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EMOTIONAL PARTICIPATION IN DECISION- MAKING

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Emotional participation in decision-making. The results of recent neurophysiological and neuropsychological research make it necessary to take into account the participation of emotions in decision processes. The amygdala, which has revealed itself as a structure capable of assigning emotional meaning to environmental stimuli (assessment) gives rise to a series of reactions that include motor, autonomic, endocrine and central nervous system adaptations (emotional expression). All of these changes also feed back on the brain, producing what is known as emotional experience or feelings. Neuropsychological research has also shown the importance of the prefrontal cortex in decision-making, demonstrating the close cooperation of the emotional limbic mechanisms with the anticipatory and planning functions of the prefrontal cortex (Damasio's somatic marker hypothesis is presented). Neurobiology is thus confirming what Pascal intuitively expressed when he wrote that "the heart has reasons that reason ignores".

Los resultados de la reciente investigación neurofisiológica y neuropsicológica nos obligan a reconsiderar los mecanismos decisorios y a tener en cuenta la participación de las emociones en estos procesos. La amígdala, una estructura capaz de asignar significado emocional a los estímulos ambientales (evaluación), pone en marcha una serie de reacciones de carácter motor, autonómico. endocrino y del sistema nervioso central. que constituyen la expresión emocional. Todos estos cambios revierten, a su vez sobre el cerebro, en lo que se conoce como la experiencia de las emociones o los sentimientos. Por otro lado, las investigaciones neuropsicológicas han revelado la importancia de la corteza prefrontal en la toma de decisiones, poniendo de manifiesto la íntima colaboración de los mecanismos límbicos emocionales con las funciones anticipatorias y planificadoras de la corteza prefrontal. (Se expone la hipótesis del marcador somático de Damasio). La neurobiología está confirmando en definitiva lo que de forma intuitiva afirmó Pascal al escribir que "El corazón tiene razones que la razón ignora".

The necessity to make decisions, often as difficult as that which tormented Hamlet, immortalised in Shakespeare's famous monologue, is not exclusive to human beings. All living creatures that possess a repertoire of diverse behaviours have to choose between several possibilities; as the complexity of the organism increases, the farther up the evolutionary scale we go, so decision-making acquires more and more complexity and difficulty, and this for several reasons. On the one hand, because more highly evolved brains are capable of discerning with far more precision the subtle environmental differences relevant to survival; on the other, because the repertoire of available behaviours in these organisms becomes progressively wider. A further reason is because the most phylogenetically recent brains are not only able to react to present environmental conditions, but, having developed the capacity to elaborate models of future circumstances (models that include the consequences of their own behaviour), they need to take into account a wide range of projected possibilities.

Thus, all living organisms that possess a nervous system have had to devote a portion of their neurons to the delicate task of making the decisions that are necessary for survival. And it is here that emotions enter the scene. Allow me, for the moment, to present emotions as an essential part of the nervous mechanism responsible for designing appropriate responses to the environmental stimuli that are of relevance for survival. They are probably the most crucial part of that mechanism, the most *decisive* part, in all senses of the word. Below, I shall try to explain why I make such a statement, and I shall briefly present the neurophysiological findings that justify it.

