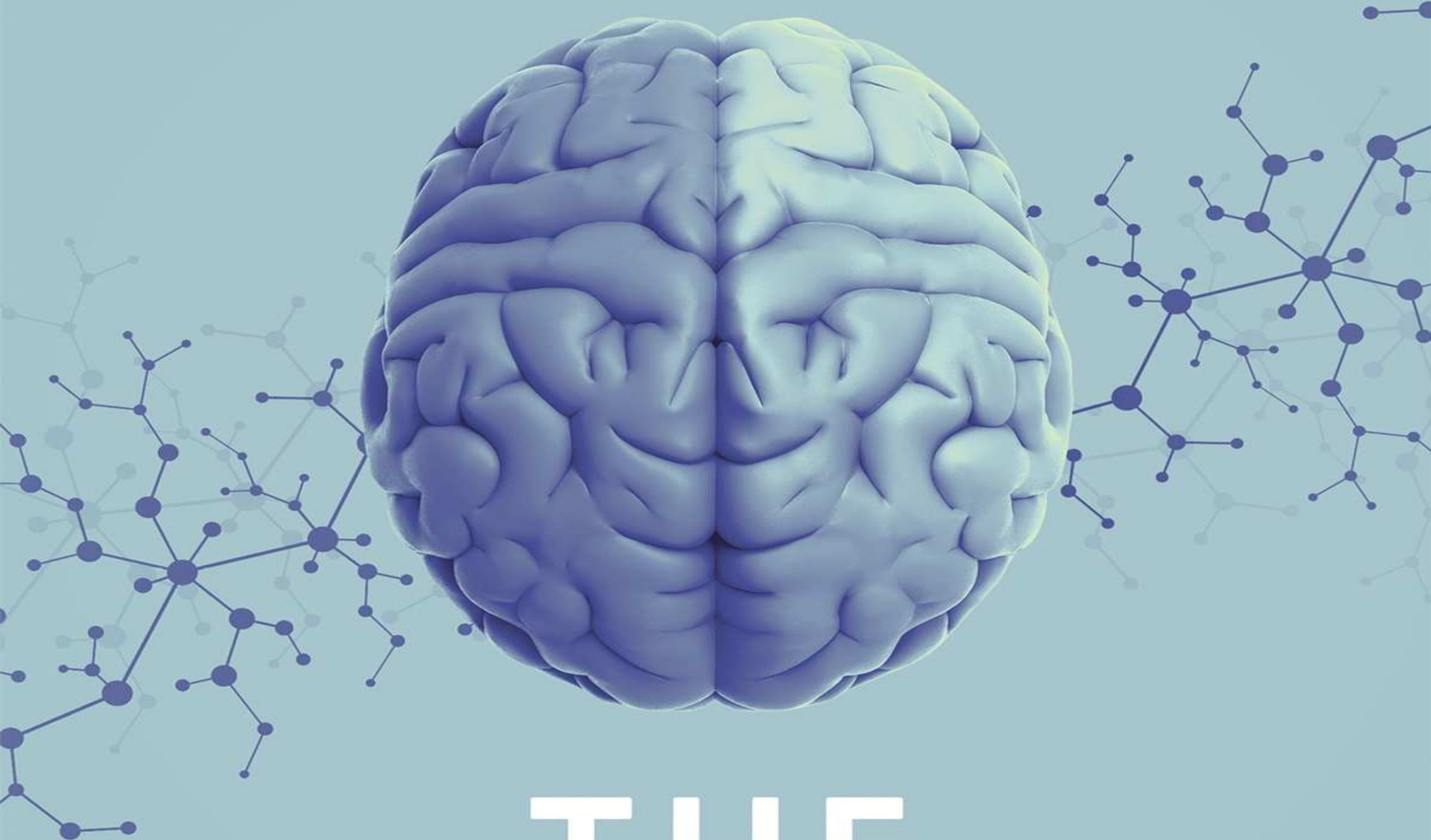
YOSSI CHALAMISH M.D.



