

## **Descartes Error - Emotion, Reason and the Human Brain.**

**Antonio R. Damasio**

### **1. Unpleasantness in Vermont.**

Phineas Gage was a 25yo construction foreman in 1848. An accident saw a 3ft x 1½”h tapered iron bar pass through his head from his left cheek to the top of his head passing through the back of the left orbital cavity and close to the midline of the frontal lobe (a little to the left). Gage did not lose consciousness and made a good physical recovery except for lost vision in his left eye. After the accident he no longer showed respect for social convention; ethics in the broad sense of the term, were violated; the decisions he made did not take into account his best interest, and he was given to invent tales “without any foundation except in his fancy” in Harlow's words.

### **2. Gage's Brain Revealed**

While the physical trajectory of the bar is fairly well understood – the functional parts of the brain is less sure because of the variation between individual brains.

On average every neuron forms about 1000 synapses (but up to 5-6000) but there are 10,000,000 neurons so each neuron is modestly connected.

Therefore: “(1) whatever neurons do depends on the nearby assemblies of neurons that they belong to; (2) whatever assemblies do depends on how assemblies influence other assemblies in an architecture of interconnected assemblies; and (3) whatever each assembly contributes to the function of the system to which it belongs depends on its place in that system.”

### **3. A Modern Phineas Gage.**

Elliot (born abt 1940) had a tumour about the size of a small orange removed from above his brain cavity which damaged both the right and left lobes of the prefrontal area. Elliot made a good recovery and retained much of his ability but became dysfunctional.

A battery of psychological tests failed to expose Elliot's behavioural defects. Finally the nature of the dysfunction became apparent, as being completely detached and observed scenes as a dispassionate, uninvolved spectator. Elliot himself noted that his own feelings had changed from before his illness. He could sense how topics that once had evoked a

strong emotion no longer caused any reaction, positive or negative.

A newly developed set of tests including 1. a task involving the generation of social options for action, 2. a task concerning the awareness of consequences, 3. a means-ends problem solving procedure, 4. the ability to predict social consequences of actions, and 5. a Standard Issue Moral Judgement Interview. Elliot performed very well on all of these.

The Standard Issue Moral Judgement Interview ranks subject in one of five successively more complex stages of moral reasoning. Stage 1. obedience and punishment orientation. Stage 2. instrumental purpose and exchange. Stage 3. interpersonal accord and conformity. Stage 4. social accord and system maintenance. Stage 5. Social contract utility and individual rights. By age 36, 89% of middle class Americans have developed to stage 3&4 and 11% have achieved stage 5.

To quote Elliot: “but after all this I still do not know what to do”

### **4. In Colder Blood.**

“Reduction in emotion may constitute an equally important source or irrational behaviour.” pg 53

Impairment of emotion and reason does not just occur with prefrontal damage but also the right cerebral hemisphere and structures of the limbic system such as the amygdala.

Moniz conducted some (many) questionable procedures. It can be concluded that “First, damage to the white matter adjacent to the orbital and medial regions of the frontal lobe altered emotion and feeling, drastically reducing both. Second, the basic instruments of perception, memory, language and movement were not effected. And third, to the degree that it is possible to separate new behavioural signs from those that led to the intervention, it appears that leucotomised patients were less creative and decisive than before.” pg 60

Anosognosia involves the inability to acknowledge disease in oneself. The type of anosognosia discussed involved damage to a select group of right cerebral cortices which are known as somatosensory. Damasio assumes that the brain regions that cross talk with within the overall region of the right hemisphere damaged in anosognosia, probably produce, through their cooperative interactions, the most comprehensive and integrated map of the current body state available to the brain.

Another example is a Supreme Court Judge who

suffered a stroke in the right hemisphere.

Another area is the amygdala

“One of the roles of serotonin in primates is the inhibition of aggressive behaviour (curiously it has other roles in other species)” pg 76

## 5. Assembling an Explanation.

Re-read the whole chapter!