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THE AMYGDALA: ITS FUNCTION IN EMOTIONAL ASSESSMENT

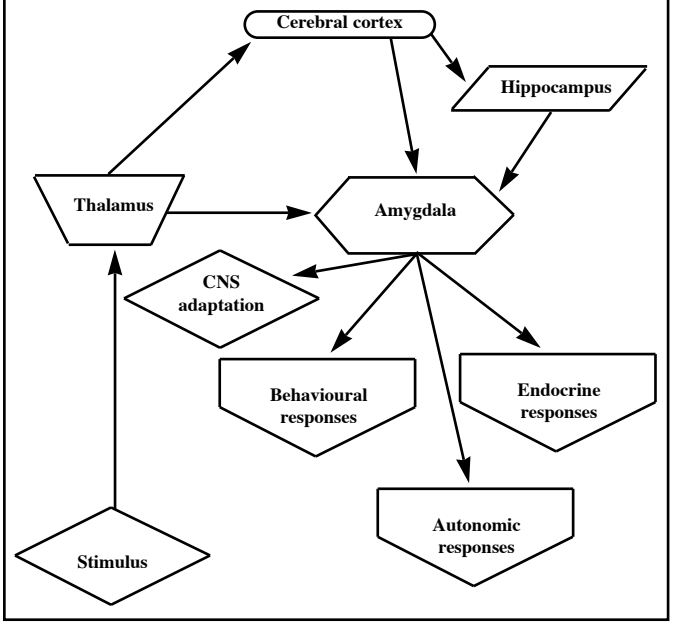
The nervous structures related to emotional mechanisms, as they are found in current mammals and in man, made their appearance on the face of the earth about 250 million years ago, at the time of the last reptiles and the first mammals (MacLean, 1993). It was not until last century, however, when human beings began to devote attention to such a fundamental part of their anatomy. The famous French neurologist Paul Broca (1878) gave the name limbic lobe ("limbic" means of the edge, frontier or margin) to the part of the brain that surrounds the brain stem under the neocortical layer. Due to the abundant connections of the limbic lobe with the sense of smell, the function initially assigned to this structure was an olfactory one, so that it was given the name "rhinencephalon". However, the limbic lobe was not associated with emotional life until much later. In 1937 Papez presented a hypothesis linking it with the hypothalamus and with emotional expression, describing an anatomical circuit which since then has become known as the "Papez Circuit" (Papez, 1937). Some years later, MacLean enlarged the structures of the Papez Circuit (including the amygdala and giving great importance to the hippocampus) and called the structure the "limbic system" (MacLean, 1949), a name that survives to this day. Currently, the concept of the limbic system is under review, since, on the one hand, there is disagreement over which specific structures should be included in the concept and, on the other hand, not all of the so-called limbic areas participate in the genesis of the emotions. Without any doubt, the anatomical structure most clearly related to emotion is, from our current perspective, the amygdala (LeDoux, 1992). We shall now, therefore, focus our attention on the amygdala and its meaning.

The amygdala is a small nervous structure, no bigger than an almond, situated at the heart of the temporal lobe (one in each temporal lobe, two in total), and which has abundant connections with a great variety of brain areas. It is the most important component of a network of structures that process emotional information. The function of this structure, as we understand it today, consists in assigning emotional significance to environmental stimuli, whatever their sensory modality. Put more simply, what the amygdala does, when a new stimulus is presented in the subject's sensory field, is to make a quick assessment of it and to tell the rest of the brain if the stimulus represents a danger or, on the contrary, promises some gain for the organism. From the point of view of cerebral functioning, this means that the amygdala is in a position to relate a particular stimulus with the potential pleasure or pain accompanying it. It is as though the amygdala were saying to the rest of the brain: "This is good and desirable for us –try and get some of it"; or, alternatively: "Watch out! This is dangerous –get away, try and avoid it".

This is clearly a greatly simplified version of things. I shall therefore attempt to explain in a little more detail. The amygdala receives information from the stimuli that are continually entering through the sensory organs. This information reaches the amygdala via two principal routes (LeDoux, 1993). One, the most common, is that which passes through the cerebral cortex. The information from the senses arrives at the thalamus, and from there, via the lemniscal route, it reaches the corresponding primary sensory cortex (auditory, visual, tactile, etc.). The stimulus is then elaborated in the different parts of the associative cortex, where its more complex characteristics are analysed and its global properties recognised. The information is also transferred to areas of intermodal association, that is, those that relate between one another different sensory characteristics of a stimulus (visual, auditory, etc.). The result of all these levels of elaboration is sent to the amygdala, as well as to the areas associated with the hippocampus (a neighbouring structure to the amygdala, related with certain aspects of the memory and with spatial thinking), which in turn communicates with the amygdala. As it receives all this information, the amygdala reaches a situation in which it is ready to "make a judgement" about the desirability or danger of the stimulus. (The information provided by the hippocampus may in some cases be crucial, since this structure supplies data relevant to the context of the stimulus. For example, the sight of a tiger at close quarters is a highly alarming stimulus if we are in the jungle, but completely harmless if it is in a cage at the zoo. This context-related information appears to be provided by the hippocampus). However, as we said, in addition to this route, which we might call the thalamo-cortico-amygdalar route, there is another way for information to reach the amygdala. It is a shorter route (with fewer synapses), extralemniscal, and one which links the thalamus directly with the amygdala, missing out the cortex (See Fig. 1); it has been clearly shown in the research of LeDoux's group (Romanski and LeDoux, 1992; LeDoux, 1995).

