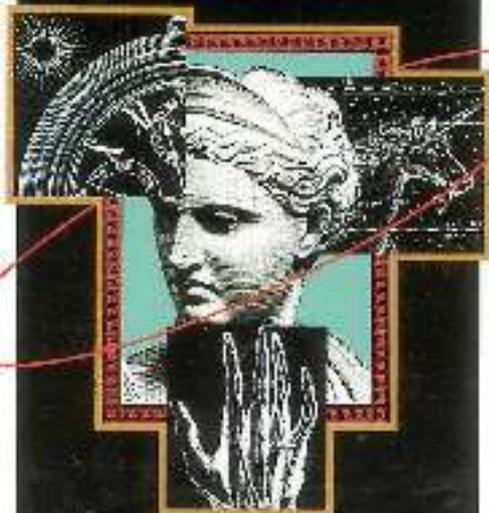


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DESCARTES' ERROR

Emotion, Reason,
and the Human Brain

ANTONIO R. DAMASIO

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For Hanna

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Introduction

ALTHOUGH I CANNOT tell for certain what sparked my interest in the neural underpinnings of reason, I do know when I became convinced that the traditional views on the nature of rationality could not be correct. I had been advised early in life that sound decisions came from a cool head, that emotions and reason did not mix any more than oil and water. I had grown up accustomed to thinking that the mechanisms of reason existed in a separate province of the mind, where emotion should not be allowed to intrude, and when I thought of the brain behind that mind, I envisioned separate neural systems for reason and emotion. This was a widely held view of the relation between reason and emotion, in mental and neural terms.

But now I had before my eyes the coolest, least emotional, intelligent human being one might imagine, and yet his practical reason was so impaired that it produced, in the wanderings of daily life, a succession of mistakes, a perpetual violation of what would be considered socially appropriate and personally advantageous. He had had an entirely healthy mind until a neurological disease ravaged a specific sector of his brain and, from one day to the next,

caused this profound defect in decision making. The instruments usually considered necessary and sufficient for rational behavior were intact in him. He had the requisite knowledge, attention, and memory, his language was flawless; he could perform calculations; he could tackle the logic of an abstract problem. There was only one significant accompaniment to his decision-making failure: a marked alteration of the ability to experience feelings. Flawed reason and impaired feelings stood out together as the consequences of a specific brain lesion, and this correlation suggested to me that feeling was an integral component of the machinery of reason. Two decades of clinical and experimental work with a large number of neurological patients have allowed me to replicate this observation many times, and to turn a clue into a testable hypothesis.¹

I began writing this book to propose that reason may not be as pure as most of us think it is or wish it were, that emotions and feelings may not be intruders in the bastion of reason at all: they may be crushed in its networks, for worse and for better. The strategies of human reason probably did not develop, in either evolution or any single individual, without the guiding force of the mechanisms of biological regulation, of which emotion and feeling are notable expressions. Moreover, even after reasoning strategies become established in the formative years, their effective deployment probably depends, to a considerable extent, on a continued ability to experience feelings.

This is not to deny that emotions and feelings can cause havoc in the processes of reasoning under certain circumstances. Traditional wisdom has told us that they can, and recent investigations of the normal reasoning process also reveal the potentially harmful influence of emotional biases. It is thus even more surprising and novel that the absence of emotion and feeling is no less damaging, no less capable of compromising the rationality that makes us distinctively human and allows us to decide in consonance with a sense of personal future, social convention, and moral principle.

Nor is this to say that when feelings have a positive action they do the deciding for us; or that we are not rational beings. I suggest only

that certain aspects of the process of emotion and feeling are indispensable for rationality. At their best, feelings point us in the proper direction, take us to the appropriate place in a decision-making space, where we may put the instruments of logic to good use. We are faced by uncertainty when we have to make a moral judgment, decide on the course of a personal relationship, choose some means to prevent our being penniless in old age, or plan for the life that lies ahead. Emotion and feeling, along with the covert physiological machinery underlying them, assist us with the daunting task of predicting an uncertain future and planning our actions accordingly.

Beginning with an analysis of the nineteenth-century landmark case of Phineas Gage, whose behavior first revealed a connection between impaired rationality and specific brain damage, I examine recent investigations of his modern counterparts and review pertinent findings from neuropsychological research in humans and animals. Further, I propose that human reason depends on several brain systems, working in concert across many levels of neuronal organization, rather than on a single brain center. Both "high-level" and "low-level" brain regions, from the prefrontal cortices to the hypothalamus and brain stem, cooperate in the making of reason.

