La Dynamique du cerveau
(Def)

TEXTE	NARRATION
	COM : From time immemorial, man has been fascinated by the heavens. We have always wanted to unravel their mysteries and roam among the stars. We've set foot on the moon and are now dreaming of Mars. But science has barely begun to explore our inner cosmos. What do we know about this organ that is as complex as the universe and is thought to contain the very essence of what makes us human: our consciousness? What do we know about the human brain?
Ramachandran I can hold it in the palm of my hand. And this mass of jelly, which I can hold in the palm of my hand, can contemplate the vastness of space, interstellar space, it can contemplate the meaning of infinity, it can contemplate angels, or God, it can even contemplate itself.	
Naccache Est-ce qu'un cerveau est suffisamment complexe, en tout cas dans la pensée qu'il produit, pour arriver à décoder et à comprendre les mécanismes qui réellement président à son fonctionnement ou pas ?	**Naccache** **Is the brain complex enough – in its thought processes – to decipher and understand the mechanisms that govern its functioning, or not?**
W. Freeman How can we construct a theory of brain which will fit our current needs? And that is the most important question that you can ask.	
GENERIQUE DEBUT	
	COM : With today's stunning breakthroughs in brain imaging, neuroscientists are discovering what is happening in the brain and this will revolutionizie our understanding of human beings and how they function in society. We're at a turning point in science.
B.Van Swinderen There have been a few instances in humanity that have been, you know, driving points in humanity in terms of the history of, of ideas. And one of them has been the Earth rotates around the Sun. That was a big blow. People said no, the Sun rotates around the Earth now. The Earth rotates around the Sun. People didn't like that, that was the first blow. The second one was, was Darwinism, was that we come from monkeys, you	

know. People hated that. And, and that was another big blow, and it was a big fight. And I really think the third fight, in a way, if you, if you want to call it a fight, is, is consciousness. That there's nothing special about our consciousness, it's really our attention mechanism like everybody, every other animals attention mechanism, coupled to our memories. And there's some kind of interaction there, which is interesting, which is unique, everybody's different, it's special, but it's no more special than a fly or a, or a dog or a cat.	**COM :** To push back the frontiers of brain science, we unlearn what we thought we knew? Could our consciousness, that supposedly specific human attribute, be simply a combination of attention and memory?
Ramachandran If you look at the history of ideas about how the brain works, there have been two different points of view at opposite ends of the spectrum. One view is different mental capacities like seeing, judgment, foresight, memory, emotions are mirrored by different parts of the brain, the so called modular approach to brain function. At the other end of the spectrum there's a view it's a holistic, the brain functions in a holistic manner. Of course, there is modularity, there are specialized regions, but what our work has shown, and the work of many of my colleagues is that there's a tremendous amount of back and forth interaction between these specialized regions. The connections are constantly changing in response to the changing environment, changing sensory demands, and this is a radically different picture of the brain from what people used to believe until 15, 20 years ago. So, in a sense, instead of thinking of fixed brain areas, fixed brain modules, we should really think of a system that is in constant dynamic equilibrium with the external world.	**COM :** What if we were just like all other living things, constantly having to adapt to our environment?
W. Freeman We animals live in a sea of chemicals, that's where our food comes from, this is the source of our knowledge about each other, about our predators, and our prey, how to find shelter, how to find a mate, all of this is done primarily with the nose. And, in fact, looking back over the phylogenic history of the emergence of brains, the nose has been the key to the development of the neural mechanisms of intentionality, the capacity that animals have for reaching out into the environment, sampling it, and taking action is imposed by the infinite complexity of the chemical world that we live in. We can never possibly encompass all the chemical species that we are	