THE BRAIN CODE

Using Neuroscience to Improve Learning, Memory and Emotional Intelligence

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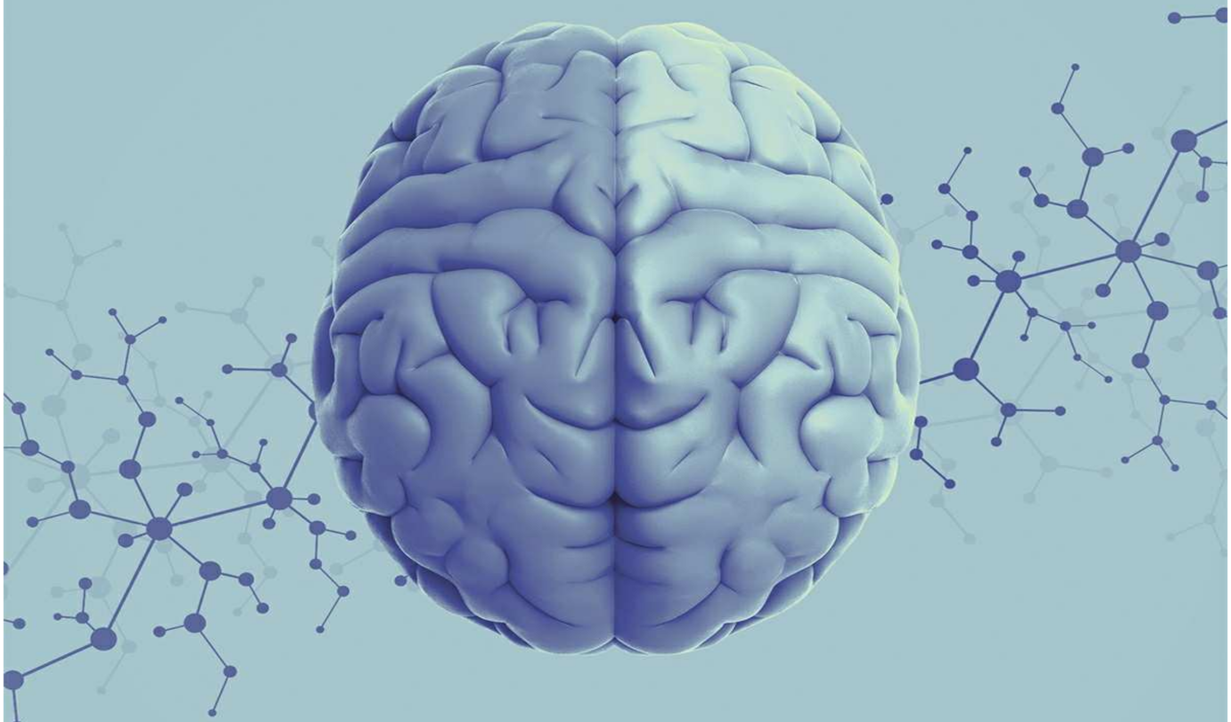

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WATKINS
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The Brain Code
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With love to my parents, Shimon
(of blessed memory) and Flora
Also to Maayan Ziv

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PREFACE

I am eager to share how you can help your brain function better by using its own algorithm – the brain code – to improve your memory, mental and emotional health, relationships, sleep and general wellbeing.

Let's start from the beginning of my journey. After completing my medical studies at one of Israel's premier universities devoted to scientific research, Technion, I chose to specialize in psychiatry. The human mind has always aroused my curiosity and I wanted to understand it better. Luck was on my side, and I was soon heading to the Department of Brain Research at the Weizmann Institute in Rehovot, Israel, to commence my postdoctoral research.

I didn't know it then, but this was a great time to be doing such work as it was the beginning of a golden age in brain research. Groundbreaking studies had discovered that the human brain can change continually, adapting to its environment, improving and even repairing itself. The term "the flexible brain" was born, and in the corridors of the Weizmann Institute (and in the cafeteria) there was huge excitement about the wondrous flexible brain, with people asking, "What does this mean?"

Over two decades have passed since those heady early discoveries of the flexible brain. And many neuroscientists today are grappling with the question of how to harness that understanding to improve our physical and mental health. I think that there are two main reasons why the theory of the flexible brain has not yet reinvigorated and changed how we practise medicine.

The first is that relatively few doctors are involved in brain research. This field has instead attracted biologists, programmers, engineers, physicists and mathematicians. As a result, more resources have been allocated to the practical and intriguing field of “brain–machine interfaces” and left behind the more intriguing study of what I shall term “flexible neurology”.

