Conscious Machines: Memory, Melody and Muscular Imagination

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Abstract

At first glance the question, "Will conscious machines perform better than 'unconscious' machines?", seems innocuous or, at least, to elicit a straightforward positive response, but it also prompts the question, "Perform what?". If the aim is to produce a machine that will perform as a human being or other phenomenally conscious agent in an intersubjectively-demanding social and moral environment, then there can be little doubt that a conscious machine would out-perform an 'unconscious' machine. But there are also circumstances in which a conscious, empathetic, decision-making, risk-taking agent would be a distinct disadvantage; I will allude to circumstances of this kind only briefly towards the end of this paper.

Following on from Damasio's [1991, 1994, 1999, 2003] claims for the necessity of pre-reflective conscious, emotional, bodily responses for the development of an organism's core and extended consciousness, I will argue that without these capacities any agent would be significantly less likely to make effective decisions and survive. Moreover, I will argue that machine phenomenology is only possible within a distributed system that possesses a subtle musculature and a nervous system such that it can, through action and repetition, develop its kinaesthetic memory, individual kinaesthetic melodies, and an enactive kinaesthetic imagination. Without these capacities a potentially conscious machine would remain unconscious. It would be without the necessary nuanced somatosensory awareness of its active engagement, even if that action is to some extent goal-directed, and would be incapable of developing the sorts of somatic markers or saliency tags that enable affective reactions, and which are indispensable for effective decision-making.

Introduction

Holland [2003] makes a distinction between weak and strong artificial consciousness. The former is the design and construction of machines that simulate consciousness or conscious cognitive processes. The latter is the design and construction of conscious machines, machines that will have the capacity for subjective conscious experience. Since weak artificial consciousness (WAC) evokes the possibility of conscious inessentialism – the claim that "for any intelligent activity *i*, performed in any cognitive domain *d*, even if we do *i* with conscious accompaniments, *i* can in principle be done without these conscious accompaniments" [Flanagan 1992, p.5] – we might think of it as presenting or, at least, proposing a form of the philosophical zombie; something which appears to have phenomenal experience and which would, from the perspective of an observer, be indistinguishable from the 'real thing', that is, from strong artificial consciousness (SAC).

The possibility of WAC has been with us since the invention of Jacques de Vaucanson's duck[1], and even though the credulity of the audience has changed very little[2] our ability to produce increasingly complex weakly artificially conscious systems has increased exponentially. However, it is not our capacity to create something which provides a good simulation of consciousness that is the issue here; the issue here is whether or not it will be possible to design and create a strongly artificially conscious machine, and, if it is, would it possess a performance advantage over an 'unconscious' machine?

Machine Phenomenology and the Body

The underpinning for any organism's sensation and feeling, that is, its phenomenology, is its body. Thus it is to the nature and functioning of the body that I will be appealing to support the claim that for a machine to have first-person phenomenal experience it requires a sensory system, a distributed nervous system, a subtle musculature, and actuators to react to its experience and bring about further change within its world. I will temper this claim slightly to admit that organisms with a more limited nervous system, and which might be exoskeletal rather than endoskeletal, might

[1] `http://fr.wikipedia.org/wiki/Jacques_de_Vaucanson`

[2] Our readiness to believe and to over-interpret the actions of the 'other' in our midst is a useful strategy for survival. Even though infants learn to distinguish animate from inanimate, and then to distinguish minded animate from non-minded animate [Stern 1985], it is still wiser to be mistaken occasionally and over-ascribe a mind to some object than under-ascibe one and risk becoming that 'object's' lunch.

still be conscious of their environment, but not to the same degree of phenomenality or with the same subtlety that a more sophisticated endoskeletal system would be capable.

It has been argued that the body plays a crucial role in providing "the unified, meaning-giving locus required to support and justify attributions of coherent experience"[3] to the agent, and it is its dynamically-coupled situatedness that expresses the integration of the system and its world; they are separate but inseparable, possessing an interdetermination that is demonstrated through continuous feedback loops of sensation, action and reaction.

