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第 31 回本田賞授与式 記念講演（2010 年 11 月 17 日）

「情動の神経生物学～医学と文化の帰結」

南カリフォルニア大学
神経科学デビッド・ドーンサイフ教授
脳・創造研究所長

アントニオ・ダマジオ博士

“The Neurobiology of Emotion: Consequences for Medicine and Culture”

Commemorative lecture at the 31st Honda Prize
Awarding Ceremony on the 17th November 2010

Dr. Antonio Damasio

David Dornsife Professor of Neuroscience
Director, Brain and Creativity Institute
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HONDA FOUNDATION

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Curriculum Vitae for Dr. Antonio Damasio

■生まれ

1944年2月25日　（66歳）ポルトガル・リスボン
（米国市民）

■学　歴

1969年	リスボン大学医学部卒業
1974年	リスボン大学医学博士

■職　歴

1989年～	ソーク生物研究所 客員教授（カリフォルニア州ラ・ジョラ）
1975～2005年	アイオワ大学 ヴァン・アレン名誉教授
2006年～	南カリフォルニア大学 神経科学デビッド・ドーンサイフ教授・脳創造研究所長

■著　書

「デカルトの誤り～情動、理性、人間の脳」（Descartes´ Error: Emotion, Reason, and the Human Brain）や「感じる脳～情動と感情の脳科学　よみがえるスピノザ」（Looking for Spinoza: Joy, Sorrow and the Feeling Brain）など７冊の著書と３５０超の出版物を執筆。今秋には「Self Comes to Mind」を出版予定。

■主な受賞歴

学術分野：欧州芸術科学アカデミー会員（1993年）、国立科学アカデミー医学協会会員（1995年）、米国芸術科学アカデミー会員（1997年）、ベルギー王立医学協会永久会員（1998年）、米国医師協会会員（1998年）、バイエルン科学アカデミー会員（2002年）、リスボン科学アカデミー会員（2006年）、心理科学協会フェロー（2009年）

名誉学位：アーヘン大学名誉博士（D. Phil. H.C.・2002年）、アヴェイロ大学名誉博士（D. Phil. H.C.・2003年）、コペンハーゲン大学ビジネススクール名誉博士（D. Merc. H.C.・2009年）、ライデン大学名誉博士（D. Phil. H.C.・2010年）

受　　賞：Pessoa 賞（Hanna Damasio 博士と共同受賞・1992年）、ポルトガル Santiago da Espada (Grand Oficial)勲章（1995年）、米国 Minerva 財団 Golden Brain 賞（1995年）、仏 Ipsen 財団 Plasticité Neuronale 賞（1997年）、フィンランド The Reenpää 賞（2000年）、科学情報協会「神経科学分野で最も引用される研究者」（2002年）、Nonino 賞（2003年）、Signoret 認知神経科学賞（Hanna Damasio 博士と共同受賞・2004年）、科学技術研究 Asturias 王子賞（2005年）、英国 Richard Wollheim 賞（2009年）

■BORN

BORN in Lisbon, Portugal ; U.S. citizen

■DEGREES

1974, PhD, University of Lisbon, Portugal
1969, MD, University of Lisbon Medical School, Portugal

■APPOINTMENTS

2006 – Present	University of Southern California, Los Angeles, CA, U.S. ; David Dornsife Professor of Neuroscience, and Director, Brain and Creativity Institute
1975 – 2005	University of Iowa, Iowa City, Iowa, U.S. ; Van Allen Distinguished Professor
1989 – Present	Adjunct Professor, The Salk Institute for Biological Studies, La Jolla, CA, U.S.

■PUBLICATIONS

Damasio is the author of over 350 scientific publications and of seven books, among them *Descartes' Error, The Feeling of What Happens,* and *Looking for Spinoza*.

His most recent book is *Self Comes to Mind*, which will be published this fall.

■SELECTED HONORS

Academies 2009, Elected Fellow of the Association for Psychological Science; 2006, Elected to the Academy of Sciences, Lisbon; 2002, Elected to Bavarian Academy of Sciences; 1998, Elected to the Association of American Physicians ; 1998, Elected to Permanent　Membership, Belgium's Royal Society of Medicine ; 1997, Elected to the American Academy of Arts and Sciences ; 1995, Elected to the Institute of Medicine of the National Academy of Sciences ; 1993, Elected to the European Academy of Arts and Sciences

Honorary Degrees 2010, Doctor Honoris Causa (D. Phil. H.C.), University of Leiden; 2009, Doctor Honoris Causa (D. Merc. H.C.), University of Copenhagen (Copenhagen Business School); 2003, Doctor Honoris Causa (D. Phil. H.C.), University of Aveiro; 2002, Doctor Honoris Causa (D. Phil. H.C.), University of Aachen

Awards 2009, Richard Wollheim Prize, London; 2005,Prince of Asturias Award for Scientific and Technical Research; 2004, Signoret Prize in Cognitive Neuroscience (shared with Hanna Damasio); 2003, Nonino Prize; 2002, Named "Highly Cited Researcher" in Neuroscience by the Institute for Scientific Information; 2000, The Reenpää Prize, Finland; 1997, Prix Plasticité Neuronale, Ipsen Foundation; 1995, Golden Brain Award (Berkeley); 1995, Order of Santiago da Espada (Grand Oficial), Portugal; 1992, Pessoa Prize (shared with Hanna Damasio)

このレポートは、2010 年 11 月 17 日　東京、帝国ホテルにおいて行なわれた第 31 回本田賞受与式記念講演の要旨をまとめたものです。

This report is the gist of the commemorative lecture at the thirty-first Honda Prize Awarding Ceremony on the 17th November 2010 Imperial Hotel, Tokyo.

Dear members of the Honda Foundation and Honda Motor Corporation, distinguished diplomatic and scientific guests, ladies and gentlemen, thank you very much for being here, and let me tell you that I have great pride and pleasure in accepting the Honda Prize. The value of established prizes such as the Honda Prize can be measured by the merit of past recipients. When I become the 31st laureate of the prize, I am joining a long and very important list, and the Honda Foundation is bringing me into the company of a number of very distinguished scholars, scientists and engineers. I'm extremely pleased to be among that group. Of course, what distinguishes that group is the desire to, either through science or through technology, to do two things: one, satisfy human curiosity, which is one of the main driving forces for science, and the other to make a positive contribution to humanity. And in my work, and in the work of my colleagues in our group, either as a neurologist or as a neuroscientist, we have always tried to aim at these two very distinct aspects: on the one hand, satisfy our curiosity for how the brain works in a variety of aspects, and try to solve a number of scientific mysteries, and on the other hand, try to alleviate human suffering. This is because, as you well know, neurology is one of the specialties that unfortunately brings to the hands of physicians who care a number of very, very troubling diseases. And whether you're dealing with stroke or depression or Parkinson's disease or Alzheimer's disease, you're dealing with diseases that progressively will be treatable, and many of them are today, but they were not even as recently as twenty years ago. And some are still not treatable. But we hope they will be.
So I would like to deeply thank you, the Honda Foundation for bringing me and Hanna here. I can tell you that this is a very important prize for us, and it will also stimulate our colleagues who were very delighted to hear about the prize.

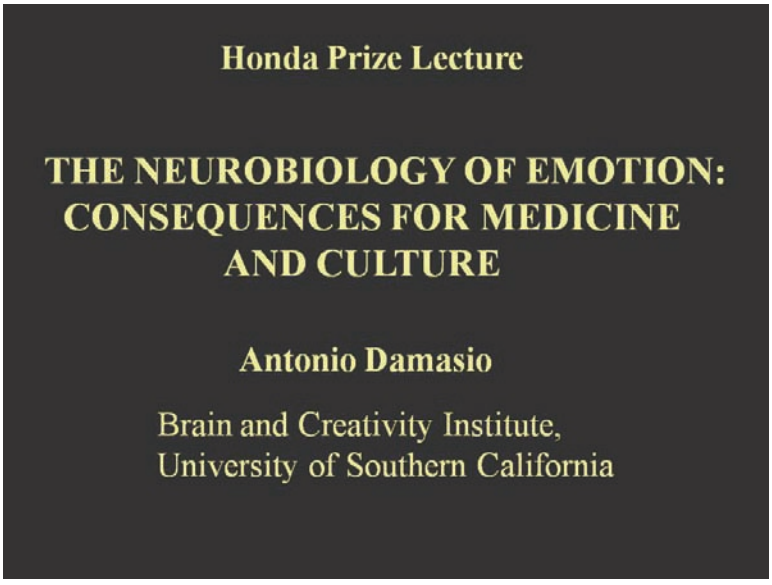

Fig 1

〈Fig 1〉　Now, I will move on to the commemorative lecture, which is entitled “The Neurology of Emotion: Consequences for Medicine and Culture”.

Fig 2

〈Fig 2〉　Let me start by giving you definitions in as simple a way as possible but still true to the science that we practice, definitions of both emotions and feelings. Since I’m going to give you definitions of both, I’m already serving notice that emotion and feeling are not exactly the same, and it is important to make that distinction.

Fig 3

〈Fig 3〉　So let me start by saying that emotions are not unwelcome, irrational disruptions of conscious behavior, although for a long time in the history of science and the history of thinking in general, they have been thought as being irrational and quite unwelcome. Also emotions are

part of the automated management of biological value in a living organism. So there is something called biological value, which we prize and which we need to manage. One way of putting this even more simply is to say that we need to manage life, and that is the main problem that we human beings face, how to manage life. This is a problem that many other species have to deal with. As long as you are alive, you have to have that problem.
What distinguishes us is that we know that we have that problem, and we know that there are things that we can do consciously to solve the problem. Emotions are a step up from reward and punishment mechanisms and from drives and motivations. Many of you have heard about emotions, reward and punishment mechanisms, drives, motivations, and sometimes you may wonder what the relation is. They're part of the same chain. Emotions come in one step up from drives, motivations, reward and punishment mechanisms, which distinguish all living creatures on the face of the earth.

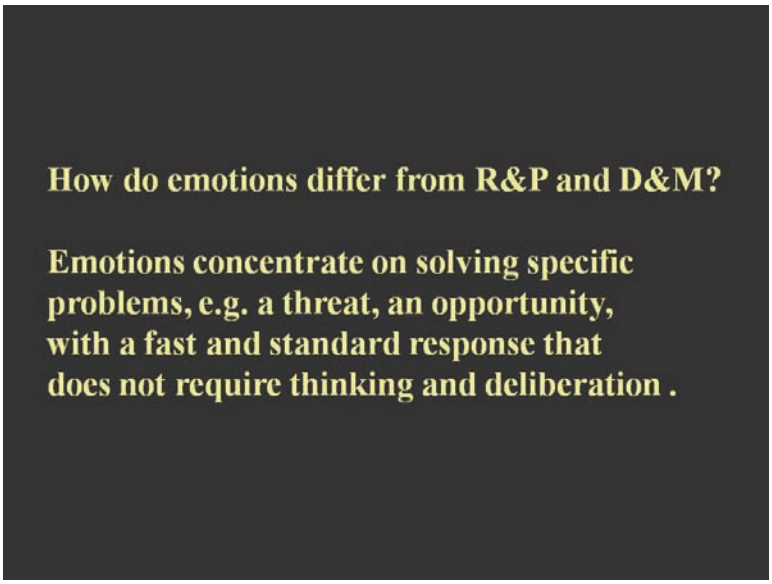

Fig 4

〈Fig 4〉　How do emotions differ from reward and punishment mechanisms and from drives and motivations? Emotions concentrate on solving specific problems—for example, a threat or an opportunity—with a very fast and standard response that does not require thinking or deliberation. So what really makes the distinction and what makes emotions are that step up from the other mechanisms is that they are focused on a specific problem. The problem could be the threat, something that we resolve with the emotion of fear, or an opportunity which may have to do with feeding, drinking or mating for that matter.

