

Feelings of Emotion and the Self

ANTONIO DAMASIO

*Department of Neurology, University of Iowa College of Medicine,
Iowa City, Iowa 52242, USA*

ABSTRACT: The self is a critical component of consciousness. The neural correlates of self have proven elusive, but it is reasonable to suggest that, in its simplest form, the self process requires a composite representation of the ongoing state of the organism as reflected in subcortical and cortical somatic maps within the central nervous system. The basis for these maps is a wealth of signals originating in different sectors of the body-proper. Some of these signals portray the actual state of the body as modified by emotions in response to interactions with the environment; but other signals are the result of internal simulations controlled from other regions of the central nervous system.

KEYWORDS: self; consciousness; body; feeling.

There are different perspectives on the self, different possible definitions, and with each perspective and definition, naturally, comes a different explanation. Yet it is likely that something like an essence of self can be uncovered behind the multiplicity of views. In this article I suggest that a neurobiological account can help us find such an essence. The title of this article includes the words “feelings” and “self” because I believe the neural basis of feelings and of self have a shared neurobiological stem.

When we use the word *self* we think of something that bespeaks individuality. The word self often stands for an individual—a mind or a body, or both as a unity. In addition, we think of something that denotes stability and continuity over time, as well as singularity. In fact, singularity is so strongly associated with the notion of self that the finding of multiple selves is regarded as pathological. The notion of self is a synonym of personhood, and,

Address for correspondence: Dr. Antonio Damasio, Department of Neurology, University of Iowa College of Medicine, 200 Hawkins Drive, Iowa City, IA 52242-1053. Voice: 319-356-4296; fax: 319-353-6277.

Antonio-damasio@uiowa.edu

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connected to whatever meaning, self always implies a *reference*, for example, to an organism, to its behavior, or to its mind.

To speak of self is also, of necessity, to speak of consciousness. If I tell you that I have a headache, I must dig below the level of language and the referent pronoun "I" to the level of self in my consciousness. If I were not conscious of the headache, that is, if I did not have a mind, awareness, and a self, I would still have the headache, but I would not know it was me having the headache. The self is the key reference in the process of consciousness. The self endows us with a subjective perspective.

The minimal level of self necessary for consciousness to occur is implemented as a mental representation. This does not mean, incidentally, that the self is some sort of mental homunculus. There has been a well-justified rejection of the notion of the homunculus, and an effective demonstration that in searching for the self we should not be looking for an all-knowing entity that thinks on its own and gives us the knowledge of who we are. Also we should not be looking for some sort of special brain center where the self would reside. To a first approximation, the self is a stable representation of individual continuity which serves as a mental reference for the organism within the conscious mind. (This first approximation corresponds to my notion of core self. To denote the notion of self which corresponds to identity and personhood, I refer to *autobiographic self* or *extended self*. The autobiographic self is physiologically based on the simpler, core self, but its discussion is beyond the scope of this brief title. See Damasio [1999] for a treatment of these different concepts.)

TOWARD A NEURAL CORRELATE OF THE SELF PROCESS

As is the case with consciousness in general, I believe the self is based on a neurobiological process. I also believe that the key to the self is the representation of the continuity of the organism. As I have suggested elsewhere (Damasio, 1999; Damasio, 2003a), a likely support for the representation of organismic continuity is the neural system responsible for the representation of our own bodies. At this point we should consider this an intuition. However, it is a plausible intuition, one which can inform valuable hypotheses, and it is not mine alone. There is a venerable tradition of seeing the self as connected to a representation of the body. One finds the notion in the philosophers Spinoza, Nietzsche, William James, Husserl, Heidegger, and Merleau-Ponty, and one can find it even in the high priesthood of neuroscience, as in the early thinking of the neurophysiologist Charles Sherrington.

This point of view can be illuminated by a simple experiment that the reader can perform by looking away from this book, toward a wall, for a few seconds, and then returning to view the book again. The visual representations

of the book page, with which the reader started, were realized in the visual cortices; but as the reader looked at the wall the representation gave way entirely, in those same cortices, to the representation of the wall; then it gave way again to the representation of the book page. While all those changes were happening, however, we know for certain about something that did not change: the representations of the body remained in continuous operation within the somatic-related cortices. There was no change of the *kind* of content available in those structures.

