The Secret Life of the Mind

How Your Brain Thinks, Feels, and Decides

Mariano Sigman

Copyrighted material

CONTENTS

Copyrighted material

Copyrighted material

Copyrighted material

Copyrighted material

Copyrighted material

To Milo and Noah

Copyrighted material

INTRODUCTION

I like to think of science as a ship that takes us to unknown places, the remotest parts of the universe, into the inner workings of light and the tiniest molecules of life. This ship has instruments, telescopes and microscopes, which make visible what was once invisible. But science is also the route itself, the binnacle, the chart leading us towards the unknown.

My voyage over the last twenty years, between New York, Paris and Buenos Aires, has been into the innermost parts of the human brain, an organ composed of countless neurons that codify perception, reason, emotions, dreams and language.

The goal of this book is to discover our mind in order to understand ourselves more deeply, even in the tiniest recesses that make up who we are. We will look at how we form ideas during our first days of life, how we give shape to our fundamental decisions, how we dream and how we imagine, why we feel certain emotions, how the brain transforms and how who we are changes along with it.

Throughout these pages we will see the brain from a distance. We will go where thought begins to take shape. And it is there where psychology meets neuroscience. This is the ocean in which many people of varied disciplines have sailed, including biologists, physicists, mathematicians, psychologists, anthropologists, linguists, philosophers, doctors. As well as chefs, magicians, musicians, chess masters, writers, artists. This book is a result of that amalgam.

The first chapter is a journey to the land of childhood. We will see that the brain is already prepared for language long before we begin to speak, that bilingualism helps us to think, and that early on we form notions of what is good and what is fair, and about cooperation and competition, that later affect how we relate to ourselves and others. This early intuitive thinking leaves lasting traces on the way we reason and decide.

In the second chapter we will explore what defines the blurry, fine line between what we are willing to do and what we aren't. Those

Copyrighted material

decisions that make us who we are. How do reason and feelings work together in social and emotional decisions? What makes us trust others and ourselves? We will discover that small differences in decision-making brain circuits can drastically change our way of deciding, from the simplest decisions to the most profound and sophisticated ones that define us as social beings.

The third and fourth chapters travel into the most mysterious aspect of thought and the human brain–consciousness–through an unprecedented meeting between Freud and the latest neuroscience. What is the unconscious and how does it control us? We will see that we can read and decipher thoughts by decoding patterns of brain activity, even in vegetative patients who have no other way to express themselves. And who is it that awakens when consciousness awakens? We will see the first sketches of how we can now record our dreams and visualize them within some sort of oneiric planetarium, and explore the fauna of different states of consciousness, like lucid dreams and thinking under the effects of marijuana or hallucinogenic drugs.

The last two chapters cover questions of how the brain learns in different circumstances, from everyday life to formal education. For example, is it true that learning a new language is much harder for an adult than for a child? We will take a journey into the history of learning, looking at effort and ability, the drastic transformation that takes place in the brain when we learn to read, and the brain's predisposition to change. This book outlines how all this knowledge can be used responsibly to improve the largest collective experiment in the history of humanity: school.

The Secret Life of the Mind is a summary of neuroscience from the perspective of my own experience. I look at neuroscience as a way to help us communicate with each other. From this perspective, neuroscience is another tool in humanity's ancestral search to express–sometimes rudimentarily–the shades, colours and nuances of what we feel and what we think in order to be comprehensible to others and, of course, to ourselves.

Copyrighted material

CHAPTER ONE

The origin of thought

How do babies think and communicate, and how can we understand them better?

Of all the places we travel throughout our lifetimes, the most extraordinary is certainly the land of childhood: a territory that, looked back on by the adult, becomes a simple, naive, colourful, dreamlike, playful and vulnerable space.

It's odd. We were all once citizens of that country, yet it is hard to remember and reconstruct it without dusting off photos in which, from a distance, we see ourselves in the third person, as if that child were someone else and not us in a different time.

How did we think and conceive of the world before learning the words to describe it? And, while we are at it, how did we discover those words without a dictionary to define them? How is it possible that before three years of age, in a period of utter immaturity in terms of formal reasoning, we were able to discover the ins and outs of grammar and syntax?

