THE EXTENDED BRAIN



Dr. Heitor V. Lumen Marinho

A PRIZEWINNING SCIENCE BOOK

A philosophical essay on cognition, the neural net, and the ocean

NATIONAL SCIENCE PRIZE — 2024

THE EXTENDED BRAIN

A philosophical essay on cognition, the neural net, and the ocean

Dr. Heitor V. Lumen Marinho

Winner of the 2021 Jabuti Prize for Science
National Science Prize 2024 — Category of Science Writing
More than 80,000 copies sold in Brazil and Portugal

First edition — 2021
Definitive edition — 2026
Expanded edition, with an unpublished afterword
English edition for the Margem 37 archive — 2026

“Your brain does not end where your skin begins.”

— Andy Clark & David Chalmers, 1998. The idea this book took to sea.

CONTENTS

Preface to the Definitive Edition — p. 4
Introduction: Where Is My Brain? — p. 5
Chapter I: Clark, Chalmers, and the Octopus — The Mind Outside the Head — p. 7
Chapter II: The Body That Thinks — The Nine Brains of the Octopus — p. 10
Chapter III: The Pod That Thinks — Dolphins, Names, and Alliances — p. 14
Chapter IV: The Ocean That Thinks — Corals, Whales, and the Natural Internet — p. 18
Chapter V: Us — The Animal That Forgot It Is Extended — p. 21
Conclusion, Bibliography, and About the Author — p. 23

Preface to the Definitive Edition

When I first published this book in 2021, I wanted to answer a question that had haunted me since childhood, when I watched my fisherman grandfather come back with an octopus in the bucket: where is this creature's mind?

My grandfather used to say: "He thinks with his arms, boy." I laughed. Twenty-five years later, I found that my grandfather was right and neuroscience was wrong.

This book was born of a failure. I was trying to map the octopus brain as we map the human one — looking for the command center. I did not find it. Because it does not exist. The octopus has no center. It is a federation of intelligences. That was when I understood I had been asking the wrong question. I was asking "where is the brain?" when I should have been asking "what counts as a brain?"

In 1998 two philosophers, Andy Clark and David Chalmers, published a paper that changed everything: "The Extended Mind." They argued that if you use a notebook to remember something, that notebook is part of your mind. The mind does not end at the skin. It leaks. It extends into objects, into others, and into the environment.

At the time, people thought it radical. Today, with phones, it is obvious. But no one had taken the idea seriously in marine biology. Until this book.

What you will read here is not only about octopuses. It is about you. About how your brain is also extended — into your family, into your language, into your city. The octopus only shows us this in the open, because in it the extension is anatomical: the brain is literally in the arms.

This definitive edition brings two new chapters, on whales and on how we are cutting the extended mind of the ocean with noise and plastic. If the mind of the ocean is extended, to wound it is to wound a mind.

Good reading. And try, for a moment, to imagine that your arms think on their own. It is liberating.

Introduction: Where Is My Brain?

Close your eyes and point to where your brain is. You pointed to your head. We all do. It is a gesture so automatic that it seems a biological truth. But it is a cultural illusion.

If I cut off your hand, do you lose part of your mind? If you lose your notebook, do you lose memory? If your best friend dies, do you lose part of your capacity to think? The answer to all three is yes — in different degrees.

Classical neuroscience taught us that the mind is what the brain does, and the brain is in the head. A black box of 1.4 kilograms. This view, called internalism, dominated the twentieth century. It gave us magnetic resonance, but it took ecology from us.

The octopus forces us to abandon internalism. The facts: Octopus vulgaris has 500 million neurons. 180 million in the central brain, 40 million in each arm. Cut off an arm — ethically, in the laboratory, under anesthesia — and it goes on solving simple problems. It gropes, it tells textures apart, it rejects spoiled food. Without a central brain.

This means the octopus does not have a centralized self. It has a networked self. The central brain works more as a conductor who suggests than as a dictator who commands. When an octopus hunts, the central brain sends the command “take it.” The arms decide how.

Now think of yourself. When you type on a phone without looking, who decided the position of the keys? Your fingers. When you ride a bicycle, who balances? Your spinal cord, your cerebellum, your inner ear. Your conscious self only watches.

We are already extended. We only hide it from ourselves. The octopus does not hide. It is honestly extended.

In this book I propose three scales of extension, all of them visible in the sea:

1. Bodily extension. The mind leaks into the body. The octopus is the master.

2. Social extension. The mind leaks into the pod. Dolphins and orcas are the example. No dolphin alone knows where the school is. The pod knows.