“First, reaching a decision about the typical personal problem posed in a social environment, which is complex and whose outcome is uncertain requires both broad-based knowledge and reasoning strategies to operate over such knowledge. The broad knowledge includes facts about objects, persons, and situations in the external world. But because personal and social decisions are inextricable from survival, the knowledge also includes facts and mechanisms concerning the regulation of the organism as a whole. The reasoning strategies revolve around goals, options for action, predictions of future outcome, and plans for implementation of goals at varied time scales.

Second, the processes of emotion and feeling are part and parcel of the neural machinery for biological regulation, whose core is constituted by homeostatic controls, drives, and instincts.

Third, because of the brain's design, the requisite broad-based knowledge depends on numerous systems located in relatively separate brain regions rather than in one region. A large part of such knowledge is recalled in the form of images at many brain sites rather than at a single site. Although we have the illusion that everything comes together in a single anatomical theatre, recent evidence suggests that it does not. Probably the relative simultaneity of activity at different sites binds the separate parts of the mind together.

Fourth, since knowledge can be retrieved only in distributed, parcellated manner, from sites in many parallel systems, the operation of reasoning strategies requires that the representation of myriad facts be held active in a broad parallel display for an extended period of time (in the very least for several seconds). In other words, the images over which we reason (images of specific objects, actions, and relational schemas; of words which help translate the latter into language form) not only must be “in focus” - something achieved by attention - but also must be “held active in mind” - something achieved by high-order working memory.” pg 83.

“My view then is that having a mind means that an organism forms neural representations which can become images, be manipulated in a process called thought, and eventually influence behaviour by helping predict the future, plan accordingly, and choose the next action” pg 90.

“In between the brains five main sensory input sectors and three main output sectors lie the association cortices, the basal ganglia, the thalamus, the limbic system cortices and limbic nuclei, and the brain stem and cerebellum. Together, this “organ” of information and government, this great collection of systems, holds both innate and acquired knowledge about the body proper, the outside world, and the brain itself as it interacts with body proper and outside world. This knowledge is used to deploy and manipulate motor outputs and mental outputs, the images that constitute our thoughts. I believe that this repository of facts and strategies for their manipulation is stored, dormant and abeyant, in the form of “dispositional representations” (“dispositions,” for short) in the in-between brain sectors. Biological regulation, memory of previous states, and planning of future actions result from cooperative activity not just in early sensory and motor cortices but also in the in-between sectors.” pg 92

“Images are based directly on those neural representations, and only those, which are organised topographically and which occur in early sensory cortices.” pg 98 This is however, not sufficient - “those neural representations must be correlated with those which, moment by moment, constitute the neural basis for the self” pg 99.

“I suspect that explicit recalled mental images arise from the transient synchronous activation of neural firing patterns largely in the same early sensory cortices where the firing patterns corresponding to perceptual representations once occurred. The activation results in a topographically organised representation.” pg 101.

“The convergence zones where dispositional representations can result in images when they fire back to early sensory cortices are located throughout the higher order association cortices (in occipital, temporal, parietal, and frontal regions), and in basal ganglia and limbic structures.” pg 102

Knowledge is embodied in dispositional representations. Innate knowledge is based on dispositional representations in the hypothalamus, brain stem and limbic system. Acquired knowledge is based on dispositional representations in higher order cortices and throughout many grey matter nuclei beneath the level of the cortex.

Thought is made largely of images (auditory or visual).

The human genome does not specify the entire structure of the brain (there are not enough genes). The expression of the genes regulates brain development. The genome help set the (nearly) precise structure in the evolutionary sectors of the brain (and their essence is shared with other species). The genome sets the general arrangement of the other higher order circuits.

Modular neurons distribute neurotransmitters to widespread regions of the cerebral cortex and subcortical nuclei which constitutes the older parts of the brain signalling the general goodness/badness (re survival) to the other parts of the brain.

## 6. Biological Regulation and Survival.

"In general, drives and instincts operate either by generating a particular behaviour or by inducing psychological states that lead individuals to behave in a particular way, mindlessly or not" pg 115

"It would not be advantageous to allow the dispositions controlling basic biological processes to change much" pg 115

Pre-organised mechanisms also help the organism classify things and events as good or bad because of impact on survival of the individual or species.