Here we will sketch out that journey, from the day we entered the world to the point where our language and thought resemble what we employ today as adults. The trajectory makes use of diverse vehicles, methods and tools. It intermingles reconstructions of thought from our gazes, gestures and words, along with the minute inspection of the brain that makes us who we are.

We will see that, from the day we are born, we are already able to form abstract, sophisticated representations. Although it sounds far-fetched, babies have notions of mathematics, language, morality, and even scientific and social reasoning. This creates a repertoire of innate

Copyrighted material

intuitions that structure what they will learn–what we all learned–in social, educational and family spaces, over the years of childhood.

We will also discover that cognitive development is not the mere acquisition of new abilities and knowledge. Quite the contrary, it often consists in undoing habits that impede children from demonstrating what they already know. On occasion, and despite it being a counterintuitive idea, the challenge facing children is not acquiring new concepts but rather learning to manage those they already possess.

I have observed that we, as adults, often draw babies poorly because we don't realize that their body proportions are completely different from ours. Their arms, for example, are barely the size of their heads. Our difficulty in seeing them as they are serves as a morphological metaphor for understanding what is most difficult to sense in the cognitive sphere: babies are not miniature adults.

In general, for simplicity and convenience, we speak of *children* in the third person, which erroneously assumes a distance, as if we were talking about something that is not us. Since this book's intention is to travel to the innermost recesses of our brain, this first excursion, to the child we once were, will be in the first person in order to delve into how we thought, felt and represented the world in those days we can no longer recall, simply because that part of our experience has been relegated to oblivion.

The genesis of concepts

In the late seventeenth century, an Irish philosopher, William Molyneux, suggested the following mental experiment to his friend John Locke:

> Suppose a man born blind, and now adult, and taught by his touch to distinguish between a cube and a sphere […] Suppose then the cube and the sphere placed on a table, and the blind man made to see: query, Whether by his sight, before he touched them, he could now distinguish and tell which is the globe, which the cube?

Could he? In the years that I have been asking this question I've found that the vast majority of people believe that the answer is no. That

Copyrighted material

the virgin visual experience needs to be linked to what is already known through touch. Which is to say, that a person would need to feel and see a sphere at the same time in order to discover that the gentle, smooth curve perceived by the fingertips corresponds to the image of the sphere.

Others, the minority, believe that the previous tactile experience creates a visual mould. And that, as a result, the blind man would be able to distinguish the sphere from the cube as soon as he could see.

John Locke, like most people, thought that a blind man would have to learn how to see. Only by seeing and touching an object at the same time would he discover that those sensations are related, requiring a translation exercise in which each sensory mode is a different language, and abstract thought is some sort of dictionary that links the *tactile words* with the *visualized words*.

For Locke and his empiricist followers, the brain of a newborn is a blank page, a *tabula rasa* ready to be written on. As such, experience goes about sculpting and transforming it, and concepts are born only when they acquire a name. Cognitive development begins on the surface with sensory experience, and, then, with the development of language, it acquires the nuances that explain the deeper and more sophisticated aspects of human thought: love, religion, morality, friendship and democracy.

Empiricism is based on a natural intuition. It is not surprising, then, that it has been so successful and that it dominated the philosophy of the mind from the seventeenth century to the time of the great Swiss psychologist Jean Piaget. However, reality is not always intuitive: the brain of a newborn is not a *tabula rasa*. Quite the contrary. We already come into the world as conceptualizing machines.

> The typical café discussion reasoning comes up hard against reality in a simple experiment carried out by a psychologist, Andrew Meltzoff, in which he tested a version of Molyneux's question in order to refute empirical intuition. Instead of using a sphere and a cube, he used two dummies: one smooth and rounded and the other more bumpy, with nubs. The method is simple. In complete darkness, babies had one of the two pacifiers in their mouths. Later, the pacifiers are placed on a table and the light is turned on. And the babies looked more at the pacifier they'd had in their mouths, showing that they recognize it.