This thalamo-amigdalar route, phylogenetically more primitive, permits that part of the stimulus information, certainly much less elaborated and lacking perceptive sophistication, reaches the amygdala more rapidly, allo-

Figure 1
Diagram of principal afferent and efferent connections of the amygdala in relation to the elaboration of emotions (modified from LeDoux, 1993).



wing it to initiate and appropiate reaction much more quickly, on which, in certain cases the survival of the organism may depend - when faced with a predator, for example.

Undoubtedly, the readers who have followed me thus far along the roads that lead stimuli from the thalamus to the amygdala will quite rightly be asking themselves at least two questions. The first is: How does the amygdala "know" what is good or bad for the organism?, and the second: What kind of response is the amygdala capable of organising?

Let us try and respond to the first question, concerning where the amygdala gets the information that allows it to assign an emotional value to stimuli. This information has a double origin. A considerable portion of the limbic system's reactions in the face of stimuli is of a hereditary nature. Pre-programmed behaviour patterns are located in neural circuits whose connections are established during the development of the nervous system, and can be considered as innate (for example, defensive reactions for dealing with predators, sexual responses, etc.). This is what Damasio refers to in the term "primary emotions" (Damasio, 1995). Secondly, to this set of innate reactions we must add all the emotions that each organism, in a personalised way, acquires over the course of its life. These are Damasio's "secondary emotions". Our experiences mean that stimuli which in principle were neutral acquire a certain affective character. This occurs as we form associations between the objects and situations with which we come into contact and primary emotions. The final result is that any constellation of stimuli with which we are presented at a given moment possesses a certain affective load, more or less strong and more or less conscious. In any case, we cannot be totally indifferent to anything in terms of emotions.

With respect to the second question, concerning the response possibilities the amygdala has at its disposal, I shall try to answer as briefly as possible.

THE ORGANISATION OF EMOTIONAL EXPRESSION

The amygdala organises a series of responses that have been quite well studied, at least in the case of fear (Davis, 1992 a), which is one of the best known and most widely-found emotions in all living beings. These responses have their origin in the central nucleus of the amygdala (Davis, 1992 b), and can be classified into at least four types: behavioural, autonomic, endocrine, and of general changes in the form of neural processing of the information (Damasio, 1995: LeDoux, 1995). My intention here is merely to present an idea of what type of activity each one deals with, and I shall do so by means of an example. Let us imagine a situation in which we are faced with physical aggression. We can choose between running away and facing up to the aggressor. *Behavioural* responses are those that refer to movements we carry out (be they of flight or of approach and fight), including responses related with the expression of emotions, for example, fright, or the making of gestures or sounds that communicate to others our affective state; these responses are the most visible part of our emotional life. In our hypothetical situation, these corporal movements are accompanied by a series of physiological changes that permit the organism to increase blood circulation and mobilise the energy that fight or flight demands. For example, blood pressure and heart rate increase so that sufficient blood reaches the muscles that are preparing for running or fighting. These changes are called *autonomic*, since they involve the autonomic or vegetative nervous system. At the same time, there is an increase by the adrenal medulla of the secretion of adrenaline and noradrenaline, hormonal substances that pass into the blood and which, as well as contributing to circulatory adjustments, facilitate the mobilisation of energy-producing metabolites. All these humoural modifications make up the so-called *endocrine* responses. Finally, general changes in the *ner-*

vous system are produced –changes which attempt to optimise the organism's condition for dealing with the emergency situation: increase in activation level, sharpening of perception in aspects related to the characteristics of the stimulus, modification of processing speed and other nervous adaptations of a general nature. All of these responses set in motion by the amygdala form part of the emotional "expression". Clearly, some of them are quite visible, but others are produced in the intimacy of the organism and remain invisible to outside observation. It is interesting to point out, in terms of practical implications, that this entire process of emotional "expression" may go unnoticed by the subject him/herself. Many of these responses are indeed accessible to the conscious mind, so that we can be aware of the affective meaning of a given stimulus, and of, at least, a fair quantity of the bodily reactions it triggers (palpitations, sweating, digestive sensations, etc.). In some people and on certain occasions, however, this whole constellation of emotional responses may take place in a partially or totally unconscious way, and result in the production of changes and disorders in the organism that lack any meaning for the subjects even if they could perceive them, and which they cannot relate to the situations that produced them. This is an aspect of the problem to which we shall return later on.

