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Art and Reductionism

All thinking is done by our brains. They are also responsible for our feelings of love and hate, and for our ability to make and appreciate art. But there is a popular reluctance to credit the brain with some of these so-called *higher* functions. We have difficulty associating our appreciation of beauty with electrical impulses propagating down nerve fibres. We don't see love as residing in the organ that is hidden away inside the skull, where it sits, shaped like a boxing glove, grey, motionless, and seemingly inert. Instead, the icon of love is that fist-sized muscle in your chest.

We have learned that the three pounds of grey mass in the head is the most delicate and liveliest object we know of in the universe, and that below its quiet, non-assuming, exterior, billions of nerve cells are constantly tending to our many needs.

Four years ago, The *Journal of Consciousness Studies* devoted two issues to the question, how art relates to what goes on in the brain. In his editorial introduction, Joseph Goguen (1999) states that the larger question confronted in this volume is, 'what does it mean to be human?'

The lead article, *The Science of Art*, by Ramachandran & Hirstein (1999) listed eight *universals,* or 'laws of artistic experience', and assigned neural mechanisms to some of these. In a follow-up interview, Ramachandran (2001) responds to frequent criticisms of his paper, by (correctly) calling reductionism the 'most powerful strategy known to science'. He defines reductionism (wrongly) as 'explaining a phenomenon in terms of the behaviour of its constituent components', which in this case means the specialized signalling cells in the brain, the *neurons.* The same misunderstanding causes Donnya Wheelwell (2000), the harshest critic of the paper by Ramachandran and Hirstein(1999), to cite the word *reductive* along with such pejorative adjectives as *superficial, tawdry, debasing, offensive,* and *anti-human.*

I wish to address this very common misunderstanding in this brief note.

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Reductionism in Physics

Physics is often considered to be a difficult subject, mainly because of its extensive use of mathematics. At the same time it is conceptually one of the simplest structures, as it attempts to weave a seamless fabric of cause and effect that takes us from the smallest and most elementary to the most complex. Drastically different sets of phenomena are shown to rest on the same underlying principles and laws. The classic case of this *unification* brought together Newtonian mechanics and the theory of heat through the work of Clerk Maxwell and Ludwig Boltzmann. Here, the *macroscopic* science of thermodynamics is *reduced* to a statistical treatment of atomic collisions.

This type of reductionism, which takes us from the large (and complex) to the small (and elementary), is almost the rule in physics. It has to do with the fact that — with inanimate matter — causality works more strongly from the small to the large than in the opposite direction. Reductionism seeks out the roots of this causality. It is the nature of the atom that determines how bulk matter behaves, but there is little effect going the other way. We *understand* what makes an ice crystal by tracing its structure to the known properties of water molecules and the forces between them, and we understand the water molecule as resulting from the binding between atoms of oxygen and hydrogen. It would seem foolish to proceed in the opposite direction. The atom of oxygen in a water molecule is no different from one in the molecular oxygen we breathe, and the molecule of water *doesn't know* whether it is part of an icicle, a waterfall, or chicken noodle soup. If we wanted to, we could continue to *descend* to the constituent electrons, protons, and neutrons, and to the *ultimate* elementary units, the quarks and gluons. Because of the search for the smallest, elementary causes, I will call this process *atomistic reductionism.*

But reductionism does not always seek understanding of the large by looking for causes in the small. Large-scale structures *do* affect phenomena on a smaller scale: the mass of a chunk of U235 determines the local cascade of fission events.

Nagel's Definition of Reductionism

The Latin root *reducere* means to *lead back* (not necessarily toward smaller scales). The *reductio ad absurdum* demonstrates a faulty argument by *leading back* to the original assumption and showing it to be untenable. In physics, as we have seen, reduction most often seeks explanation in elementary events. But there are exceptions. What, then, do we mean by a reductionist explanation?

The philosopher of science Ernest Nagel, who defined reductionism (1961), sees it as the unification of two distinct fields of inquiry. One he calls the *primary science* which has the virtue of greater range of applicability, and a generally more elegant, intellectually satisfying, structure. According to Nagel, reductionism consists of expressing the laws and rules of the secondary science in terms of those of the primary science. In this way, the secondary science of thermodynamics was shown to be expressible in terms of the concepts and laws of the primary science of Newtonian mechanics. Often the elements of the primary science are smaller, more elementary; but not always. Nagel is careful not to state this as a general rule. The field of optics was reduced to the more all-encompassing electrodynamics. Both are macroscopic theories.

Nagel set down some formal, and very stringent, conditions for the process of reduction.

> It is an obvious requirement that the axioms, special hypotheses, and experimental laws of the sciences involved in a reduction must be available as explicitly formulated statements, whose various constituent terms have meaning unambiguously fixed by codified rules of usage or by established procedures appropriate to each discipline. To the extent that this elementary requirement is not satisfied, it is hardly possible to decide with assurance whether one science (or branch of science) has in fact been reduced to another.

Later, Nagel admits that this 'ideal demand' is not always realizable in practice. Certainly, Ramachandran's eight 'laws of artistic experience' fall far short of that ideal.

Causality in Living Matter

There is a quantitative difference between living and inanimate matter in the relative strengths of the up and down streams of causality. Just as in inanimate matter, so in an organism, the properties of molecules still determine what happens on a larger scale. The details of our bodily structure and its elaborate chemistry are determined by the microstructure of DNA. The control is delicate and extends over several orders of magnitude in scale. But here, unlike in inanimate systems, the stream of causal events from the large to the small is powerful and ever-present. Bertrand Russell remarked that 'No part of any living entity and no single process of any complex organic unity can be fully understood in isolation from the structure and activities of the organism as a whole'.