The lower levels in the neural edifice of reason are the same ones that regulate the processing of emotions and feelings, along with the body functions necessary for an organism's survival. In turn, these lower levels maintain direct and mutual relationships with virtually every bodily organ, thus placing the body directly within the chain of operations that generate the highest reaches of reasoning, decision making, and, by extension, social behavior and creativity. Emotion, feeling, and biological regulation all play a role in human reason. The lowly orders of our organism are in the loop of high reason.

It is intriguing to find the shadow of our evolutionary past at the most distinctively human level of mental function, although Charles Darwin prefigured the essence of this finding when he wrote about the indelible stamp of lowly origins which humans bear in their bodily frame.⁴ Yet the dependence of high reason on low brain does not turn high reason into low reason. The fact that acting according

to an ethical principle requires the participation of simple circuitry in the brain core does not cheapen the ethical principle. The edifice of ethics does not collapse, morality is not threatened, and in a normal individual the will remains the will. What can change is our view of how biology has contributed to the origin of certain ethical principles arising in a social context, when many individuals with a similar biological disposition interact in specific circumstances.

Feeling is the second and central topic of this book, and one to which I was drawn not by design but by necessity, as I struggled to understand the cognitive and neural machinery behind reasoning and decision making. A second idea in the book, then, is that the essence of a feeling may not be an elusive mental quality attached to an object, but rather the direct perception of a specific landscape: that of the body.

My investigation of neurological patients in whom brain lesions impaired the experience of feelings has led me to think that feelings are not as intangible as they have been presumed to be. One may be able to pin them down mentally, and perhaps find their neural substrate as well. In a departure from current neurobiological thinking, I propose that the critical networks in which feelings rely include not only the traditionally acknowledged collection of brain structures known as the limbic system but also some of the brain's prefrontal cortexes, and, most importantly, the brain sectors that map and integrate signals from the body.

I conceptualize the essence of feelings as something you and I can see through a window that opens directly onto a continuously updated image of the structure and state of our body. If you imagine the view from this window as a landscape, the body "structure" is analogous to object shapes in a space, while the body "state" resembles the light and shadow and movement and sound of the objects in that space. In the landscape of your body, the objects are the viscera (heart, lungs, gut, muscles), while the light and shadow and movement and sound represent a point in the range of operation of those organs at a certain moment. By and large, a feeling is the momentary

"view" of a part of that body landscape. It has a specific content—the state of the body; and specific neural systems that support it—the peripheral nervous system and the brain regions that integrate signals related to body structure and regulation. Because the sense of that body landscape is juxtaposed in time to the perception or recollection of something else that is not part of the body—a face, a melody, an aroma—feelings end up being "qualifiers" to that something else. But there is more to a feeling than this essence. As I will explain, the qualifying body state, positive or negative, is accompanied and rounded up by a corresponding thinking mode: fast moving and idea rich, when the body-state is in the positive and pleasant band of the spectrum, slow moving and repetitive, when the body-state veers toward the painful band.

In this perspective, feelings are the sensors for the match or lack thereof between nature and circumstance. And by nature I mean both the nature we inherited as a pack of genetically engineered adaptations, and the nature we have acquired in individual development, through interactions with our social environment, mindfully and willfully as well as not. Feelings, along with the emotions they come from, are not a luxury. They serve as internal guides, and they help us communicate to others signals that can also guide them. And feelings are neither intangible nor elusive. Contrary to traditional scientific opinion, feelings are just as cognitive as other percepts. They are the result of a most curious physiological arrangement that has turned the brain into the body's captive audience.

Feelings let us catch a glimpse of the organism in full biological swing, a reflection of the mechanisms of life itself as they go about their business. Were it not for the possibility of sensing body states that are inherently ordained to be painful or pleasurable, there would be no suffering or bliss, no longing or mercy, no tragedy or glory in the human condition.

At first glance, the view of the human spirit proposed here may not be intuitive or comforting. In attempting to shed light on the complex

phenomena of the human mind, we run the risk of merely degrading them and explaining them away. But that will happen only if we confuse a phenomenon itself with the separate components and operations that can be found behind its appearance. I am not suggesting that.

To discover that a particular feeling depends on activity in a number of specific brain systems interacting with a number of body organs does not diminish the status of that feeling as a human phenomenon. Neither anguish nor the elation that love or art can bring about are devalued by understanding some of the myriad biological processes that make them what they are. Precisely the opposite should be true: Our sense of wonder should increase before the intricate mechanisms that make such magic possible. Feelings form the base for what humans have described for millennia as the human soul or spirit.