This disparity highlights a curious situation. We have some senses that are at the mercy of the movements of the body. The images we form on the basis of these senses are determined by what happens to come into our sensory fields, especially the telereceptive fields. Yet other senses are condemned, so to speak, to look continuously at precisely the same content, that is, the organism as a whole. It is this continuous representation of the organism, of the body, for short, that I consider to be the backbone of the self as we know it. It is an ongoing, composite representation of a host of body activities, which occurs in a host of brain structures, as many as a dozen, and it is based upon signals coming from the body to the brain, some purely chemical, and some neural, that is, neurochemical. There is a sameness to this representation, a stability, which contrasts with the variety and discontinuity of external sensory representations.

The content remains the same, stable and continuous, but it is important to note that the representations of the organism also vary. Yet, this variance is within a very narrow range, as mandated by survival; if the variance is excessive, one dies or gets sick. The minimal variance occurs as part of the constant adjustments and balancing needed for homeostasis, that is, for life itself. The variations operate within strict limits and contrast sharply with the infinite variability of external sensations, or the variability of our flow of memories.

The foregoing provides a context for an idea of the possible neural correlates of the self. This is not enough, however. We still need to understand what the somato-sensing system actually looks like, a task which has eluded us for a long time. One reason why we have not fully understood this system is that we have looked at the somatosensory system in far too narrow a way. For some, the notion of somatosensory simply conjures up the musculoskeletal system; for others, as was the case with William James, it conjures up mostly the visceral system. These views are most incomplete. We can grasp the system only if we understand its full scope and depth.

The first step toward the desired understanding is to overcome the tendency to limit our senses to the traditional five: sight, hearing, touch, taste, and olfaction. Such a limitation ignores kinesthesia (the sense of movement derived from proprioception via the musculoskeletal system); it ignores the vestibular sense; no less importantly, it ignores the sensing of the viscera and the internal milieu. Interestingly, if one goes back to the 19th century, one can find thinkers such as Weber, who spoke of a *Gemeingefühl*, an overall sense

of our bodies which included signals from the internal milieu; or Sherrington, toward the end of the 19th century, who spoke of “interoception,” the sense of the material “me,” or the physical self. Curiously, in later editions of his famous textbook, Sherrington no longer talked this way. Interoception, which is very much the process I regard as most critical for the self, was dropped (see Damasio [2003b] and Craig [2002] for review).

I look at the roster of “senses” differently. As noted, there are, of course, the exteroceptive senses: vision, smell, hearing, taste, and mechanical contact; but there is also a separate and most interesting grouping of interoceptive neural senses that include the proprioceptive and vestibular senses; the visceral sense; and the sense of the internal milieu which can be taken together with that of pain and temperature. Also, we must remember that, evolutionarily, before the arrival of these neural senses, the entire organism was a chemo-sensor, having an ability whose remnants are still present in humans and other complex species. Chemo-sensing occurs in the form of signals that contact “open” areas of the nervous system—areas devoid of the blood–brain barrier, such as the area postrema or the subfornical organs—where chemical molecules can influence directly the state of neural tissue and produce cascades of events within the central nervous system. Thus it is important to realize that nerve fibers are not indispensable to sense that there are changes occurring within the body. Those changes can also be sensed through chemical action on nervous tissue.

Along with this chemoreceptive system there is another major component of the neural self, the C and A delta fiber system, made up of nerve endings that are free and located in literally every nook and cranny of our bodies, in every type of tissue. They appear also in the more specific system of the vagal nerve. This system is very different from that made up by A alpha and A beta fibers. The C and A delta system is evolutionarily older, made of thin and mostly unmyelinated fibers that conduct signals at a slow velocity, between 1 and 2 meters per second. By contrast, the A alpha and A beta fibers transmit signals as fast as 60 meters per second. This faster system is well adapted to the sensing of the external world. The older, slower system is equally well adapted for sensing the internal environment of the organism.

