Neuron

Q&A

Hanna and Antonio Damasio

Hanna and Antonio Damasio work at the intersection between neuroscience, neurology, philosophy, and psychology. They discuss the value of single case studies for neuroscience, consciousness research and the limits of AI, and the fascinating relationship between creativity and the brain.

Biography

Antonio Damasio is University Professor, David Dornsife Professor of Neuroscience, Psychology, and Philosophy, and Director, Brain and Creativity Institute, University of Southern California. Antonio trained as a neurologist and neuroscientist and has made seminal contributions to the understanding of brain processes underlying decision-making, language, affect, and consciousness. His recent work focuses on the physiology of interoception and how homeostatic feelings ground sentience.

Hanna Damasio is University Professor, Dana Dornsife Professor of Neuroscience, and Director, Dana and David Dornsife Cognitive Neuroscience Imaging Center, University of Southern California. Hanna trained as a neurologist and neuroanatomist. Her recent research focuses on the neurobiology of music processing and on the neural correlates of consciousness.

Hanna and Antonio are highly cited neuroscientists, have received numerous scientific prizes and major honorary doctorates, and have written influential books translated in numerous languages.

Hanna Damasio and Antonio Damasio
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How did you get started in science, and what motivated you to become a neuroscientist?

AD: We began our careers at the same school of medicine and the same department of neurology in Lisbon, Portugal. Clinical neurology, neurosurgery, psychology, and psychiatry were almost equally considered in this environment something rare then and still rare. This was the department where cerebral angiography, one of the preludes to neuroimaging, had been invented by the Nobel Laureate neurologist Egas Moniz and also the place where the same Egas Moniz developed cerebral leucotomy, a controversial surgical procedure aimed at treating psychoses. Mind, behavior, and brain images were part of the fabric of daily conversation, both around patients and in the basic science laboratories. Still, what sealed the early direction of our careers came midway through our medical training (which in those days took an incredible long seven years!). That is when we spent a summer in Cambridge, at the Massachusetts Institute of Technology, listening to Warren McCulloch, of cybernetics fame, and, perhaps most importantly, listening to Norman Geschwind. Norman had already published the seminal "Disconnexion Syndromes in Animals and Man" and was about to influence a whole generation of neurologists from his perch as Putnam Chair of Neurology at Harvard Medical School, much to the irritation of Macdonald Critchley, his British counterpart in behavioral neurology and another mentor of ours.

At first glance it might look like we could not have escaped this web of neurology and behavior, but in retrospect I believe it was the opposite: we were the ones actively seeking these influences and teachings. We had elected to be where we were rather than the other way around. We could not stop wondering about how human minds operated, and there was already enough known, at this point, to suggest that distinct anatomical sectors of the brain were responsible for generating varied aspects of mind and behavior, ranging from perceptions to memory, reasoning, and language.

HD: I agree on that point, and I also think that, in a way, our generation was lucky and so was the field as a whole. If we had started the journey of discovery from the cellular level on *up*—instead of from the entire nervous system *down* to specific regions—*we might not have been able to see so early and so clearly how some large components of the nervous system—in the cerebral cortex, in basal ganglia, in thalamus/hypothalamus, and in brainstem—were predominantly responsible for large-scale components of human behavior such as decision making, reasoning, language, memory, movement, and sleep/wakefulness.*

AD: I would agree. Those large-scale pointers were fascinating, and that is why we looked for mentors that could give us additional tools in areas such as neuropsychology, which was the case with Arthur Benton, with whom we worked at the University of Iowa, and with Freda Newcombe at Oxford University, but also in linguistics with Ursula Bellugi at the Salk Institute and Victoria Fromkin at the University of California Los Angeles. Although we admired the neuronal modeling wizardry of Warren McCulloch, we craved the work with neurological patients and with the images of their brains.

Some of your work is inspired by single case studies. What are your thoughts on their value for neuroscience research?

AD: The importance of single cases in neurological research cannot be overstated, especially when the subject has a clearly demarcated and stable lesion. Some of the glories of neurology and neuroscience came by the way of such single case studies, as when Paul Broca and Carl Wernicke identified two kinds of aphasia with distinct linguistic defects related to two separate loci of brain damage and when Jules Déjérine described two kinds of reading disorders (alexia), with and without a writing defect (agraphia), and with separate sites of brain damage. Today, with the help of fine neuropsychology and assisted by modern neuroimaging techniques, we can apply the classical lesion method of animal studies to the study of humans with neurological damage. HM is an example, made famous because his problem was amnesia and memory is so central to the understanding of mind, but there are several other equally significant cases. Our patient EVR, for example, had focal, bilateral, and prefrontal damage and marked defects of decision-making in spite of high intelligence and normal memory and language. We studied him for many years, in collaboration with Antoine Bechara and later with Marco Verweij, and we reached important conclusions concerning the neural basis for reasoning and deciding. EVR inspired the "somatic marker hypothesis." Our patient Boswell is another important case. His herpetic encephalitis demolished his insular cortices and hippocampus bilaterally. Daniel Tranel and Ralph Adolphs were involved in the investigation of this patient for many years. Boswell taught us plenty about memory but also helped us establish the different roles of insular cortices and subcortical stations in the governance of affect. We studied countless other patients with focal lesions and with every conceivable neuropsychological condition from varied aphasia syndromes to facial recognition defects (prosopagnosia). Thomas Grabowski was a close collaborator in the studies involving language.

