as with so much in nature, the question of morality is probably more one of degree rather than of kind.

Cute Infants

At the heart of morality lies the very special social bond between parents and infants. Charles Darwin and the Nobel Prize–winning zoologist Konrad Lorenz proposed that infantile facial features are central to this bond. Lorenz argued that infantile features serve as "innate releasing mechanisms" for affection and nurturing in adult humans and that most of the features are evident in the face, including a relatively large head, predominance of the brain capsule, large and low-lying eyes, and bulging cheeks. These features increase the infant's chance of survival by evoking parental responses.

My research team also found a key difference in the early brain activity of normal adults (who are not parents) when they viewed infant faces as compared to when they viewed adult faces. Only infant faces elicited early activity in the medial orbitofrontal cortex, which has previously been implicated in reward-related behavior. We found that the processing of both adult and infant faces elicits a wave of brain activity starting in visual cortices and spreading along ventral and dorsal pathways. However, at around 130 ms after seeing an infant face, activity was found in the medial orbitofrontal cortex (Figure 2.1). The medial orbitofrontal cortex is a key region of the emotional brain and appears to be related to the ongoing monitoring of salient reward-related stimuli in the environment. The medial orbitofrontal

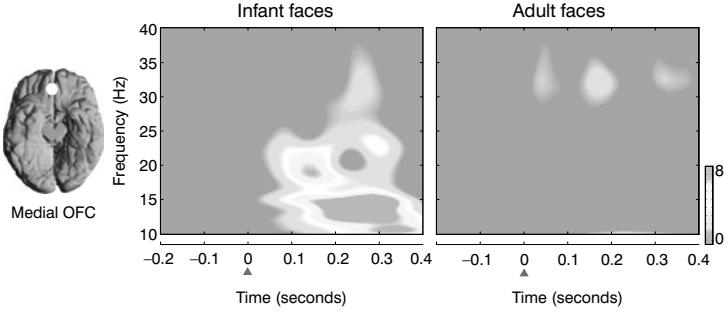

Figure 2.1 The pleasure of infant faces. Normal adults watched infant and adult faces while we measured the activity in their brains. The infant faces evoked early activity in the medial orbitofrontal cortex (left and middle panel), which was not the case when they saw the adult faces (right panel). This marker for parental instinct could potentially help identify those parents who are likely to suffer from postnatal depression.

cortex may provide the necessary emotional tagging of infant faces that predisposes us to treat infant faces as special, and so play a key role in establishing the parental bond. We also have a disproportionate interest in the infants of other animal species. It is likely that apes share similar brain mechanisms, which probably also contributed to Binti Jua's behavior toward the human child.

INTELLIGENT ACTIONS

What is intelligence quotient (IQ)? The IQ test began in 1904, in a test battery invented by French researchers, Alfred Binet and Theodor Simon. They were asked by the government to find a method for identifying children of lesser ability so those children could get help to improve. Their psychometric tests spread quickly. A *quotient* was invented as the ratio of real and mental age, and normality was defined as *100*. According to definition, 50% of all children will score between 90 and 110, precocious children will score higher, and so-called retarded children, much lower. Because this quotient was quickly seen as a measure of human intelligence, it became known as *Intelligence Quotient*, or IQ. But is it really meaningful to use a single number to denote the capacity and potential of an individual? These measures are useful to the extent that they capture something essential, but are still limited. Few people now claim that an IQ score is more than just one of many indicators for mental abilities, and some researchers have suggested that other measures are far more meaningful. Creativity and emotional intelligence are the most popular suggestions.

Mildly Retarded Analyses

Recent studies have shown that the environment plays a much larger role in IQ than most hardboiled geneticists have been willing to admit. For children of all races, IQ increases with education. The French psychologist Michel Duyme and his colleagues followed a large group of adopted children over three decades. When the children were adopted between the ages of four and six, each had an IQ below 86, which is defined as *mildly retarded*. In many cases, these children had been abused and neglected during their infancy. By the time the children entered puberty, each child's IQ had adapted to that of their adopted family. Before this study, it was widely believed that the influence of the environment had to take place within the first 6 years of life. The study showed that the possibility for children to improve their IQ score depends strongly on the environment into which they are adopted.