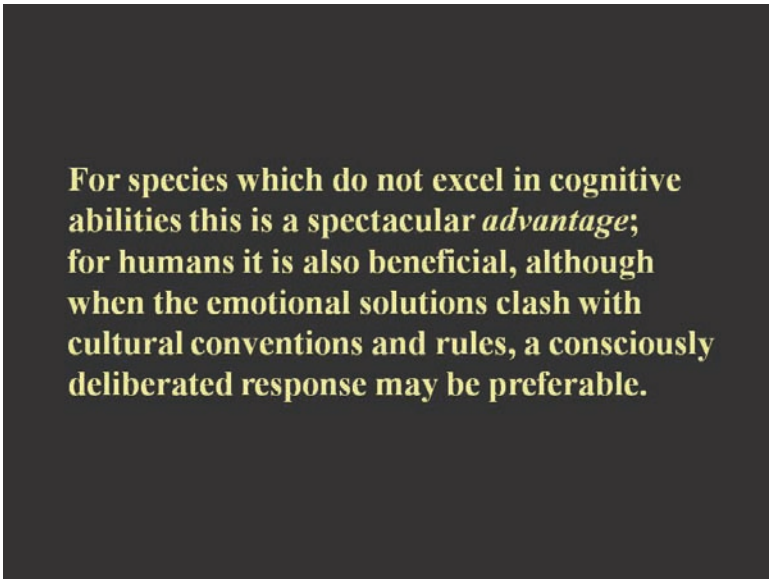

Fig 5

〈Fig 5〉　For species, many other species other than us that do not excel in cognitive abilities, having emotions is a spectacular advantage. For humans, it is also beneficial, although when the emotional solutions clash with cultural conventions and rules, a consciously deliberated response may be preferable. So something that I would like you to see is that we really have available two great mechanisms that nature has given us. On the one hand, we can have emotions, which without any deliberation offer us a very practical, rapid solution that we do not need to think through. But on the other hand, because we have consciousness, reason, a tremendous amount of knowledge and logic, we can also develop responses that are deliberated, responses that we can construct. So we really have the best of the worlds. We have both the world of responses that were generated in evolution, and others that we can generate ourselves.

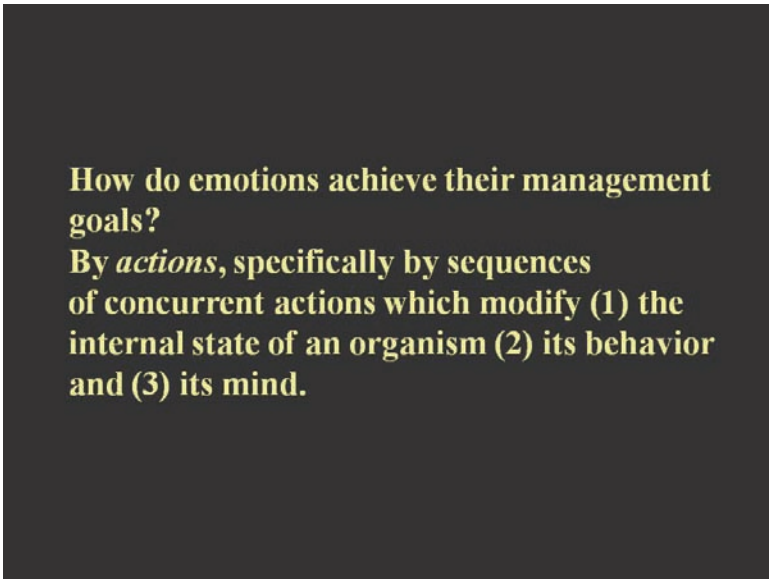

Fig 6

〈Fig 6〉　How do emotions achieve their management goals, the goal of managing life? By actions, specifically, by sequences of actions that are concurrent, they occur at the same time. And those actions modify (1) the internal state of the organism, (2) its behavior, and (3) its mind. This is very important, because I am truly talking about emotions and not yet about feelings. When I do so, I'm talking about actions. Emotions are about actions. And it is no coincidence that the word "emotion" contains the root for "motion." It is about action. It is about movement that is aimed at a particular goal.

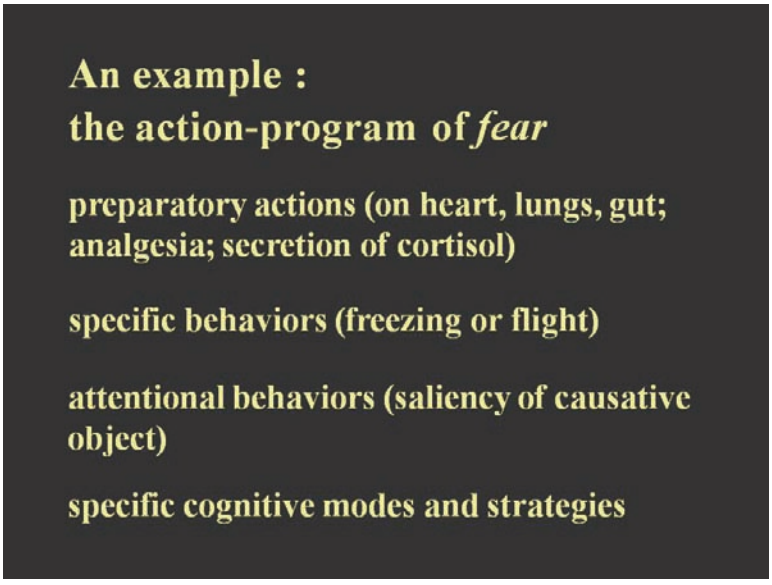

Fig 7

〈Fig 7〉　An example is the action program for fear. I don't want to make you fearful of anything, but let's use fear, because this is one of the best studied emotions from the point of view of biology. The actions that constitute the emotion of fear include preparatory actions that

occur in the heart, the lungs, the gut, that produce analgesia, because when you are about to have fear, automatically our entire system has much less responses for pain. It even includes an action that occurs in the hormonal system, which is the secretion of cortisol. All of these actions are occurring in the entire economy of our organism.

Then we also have specific behaviors, for example the behavior of freezing in place or the behavior of running away from the source of danger, what is causing the fear. Then we have attentional behaviors that provoke a saliency, a high relevance of the object that caused the emotion of fear. Then we have specific cognitive modes and strategies that allow us to think in a particular way, whether we want it or not, during the emotion of fear. So what you see here is an action program. It's not one reflex. It's something more complicated than a reflex. It's a concerted operation. And in fact, the analogy with a mini-concert in musical terms is not a bad analogy at all.

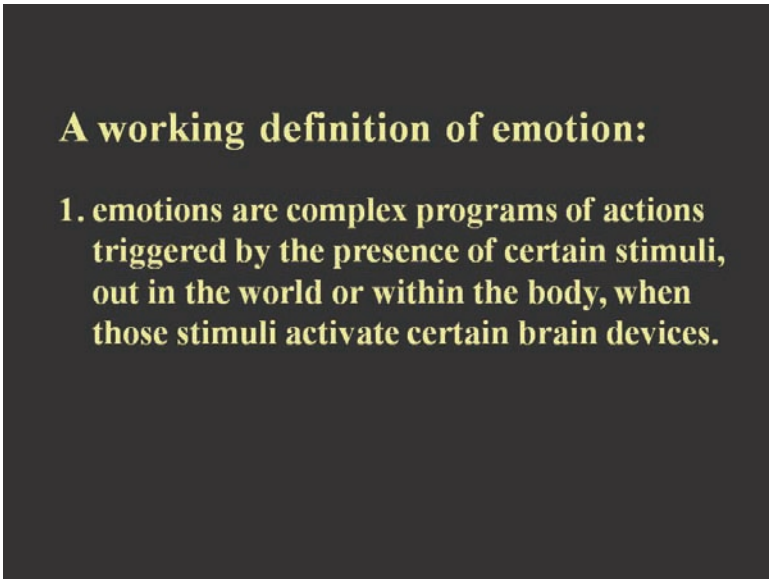

Fig 8

〈Fig 8〉　Now I can start giving you a working definition of emotion. Number one, emotions are complex programs of actions that are triggered by the presence of certain stimuli out in the world or even within the body. For example, if you have all of a sudden a heart attack, you have a myocardial infarction that is developing, you will have major pain, and you will have major fear. You're in fear of something that is happening in your own body. So it's very important to realize that the trigger for the emotion fear does not only come from the outside. It can come from within the body. And those stimuli that are out in the world or inside the body then provoke a response because they activate certain brain devices. I am purposely using terminology that fits, just as well, the world of biology or the world of engineering. You're talking about a device that is, for example, installed in a car or in an airplane, and that allows

you to have a certain response. We are ultimately technology, as the Honda Foundation indicates in the charter of the prize. We have devices in our brains that can respond very rapidly when you have the right stimulus.

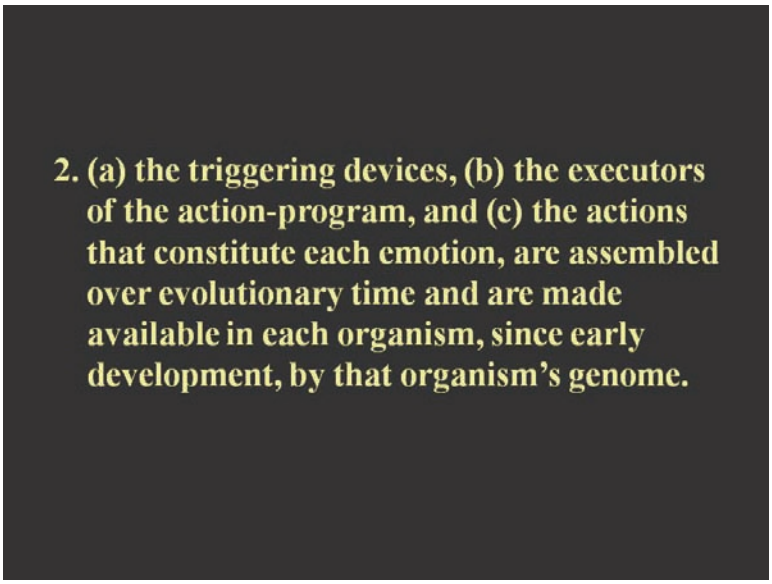

Fig 9

〈Fig 9〉　Then those triggering devices in our brain and the executors of the action programs and the actions that constitute each emotion have been assembled over evolutionary time, and are made available in each organism since very early in development by the organism's genome. What I'm pointing to here is the fact that we are born with the equipment that allows us to have emotions. We do not learn to emote. We are born with the capability to have emotions. It's something installed within our brain, within our organism.

What is very interesting is that we have the capability of controlling our emotions in part. So we can learn to modify our emotions, not completely, but in part. But we don't need to learn emotions. Nobody learns what fear is. You can learn to have fear in relation to a particular object, but we don't need to learn the motions of fear. That's given to us by our genome.