A strongly artificially conscious machine

> . . . must be able to sense its world, bring about change in its world, and distinguish itself from its world; and for these abilities it will require sensing and actuating systems. The former enables an agent to acquire information about its environment, working as an outer sense, making it possible for the animat to determine its external state. The part of the system that senses the external world links, directly or indirectly, to actuators, making action, and hence interaction with the world, possible. But in more complex agents 'sensing' will comprise an 'inner sense' that not only enables the agent to determine its goal(s) and compare its sensory input with its current internal state(s), but also, if the agent is to make appropriate decisions about its action, to monitor its position in the world, its movement through the world and its actions within the world. Such an agent [a SAC] will maintain a 'body schema' that will provide it with "continually updated, non-conceptual, non-conscious information about [its] body ... [providing] the necessary feedback for the execution of... gross motor programs and their fine-tuning" (Meijsing, 2000, p. 39). [Dobbyn & Stuart 2003, pp.197-8]

The sense of both an inner 'egocentric' space [Brewer 1992] and an affective depiction – the sensation of being 'out-there' [Aleksander & Dunmall 2003] – is formed through the rich interplay of the body's sensory channels that receive information about the environment[4], its actuating system that enables manipulation of that environment, and its proprioceptive mechanisms which make it possible to sense the position, location, orientation and movement of the body and its parts. All of these capacities are evident in the majority of human and non-human animal species, and in some – still rudimentary – machines.

The sort of experiential integration made possible at this level is neither necessarily conceptual nor cognitive though it has the potential to become both in the right kind of system. The foundational role in any phenomenally and subjectively conscious system is performed, according to Sheets-Johnstone, by the affective dynamic and tactile-kinesthetic body coupled to its correlative kinetic world [Sheets-Johnstone, 1999, 2000, & 2003]. It is this fully-immersed coupling which makes integration possible, for the very possibility of integration depends on a kinaesthetic synthesis, that is, the formation of kinaesthetic and nervous patterns established through nuanced somatosensory engagement and the repetition of self-directed muscular actions and reactions, all of which operates at a prereflective, yet possibly intentional, bodily level.

Cotterill [1995] uses the wonderful word 'plenisentience' to describe the body's being switched on to its world, perceiving, receiving, imagining, expecting and actuating. It is an echo of Whitehead's claim that "The essence of an actual entity [conscious agent or, quite possibly, conscious machine] consists solely in the fact that it is a prehending thing." [1929, p.56] Through sensors and receptors the system continuously prehends, grasps or becomes aware of incoming and internally transmitted stimuli and, in its movement and perceptual engagement it asks questions about how the world will continue to be for it. This requires a lower, non-self-conscious level of consciousness and expectation that can only be described as 'bodily' and which situates the system in its world.

In understanding the body's capacity for conscious activity, and what would be required for an artificially created conscious system to be subjectively aware of its experiences as experiences for it, we must first distinguish between the body as subject and the body as the object of consciousness, and then we must examine how the two are mutually necessitated through enaction, that is, through the structural coupling that helps a conscious system to anticipate and enact its prospective states; after all, it is enaction that brings forth its world [Varela, *et al.* 1991].

A bodily consciousness of this kind is the result of an interplay between the agent's body image, its body schema, and its being and activity in its world. The terms 'body image' and 'body schema' were first distinguished by Head and Holmes [1911], and further clarified by Gallagher [1986]. It is a distinction for which there is now neurophysiological evidence [Paillard 2005].

The body image is an "internal representation in the conscious experience of visual, tactile and motor information of corporal origin" [Head and Holmes 1911], it comes directly through looking at or touching parts of our body, or indirectly through our perception of, for example, our reflection in a mirror. On these occasions the body is both the content of our conscious experience and the object of our intentional activity and, as the object of thought, it lacks the transparency – the immediacy and lack of self-conscious awareness – that the body possesses as subject. The body schema as a pre-attentional, non-self-consciously monitored [Merleau-Ponty 1962] "real-time representation of the body in space generated by proprioceptive, somatosensory, vestibular and other sensory inputs" [Schwoebel *et al.* 2001]

[3] `http://www.consciousness.it/CAI/CAI.htm` *Viz.* Johnson 1990; Chiel & Beer 1997; Clarke 1997; Damasio 1999; Lakoff & Johnson 1999; Seitz 2001; Dobbyn & Stuart 2003; Legrand 2006; Ziemke 2003 & 2007; amongst a great many others.

[4] The concept of 'environment' is used thickly to refer to the system's world and its own variable internal states that are the subject of homeostatic functions.

possesses this transparency.

