

Does a functioning mind need a functioning body?
Thoughts on embodiment, physical computation and extended
somatic markers
(extended abstract)
Colin G. Johnson
C.G.Johnson@kent.ac.uk

NOTE: Various sections of this have been developed to different levels of depth.

Introduction

One of the main topics of the proposed book is the computational requirements for designing a functioning mind. This could either be a “purely rational” mind or it could be a mind with affective capacity. In this paper I would like to consider whether it is meaningful to consider designing such a mind without simultaneously designing a body to go with it.

We shall take a non-dualist perspective as an axiom. Therefore there is a requirement for the mind to be realized in some fashion in the physical world. The aim of this paper is to consider the relationship between those parts of the body which act as a substrate for mind (in the sense that they could be replaced in a functionalist fashion by another substrate with no difference) and those parts of the body which influence mind yet which cannot/are not part of a substitutable substrate. The “cannot/are not” in the previous sentence can be interpreted usefully at a number of levels. A strong notion may be that there are no physically possible ways of realizing the same phenomenon. Some phenomena may admit a weaker notion in that it is “easier” in some sense (e.g. faster, more energy efficient) for the mind to process this phenomenon using a physical process which is substrate-contained.

Extended somatic markers

Damasio [Dam94] introduces the notion of the *somatic marker*. The marker is a bodily state which is generated by some mental process, and then *repercieved* causing an emotional state. How important is it that such somatic markers are *somatic*, i.e. internal body states? There are two questions to be considered here. Why should the marker need to extend beyond the body, and not just reside in the mind. This is considered in Damasio’s book and in the following section of the paper. The second question is to ask why the marker need be constrained to reside within the body. One approach to this draws on ideas from Richard Dawkins’ book “The Extended Phenotype” [Daw82].

One of the key ideas in the book is that of the “extended phenotype” itself. The phenotype is the expression in the world of the genotype. The difficulty starts when we want to say where the boundary of the phenotype lies. Clearly certain things are in the phenotype for certain; e.g. the sequence of proteins associated with a particular expression of a particular gene. A standard definition would extend this to the whole body; genes influence the growth, development, and activity of the body (alongside other influences).

Dawkins’ argument is that it is naive to simply say “everything inside the body, phenotype; everything outside, not”. E.g. consider an imaginary species

of bird in which the male has a gene which predisposes itself to mate with females which have blue feathers; it could be said that this gene is also a gene for blue feathers in the female, as as a result of the presence of the gene blue feathers will spread through the female population. To abstract this, the genotype in the male bird is having a phenotypic effect in the female bird. Why should we regard the gene's effect on the feathers of the female bird in any different way to another gene which causes the male bird to have red eyes?

Now let us form a connection to the somatic marker hypothesis. Damasio argues for a body-minded brain in which we create emotions via "somatic markers". These work by parts of the brain recognizing an emotionally charged stimulus, and then rather than creating a direct link to an action on that stimulus, the "marker" consisting of a bodily reaction is created. This is then re-perceived by the brain as is the basis for emotional action.

But why does this have to be physically internal to the body? It would seem that the same reasoning could be applied to markers which I leave in the external world when I have an emotion. For example if I am anxious then I might scribble on the pad of paper in front of me, without attending to this scribbling. This could then become a marker, in this case perceived via the eyes rather than through proprioception. Why should it matter whether I use a bodily state or an external state as the substrate for the marker?

It may be that there are reasons why somatic markers need be somatic. One could be that the speed of reaction required is just too quick to be capable of being carried out by the external perceptive system. Another more convincing explanation is that the reason we use somatic markers is to communicate with multiple brain regions in a simultaneous and co-ordinated way, and therefore we need something which can be perceived in a direct way by different parts of the brain.

This might be a continuum effect. An example of a thing which might be seen as either an external or somatic marker is biting nails when anxious. This is in many ways an external physical process, nonetheless we can perceive the nail state internally via soreness of fingers. There must be other similar examples. Perhaps nail-chewing is "causing" the anxiety (in the sense of being part of the causal chain between subconscious perception of an anxiety-producing stimulus and the affective response) rather than being an epiphenomenon of the emotional state.

Hardware interlocks

In the previous section we asked why the somatic marker need be constrained to the body, and whether it is important to make a body/non-body distinction. In this section we address the opposite question: why is it not sufficient for the marker to be a mental marker? Why not just make a "mental note"?

An analogy can be drawn here with the use of hardware interlocks in safety critical systems. A number of reasons why software is specifically prone to certain kinds of failures has been given by Leveson [LT93, Lev95]. In particular the universality and flexibility of software systems gives rise to a lack of decomposability within the system. There is still a role for hardware interlocks, i.e. specific pieces of hardware designed to detect specific failures and working separately from the main machine, in complex computer-controlled mechatronic devices. These interlocks "leap out" of the complexity of the control software

for certain emergency situations. This non-decomposability seems to be even stronger for neural-network-based systems.

Perhaps some of the ways in which animals use affective states, such as the somatic markers, are examples of such interlocks. If they have continued to prove to be of use in safety-critical computer systems, perhaps evolution has leapt upon a similar mechanism for mind, making use of “off substrate hardware” to deal with emergency (or simply “high priority”) situations.

“Just do it” computation

Another related topic is that of “just do it” computation. This refers to a notion of computation where, instead of transforming natural materials into computational devices, the role of the computer is to translate problems into the starting configuration of devices which “just do” the computation [SCT⁺03]. That is we make use of physical/chemical/biological features of the world to transform the information encoded in a particular way. Complexity of such computations is not related to traditional computational complexity (e.g. gravity does not work more slowly as we add more particles into a system, despite the computational requirements for calculating that gravity being $O(n^2)$ in the number of particles. Nature “just does it”.

Perhaps some of the “off substrate” aspects of the physicality of mind are attempts to use this kind of computation. There are connections here, e.g. with ideas of Dylan Evans and Antonio Damasio about emotion being a “fast and dirty” heuristic to reduce search-time in a complex search-space.

Also to be considered

Other topics which will be considered:

- the notions of “embodiment” in robotics and the arguments which have been made against believing that progress in robotics can be made in a simulated environment
- The various ideas (e.g. [Bai03]) about the idea of a theory of computation based on the physics of the world rather than on abstract notions of a “computational machine”.
- The use of various analogue media as a substrate for computation.
- Notions of communication between substrate and off-substrate aspects of mind.

References

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