THE EMOTIONAL EXPERIENCE: THE FEELINGS

We move on now to a very important aspect of the emotional experience that is crucial to an understanding of the mechanisms involved in decision-making. The chain of bodily events triggered in response to stimuli with emotional significance does not end with what we have presented thus far. The modifications referred to that take place in the different organs are perceived by the brain via nervous paths that carry the information from the periphery of the organism to the central nervous system (these are called afferent routes). For example, quickening heartbeat, increase in muscle tone in certain areas, the reddening or blanching of the face, sweating, etc., are organic changes that do not go unnoticed by the brain, which receives a constant flow of information on the state not only of the internal organs but also of the muscles, the articulations, the limbs and all the various parts of the organism. We might consider this as the return journey of all the signals that the limbic system had emitted as a consequence of the emotional assessment of stimuli. The brain thus finds out what have been the consequences of the emotional reaction that it has itself triggered. Many readers may think that this "feedback" is not too important, or that it only comes into play in certain circumstances in which emotional excitement is extreme, but this is not the case. This flow of information on the state of all the parts of the organism is constant and unceasing. What is true is that most of the time we do not perceive this information in a conscious way; we take it for granted –it is like a background against which the rest of mental life develops. It constitutes, to use the language of Damasio, a kind of bodily "landscape" that is always present. A landscape that continually changes, precisely in response to the influences of emotional origin that it receives from the central nervous system. It is as though this basic landscape were being illuminated in a diversity of ways according to the ever-changing pattern of emotions in which now one, now another prevails. In fact, this metaphor falls short, since it is much more than changes of illumination that occur in the landscape. Arteries contract, glands secrete fluids, the heartbeat accelerates or slows down, the alimentary canal has spasms, and some areas are flooded with blood, while in others the flow is reduced to a minimum. This territory in perpetual movement is the corporal landscape that changes in response to the emotional modifications. And we can imagine the brain as a captive observer of this landscape, obliged to watch the transformations that occur, the infinite changes of hue and tone that its surface undergoes. We should bear in mind, too, that the brain's role of observer is not limited to the mere perception of all these modifications that the organism experiences through nervous routes, but that it is also literally "flooded" by the hormones secreted in response to emotional changes. This chemical tide, this impregnation it receives via the circulation massively and simultaneously influences a great number of neurones, affecting in a characteristic way the nervous system's form of response to stimuli. Thus it is that the global affective experience is formed, not only by the processes of assessment of the stimulus that occur in the central nervous system, and not only by the visceral and corporal reactions with which the nervous system responds to this assessment, but also by the way in which the brain perceives these visceral and bodily adjustments once they have occurred in the organism. For those fond of systematization, the processes referred to above can be classified in three distinct emotional components, known as "assessment", "expression" and "experience", respectively (LeDoux, 1986). Assessment of the stimulus, expression of the emotion and experience of the bodily changes. This "experience"

is what Damasio calls "feelings", thus differentiating them from the rest of the components of emotional experience (Damasio, 1995).

Let us now return to the matter we were discussing earlier, that of the awareness of emotions. The assignment of affective meaning to a given stimulus may take place without our being conscious of the fact. That is, although we are often aware of our emotions, there are many cases in which we are not. Moreover, it is possible that the following step, the production of bodily reactions to the emotional content, also takes place without us being conscious of it. With respect to this aspect, there is great variability, due not only to genetic factors, but also to the attention the body and its sensations have received during childhood and adolescence. Although it may seem surprising, we live in a society in which the internal or visceral body does not receive too much attention, and it is common to find people whose conscious life passes off inside a sphere that is quite removed from the body and its experiences; it is frequent to find a real lack of connection, and in extreme cases a veritable dissociation, between psychic experiences and bodily sensations. An intermediate situation is also possible: although the affective character of a certain stimulus does not reach the conscious mind, the subject does become aware of the somatic repercussions –the palpitations, sweating or digestive sensations. In these intermediate cases our bodily feelings tell us something important is happening, even though we have not yet noticed it and do not immediately understand what it is all about. These feelings give us a clue, an opportunity to try and discern the cause of this uneasy feeling and work out where it is coming from. If these somatic repercussions are strong and, above all, prolonged, they will probably result in more or less serious disorders in some organ or organs, this being the origin of numerous so-called functional disorders or of "psychosomatic" diseases. Emotions that find no suitable exit by other routes of expression end up manifesting themselves through the body, although, paradoxically, the subject experiences these bodily disorders as something exterior to him/herself, something that he/she does not recognise, and which causes him/her problems and suffering.