This kind of unity is only occasionally seen in inanimate matter. We mentioned the case of chain reactions in fission. Also, the integrity and size of a star are required to sustain the nuclear fires at its core. When they cease, we speak of the *death of the star*. An extreme case of *top-down control* was proposed about a hundred years ago by the German physicist Ernst Mach. He attributed the inertia of every object to its being embedded in a universe of objects.

In living things, the source of such *top-down* control is not confined to lie within the boundaries of the individual, but includes all of the ecological environment and extends backwards in time. Over millions of years, countless members of the species carried the DNA through their brief lives and, with their struggles for survival, helped shape the molecule to make the individual better able to evade predators, outwit prey, and achieve dominance among its own kind.

To *understand* the contents of a particular DNA molecule and their significance, it is therefore not sufficient to trace the physics and chemistry of its component groups and the valence bonds and hydrogen bonds that link them together, and how it is synthesized from its parent structure by codon–anticodon bonding. We must search the past history of the species and analyse how the environment *selected* the genes that gave today's individuals the best chance to live and reproduce.

Reductionism and the Brain

The human brain is shaped not just by the *bottom-up* influences of our genes, but also by a wealth of *top-down* effects of past experiences, including what we generally refer to as *culture*. Accordingly, what we perceive through our senses is determined not just by the 'upstream' transport of information — Ramachandraan refers to it as a sensory 'bucket brigade', but by a wealth of events stored and anticipated by the brain. What is more, almost any macroscopic physical event that involves the intervention by a human brain cannot be fully understood by just following the chain of cause and effect beginning with elementary neural events (Burns & Engdahl, 1998). There is no mystery involved in this.

To illustrate, consider this scenario set in a supermarket in the State of New York. Among the different items selected by the shoppers, there will be an occasional six-pack of beer. But not on Sundays. To explain that phenomenon, which is evidently controlled by the brain of the shopper, one could resort to one of the powerful new means of monitoring brain activity. An fMRI may show that certain activities in the motor cortex that have to do with the retrieval of six-packs of beer are absent on Sundays. The investigator might then be encouraged to look for a selective motor inhibitor with a seven day cycle. If we are lucky and find one, this will only raise more questions. The approach appears hopeless. But there is a simple and very satisfactory explanation: The State of New York has a law that forbids the sale of alcoholic beverages on Sundays. The shoppers know it.

The point I am making here is twofold: 1) To arrive at an *understanding* of a phenomenon, especially one involving the human brain, it is often necessary to go beyond *atomistic reductionism* and consider top-down causation: 2) A satisfactory explanation may involve *non-physical* factors, such as the knowledge of laws, in the above example, and the anticipation of being stopped at the checkout counter when in violation. Simply stated, events in the mind (knowledge, desires, etc.) 'can have the status of scientific entities', as Brown has stated (1999), that is, they can be part of an intellectually satisfying causal framework. This is not to deny the existence of a seamless chain of *physical* causes, but the details of these may be both inaccessible and uninteresting.

Beyond the Reflex

A possible division between what is understandable in brain functions in terms of elementary neural mechanisms (atomistic reductionism), and what is not, may be found in the different time scales on which these processes take place. Fast perception, including discrimination and selective motor function, sometimes called cortical reflexes, can be completed in just a few tenths of a second. Thus, Thorpe and Fabre Thorpe (2001) have shown how a visual discrimination task involves propagation of information from the retina via LGN to the primary visual cortex, then along one of the branches of the visual pathway, to the prefrontal cortex, then from there to the pre-motor and motor cortex, then down the spinal cord to the motoneurons that enervate the appropriate muscles. In the animals tested, this whole process, from eye to action, takes place in something like two tenths of a second, from which the authors concluded that no feedback loops are involved. It is strictly *feed-forward,* or what Ramachandran characterized as the *bucket brigade*.

By contrast, the duration of relevant neural mechanisms in most thought processes, including the creation and contemplation of works of art, is many times the time required for neural signals to traverse the entire brain. We conclude that this involves sustained, reverberatory activity which touches on a panoply of stored information and releases a wealth of associations, memories and emotions. I want to suggest that such brain functions — like those of the supermarket shopper — generally do not allow a detailed analysis in terms of a seamless chain of microscopic neural events.

Reductionism and Art

We appreciate and enjoy artistic expression. Some of us also try to understand its roots and phenomenology. The approach by Ramachandran and Hirstein (1999) and Ramachandran (2001), in which the causes of artistic rules are sought in the microworld of neural mechanisms, while 'ignoring the complexities imposed by culture', offers little hope for any significant insight and invites the common criticism of what is sometimes called a 'reductionist approach'. That is why most of us derive greater intellectual satisfaction from a good art history (such as E.H. Gombrich, 1960), than from a theory of art that attempts to apply atomistic reductionism while neglecting the 'complexities imposed by culture'.

Is knowledge of our brain irrelevant in relation to art? Of course not, though Zeki (1999) overstates the case saying that 'no theory of aesthetics is likely to be complete, let alone profound, unless it is based on an understanding of the workings of the brain'. Many mental states have known correlates in neural activities. The science of seeing has much to tell us about how we make and view images. Vision in the human brain is a system of loops and recurrent pathways (Yingling & Skinner, 1977; Felleman & Van Essen, 1991) that link peripheral images and central symbols, the specific and the general, sensation and knowledge. I have stressed the significance of these structures in our use of *internal sketchpads* in reasoning and imagery (Harth, *et al*., 1987; Harth, 1993; 1995), and the natural extension of this process to the creation of external images (Harth, 1999).

Ultimately, a profound evaluation of artistic expression must involve both the world at large, which is its inspiration, and the human brain, which is capable of being inspired.

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