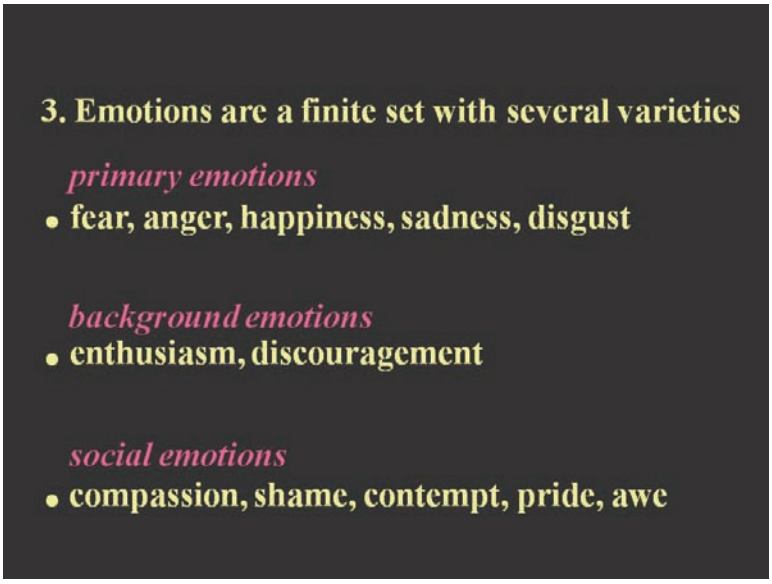

Fig 10

〈Fig 10〉　Let's look at some examples of emotions. It's very important to realize that emotions are not an infinite set. They're a very finite set. In fact, you can talk, depending on the classifications, of about a couple of dozen emotions, and no more. You have primary emotions such as fear, anger, happiness, sadness, and disgust. You have background emotions such as enthusiasm and discouragement. And you have something very important that is very often forgotten, which is social emotions, such as compassion, shame, contempt, pride, awe, and admiration. These are very important because, as I will say in closing the lecture, they have moral values incorporated in the emotion.

Let us look at compassion. First of all, we're not alone as species having compassion. If you go to other primates, they do exhibit compassion as well. But that compassion contains moral values that have to do with how you run the social group. In fact, they are in all likelihood the basis for the further development, through reason, of what we call moral systems and what we eventually call ethics.

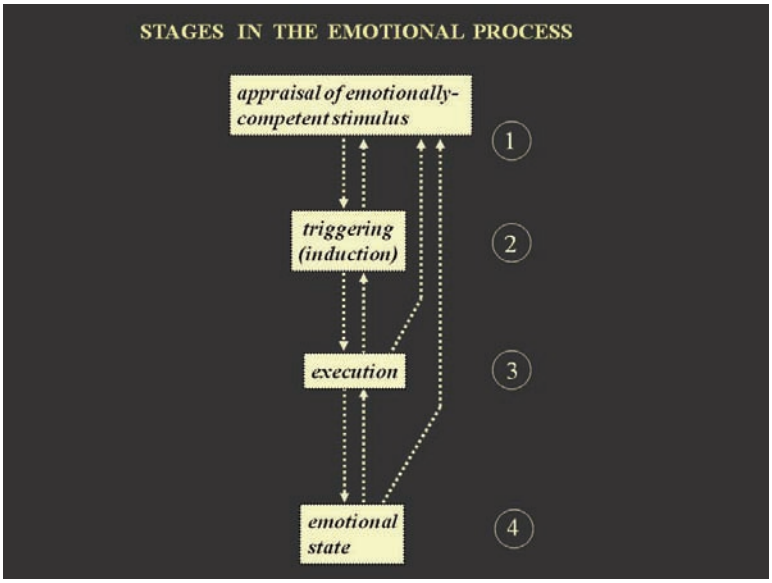

Fig 11

〈Fig 11〉　One of the areas of great progress in research on emotion is the stages of the emotional process. So there you have one, two, three, and four, four stages of the process. The great news is that we now know what parts of the brain correspond to those different components: the appraisal of an emotionally competent stimulus, the triggering of the emotion, the execution of the emotion, and then the creation, finally, of the emotional state.

What is very interesting is that the appraisal of the emotionally competent stimulus is largely given to us by the cerebral cortex. The triggering is given by a variety of structures, either in the cortex or sub cortically. The execution is largely sub cortical, in regions of the brain such as the brain stem and the hypothalamus. And finally, the emotional state occurs not only in the brain but in the body as a whole. The body is the theater of our emotions.

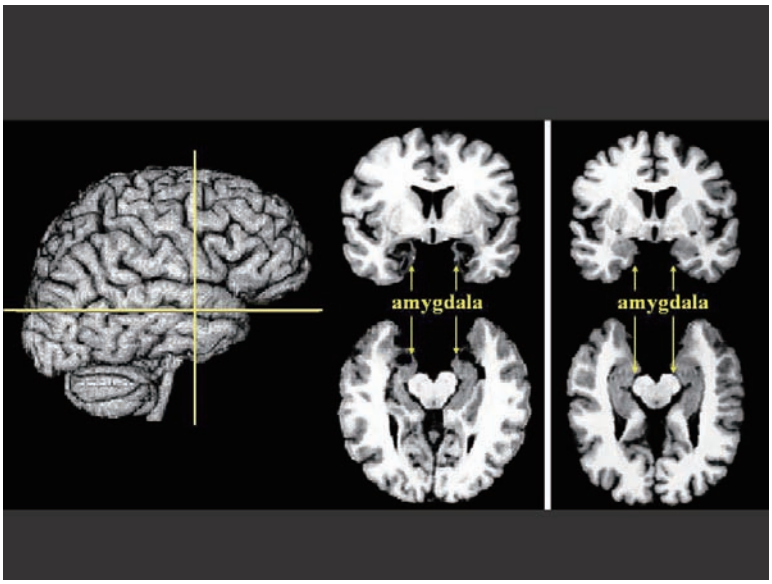

Fig 12

〈Fig 12〉　Now, you're seeing there a region of the brain known as the amygdala. And here you have a normal amygdala, cut into sections. This is done in Hanna's laboratory. Here you have two sections cut in both directions in the brain of an entirely normal person. And you see the normal amygdala. But here you see the amygdala of a patient that has a disease known as Urbach–Wiethe disease. As a result of this disease, guess what happens? You lose the ability to have fear. So this is the one of the many ways in which we have learned which parts of the brain are involved in generating certain aspects of one emotion or another.

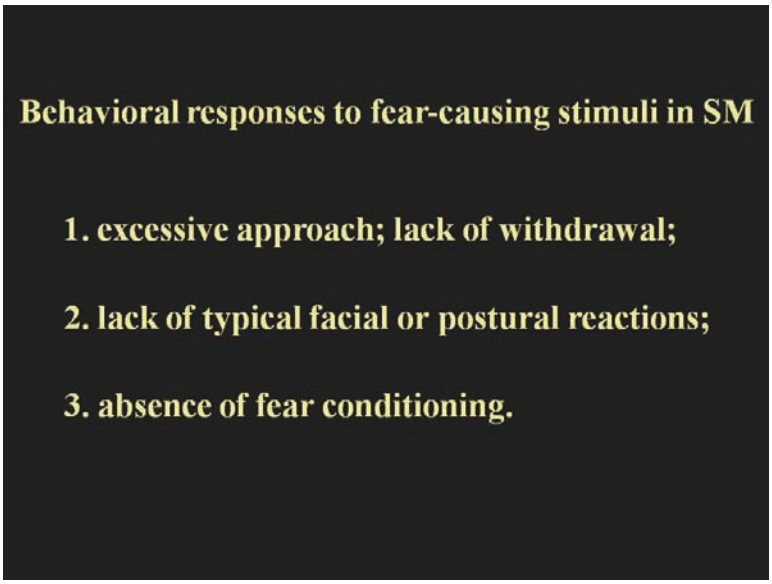

Fig 13

〈Fig 13〉　Now, I'm going to give you some examples or studies of a patient, the patient whose damage of the amygdala was shown there, patient SM, who as a result of that damage, has a variety of problems. For example, this is a patient that approaches any kind of source of danger without any fear whatsoever, and never withdraws from that source. So for example, this is a patient that can manipulate snakes and play with spiders, and will not be in fear of any of that. We never tried, but if were to come with a gun to this patient, the patient would not even recoil in fear. The patient would say, "Well, I probably should be in fear of that gun, but I am not in fear. I don't have that experience." And the person will not have facial expressions of fear, and will not even be able to be conditioned to fear. So fear conditioning, which is one way in which you can study the development of fear in animals as well as in humans, is not possible.

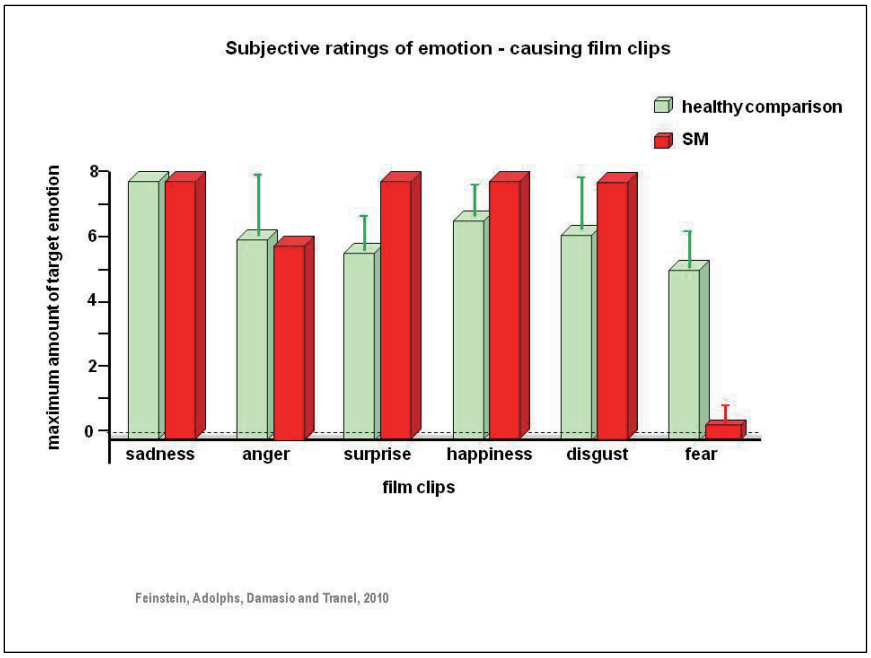

Fig 14

〈Fig 14〉 When we studied this patient with a variety of instruments, such as subjective ratings of film clips that cause emotion, what we found is that whereas healthy comparisons have responses for all the emotions at the bottom, all the way from sadness to fear, you see that the column that corresponds to SM has all the other emotions but not fear, even when she's seeing film clips that ought to cause fear.

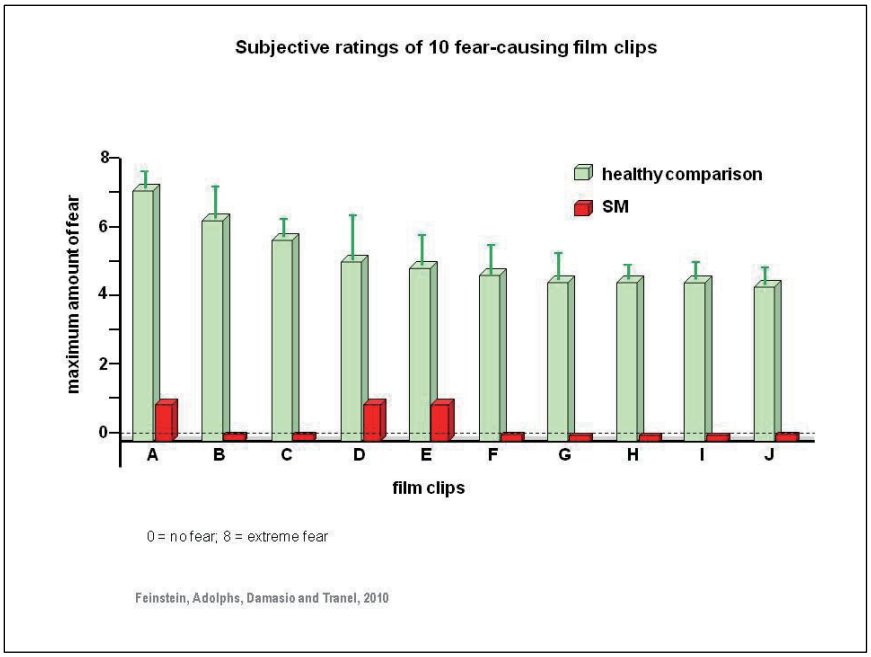

Fig 15

〈Fig 15〉 In the same way in which you can study doing subjective ratings of fear-causing film clips, and this is just for fear, you realize that the healthy comparisons have responses of

fear, but SM, which is the red columns, does not have responses for fear, even if everybody else responds with major fear.