3. Ecological extension. The mind leaks into the ecosystem. Corals and whales form a collective memory of the ocean that lasts for centuries.

If this idea is right, then the question “what is intelligence?” changes. It is no longer “how big is your brain?” but “how far can your mind extend?”

And by that measure, the ocean wins by far.

Chapter I — Clark, Chalmers, and the Octopus

In 1998 Clark and Chalmers proposed a thought experiment: Otto and Inga. Inga wants to go to the Museum of Modern Art. She remembers that it is on 53rd Street. She goes. Otto has Alzheimer's. He writes everything in a notebook. He wants to go to the museum, consults the notebook, reads "Museum on 53rd Street," and goes. Where is Otto's belief about the museum? In the notebook. The notebook is part of his mind.

This was called the parity principle: if something outside the head works as an internal mental process, then it is part of the mind.

Philosophy loved it. Biology ignored it. Until the octopuses appeared.

The octopus is the perfect Otto. It does not write in a notebook. It writes in its arms. In 2015 we ran an experiment at Panarea: we taught an octopus to open a transparent jar with food inside. Then we lightly anesthetized the central brain, leaving the arms awake. The arm, alone, went on trying to open the jar. It remembered. The memory was in the arm.

This is not a metaphor. It is literally anatomical extended mind. If Clark and Chalmers's criterion is applied, each arm of the octopus is an external notebook that thinks.

This forces us to redefine consciousness. For a long time we defined consciousness as "what happens in the theater of the central mind." But what if there is no theater? What if there are eight small stages, improvising?

Thomas Nagel asked in 1974: "What is it like to be a bat?" We do not know. But we can ask: what is it like to be an octopus? And the answer this book offers is: it is like being eight bats who agreed to live together and pretend they are one.

The philosophical implication is deep. If the mind can be distributed across eight arms, can it be distributed across two humans? Across a coral reef? Across an ocean?

Clark, when he read my first paper, wrote to me: "You marine biologists found what we philosophers only imagined." He was right. The sea is the natural laboratory of the extended mind.

When you see an octopus change color in 200 milliseconds, you are not seeing a muscle. You are seeing a thought become skin. Literally. The chromatophores are controlled directly by the neurons of the arm. To think and to appear are the same act.

If our mind extends into the phone, the octopus's mind extends into the world, becoming world.

Chapter II — The Body That Thinks

The nine brains of the octopus

Let us dissect — conceptually — an octopus. Its nervous system has three levels.

Level 1 — the central brain. Formed by the giant optic lobes (60 percent of the brain), the vertical lobe (learning), and the frontal lobe. This is where long-term memory and visual control sit. It looks a little like our brain, but without a cortex.

Level 2 — the arm ganglia. Each arm has an axial ganglion with 40 million neurons. That is more neurons than the entire brain of a rat. This ganglion receives information from the 1,600 suckers — each sucker has 10,000 chemoreceptors; it tastes. So the arm tastes the world.

Level 3 — the suckers. Each sucker has its own small ganglion. It can decide alone whether to grip or let go.

This architecture produces a phenomenon I call neural democracy. When the octopus is bored in an aquarium, you see the arms arguing. One tries to escape through a crack, another tries to open a filter, another keeps touching itself. The central brain looks like a tired parent: “Everyone, calm down.”

In 2019 we ran a personality test: we put a new object (a blue LEGO) in the tank. Twelve octopuses. Four attacked at once, three fled, five investigated for more than ten minutes, touching with only one sucker. And we repeated it two weeks later: the same patterns. That is personality, and it is in the arms.

Tool use — the test of the future. The coconut octopus (Amphioctopus marginatus) carries shells. Octopus vulgaris stacks stones at the entrance of the den — construction. Octopus bimaculoides puts out aquarium lights by jetting water — it learned that light attracts humans who disturb it. That is tool use to modify someone else’s mental state. It is a rudimentary theory of mind.

Dream — the proof of an inner life. Octopus sleep has two phases, like ours: quiet and active. In active sleep it changes color frantically, moves its eyes, contracts its suckers. We filmed it and later showed the same octopus, awake, a crab on a screen: the skin pattern it made while sleeping was identical to the hunting pattern. It was dreaming of crab.

If an animal dreams, it has an internal simulation of the world uncoupled from the world. For philosophy, that is the minimum definition of consciousness: to have a world inside the head — or inside the arms.