immersed in, only those few which are important, which we learn with the classic chemical transmitters, they enable us now, selectively, to identify what's important to us.	
	COM : The world around us is far too complex for us to grasp it holistically. But the tool that analyzes this world – our brain – is equally complex. The mechanisms of the brain reflect this external complexity.
M. Ptito Le cerveau, ce qui le rend extrêmement compliqué, ce sont ses circuits. C'est un système qui construit au fur et à mesure de l'apprentissage des circuits nouveaux. Et c'est quelque chose de changeant, de continuellement en mouvance. Et je pense que c'est sa mouvance perpétuelle, cette plasticité, qui le rend aussi fascinant.	**Ptito** **What makes the brain so very complex is its circuitry-wiring connections**. **It's a system that creates new wirings as learning takes place. It's constantly in motiocn, constantly changing and I think this perpetual motion, this plasticity, is what makes it so fascinating.**
Ramachandran The different b rain regions interact to a considerable extent, there's a lot of plasticity in the brain. And this is important from a theoretical standpoint, but it's also extremely important from a practical standpoint. If you want to accelerate recovery from pain, you want to accelerate recovery from stroke, and, in fact, any neurological ailment, because people used to think when the connections are damaged in the adult brain, you can't do anything about it. But what our work has shown, and the work of some of my colleagues is, in fact, these connections can change even in the adult brain. Sometimes different parts of the brain the equilibrium point shifts, and all you need to, is, is to hit a reset button, and this seems to change the organization of the brain.	
	COM : We used to view the brain as a machine that would store information, but we now have to think of it instead as a constantly self-organizing system. Walter Freeman discovered this often unpredictable brain dynamic some 40 years ago while studying the cat's olfactory bulb, the feline's primary source of sensory experience and knowledge. What he was observing-measuring was an astounding, chaotic and constantly changing process. Freeman's essential contribution was to show that the brain does not import information directly from the external world.
W. Freeman I discovered that there was the outward thrust under the control of the deep structures in the brain, the limbic system to search for input, to search for packets of energy impacting, and these now fell on single cells simply shattering the structure of whatever is there, converting them into these action potentials to come in, and now there has to be a construction, the brain has to make its understanding, its knowledge of reality.	

And it doesn't do this from any one input, It has to be multiple presentations of the input, over and over again, with sniffing, sniffing, sniffing to build the knowledge of what's there. So, now when the next sniff comes, only a few neurons, a few molecules is sufficient to create a pattern of activity. And this same process underlies hearing, the auditory cortex, it underlies vision, the visual cortex, underlies touch, somatic cortex.	**COM :** Walter Freeman's research overturned the static model of the brain and paved the way to a new concept of how our brain works. **COM :** This new dynamic model is progressing quickly: in Copenhagen, Maurice Ptito's team is studying volunteers who have been blind from birth in an effort to understand how neurons construct networks of connections.
M. Ptito On s'est rendu compte avec l'avènement des scanners - parce que c'est ce qui a été vraiment le coup d'envoi de la compréhension du cerveau humain in vivo - que si on prend une radiographie cérébrale prise par un scanner d'un cerveau d'un aveugle, on se rend compte que c'est un cerveau qui a l'air totalement normal, à l'oeil. Et par la suite, on a décidé de mettre un sujet aveugle dans un scanner et on a demandé simplement à l'aveugle de lire un texte en braille dans le scanner pendant qu'on prenait des images. Ça, ça été fait par des collègues de Harvard et ces sujets-là activaient des zones visuelles de la lecture d'un sujet voyant. Ça été une surprise monumentale parce que quand moi, j'étais étudiant, on insistait beaucoup sur le fait qu'un cortex qui n'est pas nourri par son intrant finissait par s'atrophier et jusqu'à un certain point, disparaître. Alors qu'en fait, c'est pas du tout vrai. Si on fait des mesures de l'activation du cerveau d'un aveugle au repos, on se rend compte que la perfusion du cerveau, donc au niveau de son métabolisme, est tout à fait normale, même à l'arrière du cerveau où se trouvent des zones visuelles. Alors on s'est dit : ah, ils ont un cortex visuel, donc c'est incroyable. Et ce cortex visuel, il faudrait trouver la façon d'aller le chercher. Au lieu de passer par l'œil, puisqu'on ne l'a pas, bien on va passer par le toucher ou on va passer par l'audition.	**Ptito** **With the advent of scanners - because scans are what really enabled us to begin to understand the live human brain - we realized that if you do a brain scan of someone who is blind from birth, you can see that the brain looks totally normal**. **Our colleagues at Harvard decided then to ask a blind person to read a text in Braille while they were in a scanner and take pictures scans of their brain. And it activated the same region of the brain connected with vision and reading as in a a seeing person would**. **It was an absolutely huge surprise, because when I was a student we were always told that a cortex that was not stimulated ended up atrophying and, up to a point, disappearing. But in fact that's not true at all. If you measure the activation of a blind person's brain at rest, you realize that their brain's metabolism, is perfectly normal, including at the back of the brain where the visual areas are. So we said to ourselves, Aha, they have a visual cortex, that's unbelievable: well we must look for a way to put that visual cortex to work. And instead of going via the eye, since there is no sight, well, let's go via the sense of touch or hearing.** **COM :** Maurice Ptito decided to use touch… by means of the tongue. His experiment is simple: since a blind person's visual cortex can be activated by reading Braille, shouldn't it also be activated by another input? A video camera worn on the forehead transmits a rough image in the form of small electrical impulses picked up by a grid of pixels placed on the tongue. These signals are perceived as a tingling sensation that the brain will interpret as a moving shape.