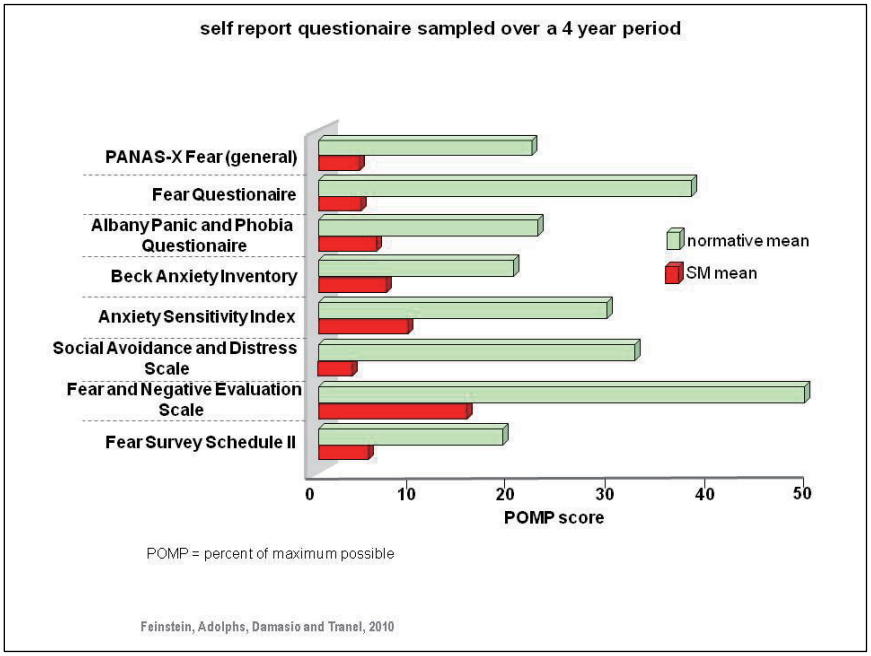

Fig 16

〈Fig 16〉 And when you do questionnaires to find out how this person responds to fear over a long period of time by systematic probing of your responses, you realize that in all instruments, she has very little fear.

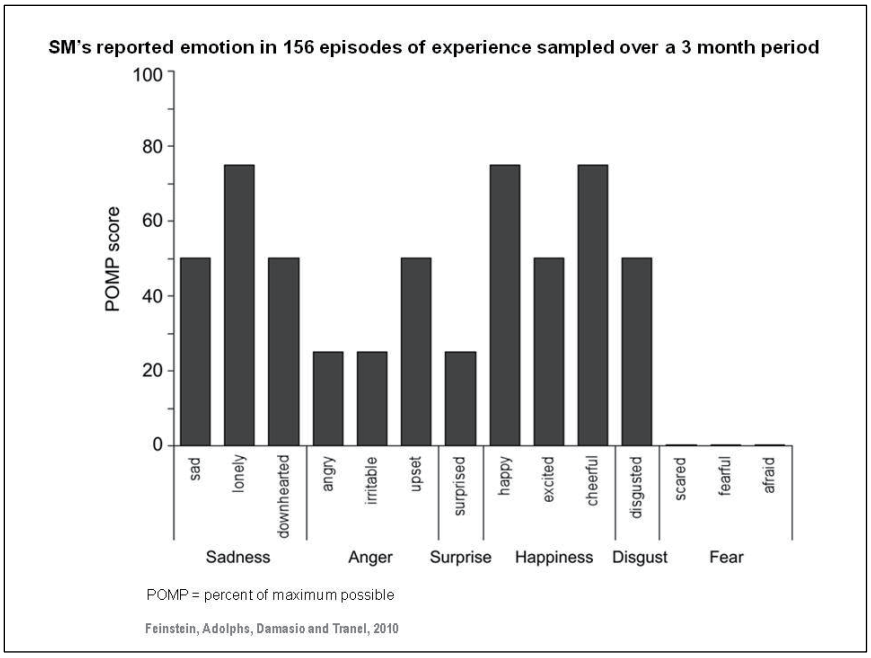

Fig 17

〈Fig 17〉 So we do know that this is a very severe problem, and it has established, in this

patient and others, a very solid relation between this structure and the causation of fear.

Fig 18

〈Fig 18〉　What about feelings of emotion? I told you that feelings are different from emotion, so I'd better give you a definition. And here it is.

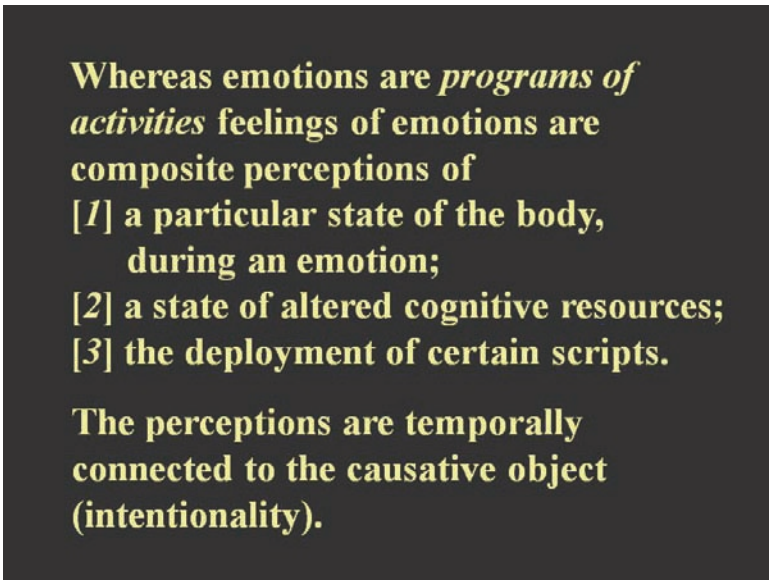

Fig 19

〈Fig 19〉　Whereas emotions are programs of activities, feelings of emotion are composite perceptions of (1) a particular state of the body during an emotion, (2) a state of altered cognitive resources, and (3) the deployment of certain scripts in the mind. So the critical point is the (1) here. When you have an emotion, your body acts and are changed. When you have a feeling, you perceive the change that is going on in your body, and the changes that are going on in your mind at the same time.

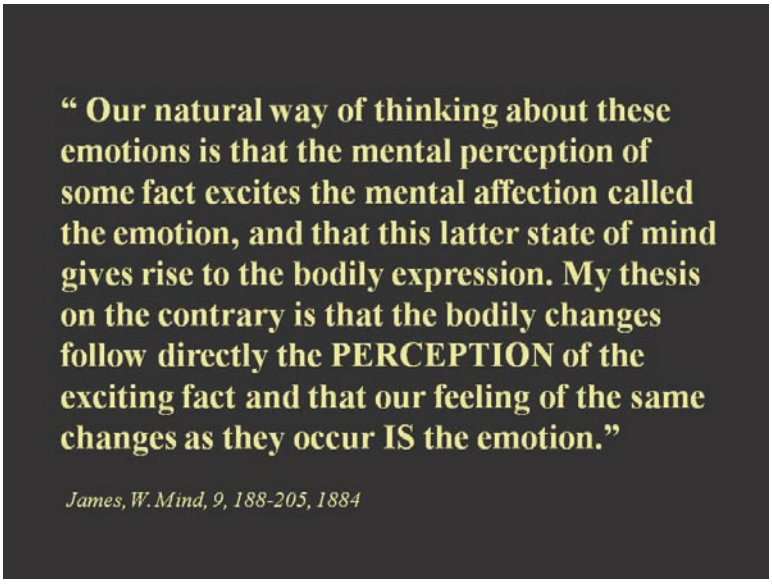

Fig 20

〈Fig 20〉　I may as well give you a comment on one person that is a great intellectual hero of mine, and that is William James, the founder of psychology and pragmatic philosopher, an American philosopher and psychologist. William James, who by the way was the brother of the writer Henry James, in a very famous paper in 1884, had the intuition that the body would be extremely relevant to this. He has a passage that is vey famous that I reproduce here, in which he said, well, contrary to the usual thinking, which is that you have an emotion, and then once you have that emotion in your brain, you end up changing the body, he thought that it was entirely right that once you perceive the source of fear, you change the body first, and it is only after you change the body that you really realize what is going on. So he literally did an inversion of the way the process is normally conceived.

The big problem is that he ended up conflating the idea of emotion and the idea of feeling, as a result of which this did not become quite as clear as one would wish, for a long, long time. So there you have his text.

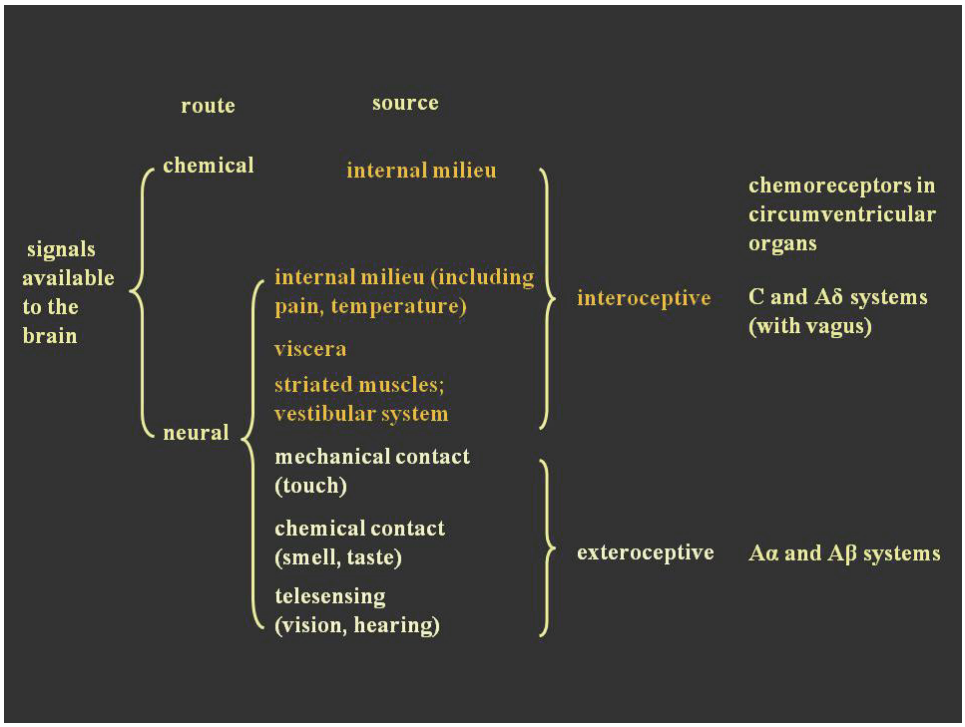

Fig 21

〈Fig 21〉　One thing that William James gave us is the idea that somehow we would get the feeling, precisely because the body would be able to transmit information to the brain, and little did Mr. James know at that time the degree to which different strands of information are conveyed to the brain, and there are very many, all the way from chemical and neural sources of information, from practically every aspect of the body economy.