The body schema is "a combined standard against which all subsequent changes of posture are measured . . . before the changes of posture enter consciousness" [Head and Holmes 1911]. It is extra-intentional, subconscious, subpersonal and unowned, operating through a set of sensori-motor laws which are "constraining and enabling factors that limit and define the possibilities of intentional consciousness" [Gallagher 1995 p.239] making perception and action possible. It remains hidden phenomenologically from the agent, and is set in stark contrast with the sensory images that go to make up the body image. The body schema "organizes the body as it functions in communion with its environment" [Gallagher 1985, p.549] as it actively, and mostly unconsciously, organises its perceptual experience in relation to its pragmatic concerns [Merleau-Ponty 1962; Heidegger 1968].

The essential role of the body and its dynamic self-directed movement in the generation of consciousness can be established by examining what happens to an agent's consciousness when their body has lost its proprioceptive ability. It is not unusual in cases of such severe deafferentation for a diminution of the sense of self to follow. It is as though the agent's capacity to draw together or integrate their identity has also evaporated, and it is only when they are able to replace their internal feedback system with an external feedback system, most usually their visual sense, that they become able to move – with a great deal of concentration – and regain their sense of self or identity.[5] It seems that just as our eye is not our servant but our ambassador [Ings 2007], so too is our body; that just as our eyes are ceaselessly active, questioning and interrogating our world, so too is our body, and in the absence of afferent stimulation the body loses its integrity and only the eye with its incessant inquiry can provide some compensatory evidence for the agent's bodily perdurance. Thus, it is is not just the passively received information about a changing environment, but the interplay between this information and active self-movement that places the self, an integrated and coherent unity, firmly at the centre of its world [Meijsing, 2000].

In a very similar way locked-in syndrome, with its lesion to the brain stem and damage to the under side of the pons, provides another example of the evaporation of an integrated and depicted subject. In this short passage Jean-Dominique Bauby quotes a half-imaginary exchange with his friend Florence: "'Are you there, Jean-Do?' she asks anxiously over the air. And I have to admit that at times I do not know any more." [Bauby 1997, pp.49-50]

A normal level of sensory bombardment is also absent in patients with spinal cord injury (SCI). Depending on the location and severity of the damage, SCI can result in restricted or absent sensory and sensory-motor input and can, sometimes, be accompanied by, mostly, visual hallucinations. Thus, in the absence of direct afferent input and efferent feedback from the somato-sensory motor cortex, the brain compensates and activation from the visual regions is likely to overlap, even invade, an area of inactivity. However, in some cases the brain, left without sensation, imagines or creates the sensation of pain, often severe and usually situated below the level of the lesion. "Pain, a particular form of imagination of sensory experience without sensory input from the periphery, is a vicious way the brain extracts revenge for being left without sensation" [Cole 2005, p.191]; yet through this revenge the agent once again feels situated in their world.

A still clearer case for the necessity of affection and action is provided by the example of people who have fully-sentient heads but unfelt bodies and who experience themselves as 'floating' unthethered from their body. [Cole 2005, p.185] There can be little doubt that whatever subjective, phenomenal consciousness they experience it is ungrounded, unsituated, and unembodied.

A much less severe, though nonetheless significant, example is provided by Oliver Sacks and describes the phenomenality of severe nervous and muscular damage to his knee. "When I looked straight ahead, I had no idea where my left leg was, nor indeed any definite feeling of its existence. I had to look down, for vision was crucial. And when I did look down I had momentary difficulty in recognizing the 'object' next to my right foot as my left foot. It did not seem to 'belong' to me in any way." [Sacks 1984, p.137]

In each of these cases there has been damage to the body in the form of damage to the nervous system and subsequent damage to the individual's body schema.[6] Each case demonstrates that the body, with its subtleties of sensing and perceiving – its nuanced somatosensory awareness – combined with its capacities for self-directed movement and actuation, is capable of (i) creating and establishing a feeling of how and where the system *is*, its extent and limitation – its *depiction* [Aleksander & Dunmall 2003] – and also for (ii) anticipating how it might be in its world, that is, how it might act given its awareness and selection of those things that have a particular affordance for it. [Gibson 1968 & 1979]

Enactivity is evident in both (i) and (ii), but it is a bodily or kinaesthetic enactivity that produces non-conceptual yet intentional anticipations for how the agent and its world are currently, and how the agent and its world could be should certain potential changes come to pass. None of this enactivity need be conscious or conceptual though under certain circumstances, perhaps of heightened tension or attention, it might be. Think only of attempting to walk silently across a forest floor. The awareness of every movement is intense. The flexing of each muscle is the subject of minute attention. The vigilance with which we scan our surroundings and place each foot is concentrated and precise, and