Not all major case studies were due to damage in the cerebral cortices. In fact, the study of focal lesions in subcortical territories—especially in brainstem—yielded extremely valuable results. Damage to the *anterior* sector of the cerebral peduncles and the pons causes motor defects, especially tragic when the lesion is bilateral and causes "locked-in syndrome." On the other hand, damage to the *posterior* sector of the brainstem disrupts consciousness and can present as coma. This is due to the destruction of regions such as the periaqueductal gray and the parabrachial nucleus, as shown in our studies with Josef Parvizi. It is difficult to exaggerate the significance of these findings for the overall conceptualization of consciousness.

In conclusion, the facts that emerged from single case studies involving focal lesions were novel and revealing and have stood the test of time.

HD: Let me add that in order to study neurological patients with research protocols and investigate both their behavior and their brain lesions, we had created the University of Iowa Patient/Lesion Registry, which continues to this day under the direction of our colleague Daniel Tranel.

While we value lesion studies, functional computerized tomography imaging has opened the possibility of conducting well-designed neuroimaging experiments in normal humans. For example, lesion studies could never have helped us establish that concepts are "represented" in temporal and parietal cortices, in an abstract manner, independent of sensory-modality, and yet that is what our work with Jonas Kaplan, Kingson Man, and Morteza Dehghani established using fMRI data and multivariate pattern analysis. Those studies showed how a particular idea is "represented" in the cerebral cortex, independently of the sensory channels that contributed to forming such a "representation" and of the word that denotes the particular idea, in whatever language.

Of note, this is relevant to the operations of ChatGPT and comparable artificial intelligence (AI) devices. How do they accomplish their amazing tricks? Starting from the entirety of texts available on the internet, they interrelate language morphology and syntax with their corresponding abstract representations so that they can then generate reasonably coherent text on whatever topic they are asked to cover. Very ingenious, but the human cerebral cortices have been doing it for quite a while!

With regards to the current state of AI, do you think that machines can become conscious one day?

AD: Given its new powers, will AI ever develop feelings or consciousness? This is perhaps the most pressing question posed by the new AI devices. To the best of our knowledge the answer is a firm *no*, as we explain in a recent text with Lisa Aziz-Zadeh. Feelings and consciousness are about life inside living organisms. They reflect the state of life regulation in such organisms and express how well or how poorly the life process is going. AI devices are not exposed to the vagaries of life; they do not need to feed themselves and are not victims of diseases in the same way that living things are. They do not *feel* and they do not *need* to *know*. They are at the mercy of good or bad engineers and of ourselves, their owners and controllers. Have no fear of AI devices but beware of the humans who control them!

HD: I completely agree. AI and related devices are simply *tools* that should improve our lives; they are not independent entities. The danger is that they can be misused.

Can you elaborate on your interest in consciousness research?

AD and HD: In a curious way our group has been concerned with consciousness for over two decades. But while we have been able to contribute bits and pieces to solve the grand puzzle of consciousness, it is apparent that until now we had not solved the problem, "hard" or "soft" or whatever, in the sense of doing away with the problem and declaring victory.

What has changed and is new, this time around, is as follows: homeostatic feelings—which include the feelings of body temperature, breathing, hunger, thirst, pain, and pleasure—are spontaneously and automatically conscious, and when they first developed in evolution, they inaugurated consciousness. In brief, consciousness began with homeostatic feelings, and a good part of the solution to its mystery sits with the elucidation of homeostatic feelings. They naturally provide the mind process with an experience of the body.

The history of biology can be easily divided in two periods: *before* the appearance of homeostatic feelings and *after*. Before homeostatic feelings, life regulation was ''blind'' and ''covert'': no one was in charge. Once homeostatic feelings appeared, life regulation could be guided by *individual deliberation*, the deliberation of an experiencer's self, a self that is being informed of how life is doing presently, well or not so well, within its own organism. Homeostatic feelings do double duty: they provide the mind with an experience of the body, which constitutes the beginning of consciousness, and with an incipient self that can then steer the life process in the direction most convenient to maintaining it.