THE FUNCTION OF THE FRONTAL LOBES

After this brief discussion of the mechanisms responsible for emotion, it is time for us to return to the matter of how emotion is related to decision. As we have already said, the most primitive organisms, given the simplicity of their behavioural repertoire, do not have too many decisions to make. Decisions about behaviour with which they are faced are mainly resolved by genetically-programmed mechanisms. As we ascend the evolutionary scale, to these innate mechanism (which have not completely disappeared in the evolutionary ascent) is added a growing capacity for learning about the environment and about the consequences of the organism's own behaviour on interacting with that environment. This increase in processing capacity is accompanied by an increase in the volume and complexity of the cerebral cortex in the course of evolution, which attains considerable proportions in the case of man. The capacities that the evolved cortex confers on the organism are projected in the two directions of the time dimension. On the one hand, the living being accumulates information on what has gone before; his/her experiences leave their mark on the brain, which will influence, if not totally determine, the decisions he or she will make in the future. But moreover, this same cerebral cortex will allow him or her to create models of future reality, that is, to imagine the future, to construct images about it. These images will be generated, inevitably, using as basic material images of the past, knowledge about the world and the way it works that have been provided by our experience. It is for this reason that this imaginative capacity has been called "future memory", it being based fundamentally on memories. The area of the brain that sets in motion these superior functions of future planning is the frontal lobes, an anatomical region whose role has only recently begun to be understood.

In the course of the evolutionary process, all of this increasing capacity for elaborating information has had to be integrated with the already existing basic functions which, essentially, have gone unmodified. As regards the emotions, the amygdala and other limbic structures have conserved the primordial role they have played since the earliest mammals. It falls to them to assign affective value to stimuli and to start up the appropriate responses according to the result of that assessment. The novelty consists in that the amygdala now has, to use a computer metaphor, many more databases to consult in order to reach a conclusion. An evolution has taken place similar to that which has occurred in the field of aeronautics. Modern aeroplanes fly by means of mechanical systems which are fundamentally the same as those of all aeroplanes in the past: movements in the ailerons and changes in the power of the motors. The difference lies in that in the aeroplanes of the past these movements were governed entirely by the decisions of the pilots, while today's craft are equipped with sophisticated com-

puters that can make complex calculations very quickly, and deal with more difficult navigational conditions, thus relieving the crew of some of their former tasks. In the end, however, the result of all these operations has to be translated into the same relatively simple mechanical orders. Something analogous appears to be the case in the field of emotions. In spite of the complexity and sophistication of the human cerebral cortex, the result of all its considerations ends up having to be approved or rejected by the amygdala or structures with equivalent functions in the limbic system. In order to remove some of the oversimplification of such a statement, we shall briefly examine the experimental data behind it. It will therefore be necessary to turn our attention briefly to the frontal lobes.

The frontal lobes of the human brain are a fascinating anatomical structure, partly because of the tenacious resistance they have shown in their reluctance to reveal the role they play in the complex cerebral machinery. It should be borne in mind that they account for approximately a third of the brain's volume, and that this enormous percentage is not found in other species. For example, in chimpanzees it is 17%, while in cats they represent only 3% of total encephalic mass (Junqué, 1994). This suggests that at least some of the specifically human mental functions may be related to the frontal lobes. One of the reasons why the frontal lobes have constituted an enigma for clinicians and researchers for so long is the scarcity of disorders found through psychological tests carried out on patients with lesions or tumours in this region of the brain. However, these people, in contrast to their good results in psychological tests, have presented great difficulties for resolving life's practical problems. At the present time it is beginning to be understood why this is so, and much of this understanding we owe to the study of patients who have suffered important lesions in this area, either as a result of traumatism, or as a consequence of cerebral tumours and their surgical treatment.