Copyrighted material

The experiment is very simple and destroys a myth that had persisted over more than three hundred years. It shows that a newborn with only tactile experience–contact with the mouth, since at that age tactile exploration is primarily oral as opposed to manual–of an object has already conceived a representation of how it looks. This contrasts with what parents typically perceive: that newborn babies' gazes often seem to be lost in the distance and disconnected from reality. As we will see later, the mental life of children is actually much richer and more sophisticated than we can intuit based on their inability to communicate it.

Atrophied and persistent synaesthesias

Meltzoff's experiment gives–against all intuition–an affirmative response to Molyneux's question: newborn babies can recognize by sight two objects that they have only touched. Does the same thing happen with a blind adult who begins to see? The answer to this question only recently became possible once surgeries were able to reverse the thick cataracts that cause congenital blindness.

The first actual materialization of Molyneux's mental experiment was done by the Italian ophthalmologist Alberto Valvo. John Locke's prophecy was correct; for a congenitally blind person, gaining sight was nothing like the dream they had longed for. This was what one of the patients said after the surgery that allowed him to see:

> I had the feeling that I had started a new life, but there were moments when I felt depressed and disheartened, when I realized how difficult it was to *understand* the visual world. […] In fact, I see groups of lights and shadows around me […] like a mosaic of shifting sensations whose *meaning* I don't understand. […] At night, I like the darkness. I had to die as a blind person in order to be reborn as a seeing person.

This patient felt so challenged by suddenly gaining sight because while his eyes had been 'opened' by the surgery, he still had to learn to see. It was a big and tiresome effort to put together the new visual experience with the conceptual world he had built through his senses of

Copyrighted material

hearing and touch. Meltzoff proved that the human brain has the ability to establish spontaneous correspondences between sensory modalities. And Valvo showed that this ability atrophies when in disuse over the course of a blind life.

On the contrary, when we experience different sensory modalities, some correspondences between them consolidate spontaneously over time. To prove this, my friend and colleague Edward Hubbard, along with Vaidyanathan Ramachandran, created the two shapes that we see here. One is Kiki and the other is Bouba. The question is: which is which?

Almost everyone answers that the one on the left is Bouba and the one on the right is Kiki. It seems obvious, as if it couldn't be any other way. Yet there is something strange in that correspondence; it's like saying someone *looks like a Carlos*. The explanation for this is that when we pronounce the vowels /o/y/u/, our lips form a wide circle, which corresponds to the roundness of Bouba. And when saying the /k/, or /i/, the back part of the tongue rises and touches the palate in a very angular configuration. So the pointy shape naturally corresponds with the name Kiki.

These bridges often have a cultural basis, forged by language. For example, most of the world thinks that the past is behind us and the future is forward. But that is arbitrary. For example, the Aymara, a people from the Andean region of South America, conceive of the association between time and space differently. In Aymara, the word 'nayra' means past but also means in front, in view. And the word 'quipa', which means future, also indicates behind. Which is to say that in the Aymaran language the past is ahead and the future behind. We know that this reflects their way of thinking, because they also express that relationship with their bodies. The Aymara extend their arms backwards to refer to the future and forwards to allude to the past. While on the face of it this may seem strange, when they explain it, it seems so reasonable that we feel tempted to change our own way of envisioning it; they say that the past is the only thing we know–what our eyes see–and

Copyrighted material

therefore it is in front of us. The future is the unknown–what our eyes do not know–and thus it is at our backs. The Aymara walk backwards through their timeline. Thus, the uncertain, unknown future is behind and gradually comes into view as it becomes the past.

We designed an atypical experiment, with the linguist Marco Trevisan and the musician Bruno Mesz, in order to find out whether there is a natural correspondence between music and taste. The experiment brought together musicians, chefs and neuroscientists. The musicians were asked to improvise on the piano, based on the four canonical flavours: sweet, salty, sour and bitter. Of course, coming from different musical schools and styles (jazz, rock, classical, etc.) each one of them had their own distinctive interpretation. But within that wide variety we found that each taste inspired consistent patterns: the bitter corresponded with deep, continuous tones; the salty with notes that were far apart (*staccato*); the sour with very high-pitched, dissonant melodies; and the sweet with consonant, slow and gentle music. In this way we were able to *salt* ‘Isn’t She Lovely’ by Stevie Wonder and to make a *sour* version of *The White Album* by the Beatles.