[5] 'Oliver Sacks remarks (in the 'Forward' to Cole, 1991) that the case of IW "shows how such a peripheral disorder can have the profoundest 'central' effects on what Gerald Edelman called the 'primary consciousness' of a person: his ability to experience his body as continuous, as 'owned,' as controlled, as his. We see that a disorder of touch and proprioception, itself unconscious, becomes, at the highest level, a 'disease of consciousness"' (xiii).' [Gallagher & Cole (1995), Footnote 7]

[6] There may also have been some corresponding effect on the individual's body image but this cannot be an issue here.

the judgement of the likelihood of this twig snapping or that twig bending is made with great diligence. But this kind of scenario is rare. In most of our activity and actuation we rely on the body's natural propensity to automate habituated kinaesthetic activity. The seamless use of any tool, to run and skip, to sign our name, or to throw a curveball is the result of our capacity to memorise and form fluent, non-cognitive melodic movements. [Stuart 2007] As Luria says "with the development of motor skills the individual impulses are synthesized ... into integral kinaesthetic structures or kinetic melodies." [Luria 1973, p.176] Thus it is through sensation, action and repetition that the agent develops an enactive kinaesthetic imagination, its kinaesthetic memory, and its own unique individual kinaesthetic melodies. Such melodies can correspond to gross motor skills but they can also correspond to subtle and more local bodily affective activity, for example, the unreflexive or 'gut' response that provides us with a pre-cognitive 'feeling' about potential actions. In terms of effective decision-making, consciousness, even at this bodily level, presents a significant advantage for any situated and embodied agent.

The Somatic Marker Hypothesis

Over the last two decades Antonio Damasio has presented a consistently forceful case for the role of the body, and specifically for the emotions, in effective decision-making. [*Viz.* Damasio *et al.* 1991; Damasio 1994, 1999, & 2003; and Damasio *et al.* 2000] According to his theory, emotions – defined as spontaneous neural and chemical responses to changes in the agent's physiological state – play a central role in the agent's homeostatic functioning. "[T]he subjective process of feeling emotions is partly grounded in dynamic neural maps, which represent several aspects of the organism's continuously changing internal state". [Damasio *et al.* 2003, p.1049] They are the body's pre-reflective, pre-cognitive affective activity which act to underpin the development of the agent's successful adaptive behaviour.

It is impossible, in this paper, to go into the finer details of Damasio's breakdown of emotions into six primary (universal) emotions [*Viz.* Ekman 1992]; a number of secondary (social) emotions, for example, embarrassment and pride; and background emotions, for example, calm or tension, anticipation or dread; but even simply stating them goes some way to demonstrate the manifest complexity and subtlety of the phenomenally conscious subject.

Decision-making in such a subject isn't simply a cognitive and evaluative process involving a judgement about how best to reach the desired goal; it is also a matter of determining the emotional salience a state of affairs or potential action has for the agent. Thus, it requires sensory and affective elements and, only on some occasions, perhaps involving the secondary social emotions, will it also require a cognitive element. Without an affective element the agent will be unable to rank the items to be judged in order of their significance to her directly, or to her indirectly by the affect they are likely to have on those about whom she is concerned. This ranking is termed 'saliency tagging' and the capacity to tag in this manner is formed through our experience of primary inducers, for example, direct or immediate experience of something dangerous, which establish in us a network of secondary inducers making it possible for us to recall in similar future situations – though not necessarily consciously for that would hinder the speed of our reactions – the sensation we had on experiencing the primary inducer and now disposing us to react with appropriate caution or incaution to whatever it is we now experience. Thus patterns of bodily affective actions speed up effective decision-making in the same and similar future contexts.

The feelings we have as a response to these emotions can be conscious or unconscious, but when conscious they represent the relation of the emotion to ourselves as agents in the world. In Damasio's language and theory this is expressed through the relation of the proto-self to the core-conscious self, or core-consciousness. So, there is some 'primary mode of being' [Heidegger 1962] which is phenomenologically and ontologically prior to, and necessary for, the formation of a core-consciousness, and the "absence of emotion [the primary mode of being] is [or can be taken to be] a reliable correlate of defective core consciousness". [Damasio 2003, p.100]

Several areas of the brain are crucial for effective decision-making; they include the amygdala, the anterior cingulate cortex, the brain stem, the hypothalamus and the ventromedial prefrontal cortex [vmPFC]. The vmPFC mediates between the limbic system and the cerebral cortex and damage to it can leave the subject intellectually unimpaired yet incapable of making ordinary everyday decisions in real-life situations. Damasio quotes patient EVR as having suffered damage to the vmPFC and to the connection between the amygdala and the hypothalamus. As a result EVR is incapable of making a decision about trivial matters like where he should go for dinner for he becomes overwhelmed by irrelevant information. He is incapable of tagging and prioritising informational criteria as relevant or irrelevant for all criteria carries the same emotional weight.