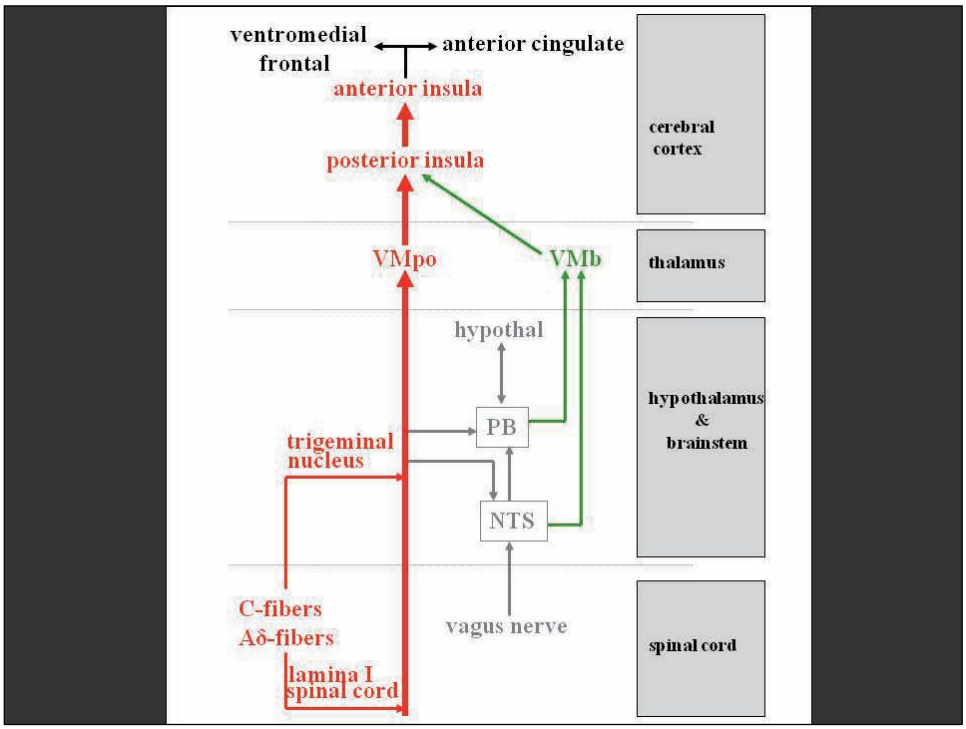

Fig 22

〈Fig 22〉　And you have here a chart that gives you an idea of the different sources of information. I'm not going to go into detail here, because this is extremely complex and would take quite a lot of time. I just want you to realize that there is information from the body that comes at the level of the spinal cord and the hypothalamus and brain stem, the thalamus, and finally the cerebral cortex, ending up in a structure known as the insula.

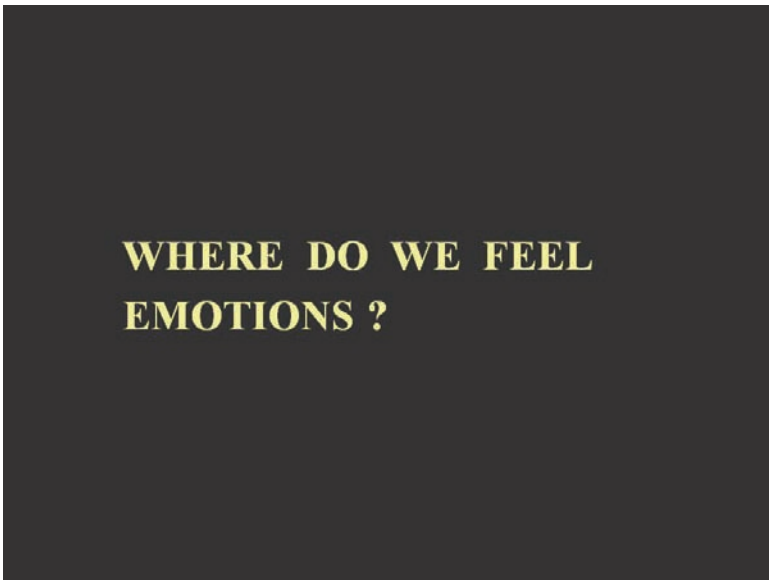

Fig 23

〈Fig 23〉　Where do we feel our emotions?

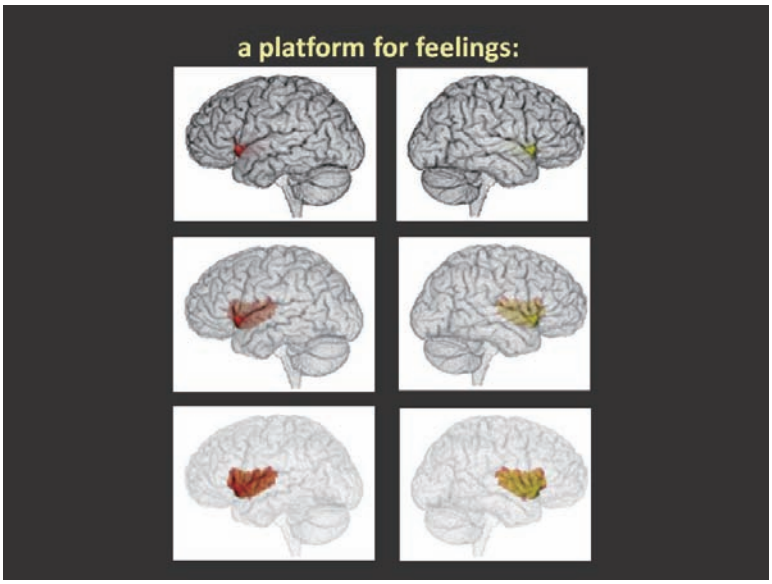

Fig 24

〈Fig 24〉　Many years ago we proposed that emotions would be felt largely with a platform in our cerebral cortex known as the insular cortex. And you have it marked here. These are, by the way, human brains from a normal individual, and this structure, you barely see it if you

look at the outer surface. But then, as you go in, in the transparency inside the brain, you see more and more that there is this very large, literally isolated, cortex, end of the surface of the cortex. It is known as the insula, which of course, as you know, simply means “island.” It is like an island of cortex.

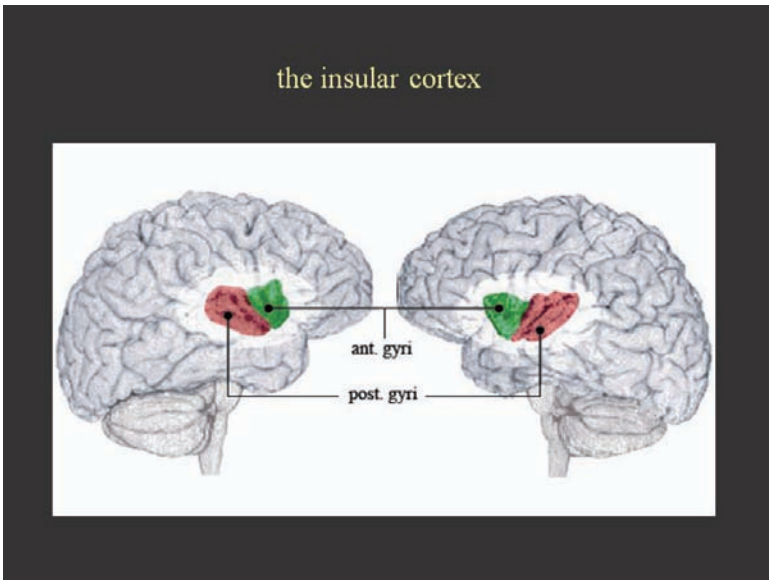

Fig 25

〈Fig 25〉　This region, which here you see more clearly marked, is a region that without a doubt, it’s now clear, is serving as a processor of feelings. But the thing that I can tell you is that although it is quite unequivocal that it is a correlate of our feeling states, whether it is feelings of sadness or joy or compassion or what have you, we now know that it is not the whole story, and there are other structures in the brainstem that are also important for the generation of feelings.

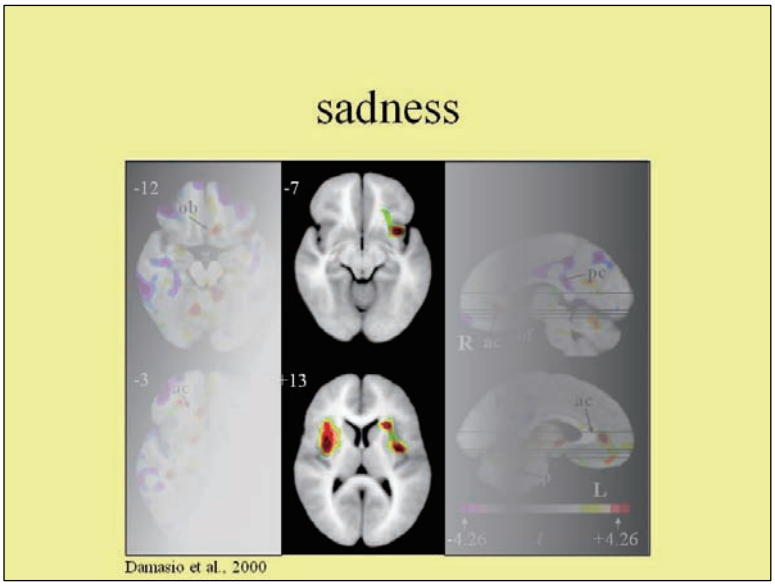

Fig 26

〈Fig 26〉　This is just work from actually ten years ago, in which we first showed that the insula, which is marked here by the IN, was involved when you were having feelings of sadness, but also, as you can see there, when you are having feelings of happiness.

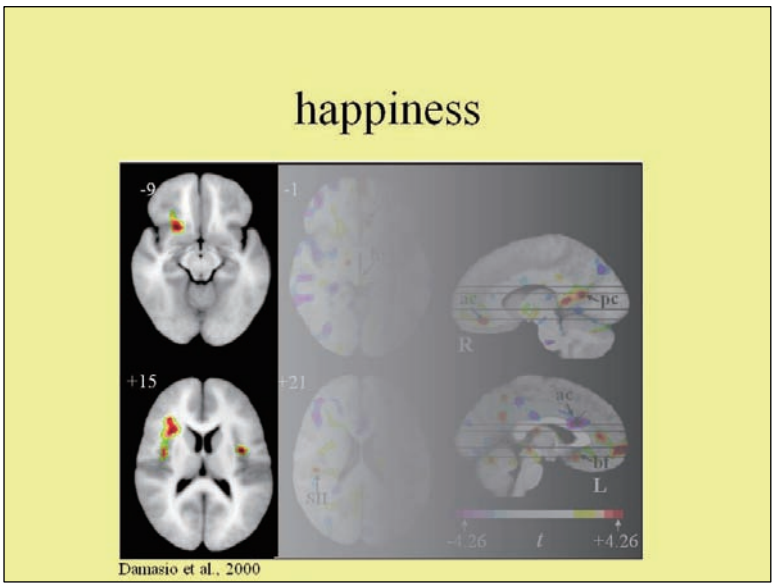

Fig 27

〈Fig 27〉　As you can see here, there is the insula again. So in different kinds of emotion, this region is very active. It is also very active if you are having feelings, for example, of pleasure listening to music that you love, or feelings of complete detestation from music that you hate, or if you're drinking wine, or if you're watching highly erotic movies, or what have you. Practically every kind of feeling will reflect itself in changes in the insula. So you can walk out of this room and say, when I'm having feelings of one kind or another, the insular cortex is going to have some changes. No doubt that is true.