The mirror between perception and action

Our representation of time is random and fickle. The phrase ‘Christmas is fast approaching’ is strange. Approaching from where? Does it come from the south, the north, the west? Actually, Christmas isn’t located anywhere. It is in time. This phrase, or the analogous one, ‘we’re getting close to the end of the year’, reveals something of how our minds organize our thoughts. We do it in our bodies. Which is why we talk of the *head* of government, of someone’s right-*hand* man, the *armpit* of the world and many other metaphors[*] that reflect how we organize thought in a template defined by our own bodies. And because of that, when we think of others’ actions, we do so by acting them out ourselves, speaking others’ words in our own voice, yawning someone else’s yawn and laughing someone else’s laugh. You can do a simple experiment at home to test out this mechanism. During a conversation, cross your arms. It’s very likely that the person you are speaking to will do the same. You can take it further with bolder gestures, like touching your head, or scratching yourself, or stretching. The probability that the other person will imitate you is high.

Copyrighted material

This mechanism depends on a cerebral system made up of *mirror neurons*. Each one of these neurons codifies specific gestures, like moving an arm or opening up a hand, but it does so whether or not the action is our own or someone else's. Just as the brain has a mechanism that spontaneously amalgamates information from different sensory modes, the mirror system allows–also spontaneously–our actions and others' actions to be brought together. Lifting your arm and watching someone else do it are very different processes, since one is done by you and the other is not. As such, one is visual and the other is motor. However, from a conceptual standpoint, they are quite similar. They both correspond to the same gesture in the abstract world.

And now after understanding how we adults merge sensory modalities in music, in shapes and sounds and in language, and how we bring together perception and action, we go back to the infant mind, specifically to ask whether the mirror system is learned or whether it is innate. Can newborns understand that their own actions correspond to the observation of another person's? Meltzoff also tested this out, to put an end to the empirical idea that considers the brain a *tabula rasa*.

Meltzoff proposed another experiment, in which he made three different types of face at a baby: sticking out his tongue, opening his mouth, and pursing his lips as if he were about to give the child a kiss. He observed that the baby tended to repeat each of his gestures. The imitation wasn't exact or synchronized; the mirror is not a perfect one. But, on average, it was much more likely that the baby would replicate the gesture he or she observed than make one of the other two. Which is to say that newborns are capable of associating observed actions with their own, although the imitation is not as precise as it will later become when language is introduced.

Meltzoff's two discoveries–the associations between our actions and those of others, and between varying sensory modalities–were published in 1977 and 1979. By 1980, the empirical dogma was almost completely dismantled. In order to deal it a final death blow, there was one last mystery to be solved: Piaget's mistake.[*]

Piaget's mistake!

One of the loveliest experiments done by the renowned Swiss

Copyrighted material

> psychologist Jean Piaget is the one called *A-not-B.* The first part goes like this: there are two napkins on a table, one on each side. A ten-month-old baby is shown an object, then it is covered with the first napkin (called 'A'). The baby finds it without difficulty or hesitation.

Behind this seemingly simple task is a cognitive feat known as object permanence: in order to find the object there must be a reasoning that goes beyond what is on the surface of the senses. The object did not disappear. It is merely hidden. A baby that is to be able to comprehend this must have a view of the world in which things do not cease to exist when we no longer see them. That, of course, is abstract.[*]

> The second part of the experiment begins in exactly the same way. The same ten-month-old baby is shown an object, which is then covered up by napkin 'A'. But then, and before the baby does anything, the person running the experiment moves the object to underneath the other napkin (called 'B'), making sure that the baby sees the switch. And here is where it gets weird: the baby lifts the napkin where it was first hidden, as if not having observed the switch just made in plain sight.

This error is ubiquitous. It happens in every culture, almost unfailingly, in babies about ten months of age. The experiment is striking and precise, and shows fundamental traits of our way of thinking. But Piaget's conclusion, that babies of this age still do not fully understand the abstract idea of object permanence, is erroneous.