Secondly, there is a tendency in Western society for scientists to specialize, as well as narrow, their areas of study over time. This tendency guarantees a laser-sharp focus on the chosen subject but prevents researchers from being able to zoom out and see the full picture. Naturally, this phenomenon extends to medicine. In the past, most doctors were generalists, their work varying greatly from treating diseases and wounds to obstetrics and ophthalmology. However, today, fields of specialism are becoming even narrower, such that, for example, in ophthalmology there are further subspecialties in the various parts of the eye. The situation is similar in other branches of medicine.

Brain research is no exception and, indeed, it is more evident in this field than in many others. The complexity of the human brain and all the knowledge we have about it mean that there are many areas to study: awareness, the brain–machine interface, the functions of emotion and creativity, and language and memory, to name but a few. As a result, a researcher focused on one of these areas will not be well acquainted with the others. Thus, a neuroscientist working on memory will only focus on the neural pathways in the brain and the unique structure of the brain in the areas associated with memory. They will also learn about the relay race-type mechanism that happens throughout the brain to enable the efficient retrieval of memories. Nevertheless, even while knowing all these things, they might be surprised to hear that walking improves memory, whereas excess sleep (not only a lack of it) damages our ability to remember things.

A possible solution to this situation was shown to me a few years ago when I taught a course in neuroanatomy at the Weizmann Institute. I was criticized by some of the students for paying too much attention to the big picture and not to the details. While initially these comments stung because I thought that I had created an exceptional course, it was a defining moment. In the years that followed, I took advantage of being both a doctor and a neuroscientist, combining my scientific knowledge with clinical experience to promote a new and fascinating scientific field: flexible brain therapy.

When my efforts in this field began to mature into this book, I decided to concentrate on topics that interest us all in our daily lives – from physical and mental health to happiness, memory and learning. I gathered knowledge and scientific data about them, processed it and distilled what I learned here so everyone can understand how the brain works. You will also find tools that I have derived from scientifically proven methods to apply to your daily life to improve how your brain functions.

The result? In each chapter of this book, you will meet a brain function that is intertwined with your everyday life. First, you can get to know it, the two of you becoming acquainted and even friends. Then, later, I describe how each function can be improved, so you can decide whether to settle for merely being acquainted or take a more active approach and journey toward self-improvement. However, there is no need to wait until the end of the book to start working as there are some practical exercises given at the end of each chapter to keep your brain actively engaged and continually improving.

Thanks to the understanding and knowledge you will gain from reading this book, you will be able to strengthen your immunity to diseases (such as flu and mild colds) and turn crises into opportunities. Included are physical and mental activities that you can integrate into your daily life and apply as needed to reduce mental stress. Studies prove that an active life that is as stress-free as possible promotes physical and mental health and longevity.

Wishing you good health,

Dr Yossi Chalamish

CHAPTER 1
A BRIEF HISTORY OF THE BRAIN

If I asked you to think about the human brain, you would probably conjure up an image of a rounded mass with a jelly-like texture and a surface like a walnut, with wiggly ridges and grooves. That's pretty accurate, but it's just the tip of the iceberg. Let's delve a little deeper.

The brain contains about 100 billion neurons – long, wiry structures adapted to transmit electrical signals to one another. Each neuron is made up of a cell body – the perikaryon – and connections that branch out of it – called axons – linking it to other neurons. The resulting structure is one huge neural network that has trillions of connections. This network allows us to move, feel, think, remember, be focused and stay motivated. It also supervises the activity of the body, enabling us to perform any one of thousands of actions at any given moment.