This book is also about a third and related topic: that the body, as represented in the brain, may constitute the indispensable frame of reference for the neural processes that we experience as the mind; that our very organism rather than some absolute external reality is used as the ground reference for the constructions we make of the world around us and for the construction of the ever-present sense of subjectivity that is part and parcel of our experiences; that our most refined thoughts and best actions, our greatest joys and deepest sorrows, use the body as a yardstick.

Surprising as it may sound, the mind exists in and for an integrated organism: our minds would not be the way they are if it were not for the interplay of body and brain during evolution, during individual development, and at the current moment. The mind had to be first about the body, or it could not have been. On the basis of the ground reference that the body continuously provides, the mind can then be about many other things, real and imaginary.

This idea is anchored in the following statements: (1) The human brain and the rest of the body constitute an indissociable organism,

integrated by means of mutually interactive biochemical and neural regulatory circuits (including endocrine, immune, and autonomic neural components); (2) The organism interacts with the environment as an ensemble; the interaction is neither of the body alone nor of the brain alone; (3) The physiological operations that we call mind are derived from the structural and functional ensemble rather than from the brain alone: mental phenomena can be fully understood only in the context of an organism's interacting in an environment. That the environment is, in part, a product of the organism's activity itself, merely underscores the complexity of interactions we must take into account.

It is not customary to refer to organisms when we talk about brain and mind. It has been so obvious that mind arises from the activity of neurons that only neurons are discussed as if their operation could be independent from that of the rest of the organism. But as I investigated disorders of memory, language, and reason in numerous human beings with brain damage, the idea that mental activity, from its simplest aspects to its most sublime, requires both brain and body proper became especially compelling. I believe that, relative to the brain, the body proper provides more than mere support and modulation; it provides a basic topic for brain representations.

There are facts to support this idea, reasons why the idea is plausible, and reasons why it would be nice if things really were this way. Foremost among the last is that the body precedence proposed here might shed light on one of the most vexing of all questions since humans began inquiring about their minds: How is it that we are conscious of the world around us, that we know what we know, and that we know that we know?

In the perspective of the above hypothesis, love and hate and anguish, the qualities of kindness and cruelty; the planned solution of a scientific problem or the creation of a new artifact are all based on neural events within a brain, provided that brain has been and now is interacting with its body. The soul breathes through the body, and suffering, whether it starts in the skin or in a mental image, happens in the flesh.

I wrote this book as my side of a conversation with a curious, intelligent, and wise imaginary friend, who knew little about neuroscience but much about life. We made a deal: the conversation was to have mutual benefits. My friend was to learn about the brain and about those mysterious things mental, and I was to gain insights as I struggled to explain my idea of what body, brain, and mind are about. We agreed not to turn the conversation into a boring lecture, not to disagree violently, and not to try to cover too much. I would talk about established facts, about facts in doubt, and about hypotheses, even when I could come up with nothing but hunches to support them. I would talk about work in progress literally, about several research projects then under way, and about work that would start long after the conversation was over. It was also understood that, as with a conversation, there would be byways and diversions, as well as passages that would not be clear the first time around and might benefit from a second visit. That is why you will find me returning to some topics, every now and then, from a different perspective.

At the outset I made my view clear on the limits of science: I am skeptical of science's presumption of objectivity and definitiveness. I have a difficult time seeing scientific results, especially in neurobiology, as anything but provisional approximations, to be enjoyed for a while and discarded as soon as better accounts become available. But skepticism about the current reach of science, especially as it concerns the mind, does not imply diminished enthusiasm for the attempt to improve provisional approximations.

Perhaps the complexity of the human mind is such that the solution to the problem can never be known because of our inherent limitations. Perhaps we should not even talk about a problem at all, and speak instead of a mystery, drawing on a distinction between questions that can be approached suitably by science and questions that are likely to elude science forever.⁵ But much as I have sympathy for those who cannot imagine how we might unravel the mystery (they have been dubbed "mysterians"⁶), and for those who think it is knowable but would be disappointed if the explanation were to rely

on something already known, I do believe, more often than not, that we will come to know.

By now you may have concluded that the conversation was neither about Descartes nor about philosophy, although it certainly was about mind, brain, and body. My friend suggested it should take place under the Sign of Descartes, since there was no way of approaching such themes without evoking the emblematic figure who shaped the most commonly held account of their relationship. At this point I realized that, in a curious way, the book would be about Descartes' Error. You will, of course, want to know what the Error was, but for the moment I am sworn to secrecy. I promise, though, that it will be revealed.

Our conversation then began in earnest, with the strange life and times of Phineas Gage.

Part

1

One

Unpleasantness in Vermont

PHINEAS P. GAGE

IT IS THE summer of 1848. We are in New England. Phineas P. Gage, twenty-five years old, construction foreman, is about to go from riches to rags. A century and a half later his downfall will still be quite meaningful.