When revisiting the experiment, decades later, the more plausible–and much more interesting–interpretation is that babies know the object has moved but cannot use that information. They have, as happens in a state of drunkenness, a very shaky control of their actions. More precisely, ten-month-old babies have not yet developed a system of inhibitory control, which is to say, the ability to prevent themselves doing something they had already planned to do. In fact, this example turns out to be the rule. We will see in the next section how certain aspects of thought that seem sophisticated and elaborated–morality or mathematics, for example–are already sketched from the day we are

Copyrighted material

born. On the other hand, others that seem much more rudimentary, like halting a decision, mature gradually and steadily. To understand how we came to know this, we need to take a closer look at the executive system, or the brain's 'control tower', which is formed by an extensive neural network distributed in the prefrontal cortex that matures slowly during childhood.

The executive system

The network in the frontal cortex that organizes the executive system defines us as social beings. Let's give a small example. When we grab a hot plate, the natural reflex would be to drop it immediately. But an adult, generally, will inhibit that reflex while quickly evaluating if there is a nearby place to set it down and avoid breaking the plate.

The executive system governs, controls and administers all these processes. It establishes plans, resolves conflicts, manages our attention focus, and inhibits some reflexes and habits. Therefore the ability to govern our actions depends on the reliability of the executive function system.[*] If it does not work properly, we drop the hot plate, burp at the table, and gamble away all our money at the roulette wheel.

The frontal cortex is very immature in the early months of life and it develops slowly, much more so than other brain regions. Because of this, babies can only express very rudimentary versions of the executive functions.

A psychologist and neuroscientist, Adele Diamond, carried out an exhaustive and meticulous study on physiological, neurochemical and executive function development during the first year of life. She found that there is a precise relationship between some aspects of the development of the frontal cortex and babies' ability to perform Piaget's *A-not-B* task.

What impedes a baby's ability to solve this apparently simple problem? Is it that babies cannot remember the different positions the object could be hidden in? Is it that they do not understand that the object has changed place? Or is it, as Piaget suggested, that the babies do not even fully understand that the object hasn't ceased to exist when it is hidden under a napkin? By manipulating all the variables in Piaget's experiment–the number of times that babies repeat the same action, the length of time they remember the position of the object, and the way they

Copyrighted material

expresses their knowledge–Diamond was able to demonstrate that the key factor impeding the solution of this task is babies' inability to inhibit the response they have already prepared. And with this, she laid the foundations of a paradigm shift: children don't always need to learn new concepts; sometimes they just need to learn how to express the ones they already know.

The secret in their eyes

So we know that ten-month-old babies cannot resist the temptation to extend their arms where they were planning to, even when they understand that the object they wish to reach has changed location. We also know that this has to do with a quite specific immaturity of the frontal cortex in the circuits and molecules that govern inhibitory control. But how do we know if babies indeed understand that the object is hidden in a new place?

The key is in their gaze. While babies extend their arms towards the wrong place, they stare at the right place. Their gazes and their hands point to different locations. Their gaze shows that they know where it is; their hand movement shows that they cannot inhibit the mistaken reflex. They are–we are–two-headed monsters. In this case, as in so many others, the difference between children and adults is not what they know but rather how they are able to act on the basis of that knowledge.

In fact, the most effective way of figuring out what children are thinking is usually by observing their gaze.[*] Going with the premise that babies look more at something that surprises them, a series of games can be set up in order to discover what they can distinguish and what they cannot, and this can give answers as to their mental representations. For example, that was how it was discovered that babies, a day after being born, already have a notion of numerosity, something that previously seemed impossible to determine.

> The experiment works like this. A baby is shown a series of images. Three ducks, three red squares, three blue circles, three triangles, three sticks… The only regularity in this sequence is an abstract, sophisticated element: they are all sets of three. Later the baby is shown two images. One has three flowers and the

Copyrighted material

> other four. Which do the newborns look at more? The gaze is variable, of course, but they consistently look longer at the one with four flowers. And it is not that they are looking at the image because it has more things in it. If they were shown a sequence of groups of four objects, they would later look longer at one that had a group of three. It seems they grow bored of always seeing the same number of objects and are surprised to discover an image that breaks the rule.