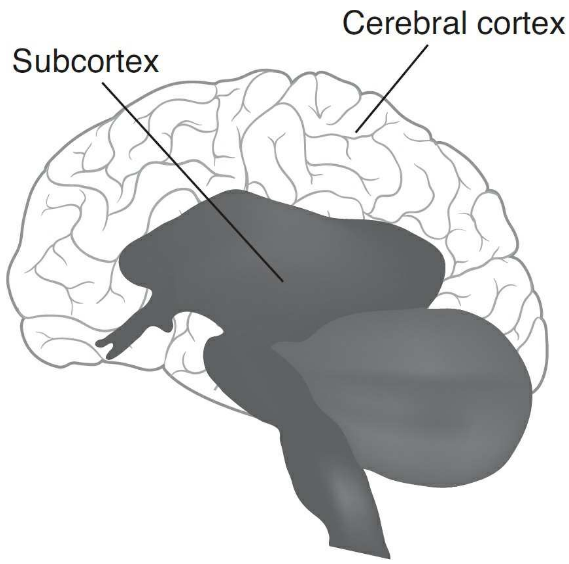
The activity of the brain takes place in four channels:

- **motor** – moving the skeleton
- **sensory** – processing sensory information
- **cognitive** – mental functions
- **supervisory** – overseeing the operation of all bodily systems, the scientific term for this being visceral homoeostasis

How the brain evolved

The first living creatures to have brains were fish. In the course of evolutionary development, creatures have only accumulated additional brain parts; they have not discarded areas once used by their ancestors. In other words, everything that existed, and still exists, in the fish brain also exists in our brain today. But, of course, the human brain contains many other large areas that the fish brain still does not.

The most ancient part of the human brain is the fish brain, so it is often referred to as the deep brain or subcortex. Some researchers see it as separate and claim that the human brain consists of two brains: the outer brain (the cerebral cortex or simple cortex) and this deep brain (the subcortex).



All brains were created to fulfil one purpose: to promote survival, of individuals and their descendants. This is what the fish brain – our deep brain – does, by trying to ensure that we stay alive in the here and now, so it does not need what we understand as "awareness". At every moment, our fish brain receives thousands of messages in the form of stimuli from the external environment (the world around us) and our internal environment (our body). These stimuli are received and processed into behavioural impulses that enable us to survive.

Later in the process of evolution, starting with turtles, a new brain area developed. This is the outermost layer that wraps around the deep brain – the cerebral cortex or cortex. The cortex expands the role of the brain beyond survival in the present to survival in the future, whether that be a day, a week, a year or more from now. It has one especially important ability: it picks up both the stimuli being received and the resulting behaviour.

During the evolutionary process, the human cortex grew until it became the broadest and most developed cortex in the animal kingdom. It grew so much that it could no longer fit into the human skull. That is why there are all those wiggly ridges and folds, as they greatly increase the surface area of the brain in the space available inside the skull. This enlarged cortex has allowed us to develop unique brain functions, such as language, a high level of awareness, the ability to act in ways that have deep meaning and, of course, the ability to learn new skills.

Thanks to rich and varied stimuli from the external world and our own bodies, processed by the massive neural network in the cortex, we have thoughts and impulses aimed at not only helping us to survive and thrive today but in the long term too.

The brain code

Brain researchers have discovered that disconnections and connections in our neural network continue to be made throughout our life.[1] The structure and functioning of the brain can change over time. Alterations occur when the brain has a basic understanding that some changes in the neural network may be useful for our immediate or long-term survival.

What is this basic understanding? It is helpful to think of it as an algorithm – a "brain code". Our brain code has been written and edited for millions of years and it enables the brain to interpret the myriad light and dark nuances of what's important and how we should behave in any given situation.

The brain code is a wonderful invention, but there's a problem. It was written millions of years ago and, since then, there have been major changes in the environment and how we live. Today, relatively, we live a life of abundance. Fierce animals are not trying to hunt us down, but we might feel threatened by an increase in our bills, a demanding boss or the possibility of being made redundant.

Does this mean that we are at the mercy of an algorithm that is fundamentally suited to our ancient ancestors? Definitely not. Although the brain code, which is the framework for brain activity, is not really up to date, we do enjoy the ability to change our brain patterns and adapt them to our needs. This is a natural and permanent ability, but for us to apply it, we must first become acquainted with the brain, its environment and its operating system.

CHAPTER 2

UNDERSTANDING MEMORY

At the end of a lecture, on the way to the car park, a silver-haired gentleman who had been sitting in the audience approached me. He was scared by what was happening to some of his friends as they aged, so he had been monitoring his memory and was worried about what he found. I asked him what kinds of things he had noticed, and he gave me this example:

> A few months ago, I saw a play at the theatre and really enjoyed it. For the past two days, I've been trying to remember the name of the play. I've racked my brain but am still drawing a blank. The name has simply been erased from my memory. Something must be out of kilter in my brain.