These innate patters that seem most critical for survival are maintained in circuits of the brain stem and hypothalamus.

Some of these influences are via neurons and others via chemical release.

"the brain structures involved in basic biological regulation are also part of the regulation of behaviour and are indispensable to the acquisition and normal function of cognitive process.

"For most ethical rules and social conventions, regardless of how elevated their goal, I believe one can envision a meaningful link to simpler goals and to drives and instincts.

## Emotions and Feelings.

John Allman found that independently of body size, the neocortex of fruit eating monkeys is larger than that of leaf eating monkeys – which is taken as a blatant indication of the processing capacity of the neocortex. However, it is also correlated with and

increased size of the hypothalamus.

William James "postulated a basic mechanism in which particular stimuli the environment excite, by means of an innately set and inflexible mechanism, a specific pattern of bodily reaction. There was no need to evaluate the significance of the stimuli in order for the reaction to occur." pg 130

"In short, feeling your emotional states, which is to say being conscious of emotions, offers you flexibility of response based on the particular history of your interactions with the environment. Although you need innate devices to get the ball of knowledge rolling, feelings offer you something extra ..... Primary emotions (read: innate, pre-organised) depend on limbic system circuitry, the amygdala and anterior cingulate being the prime players.)" pg 133

"The prefrontal, acquired dispositional representations needed for secondary emotions are a separate lot from the innate dispositional representations needed for primary motions." pg 137

" Those same prefrontal patients can have primary emotions, however, and that is why their affect may appear intact at first glance ..... On the contrary, patients with limbic system damage in the amygdala or anterior cingulate usually have a more pervasive impairment of both primary and secondary emotions, and this are more recognisably blunted in their affect." pg 138

"the motion control for an emotion related movement sequence is not in the same location as the control for a voluntary act" pg 140 (some stroke victims cannot voluntarily move their mouth symmetrically but still smile ok) this also relates to the difference between false and real smiles.

Feelings vs Emotions. All emotions generate feelings but not all feelings originate in emotions.

"the essence of feeling an emotion is the experience of such changes in juxtaposition to the mental images that initiated the cycle" pg 145 for instance, a fright initiates many changes in the physical tone of the body which one feels. The term juxtaposition is used as the neural "fright" comes first, followed by the neural "feeling" of the fright and the two are juxtaposed but not blended as such.

"a further condition for the experience is a correlation of the ongoing representation of the body with the neural representations constituting the self" pg147. (interestingly a picture of a happy face can invoke a partial feeling of happiness)

Varieties of feelings: Basic universal emotions

(happy, sad, angry, fearful, disgusted etc.), Subtle universal emotions (euphoria and ecstasy as variations of happiness, panic and shyness as variations of fear) and Background feelings (body state that prevails between emotions, vaguely positive or negative)

Background feelings include on-line dynamic body maps and more stable maps of general body structure. The state of the body is uninterrupted but often outside of attention.

Patients with anosognosia offer a view of a mind deprived of the possibility of sensing current body state.

“the brain is unlikely to predict how all the commands ..... will play out in the body, because the play out and the resulting states depend on local biochemical contexts and on numerous variables within the body itself which are not fully represented neurally ..... **I suspect that the body states are not algorithmically predictable by the brain, but rather that the brain waits for the body to report what actually has transpired.**” pg 158

feelings and emotions must be included in accounts of cognition.

“The question of how we feel rests on our understanding of consciousness, something about which it pays to be modest.” pg 160 :-)

re-read pg160-164 for some cognitive structural comments.

## 8. The Somatic Market Hypothesis.

There are decisions which don't required conscious thought (getting hungry, avoiding a falling object) and others which do (decisions in social groups and engineering design) but they all rest on the same mechanism. In those that require conscious thought, complexities and uncertainty loom so large that reliable predictions are not easy to come by.

“The personal and immediate social domain is the one closest to our destiny and the one which involves the greatest uncertainty and complexity” pg 169

pg 171. If you just used logic then you would never get an answer. In addition, there is “humans devastating ignorance and defective use of probability theory and statistics” pg 172.