The range of sensitivity of the C and A delta fiber system is wide. It responds to local pH, partial pressure of oxygen and CO₂, glucose levels, levels of lactic acid, glutamate, histamine, serotonin, and so on. It further includes the local assessment of temperature and mechanical stress, and registers processes such as the flush of the skin, itches, tickles, sensuous touch, and genital arousal. I suspect the grounding for the perception of our own being, at any given moment, is conveyed by this general system originating in sensors that are located throughout the structure of our bodies. The system can register activities as gross as mechanical stress, but also as subtle as a moment of genetically programmed cell death, or apoptosis. When a cell is injured through, say, ischemia, the system responds. These fibers signal continuous-

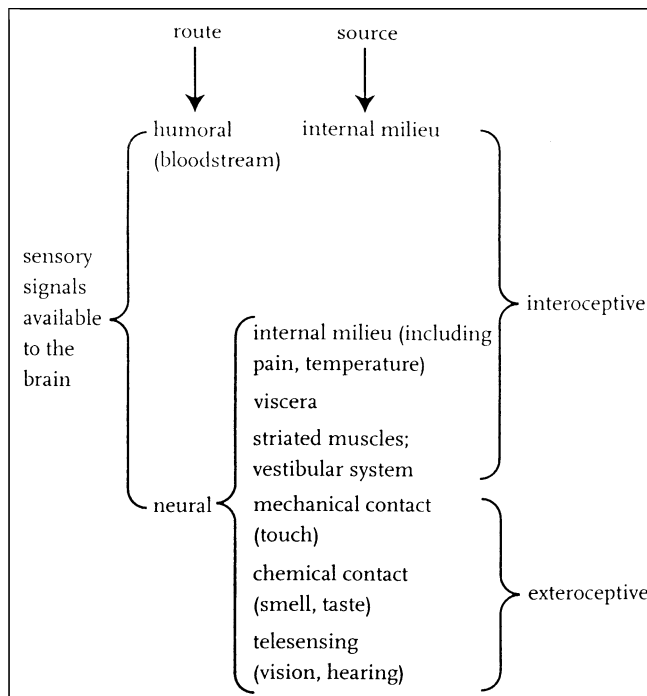


FIGURE 1. The kinds of sensory signal received by the brain. There are two routes of transmission: humoral (in which chemical molecules conveyed by the bloodstream directly activate neural sensors in the hypothalamus or in circumventricular organs such as the area postrema); and neural (in which electrochemical signals are transmitted in neural pathways). There are two sources for all these signals: the external world (exteroceptive signals), and the inner world of the body (interoceptive signals). The main source of the latter is the viscera and the internal milieu, but signals related to the state of the musculoskeletal and vestibular systems participate as well.

ly, whether we want them to or not; no control is possible on our part (FIG. 1).

A DEDICATED SYSTEM

Within the central nervous system all these signals are transmitted by a dedicated set of pathways and nuclei. In the spinal cord the system recruits lamina I of the posterior horn, the region where the C and A delta fibers ter-

minate. These fibers do not go into the other posterior horn laminae and do not enter the white matter either. They go only to this particular region. Above the level of the spinal cord, in the brainstem, they go to the trigeminal nucleus, specifically to the segment known as the pars caudalis, which is the direct equivalent of lamina I in the spinal cord. These brainstem fibers carry signals from the body structures of the head, the oral cavity, the skin, of face and scalp, and the facial muscles of emotion and jaw movement.

Other interesting aspects of this system reflect its specialization. In the posterior horn of the spinal cord we see that the neurons arising from these fibers traverse from one side of the spinal cord to the other, within the gray matter, and then ascend toward the telencephalon, via the brainstem. Neurons carrying signals from muscles and from outside the body take quite a different route: they enter the white matter, rather than the gray matter of the posterior horn, and then ascend into the telencephalon without making any synapses until they reach the brainstem. The C and A delta fiber pathway, the system that gives us the overall sense of the body's interior, allows for intervention from top-down control which arises in nuclei of the periaqueductal gray and of the hypothalamus, the periventricular nucleus in particular. These regions can influence the signals coming from the body's interior.