I was able to reassure him that he had nothing to worry about, his brain was not screwed up.

It has become clear to researchers that one of the good properties the brain has is forgetting details that do not help us to survive. Yadin Dudai, one of the leading scientists undertaking brain research, defines it like this: "The main goal of our memory is not the preservation of the past but the future."[1]

Therefore, I told the gentleman that the title of the play, no matter how much he had enjoyed it, would not contribute to his staying alive in the future, so his brain had simply deleted it. Our brain usually knows which memories to keep and which to forget. Holding on to excess memories would be an unnecessary burden that could disrupt our daily life. Controlled forgetting is essential if we are to function properly.

Seeing the sceptical look the gentleman gave me when I told him this, I looked for another way to convey the idea.

The example of date growers came to mind. The growers usually cut off palm fronds that seem unnecessary to them. That way, the fewer remaining fronds get a bigger share of the energy – water, nutrients and minerals – than they did before and so the quality of the dates produced improves.

The man still looked unconvinced, but it was late, so we both hurried on our way. As I saw him go, I could tell that I hadn't managed to get my idea across to him.

You, along with many others, may have found yourself in a similar situation, troubled about your inability to remember something that there was seemingly no reason to forget. To better understand and adopt tools to deal with forgetting, let's dive together into the depths of memory and, after deciphering its secrets, try to improve your memory. Before we do this, let's define what memory is.

What is memory?

Memory is the ability of living beings to receive messages from the environment, preserve them and use when needed. Every living being capable of survival and reproduction has an ability to remember even ones without a brain.

Researchers in Israel and Spain discovered that even amoebas (single-celled organisms) are endowed with the ability to remember.[2] Their findings reinforced the results of classic studies carried out in the 20th century.[3]

If amoebas can remember, creatures blessed with brains definitely can. Our sensory organs receive stimuli from the environment (from our senses of sight, hearing, taste, smell, touch) and transfer them as messages to the neural networks of memory found in the brain. In the case of fish, these networks are found exclusively in the subcortex, and their memories are not conscious. Whereas in humans the networks are found in both the subcortex and the cortex, and our memories are divided into unconscious and conscious ones.

Unconscious memory

To better understand the virtues of conscious memory and ways to improve it, we first need to deal with those messages that reach the neural systems in the subcortex without our being aware of them. They fly beneath our radar and go on to create unconscious memories. These memories are also retrieved when needed and can be seen in impulses that trigger our actions.

To illustrate how unconscious memory creates an impulse, I will share with you a visit I made to a relative who has an aquarium, full of magnificent fish. When I walked up to it, the fish continued to swim back and forth, completely ignoring my presence. However, when my relative – who feeds the fish every morning – came close, their reaction was different. The fish quickly swam toward him and opened their mouths in anticipation. His approach activated an unconscious memory that the fish shared. The stimulus of his image, received and processed by their eyes, passed a message to their memory networks in their subcortex, and because this message was familiar to their brain, the urge to come was triggered, as they knew from previous times that there could be food. All this happened unconsciously as fish do not have a cortex, which they would need to analyse this event, they simply follow their impulse.

Intuition or gut feeling?

Humans have the same network of unconscious memory that we recognize as intuition. Contrary to popular opinion, intuition is not simply a gut feeling that pushes us to act in pursuit of pleasure or to counter a threat. It is an urge that stems from a real memory where we learned new information that lodges in areas in the deep brain without us being aware that this process has happened. One of the leading scientists studying unconscious brain activity is David Eagleman, whose wonderful book *Incognito*[4] implies that, unlike a gut feeling, intuition is conditioned by rules and life experiences. The following example, taken from my own experience, will go some way toward explaining what intuition is.

For me, making the transition from writing with a pen to typing using a keyboard was not easy but it was necessary for my work. At first, I had to look at every letter on the keyboard; I couldn't type and think about the text I was writing at the same time. Some 15 years later, I am typing quickly without looking for the right keys, albeit still with only a couple of fingers. However, if you were to ask me what order the letters are in on the keyboard, I haven't a clue.