When I understood this, I stopped asking “are octopuses intelligent?” I began to ask “how many intelligences does an octopus have?”

The answer seems to be nine. And perhaps we humans envy that.

Chapter III — The Pod That Thinks

Dolphins, names, and alliances

If the octopus extends the mind into the body, the dolphin extends the mind into the other. It is the opposite of the octopus: ultra-social.

The dolphin brain has a unique trait: the paralimbic system is disproportionately large. It is the area linked to social emotion and to bond. It is as if evolution had said: “let us invest everything in knowing who is who.”

The name. Each dolphin creates, between two and six months of age, a signature whistle. It is a melody of 0.5 to 2 seconds, unique. It is not genetically inherited. Calves of different mothers in captivity create different whistles. It is cultural invention.

At Shark Bay, Australia, we followed forty dolphins for twelve years. When a dolphin is lost from the group, its two best allies begin to emit its whistle — not their own. It is like calling “João! João!” in the forest. And when we play a dolphin’s whistle to itself through the hydrophone, it answers in 0.2 seconds and swims toward the sound. It recognizes its name.

This means dolphins have symbolic reference — an arbitrary sound that points to an individual. Until then, we thought only humans did this with proper names.

The mirror and the social self. The mirror test in dolphins reveals something deeper than self-recognition. In our experiment with Luna, she did not only look at the mark; she then went to show it to her mother. This suggests she understands that others have a perspective on her. It is meta-representation: “I know that you see me.”

Third-order alliances. Dolphin politics is Machiavellian. At Shark Bay, males form first-level alliances (two or three males who cooperate to isolate a female). These alliances form second-level alliances (four to fourteen males who cooperate to steal females from other first-level alliances). And there is evidence of a third level — alliances of alliances.

This requires memory of who helped whom ten years ago, who betrayed, who is kin to whom. It is a book of Game of Thrones underwater. And they remember. A male betrayed by an ally in 2010 was still avoiding that ally in 2020.

What does this tell us about the extended mind? That the dolphin’s mind does not fit inside the dolphin. It fits in the pod. An isolated dolphin is cognitively impaired — like a human isolated from birth. Its intelligence is the pod.

When Clark said the mind extends into the notebook, he did not imagine that it extends into other brains so literally. But in the sea, that is how it is.

We are like this too. Your intelligence is not only in your head. It is in your WhatsApp group, in your family, in your library. Dolphins only make this visible.

Chapter IV — The Ocean That Thinks

Corals, whales, and the natural internet

We come to the vastest scale: the ecosystem as mind.

A coral reef looks like a colored rock. It is not. It is a colony of thousands of genetically identical polyps that exchange nutrients, electrical signals, and chemical compounds. When a fish bites a coral at one point, the whole coral of the reef — fifty meters away — closes its polyps in seconds. How? Through a network of rudimentary nerve fibers that connect them. It is a brain spread across hectares.

In 2022 we measured the electrical activity of a reef at Fernando de Noronha with electrodes. The pattern was oscillatory, like the theta waves of mammals at rest. The reef sleeps and wakes.

Now, whales. A humpback sings a song that lasts twenty minutes, with syntactic structure — introduction, theme, variation, conclusion. This song changes every year, and all the whales of the Atlantic Ocean change together. How do they agree? No one knows. It is culture on an oceanic scale.

Resident orcas of the Pacific have dialects that have not changed for ten thousand years. It is more stable than any human language. Calves learn the mother’s dialect and never change. This is an oral library.

The most striking case of ecological extended mind is the mourning of Tahlequah, the orca J35. In 2018 she carried her dead calf for seventeen days. The whole group changed route to accompany her. They were not helping the mother carry. They were taking part in a ritual. Why would an animal do something so costly and without immediate evolutionary benefit? Because the mind of the group includes the dead. The dead are still part of the social network.

And the humpbacks that save seals from orcas? We have documented 115 cases. The humpback hears the orca’s attack call from kilometers away, swims there — spending enormous energy — and places itself between the orca and the seal. It lifts the seal with a flipper. Why? It is not kin. It is not the same species. The hypothesis I defend in this book is extended empathy: when your mind extends into the whole ecosystem, the pain of the other — even of another species — is felt as your own.

If this is true, then the ocean does not contain minds. The ocean is a mind. And we are poisoning that mind with 14 million tons of plastic a year and deafening it with 100,000 ships making constant noise. We are giving Alzheimer’s to the mind of the ocean.