How does this system participate in making the maps of the body state that I regard as the key correlate for the sense of self? The answer is that the signals that enter the spinal cord and trigeminal nucleus eventually ascend to an equally dedicated nucleus of the thalamus, the VMpo nucleus (ventromedial nucleus, posterior part). Until recently it had been thought that the signals projected to the VP nuclei of the thalamus (ventroposterior), but the work of A.D. Craig (Craig, 2002) has shown that the VMpo constitutes the terminal region for these signals. From the VMpo, projections continue to the dorsal and anterior insula.

The insular regions receive other important body signals along the way, namely those that travel in projections from the parabrachial nucleus in the brainstem, and also from the nucleus tractus solitarius, which picks up on information from the viscera through the vagus nerve. Also, there is a further convergence of information from the circumventricular organs, which pick up information directly through sensing the chemical environment in the brain. All of these other structures use another relay nucleus in the thalamus, the VMb nucleus (ventromedial, basal part), which then projects to the dorsal insula. This means that signals from the body's interior ultimately come together, continuously, in the insula. The organization of the insula even appears to be graded, across subregions, in a manner similar to that of visual regions within the visual cortices. The body's interior is mapped neurally from back to front. It is even possible that the highest level of this representation is integrated mostly in the right anterior insula, as has been suggested by Craig. Signals from the insula are then made available to the anterior cingulate and orbitofrontal cortices (FIG. 2).