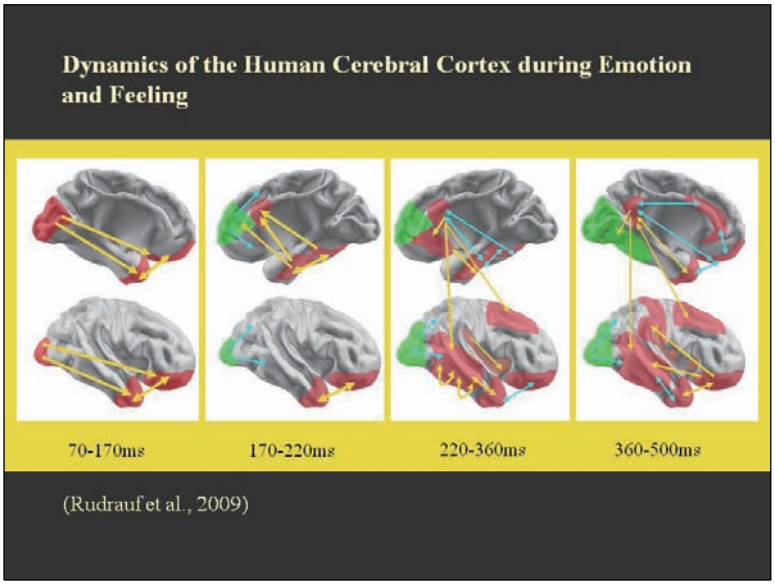

Fig 28

〈Fig 28〉　However, there is more to it, and I'm going to ask this question.

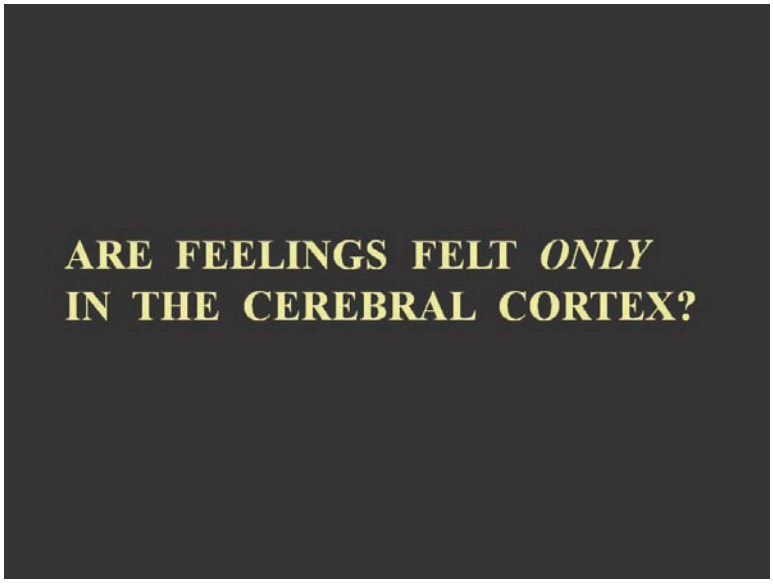

Fig 29

〈Fig 29〉　Are feelings felt only in the cerebral cortex? The answer is no.

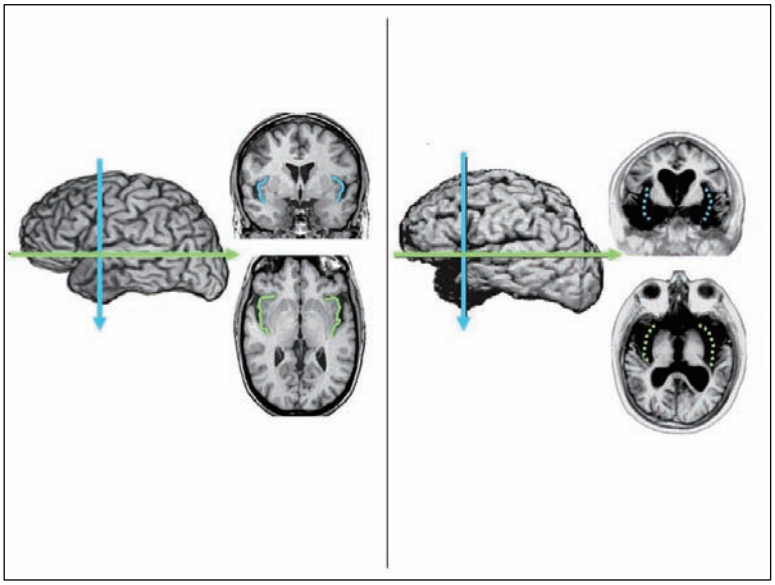

Fig 30

〈Fig 30〉　We know that that's the case by studying patients such as this patient here. If you look here, this is a normal individual with a normal insula. The insula is marked there with the blue. Now, you have a patient here that has had a disease that completely destroyed the insula on both sides. We're going to mark it there. You see that the insula is missing. This is now a void, an entirely destroyed region. What we have to report is that even when you have this kind of damage, the patients maintain feelings. So what we have discovered is that there are two levels of the brain in which feelings can be organized. One is at the level of the

brainstem. I'm going to talk about it in a second. The other is high up at the level of the insula. One contributes to the other.

Here we started out by discovering the most complicated level, which is the insula, and now we've discovered that there is this other level, which is lower down.

Fig 31

〈Fig 31〉　One of the other sources of information for this conclusion is that there are certain patients that are born without any cerebral cortex, without insula whatsoever. Those patients, such as the one shown here in the photograph, with a scan like that, have a condition called hydranencephaly, and these patients can actually grow for many, many years, and attain ages as high as their twenties. These patients actually have emotions and feelings in spite of the fact that they don't have insula cortex. So that is telling us that there are, once again, multiple levels of the organization of the feeling system.

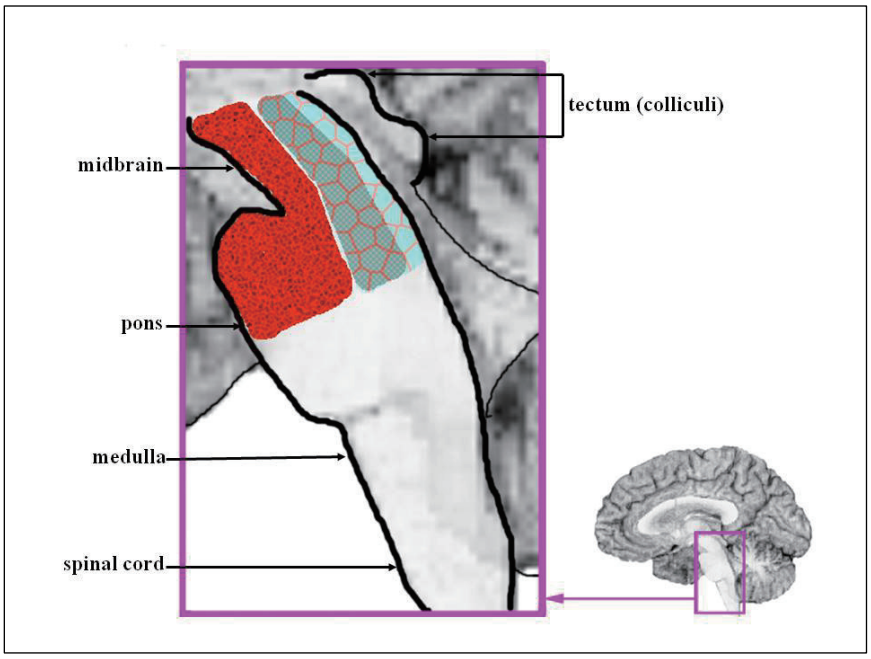

Fig 32

〈Fig 32〉　Where those patients are having feelings such as, for example, the patient with damage to the insula that I showed earlier, it is in this part of the brain, that is known as the brainstem. I'm showing you this part here, which is known as the tegmentum, and which is really in the midbrain.

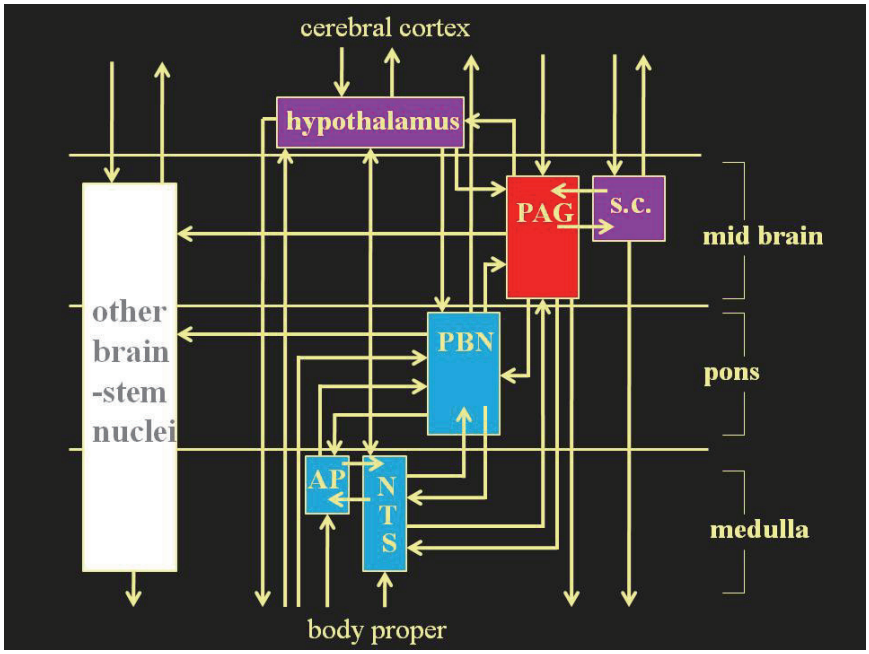

Fig 33

〈Fig 33〉　This region—let me show you one image, and I promise that I'm not going to talk about all the details of this—seems like a very small area, but in fact it's a whole universe of modules, very much like the modules that you can have in a very complex computer system.

Those modules, which include the area postrema, the nucleus tractus solitaries, the par brachial nucleus, the periaqueductal gray, and the hypothalamus, these modules are all heavily interconnected. So these are regions of the brain that are very small, and yet they have very complex maps of our entire body, so they can represent the body when we are undergoing an emotion. They have topographic maps as detailed, in fact, as the maps that you have on the cerebral cortex. And they have this property of reclusiveness. For example, you see that the periaqueductal gray connects to the PBN (par brachial nucleus), but the PBN also connects to the periaqueductal gray. You have all of these loops. You go in one direction, you come in the opposite direction, and so on. So what this creates is a world capable not just of sending signals from the body to the brain, which is of course what William James would have wanted to have over 100 years ago, but also of transforming those signals and generating something new, which is the source of feelings to begin with, the first platform. Just as one aside, I can tell you that this is also extremely important for the generation of consciousness. So we end up constructing our sense of self thanks to these structures, which is the reason why, when you have damage to these structures, one of the main results is coma and vegetative state. It's because this region is so vital to the generation of the first levels of consciousness, which are really in the form of primordial feelings.