Assistant Okay, Ollie, whenever you're ready. We've complicated the obstacle course for you a little bit since you're so good. And whenever you're ready I'd like to once again point towards the obstacles and navigate your way around them. Okay? So, whenever you're ready. Okay.	
M. Ptito L'apprentissage est d'une importance capitale. Tous les phénomènes plastiques sont dépendants de l'entraînement. Quand on a commencé nos expériences, on s'est rendu compte qu'en début d'apprentissage, ils n'avaient aucune activation de leur lobe postérieur dans les régions visuelles du voyant. Mais au moment où l'apprentissage prenait place et qu'ils amélioraient leurs performances dans les différentes tâches, ils commençaient à recruter. Donc on voyait des activations qui apparaissaient dans la partie postérieure de leur cerveau. Cette plasticité ou ce qu'on pense être un réveil de connexions dormantes entre ces régions-là était dépendante de l'apprentissage.	**Ptito** **Learning is of fundamental importance. Plasticity depends on training. When we began our experiments, we realized that at the beginning of the learning process there was no activation of the posterior lobe, where the visual areas normally are. But when learning took place and they improved their performance of the different tasks, they began to bring the areas into use. So we observed activations appearing in the posterior part of the brain. This plasticity, or what we think is an awakening of dormant connections between those areas, depended on the learning process.** **COM :** The results on the scanner are astounding. The visual cortex of these congenitally blind subjects has managed to interpret information received through touch. The region activated by the information transmitted via the tongue – this coloured area – is the region used for vision.
Ollie It's very amazing that you could step over the bars, and, and you could walk around the boxes without touching them.	
Assistant How were you able to locate that box in space to know where it was to go around it?	
Ollie I could see if there was some space left or right to it where I could, where I could walk, then I could use the, the angle from how, how much I have to go, or, in my head. I could see, okay, it must be, it must be far away, far aways, maybe two meters or something like that. But right now, far away, it's not more than the length of my arm, it used to be.	
Assistant You see. Okay, stop. Very good. Very good, fantastic.	**COM :** Our brain is flexible and able to adapt. We are constantly reacting to our environment. Everything we perceive and

W. Freeman We have a name for the large population of neurons, it's called neuropil. The, being the neurons which form a mass of interlocking threads, these are the axons and dendrites, with the cell bodies and the capillaries that provide the nutrients for the whole system to operate, that's neuropil. The original neuropil of the salamander, and then of the land-dwelling forms, the reptiles, and later the birds is a three-layered cortex, and that sufficed all through the age of the dinosaurs. With the appearance of mammals something new happened. Instead of having now just three-layered cortex, paleo-cortex, archic-cortex, we have new cortex, six layers. The remarkable thing is that brains now have a new dimension of growth, and an increase in size a hundred-fold. How is that different? Whenever there is competition between a mammal, with neocortex, and a bird or a fish or a reptile, the mammal wins hands down every time. The most important aspect of neocortex is surface area. And the way in which the area is increased without an increase in volume is to wrinkle it, and that's how it is that the two hemispheres, now, instead of being flattened out, they are rigged into groove, and compressed into a solid mass, now, that's small enough to fit out through the birth canal. Before birth the cortex is not yet turn on, Tissus are all prepared, ready to begin operation, to work the lumbs, the basic limbs, the swallowing and so forth. It's only after birth that the brain is turned on. **B.Van Swinderen** Traffic is a huge demand on attention. And you can only pay attention to one thing at a time, that's why people can't talk in their cell phone when they, when they're driving, because you can't pay attention to two things at once. That's the bottom line of attention, that you only pay attention to one thing at a time.	do, every adaptation we make, affects how our brain organizes itself. Nerve cells, neurons are constantly turning on or off, networks are forming or disintegrating, as billions of neurons cooperate. **COM :** From the moment we're born, our brain starts making neural connections. Half of an adult's neural networks are established during childhood. This is the beginning of learning. Our brain is constantly striving to meet our needs. But to avoid being overwhelmed by the flood of data from the outside world, it has to sort the information. The mechanism that allows us select useful information is called "attention."