This study is one of many that have undermined the conclusions from Herrnstein and Murray's biased and racist book, *The Bell Curve*, which sold, sadly, over half a million copies. Since the publication of this book, other researchers have had the opportunity to reanalyze its data. The result is that many of the conclusions in the book appear to be just plain wrong. Notably, Herrnstein and Murray proposed that the genetic influence on intelligence is at least 60% and probably closer to 80%. Much other research has shown that the number is probably in the area of 50%, and may be even lower. The rest is determined by environmental factors such as social environment, diet, and education. On the basis of

these studies, it is tempting to ask whether IQ tests are more culturally biased than previously acknowledged. Probably the best thing to be said for the *The Bell Curve* is that it sparked interest in the continued debate on the importance of intelligence in the organization of society. It is increasingly clear that IQ tests are not particularly good tools for creating a better society. IQ tests primarily reveal many things about the people who created them, but only a tiny and perhaps even obscure fraction of what goes on in our brains. These limitations do not mean that IQ tests are useless, but that they must be supplemented with other measures, and regarded with a healthy dose of skepticism.

Intelligence in the Brain

What is the relationship between IQ and intelligence? The answer depends on how intelligence is defined, and the definition must be based on what we know about brain function, as the brain forms the basis of our intelligence. To get closer to an answer, we need to understand how the smallest parts of the brain function in neural networks that underlie all of our thoughts, emotions, and actions. This may in turn help us to better understand what might be the machinery of intelligent actions.

The brain is far too often compared with the computer, but there are a couple of important things we can learn from this comparison. Brains are patched together from various components that have evolved over time, whereas computers are designed and constructed from logical principles. The differences in design and history mean that brains, like computers,

are good at some things and not as good at others. For example, the human brain is relatively good at surviving, reproducing, and making decisions in very complex environments, but it is not as good at making exact calculations, which are seldom needed for survival. By contrast, computers do not need to survive or reproduce, and are rarely asked to make their own decisions, yet they can do endless calculations.

A neuron is one of the smallest, but most significant, parts of the brain. Neurons are small, advanced machines that can summate activity from each other and decide whether this activity should be transferred to yet other neurons. We are still learning about the functioning of neurons. Neuron connections create the neural networks that form the biological basis of brain activity. A collection of neurons can initiate cascades of activity from one neuron to the next, just like dominos falling onto each other. But unlike dominos, neurons will continue to repeat this activity and can decide if and when they will contact the next part of the chain. The central property of neurons is that they are able to learn. A neuron can selectively change its influence on other neurons, which would be like dominos deciding which of the other dominos would get the biggest push. In the central nervous system, there are many different types of neurons in many different shapes and with many different functions. For instance, clear anatomical differences are found between the neurons that receive sensory information from the skin and those in the main motor cortex that control motor movements.

More important than the function of a single neuron are the possibilities for learning that are endowed by networks of neurons. This learning forms the basis for our mental abilities

and intelligence. In 1948, Canadian psychologist Donald Hebb proposed the fundamental principle for learning in neural networks: that synapses can change their strength so that they can influence other neurons more or less. A more complete description of what we have learned about neural networks in the brain from using computers is described in readable details elsewhere. Here we are concerned with understanding the mechanisms that underlie the decisions made by our brain all the time. For this purpose, the study of artificial neural networks has contributed quite a lot to our understanding.

THE SOCIAL CHOICES OF THE BRAIN

We are now in a much better position to assess how the real neural networks in the brain make decisions. One of the hallmarks of human nature in general and social intelligence in particular is our flexible behavior. A fundamental characteristic of social intelligence is the ability to quickly change our behavior. Our flexible social skills are already being honed as children and young adolescents, when we quickly become very adept at forming and breaking alliances within and between groups, and we engage in complex social interactions. This type of social intelligence, untested by conventional intelligence tests, is crucial for social behavior. It must be a major reason for our relative evolutionary success and probably is better than IQ at predicting how well a person will do in life.

Although it is obviously important that we can learn arbitrary associations between stimuli, it is equally important that we can relatively easily break these associations and