Gage works for the Rutland & Burlington Railroad and is in charge of a large group of men, a "gang" as it is called, whose job it is to lay down the new tracks for the railroad's expansion across Vermont. Over the past two weeks the men have worked their way slowly toward the town of Cavendish; they are now at a bank of the Black River. The assignment is anything but easy because of the outcrops of hard rock. Rather than twist and turn the tracks around every escarpment, the strategy is to blast the stone and make way for a straighter and more level path. Gage oversees these tasks and is equal to them in every way. He is five-foot-six and athletic, and his movements are swift and precise. He looks like a young Jimmy Cagney, a Yankoe Doodle

dantly dancing his tap shoes over ties and tracks, moving with vigor and grace.

In the eyes of his bosses, however, Gage is more than just another able body. They say he is "the most efficient and capable" man in their employ. This is a good thing, because the job takes as much physical prowess as keen concentration, especially when it comes to preparing the detonations. Several steps have to be followed, in orderly fashion. First, a hole must be drilled in the rock. After it is filled about halfway with explosive powder, a fuse must be inserted, and the powder covered with sand. Then the sand must be "tamped in," or pounded with a careful sequence of strokes from an iron rod. Finally, the fuse must be lit. If all goes well, the powder will explode into the rock; the sand is essential, for without its protection the explosion would be directed away from the rock. The shape of the iron and the way it is played are also important. Gage, who has had an iron manufactured to his specifications, is a virtuoso of this thing.

Now for what is going to happen. It is four-thirty on this hot afternoon. Gage has just put powder and fuse in a hole and told the man who is helping him to cover it with sand. Someone calls from behind, and Gage looks away, over his right shoulder, for only an instant. Distracted, and before his man has poured the sand in, Gage begins tamping the powder directly with the iron bar. In no time he strikes fire in the rock, and the charge blows upward in his face.²

The explosion is so brutal that the entire gang freezes on their feet. It takes a few seconds to piece together what is going on. The bang is unusual, and the rock is intact. Also unusual is the whistling sound, as of a racket hurled at the sky. But this is more than fireworks. It is assault and battery. The iron enters Gage's left cheek, pierces the base of the skull, traverses the front of his brain, and exits at high speed through the top of the head. The rod has landed more than a hundred feet away, covered in blood and brains. Phineas Gage has been thrown to the ground. He is stunned, in the afternoon glow, silent but awake. So are we all, helpless spectators.

"Horrible Accident" will be the predictable headline in the *Boston Daily Courier* and *Daily Journal* of September 20, a week later.

"Wonderful Accident" will be the strange headline in the *Vermont Mercury* of September 22. "Passage of an Iron Rod Through the Head" will be the accurate headline in the *Boston Medical and Surgical Journal*. From the matter-of-factness with which they tell the story, one would think the writers were familiar with Edgar Allan Poe's accounts of the bizarre and the horrific. And perhaps they were, although this is not likely; Poe's gothic tales are not yet popular, and Poe himself will die the next year, unknown and unappreciated. Perhaps the horrible is just in the air.

Noting how surprised people were that Gage was not killed instantly, the Boston medical article documents that "immediately after the explosion the patient was thrown upon his back"; that shortly thereafter he exhibited "a few convulsive motions of the extremities," and "spoke in a few minutes"; that "his men (with whom he was a great favourite) took him in their arms and carried him to the road, only a few rods distant (a rod is equivalent to 5 1/2 yards, or 16 1/2 feet), and set him into an ox cart, in which he rode, sitting erect, a full three quarters of a mile, to the hotel of Mr. Joseph Adams"; and that Gage "got out of the cart himself, with a little assistance from his men."

Let me introduce Mr. Adams. He is the justice of the peace for Cavendish and the owner of the town's hotel and tavern. He is taller than Gage, twice as round, and as solicitous as his Falstaff shape suggests. He approaches Gage, and immediately has someone call for Dr. John Harlow, one of the town physicians. While they wait, I imagine, he says, "Come, come, Mr. Gage, what have we got here?" and, why not, "My, my, what troubles we've seen." He shakes his head in disbelief and leads Gage to the shady part of the hotel porch, which has been described as a "piazza." That makes it sound grand and spacious and open, and perhaps it is grand and spacious, but it is not open; it is just a porch. And there perhaps Mr. Adams is now giving Phineas Gage lemonade, or maybe cold cider.

An hour has passed since the explosion. The sun is declining and the heat is more bearable. A younger colleague of Dr. Harlow's, Dr. Edward Williams, is arriving. Years later Dr. Williams will describe

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