This kind of day-to-day affective activity and effective decision-making requires a phenomenally conscious agent. But if our system is, in fact, a façade of conscious engagement, a WAC, it will have no capacity for creating and establishing a feeling of how and where *it is*, or for anticipating, pre-cognitively yet affectively, how *it might be*. There can be little doubt that, as a consequence, it will be much less efficient than a phenomenally conscious, subjectively aware system. With no sensation a WAC has no affective somatosensory, motor, and efferent feedback system, it will be unable to develop the sorts of somatic markers or saliency tags that enable affective responses and, thus, the formation and reformation of adaptive behaviours and strategies. Without these a WAC will either take an unconscionable amount of time because it will be unable to decide between equally-weighted items, becoming a modern-day Buridan's ass, or it will make a decision that could impact unfavourably on its continued survival. It will have no natural feel for itself in its world; there won't be *a world* for it; indeed, there won't be an *it*.

Phineas Gage is the best example of someone who falls into the latter category as being perfectly able to continue to make decisions, but which ceased to be effective. [Damasio *et al.* 1994]. Phineas Gage could not be considered equivalent to a WAC, he remained conscious, even through and after his accident, but the damage to his vmPFC left his social action and interaction very seriously impaired. An account from his own doctor reveals that he went from being a hard-working and reliable family man to a confabulator whose decision-making skills were limited to the formation of unrealistic schemes.

> His contractors …considered the change in his mind so marked that they could not give him his place again. He is fitful, irreverent, indulging at times in the grossest profanity …manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires, at times pertinaciously obstinate, yet capricious and vacillating, devising many plans of future operation, which are no sooner arranged than they are abandoned …. [Harlow 1848]

After the cortical damage Gages chances of survival outside the protection of his social group would have been extremely limited. Not only had he lost any sensitivity to, or capacity for, informative visceral responses, but in his devising of wild schemes and lack of consideration for others he seemed also to have lost his basic endogenous intersubjectivity [Gallagher 2007], the practical knowledge of oneself that guides one's actions from the inside out.

Damasio's account does not rule out the evaluative capacity that we associate with judgement, it's just that it comes much later on and at a much higher, possibly consciously cognitive, level as the result of reflection and feeling, where feeling is "the realization of a nexus between an object and an emotional body state' [Damasio 1994, p.132]. It would be hoped that with the creation of a SAC the reflexive evaluative capacity would emerge through the ongoing felt dynamics of the agent's social action and interaction but, as Damasio [2003] has shown, damage to certain regions of the frontal lobe in young children can inhibit the development of social emotions, like compassion, shame, and guilt; the very emotions we tend to associate with mature subjective reflection, evaluation and judgement.

Conclusion

We began with the doctrine of conscious inessentialism and the possibility of building a machine that could do everything that a phenomenally conscious subjective agent could but without the phenomenal subjectivity. But conscious inessentialism is a false doctrine; a WAC could never succeed in a SAC environment for the effective decision-making activity of a SAC requires the very thing that conscious inessentialism denies: it requires a self-directed active, dynamically-coupled agent with a capacity for affective bodily activity that makes possible the development and automatisation of appropriate responses and adaptive behaviours in social and moral environments.

Placing a WAC in the SAC social environment, where judgements and decisions have to be made in real-time and concerning the well-being of the machine and relevant others, is destined to fail. It can neither feel nor think. In these circumstances the zombie, the WAC, is an evolutionary dead-end, and the answer to the question "Will conscious machines perform better than 'unconscious' machines?" must be 'Yes'. But there are times when a phenomenally affective conscious agent can entail ineffective decision-making, and where the operation of an unconscious machine would be preferable.

In the case of the mid-air collision of the Bakshirian Airlines Tupolov 154 and the DHL Boeing 757 on 1 July 2002 the pilots gave the conscious human flight controller the benefit of the doubt as he over-ruled the 'unconscious' ACAS II-compliant collision-avoidance system's message; had they not, the disaster might just have been avoided.

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