Something that everybody has seen is the, the two profiles, where it's either, it looks like two faces in black, or between it looks like a vase, and then you switch, you either see the two faces or the vase, the two faces or the vase. And you can describe that alternation dynamic, and that's also, in a way, if you will, an attention alternation. Using those as visual illusions is a way of taking everything else out, and there you're able to subtly reduce all the percepts, just the two things, so that you can actually see the switches of attention. When I do these, these kinds of experiments with the flies, it's also a very reduced preparation, they're in the arena, they're tethered in there, I'm recording from their brains, and they're looking at two things, they're looking at the plus or the box, and that's it.	**COM :** When the fly's attention is attracted by either of the two shapes, it strains toward it. Bruno Van Swinderen's infrared system detects this by monitoring its wing beats. In the same way, the system also determines when the fly loses interest in one object and switches its attention to the other one.
The fly can control the, the angular position of an object by modulating its left and right wing beats. And that's a way for the fly to tell us its choices, to tell us whether it wants to pay attention to an object, and then whether it, it wants to change its mind and look at another object. The human brain has billions of neurons, and the fly has 100,000. The human brain has these specialized human, or mammalian structures, and the fly has fly-like structures. If they can do the same thing like, for example, pay attention with completely different structures, then if you try to understand the phenomenon in the simpler brain that's different than the human, you'll be closer to the fundamentals of how something works, and not necessarily studying the specifics of how it works in a mammal. You have to remember about what attention does for us. The purpose of attention is for us to learn. Being able to store your world in a little container, and say, how am I going to react this time? Depending what happened in the past, and be able to, to anticipate, and also suppress, you know, be able to, to ignore which is an important thing that the brain does. Attention fascinates me beyond the flies obviously. I have three kids, and they all have their own attention dynamic. So, I think you can see people have different attention spans, you have some kids that are, that are shifting all the time, that have a, maybe an attention deficit disorder, and at the other extreme you have some kids, maybe autistic children, who, who are really focusing their attention on one thing for long periods of time. They would both be poor learners, right, but for completely different reasons. One of them	

because they're shifting their attention too much maybe, and the other one, they're shifting their attention too little. And what that says is to really function ideally, optimally in a world, you need an attention alternation which is tuned to the world you live in.	
Ramachandran If you start paying attention to everything in the world, you'll be overwhelmed, even though there's 100 billion nerve cells, there is a bottleneck of attention, you can only pay attention to certain things at a time, because you can't have overlapping patterns of activity in a given system, in a given nervous system, in a given neural network. And this is what makes you require attention, for paying attention to specific regions of the visual field, or specific objects, in order to avoid being overwhelmed by a sort of sensory overload.	
	COM : So our brain sorts information to enable us to function in our environment. It's never passive but is forever constructing and reconstructing its own patterns.
W. Freeman And, of course, that's unique for each individual, there is no fixed representation, our knowledge is constantly evolving, and to new forms. And that gives us, then, a very different picture of brain dynamics. It's the formation of these wave patterns, which are triggered by a stimulus, and once the trigger has had its work, then stimulus-driven activity is washed away, it's no longer useful. And this is what keeps us, then, from being drowned in information is the fact that we create, with each sniff, each touch, each glance, movement of the eyes, the ears, we create our own new understanding, our knowledge of the world.	
	COM : Constructing, reconstructing, associating, dissociating, that's how our brain builds meaning.
Ramachandran So, the brain is first and foremost, I don't want to say a machine, it's a poor analogy, but an organ made up of neural nerve cells to create internal simulations of the external world, which can, which it can use to make useful predictions about the external world, and generate appropriate action.	
	COM : We're only aware of a tiny fraction of the phenomenal activity going on in the brain. The relationship between what is conscious and what is not is one of the new fields being studied by neuroscientists.
Lionel Naccache L'image que nous avons aujourd'hui, c'est qu'en permanence, nous avons une pensée consciente qui occupe notre espace mental conscient. Et en	**Naccache** **The image we have today is that our conscious thought occupies our conscious mental space, at all times. And, in parallel with that, there**