Our intuition that consciousness depends on low rather than high levels of biological processing is not new. We have long defended the idea that we do not become conscious by the grace of higher cognition. We do not think hard and become conscious. The beginnings of consciousness are humble and are tied with life regulation, not with metaphysical anguish. What is new is the idea, staring us in the face, that homeostatic feelings themselves are *fully conscious* events and that they open the consciousness proceedings in the history of life in each and every one of us. This is new, and we have been explaining it in recent papers published in *Brain*, *Neural Computation*, and *Animal Sentience*, among others.

The idea is complemented by a plausible physiological mechanism to explain the rise of homeostatic feelings. We now believe that we are pointing not only to the actual beginning of consciousness but also to *how* living creatures, such as we are, arrived at that beginning. Here, we are assisted by the peculiarities of interoception. Interoceptive neurons are so evolutionarily ancient, so poorly insulated from their environment (or not insulated at all), that they can mingle with abandon in the visceral/interoceptive world and comingle with the flesh in the middle of which they travel—the mucosae, hollow viscera, blood vessels of our entrails, and so forth. We believe that the result of this mixing partnership is a peculiar *interactive perception* of that internal visceral world, a give and take process that allows us to glean the foundation of our beings, nothing less than sensing life as it is pursued inside the body. These experiential feelings anchor our beings, anchor the perceptions we construct concerning the world around each of us as well as the rest of our bodily world, namely, the musculo-skeletal armature of the whole organism.

You are both the directors of the Brain and Creativity Institute. Can you explain how art and brain research influence each other?

AD: No matter how the biology behind the human conscious mind evolved, it is important to realize that its instruments—memory, reasoning, problem-solving, language, creativity—helped humans solve the dramas of their existence and that such an existence was not isolated. Humans were social, their glories and tragedies were often socially related, and consistently created instruments aimed at resolving social problems: moral systems, religions, politics, economics, education, the arts, philosophy.

We have wished to contribute to the public conversation on those themes not only with the science we practice but also with public engagement. That is probably the reason why the first appointment we made at our institute was for an education researcher, Mary Helen Immordino-Yang.

That is also why the Brain and Creativity Institute was organized around two functional centerpieces: a *neuroimaging center*, where human MRI and electroencephalogram (EEG) studies are pursued as needed by different projects, and an *auditorium* with state-of-the-art acoustics, where concerts, lectures, seminars, symposia, and debates can reflect the cultural and scientific moment. As examples, the composer and musicologist Bruce Adolphe has discussed bridges between music and neuroscience, while the pianist Alfred Brendel traded the keyboard for the lectern and read his poetry; Yo-Yo Ma sat by his cello and spoke unrehearsed on the social impact of music; and one of our first Brain and Creativity Institute Fellows, the young violinist Etienne Gara, invented a remarkable ensemble with 17 string instrument players he called ''Delirium Musicum,'' which has been met with delirious audiences and won awards for its novelty.

HD: On that topic, we have created an active program of research on the consequences of music listening and practice on the developing brain—beginning at age 6—and on the effects of music throughout the life span. This is the result of collaborations with the Los Angeles Philharmonic, the Colburn School of Music, the Los Angeles Opera, and GRoW @ Annenberg. Assal Habibi, a young neuroscientist who is also a classical pianist, is in charge of that program.

We are beginning to see the results of these longitudinal studies, and it is already apparent that early exposure to music execution has a beneficial influence on social behavior and on individual emotional and intellectual development. We need to wait and see how these early results translate into positive effects later in development and in adult life. We also need to separate the effects related to the discipline required for practice, on the one hand, from the effects due to what the children actually practice, that is, music! We expect that the practice will leave a signature in the human brain, such as, for example, functional and anatomical changes in varied brain systems.

What keeps you awake at night?

AD: Yes, there are things that can delay my sleep. One of them concerns our assumptions regarding the stability and immutability of the universe. Here is the issue: we study biology in general and brains and minds in particular as if the standard model of cosmology will be forever the same and as if its deep operations would have no relevance to what goes on in our cognitive and affective functions. The sort of questions that arise in quantum physics, for example, do not interfere with our studies (with the possible exception of the situation of some investigators who have created a problem for themselves by approaching consciousness through the lens of quantum physics).

But what if the standard model is not forever fixed? Or even more plausibly, what if we are wrong about the idea that all those invisible physical undergirdings play no role in the biological phenomena we study? What if life or the behavior of neurons is not as independent as we have assumed? These are the sort of worries that clearly delight a physicist-philosopher like Marcelo Gleiser at Dartmouth but that could become a nightmare for us, hopefully in another life!

DECLARATION OF INTERESTS

The authors declare no competing interests.

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