Liz Spelke and Véronique Izard proved that the notion of numerosity persists even when the quantities are expressed in different sensory modalities. Newborns that hear a series of three beeps expect there then to be three objects and are surprised when that is not the case. Which is to say, babies assume a correspondence of amounts between the auditory experience and the visual one, and if that abstract rule is not followed through, their gaze is more persistent. These newborns have only been out of the womb for a matter of hours yet already have the foundations of mathematics in their mental apparatus.

Development of attention

Cognitive faculties do not develop homogeneously. Some, like the ability to form concepts, are innate. Others, like the executive functions, are barely sketched in the first months of life. The most clear and concise example of this is the development of the attentional network. Attention, in cognitive neuroscience, refers to a mechanism that allows us to selectively focus on one particular aspect of information and ignore other concurrent elements.

We all sometimes–or often–struggle with attention. For example, when we are talking to someone and there is another interesting conversation going on nearby.[*] Out of courtesy, we want to remain focused on our interlocutor, but our hearing, gaze and thoughts generally direct themselves the other way. Here we recognize two ingredients that lead and orient attention: one endogenous, which happens from inside, through our own desire to concentrate on something, and the other exogenous, which happens due to an external stimulus. Driving a car, for example, is another situation of tension between those systems, since we

Copyrighted material

want to be focused on the road but alongside it there are tempting advertisements, bright lights, beautiful landscapes–all elements that, as admen know well, set off the mechanisms of exogenous attention.

Michael Posner, one of the founding fathers of cognitive neuroscience, separated the mechanisms of attention[*] and found that they were made up of four elements:

(1) Endogenous orientation.
(2) Exogenous orientation.
(3) The ability to maintain attention.
(4) The ability to *disengage* it.

He also discovered that each of these processes involves different cerebral systems, which extend throughout the frontal, parietal and anterior cingulate cortices. In addition, he found that each one of these pieces of the attentional machinery develops at its own pace and not in unison.

For example, the system that allows us to orient our attention towards a new element matures much earlier than the system that allows us to disengage our attention. Therefore, voluntarily shifting our attention away from something is much more difficult than we imagine. Knowing this can be of enormous help when dealing with a child; a clear example is found in how to stop a small child’s inconsolable crying. A trick that some parents hit upon spontaneously, and emerges naturally when one understands attention development, is not asking their offspring to just cut it out, but rather to offer another option that attracts their attention. Then, almost by magic, the inconsolable crying stops *ipso facto*. In most cases, the baby wasn’t sad or in pain, but the crying was, actually, pure inertia. That this happens the same way for all children around the world is not magic or a coincidence. It reflects how we are–how we were–in that developmental period: able to draw our attention towards something when faced with an exogenous stimulus, and unable to voluntarily *disengage*.

Separating out the elements that comprise thought allows for a much more fluid relationship between people. No parent would ask a six-month-old to run, and they certainly wouldn’t be frustrated when it didn’t happen. In much the same way, familiarity with attentional development

Copyrighted material

can avoid a parent asking a small child to do the impossible; for example, to just quit crying.

The language instinct

In addition to being connected for concept formation, a newborn's brain is also predisposed for language. That may sound odd. Is it predisposed for French, Japanese or Russian? Actually, the brain is predisposed for all languages because they all have–in the vast realm of sounds–many things in common. This was the linguist Noam Chomsky's revolutionary idea.

All languages have similar structural properties. They are organized in an auditory hierarchy of phonemes that are grouped into words, which in turn are linked to form sentences. And these sentences are organized syntactically, with a property of recursion that gives the language its wide versatility and effectiveness. On this empirical premise, Chomsky proposed that language acquisition in infancy is limited and guided by the constitutional organization of the human brain. This is another argument against the notion of the *tabula rasa*: the brain has a very precise architecture that, among other things, makes it ideal for language. Chomsky's argument has another advantage, since it explains why children can learn language so easily despite its being filled with very sophisticated and almost always implicit grammatical rules.

> This idea has now been validated by many demonstrations. One of the most intriguing was presented by Jacques Mehler, who had French babies younger than five days old listen to a succession of various phrases spoken by different people, both male and female. The only thing common to all the phrases was that they were in Dutch. Every once in a while the phrases abruptly changed to Japanese. He was trying to see if that change would surprise a baby, which would show that babies are able to codify and recognize a language.