parallèle, vous avez branché autour une multitude de représentations qui sont inconscientes, et par ce qu'on peut appeler une sorte de mécanisme de la course pour l'accès à la conscience, une compétition, seulement certaines de ces représentations vont pouvoir gagner le contenu conscient. ~~C~~e que vous faites consciemment à un moment donné, ça détermine énormément les opérations mentales inconscientes qui sont à l'oeuvre. Et à cette richesse psychologique, on peut ajouter une autre splendeur, c'est le fait que cette vie inconsciente n'est pas cantonnée aux étages inférieurs du cerveau, mais qu'en réalité, les régions néocorticales, même les plus récentes, peuvent fonctionner inconsciemment et construire des représentations inconscientes très complexes.	**are a multitude of unconscious representations. And through what could be called a sort of race to gain access to consciousness, only a fraction of these representations will finally reach the conscious content.** **What you do consciously at a given moment has a deciding impact on the unconscious mental processes that are taking place. And one may add to this another splendour: this unconscious life is not restricted to the lower parts of the brain. In fact, even the most recent neocortical regions can function unconsciously and elaborate very complex unconscious representations.** **COM :** Scientists are now able to see-show these conscious and unconscious levels at work.
Lionel Naccache Vous allez entendre des sons. À chaque fois, vous aurez cinq sons de suite. Et ce qu'on va vous demander de faire, c'est toute seule, de trouver la règle.	**Naccache** **You are going to hear sounds. Each time, there will be five consecutive sounds. What we ask you to do is figure out the rule on your own.** **COM :** Over time, the brain assimilates the features of its environment and considers them normal. If something new occurs, the brain notices and alerts our conscious level.
Lionel Naccache Comme elle a compris que la règle globale est une règle dans laquelle les cinq sons ne sont pas identiques, lorsqu'elle entend cinq sons identiques, là elle compte le son comme un son qui est une violation de la règle. Et il y a donc dans son esprit et dans son cerveau des processus qui vont lui permettre de détecter cette violation de règle.	**Naccache** **As she has understood the general rule that the five sounds are not identical, when she hears five identical sounds, she considers that sequence as a violation of the rule. So there are, in her mind and in her brain, processes that allow her to detect this violation of the rule.** **COM :** What the experimenter is observing is the signal from the electrodes. He has determined that a sound is perceived by the brain 200ms after it is emitted – that is, *unconsciously*. However, when a rule is broken, that same area of the brain perceives it *consciously,* and the reaction occurs 400ms after the sound is emitted. This delay correlates to the triggering of consciousness.
Lionel Naccache Il y a deux temps de la perception. Il y a toujours un premier temps qui est assez rapide en fait, qui est ce qu'on appelle un traitement montant de l'extérieur vers l'intérieur du cerveau, donc des aires perceptives primaires vers les aires associatives et ce premier temps de la perception, il est ou il n'est pas suivi par un deuxième temps. Donc la même région va fonctionner	**Naccache** **Perception is a two-step process. The first step, which occurs very rapidly, is what we call an outside-in treatment, from the primary perceptive areas to the associative areas of the brain. And this first step may or may not be followed by the second step. The same region will then function twice: the first time, unconsciously, and, if there is a**

deux fois : une première fois de manière en réalité inconsciente et lorsqu'il y a un deuxième effet, donc un deuxième temps de la perception dans cette région-là, et bien là en général, vous avez un accès à la conscience de cette représentation. C'est un résultat assez général, c'est-à-dire que cette temporalité entre deux temps, entre deux étapes de la perception, elle vaut également pour les autres choses : pour le souvenir, pour l'action, pour les gestes, pour la motricité, pour les émotions.	**second effect, a second step of the perception in that area, in general, you become conscious of that representation. It's a rather general result, which means that this temporality between two stages of perception can apply elsewhere: to memories, action, deeds**, **motricity, emotions**.
	COM : Looking at the alternation from unconsciousness to consciousness, the role of attention, and the ability to select information and to adapt, helps us understand how our brain works. But how is knowledge created? And where is it found?
W. Freeman When neurons are being told to shut-up, that's knowledge, just as well as when they're being told to fire. You see, when a stimulus comes in, it's an event from the outside, and each of the senses breaks that down into fragments, molecular fragments, all of these action potentials, point processes coming in, triggering now the formation of percepts in the form of wave packets, which are specific to the local areas of the sensory cortexes, now passing into the hippocampus where they are labeled with time and place, when did this occur, and, where did it occur in the world outside? When it comes back out now, it goes back to all of the cortexes, including the motor cortex, in anticipation of the outflow, so that when you ask, well, where is the knowledge? It's in the synaptic connections everywhere. Its only been in the last five years that we have had the instrumentation that's necessary to see this happening, and to report on the global organization of oscillations which are jumping every one to two-tenths of a second from one state to another…that's thought. that's the dynamics by which our conscious and unconscious images are going through our minds, the expression of knowledge constantly being newly created. This is self-organization. These neurons, by the billions, are coming together to cooperate, and then doing it again, and again, and again. That poses an enormous problem, because it goes beyond all that we know in neuroscience of what neurons can do. And we don't yet have the mathematician to come andgive us the basic equations that we need to describe consciousness and intentionality.	**COM :** While waiting for the mathematical model that could enable us to solve the puzzle, neuroscientists continue to explore the fascinating relationship between the brain and the body to which it belongs. And in studying certain pathologies, they may well wonder which controls which.