The somatic marker hypothesis - **“somatic markers are a special instance of feelings generated from**

**secondary emotions. Those emotions and feelings have been connected by learning, to predicted future outcomes of certain scenarios”** pg 174. They act as a general heuristic or filter for decision making. i.e. A primary emotion is triggered by a basic, evolutionary developed survival response to a particular aspect of the environment (loud noise, dark). This results in goose-bumps, twisted gut etc. which are literally felt by the brain and associated in memory with the original trigger situation (car hits pole ... power cut ... dark).

When decisions with large risk and large potential are faced in a short time-frame then the natural bias is to take the low risk option.

Willpower is just long term decision making. Altruism is social survival instincts and self-esteem etc.

“The build-up of adaptive somatic markers requires that both brain and culture are normal” pg 177

Acquisition of somatic markers is performed in the pre-frontal cortices. 1. They receive signals from all other sensory regions in which images are formed. 2. they receive signals from several bio-regulatory sectors of the brain 3. They themselves represent categorisations of the situations in which the organism has been involved. “Convergence zones located in the prefrontal cortices are thus the repository of dispositional representations for the appropriately categorised and unique contingencies of our life experience” pg 182 4. they are ideally suited to deciding and reasoning because they are directly connected to every avenue of motor and chemical response available.

Overt and covert somatic markers. Children begin to learn by experiencing pain but later only require an “as-if” symbol of pain to learn (i.e. a threat). Much can happen without requiring conscious attention. The honey bee learns profitable flowers from 3 samples with minimal neural machinery. Covert markers do not go via the body but act directly to inhibit decisions (potentially just to gain time to decide consciously).

“From and evolutionary perspective, the oldest decision making device pertains to basic biological regulation; the next to the personal and social realm; and the most recent, to a collection of abstract symbolic operations under which we can find artistic and scientific reasoning, utilitarian- engineering reasoning, and the developments of language and mathematics.” pg 191

The process of knowledge display must be able to draw on attention (probably increased relevant

neural activity and depression of other) and working memory (to sustain topographically organised representations to support images). This can only be driven by basic value – the basic collection of basic preferences inherent in biological regulation (Sperber Relevance!)

“I propose that a somatic state, negative or positive, caused by the appearance of a given representation, operates not only as a marker for the value of what is represented, but also as a booster for continued working memory and attention.” pg 197

“The images which constitute our thoughts must be structured in phrases, which in turn must be sequentially ordered in time” pg 198

Somatic markers act as a bias to decision making.

### 9. Testing the Somatic Marker Hypothesis.

It was found that patients with frontal lobe damage could generate a skin conductance response to “startle” as could “normal” patients. However frontal damage patients did not generate any skin conductance response to “disturbing” pictures. One of the patients observed that he knew the pictures should be disturbing but that he was not disturbed – he knew but did not feel.

In gambling experiments, the frontal lobe damaged patients continued to choose the high gain / high risk option and continued to lose as a result while normals tended towards the low risk / low gain option to receive a net gain. This combined with the inverted version of the game demonstrated that frontal lobe damage patients were not merely insensitive to punishment but had developed myopia for the future.

“Activation of pertinent somatic states is the critical factor. But I also suspect that the somatic-state mechanism acts as a booster to maintain and optimize working memory and attention concerned with scenarios of the future.” pg 219

Further experiments combining the gambling games and the skin conductance responses. Both normal and frontal lobe damage patients generated a skin conductance response as each punishment and reward was issued. “It was apparent that [frontal lobe damage patients] respond to stimuli that are occurring now .... but that they will not respond if the trigger was a mental representation of something related to the stimulus but not available in direct perception.” pg 220. The normal subjects developed (acquired) an increasing skin conductance response immediately prior to selecting from the high risk

option while frontal lobe damage patients showed no acquired anticipatory response whatsoever.

### 10. The Body-Minded Brain.

“... the body contributes more than life support and modulatory effects to the brain. It contributes a content that is part and parcel of the workings of the normal mind.” pg 226

on the evolutionary basis ... “representing the outside world in terms of the modifications it causes in the body proper, that is, representing the environment by modifying the primordial representations of the body proper whenever an interaction between organism and environment takes place.” pg 230.