Such patients are not especially numerous, at least those that have been properly studied. Their history begins in 1848 with the famous case of Phineas Gage. Gage was a foreman working on the construction of the railroad in the state of Vermont. As a consequence of an explosion, he was hit by a tumping iron, which entered his cheek and exited through the top of his head, destroying much of his frontal lobes. The case of Phineas Gage is an extraordinarily interesting, curious and moving one (Barker II, 1995). However, although it helped to solve part of the enigma of the frontal lobes, it was not until recently that researchers began to get to the bottom of the mystery. With the aim of presenting briefly what these patients have allowed us to learn, I would prefer to refer to a far more recent case, studied with modern techniques, and for which a considerable body of data is available. The case in question is that of the patient EVR, a case reported by Eslinger and Damasio (1985). EVR –or Elliot, as Damasio calls him, was diagnosed as having a meningioma (a benign tumour in the meninges) that had begun to grow from the midline, above the nasal cavity and the eye sockets, and which was pushing the frontal lobes upwards. Although in themselves benign, it becomes necessary to extirpate these tumours, since otherwise they end up compressing the brain and destroying it. Elliot underwent an operation which was, from a surgical point of view, a success; the tumour was completely removed and all the previous symptoms disappeared. Elliot was a young businessman with a happy family for whom things were going very well. However, after the operation, nothing was as before. First, he lost his job, as he was unable to complete successfully the tasks he was given, even though he was capable of carrying out correctly any of them separately. He then entered into a series of business ventures that did not go at all well. Above all, his partnership with another businessman with a bad reputation was a disaster, and led to Elliot's ruin, as he had invested all his reserves of capital in the enterprise. As regards family life, things went no better. His first marriage ended in divorce. He married again and got divorced again. Finally, unhappy in his personal life and jobless, he was denied disability benefit by the welfare department and forced to go and live with his brother. The surprising thing about Elliot's case was that all of these disasters in his real life occurred without any of the neuropsychological tests to which he was submitted revealing any important deficit. On the contrary, Elliot's scores were average or high in all of the tests. His perceptive capacity, his memory of the past and capacity to learn new things, his language and his mathematical abilities remained intact and were all above average, as they had been before the operation. Even in the Wisconsin Card Sorting Test, especially designed to detect disorders caused by prefrontal lesions, Elliot had no problems. However, in spite of everything, something was not functioning in his life, as evidenced by the unfortunate decisions that one by one had ruined his existence.

How can we explain this divergence between the capacity to solve the problems of real life and the ability to deal with the questions found in intelligence tests or carry out tasks in the artificial context of the laboratory? It is clear that the tests to which he was submitted were unable to detect a subtle psychological deterioration

which, despite its elusive nature, was to have catastrophic consequences for Elliot's ability to make personal decisions of vital importance. From all appearances it would seem that the theoretical and abstract reasoning and problem-solving of the laboratory bears scant relation to the reasoning and decision-making involved in personal life and social relationships in the real world. For reasons of space, we are unable to present here either all the arguments nor the entire process that led Damasio to formulate his hypothesis on the role of the frontal lobes in decision-making. I shall confine myself to an exposition of the hypothesis and of the main arguments supporting it. Those wishing to read more about this fascinating matter may wish to begin with Damasio's book *El Error de Descartes* ("Descartes' Error") (Damasio, 1996).