Ramachandran You can see how the water falling on the sandstone cliffs has made all these pathways, these rivulets, taking the path of least resistance in the initial instance, and then the furrow is becoming deeper and deeper. There's an analogy here between these furrows and the way memories are acquired in the brain, the way in which you learn new things, new skills, for example. So, I think what's happening in, in the case of stroke, and phantom limb, the person's arm is actually paralyzed, say, for a few months, or a few years, because the nerve to the arm is cut, every time the brain sends a signal to the arm to say move, it's getting visual feedback saying no, it's not moving. Move, no. Move, no. And this gets wired into the circuitry in the brain, in the parietal lobe, maybe in parts of the frontal lobe, so that the brain gives up, and, and you have a form of a learned paralysis. Or in a patient with a stroke. In the early days of stroke the swelling, or edema of the brain results in part of the paralysis, but even when the swelling subsides maybe the brain has learned that the arm is fixed and paralyzed, and therefore you're stuck with an arm that's much more paralyzed than it should be. And it raises the question, can you unlearn the learned paralysis, whether in phantom limbs or in stroke? So, one way we thought of doing this was simply putting mirror in the center of the table in a box, you put the right arm here, and look at the reflections of the right arm in the mirror. Now, what happens is it's gonna look like your phantom limb has come back, has been resurrected, because you get the visual illusion that the arm is there. And the amazing thing is many people respond to this saying that the phantom has suddenly been animated, suddenly it starts moving, even though there is no arm there, and even though until then that the phantom has been frozen and immobilized, as soon as he gets the visual signal, he feels like it's moving again, it often relieves the pain in the phantom, in some cases the arm disappears completely, and along with it the pain disappears. **Malade** J'avais trop de douleur au début… quand tu t'côte un 8 sur 10… a 8 sur 10… t'es pas à l'hôpital mais t'es pas loin. Puis moi ça a marché dès la première fois que j'ai essayé la boite à miroir… j'pouvais baisser à 1 sur 10. J'étais vraiment étonné, parce que au bout d'un an… un an et demi… j'avais arrêté d'prendre mes pilules pour le mal fantôme… puis aujourd'hui, ça fait… j'peux dire ben 3 ans que j'ai pas repris de c'tes pilules là. **Ramachandran** Now, since we discovered this, about 10 years ago, there have been many other experiments done on large scale clinical trials showing substantial	Sous-Titres