“Signals from the outside are thus double. Something you see or hear excites the special sense of sight or sound as a “non-body” signal, but it also excites a “body” signal hailing from the place in the skin where the special signal entered. As the special senses are engaged, they produce a dual set of signals. The first set comes from the body, originating in the particular location of the special sense organ (the eye in seeing, the ear in hearing), and is conveyed to the somatosensory and motor complex which dynamically represents the entire body as a functional map. The second set comes from the special organ itself and is represented in the sensory units appropriate to the sensory modality. (For seeing, these include the early visual cortices and the superior colliculi.)” pg 232

“you do not just see: you feel you are seeing something with your eyes.” pg 232

The concept of “self” is illuminated by contrasting some patients who can identify the “loss” of function and the time that it occurred and those patients with complete anosognosia who do not realise that something has happened or when. The state of self that they construct is impoverished because of the impaired ability to process current body states.

“The neural basis for self, as I see it, resides with the continuous reactivation of at least two sets of representations. One set concerns representations of key events in an individual's autobiography ..... second set of representations underlying the neural self consists of the primordial representations of an individual's body” pg 238.

“Consider, first of all, that the brain possesses a third set of neural structures which is neither the one which supports the image of an object nor the one that supports the images of the self but is

reciprocally interconnected with both. In other words, the kind of third-party neuron ensemble, which we have called a convergence zone, and which we have invoked as the neural substrate for building dispositional representations all over the brain, in cortical regions as well as subcortical nuclei. Next, imagine that such a third-party ensemble receives signals from both the representation of the object and the representations of the self, as the organism is perturbed by the representation of the object. In other words, imagine that the third-party ensemble is building a dispositional representation of the self in the process of changing as the organism responds to an object. There would be nothing mysterious about this dispositional representation which would be of precisely the same kind that the brain seems to be exceedingly good at holding, making, and remodelling. Also, we know that the brain has all the requisite information to build such a dispositional representation: Shortly after we see an object and hold a representation of it in early visual cortices, we also hold many representations of the organism reacting to the object in varied somatosensory regions. The dispositional representation I have in mind is neither created nor perceived by a homunculus, and, as is the case with all dispositions, it has the potential to reactivate, in the early sensory cortices to which it is connected, an image of what the disposition is about: a somatosensory image of the organism responding to a particular object. Finally consider that all ingredients I have described above—an object that is being represented, an organism responding to the object of representation, and a state of the self in the process of changing because of the organism's response to the object—are held simultaneously in working memory and attended, side-by-side or in rapid interpolation, in early sensory cortices. I propose that subjectivity emerges during the latter step when the brain is producing not just images of an object, not just images of organism responses to the object, but a third kind of image, that of an organism in the act of perceiving and responding to an object. I believe the subjective perspective arises out of the content of the third kind of image. The minimal neural device capable of producing subjectivity thus requires early sensory cortices (including the somatosensory), sensory and motor cortical association regions, and subcortical nuclei (especially thalamus and basal ganglia) with convergence properties capable of acting as third-party ensembles. This basic neural device does not require language. The meta-self construction I envision is purely non-verbal, a schematic view of the main protagonists from a perspective external to both. In effect, the third-party view constitutes, moment-by-moment, a non-verbal narrative document of what is happening to those protagonists. The narrative can be accomplished

without language, using the elementary representational tools of the sensory and motor systems in space and time. I see no reason why animals without language would not make such narratives. Humans have available second order narrative capacities, provided by language, which can engender verbal narratives out of non-verbal ones. The refined form of subjectivity that is ours would emerge from the latter process. Language may not be the source of the self, but it certainly is the source of the "L" pg 240.

## 11 A Passion for Reasoning.

### Postscriptum.

### Further Reading

- Many of the references for chapter 5 would be worth reading
- E.G.Jones and T.P.S. Powell (1970)
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**Further Reading**

The following is a brief list of books pertaining to the topics I have just discussed. This is obviously not a comprehensive list of references. The titles are grouped by general area, but it should be clear that many of them belong in more than one category.

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