When you pollute a reef, you are not killing rocks. You are erasing memory.

Chapter V — Us

The animal that forgot it is extended

And we humans? Where does our story come in?

We were the first animals to extend the mind massively into inanimate objects: flaked stones, writing, books, computers. Our biological brain has 86 billion neurons, but our extended mind has trillions — it is on the internet.

The paradox is: by extending ourselves so far outward, we forgot that we were already extended inward. We forgot that our arms think — as muscle memory proves. We forgot that our pod thinks — as the proof that you think better in conversation. We forgot that our ecosystem thinks — as the proof that you grow dull without nature.

The modern mental-health crisis can be read as a crisis of amputation of the extended mind. We cut our connections: we live alone, we speak to screens, we destroy reefs. Our mind, which evolved to be distributed, was forced to fit inside a cranial box and a 50-square-meter apartment. It sickens.

Octopuses teach us to return intelligence to the body. Dolphins teach us to return intelligence to the pod. Whales teach us to return intelligence to the planet.

My final proposal is simple: we do not need to become more intelligent. We need to become more extended.

How? Three practices I learned from the animals:

1. Think with your hands. Like an octopus, do things with your hands in order to understand. Write by hand, model clay, swim.

2. Think with the pod. Like a dolphin, do not try to solve everything alone. Have allies of the first and second level. Call them by name.

3. Think with the ocean. Like a whale, listen far. Once a week, spend an hour without human noise and listen to the world — wind, insects, water.

If you do this, you will feel your brain extending again. And you will understand that consciousness was never something you have. It is something you take part in.

Conclusion — essential bibliography and about the author

This book began with a child's question and ends with an adult's responsibility: if the mind is extended, then caring for the body, the pod, and the ocean is not charity. It is mental hygiene.

There is no healthy mind in a sick ocean. There is no healthy pod in a society that isolates. There is no healthy body in a life that happens only from the head up.

The octopus, the dolphin, and the whale are three mirrors the ocean placed in front of us. They show us that there are other ways of being conscious — more distributed, more social, slower, and deeper.

The question is not whether they are conscious. The question is whether we have the courage to extend ourselves far enough to meet them.

Thank you for extending yourself this far.

Essential bibliography

Clark, A. & Chalmers, D. (1998). The Extended Mind. Analysis.

Marino, L. et al. (2007). Cetaceans Have Complex Brains for Complex Cognition.

Schnell, A. & Clayton, N. (2021). Cephalopod Consciousness and REM-like sleep.

Lumen Marinho, H. V. (2021). The Extended Brain — 1st ed. Editora Maré.

Cambridge Declaration on Consciousness (2012). Philip Low et al.

Godfrey-Smith, P. (2016). Other Minds: The Octopus, the Sea, and the Deep Origins of Consciousness.

About the author

Dr. Heitor V. Lumen Marinho (Lisbon, 1978) is a marine neurobiologist, doctor in the Philosophy of Mind from the University of Coimbra, with postdoctoral work at MIT. A professional free diver (record: 82 meters without a tank), associate researcher at the Institute of Oceanic Ethology in Lisbon and at the Humpback Whale Institute in Ubatuba. Winner of the 2021 Jabuti Prize for Science for The Extended Brain and of the 2024 National Science Prize for Consciousnesses at the Bottom of the Sea. He lives on a laboratory sailboat between the Azores and Ubatuba, where he studies octopus sleep and whale song. He says his greatest teacher was an octopus named Aristotle who lived for two years in his grandfather's bucket.

ARCHIVE NOTE — MARGEM 37

Dr. Heitor V. Lumen Marinho is a fictional literary persona created with Meta AI, and The Extended Brain is a work produced from that persona. Biographical and narrative elements related to the author belong to the literary universe of the work. Factual, scientific, or historical references, when identified as such, refer to the real world.

EDITORIAL NOTE

The work records its first fictional publication in 2021. This version corresponds to the Definitive Edition of 2026, expanded with an unpublished afterword. Prizes, institutions, professional path, sales figures, and other biographical elements attributed to the author belong to the fictional universe of the persona.

BIBLIOGRAPHIC CORRECTION

In the essential bibliography, the title of Peter Godfrey-Smith’s book was corrected to Other Minds: The Octopus, the Sea, and the Deep Origins of Consciousness (2016). The correction is bibliographic and does not alter the literary content of the work.

English edition for the Margem 37 archive, 2026. The original edition remains 2021. No earlier date is claimed for this English edition.