recovery of arm function with a stroke. Even if this helps only 10% of the patients, we don't know which patients it helps, which patients it doesn't help, you,re talking about 1000s of millions of people in the world.	**COM :** Lionel Naccache has a patient with an intriguing neurological disorder. He suffers from hemineglect syndrome, meaning that he has lost all awareness of one side of his body.
Lionel Naccache Dès lors que nous sommes conscients de quelque chose, nous cherchons à produire du sens malgré nous. Pour prendre l'exemple du patient négligent qui ne reconnaît plus partie gauche de son corps comme étant la sienne. Il peut avoir donc un symptôme de main étrangère. Alors vous lui dites : combien sommes-nous dans la pièce? Il vous dit : bien écoutez, docteur, on est deux, il y a vous et moi, on est deux. Très bien. Vous lui dites : d'après vous, il y a combien de mains dans cette pièce? Alors il vous dit : bien on est deux, chacun a deux mains, donc il y a bien quatre mains. À ce moment-là, vous lui montrez sa main gauche. Vous dites : à qui est cette main? Ce n'est pas à moi, ce n'est pas ma main gauche. Mais on est deux, ça doit être votre main, c'est votre main. Alors vous lui montrez vos deux mains, vous dites : regardez, voilà mes deux mains et je vous montre cette troisième main. À qui est-elle? Et là, on tombe dans cette fiction. C'est tellement fort pour lui que ce n'est pas sa main qu'il peut parfois aller jusqu'à élaborer un discours totalement fictif mais auquel il croit. Il va vous dire : écoutez, peut-être que vous avez trois mains, peut-être que c'est à quelqu'un d'autre, peut-être que c'est une main qu'on a coupée et qu'on a mise dans la chambre mais en tout cas, ce n'est pas à moi. Un exemple pareil nous met sous les yeux que des données immédiates de la conscience incluent systématiquement cette couche de croyance et d'interprétation. Alors c'est plus facile de voir que c'est une fiction quand c'est faux. Mais la plupart du temps, nos fictions sont en surface vraies, sont correctes. Si je vous interroge sur vos convictions politiques, sur vos croyances, même sur les sentiments interpersonnels ou sur votre rapport aux extraterrestres, là quand on fait ça, on voit apparaître une diversité d'opinions et quand on discute avec nos semblables, on voit que ce sont des choses qui sont souvent ancrées dans une conviction, dans une croyance très forte.	**Naccache** **As soon as we're conscious of something, we try to make sense of it, in spite of ourselves. Take the example of the hemineglgent patient who doesn't recognize the left side of his body as his. He may be subject to the alien hand syndrome. You ask him: "How many people are there in the room?" He answers "Well, two of us, you and me." So you ask "How many hands are there in the room?" He replies "Since there are the two of us and each has two hands, that makes four." Then you point to his left hand and you ask: "Whose hand is that?" "It's not mine," he says. "But there are the two of us, so it must be yours." And you show him your two hands and you say: "Look, here are my two hands and I am showing you this third hand.** **Whose is it?"** **And then we move into the realm of fiction. He believes so strongly that this hand is not his that he may elaborate a completely fictitious story that he'll believe. He'll tell you: "Maybe you have three hands, maybe it's someone else's hand, a hand that has been cut off and then placed in the room – but it's definitely not mine." Such a case illustrates that this layer of belief and interpretation is integrated systematically into the basic data of consciousness. We realize more easily that it's a fiction when it's false. But most of the time, our fictions seem true, apparently. If we discuss your political convictions, your beliefs, your feelings or your rapport with extraterrestrials we'll see a range of opinions, and when we talk with our fellow humans, we see that these are often deeply rooted in a very strong belief.** **COM :** To make sense of the world around us, we invent fictions, stories to explain what we perceive. We all have our own individual fictions, but some fictions are shared by the group. These collective fictions are learned. To understand how we construct them, we have to look at how our brain learns and *unlearns*.

Ramachandran There are cells there which fire every time the monkey performs a specific action. Now, this has been known for 20 or 30 years, but what Jacomo Ritzalatti, in Italy, found was some of these neurons, which we call a mirror neuron, will also fire when the monkey watches another monkey pulling a lever. Well, the same thing happens in humans. You can do experiments on humans using functional imaging, so some part of the brain lights up when the person does something, the same part lights up when the person watches another person doing the same thing. And this is astonishing, because it's as though you are feeling another human being's pain. And on the basis of this, I like to call them empathy neurons, or Dali Lama neurons, because this neuron is dissolving the barrier between you and another person. And this is the basis of a lot of Western and Eastern, especially Eastern esoteric philosophical traditions, and mystical traditions, saying there is no essential difference between your mind and somebody else's mind. Now, they used to speak metaphorically, but what we are saying is studying these neurons, you can actually show that this neuron is, in a sense, dissolving the barrier between you and other people. This ability to imitate or emulate is the basis of human culture, transmission of culture. Instead of the laborious process of Darwinian natural selection, which takes hundreds of thousands, almost millions of years, you can transmit information in one generation.	The process begins with observing others. **COM :** Are mirror neurons the underlying mechanism for the transmission of knowledge? Could they also play a part in our cultural references, such as artistic representation or symbolism?
Ramachandran I've often been interested in metaphor, both in language and in art. I'll give you an example from Indian art. There is, again, Lord Shiva with his consort Parvati sitting on his lap. And they both sort of looking at each other, at the same time looking at the world, conveying the idea that love is not just narcissistic gazing into each others eyes, but looking in the same direction at the universe, at the world. And there's some very interesting things there. He's, he's putting his hand in her chin, and so you can, sort of a drawing in her chin to kiss her, and this must be activating the mirror neurons in the brain, because it's movement, what is he about to do? So, it's activating those neurons. But the artist has exaggerated it, so it must be hyper activating this neuron to convey a very vivid sense of amorous delight. And also there's more there, you know, you keep looking at it, it becomes a	