THE HYPOTHESIS OF THE SOMATIC MARKER

Damasio's explanation of the way we make decisions is based on what he calls "the hypothesis of the somatic marker", which, at a neurobiological level, consists fundamentally in a collaboration between the modern prefrontal structures and the more primitive systems of the amygdala and other limbic areas related to it. Damasio argues that the strictly rational processes are not alone responsible for the majority of the decisions we make in everyday life. And this is due, basically, to the manifest incapacity of these rational mechanisms for providing a quick and appropriate response to the problems presented to it. A purely "rational" solution to many of the problems we have to deal with would require enormous amounts of time to consider all the possibilities and to predict outcomes, then calculate all the costs and benefits in order to make comparisons and come to our decision. Just to keep abreast of all the diverse results of the calculations we were making would demand a memory capacity and time that we do not have available and do not employ in the majority of our decisions. But this does not mean "rational" processes are not involved. What Damasio argues is that these processes are powerfully assisted by other mechanisms of a basically emotional nature. What happens when we are faced with the need to choose between several alternatives? All of us can think of a personal example of a decision we have had to make recently, or that we will have to make in the near future. These decisions may be of very different types, but in all of them we can find similar features that allow us to discover a common problem. Let us consider the choice of a career, of a marriage partner, or of a doctor to consult about a health problem. Or, alternatively, where we will spend our holidays, or whether to ask for a mortgage to buy a flat. The argument we presented above was that, besides rational elements, which undoubtedly play a greater or lesser role in any of these decisions (for example, the economic factors involved in planning holidays), the emotions represent a fundamental factor.

How, then, do emotions intervene? The hypothesis of somatic markers explains it like this: faced with the different possibilities of action the prefrontal cortex is capable of creating a representation, albeit quite fleeting, of the diverse scenarios that may occur as a consequence of each possible decision. That is, it is able, with the cooperation of diverse regions of the sensory cortex, to generate images related to how things would be in the event of our taking decision a, b, c or x. These images or fragments of images contain not only the purely descriptive elements of the situation, but also serve to sketch out, to evoke some idea of the emotional reaction that the real situation would cause in us. And this sketch includes a foretaste of the visceral and somatic modifications linked to the emotion. It is these physical modifications that Damasio calls "somatic markers", since they provide the different scenarios presented to us by the imagination with a kind of corporal label, with a somatic identifier that shows us how the visceral landscape referred to above would look if the imagined situation were to become a reality. The modification of this landscape may be positive, that is, the changes produced may be pleasant, or negative, awakening "unpleasant" visceral sensations. The result of this "marking" allows the brain to discard quite rapidly the action possibilities that have, so to speak, "scored poorly" in this brief emotional exam. By contrast, in the case of those possibilities marked positively, the way is opened for preselection as candidates for the final choice. This procedure permits a processing speed with which strictly rational calculations cannot compete. It should be stressed that this "somatic marking" of the possibilities presented by the imagination does not always occur in a conscious way; however, although the visceral reaction provoked by the marking may take place unconsciously, this does not prevent it from having the effect required for making the decision.

Another of the characteristics of this mechanism is that it allows a totally personal assessment of the possibilities presented. It is not an abstract simulation of the advantages and disadvantages of a given course of action, but rather a kind of "dress rehearsal", with a customised and finely-tuned assessment taking into account one's own personal history. Patients with lesions of the

frontal lobes are able to solve problems that require abstract intelligence quite well, but they fail when they have to interpret and deal with real situations using their own affective history to put them in context. It is precisely in making personal decisions that they fail, since the fine communication between the prefrontal and limbic structures has broken down, so that they are unable to carry out the delicate task of subjecting the scenarios predicted by their imagination to the consideration and assessment of their own emotional characteristics. These patients are obliged to use an excess of purely rational mechanisms, which are seen to be inappropriate for resolving the majority of difficult problems in real life.

CONCLUSIONS

We find ourselves, then, before a new perspective: that of having to consider that the emotions, far from being an obstacle to appropriate decision-making, as they have been viewed from the rationalist perspective, are an indispensable requirement for it. It is as though current neurobiological research is confirming what Pascal's intuition famously told him –"the heart has reasons that reason ignores". This does not mean that the emotions cannot make mistakes. Nor does it mean that certain very strong emotions (specifically those more primary ones which, due to the nature of the stimulus or one's personal history, irrupt violently into psychic life, precluding the delicate mechanism of consultation with the frontal lobes) may not give rise to unpremeditated acts with disastrous implications for the person's life. It is precisely in such cases that the decision process we have described does not take place, as it is swept aside by more primitive mechanisms (you will recall the direct routes from the thalamus to the amygdala, referred to earlier) that "hijack" the capacity for decision.

The new frontier of knowledge about the emotions is modifying our view of the relationship between the cognitive and affective worlds of the human being. We are beginning to understand more and more how our whole life is governed by the mysterious and disturbing helmsman of our deepest feelings.

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