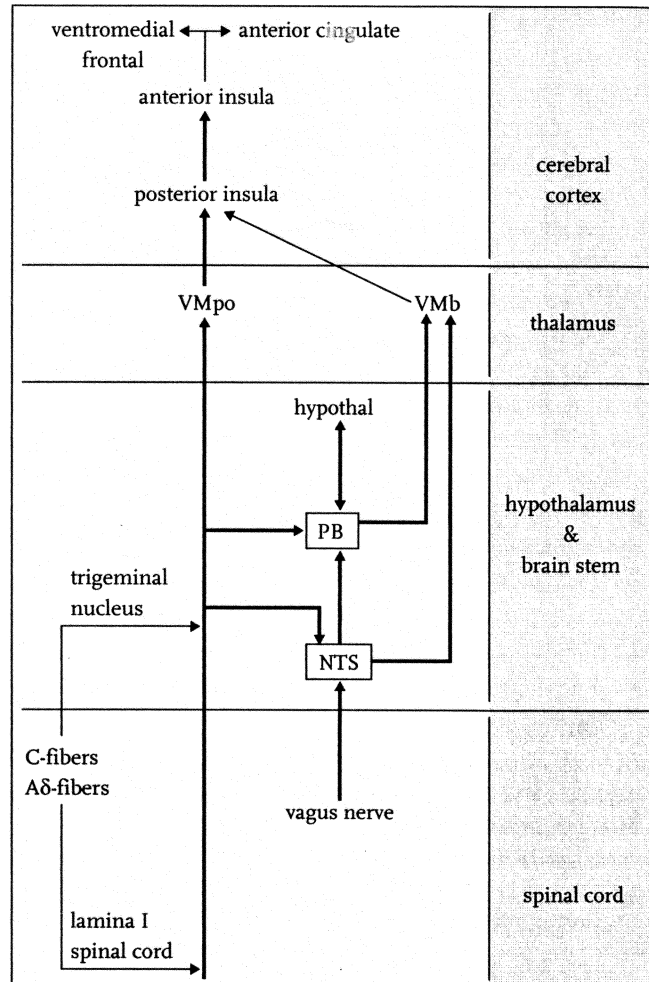


FIGURE 2. Signaling from body to brain. A diagram of the critical structures involved in conveying internal milieu and visceral signals to the brain. A substantial part of the critical signaling is conveyed by pathways from the spinal cord and the brainstem’s trigeminal nucleus. At every level of the spinal cord, in a region known as “lamina I” (in the posterior horn of the spinal cord’s gray matter, and in the caudal part of the trigeminal nucleus), the information conveyed by peripheral nerve fibers of the C and Aδ types (thin, unmyelinated, and slow-conducting) is brought to the central nervous system. This information hails from literally everywhere in our entire body and relates to parameters as diverse as the state of contraction of smooth muscles in arteries, the amount of local blood flow, local temperature, the presence of chemicals signifying injury to local tissue, the level of pH, O₂ and CO₂. All of this information is further conveyed to a dedicated nucleus of the thalamus (VMpo) and then on to neural maps in the posterior and anterior insula. Subsequently the insula can signal to regions such as the ventromedial prefrontal

[over]

BODY REPRESENTATION, FEELINGS, AND SELF

It is intriguing to learn that these same parts of the insula are involved systematically in the feelings of emotion. As shown in functional imaging studies, feeling emotions such as happiness, anger, fear, and sadness is accompanied by different patterns of activity in structures of the insula, along with other regions of the central nervous system in the brainstem and diencephalon (Damasio et al., 2000). Feelings of coolness and heat, pain of various sorts, sensations related to respiration and exercise, itch, disgust, sexual arousal, the highs associated with drugs such as ecstasy and morphine, and even the feelings of craving associated with these drugs, all of these engage the insular cortices, emphasizing the point that this region thoroughly relates to bodily state (see Craig [2002] and Damasio [2003b] for review).

Parts of this robust system are found in non-human species. The basic system, through the brain stem and hypothalamus, can be seen in most mammals. However, the final leg of the system, from the VMpo to the insula, appears to be present only in primates. This suggests that while many species can have a continuous representation of the body capable of supporting feelings of emotion and a sense of self, only primates might, through the addition of structures that facilitate high-level convergence, generate the sort of higher-order mappings that would make the sense of self become most encompassing.

The notion that the right insula would provide the highest level of integration is in keeping with this possible evolutionary progression. We got a preliminary inkling of this possibility while looking at data arrived at through the study of lesions in humans. Lesions which compromise the ability to experience emotional feelings and to sense the body are often located on the right side of the somatosensory complex, including and in particular to the right insula cortex. The patients so affected have a compromised sense of self as well.

cortex and the anterior cingulate cortex. On the way to the thalamus, this information is also made available to the nucleus tractus solitarius (NTS), which receives signals from the vagus nerve (a major path for information from the viscera that bypasses the spinal cord); to the parabrachial nucleus (PB); and to the hypothalamus (hypothal). In addition to being important recipients and processor of this information (it is conceivable that some sense of self might actually emerge from activity at this level), the PB and the NTS also convey signals to the insula via yet another thalamic nucleus (VMb). Intriguingly, the pathways related to the movement of the body and to its position in space use an entirely different chain of transmission. The peripheral nerve fibers convey those different chains of transmission. The peripheral nerve fibers that convey those signals ($A\beta$) are thick and conduct at fast speeds. The parts of the spinal cord and trigeminal nerve nucleus used for body movement signaling are also different, and so are the thalamic relay nuclei and the ultimate cortical target (the somatosensory cortex I).

We begin, then, with a multi-level coalescence of signals from a vast array of sources: the chemically based circumventricular organs and the hypothalamus, the C and A delta fiber system, and the vagal system. These signals are conveyed through special thalamic lines into the insula. Other regions of the somatosensory system, namely, the cortices of SI and SII (somatosensory cortex I and somatosensory cortex II) in both hemispheres along with their attending association cortices, incorporate signals arising in the musculoskeletal system and the vestibular system. These cortices are richly interconnected with those of the insula. The ensuing cross-signaling provides a composite and continuous map of the body state. The composite brings together the internal milieu and viscera—which narrowly change in their constant search for homeostasis—along with the invariant aspects of the musculoskeletal system. As I see it, this composite is the neural foundation for the self, the grounding of the material “me” (Damasio, 2003a). This is only the beginning of the self process, of course. To build the kind of self we associate with personhood it takes abundant personal memory and to generate a sense of identity and autobiography with the complexity we find in humans it takes language as well.

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