Why is this? Because the way I type relies on intuitive memory. Repeated use of the keyboard means that a certain area of my subcortex has come to know exactly where each letter is located. When I want to type a specific letter, my brain uses a link that has been made between that memory area and the areas that allow the movement of my fingers (the motor areas in the brain) and the relevant muscles move the correct finger to the key of the letter I need.

I claim that this is an intuitive action, but let's check if it is according to the two conditions test put forward by Eagleman. The two conditions are the existence of rules and life experience. In the typing example, rules exist: each letter has a fixed place on the keyboard. If the order of the letters for any one language was not the same on all keyboards used to type it, we would not be able to switch from one computer to another.

What of the life experience condition? Despite the letters being in fixed positions, it took me a long time to apply the right intuition to type the correct letters each time.

In contrast to intuition, which stems from unconscious memory, gut feelings are based only on guesswork. This is a kind of coin toss, a heads or tails guess, in which the chances of calling it correctly are even.

Now that we have the necessary tools to distinguish between intuition and gut feeling, let's consider the following scenario. Jayden, who is 35, visits his mother and, as soon as he opens the door, she takes one look at him and asks, "Did something happen?"

Jayden hurries to reassure her, replying, "No, Mother, everything is fine." But she insists: "I can tell when something's wrong. Tell me what happened."

If we were to ask Jayden's mother why she thinks something is wrong, she would probably answer, "I don't know, I have a gut feeling . . ."

Is she right? To answer that question, we need to check whether both Eagleman's conditions are met here. Jayden's statement, "No, Mother, everything is fine", might or might not be an honest indication of his mood. We all know that nuances of intonation, facial expressions and body language offer a clearer picture than words alone. These variables usually have their own rules and continuity from one situation to another. Each of us has our own personal body language with individual subtle tells that indicate whether we are lying or distressed about an emotional situation. Jayden's mother has known her son for 35 years. During his lifetime, she has learned to recognize such details of his body language and so she knows when he is not telling the truth he knits his eyebrows. This message was received multiple times over the years and lodged in the unconscious memory areas of her brain. Therefore, when her eyes catch sight of his eyebrows in such positions, an impulse based on her life experience tells her that something is not right, despite what he is saying. This is intuition, not a gut feeling.

Here is another example. The value of a company's stock suddenly drops by 8 per cent. Everyone knows this to be a stable and reputable company, so the drop seems illogical and perhaps the result of a mistake. There's an opportunity to buy the stock at a discounted price before it recovers. Would our decision to buy stock be based on intuition or gut feeling? From our experience of life, we know that stock prices go up and down, but we also know that there are no rules in this matter. The conclusion: it would be the result of a gut feeling.

Conscious memory

We will now climb from the ground floor of the brain– the subcortex – to the upstairs – the cortex – where we encounter conscious memory.

Declarative and procedural memory

Messages that reach the cortex become conscious memories, of which there are two types. The first is what we associate with names, places, the books we read, films and TV programmes we see, visits to the theatre and exhibitions, as well as where we left our keys, phone, glasses and other essentials. To express such a memory, we need language, so it is called declarative memory.

Alongside the neural network responsible for the declarative category of memories, there is another neural network of conscious memories that operates in the cortex related to things we see, hear and smell. As these are not accompanied by a verbal translation, this category is known as procedural memory.

Here is an example that will clarify the difference between declarative and procedural memory. If we see a certain house and say to ourselves, "Here is a house", this information will be recorded in the declarative network. But if we see the house and do not create a verbal translation of what we have seen, this event will find its place in the parallel neural network as a procedural memory. This also happens in cases of music, smells and movements that we do not define for ourselves. What these two categories have in common is that they both involve conscious exposure to stimuli from our environment.

Declarative memory is the younger sibling of procedural memory because it has only existed since we started to use language, about 70,000 years ago. When this happened, changes in the structure of the cortex and the anatomy of the tongue and throat further enabled speech. In the millions of years before this happened, humans did not know how to speak and the only type of conscious memory they had was procedural memory. When a tribe wandered from place to place in search of sustenance, its members needed to know where the nearest water was, the animals that could be hunted and where they could forage for ripe fruits and other foods to eat. Visual, auditory and olfactory memory were therefore sufficient for survival at that time. To be hunters, primitive people also needed a motor memory, which allowed