In this case, the way to measure their surprise wasn't the persistence of their gaze but the intensity with which they sucked on their dummies. Mehler found that when the language changed, the babies sucked harder–

Copyrighted material

to the fact that in spoken language there are no pauses that are equal to the space between written words. Thatmeansthatlisteningtosomeonespeakisliketryingtoreadthis.[*] And if babies don't know which are the words of a language, how can they recognize them in that big tangle?

One solution is talking to babies–as we do when speaking *Motherese*–slowly and with exaggerated enunciation. In *Motherese* there are pauses between words, which facilitates the baby's heroic task of dividing a sentence into the words that make it up.

But this doesn't explain *per se* how eight-month-olds already begin to form a vast repertoire of words, many of which they don't even know how to define. In order to do this, the brain uses a principle similar to the one many sophisticated computers employ to detect patterns, known as statistical learning. The recipe is simple and identifies the frequency of transitions between syllables and function. Since the word *hello* is used frequently, every time the syllable 'hel' is heard, there is a high probability that it will be followed by the syllable 'lo.' Of course, these are just probabilities, since sometimes the word will be *helmet* or *hellraiser*, but a child discovers, through an intense calculation of these transitions, that the syllable 'hel' has a relatively small number of frequent successors. And so, by forming bridges between the most frequent transitions, the child can amalgamate syllables and discover words. This way of learning, obviously not a conscious one, is similar to what *smart*phones use to complete words with the extension they find most probable and feasible; as we know, they don't always get it right.

This is how children learn words. It is not a lexical process as if filling a dictionary in which each word is associated with its meaning or an image. To a greater extent, the first approach to words is rhythmic, musical, prosodic. Only later are they tinged with meaning. Marina Nespor, an extraordinary linguist, suggests that one of the difficulties of studying a second language in adulthood is that we no longer use that process. When adults learn a language, they usually do so deliberately and by using their conscious apparatus; they try to acquire words as if memorizing them from a dictionary and not through the musicality of language. Marina maintains that if we were to imitate the natural mechanism of first consolidating the words' music and the regularities in the language's intonation, our process of learning would be much simpler and more effective.

Copyrighted material

sophisticated concepts, that they have notions of mathematics, and display some understanding of language. At just a few months old, they already exhibit a sophisticated logical reasoning. Now we will see that young children who do not yet speak have also forged moral notions, perhaps one of the fundamental pillars of human social interaction.

The infants' ideas of what is good, bad, fair, property, theft and punishment–which are already quite well established–cannot be fluently expressed because their control tower (circuits in the prefrontal cortex) is immature. Hence, as occurs with numerical and linguistic concepts, the infants' mental richness of moral notions is masked by their inability to express it.

> One of the simplest and most striking scientific experiments to demonstrate babies' moral judgements was done by Karen Wynn in a wooden puppet theatre with three characters: a triangle, a square and a circle. In the experiment, the triangle goes up a hill. Every once in a while it backs up only to later continue to ascend. This gives a vivid impression that the triangle has an intention (climbing to the very top) and is struggling to achieve it. Of course, the triangle doesn't have real desires or intentions, but we spontaneously assign it beliefs and create narrative explanations of what we observe.
>
> A square shows up in the middle of this scene and bumps into the triangle on purpose, sending it down the hill. Seen with the eyes of an adult, the square is clearly despicable. As the scene is replayed, the circumstances change. While the triangle is going up, a circle appears and pushes it upwards. To us the circle becomes noble, helpful and gentlemanly.

This conception of good circles and bad squares needs a narrative–which comes automatically and inevitably to adults–that, on the one hand, assigns intentions to each object and, on the other, morally judges each entity based on those intentions.

As humans, we assign intentions not only to other people but also to plants ('sunflowers seek out the sun'), abstract social constructions ('history will absolve me' or 'the market punishes investors'), theological entities ('God willing') and machines ('damn washing machine'). This ability to theorize, to turn data into stories, is the seed of

Copyrighted material