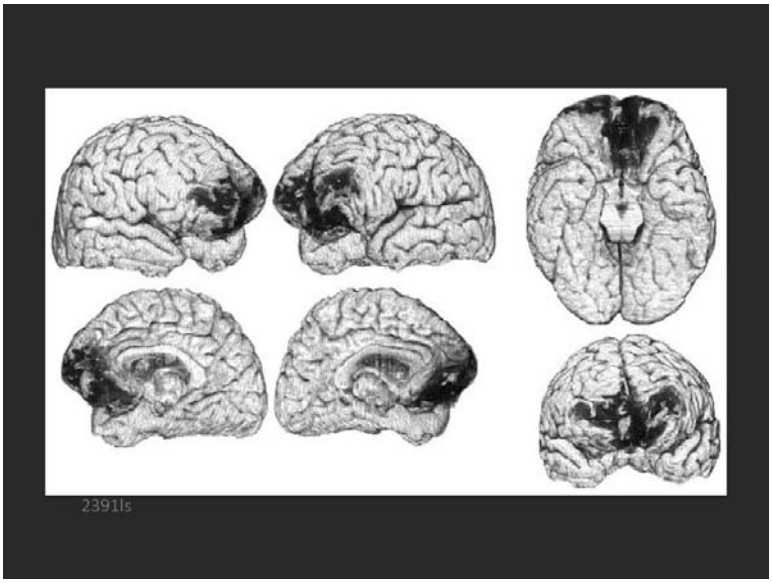

Fig 34

〈Fig 34〉　Let me just conclude my comments for tonight with two series of commentaries. One has to do with the fact that emotion, as I mentioned in the title of the lecture, has consequences, and consequences that are obviously very good for the organization of our brain and for our mind. And some of those consequences have to do with decision-making. It was mentioned today by several of the speakers that we talked about semantic markers, and about

the role of semantic markers in making decisions. Quite simply, what we wanted people to understand is that after a long period of pure rationality, in which we were thinking that reason and logic and knowledge were the only sources of proper decision-making, we thought that it was important, in many conditions and in many situations, to have the contribution of prior experience with emotion in order to rearrange the process of decision-making and make it more adapted to the reality of the moment. This is something that today is very much acknowledged, even in the world of economics. It's quite obvious that the idea of individuals, human beings that would make their economic decisions, whether they are making policy in the financial system or running their investments, the idea that everyone does make those decisions in terms of knowledge of facts, logic, and reasoning, is complete folly, because that is not the way human beings work. We all know that people make very irrational decisions sometimes, which are driven by emotions, and that sometimes they make things that appear to be very rational that are also driven by emotions. So there is a factor that is emotional in these processes of decision that we have to account for. I would just like, since this was mentioned in the citation of the prize, to say that the reason why we tumbled on to that fact comes from looking at damage like this. Here you have a brain of a patient that appears largely normal except for the region of the frontal lobe, that you see here and here and here.

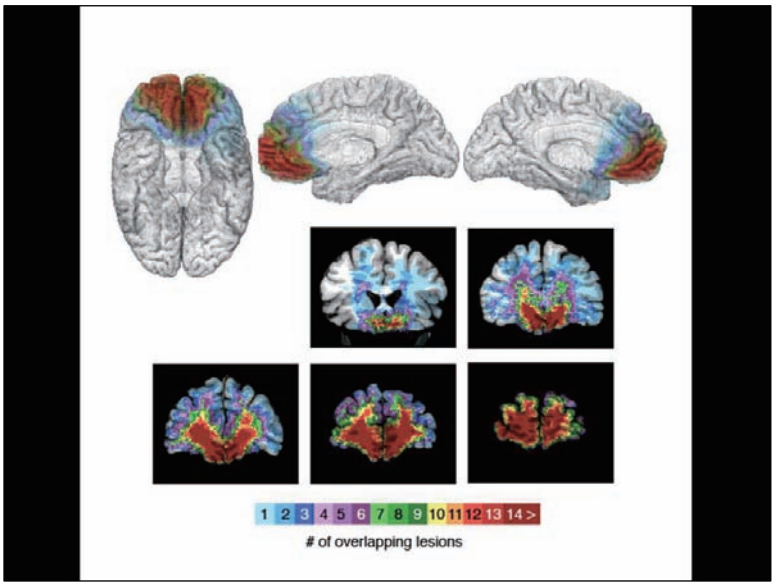

Fig 35

〈Fig 35〉 These are all different views of the same brain of the same patient, and the patient is alive by the way. This is all reconstructions done with magnetic resonance in Hanna's lab, and it's all non-invasive and very beautiful and very detailed, looks like post-mortem but is not a post-mortem study. This is a living patient whose brain has been analyzed in the laboratory. When you have this, guess what happens? People are intelligent. They have good memory.

They have good knowledge. They have a good motor system. They look, for all intents and purposes, like normal individuals. If you have a conversation with them, you're not going to say there's something wrong this person.

Take this person out into the real world, however, and what you find is that this person systematically makes decisions that violate what the rules would be, whether it is decisions in the realm of social behavior or even personal financial decisions. So something is wrong here. What is wrong is the possibility of bringing information of past emotional experience of decisions to bear on the decision of the moment.

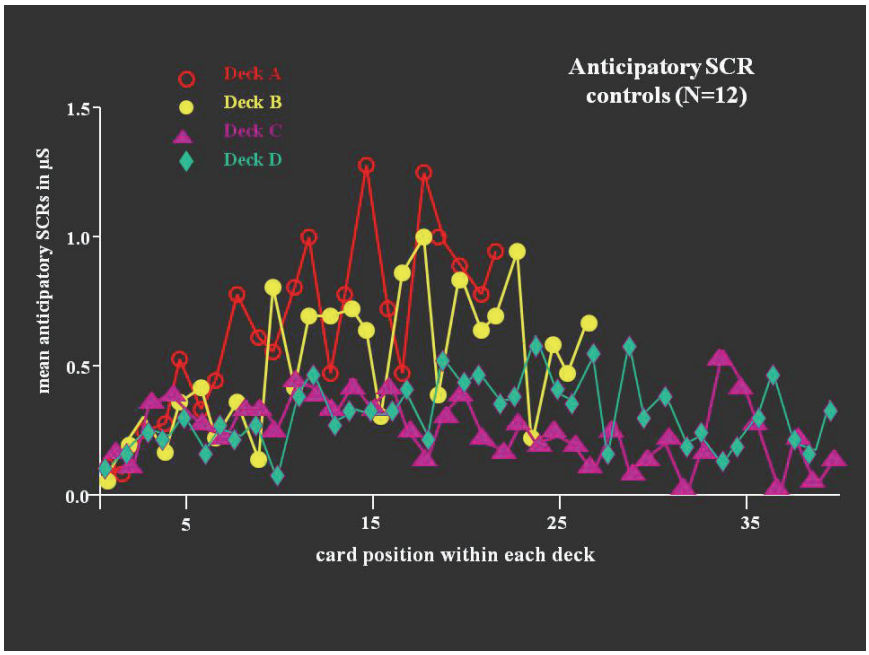

Fig 36

〈Fig 36〉　By the way, when you plot many, many of these patients, you realize that that's the area that is the culprit, the area that is really the problem in this condition.

Now we did, in work that involved colleagues of ours, of Hanna and myself, Antoine Bechara and Daniel Tranel, we did a study that focused on how, in a gambling task, patients or normal individuals would be able to learn what was happening in a variety of exchanges that involved punishment or reward, and we studied what was happening in terms of emotional reactions, for example with skin conductors.

And what we found out is that if you are a normal individual, when you're playing that game, you very rapidly learn, even if you are not aware of it, that there are certain decks in this particular game. There are good decks, and certain decks that are bad decks. And here, you have the following. You see that decks A and B, which are the bad decks, start giving a skin conductance response that is very high, that gives you all of these very high responses,

whereas the good decks are not giving you those responses. So there is something in the brain that is allowing you to make a distinction between things that are good bets and things that are bad bets, but you don't know that that is happening.

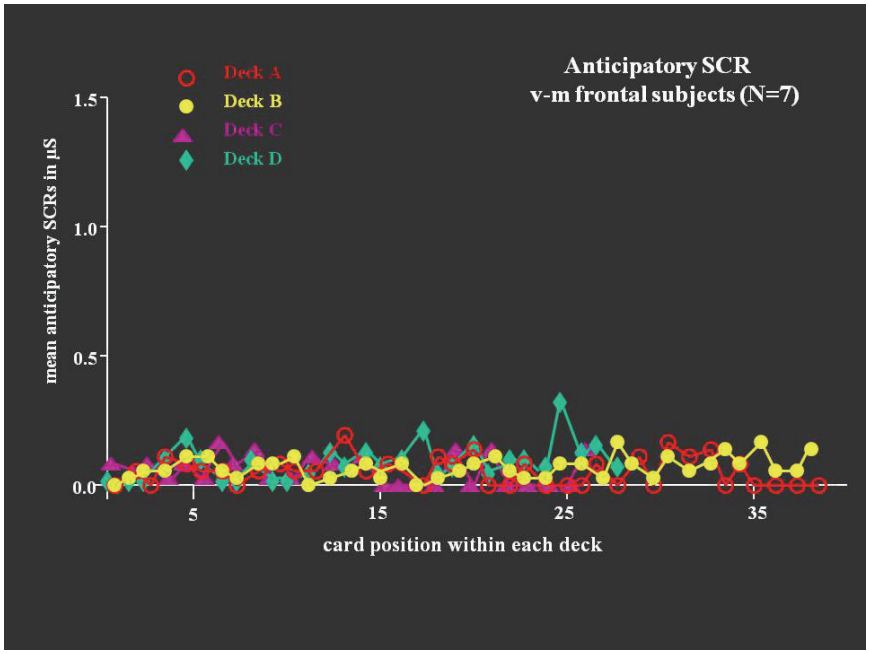

Fig 37

〈Fig 37〉　If you turn to patients with frontal lobe damage, like the one you saw, and you look at good decks and then you look at the bad decks, you realize it's all the same. So the patients that have that damage no longer have the mechanism that would allow them to differentiate between good options and bad options. All of that process is occurring non-consciously, and it is out of that non-conscious process, which is governed by emotion, that you influence your decisions and you go either in one direction or another.