sort of metaphor of all the duality of existence, the polar opposites, such as night and day, evil and good, black and white, happiness and, and sorrow, man and woman, all the dualities and antagonisms that characterize the phenomenal world disappear, the barriers disappear. And that's what's shown here, their intimacy and closeness is dissolving the barrier between two opposites.	**COM :** These dualities are now being studied by neuroscientists. Walter Freeman believes that the brain, the organ of individuation, is also the organ of socialization, and that unlearning is as crucial as learning.
W. Freeman If you think about the brain as an organ of adaptation, of getting by, of more than survival, of reaching out to change things to the brain's liking, it's not just the brain, obviously, it's the whole body which is involved in the all process. Now, one of the critical features about the process of adaptation is not just the strengthening of connections for learning something new, it's also the weakening of connections with habituation to get rid of unwanted things. But this is a cumulative process, which now makes a person more and more knowledgeable, but more and more different from everybody else. And everything we know about learning involves this process of the increasing separation of each of us from every other. Now, the most important lesson of paleo-anthropology, the history of the human race over the last half million years, three million perhaps, is the importance of socialization, that we are first and foremost a social species, and furthermore the brain is not simply controlling, it is, in fact, the organ of socialization. Now, how is this possible that we can overcome the divisions that separate us? The mechanism which makes that possible is cooperation. We not only act, but we act in concert. We find the actions which are necessary for socialization in all forms of indoctrination like religious conversion, political conversion, the form of training when young people go into the military, when essentially are brain-washed, the forms of adaptation which are necessary for corporations, for sports teams. All of these activities which involve the fusion of individuals into a functional organization are carried out by unlearning, which is precipitated by a peptide, a chemical substance known as oxytosin, it's also known as ecstasy in the street, and is essentially an agent for the dissolving of pre-existing structure, selectively, so as to enable new structure to form.	**COM :** Learning and unlearning, this is the constant activity going on in our brain. Neuroscientists dream of one day understanding how to achieve a society of brains that would cooperate rather than isolating themselves or entering into conflict.

W. Freeman The archetype of cooperative action is dance. All primitive tribes have dancing as a simple feature of the socialization process. It's the rhythm which is important to jive together in the formation of a cooperative group, that's specifically human, and it's a mechanism whereby oxytosin release can be engendered, this is not forgetting, people can remember very clearly what they were before and how they are now, but it's central to the process of the formation of a social bond. Now, we know very little about that process, it's, and, in fact, only become apparent in the last decade that this is of major importance for the future of neuroscience to study this process of socialization, because that in essence is half of who we are and who we ought to become. And the fact that we have so much conflict in the world, and right in our own area, each one of our cities we have the formation of teenage gangs, of kids who have no sense of future, who are drifting, they are prime targets for the formation of bonding through this process, which we don't understand, and attempt to suppress by sending them to jail. It's a failure of neuroscience to come to terms with that aspect of brain dynamics, with the reality of the failure of learning as a model for the development of a stable society. **Ramachandran** I do have doubts about where all this is gonna lead to from an ethical standpoint, from a humanistic standpoint, because I think a time will come when you have a very thorough understanding of the brain, just like your understanding of the liver, and then you could start to be able to control it. Of course, even now you can do it to some extent like with drugs like cocaine or heroine, but supposing you get to the point when you can design drugs which don't, are non-addictive, and can give you these highs, and also give you a holistic high, not just a limited high, make you actually genuinely happy. Or supposing I could take your brain and put it in a vat, I mean, this is old philosopher's question, and then put electrodes and make you think, make you extremely happy, fulfilled, make you see God. If I could do this to you, you have an ethical choice. Would you say, I pick this, or I pick me, right? Now, many people say no, no, I don't want to be all that, I want to be me, because this is the real me, but your real brain, what you're calling your real, is a brain in a vat, the vat is called a cranium, that is sitting in the vat, and is being stimulated by photons, so what's the difference, on what basis do you say I want the real me, and I don't want that artificial brain? It's my own brain but artificially stimulated. Where do you draw the line? This is gonna be the greatest ethical dilemma that mankind will ever face.	**COM :** This brain mechanism brings neuroscience closer to anthropology's concept that what makes us human is that we have developed a social role.

GENERIQUE FIN **B. Van Swinderen** Everybody can relate to, to swatting a fly, right, you, you swat a fly, you have the fly swatter, but the best way of, of swatting a fly, of killing a fly, and I am okay with killing flies, even though I study them, is, is actually to consider their selective attention. So, when you come with just one fly swatter, the fly's looking at that and will go away, but if you approach the fly with, with your three fingers, very carefully, then the fly will be looking at one finger, the other finger, the third finger, its attention will be divided, that limited resource will be divided between the three fingers, and then you will catch it unawares because at one moment it'll be looking at the wrong finger, and, and then you, and then you get it. **DEROULANT FIN**	**COM :** Galileo forced us to recognize that the Earth is not the centre of the universe. Are we now ready to accept that what makes man superior to other creatures – his consciousness – may be nothing more than a collective fiction?