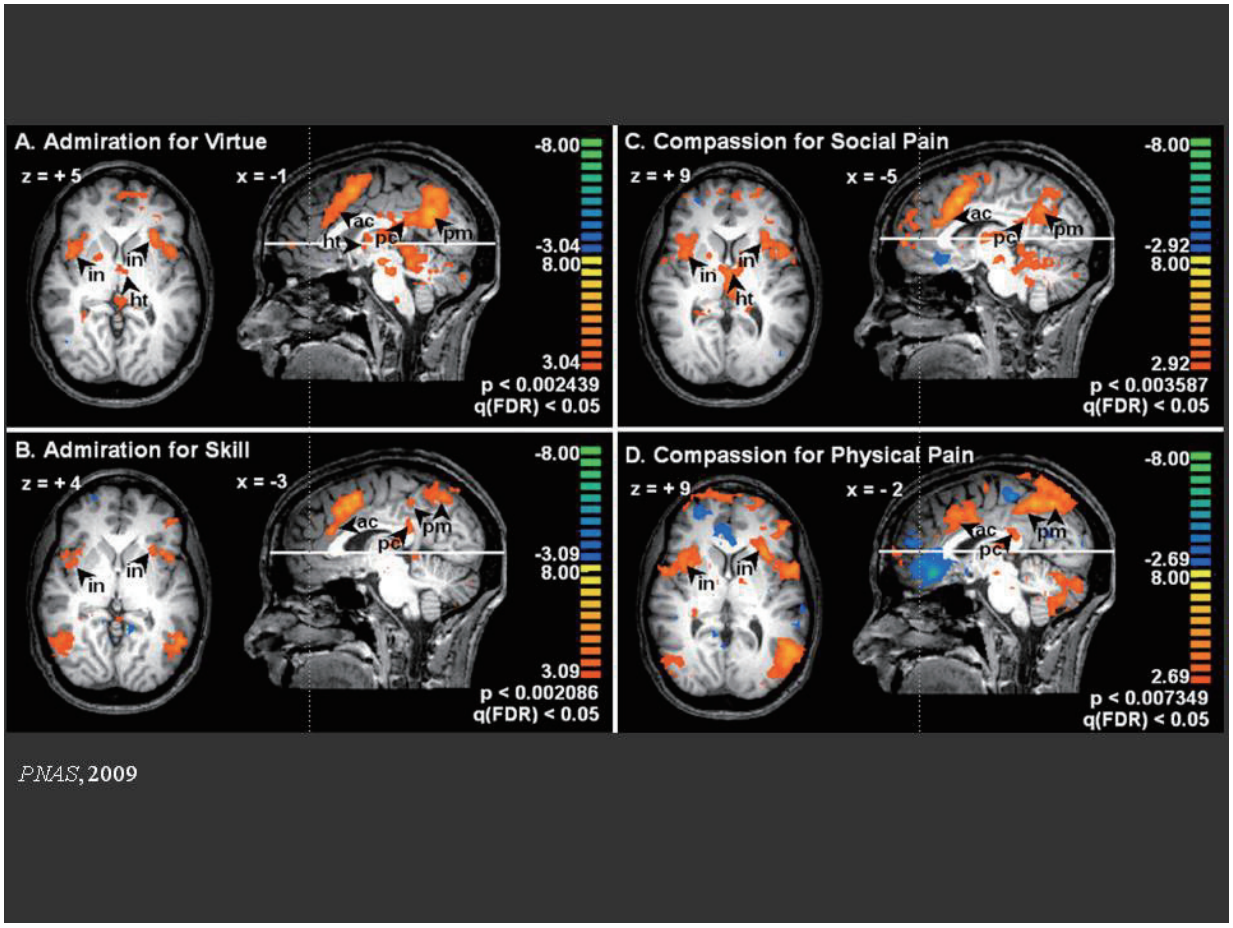

Fig 38

〈Fig 38〉 Finally, let me conclude by saying, I mentioned social emotions earlier in the talk. I just wanted to tell you about one study that was published last year in the proceedings of the National Academy of Sciences, and actually received a prize from the National Academy of Sciences, in which we contrasted four social emotions. They are given under A, B, C, and D. They are respectively admiration for virtue (the kind of admiration that you can have for someone who does an act of enormous generosity), admiration for skill (the kind of admiration that you can have for a great performer like Midori Goto or Yo-Yo Ma), the kind of compassion that you have for social pain (the compassion that you have for somebody who lost face, somebody who lost his position or lost somebody that he or she loved), and finally you have compassion for physical pain (the kind of compassion that you feel for somebody who is involved in an accident and whom you have seen just breaking a bone, for example). There were three questions that we wanted to get at.

One was this. Given that these are social emotions, and that they are presumed to be learned culturally, learned in society, inculcated by school and parents and the culture in general, could it be that these emotions are different from the other ones and do not engage the insular cortex or the brainstem, because they are somehow more located at the surface, more located at the

level of the surface of the cerebral cortex. The answer to that question is resolutely no. These emotions that have to do with moral systems are just as deep in the flesh, as it were, as the other emotions, and they involve exactly the same structures, for example in the insular cortex, and they involve structures also in the brainstem. So this goes very much in line with the fact, as I mentioned, that social emotions are not exclusively human. They appear in other species. For example, in cetaceans they appear. They appear in the big apes, and in a variety of other species. In fact, you can find them in bats, in bears, and in wolves. So this is one thing.

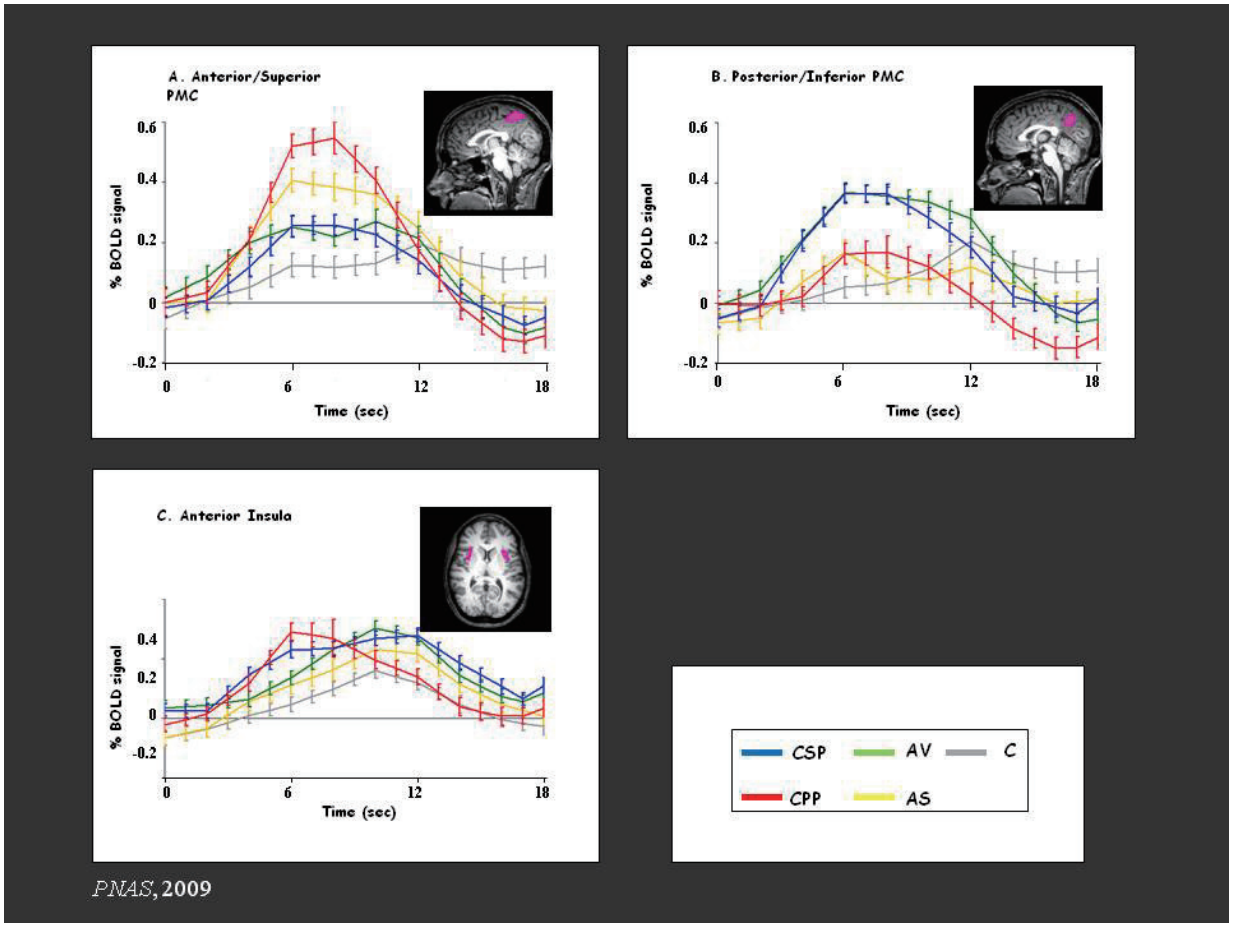

Fig 39

〈Fig 39〉 The other thing that we wanted to get at has to do with time. Is it a fact that all of these emotions in the brain play out in the time course the same way? And the answer is no. We tested the hypothesis, which was as follows. Given the fact that compassion for physical pain is something that you see animals have in relation to other animals, and even in relation to humans in some circumstances, we though, well, maybe because this is evolutionarily older, it will be turn out to be very fast in terms of deployment in the brain. On the other hand, something like compassion for mental pain, the compassion you have for the pain that you suffer when you have a major loss of someone you love, that ought to take longer because that

is more recent, that is, as far as we know, exclusively human, and it is something that involves so much memory and analysis. And that is in fact what we found. We confirmed that hypothesis.

If you look here at the interior insula, we have compassion for physical pain, which is a process that rises very rapidly. In fact, in something like six seconds, it peaks in the brain, and then it drops very fast. Whereas for something like compassion for social pain, which is marked here in blue, it take much longer to peak. In fact, it takes almost another six seconds to peak, and then it stays longer. The idea that this is a process that is more recent, and that it takes more time to develop in brain processing and then more time to dissipate, was in fact confirmed.

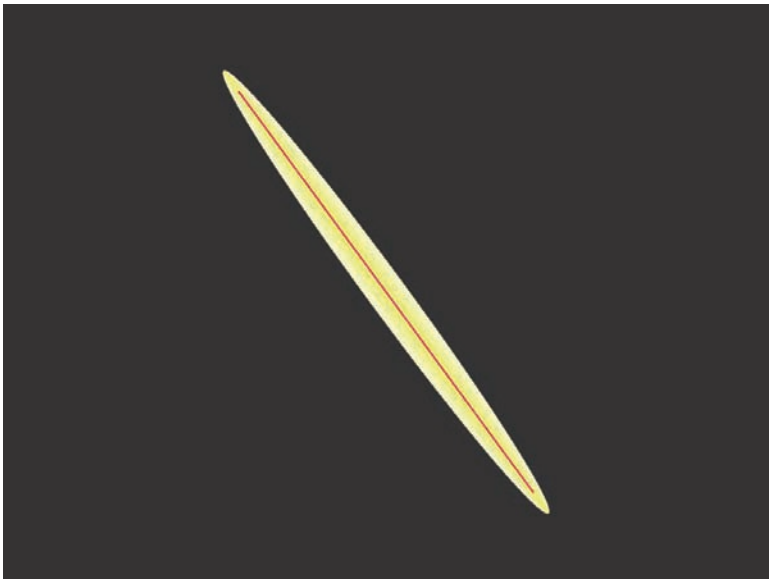

Fig 40

〈Fig 40〉　I just wanted to conclude by saying that studying emotions is not studying irrational things. It's studying processes that are very old in our evolution and that generate feelings have a variety of applications in decision-making, in guiding and serving as the basis for a lot of our social behavior, and even our ethical systems, at the root of those ethical systems. It is true that sometimes emotions are disruptive. We all know that if you need to make a decision and to give yourself to anger or to excessive joy, you're probably not going to make the best decision. But it's very important not to confuse excessive emotionality, which is dangerous, with no emotionality whatsoever, which is also very dangerous. It's a way of putting emotion back where it belongs, something that is obviously positive most of the time, but has its own dangers, and something that allows us to see human beings in this progression from very simple organisms, from the days when all that existed in terms of rationality was in fact our emotions. Our emotions were the beginnings of reason, because when an animal runs away from danger, there is reason, there is rationality in that particular behavior, except that is not

a behavior that is being decided upon consciously. It's a behavior that is being implemented as a result of evolution and our genome equipping the brain with a way to create that reaction. We are extremely fortunate as human beings to have not only that system, which is very old, but also this system that we have been generating throughout our culture and civilizations which allow us to intervene and in some cases allow emotions to do their job, and in some cases allow us to say no. We're not going to allow emotions to do their job because we have a better solution for the problem.

Thank you very much for your attention.

〈MEMO〉

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